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Report of the Working Group on Assessment of Demersal Stocks in the North Sea and Skagerrak (2017)

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Contents

Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met 26 April–5 May 2017 at ICES HQ, Copenhagen, Denmark. There were 27 full and part-time participants (+ three by correspondence) from 9 countries. The main terms of reference for the Working Group were: to update, quality check and report relevant data for the working group, to update and audit the assessment and forecasts of the stocks, to produce a first draft of the advice on the fish stocks and to prepare planning for benchmarks next year. Ecosystem changes have been analytically considered in the assessments for cod, haddock and whiting in the form of varying natural mortalities estimated by the ICES Working Group on Multi Species Assessment Methods (WGSAM).

Working procedures

WGNSSK met for 10 days to deal with the TORs, including one which required MSY proxy reference points to be derived for Category 3 stocks (this substantially increased the workload for the group).

Data were requested through a joint DCF-based data call for all assessment working groups, and the deadline for early data delivery were largely held, and any delays did not significantly impede work progress.

The principle analytical models used for the stock assessments were SAM, XSA, TSA and the Aarts and Poos model (AAP), as well as SURBAR (for one data-limited stock). For Category 3 stocks, SPiCT and the Length-based Indicator (LBI) approach developed within WKLIFE were used to estimate stock status relative to reference points.

WGNSSK works in close cooperation with WGMIXFISH and assessment and forecast results are directly used by WGMIXFISH to produce mixed fisheries advice. Similar links are established between WGNSSK and WGSAM to allow for an effective exchange of data and knowledge regarding multi species assessments.

Benchmarks and Inter-benchmarks in 2016/2017

Benchmark meetings were held for Norway Pout (WKPOUT meeting 2016), *Nephrops* FU 32 and FU 3–4 (WKNEP meeting 2016), and plaice in 4 and 3.a.20 and sole in 7.d (WKNSEA meeting 2017). For Norway Pout the main change was moving from a seasonal XSA (SXSA) model to a seasonal SAM (SESAM) model that excludes commercial cpue data, omits 1 983 data from the assessment and omits the years of fishery closure from the random walk variance calculation; furthermore, Blim is set equal to Bloss based on quarter 4 SSB values to align with the new fishing season (1st November to 31st October), and the short-term forecast is stochastic, which al-lows the probability of SSB being below Blim to be evaluated immediately following the fishing season.

The status of FU 32 was also considered, but any reliable assessment for this stock is currently out of reach due to the lack of data; nevertheless, the benchmark considered that a biomass index for Norwegian Deep developed during the benchmark should be presented and updated as part of the annual assessment procedure of the FU 32 stock; furthermore, the benchmark decided to use the union of the fishing areas for 2013–2015 as the area estimate in the harvest rate table (3613 km^2). For FUs 3–4, UWTV surveys have been used for several years to assess the stock, and the benchmark agreed that the proposed improvements and refinements were acceptable and appropriate for providing scientific advice on the abundance of this stocks. The benchmark concluded

that for deriving reference points, and hence translating the stock abundance estimate to recommended removals, the common length-based yield per recruit method was not appropriate (see "state of the stocks" for *Nephrops* below).

For plaice in 4 and 3.a.20, the assessment model was changed from XSA to a smoother-based age structured stock assessment, based on Aarts and Poos, but the F-at-age matrix is generated using a tensor spline, and rather than using the discards and landings-at-age as separate data sources, the final assessment uses the catches (the sum of landings and discards) as data and the basis for the likelihood fitting. For sole in 7.d, XSA was kept as the assessment model and included catch data (2003–2015), discards, new stock weights, new maturity ogive, three research surveys (the UK BTS sur-vey, and the UK and French YFS surveys), and three commercial surveys (a newly constructed Belgium commercial survey 2004–2015, a new French otter trawl series 2002–2015, and the UK CBT commercial series). The new model resulted in an increase in SSB and decrease in F, especially in more recent years.

An inter-benchmark protocol meeting was held during the summer of 2016 for haddock in order to investigate the cause of the apparent failure of the TSA model, to remedy this failure, if possible, or to consider alternative models, if not, and to re-estimate reference points based on the newly selected model. The IBP identified the problem as a retrospective pattern caused by the way in which the larger post–1999 recruitment events were treated, and was able to find a TSA model configuration that remedied this problem; this was achieved by not treating any of the post–1999 year classes as "outstanding". The post–1999 period was then used as a basis for estimating reference points, apart from B_{lim} which was taken as the lowest SSB that produced an outstanding year class (1979).

State of the Stocks

The main impression in 2017 is that fishing mortality has been reduced significantly for many North Sea stocks of roundfish and flatfish compared to the beginning of the century. All fish stocks with agreed biomass reference points are above B_{lim}, and only the SSB of sole in 7.d is below MSY $B_{trigger}$ at the beginning of 2017. Several North Sea stocks are exploited around or below F_{msy} levels; exceptions are cod in 4, 3.a.20 and 7.d, haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d and sole in 4 (the latter only slightly above F_{msy}). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries. For all of these stocks, catch advice was provided in 2015 for the first time, and again in 2017. In 2017, for data-limited *Nephrops* stocks (FUs 5, 10, 32, 33 and 34), pollack and grey gurnard, it was only necessary to determine whether the perception of the stock has changed compared to 2016; because perceptions have not changed compared to 2016, no reopening of the advice was needed for these stocks.

Reopening of advice was triggered for several stocks in the autumn, namely cod in 4, 7.d and 3.a.20, haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d, plaice in 4 and 3.a.20, sole in 4, and *Nephrops* in FU 6, 7 and 8.

The summary of stock status is as follows:

a) *Nephrops*: Although the stock abundance index for FU 6 increased from 2015 to 2016, it has been below MSY $B_{trigger}$ since 2011, and harvest rates have been above the MSY level since 2008. The stock size for FU′7 declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015, but increased again in 2016 and is now above MSY $B_{trigger}$, while the harvest rate has declined since 2010 and remains well below F_{MSY}. For FU 8, the stock size has been above MSY $B_{trigger}$ for most of the time-series, and the harvest rate varying and now below F_{MSY}. For FU 9, the stock has been above MSY $B_{trigger}$ for the entire time-series, while the harvest rate has fluctuated around F_{MSY} and is now slightly above it. The stock size of *Nephrops* in 3.a is considered to be stable, while the harvest rate for this stock is currently below F_{MSY}. The FUs 5, 10, 32, 33 and 34 are data limited, and new catch advice was not provided in 2017 (biennial advice was set in 2016). The state of *Nephrops* outside the functional units is unknown; landings have been increasing since 2014. Because the TAC is set for the whole North Sea and not at a functional unit level, this contributes to F_{MSY} reference points being exceeded in some FUs.

b) During the WKNEP 2016 benchmark, the reviewers agreed that for deriving reference points, and hence translating the stock abundance estimate to recommended removals, the common length-based yield per recruit method was not appropriate. The reviewers agreed that deriving harvest rates from historical experience and from experience with similar stocks, as suggested by WKNEP, was acceptable as an interim solution until a firmer basis for generating advice from UWTV survey abundance estimates can be developed. The advice-drafting group for the greater North Sea (ADGNS 2017) decided that, until an alternative, approved methodology for deriving reference points was in place, the reference points derived by the current methodology should continue to be used.

c) Norway Pout in 4 and 3.a: The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass is above B_{pa} in 2017. Fishing mortality has been fluctuating at a lower level than previously since 1995. Recruitments in 2014 and 2016 were high, while recruitments in 2015 and 2017 are below the long-term average recruitment.

d) Cod in 4, 7.d and 3.a.20: Fishing mortality has declined since year 2000, but is estimated to be above F_{MSY}. Spawning-stock biomass has increased from the historical low in 2006 to above MSY $B_{trigger}$ in 2017. There are indications of increased recruitment in 2017.

e) Haddock in 4, 6.a and 3.a.20: Fishing mortality has been fluctuating above F_{MSY} for most of the time-series and is above F_{MSY} in 2016. Spawning-stock biomass has been mostly above MSY $B_{trigger}$ since 2002. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing. The 2014 recruitment estimate is higher than recent low recruitment, but is still below the long-term average.

f) Whiting in 4 and 7.d: Spawning-stock biomass has fluctuated around, and is now above MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} throughout the time-series. Since 2003 recruitment has been generally lower than in previous years.

g) Saithe in 3.a, 4 and 6: Recruitment has fluctuated over time and has generally been below the long-term average since 2003. Fishing mortality has been below F_{MSY} since 2013. Spawning stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996.

h) Plaice in 4 and 3.a.20: The spawning-stock biomass is well above MSY $B_{trigger}$, and has markedly increased in the past ten years. Recruitment has been around the long-term average since the mid–1990s. Since 2009, fishing mortality has been estimated at around F_{MSY}.

i) Sole in 4: The spawning-stock biomass has increased since 2007 and has been estimated at above MSY $B_{trigger}$ since 2012. Fishing mortality has declined since 1997 and is slightly above F_{MSY} in 2016. Recruitment has fluctuated below average without trend since the early 1990s.

j) Plaice in 7.d: Fishing mortality has declined since the early 2000s and has been below F_{MSY} since 2009. Spawning-stock biomass has increased since 2008 and has been above MSY $B_{trigger}$ since 2012. Recruitment in 2016 is the lowest in the time-series.

k) Sole in 7.d: The spawning-stock biomass has been fluctuating between B_{lim} and MSY $B_{trigger}$. Fishing mortality has been decreasing since 2014 and is below F_{MSY} in 2016. Recruitment has been fluctuating without trend and was in 2012–2016 at the lowest of the time-series, with the exception of 2015.

l) Category 3–6 finfish stocks: In 2017 new advice has been produced for several Category 3 and 5 stocks, but not for pollack and grey gurnard (for which biennial advice was given in 2016).

i. Brill in 3.a, 4 and 7.d-e: The biomass index has been gradually increasing over the time-series with moderate interannual variability. It has been higher in the last two years than in the three previous years.

ii. Dab in 3.a and 4: The assessment is indicative of trends only. The spawning-stock biomass has been increasing since 2006. Total mortality has declined since 2003. Recruitment showed an increasing trend until 2014, but has declined in the latest two years of the time-series. As a result of ICES advice following a Special Request from the Commission on the joint TAC for dab and flounder (ICES, 2017b), dab has been removed from TAC regulations (paragraph 8 of Council Regulation (EU) 2017/595).

iii. Flounder in 3.a and 4: Landings have been decreasing since 2006 and are stable in the most recent years. The available survey information indicates no clear trend in stock biomass. As a result of ICES advice following a Special Request from the Commission on the joint TAC for dab and flounder (ICES, 2017b), flounder has been removed from TAC regulations (paragraph 8 of Council Regulation (EU) 2017/595).

iv. Lemon sole in 3.a, 4 and 7.d: The biomass index (IBTS–Q1 SSB per hour) has fluctuated without significant trend since the mid–1980s. Landings have mostly decreased since the early 1980s, with a small increase in recent years. The discard rate is similar over the four years for which estimates are available.

v. Striped red mullet in 3.a, 4 and 7.d: The assessment is indicative of trends only. Biomass estimates and landings showed increases in 2014–2015. Based on survey indices and landings-at-age structure, this increase was caused by a strong recruitment in 2014. Spawning-stock biomass decreased in 2016 as a consequence of the poor recruitment and high catches seen since 2015.

vi. Turbot in 3.a: The IBTS–Q1 biomass index is variable and has been fluctuating without trend over time. The IBTS–Q3 biomass index is also variable but has shown an increased level after 2005.

vii. Turbot in 4: This stock underwent an inter-benchmark during the summer of 2017. The resultant assessment indicates that recruitment is variable without a trend. Fishing mortality is estimated to have decreased since the mid–1990s and has been stable for the past ten years. SSB has increased since the late 1990s.

viii. Whiting in 3.a: Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid–1990s. The state of the stock is not known.

ix. Witch in 3.a, 4 and 7.d: Landings declined from a peak in the 1990s to a low at the end of the 2000s, and have recently increased. The spawning biomass index (IBTS–Q1) declined from a high value in the mid–1990s to a low at the end of the 2000s, and has shown a recent increase. The spawning biomass index (IBTS–Q3) has fluctuated without trend.

1 General

1.1 Terms of Reference

2016/2/ACOM05: The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on ecosystem and fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

i. Descriptions of ecosystem impacts of fisheries

ii. Descriptions of developments and recent changes to the fisheries

iii. Mixed fisheries overview, and

iv. Emerging issues of relevance for the management of the fisheries.

c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the Stock Annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant:

i. Input data and examination of data quality

ii. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information

iii. For relevant stocks (i.e., all stocks with catches in the NEAFC Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year

iv. The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the Stock Annex

v. The state of the stocks against relevant reference points

vi. Catch options for next year

vii. Historical performance of the assessment and catch options and brief description of quality issues with these.

d) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines;

e) Review progress on benchmark processes of relevance to the expert group;

f) Prepare the data calls for the next year update assessment and for the planned data evaluation workshops;

g) Identify research needs of relevance for the expert group.

Specific ToRs

2016/2/ACOM22: The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), chaired by José De Oliveira, UK, will:

Meet in Copenhagen, 26 April–5 May 2017 to:

a) Address generic ToRs for Regional and Species Working Groups, with the exception of the Norway pout assessment;

b) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017 (see table below):

i. Collate necessary data and information for the stocks listed below prior to the Expert Group meeting. An official ICES data call was made for length and select life history parameters for each stock in the table below

ii. Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) along with available data and expert judgement.

Stock Code	Stock name description	EG	Data Category
bll-nsea	Brill (*Scophthalmus rhombus*) in Subarea 4 and divisions 3.a and 7.d–e (North Sea, Skagerrak and Kattegat, English Channel)	WGNSSK	3.2
dab-nsea	Dab (*Limanda limanda*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	WGNSSK	3.2
fle-nsea	Flounder (*Platichtys flesus*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)	WGNSSK	3.2
lem-nsea	Lemon sole (*Microstomus kitt*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	WGNSSK	3.2
nep-32	Norway lobster (*Nephrops norvegicus*) in Division 4.a, Functional Unit 32 (northern North Sea, Norway Deep)	WGNSSK	4.14
mur-347d	Striped red mullet (*Mullus surmuletus*) in Subarea 4 and divisions 7.d and 3.a (North Sea, eastern English Channel, Skagerrak and Kattegat)	WGNSSK	3.2
tur-kask	Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)	WGNSSK	3.2
tur-nsea	Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)	WGNSSK	3.2
wit-nsea	Witch (*Glyptocephalus cynoglossus*) in Subarea 4 and divisions 3.a and 7.d (North Sea, Skagerrak and Kattegat, eastern English Channel)	WGNSSK	3.2

By correspondence in September 2017 to:

- Address generic ToRs for Regional and Species Working Groups for the Norway pout stock.

By correspondence in October 2017 to:

- Report on reopened advice if appropriate.

The assessments will be carried out on the basis of the Stock Annex in National Laboratories, prior to the meeting. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 11 April 2017 according to the Data Call 2017.

WGNSSK will report by 19 May 2017, and by 2 October 2017 (Norway pout) for the attention of ACOM. Concerning ToR c) the group will report on the ACOM guidelines on reopening procedure of the advice before 12 October and will report on reopened advice before 28 October.

1.2 InterCatch

1.2.1 Métier-based data call for WGNSSK (and other working groups)

The year 2012 represented a major change in the process of data collection for WGNSSK. Following an initiative launched by ICES WGMIXFISH in August 2011, it had been decided to merge the data calls and data collection of both groups WGNSSK and WGMIXFISH, on the basis of:

1) Improving the availability of metier-based data and their consistency with the stock-based data used for single-stock assessment.
2) Allowing WGMIXFISH to meet earlier and as such integrate the mixed-fisheries advice within the single-stocks advice sheets.

In 2014 data limited stocks were included in the data call for the first time to improve the knowledge base for these stocks. Under the landing obligation these stocks become more important and discard information is a prerequisite to give catch advice and to carry out mixed fisheries scenarios under the landing obligation. In 2015, for the first time a joint data call for all relevant assessment working groups was launched.

The principle of the data call is to define the aggregation (metier) level for the data individual countries should deliver following the requirements of the EU Data Collection Framework (DCF), and to use these as the basis for providing and subsequently raising data for all North Sea demersal stocks. ICES InterCatch database was chosen as the most appropriate tool to use until the planned Regional Data Bases are fully established and operational. Basic strata for the submission of catch and effort data were by country, quarter, area, and metier and catch category.

In 2017 the procedure for data submission was similar to 2016, but with the additional requirement of length compositions for historic landings and discards for stocks identified as "DLS" (essentially Category 3 stocks) from at least the three most recent consecutive years (e.g. 2014–2016). An official data call was issued by ICES, with a deadline for data delivery of the 3rd of April 2017. No major issues occurred at that stage, despite delays in some data submissions compared to this date and some errors needing to be corrected before the working group; these delays and corrections had no major impact on the work.

1.2.2 Data raising and allocation to unsampled strata

Major changes occurred in recent years with the raising of data within InterCatch. Different initiatives can be mentioned here.

1) Age and length data in parallel in InterCatch

InterCatch can now work with age and length data in parallel, but it demands that length sample data have to be imported last for species with both age and length distribution data. This is due to InterCatch ignoring strata of other sample types. However, InterCatch will always take the latest imported strata without samples. Also, there is no problem with overwriting data in InterCatch as long as length data are imported latest, for stocks with both length and age samples. There is still no age-length-keys in InterCatch. It is important that when importing catches with and without age samples all strata have to be imported, all strata also have to be imported when importing catches with and without length samples.

2) Technical improvements in the InterCatch interface

- Allocation Group Setup: define a group of unsampled catch/strata for which each distribution will be calculated according to the (for the group) allocated sampled catches/strata;
- Automatic allocation 'same' strata: automatically find and allocate identically sampled strata from other countries to unsampled catches/strata (with the identical stratum);
- Discard Group setup: Define a group of raised discards for which each discard weight will be calculated according to the (for the group) selected landing-discard ratios;
- CATON and age/length data overviews: it is possible to examine all imported data in detail;
- Allocation overview for pivot table/matrix: all unsampled strata are shown in the first column and all sampled strata are shown as the first row, then all the selected combinations are shown in the matrix;
- Possibility to save allocation schemes.

3) Summary outputs and inspection of data before raising

The new features included in InterCatch allowed improved inspection and visualization of the data submitted by national data providers and a comparison with data from previous years. A generic R script has been developed in 2016 and improved in 2017 by Y. Vermard (IFREMER) mapping out the raw data, through e.g. quantification of the proportion of catches covered by sampling, identification of major gaps and outliers, plot of the age distribution and discards ratio of the various strata etc.

4) Raising procedures

Based on statistical principles discussed within WKPICS, RCMs, PGCCDBS and DC-MAP etc, the suggestions for the basis on which to proceed regarding raising of age distributions and discards ratio have been revisited. In 2012, the raising and allocating was based on finding similar strata from other countries, but this was judged not fully defendable in terms of statistical integrity. In 2016 the underlying principles applied were thus:

- Main strata are supposed to be sampled. In essence one should expect that the largest share of catches should have age-based and discards information in InterCatch. Even though there may be a great number of unsampled strata, in reality these should represent only a minor part of the catches. Large strata without sampling information would need to be investigated further.
- Therefore, the suggestion was that by default, unsampled strata should be raised by all sampled strata, unless there is a good and informed reason for choosing differently after the data inspection process. Each stock coordinator has developed general principles for the allocation scheme. The main principles are mentioned in the respective report sections.

Ultimately, all these changes have triggered in-depth investigation and understanding of the data submitted, and are hopefully contributing to improved consistency and transparency in the assessment data. However, if more than one year needs to be raised, the InterCatch procedure is still very time consuming. The saving of allocations schemes does not always function, especially when the metiers differ between years, and currently, only the age allocation scheme can be copied (not the discard ratio allocation scheme). It would be beneficial to allow for more flexible automatic matching based on e.g., gear type or area only. Also the possibility of entering allocation schemes via scripts (instead of the need to click through the options and metiers) would allow for fast sensitivity checks and would make InterCatch much more user-friendly.

Because of the landing obligation new catch categories need to be reported from 2016 onwards. There is currently limited and ambiguous guidance about how the different catch categories should be reported (particularly BMS landings), and how they should be used in raising discards where discard information is not provided. This is an issue that affects all Expert Groups that have to provide catch advice, so a common approach is needed. BMS landings, observer discards and logbook recorded discards should sum up to discard data provided prior to 2016 (i.e. double-counting should be avoided), and when performing raising procedures, the raising procedure in InterCatch should be adapted as necessary to provide a robust approach, independent of how countries categorize catches when providing catch data. The general approach adopted by WGNSSK during 2017 was to raise discards using only the observed discards (catch category "D" from the datacall), and to allocated discard age compositions to BMS landings (category "B" from the datacall), if reported and given a "CATON" value. WGNSSK recommends that ICES provides a harmonized approach across all Expert Groups, and clearer guidance on how to report the different catch categories in InterCatch.

InterCatch summary data have been made available on the SharePoint, and will be investigated further during ICES WGMIXFISH.

By the end of the WG, the status of InterCatch use was as follows:

Stock	Data Year	Extracted (work started in InterCatch)	Exported (work finished in InterCatch)	Status of Data filled in
bll.27.3a47de	2016	Extracted	Exported	DataUsedForAssessment
cod.27.47d20	2016	Extracted	Exported	DataUsedForAssessment
dab.27.3a4	2016	Extracted	Exported	Notfilled
fle.27.3a4	2016	Extracted	Exported	Notfilled
gug.27.3a47d	2016	Extracted	Exported	DataUsedForAssessment
had.27.46a20	2016	Extracted	Exported	DataUsedForAssessment
lem.27.3a47d	2016	Extracted	Exported	DataUsedForAssessment
mur.27.3a47d	2016	Extracted	Exported	DataUsedForAssessment
nep.27.4outFU	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.10	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.32	2016	Extracted	No	Notfilled
nep.fu.33	2016	Extracted	No	Notfilled
nep.fu.34	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.3-4	2016	Extracted	No	Notfilled
nep.fu.5	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.6	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.7	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.8	2016	Extracted	Exported	DataUsedForAssessment
nep.fu.9	2016	Extracted	Exported	DataUsedForAssessment
nop.27.3a4	2016	No	No	Notfilled
ple.27.420	2016	Extracted	Exported	DataUsedForAssessment
ple.27.7d	2016	Extracted	Exported	DataUsedForAssessment
pok.27.3a46	2016	Extracted	Exported	DataUsedForAssessment
pol.27.3a4	2016	Extracted	Exported	DataUsedForAssessment
sol.27.4	2016	Extracted	Exported	DataNOTusedForAssessment
sol.27.7d	2016	Extracted	Exported	DataUsedForAssessment
tur.27.3a	2016	Extracted	Exported	DataUsedForAssessment
tur.27.4	2016	Extracted	Exported	DataUsedForAssessment
whg.27.3a	2016	Extracted	No	Notfilled
whg.27.47d	2016	Extracted	Exported	DataUsedForAssessment
wit.27.3a47d	2016	Extracted	Exported	DataUsedForAssessment

1.3 General uncertainty considerations

Data or inputs used in this report are based on sampling or on census. Typical census data are landings data from sales slips representing total landing, while sampled data are random samples (design based) used to produce estimates of total, relative indices or to characterize composition (like catch at age). All sources of input may introduce error in estimates/calculations and are a limiting factor in the amount of signal in data and/or interpretation of model results. The scientist at this working group are only responsible for a modest fraction of the input data used and are relying heavily on assumptions regarding their validity and quality. The information based on sampling will contain sampling errors (random errors due to the stochastic nature of such sampling) and estimates of sampling error are generally not used by this working group. Such errors will show up in residuals (residual plots are an important diagnostic in the report), but other sources of error will also show up in the same residuals and are not easily separated from random errors. Non-random errors are either bias or model errors. Systematic bias over time is a particular concern and an example of such can be underreporting of catches, which will compromise the validity of the model results as basis for advice. Model errors may represent the use of the "wrong" equations to describe relations, but will in this report typically be linked to assumptions regarding natural mortality, the relationship between survey indices and stock size (catchability) and exploitation pattern. Some assumptions are needed since, for example, the Baranov catch equations do not have unique solutions (too many parameters to estimate).

Assessment working groups are in many ways end users of data and it would be preferable to have such information presented as point estimates together with estimates of uncertainty or confidence bands and with a description of potential sources of bias and qualitative remarks related to specific observations. InterCatch is still not fully operational in this respect.

The working group appreciates the effort made by so many supporting hands involved in creating all information needed in fish stock assessment and is dependent on the quality of information being upheld over time. An assessment working group is where information from the commercial fishery is handled together with fishery independent information to create estimates of stock status and the impact of fishing.

Demersal trawl surveys are the most used source of fishery independent information in this working group (WGNSSK). A demersal trawl survey uses a standardized procedure of trawling to create samples from a fish population. The "population" in statistical terms is the population of possible trawl stations with trawl station being the primary sampling unit. The estimates of uncertainty from a demersal trawl survey is very much dependent on the number of samples (trawl stations) and it seems that demersal trawl surveys on gadoids produces very similar estimates of uncertainty given the same number of trawl stations (ICES, 1992) regardless of the size of the area. The relationship between sample size and precision can be illustrated using the following example: If a survey of 400 trawl stations produces an estimate (for a parameter of interest) with a corresponding relative standard error of 0.1 a reduction in survey effort to 100 trawl stations is likely to produce estimates with a relative standard error of 0.2 (divide the number of stations by 4 and the relative standard error is doubled). This is also likely to hold (at least as a rule of thumb) if one looks at results from a subarea of the original (400 station) area. When estimates of relative standard error approaches 0.3, trends over time will be very difficult to detect, and with relative standard errors above 0.3, the estimator can only be used to detect sudden events. WGNSSK recommends that, along with survey index point estimates, DATRAS should also provide the uncertainty around these estimates as standard output.

1.4 Survey corrections during 2016 and 2017

During the last year no major resubmissions occurred for IBTS data and the indices produced by DATRAs as tuning indices only showed very minor changes compared to last year.

1.5 Internal auditing and external reviews

ICES removed in general the external review process that had been in place for some years, and replaced it by an internal audit process within the Working Group itself. WGNSSK understands the motivations and reasoning behind this choice, and recognizes also that the process has some merit and direct benefits such as increased participation and collaboration within the group across countries and stocks. However, WGNSSK wishes to underline that this audit is another heavy task pending on group members, and it was not possible to complete most audits during the meeting itself. WGNSSK operates with seldom more than one scientist per stock (sometimes one scientist is responsible for two or more stocks), and there was in most cases not enough time to have the reports finalized in order to carry out the audit within the WG meeting itself. Audits had to be conducted by correspondence after the WG time, which is neither very efficient nor very motivating given the heavy workload under which most members usually operate back in home institutes. WGNSSK recommends exploring alternative ways to strengthen the audit process (e.g., professional auditors as part of the ICES secretariat, external audit).

Finally, all WGNSSK stocks with an updated advice in 2017 could be covered by the internal audit (Table 1.5.1). The audit sheets can be found on the WGNSSK SharePoint. External reviews were also needed for the corrections to the maturity estimation procedure and change to the forecasting procedure for North Sea cod (Annex 10), and an external review will accompany the Inter-benchmark for North Sea turbot during the summer of 2017.

Table 1.5.1. Fish stocks covered by the internal audit and external reviews.

Stock	Internal Audit	External Review
bll.27.3a47de	✓	
cod.27.47d20	✓	✓
dab.27.3a4	✓	
fle.27.3a4	✓	
gug.27.3a47d	no new advice in 2017	
had.27.46a20	✓	
lem.27.3a47d	✓	
mur.27.3a47d	✓	
nep.27.4outFU	✓	
nep.fu.10	no new advice in 2017	
nep.fu.32	no new advice in 2017	
nep.fu.33	no new advice in 2017	
nep.fu.34	no new advice in 2017	
nep.fu.3-4	✓	
nep.fu.5	no new advice in 2017	
nep.fu.6	✓	
nep.fu.7	✓	
nep.fu.8	✓	
nep.fu.9	✓	
nop.27.3a4	no assessment in spring	
ple.27.420	✓	
ple.27.7d	✓	
pok.27.3a46	✓	
pol.27.3a4	no new advice in 2017	
sol.27.4	✓	
sol.27.7d	✓	
tur.27.3a	✓	
tur.27.4	advice postponed	✓
whg.27.3a	✓	
whg.27.47d	✓	
wit.27.3a47d	✓	

1.6 Mixed Fisheries

The mixed fisheries analyses have not been performed by WGNSSK over the last years. Instead, these are now being performed within the Working Group for Mixed Fisheries Advice for the North Sea (WGMIXFISH), which aims at evaluating the consistency of the ICES advice for the individual stocks in a mixed fisheries context, using the Fcube model (Ulrich *et al.*, 2011).

The two groups have developed and issued a common data call since 2012, which greatly improved the quality and scheduling of data delivery. WGMIXFISH will meet in late May 2017 in order to integrate mixed-fisheries advice for the North Sea into single stock advice.

It is therefore referred to the ICES WGMIXFISH 2017 report for any further description of mixed-fisheries context.

However, the group discussed mixed fisheries issues under the landing obligation in the last years. There is a potential problem with choke species in the North Sea. Target species as well as bycatch species can become choke species for certain fleet segments. One way to deal with the situation could be to use the recently defined ranges for F_{MSY} instead of point estimates (see ICES WKMSYREF III 2014 and ICES WKMSYREF IV 2016). Ranges can introduce the flexibility needed to minimize the discrepancies in available quotas for species in a mixed fishery. However, further objectives are needed to determine which F inside the range should be applied. Ideas exist for an algorithm that minimises the discrepancy between TACs and ensures that a maximum of TACs can be utilised. It should be avoided that TACs are blindly set at the upper range for all stocks by managers. In the long-term there is no gain to fish stocks above F_{MSY} as the yield becomes lower and the risk for the stocks increases. Selectivity in mixed fisheries should be improved instead to avoid choke effects.

The management of bycatch species (e.g. lemon sole, turbot) by TAC further complicates the situation. If the TAC management for these species continues and F_{MSY} proxies implemented, these species can become serious choke species. The inter-institutional task force on multi annual plans between the European parliament, the council and the Commission write in their agreement (EU 8529/14): "With regard to bycatch species, the co-legislators will have to determine, taking account of the available scientific advice, whether these are sufficiently covered through the management measures according to MSY for the key species". Policy has to define what sustainable exploitation means for bycatch species and it has to be evaluated by science whether MSY targets for target stocks are enough to ensure a sustainable exploitation of bycatch species.

1.7 Multispecies considerations

ICES gave advice on multi species considerations for the North Sea in 2013 for the first time to start a dialogue between ICES and its stakeholders on this topic. Simulations were carried out with the stochastic multi species model SMS to analyse F_{MSY} in a multi species context. The multi species considerations can be found under: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf

WGNSSK supports this step. However, the group also raised concerns about the data basis for the simulations (stomach data mainly from 1981 and 1991) and the high number of assumptions behind the model results.

Already in 2013 the group discussed the progress achieved under various initiatives such as ICES WGSAM (2011, 2012), ICES WKMTRADE (2012) and the EU project MYFISH. The group noted that a multispecies benchmark as in the Baltic may be needed where the North Sea SMS model and keyrun settings are reviewed by external experts before a final multi species advice can be given.

There are many direct and indirect interactions between species, making it difficult to reach a single and robust best solution. Optimization scenarios carried out so far show that the result (target F) depends very much on the objectives (objective function) and SSB constraints used. The exact combination of species target F depends also on the weighting factors (e.g. price per kg when optimizing value) actually used for calculating these objectives. During a stakeholder workshop organized by ICES and MYFISH

(ICES WKMTRADE 2012) it has been agreed that when offering trade-offs, ICES can provide scenarios below F_{MSY} for the exploitation of some populations. This will allow a policy choice to be made within the limits defined and explained by ICES. F_{MSY} ranges (see also under mixed fisheries) could also help here to reach consensus based on a pretty good yield concept instead of trying to reach the absolute maximum for each stock, which is impossible given the biological interactions between predator and prey.

1.8 Estimation of MSY proxies for Category 3 stocks

A new ToR was introduced for 2017 which required the estimation of MSY proxies for Category 3 and 4 stocks. Although nep.fu.32 was on the list for this ToR (see Section 1.1), it was removed from the list because no new advice was due for this stock in 2017. This left only Category 3 stocks requiring MSY proxy estimation for WGNSSK. This additional ToR, requiring the potential application of several data-limited methods, placed a heavy burden on some of the stock-coordinators, and it was clear that a prioritisation of methods was required. The decision was therefore taken to prioritise the application of SPiCT (Pedersen and Berg, 2017), and where a viable SPiCT run was not possible, to then try the other methods (mean-length Z and length-based indicators). The decision of whether a SPiCT run was acceptable or not was based on the quality of the input data, model diagnostics, whether the data covered the production curve range, confidence bounds around the F/F_{MSY} and B/B_{MSY} relative plots, and retrospective patterns on these relative plots.

Viable SPiCT assessments were found for bll.27.3a47de, dab.27.3a4, lem.27.3a47d, tur.27.3a and wit.27.3a47d, but not for fle.27.3a4 and mur.27.3a47d. For the latter two stocks, the other data-limited methods were explored, but the availability of only three years' length composition data from InterCatch severely limited the application of the mean-length Z method (although attempts were made to apply this method to survey data - see relevant chapters), and there was simply not enough time to explore the LB–SPR method within the time-frame of the meeting. Length-based indicators were explored for fle.27.3a4 and mur.27.3a47d during the meeting, and for the remaining stocks after the meeting.

The MSY proxy estimation posed a significant challenge for WGNSSK, where benchmark-type work is no longer the norm. This was highlighted by the fact that, although WGNSSK accepted the SPiCT assessment for tur.27.3a, a decision supported by RGProxy, the review group that reviewed the MSY proxy work across EGs, the ADGNS decided to reject this SPiCT assessment. This divergence of views between the three groups, and the challenge this type of work poses within the EG setting, where there is no longer the time needed to conduct in-depth benchmark-type work, makes a strong case that the task of deriving appropriate MSY proxy reference points should reside within benchmark meetings. Therefore, the WG recommends that MSY proxy calculations be conducted either in dedicated benchmarks or as part of the routine benchmarks for the stock.

Annex 11 includes the RGProxy reviews for the Category 3 stocks that attempted to estimate MSY proxy reference points.

1.9 Special requests

In December 2016, ICES received the following Special Request from the Commission:

"The EU has implemented a combined TAC for dab and flounder in Union waters of ICES areas 2a and 4. The COM requests ICES to assess the risk to the stock of dab and flounder of having no catch limits for the stock. If ICES assess the risk to the stock of having no catch limits to be inconsistent with the objectives of the CFP, ICES is requested to identify management measures besides catch limits that could remedy this risk".

Due to insufficient availability of information to conduct a quantitative evaluation of the risk of having no catch limits for dab and flounder in the North Sea, ICES performed a qualitative evaluation based on answering the following questions:

1) Was the TAC restrictive in the past?
2) Is there a targeted fishery for the stock or are the species mainly discarded?
3) Is the stock of large economic importance or are the species of high value?
4) How are the most important fisheries for the stock managed?
5) What are the fishing effort and stock trends over time?
6) What maximum effort of the main fleets can be expected under management based on F_{MSY} (ranges) for the target stocks, and has the stock experienced similar levels of fishing effort before?

The answers to these questions (ICES, 2017) lead ICES to advise that the risk of having no catch limits for the dab and flounder stocks is currently considered to be low and not inconsistent with the objectives of the Common Fisheries Policy (CFP). The advice is valid as long as dab and flounder remain largely bycatch species, with the main fleets catching dab and flounder continuing to fish the target species (plaice and sole) sustainably within the F_{MSY} ranges provided by ICES.

In May 2017, ICES received another Special Request from the Commission:

"ICES is requested to provide plausible values around F_{MSY} (range for F_{MSY}) for Whiting in Subarea IV (North Sea) and Division VIId (Eastern Channel)".

Whiting has recently undergone an inter-benchmark (ICES, 2016) which tested the impact of updated estimates of natural mortality (from multispecies analysis) on the whiting assessment, and whether the management strategy used previously for advice was precautionary, given these updates. New reference points were estimated as part of this process, using the standard ICES software, and this analysis is available. The additional work that is required to fulfil this request is to extract the estimates for the F_{MSY} ranges, following ICES guidelines. This requires code that has already been developed for haddock to be adapted for whiting. An answer to the Special Request was provided by ICES in the summer of 2017, with the advice that the precautionary range of F_{MSY} values for whiting in Subarea 4 and Division 7.d (North Sea and eastern English Channel) goes from an F_{MSY} lower of 0.140 to F_{MSY} upper of 0.150. The current F_{MSY} is 0.150

2 Overview

2.1 Introduction

The demersal fisheries in the North Sea can be categorised as a) human consumption fisheries, and b) industrial fisheries which land the majority of their catch for reduction purposes. Demersal human consumption fisheries usually either target a mixture of roundfish species (cod, haddock, whiting), a mixture of flatfish species (plaice and sole) with a bycatch of roundfish and other flatfish (e.g., turbot, brill, dab), or *Nephrops* with a bycatch of roundfish and flatfish. A fishery directed at saithe with some bycatch of hake and other roundfish exists along the shelf edge.

The industrial fisheries which used to dominate the North Sea catch in weight have become much less prominent. Human consumption landings have steadily declined over the last 30 years, with an intermediate high in the early 80's. The landings of the industrial fisheries show the largest annual variations, resulting from variable recruitment and the short life span of the main target species. The total demersal landings from the Greater North Sea peaked above 1.5 million tons in the 1980s, showed a strong decline from the mid to late 1990s, and is now just above 500 000 tons (ICES, 2017a).

For some stocks, the North Sea assessment area may also cover other regions adjacent to ICES Subarea 4. Thus, combined assessments are made for cod including Division 7.d and Subdivision 20 (i.e. Skagerrak), haddock including Division 6.a and Subdivision 20, Norway pout including Division 3.a, whiting including Division 7.d, and saithe including Subarea 6 and Division 3.a. Since the benchmark in 2015, plaice in Subdivision 20 is now assessed together with plaice in Subarea 4. The state of *Nephrops* stocks are evaluated on the basis of discrete Functional Units (FU) on which estimates of appropriate removals are based. However, quota management for *Nephrops* is still carried out at the Subarea and Division level.

The sandeel assessment has been moved to ICES HAWG and is therefore not presented anymore in WGNSSK report.

The analysis of biological interactions (predator-prey relationships) among species has been a central theme in ICES over the last 30 years, primarily for the Baltic Sea and the North Sea. The 2011 and 2014 North Sea key run performed by the multispecies group WGSAM represents the ultimate state of the art in terms of multispecies assessment, with the dynamic estimation of predation mortality. This has led to the publication of the first multispecies advice by ICES in 2013 (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf). The single-stock assessments and advice presented in this report are not produced by the multispecies assessment model, but time-variant values of natural mortalities estimated by multispecies assessments for cod, haddock and whiting are incorporated in the assessments of these species. Flatfish are not part of the current multispecies assessment and more work is needed to incorporate information on flatfish in the multispecies advice.

Gear types vary between fisheries. Human consumption fisheries use otter trawls, pair trawls, *Nephrops* trawls, seines, gill nets, or beam trawls, while industrial fisheries use small meshed otter trawls. Trends in reported effort in the major fleets fishing in the North Sea are described annually by the ICES WG on Mixed Fisheries Advice for the North Sea (ICES WGMIXFISH 2017), which meets straight after the WGNSSK.

Both WGs share a joint data call issued by ICES for fulfilling the data needs of both groups.

The data distinguish between two basic concepts, the Fleet (or fleet segment), and the Métier. Their definition has evolved with time, but the most recent official definitions are those from the EC's Data Collection Framework (DCF, Reg. (EC) No 949/2008), which we adopt here*:*

- A **Fleet** segment is a group of vessels with the same length class and predominant fishing gear during the year. Vessels may have different fishing activities during the reference period, but might be classified in only one fleet segment.
- A **Métier** is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterized by a similar exploitation pattern.

Fleets and métiers were defined to match with the available economic data and the cod long term management plan. In 2013 and 2014 WGMIXFISH included new stocks in its analyses (plaice and sole in the Eastern Channel as full analytical stocks; hake in the North Sea and plaice in Skagerrak as additional "lpue" stocks as well as turbot, see WGMIXFISH 2013 and 2014 report). Plaice in the Subdivision 20 has been merged with plaice in Subarea 4 in 2015. Mixed-fisheries considerations are based on the single-stock assessments, combined with information on the average catch composition and fishing effort of the demersal fleets and fisheries in the Greater North Sea catching cod (cod.27.47d20), haddock (had.27.46a20), whiting (whg.27.47d), saithe (pok.27.3a46), plaice (ple.27.420 and ple.27.7d), sole (sol.27.4 and sol.27.7d), and Norway lobster *Nephrops norvegicus* (functional units [FUs] 5–10, 32, 33, 34, and 4outFU). In the absence of specific mixed-fisheries management objectives, ICES does not advise on unique mixed-fisheries catch opportunities for the individual stocks but develop scenarios that might show potential discrepancies in the single stock advices in a mixed fisheries context.

In 2017, WGMIXFISH introduced a new scenario, the 'range' scenario taking advantage of the F_{MSY} ranges to reduce the potential inconsistencies in the single species advices. More effort will be put in the future in the inclusion of other stocks without analytical assessment and/or mostly distributed in other areas (i.e. hake) because many of them are important bycatch and are potential "choke species" once under the landing obligation.

ICES WGMIXFISH also produces a number of Figures describing main trends, of effort and catches and landings by fleet and stock.

Overall nominal effort (kW-days) by EU demersal trawls regulated in the cod management (TR1, TR2, TR3, GN1, GT1, LL1, BT1, BT2) in the North Sea, Skagerrak, and Eastern Channel had been substantially reduced since the implementation of the two successive effort management plans in 2004 and 2008 (-30% between 2004 and 2014, −12% between 2008 and 2014). Following the introduction of days-at-sea regulations in 2003, there was a substantial switch from the larger mesh (>100 mm, TR1) gear to the smaller mesh (70–99 mm, TR2) gear. Subsequently, effort by TR1 has been relatively stable, whereas effort in TR2 and in small-mesh beam trawl (80–120 mm, BT2) has shown a pronounced decline (+2%, -43%, and -49%, respectively, between 2004 and 2014). Gill and trammelnet fisheries have increased (+20%, +13%). Effort in large-meshed beam trawl (≥120 mm, BT1) has increased significantly in 2012 and 2013 after a decade of continuous decline.

ICES has evaluated technical interactions between species captured together in demersal fisheries by examining their co-occurrence in the landings at the scale of gear/mesh size range/ICES square/calendar quarter (hereafter referred to as 'strata'). The percentage of landings of species A, where species B is also landed and constitutes more than 5% of the total landings in that stratum, has been computed for each pair of species. Cases in which species B accounts for less than 5% of the total landings in a stratum were ignored.

To illustrate the extent of the technical interactions between pairs of species, a qualitative scale was applied to each interaction (Figure 2.1.1). In this figure, rows represent the share of each species A that was caught in fisheries where the B species (columns) accounted for at least 5% of the total landing of the fisheries. A high proportion of the catches of lemon sole was for example taken in fisheries where plaice landings where at least 5% of the total landings. The amounts of lemon sole caught in fisheries where cod, haddock, hake or saithe accounted for at least 5% of the total landings were medium. The amount of lemon sole caught in fisheries where lemon sole constituted 5% or more of the total landings were low, indicating that there is no (or very limited) target lemon sole fishery.

The vertical bars illustrate the degree of mixing. Fisheries where plaice (species B) constitute 5% or more of the total landings account for a high share (red cells) of the total landings of dab, lemon sole, plaice, sole, turbot, flounder, brill, haddock, and which, and a medium share (orange cells) of the landings of whiting, hake and *Nephrops*. The lemon sole column shows that the landings of lemon sole in fisheries where the species constituted 5% or more of the total landing were low and the relative landings of other species in these fisheries were also low. The columns can be used to identify the main fisheries (target fisheries) and the degree of mixing in these fisheries.

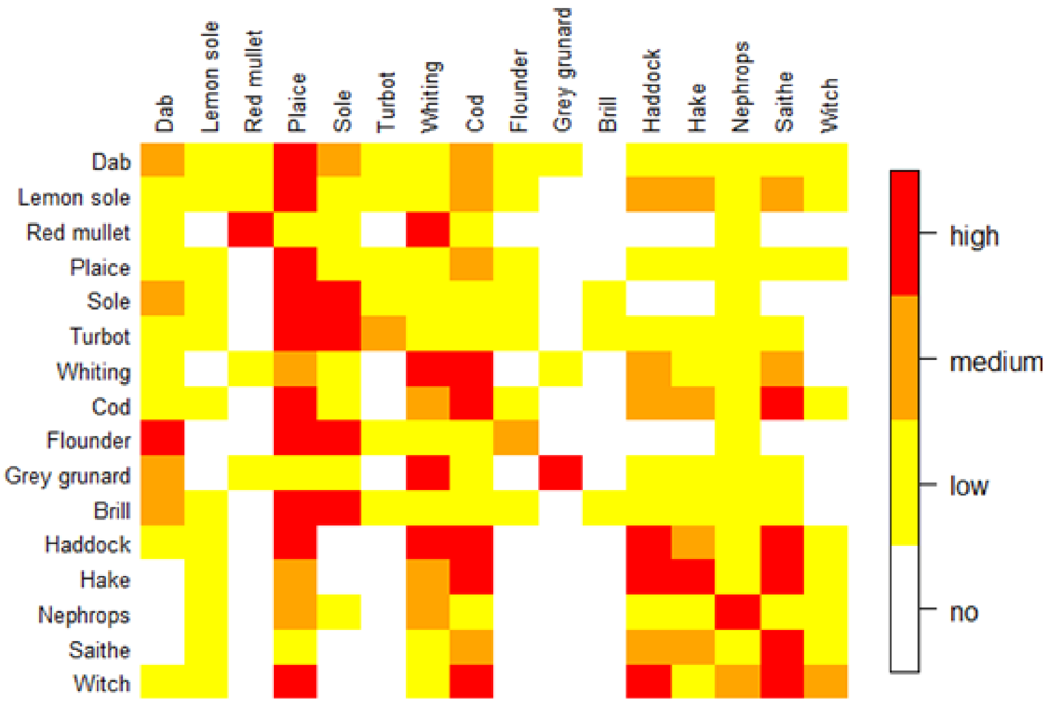


Figure 2.1.1. Technical interactions amongst North Sea demersal stocks. Horizontal lines of the figure represent the target species of the fishery (species A) for which the interaction with species in each column (species B) was assessed. Red cells indicate that the species are frequently caught together. Orange cells indicate medium interactions and yellow cells indicate weak interactions. For example, haddock sometimes occur in catches in the whiting fishery (a 'medium' interaction) but whiting often occur in catches in the haddock fishery (a 'high' interaction).

2.2 Main management regulations

The near-collapse of the North Sea cod stock in the beginning of the 2000s led to the introduction of effort restrictions alongside TACs as a management measure within EU fisheries. There has also been an increasing use of singlespecies multiannual management plans, partly in relation to cod recovery, but also more generally. With the implementation of the landing obligation in 2016 mixed fisheries multi species plans are under development but have not yet been agreed for the North Sea.

The management frames can be summarised as such:

2.2.1 Landing obligation

Fisheries in Norwegian waters have been subject to a landing obligation for cod and haddock from 1987 and for most species since 2009. A landing obligation for EU fisheries on demersal species in the North Sea is implemented from 2016 in a phased approach with all quota stocks subject to the landings obligation from 2019 onwards. Detailed definitions of the landing obligation can be found in Article 15 of regulation 1380/2013. Discard plans have been agreed for 2017–2018 in the North Sea (Subarea 4, Division 3.a and Union waters of Division 2.a; Table 2.2.1.1) and for 2017 in Union and international waters of Subarea 6 and Division 5.b (Table 2.2.1.2), and in Division 7.d (Table 2.2.1.3), defining for which species, gear and mesh size combinations the landing obligation applies. The discard plans will be amended to define which additional species and gear combinations will fall under the landing obligation in future years until 2019, when it is expected that the landing obligation is fully implemented.

Table 2.2.1.1. Fisheries under the landing obligation in Subarea 4, Division 3.a and Union waters of Division 2.a (from Commission delegated regulation (EU) 2016/2250).

Fishing gear (1) (2)	Mesh size	Species concerned
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	≥ 100 mm	In 2017 and 2018: all catches of saithe (if caught by a saithe targeting vessel (3)), plaice, haddock, whiting, cod, Northern prawn, common sole and Norway lobster.
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	70-99 mm	In 2017 and 2018: all catches of Norway lobster, common sole, haddock and Northern prawn In 2018: all catches of whiting.
Trawls: OTB, OTT, OT, PTB, PT, TBN, TBS, OTM, PTM, TMS, TM, TX, SDN, SSC, SPR, TB, SX, SV	32-69 mm	In 2017 and 2018: All catches of Northern prawn, Norway lobster, common sole, haddock and whiting.
Beam trawls: TBB	≥ 120 mm	In 2017 and 2018: All catches of plaice, Northern prawn, Norway lobster, common sole, cod, haddock and whiting.
Beam trawls: TBB	80-119 mm	In 2017 and 2018: All catches of common sole, Northern prawn, Norway lobster and haddock. In 2018: all catches of whiting.
Gillnets, trammel nets and entangling nets: GN, GNS, GND, GNC, GTN, GTR, GEN, GNF		In 2017 and 2018: All catches of common sole, Northern prawn, Norway lobster, haddock, whiting and cod (4)
Hooks and lines: LLS, LLD, LL, LTL, LX, LHP, LHM		In 2017 and 2018: All catches of hake, Northern prawn, Norway lobster, common sole, haddock, whiting and cod
Traps: FPO, FIX, FYK, FPN		In 2017 and 2018: All catches of Norway lobster, Northern prawn, common sole, haddock and whiting.

(1) Gear codes used in this Table refer to those codes in Annex XI to Commission Implementing Regulation (EU) No 404/2011.
(2) For the vessels whose LOA is less than 10 metres gear codes used in this table refer to the codes from the FAO gear classification.
(3) Vessels are considered as saithe targeting if, when using trawls with mesh size ≥ 100 mm, they have had annual average landings of saithe of ≥ 50 % of all landings by the vessel taken in both EU and third country zone of the North Sea over the period of x − 4 to x − 2 where x is the year of application; i.e. 2012-2014 for 2016, 2013-2015 for 2017 and 2014-2016 for 2018. If a vessel has been considered as a saithe targeting vessel in one year it shall continue to be considered as such in the following years.
(4) The landing obligation for cod caught with gillnets, trammel nets and entangling nets shall not apply in ICES area IIIaS.

Table 2.2.1.2. Fisheries under the landing obligation in Union and international waters of Subarea 6 and Division 5.b (from Commission delegated regulation (EU) 2016/2375).

Fishery	Gear Code	Fishing gear description	Mesh Size	Species to be landed
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls & Seines	All	All catches of haddock and by-catches of sole, plaice and megrims where total landings per vessel of all species in 2014 and 2015 (*) consisted of more than 5 % of the following gadoids: cod, haddock, whiting and saithe combined
Norway lobster (*Nephrops norvegicus*)	OTB, SSC, OTT, PTB, SDN, SPR, FPO, TBN, TB, TBS, OTM, PTM, SX, SV, FIX, OT, PT, TX	Trawls, Seines, Pots, Traps & Creels	All	All catches of Norway lobster and by-catches of haddock where the total landings per vessel of all species in 2014 and 2015 (*) consisted of more than 20 % of Norway lobster

(*) Vessels listed as subject to the landing obligation in this fishery in accordance with Delegated Regulation (EU) 2015/2438 remain on the list indicated in Article 4 of this Regulation despite the change in the reference period and continue being subject to the landing obligation in this fishery.

Table 2.2.1.3. Fisheries under the landing obligation in Division 7.d (from Commission delegated regulation (EU) 2016/2375).

Fishery	Gear Code	Fishing gear	Mesh Size	Species to be landed
Common Sole (*Solea solea*)	TBB	All Beam trawls	All	All catches of common sole
Common Sole (*Solea solea*)	OTT, OTB, TBS, TBN, TB, PTB, OT, PT, TX	Trawls	< 100 mm	All catches of common sole where the total landings per vessel of all species in 2014 and 2015 (*) consisted of more than 5 % of common sole
Common Sole (*Solea solea*)	GNS, GN, GND, GNC, GTN, GTR, GEN	All Trammel nets & Gill nets	All	All catches of common sole
Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Whiting (*Merlangius merlangus*) and Saithe (*Pollachius virens*)	OTB, SSC, OTT, PTB, SDN, SPR, TBN, TBS, OTM, PTM, TB, SX, SV, OT, PT, TX	Trawls and Seines	All	All catches of whiting, where total landings per vessel of all species in 2014 and 2015 (*) consisted of more than 20 % of the following gadoids: cod, haddock, whiting and saithe combined

(*) Vessels listed as subject to the landing obligation in this fishery in accordance with Delegated Regulation (EU) 2015/2438 remain on the list indicated in Article 4 of this Regulation despite the change in the reference period and continue being subject to the landing obligation in this fishery.

There is a high probability that the implementation of the EU landing obligation with its complex definitions, exemptions and rules (e.g. *de minimis*, high survival, 9% inter-species flexibility) has implications for the quality of monitoring of the catches and the quality of assessments of the stock status and exploitation rate. *De minimis* exemptions and the 9% inter-species flexibility rule may have serious implications for stocks dependent on the interpretation of the respective paragraphs in the regulation (STECF, 2014a, b). The possibility of using up to 9% of the quota of a target species for bycatch of any other species constitutes a major factor for uncertainty in future management because it is not possible to predict what will happen, at least in the first few years.

In 2016, a high survival exemption has been granted for the main métiers catching *Nephrops* in Division 3.a, and discarding of *Nephrops* below the minimum conservation reference size (MCRS) up to a *de minimis* of 6% is still allowed in Subarea 4. Furthermore, the MCRS has been reduced substantially in Division 3.a. WGNSSK tries to take this into account in the forecasts for *Nephrops* by assuming the 2016 selection pattern in the respective fisheries, but that only discards below the agreed MCRS continue under the landing obligation (this is one of three scenarios provided in the forecast, the others being zero discarding, and discarding continues as in the past). There was no evidence presented to the Working Group that the introduction of the landing obligation had caused any change to discarding practices for the 2016 *Nephrops* fishery.

For sole and haddock, several *de minimis* exemptions have been agreed. The default ICES assumption is that the same exploitation patterns as observed in recent years will continue and former discards are now called unwanted catch. How much of this unwanted catch will be landed in the future (catch category BMS) and how much will still be discarded is pure speculation. Given that stocks are impacted by the total F independent of how the total catch is split up (at least under the assumption of no survival of discards), the results of forecasts are robust to assumptions regarding which fraction of the total catch will be landed. In contrast, the landing obligation will mean a serious change and therefore exploitation patterns of fleets will most likely change in the future. Predicting these changes is impossible at the current stage, which leads to an increased uncertainty in short term forecasts until more information becomes available.

It would be expected that under the EU Landing Obligation fish caught under the minimum conservation reference size (MCRS) would be landed and recorded as BMS landings in log books rather than discarded as happened before the Landing Obligation. The log book records of BMS landings would then be reported to ICES. However, low BMS values may be seen if the fish caught below MCRS are either not landed, not recorded in log books, not reported to ICES, reported to ICES incorrectly, or a mixture of any of these. For all stocks where BMS landings were reported to ICES for 2016, these values were either zero or very low, substantially lower than the estimated discards.

2.2.2 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in 2003 and subsequently revised annually. Initially days at sea allowances were defined by calendar month. From 2006 the limit was defined on an annual basis. The maximum number of days a fishing vessel could be absent from port varied according to gear type, mesh size (where applicable) and region. A complex system of 'special conditions' (SPECONs) developed upon request from the Member States, whereby vessels could qualify for extra days at sea if special conditions (specified in the Annexes) were met. Increasingly detailed micromanagement took place until 2008 (Ulrich *et al.*, 2012).

In 2008 the system was radically redesigned. From 2009, a total effort limit (measured in kW days) was set and divided up between the various nation's fleet effort categories. The baselines assigned in 2009 were based on track record per fleet effort category averaged over 2004–2006 or 2005–2007 depending on national preference, and the effort ceilings were updated in 2010. After some reductions based on the cod management plan to support the recovery of the cod stock, an effort roll-over for the maximum allowable fishing effort was decided for 2013–2016 (Table 2.2.2.1). The effort management regime, which formed part of the long-term management plan for North Sea cod, has been revoked from 2017 onwards, but the effort management regime for plaice and sole remains in place; the maximum allowable fishing effort applied to beam trawls of mesh larger than or equal to 80 mm (BT1 and BT2) in Subarea 4 is shown in Table 2.2.2.2 for different countries.

The grouping of fishing gear concerned are: Bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≤ 100 mm), TR2 (≤ 70 and < 100 mm), TR3 (≤ 16 and < 32 mm); Beam trawl of mesh size: BT1 (≤ 120 mm), BT2 (≤ 80 and < 120 mm); Gill nets excluding trammel nets: GN; Trammel nets: GT and Longlines: LL.

Table 2.2.2.1. Maximum allowable fishing effort in kilo watt days in 2013–2016 for: Skagerrak, that part of Division 3.a not covered by the Skagerrak, and the Kattegat; Subarea 4 and EU waters of Division 2.a; Division 7.d. Note for 2016, TR1 and TR2 were combined.

Regulated gear	BE	DK	DE	ES	FR	IE	NL	SE	UK
TR1	895	3 385 928	954 390	1 409	1 505 354	157	257 266	172 064	6 185 460
TR2	193 676	2 841 906	357 193	0	6 496 811	10 976	748 027	604 071	5 037 332
TR3	0	2 545 009	257	0	101 316	0	36 617	1 024	8 482
BT1	1 427 574	1 157 265	29 271	0	0	0	999 808	0	1 739 759
BT2	5 401 395	79 212	1 375 400	0	1 202 818	0	28 307 876	0	6 116 437
GN	163 531	2 307 977	224 484	0	342 579	0	438 664	74 925	546 303
GT	0	224 124	467	0	4 338 315	0	0	48 968	14 004
LL	0	56 312	0	245	125 141	0	0	110 468	134 880

Table 2.2.2.2. Maximum allowable fishing effort in kilowatt days in 2017 for Subarea 4.

Regulated gear	BE	DK	DE	NL	UK
BT1+BT2	5 474 635	1 377 012	1 896 306	37 956 887	10 161 710

The STECF and ICES WGMIXFISH has performed annual monitoring of deployed effort trends since 2002. In addition, a more detailed overview and analyses of the various measures implemented in the frame of the cod recovery plan can be found in the 2011 joint STECF/ICES evaluation of this plan (ICES WKROUNDMP 2011, Kraak *et al.*, 2013).

2.2.3 Stock-based management plans

Cod, haddock, whiting, saithe, plaice and sole are currently or have previously been subject to multiannual management strategies (the latter two, being EU strategies, not EU-Norway agreements). These plans all consist of harvest rules to derive annual TACs depending on the state of the stock relative to biomass reference points and target fishing mortalities. The harvest rules also impose constraints on the annual percentage change in TAC. These plans have been discussed, evaluated and adopted on a stock-by-stock basis, involving different timing, procedures, stakeholders and scientists involved, disregarding mixed-fisheries interactions (ICES WGMIXFISH 2012). The technical basis of the individual management plans is detailed in the relevant stock section. Most of these plans are no longer used as basis of advice and to set TACs due to benchmarks and the general change from individual target fishing mortalities to F_{MSY}.

With the new CFP, the demand for mixed fisheries management plans covering all species caught in a fishery is increasing. However, so far no multi species (fishery based) management plans have been agreed for the greater North Sea. With the implementation of the landing obligation from 2016 onwards for the North Sea demersal fisheries, problems caused by the management of mixed fisheries with single species plans will become more evident. In addition, benchmarks have caused major changes in the assessment and reference points in recent years.

2.2.4 Additional technical measures

The national management measures with regard to the implementation of the available quota in the fisheries differ between species and countries. The industrial fisheries are subject to regulations for the bycatches of other species (e.g. herring, whiting, haddock, cod). Technical measures relevant to each stock are listed in each stock section, along with additional management measures, e.g., real time closures or Fully Documented Fisheries (FDF).

2.2.4.1 Minimum landing size/Minimum conservation reference size

"Undersized marine organisms must not be retained on board or be transhipped, landed, transported, stored, sold, displayed or offered for sale, but must be discarded immediately to the sea" (EC 850/98)). After the implementation of the landing obligation minimum landing sizes have been transformed into Minimum Conservation Reference Sizes (MCRS) that apply from 2016 onwards. The current MCRS can be found in Table 2.2.4.1. Individuals below MCRS have to be landed now but are not allowed to be sold for human consumption.

Table 2.2.4.1. Current MCRS.

Species	MCRS region 1–5	MCRS Skagerrak and Kattegat
Cod	35 cm	30 cm
Haddock	30 cm	27 cm
Saithe	35 cm	30 cm
Pollack	30 cm	–
Whiting	27 cm	23 cm
Sole	24 cm	24 cm
Plaice	27 cm	27 cm
Nephrops	85 mm (25 mm)	105 mm (32 mm)

2.2.4.2 Minimum mesh size

Regulations on mesh sizes are more complex than those on landing sizes, as they differ depending on gears used, target species and fishing areas. Many other accompanying measures are implemented simultaneously with mesh sizes. They include regulations on gear dimensions (e.g. number of meshes on the circumference), square-mesh panels, and netting material. The most relevant mesh size regulations of EC No 2056/2001 are presented below.

Towed nets excluding beam trawls

Since January 2002, the minimum mesh size for towed nets fishing for human consumption demersal species in the North Sea is 120 mm. There are however many derogations to this general rule, and the most important are given below:

- ***Nephrops* fishing.** It is possible to use a mesh size in range 70–99 mm, provided catches retained on board consist of at least 30% of *Nephrops*. However, the net needs to be equipped with a 80 mm square-mesh panel if a mesh size of 70–99 mm is to be used in the North Sea and if a mesh size of 90 mm is to be used in the Skagerrak and Kattegat the codend has to be square meshed.

- **Saithe fishing.** It is possible to use a mesh size range of 110–119 mm, provided catches consist of at least 70% of saithe and less than 3% of cod. This exception however does not apply to Norwegian waters, where the minimum mesh size for all human consumption fishing is 120 mm. Since January 2002 Norwegian trawlers (human consumption) have had a minimum mesh size of 120 mm in EU-waters. However, since August 2004 they have been allowed to use down to 110 mm mesh size in EU-waters (but minimum mesh size is still 120 mm in Norwegian waters).
- **Fishing for other stocks.** It is possible to use a mesh size range of 100–119 mm, provided the net is equipped with a square-mesh panel of at least 90 mm mesh size and the catch composition retained on board consists of no more than 3% of cod.
- **2002 exemption.** In 2002 only, it was possible to use a mesh size range of 110–119 mm, provided catches retained on board consist of at least 50% of a mixture of haddock, whiting, plaice sole, lemon sole, skates and anglerfish, and no more than 25% of cod.

Beam trawls

- **Northern North Sea.** It is prohibited to use any beam trawl of mesh size range 32 to 119 mm in that part of ICES Subarea 4 to the north of 56° 00' N. However, it is permitted to use any beam trawl of mesh size range 100 to 119 mm within the area enclosed by the east coast of the United Kingdom between 55° 00' N and 56° 00' N and by straight lines sequentially joining the following geographical coordinates: a point on the east coast of the United Kingdom at 55° 00' N, 55° 00' N 05° 00' E, 56° 00' N 05° 00' E, a point on the east coast of the United Kingdom at 56° 00' N, provided that the catches taken within this area with such a fishing gear and retained on board consist of no more than 5% of cod.
- **Southern North Sea.** It is possible to fish for sole south of 56° N with 80–99 mm meshes in the cod end, provided that at least 40% of the catch is sole, and no more than 5% of the catch is composed of cod, haddock and saithe.

Combined nets

It is prohibited to simultaneously carry on board beam trawls of more than two of the mesh size ranges 32 to 99 mm, 100 to 119 mm and equal to or greater than 120 mm.

Fixed gears

The minimum mesh size of fixed gears is of 140 mm when targeting cod, which is when the proportion of cod catches retained exceeds 30% of total catches.

2.2.4.3 Closed areas

Twelve mile zone

Beam trawling is not allowed in a 12 nm wide zone along the British coast, except for vessel having an engine power not exceeding 221 kW and an overall length of 24 m maximum. In the 12 mile zone extending from the French coast at 51°N to Hirtshals in Denmark trawling is not allowed to vessels over 8 m overall length. However, otter trawling is allowed to vessels of maximum 221 kW and 24 m overall length, provided that catches of plaice and sole do not exceed 5% of the total catch. Beam trawling is only allowed to vessels included in a list that has been drawn up for the purposes. The number of vessels on this list is bound to a maximum, but the vessels on it may be replaced by other ones, provided that their engine power does not exceed 221 kW and their overall length is 24 m maximum. Vessels on the list are allowed to fish within the twelve miles zone with beam trawls having an aggregate width of 9 m maximum. To this rule there is a further derogation for vessels having shrimping as their main occupation. Such vessels may be included in annually revised second list and are allowed to use beam trawls exceeding 9 m total width.

Plaice box

To reduce the discarding of plaice in the nursery grounds along the continental coast of the North Sea, an area between 53°N and 57°N has been closed to fishing for trawlers with engine power of more than 221 kw (300 hp) in the second and third quarter since 1989, and for the whole year since 1995. Beare *et al.* (2013) conducted a thorough analysis of the potential effect of the plaice box on the stock of plaice, and concluded that no significant effect, neither positive nor negative, could be related to the implementation of the plaice box.

Sandeel box

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, ICES advised in 2000 for a closure of the sandeel fisheries in the Firth of Forth area east of Scotland. All commercial fishing was excluded, except for a maximum of 10 boat days in each of May and June for stock monitoring purposes. The closure was initially designated to last for three years but has been repeatedly extended and remains in force. The level of effort of the monitoring fishery was increased in 2006.

Natura 2000

To protect habitats several Natura 2000 areas have been defined. It is still under negotiation which fisheries will be prohibited in these areas exactly. It is likely that for each of these areas different rules will apply.

Unilateral management

In addition to the EU-wide statutory regulations, some countries impose additional management schemes on their fleets. One example of this is the Scottish Conservation Credits scheme which encompasses technical regulation and temporary spatial closures in return for derogation from some EU effort controls. This scheme, and others are described in the stock sections to which they pertain.

2.3 Environmental considerations

WGNSSK welcomes the progress made to provide ecosystem overviews (ICES, 2016). These overviews give a good overview on environmental factors influencing the current development of fish and shellfish stocks. However, from these overviews it is still difficult to relate certain changes to observations made in the assessments. Therefore, the WG considers that although it is clear that the North Sea ecosystem is undergoing change and this will affect fish stocks, the causal mechanisms linking the environment with fish stock dynamics are in most cases not yet clearly-enough understood. However, for gadoids the choice of appropriate reference points now takes into account the current low productivity of the stocks although the exact causes of this low productivity are not fully understood. F_{msy} is estimated based on shortened stock recruitment time series and the upper range of F_{msy} is constraint by $F_{P.05}$ estimated for the current low recruitment period. To improve the situation, ICES may provide a database with all available environmental data and indicators from the various working and study groups to make them available to the scientific community. The longer the time series and the higher the contrast in these time series, the more likely that causal relationships can be identified.

Next to this WGNSSK made the following observations during the discussion on the ecosystem overviews:

1) The current low productivity of gadoids in the North Sea is not mentioned in the document. In general, under impact on commercial stocks an overview figure showing recruitment trends for the different guilds could provide valuable information.
2) The word crustaceans should be replaced with *Nephrops* in Figure 6.1.7. Only for *Nephrops* assessments are available and *Nephrops* constitutes only a small part of the crustacean biomass.
3) No flatfish are in the figure showing the North Sea food web. This is questionable for a flatfish dominated system.
4) The OSPAR table on threatened and declining species needs a review. Some of the species should not be mentioned any more (e.g., thornback ray, cod)
5) The ranking of the strength of interactions between pressure and state are purely qualitative (Figure 6.1.3). It is also unclear who has decided on the ranking. There are excellent expert elicitation methods available that could be applied to get an objective ranking based on the opinions of ICES experts.
6) The overviews need to be a living document. New knowledge needs to be incorporated when becoming available.

2.4 Human consumption fisheries

2.4.1 Data

Estimates of discarding rates provided by a number of countries through observer sampling programme were used in the assessments of various roundfish and flatfish as well as *Nephrops* FUs, to raise landings to catch (see also section 01 on InterCatch). During recent benchmarks discards could be included in the assessments of sole in 4, saithe in 4, 3.a and 6, plaice in 7.d and sole in 7.d. Discards could also be estimated for bycatch species (e.g., dab, flounder, lemon sole, witch, brill, and turbot). Finally, catch advice could be given for all WGNSSK stocks.

In the EU, national sampling programs are defined and implemented as part of the Data Collection Framework (DCF). Other sampling programmes (e.g. industry self-sampling for discards and biological data) have been in place in recent years and the data are increasingly entering the assessment process in some instances (e.g., plaice in 4, haddock). In general, some discarding occurred in most human-consumption fisheries until 2016. As TACs have become more restrictive for some species (e.g. cod), an increase in discarding of marketable fish (i.e. over minimum landing size) has been observed. In 2013, a landing obligation has been agreed between the EU Parliament and the Council of Ministers, as one of the most important aspects of the reform of the Common Fishery Policy (CFP), and this is going to have fundamental implications for the demersal fisheries and associated data collection program (see above).

For a number of years there had been indications that substantial under-reporting of roundfish and flatfish landings is likely to have occurred. It is suspected to have been particularly strong for cod until 2006, and catches were expected to be larger than the TAC. Since the middle of the 2000s, the WG had used an assessment method for North Sea cod (Section 4) which estimated unallocated removals, potentially due to reporting problems, unrecorded discards, changes in natural mortality, or changes in survey catchability. In 2013, WGNSSK considered that the assumption of unallocated removals after 2006 could not be justified by any known factors (cf also ICES WKCOD 2011), and relaxed that assumption in the assessment.

Several research vessel survey indices are available for most species, and were used both to calibrate population estimates from catch-at-age analyses, and in exploratory analyses based on survey data only. Commercial cpue series were available for a number of fleets and stocks, but for various reasons few of them could be used for assessment purposes (although they are presented and discussed). The use of commercial cpue indices has been phased out where possible and only the saithe and sole in 7.d assessment still relies on a commercial index.

Bycatches in the industrial fisheries were significant in the past for haddock, whiting and saithe, but these have reduced considerably in recent years.

2.4.2 Summary of stock status

The main impression in 2017 is that fishing mortality has been reduced significantly for many North Sea stocks of roundfish and flatfish compared to the beginning of the century. All fish stocks with agreed biomass reference points are above B_{lim}, and only the SSB of sole in 7.d is below MSY $B_{trigger}$ at the beginning of 2017. Several North Sea stocks are exploited around or below F_{msy} levels; exceptions are cod in 4, 3.a.20 and 7.d, haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d and sole in 4 (the latter only slightly above F_{msy}). An important feature is that recruitment still remains poor compared to historic average levels for most gadoids.

WGNSSK is also responsible for the assessment of several flatfish species that are mainly by catch in demersal fisheries. For all of these stocks, catch advice was provided in 2015 for the first time, and again in 2017. In 2017, for data-limited *Nephrops* stocks (FUs 5, 10, 32, 33 and 34), pollack and grey gurnard, it was only necessary to determine whether the perception of the stock has changed compared to 2016; because perceptions have not changed compared to 2016, no reopening of the advice was needed for these stocks.

Reopening of advice was triggered for several stocks in the autumn, namely cod in 4, 7.d and 3.a.20, haddock in 4, 6.a and 3.a.20, whiting in 4 and 7.d, plaice in 4 and 3.a.20, sole in 4, and *Nephrops* in FU 6, 7 and 8 (Annex 7).

The summary of stock status is as follows:

1) *Nephrops*: Although the stock abundance index for FU 6 increased from 2015 to 2016, it has been below MSY $B_{trigger}$ since 2011, and harvest rates have been above the MSY level since 2008. The stock size for FU 7 declined from the highest observed value in 2008 to the lowest abundance estimate in the time-series in 2015, but increased again in 2016 and is now above MSY $B_{trigger}$, while the harvest rate has declined since 2010 and remains well below F_{MSY}. For FU 8, the stock size has been above MSY $B_{trigger}$ for most of the time-series, and the harvest rate varying and now below F_{MSY}. For FU 9, the stock has been above MSY $B_{trigger}$ for the entire time-series, while the harvest rate has fluctuated around F_{MSY} and is now slightly above it. The stock size of *Nephrops* in 3.a is considered to be stable, while the

harvest rate for this stock is currently below F_{MSY}. The FUs 5, 10, 32, 33 and 34 are data limited, and new catch advice was not provided in 2017 (biennial advice was set in 2016). The state of *Nephrops* outside the functional units is unknown; landings have been increasing since 2014. Because the TAC is set for the whole North Sea and not at a functional unit level, this contributes to F_{MSY} reference points being exceeded in some FUs.

During the WKNEP 2016 benchmark, the reviewers agreed that for deriving reference points, and hence translating the stock abundance estimate to recommended removals, the common length-based yield per recruit method was not appropriate. The reviewers agreed that deriving harvest rates from historical experience and from experience with similar stocks, as suggested by WKNEP was acceptable as an interim solution, until a firmer basis for generating advice from UWTV survey abundance estimates can be developed. The advice-drafting group for the greater North Sea (ADGNS 2017) decided that, until an alternative, approved methodology for deriving reference points was in place, the reference points derived by the current methodology should continue to be used.

2) Norway Pout in 4 and 3.a: The stock size is highly variable from year to year, due to recruitment variability and a short life span. Spawning-stock biomass is above B_{pa} in 2017. Fishing mortality has been fluctuating at a lower level than previously since 1995. Recruitments in 2014 and 2016 were high, while recruitments in 2015 and 2017 are below the long-term average recruitment.

3) Cod in 4, 7.d and 3.a.20: Fishing mortality has declined since year 2000, but is estimated to be above F_{MSY}. Spawning-stock biomass has increased from the historical low in 2006 to above MSY $B_{trigger}$ in 2017. There are indications of increased recruitment in 2017.

4) Haddock in 4, 6.a and 3.a.20: Fishing mortality has been fluctuating above F_{MSY} for most of the time-series and is above F_{MSY} in 2016. Spawning-stock biomass has been mostly above MSY $B_{trigger}$ since 2002. Recruitment since 2000 has been characterized by a low average level with occasional larger year classes, the size of which is diminishing. The 2014 recruitment estimate is higher than recent low recruitment, but is still below the long-term average.

5) Whiting in 4 and 7.d: Spawning-stock biomass has fluctuated around, and is now above MSY $B_{trigger}$. Fishing mortality has been above F_{MSY} throughout the time-series. Since 2003 recruitment has been generally lower than in previous years.

6) Saithe in 3.a, 4 and 6: Recruitment has fluctuated over time and has generally been below the long-term average since 2003. Fishing mortality has been below F_{MSY} since 2013. Spawning-stock biomass has fluctuated without trend and has been above MSY $B_{trigger}$ since 1996.

7) Plaice in 4 and 3.a.20: The spawning-stock biomass is well above MSY $B_{trigger}$, and has markedly increased in the past ten years. Recruitment has been around the long-term average since the mid–1990s. Since 2009, fishing mortality has been estimated at around F_{MSY}.

8) Sole in 4: The spawning-stock biomass has increased since 2007 and has been estimated at above MSY $B_{trigger}$ since 2012. Fishing mortality has de-

clined since 1997 and is slightly above F_{MSY} in 2016. Recruitment has fluctuated below average without trend since the early 1990s.

9) Plaice in 7.d: Fishing mortality has declined since the early 2000s and has been below F_{MSY} since 2009. Spawning-stock biomass has increased since 2008 and has been above MSY $B_{trigger}$ since 2012. Recruitment in 2016 is the lowest in the time-series.

10) Sole in 7.d: The spawning-stock biomass has been fluctuating between B_{lim} and MSY $B_{trigger}$. Fishing mortality has been decreasing since 2014 and is below F_{MSY} in 2016. Recruitment has been fluctuating without trend and was in 2012–2016 at the lowest of the time-series, with the exception of 2015.

11) Category 3–6 finfish stocks: In 2017 new advice has been produced for several Category 3 and 5 stocks, but not for pollack and grey gurnard (for which biennial advice was given in 2016).

i. Brill in 3.a, 4 and 7.d-e: The biomass index has been gradually increasing over the time-series with moderate interannual variability. It has been higher in the last two years than in the three previous years.

ii. Dab in 3.a and 4: The assessment is indicative of trends only. The spawning-stock biomass has been increasing since 2006. Total mortality has declined since 2003. Recruitment showed an increasing trend until 2014, but has declined in the latest two years of the time-series. As a result of ICES advice following a Special Request from the Commission on the joint TAC for dab and flounder (ICES, 2017b), dab has been removed from TAC regulations (paragraph 8 of Council Regulation (EU) 2017/595).

iii. Flounder in 3.a and 4: Landings have been decreasing since 2006 and are stable in the most recent years. The available survey information indicates no clear trend in stock biomass. As a result of ICES advice following a Special Request from the Commission on the joint TAC for dab and flounder (ICES, 2017b), flounder has been removed from TAC regulations (paragraph 8 of Council Regulation (EU) 2017/595).

iv. Lemon sole in 3.a, 4 and 7.d: The biomass index (IBTS–Q1 SSB per hour) has fluctuated without significant trend since the mid–1980s. Landings have mostly decreased since the early 1980s, with a small increase in recent years. The discard rate is similar over the four years for which estimates are available.

v. Striped red mullet in 3.a, 4 and 7.d: The assessment is indicative of trends only. Biomass estimates and landings showed increases in 2014–2015. Based on survey indices and landings-at-age structure, this increase was caused by a strong recruitment in 2014. Spawning-stock biomass decreased in 2016 as a consequence of the poor recruitment and high catches seen since 2015.

vi. Turbot in 3.a: The IBTS–Q1 biomass index is variable and has been fluctuating without trend over time. The IBTS–Q3 biomass index is also variable but has shown an increased level after 2005.

vii. Turbot in 4: This stock underwent an inter-benchmark during the summer of 2017. The resultant assessment indicates that recruitment is variable without a trend. Fishing mortality is estimated to have decreased since the mid-1990s and has been stable for the past ten years. SSB has increased since the late 1990s.

viii. Whiting in 3.a: Catches have been relatively low in recent years after a substantial industrial fishery ceased in the mid–1990s. The state of the stock is not known.

ix. Witch in 3.a, 4 and 7.d: Landings declined from a peak in the 1990s to a low at the end of the 2000s, and have recently increased. The spawning biomass index (IBTS–Q1) declined from a high value in the mid-1990s to a low at the end of the 2000s, and has shown a recent increase. The spawning biomass index (IBTS–Q3) has fluctuated without trend.

Industrial fisheries

The Norway Pout assessment was benchmarked in 2012 through an inter-benchmark protocol (IBPNPOUT), resulting in changes in biological parameters (growth, maturity and natural mortality), and again in 2016 (WKPOUT) during which the assessment model was changed, but the general perception of the stock hasn't changed substantially. Advice for Norway pout is due in the autumn 2017.

2.5 Fisheries Overviews

ICES has published a Fisheries Overview for the Greater North Sea Ecoregion (ICES 2017a). The Executive Summary is as follows:

Around 6600 fishing vessels are active in the Greater North Sea. Total landings peaked in the 1970s at 4 million tonnes and have since declined to about 2 million tonnes. Total fishing effort has declined substantially since 2003. Pelagic fish landings are greater than demersal fish landings. Herring and mackerel, caught using pelagic trawls and seines, account for the largest portion of the pelagic landings, while sandeel and haddock, caught using otter trawls/seines, account for the largest fraction of the demersal landings. Catches are taken from more than 100 stocks. Discards are highest in the demersal and benthic fisheries. The spatial distribution of fishing gear varies across the Greater North Sea. Static gear is used most frequently in the English Channel, the eastern part of the Southern Bight, the Danish banks, and in the waters east of Shetland. Bottom trawls are used throughout the North Sea, with lower use in the shallower southern North Sea where beam trawls are most commonly used. Pelagic gears are used throughout the North Sea.

In terms of tonnage of catch, most of the fish stocks harvested from the North Sea are being fished at levels consistent with achieving good environmental status (GES) under the EU's Marine Strategy Framework Directive; however, the reproductive capacity of the stocks has not generally reached this level. Almost all the fisheries in the North Sea catch more than one species; controlling fishing on one species therefore affects other species as well. ICES has developed a number of scenarios for fishing opportunities that take account of these technical interactions. Each of these scenarios results in different outcomes for the fish stocks. Managers may need to take these scenarios into account when deciding upon fishing opportunities. Furthermore, biological interactions occur between species (e.g. predation) and fishing on one stock may affect the population dynamics of another. Scenarios that take account of these various interactions have been identified by ICES and can be used to evaluate the possible consequences of policy decisions. The greatest physical disturbance of the seabed in the North Sea occurs by mobile bottom-contacting gear during fishery in the eastern English Channel, in near-shore areas in the south eastern North Sea, and in the central Skagerrak. Incidental bycatches of protected, endangered, and threatened species occur in several North Sea fisheries, and the bycatch of common dolphins in the western English Channel may be unsustainable in terms of population.

3 Brill in Subarea 27.4, Divisions 3.a, 27.7.d and 27.7.e

Brill (*Scophthalmus rhombus*) is assessed in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) since 2013. Because only official landings and survey data were available, brill in subarea 27.4, divisions 27.3.a, 27.7.d,e was defined as a category 3 stock (ICES 2012a). For this stock biennial advice is provided based on the lpue trends of the Dutch beam trawl fleet (vessels > 221 kW). From 2015 onwards, also discards by metier were requested from all countries contributing to this stock through InterCatch. For the WGNSSK data call in 2017 also all available age and length data were requested through InterCatch for three years back in time (2014–2016).

3.1 General

3.1.1 Biology and ecosystem aspects

Brill is a shallow-water flatfish mainly found in areas close inshore. It prefers sandy bottoms, but can sometimes also be found on gravel and muddy grounds. Its vertical distribution ranges from 4 meters to 73 meters, although small juvenile fish are often common in sand shore pools. Mature brill are rarely observed inshore, whereas immature specimens are often caught near the coast and even in estuaries.

The distribution of brill in the North Eastern Atlantic ranges along the European coastline from 64° N (the Lofotes) down to 30° N, extending into the Mediterranean and even into the Black Sea (Nielsen, 1986). Brill is also found in the Skagerrak, the Kattegat, and small quantities in the Baltic Sea. The western limit of its distribution area is reached in southern Iceland.

The feeding habits of this species closely resemble those of turbot and were extensively reviewed by de Groot (1971) and Wetsteijn (1981). The pelagic larvae feed primarily on copepod nauplii, decapod and mollusk larvae. With increasing size, this diet gradually changes from larger invertebrate prey and larvae of several fish species to small fish. Larger brill (> 40 cm) are primarily piscivorous.

More information on the biology of brill can be found in Annex 5 of WGNEW 2010 (ICES 2010).

3.1.2 Stock identity and possible assessment areas

The oldest study that could be found containing information on the genetic structure of brill was carried out by Blanquer *et al*. (1992), using allozyme electrophoresis. No genetic differentiation could be found between Atlantic and Mediterranean populations, suggesting that there are also very low levels of differentiation in brill from different areas.

In the EU funded study on "Stock discrimination in relation to the assessment of the brill fishery" the following was concluded (Delbare and De Clerck, 1999): "As a final conclusion, biological parameters (composition of Belgian brill landings, growth rate and reproduction characteristics) and the sequencing of the D-loop resulted in insignificant differences between brill from the different areas. Therefore, arguments favour the hypothesis that brill from the NE Atlantic might be considered to be only one population: the Northeastern Atlantic brill population. Further research on spawning areas and migration through respectively egg surveys and tagging experiments, could generate valuable information about (sub) population structures of brill throughout its entire distribution area. Therefore it is advisable to extend the sampling area to the Mediterranean Sea and the Black Sea."

Recently, the genetic structure of brill over its entire distribution area has being characterized by Vandamme (2014). Genetic variation was found to be of mean to high levels, but the results show almost no differentiation between potential biological populations and/or management units. Therefore, we still feel confident in treating brill in 3.a, 4 and 7.d,e as a single stock that could potentially have an even wider geographical spread.

Further research on brill spawning areas (egg surveys), and of migration of adult (tagging experiments) and especially immature brill (tagging experiments and genetic analysis of the immature population components) could still generate valuable information about (sub)population structure of brill throughout its entire distribution area.

More information on the delineation of potential brill stocks can be found in Annex 5 of WGNEW 2010 (ICES 2010).

3.1.3 Management regulations

Although several EC regulations affect the flatfish fisheries in the North Sea (e.g. effort restrictions, minimum mesh sizes), no explicit management objectives have been defined for the stock of brill in 3.a 47:d,e, and no management plans are in place. However, for the EU-waters in Division 27.2.a and Subarea 27.4, precautionary TACs have been defined for brill and turbot (combined). It is unclear how the quantitative single species advices for turbot and brill are used to formulate a combined TAC that belongs entirely to the EU-fisheries. A historical overview is presented in the table below.

Historical overview of combined TACs for brill *Scophthalmus rhombus* and turbot *Scophthalmus maximus* in Division 27.2.a and Subarea 27.4.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	9000	9000	6750	5738	4877	4550	4323	4323	5263
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	5263	5263	4642	4642	4642	4642	4642	4488	4937

No restriction on the minimum length for landing brill is imposed by the EC. Some authorities or producer organisations have however installed Minimum Landing Sizes (MLS) for brill. The most frequently applied MLS is 30 cm (e.g. in Belgium).

3.2 Fisheries data

3.2.1 Landings

Tables 3.1–3 summarise the official brill landings by country for division 3.a, subarea 27.4, and divisions 27.7:de respectively (Source: ICES Fishstat). The total official landings can be consulted in Table 3.4 and Figure 3.1. Over the period 1950–1970, total landings ranged from 582 tons to 947 tons per year, followed by a gradual increase to 2 121 tons in 1977. During 1978–2014, total landings varied between 1 517 tons (in 1980) and 3 141 tons (in 1993). In 2000–2014, annual total landings fluctuated around an average of 2 112 tons (range: 1 781 tons–2 409 tons). In 2015, landings increased to the third highest value in the time series (2 489 tons) and also in 2016, landings stayed in the same range (2 409 tons). Subarea 27.4 accounts for the major part of these landings (Figure 3.2), on average generating 68% of the totals over the time series (range: 50–

86%). The English Channel and Skagerrak are responsible for average contributions to the international brill landings of 20% and 13% respectively. Skagerrak was responsible for a higher relative importance in the total landings during the first two decades of the time series, and the English Channel has gained importance since the late seventies. No trend towards a higher or lower mean relative contribution of a certain Subarea or Division is apparent in the data for the more recent years. It is however possible that these trends (or lack thereof) are influenced by incomplete statistics for the early part of the time series.

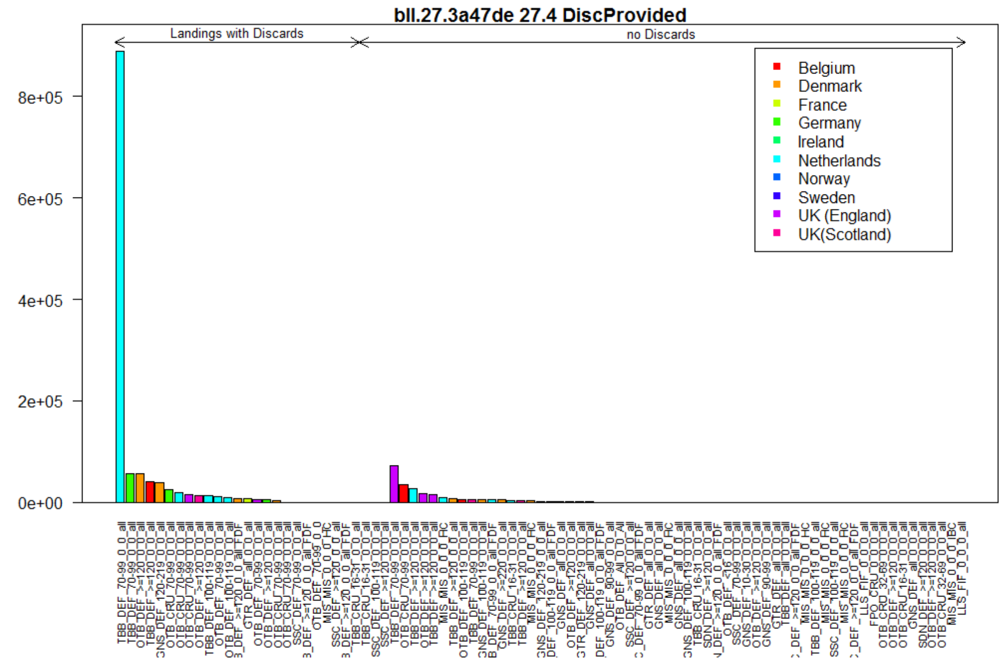
Uptake percentages for brill in the Greater North Sea assessment area cannot be reliably calculated, as the TAC is set combined with turbot. Additionally, there is a mismatch between the assessment and the management areas, as the TAC is set for Subareas 27.4 and Division 27.2.a.

More details on the Belgian, Dutch, French and UK fisheries catching brill, and information on length and age distributions of Belgian brill landings can be found in Annex 5 of WGNEW 2010 (ICES 2010). For the WGNSSK data call in 2017, available age and length data were requested through InterCatch for three years back in time (2014–2016). An overview of what was received per season and métier is presented in Figures 3.3–3.8.

3.2.2 Discards

Due to its high value and the absence of a European Minimum Landing Size, brill is not expected to be discarded easily by fishermen catching the species as long as the quota have not been fully taken. The fact that the species is characterised by a fast growth, quickly reaching commercially interesting lengths, explains why smaller individuals are rather rare in commercial catches, contributing to the low numbers of discards. Therefore, earlier evaluations resulted in the labelling of this stock as one with negligible discards, and landings were considered to be a reliable proxy for total catch. The amount of discarding of brill was not thought to be a substantial problem for the assessments of the state of the species' stocks in terms of data completeness. However, it should be monitored whether brill ending up in the catch have already had the opportunity to spawn.

In 2014, discard rates and/or discard data that were raised to fleet levels were available for the first time through InterCatch, for some countries participating in the brill fishery. However, these were not analysed or incorporated in the assessment, or to top up the landings in order to issue a catch advice, as 2014 was an update year. Under the 2015 data call, eight countries (Belgium, Denmark, France, Germany, Ireland, The Netherlands, Sweden and the United Kingdom) were expected to upload quarterly discard data by métier and Division in InterCatch, for the years 2012–2014. The response to this data call can be evaluated as very good for this stock. Five countries delivered data for all three years (Belgium, Germany, Netherlands, Norway, that was not in the call, and United Kingdom, both England and Scotland), three countries for 2013 and 2014 (Denmark, France and Sweden), and Ireland for 2014. All subdivisions and the main métiers catching brill (gear types: TBB, OTB, GNS, GTR) were covered in this way, and quarter/country combinations for which discard information was lacking could be easily filled by allocating discard rates of similar/identical métiers or quarters. The 2016 data call listed the same data demands, and also the response of the different countries can be evaluated as well (both quantitatively and qualitatively). The 2017 data call asked for data from 2014–2016 with a positive response rate (Figure below giving a summary of the information provided to InterCatch for 2016; Landing data by métier and country, with and without discard information provided). Some data (2014 and/or 2015) has been updated by some countries (e.g. France).



Discard rates were calculated for 2012–2016 using the available data in InterCatch (Table 3.5).Table 3.6 and 3.7 show the discard rates broken down by country and Subarea/Division respectively for the years 2014–2016. The overall discard rates show no trend (Table 3.5). The discard rate overview by country (Table 3.6) shows rates that are well above the average for e.g. Denmark (21% and 22% in 2014 and 2015 respectively) and Sweden (35% and 29% in 2014 and 2015 respectively), corresponding to the higher discard rates in the North of the stock area (up to 38% in 27.3:a; Table 3.7). These higher numbers in the North are largely caused by gillnet and trammel net fisheries taking place there. However, for both Denmark and Sweden, discard rates have gone down in 2016, resulting in an overall discard rate for 27.3.a of 10%. Remarkably, the high discard rate of 16% for Germany in 2014 dropped to only 1% in 2015 and 3% in 2016.

For the WGNSSK data call in 2017, available age and length data were requested through InterCatch for three years back in time (2014–2016). An overview of what was received per season and métier is presented in Figures 3.3–3.8.

3.3 Tuning series

3.3.1 Survey Data

General

Catches of brill are generally very low on surveys. These low catch numbers often result in an underrepresentation of some year or length classes (mainly the older or bigger ones), leading to a poor quality of the resulting survey abundance series and indices, and poor agreement among different surveys.

WGNEW 2012 (ICES 2012b) tested four surveys for their potential use in describing stock trends of brill in the greater North Sea. Three of these surveys take place in the North Sea (IBTS_TRI_Q1, BTS_TRI_Q3 and BTS_ISI_Q3) and one in the English Channel (CGFS_Q4). Time series of total numbers of brill caught by the three North Sea surveys and the Channel are depicted in WGNEW 2012 (ICES 2012b), but only the BTS_ISI_Q3 was found to catch a sufficient number of individuals to be useful in the context of evaluating stock trends of North Sea brill. WGNEW 2013 and the following WGNSSK-meetings did not go into these surveys again, with exception for the BTS_ISI_Q3 and BITS_HAF_Q1&4 that were updated because of their use as indicators in the advice in the North Sea and the Skagerrak respectively. Plots and tables for these surveys were also updated during WGNSSK 2017.

North Sea (Subarea 27.4)

The abundance indices (numbers per hour) for brill in the BTS_ISI_Q3 in 27.4 are spatially plotted per rectangle in Figure 3.9 and over time in Figure 3.10 and Table 3.8. These seem to illustrate a recovery of the species in 27.4 since 2009 after a period of consistent lower catches during 2001–2008, followed by a drop in abundance in 2012–2013, a steep increase in 2014 and again a drop in 2015. In 2016, numbers per hour showed a further decrease. However, it should be noted that the recorded numbers per hour are low and that interannual variation over the years is large. Therefore, no real trend can be identified in this time series.

The corresponding age–length key, length distributions (per 5 years) and length-at-maturity are illustrated in Figures 3.11–13. These show that mainly brill of ages 1–2 and lengths of 20–45 cm are caught in this survey and that no obvious shifts in length distributions are apparent over the time series (1987–2016). No brill specimens larger than 30 cm were found to be still immature. Specimens in maturity stage 'maturing' (62) had a very large length range (23–49 cm). Maturity information provided through DATRAS this year seemed to be different than what was provided last year.

Kattegat (Division 27.3.a22)

The abundance indices (numbers per hour) for brill in the BITS_HAF_Q1&4 are spatially plotted per rectangle in Figure 3.14 and over time in Figure 3.15 and Table 3.9. These illustrate a period with higher catches (2006–2011) after a period of consistent lower catches (1996–2005). In 2012, the numbers caught per hour dropped to the level of 2004–2005 again but given the noise in the data (large inter-annual variations) it was considered to be preliminary to interpret this as a sign of a decreasing stock. As in the survey used as an indicator for brill in the North Sea, the lower abundance of 2012 (2.27/hr) in 3.a was also followed by an even lower abundance in 2013 (2.13/hr.), and a steep increase in 2014 (3.86/hr.). Although the survey index values are generally higher in 3.a compared to 27.4, the trends are remarkably similar in the past few years, except for 2015 (decrease in 27.4, increase in 3.a). In 2016, both survey indices showed a decrease.

The corresponding length distributions for the BITS_HAF_Q1&4 in 27.3.a are shown in Figure 3.16. As in Subarea 27.4, no alarming shifts in length distributions (no obvious loss of larger/older individuals from the population) are apparent over the time series (1996–2016).

Note that the BITS is performed using another research vessel since 2016. The term BITS_"HAF" could therefore cause confusion.

English Channel (Divisions 27.7.d,e)

Unfortunately, no useful survey index could be identified for the evaluation of the brill sub-stock in the English Channel during previous WGNEW meetings (ICES, 2010, 2012b, 2013a).

3.3.2 Commercial lpue series

Although the survey indices presented above are useful indicators when evaluating the state of the brill stock in (parts of) the stock area, the spatial coverage of both surveys was evaluated as insufficiently spanning the stock area, and the catches too low, to use these surveys as a basis for catch advice, by previous WGNEW and WGNSSK meetings.

A corrected Landings Per Unit of Effort (lpue) series from the Dutch beam trawl fleet > 221 kW was presented to and discussed for the first time during WGNEW 2013 (see ICES, 2013a for interpretation), and has been used as the basis for the advice since. These lpue were standardised for engine power and corrected for targeting behaviour. The standardisation for engine power is relevant as trawlers are likely to have higher catches with higher engine powers, as they can trawl heavier gear or fish at higher speeds. The correction for targeting behaviour relies on reducing the effects of spatial shifts in fishing effort by calculating the fishing effort by ICES rectangle and subsequently averaging these over the entire fishing area. More information on the data that were used (EU logbook auction data and market sampling data), the calculation of the LPUEs, the standardization of engine power, the correction for targeting behaviour and the results can be found in van der Hammen *et al*. (2011).

The Dutch lpue series used during the WGNSSK 2017 is shown in Table 3.10a and Figure 3.17. The series showed a consistently increasing lpue (kg/day) up to 2012, dropping slightly over 2013–2014 (6% decrease between 2010–2012 and 2013–2014) but increasing again in 2015. In 2016, a slight decrease is observed (from 61.11 to 57.44 kg/day).

During the Advice Drafting Group of the North Sea (June 2017), it was decided to use the extended Dutch lpue series (from 1995). This series was used for the final SPiCT run (see section 3.4.3) and is presented in Table 3.10b. The longer time series confirms the increasing trend in lpue from the late 90s onwards. The short and long time series do not fully overlap. This is due to the fact that the short series is age-structured and the sum over all ages is made, while the long series is not age-structured.

3.4 Analyses of stock trends and potential status indicators

So far, no analytical assessments leading to fisheries advice have been carried out for brill in the Greater North Sea by ICES. In the absence of collated and analysed biological data, Category 3 of the ICES Data Limited Stocks Methodology (ICES 2012a) is currently the highest attainable category for this stock. However, the ICES questionnaire to evaluate whether a stock could upgrade to a higher category was completed. It was concluded that this stock can be considered as a potential candidate for Category 1, but for an age or length based assessment more information is needed on available age and length samples and scientific resources to provide them. Additionally, an appropriate fisheries independent index series targeting large flatfish species such as brill and turbot, covering the entire stock area is currently missing and could provide better insight in the status of the stock.

During WGNSSK 2017, three different methods were used to get an idea of the stock trends and status. The ICES biennial advice was based on the Dutch commercial lpue series (see Section 3.4.1). Note that during the ADG North Sea, the extended Dutch commercial lpue series (from 1995) was preferred over the short series (from 2007).

3.4.1 Dutch commercial lpue series

WGNEW and WGNSSK tested several surveys for their information content regarding brill in the Greater North Sea over the last few years, and decided to retain only the BTS_ISI_Q3 in 27.4 and the BITS_Q1&4 in 27.3.a22 as useful indicators for this stock. As basis for the advice, the commercial lpue series from the Dutch beam trawl fleet > 221kW was used being a more reliable time series. As a result, applying the 2:3 rule leads to an increase of 13% between 2012–2014 and 2015–2016 (suggested biennial ICES advice for 2017 and 2018; Figure 3.17 and Table 3.10a). During the ADG North Sea, it was decided to use the extended Dutch lpue series which slightly deviated from the short one. This resulted in an increase of 15% when applying the 2:3 rule (Table 3.10b; Figure 3.18).

3.4.2 Length-based indicator screening

Length-based indicators (LBI) were estimated for three years of data (2014–2016), following the standard approach outlined by WKLIFE (ICES, 2017a) and WKPROXY (ICES 2017b), using the length distributions provided through InterCatch.

Discards were raised and length compositions were allocated using InterCatch (Table 3.11). Discard raising was performed on the gear level, regardless of season or country, using the following gear groups: TBB, OTB/SSC/SDN and GTR/GNS. All remaining strata were raised using all available data (overall). The weighting factor for raising the discards was 'Landings CATON'. Two issues should be highlighted: 1) Dutch landings data were provided at quarterly level, while discards were provided at yearly level. Consequently, these discard strata were raised by matching them with the corresponding landings strata, prior to raising by gear group. 2) Some matched strata showed very large discard ratios. These were included in the raising process, which will have affected the final result of the raising. To allocate length compositions, landings and discards were handles separately. When length distributions had to be borrowed from other strata, allocations were completed using the same gear groups as for discard raising (TBB; OTB/SSC/SDN; GTR/GNS; overall). The weighting factor used was 'Mean weight weighted by numbers at age'.

Life history parameters were obtained from van der Hammen *et al.* (2013). Note that sexually dimorphic growth is present in brill with females reaching larger maximum body sizes than males. Additionally, brill shows sex differences in size at 50% maturity. Assuming a 50:50 sex ratio (cf. turbot in lack of data on brill), Linf and Lmat values were obtained by averaging sizes for males and females (Table 3.11). This was necessary as all data in InterCatch was provided for undetermined sex.

The following table summarised the output from the LBI analysis.

Traffic light indicators

	Conservation				**Optimizing Yield**	**MSY**
	Lc/Lmat	**L25%/Lmat**	**Lmax5%/Linf**	**Pmega**	**Lmean/Lopt**	**Lmean/$L_{F=M}$**
Ref	>1	>1	>0.8	>30%	~1 (>0.9)	≥1
2014	0.84	0.88	1.07	0.2	1.00	1.19
2015	0.36	1.08	1.07	0.3	1.00	1.74
2016	1.33	1.20	1.09	0.4	1.19	1.07

Most of the indicators appeared closed to the established references.

- Length at first catch (Lc) and Length of 25% of catches (L25%) are both above $L_{maturity}$ (24.9 cm) in 2016 and have thus gradually improved from 2014 onwards. This indicates a low number of immature individuals in the catches.
- The ratio of the mean length of upper 5th percentile of catches to Linf (50.7 cm) is above 0.8 over all three years, which suggest enough large (and hence old) fish in the population.
- The Lmean/Lopt ratio of around 1 suggest that the exploitation targets the most productive length classes.
- Finally, Lmean/$L_{F=M}$ is greater than 1, which suggests this stock is exploited at MSY.
- Pmega (proportion of individuals above Lopt + 10%) only gave a value below the desired reference (30%) in 2014.

This indicates that the stock status has improved from 2014 onwards and may be considered to be exploited somehow sustainably and in the vicinity of MSY.

3.4.3 SPiCT MSY proxy reference points

A Surplus Production Model in Continuous Time (SPiCT, Pedersen & Berg, 2017) to estimate MSY proxy reference points was applied. Three fishery independent survey time series (BTS_ISI_Q3, Baltic International Trawl Survey BITS_Q1 and _Q4), a standardized lpue from the Dutch beam-trawl fleet (with vessels > 221 kW), and a catch time series (1950–2016) were used as input for the model.

Eight exploratory SPiCT assessments were performed during the WGNSSK 2017. These different runs explored the effects of:

- The length of the time series of the official ICES landings (starting either in 1950 or in 1987 i.e. the start of the BTS_ISI_Q3 time series);
- The length of the time series of the standardized lpue from the Dutch beam trawl fleet (starting either in 1995 or 2007) (Figure 3.18);
- Various combinations of BTS and BITS indices;
- The removal of age 0 and 1 fish from the standardized lpue from the Dutch beam-trawl fleet (vessels > 221 kW) (Figure 3.19).

The final run used in the advice sheet uses the following settings:

- Landings data from 1987 onwards;
- Including BTS Q3 survey (1987–2016) and standardized lpue from the Dutch beam-trawl fleet (vessels > 221 kW) (1995–2016);
- Including age 0 and 1 for the standardized lpue from the Dutch beam trawl fleet with vessels > 221 kW;
- Excluding BITS_Q1 and BITS_Q4;
- Default priors.

We excluded the BITS_Q1 and BITS_Q4 from the final run because the landings from the 27.3.a are only 6.9% of the total landings for this stock. A longer time series for the Dutch lpue index was used for the SPiCT assessment than for the indicator used in the advice in order to increase coverage of the landings. Landings data were trimmed from 1987–2016 to have a full coverage of the landings time series by tuning series.

All results of the final SPiCT assessment are given in Figure 3.20–3.24 and in Table 3.12. These results suggest that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is well above the reference B_{MSY}* 0.5 proxy. Therefore, the Precautionary Approach Buffer (PA Buffer) was not applied for the advice for this stock. The retrospective analysis (Figure 3.24) shows a relative stability in the model outcomes. There is quiet some variation, but the model is performing relatively well. The trends are similar and the estimated status with respect to reference points is consistent.

Table 3.1. BLL 27.3a47de: Official landings (tons) of brill in Division 3.a (Skagerrak) by country, over the period 1950–2016 (Source: ICES Fishstat).

Year	BEL	GER	DNK	NLD	NOR	SWE	TOTAL
1950	0	0	234	0	0	85	319
1951	0	0	260	0	4	73	337
1952	0	0	170	0	1	65	236
1953	0	0	175	0	0	71	246
1954	0	0	155	0	1	78	234
1955	0	0	150	0	0	62	212
1956	0	0	163	0	0	50	213
1957	0	0	110	0	0	38	148
1958	0	0	166	0	0	37	203
1959	0	0	175	0	0	58	233
1960	0	0	272	0	0	46	318
1961	0	0	255	0	0	50	305
1962	0	0	207	0	0	0	207
1963	0	0	120	0	0	0	120
1964	0	0	106	0	0	0	106
1965	0	0	155	0	0	0	155
1966	0	0	187	0	0	0	187
1967	0	0	106	0	0	0	106
1968	0	0	100	0	0	0	100
1969	0	0	99	0	0	0	99
1970	0	0	97	0	0	0	97
1971	0	0	104	0	0	0	104
1972	0	0	120	0	0	0	120
1973	0	0	131	0	0	0	131
1974	0	0	200	0	0	0	200
1975	0	0	167	1	0	19	187
1976	1	0	185	26	0	12	224
1977	1	0	276	99	0	12	388
1978	0	0	178	27	0	11	216
1979	0	0	156	17	0	11	184
1980	2	0	69	1	0	10	82
1981	0	0	54	0	0	5	59
1982	1	0	64	1	0	8	74
1983	0	0	73	3	0	7	83
1984	0	0	89	0	0	8	97
1985	0	0	100	0	0	10	110
1986	0	0	94	0	0	13	107
1987	0	0	93	0	0	12	105
1988	0	0	91	0	0	10	101
1989	0	0	88	0	0	9	97
1990	1	0	116	0	0	11	128
1991	1	0	81	0	7	10	99
1992	1	0	123	0	7	15	146

1993	2	0	184	0	10	16	212
1994	0	0	191	0	12	19	222
1995	0	0	124	0	13	14	151
1996	0	0	94	0	12	6	112
1997	0	0	83	0	11	12	106
1998	0	0	108	0	10	14	132
1999	0	0	126	0	13	18	157
2000	0	0	112	0	12	17	141
2001	0	0	73	0	13	12	98
2002	0	0	66	0	12	12	90
2003	0	0	99	1	12	16	128
2004	0	0	119	4	15	18	156
2005	0	0	101	3	16	13	133
2006	0	1	105	3	16	15	140
2007	0	1	119	3	15	20	158
2008	0	2	138	1	13	30	184
2009	0	1	98	1	14	33	147
2010	0	1	95	1	9	16	122
2011	0	1	103	0	15	12	131
2012	0	0	89	0	16	15	120
2013	0	0	70	0	9	13	92
2014	0	0	59	0	8	11	79
2015	0	0	104	11	8	19	143
2016	0	0	124	7	8	25	164

Table 3.2. BLL 27.3a47de: Official landings (tons) of brill in Subarea 27.4 by country, over the period 1950–2016 (Source: ICES Fishstat).

Year	BEL	GER	DNK	FRA	GBR	NLD	NOR	SWE	TOTAL
1950	34	0	39	0	183	108	1	19	384
1951	23	0	53	0	322	93	1	19	511
1952	21	0	65	0	350	117	3	9	565
1953	23	0	49	0	376	130	0	11	589
1954	19	0	53	0	330	106	14	7	529
1955	23	0	51	0	357	137	3	0	571
1956	28	0	47	0	276	156	0	9	516
1957	32	0	27	0	247	154	0	8	468
1958	43	0	42	0	223	162	0	10	480
1959	41	0	30	0	219	125	0	9	424
1960	55	0	37	0	235	150	1	8	486
1961	102	0	40	0	264	166	0	9	581
1962	97	0	42	0	238	214	0	0	591
1963	79	0	59	0	307	175	0	0	620
1964	79	0	46	0	161	279	0	0	565
1965	71	0	56	0	127	281	0	0	535
1966	100	0	63	0	119	264	0	0	546
1967	138	0	29	0	105	137	0	0	409
1968	152	0	43	0	110	274	0	0	579
1969	145	0	47	0	102	364	0	0	658
1970	114	0	42	0	76	386	0	0	618
1971	187	0	72	0	94	720	0	0	1073
1972	213	0	65	0	51	665	0	0	994
1973	185	0	55	0	39	710	0	0	989
1974	135	0	68	0	44	905	0	0	1152
1975	164	0	76	13	44	925	0	0	1222
1976	148	0	65	10	45	940	0	0	1208
1977	166	0	88	17	60	1079	0	0	1410
1978	175	0	123	26	84	967	0	0	1375
1979	188	0	154	10	103	908	0	0	1363
1980	129	0	104	8	45	747	0	0	1033
1981	148	0	66	5	42	957	0	0	1218
1982	182	0	53	11	41	1007	0	0	1294
1983	182	0	62	23	28	1153	0	0	1448
1984	190	0	73	30	29	1200	0	0	1522
1985	187	0	71	35	46	1370	0	0	1709
1986	131	0	76	4	46	950	0	0	1207
1987	140	0	50	17	48	715	0	0	970
1988	102	0	33	18	52	880	0	0	1085
1989	112	0	43	9	58	1080	0	0	1302
1990	168	0	139	24	82	480	0	0	893
1991	205	38	145	28	147	1111	8	0	1682
1992	203	59	77	34	218	1196	22	1	1810
1993	291	63	118	38	268	1647	14	0	2439
1994	208	90	109	28	235	1235	11	0	1916
1995	194	67	55	24	145	943	6	0	1434
1996	206	47	64	15	175	732	8	0	1247
1997	129	48	38	1	135	590	16	0	957
1998	160	58	58	11	172	808	16	0	1283
1999	161	51	91	0	156	805	16	0	1280

2000	167	77	93	16	141	998	16	0	1508
2001	182	66	67	12	158	1075	13	0	1573
2002	145	58	52	10	120	907	10	0	1302
2003	145	70	57	9	119	934	12	0	1346
2004	140	66	77	7	168	772	19	0	1249
2005	120	62	89	7	138	716	28	0	1160
2006	105	55	75	9	154	765	12	0	1175
2007	110	47	52	12	156	854	9	0	1240
2008	117	42	86	5	93	650	11	0	1004
2009	109	54	96	8	105	786	4	0	1162
2010	104	75	97	12	136	1072	4	0	1500
2011	101	57	122	13	137	1061	6	0	1497
2012	110	71	126	12	102	1084	7	0	1512
2013	100	63	123	10	117	972	4	0	1389
2014	98	69	96	9	116	811	9	4	1212
2015	149	115	122	7	136	1124	1	0	1655
2016	175	90	131	8	156	965	1	0	1526

Table 3.3. BLL 27.3a47de: Official landings (tons) of brill in Subareas 27.7d,e (English Channel) by country, over the period 1950–2016 (Source: ICES Fishstat).

Year	BEL	DNK	FRA	GBR	IRL	NLD	XCI	TOTAL
1950	11	0	0	48	0	0	0	59
1951	8	0	0	70	0	0	0	78
1952	6	0	0	66	0	0	0	72
1953	2	0	0	60	0	0	0	62
1954	1	0	0	59	0	0	0	60
1955	4	0	0	57	0	0	0	61
1956	2	0	0	58	0	0	0	60
1957	4	0	0	66	0	0	0	70
1958	2	0	0	65	0	0	0	67
1959	1	0	0	58	0	0	0	59
1960	6	0	0	46	0	0	0	52
1961	1	0	0	46	0	0	0	47
1962	3	0	0	52	0	0	0	55
1963	1	0	0	50	0	0	0	51
1964	0	0	0	60	0	0	0	60
1965	2	0	0	46	0	0	0	48
1966	0	0	0	53	0	0	0	53
1967	1	0	0	66	0	0	0	67
1968	3	0	0	54	0	0	0	57
1969	2	0	121	67	0	0	0	190
1970	10	0	0	49	0	0	0	59
1971	18	0	0	48	0	0	0	66
1972	20	0	0	52	0	3	0	75
1973	20	0	0	70	0	0	0	90
1974	25	0	0	56	0	0	0	81
1975	24	0	55	56	0	0	2	137
1976	41	0	170	72	0	0	2	285
1977	45	0	197	77	0	0	4	323
1978	58	3	227	120	0	0	3	411
1979	55	0	262	140	0	0	2	459
1980	64	2	213	118	3	0	2	402
1981	83	0	271	130	0	0	6	490
1982	105	0	225	149	0	1	7	487
1983	107	0	234	181	0	1	3	526
1984	114	0	226	186	0	0	5	531
1985	94	0	213	177	0	0	10	494
1986	115	0	183	147	0	0	11	456
1987	126	0	216	141	0	0	10	493
1988	112	0	202	133	0	0	5	452
1989	89	0	213	121	0	0	2	425
1990	99	0	249	187	0	0	8	543
1991	81	0	249	140	0	0	0	470
1992	82	0	223	151	0	0	7	463

1993	78	0	256	152	0	0	4	490
1994	88	0	227	170	0	0	5	490
1995	91	0	248	200	1	0	18	558
1996	105	0	240	253	0	0	10	608
1997	107	0	185	198	1	0	10	501
1998	70	0	196	173	0	2	10	451
1999	97	0	0	127	0	3	13	240
2000	164	0	260	232	1	4	17	678
2001	212	0	256	251	0	2	17	738
2002	204	0	268	227	0	1	16	716
2003	217	0	287	238	1	1	15	759
2004	165	0	259	223	1	3	15	666
2005	138	0	267	183	0	2	21	611
2006	180	0	281	170	0	3	15	649
2007	205	0	325	199	0	1	11	741
2008	154	0	225	199	0	2	13	593
2009	131	0	278	171	0	1	10	591
2010	145	0	340	198	0	1	11	695
2011	141	0	277	204	0	0	0	622
2012	121	0	263	232	0	1	0	617
2013	143	0	237	214	0	1	6	601
2014	165	0	243	232	0	1	10	651
2015	162	0	274	250	0	0	5	691
2016	143	0	286	284	0	1	5	719

Table 3.4. BLL 27.3a47de: Total official landings (tons) of brill in the 27.3a47de (Greater North Sea) over the period 1950–2016, subdivided into Subarea 27.4 and Divisions 3.a and 27.7d,e (Source: ICES Fishstat).

Year	3.a	4	7 de	TOTAL
1950	319	384	59	762
1951	337	511	78	926
1952	236	565	72	873
1953	246	589	62	897
1954	234	529	60	823
1955	212	571	61	844
1956	213	516	60	789
1957	148	468	70	686
1958	203	480	67	750
1959	233	424	59	716
1960	318	486	52	856
1961	305	581	47	933
1962	207	591	55	853
1963	120	620	51	791
1964	106	565	60	731
1965	155	535	48	738
1966	187	546	53	786
1967	106	409	67	582
1968	100	579	57	736
1969	99	658	190	947
1970	97	618	59	774
1971	104	1073	66	1243
1972	120	994	75	1189
1973	131	989	90	1210
1974	200	1152	81	1433
1975	187	1222	137	1546
1976	224	1208	285	1717
1977	388	1410	323	2121
1978	216	1375	411	2002
1979	184	1363	459	2006
1980	82	1033	402	1517
1981	59	1218	490	1767
1982	74	1294	487	1855
1983	83	1448	526	2057
1984	97	1522	531	2150
1985	110	1709	494	2313
1986	107	1207	456	1770
1987	105	970	493	1568
1988	101	1085	452	1638
1989	97	1302	425	1824
1990	128	893	543	1564
1991	99	1682	470	2251
1992	146	1810	463	2419
1993	212	2439	490	3141
1994	222	1916	490	2628
1995	151	1434	558	2143
1996	112	1247	608	1967
1997	106	957	501	1564
1998	132	1283	451	1866

1999	157	1280	240	1677
2000	141	1508	678	2327
2001	98	1573	738	2409
2002	90	1302	716	2108
2003	128	1346	759	2233
2004	156	1249	666	2071
2005	133	1160	611	1904
2006	140	1175	649	1964
2007	158	1240	741	2139
2008	184	1004	593	1781
2009	147	1162	591	1900
2010	122	1500	695	2317
2011	131	1497	622	2250
2012	120	1512	617	2249
2013	92	1389	601	2082
2014	79	1212	651	1942
2015	143	1655	691	2489
2016	164	1526	719	2409

Table 3.5. BLL 27.3a47de: Overall discard rates (all countries and métiers) for brill over the period 2012–2016 (Source: InterCatch).

Year	Discard rate
2012	0.07
2013	0.05
2014	0.08
2015	0.07
2016	0.07

Table 3.6. BLL 27.3a47de: Discard rates for brill by country for 2014–2016 (updated after the 2017 WGNSSK data call; source: InterCatch).

Country	Discard rate 2014	Discard rate 2015	Discard rate 2016
Belgium	0.01	0.03	0.10
Denmark	0.21	0.22	0.05
France	0.06	0.07	0.03
Germany	0.16	0.01	0.03
Ireland			
Netherlands	0.09	0.05	0.09
Norway			
Sweden	0.35	0.29	0.13
UK (England)	0.02	0.02	0.01
UK(Scotland)	0.10	0.20	0.14
Overall	0.08	0.07	0.07

Table 3.7. BLL 27.3a47de. Discard rates for brill for 2014–2016 by Subarea/Division (Source: InterCatch).

Subarea/ Division	Discard rate 2014	Discard rate 2015	Discard rate 2016
27.3a	0.38	0.33	0.10
27.4	0.08	0.04	0.07
27.7.d	0.03	0.08	0.11
27.7e	0.03	0.02	0.00
Overall	0.08	0.07	0.07

Table 3.8. BLL 27.3a47de: Survey index (N°/hr) for brill in the BTS_ISI_Q3, Subarea 27.4.

Year	N/hr	Year	N/hr
1987	1.9957265	2002	0.7947304
1988	0.6666667	2003	1.0000000
1989	0.9362745	2004	0.8214286
1990	2.2962963	2005	0.6060606
1991	1.8710526	2006	0.8716931
1992	3.6793860	2007	1.0952381
1993	3.3062753	2008	0.5138889
1994	2.3622590	2009	1.4246488
1995	1.8011775	2010	2.1853733
1996	0.7647059	2011	2.4057061
1997	2.0000000	2012	1.0411007
1998	1.4301503	2013	0.7586207
1999	0.7523810	2014	3.0445977
2000	2.1945342	2015	1.8429119
2001	0.6913580	2016	1.046875

Table 3.9. BLL 27.3a47de: Survey index (N°/hr) for brill in the BITS_HAF_Q1&4, Division 3.a.

Year	N/hr
1996	1.9090909
1997	0.3888889
1998	0.5000000
1999	1.8333333
2000	0.5555556
2001	1.0416667
2002	1.8030303
2003	1.3636364
2004	2.2045455
2005	2.0833333
2006	3.8181818
2007	3.6196970
2008	4.0500000
2009	3.0912698
2010	3.8893939
2011	3.6136364
2012	2.2651515
2013	2.1390227
2014	3.8551515
2015	4.4682540
2016	3.772727

Table 3.10. BLL 27.3a47de: Commercial lpue (kg/day) for brill in the Dutch beam trawl fleet > 221 kW, Subarea 27.4; a) short series; b) long series (see section 3.3.2).

a)

Year	lpue (kg/day)
2007	33.73
2008	41.39
2009	41.02
2010	50.53
2011	52.80
2012	55.82
2013	53.07
2014	48.05
2015	61.11
2016	57.44

b)

Year	lpue (kg/day)
1995	19.67
1996	19.19
1997	13.39
1998	23.75
1999	22.97
2000	24.08
2001	26.10
2002	21.99
2003	26.61
2004	27.25
2005	25.88
2006	26.67
2007	33.03
2008	39.66
2009	40.15
2010	50.54
2011	52.32
2012	55.82
2013	53.21
2014	46.04
2015	61.47
2016	57.44

Table 3.11. BLL 27.3a47de: Information for estimation of length-based indicators.

Data type		Sex	Value	Source
von Bertalanffy growth parameter	Linf	females	58.0 cm	van der Hammen et al. (2013)
		males	43.3 cm	van der Hammen et al. (2013)
		used	50.7 cm	averaged, assuming 50:50 sex ratio
Length at maturity	Lmat	females	31.3 cm	van der Hammen et al. (2013)
		males	18.4 cm	van der Hammen et al. (2013)
		used	24.9 cm	averaged, assuming 50:50 sex ratio
Catch at length			2014–2016	discard raising by landing CATON using InterCatch
Length-weight relationship parameters for landings and discards			2014–2016	Length allocations by mean weight weighted by numbers at length using InterCatch

Table 3.12. BLL 27.3a47de: SPiCT summary output.

Convergence: 0 MSG: relative convergence (4)

Objective function at optimum: 14.213574

Euler time step (years): 1/16 or 0.0625

Nobs C: 30, Nobs I1: 30, Nobs I2: 22

Priors

logn ~ dnorm[log(2), 2^2]

logalpha ~ dnorm[log(1), 2^2]

logbeta ~ dnorm[log(1), 2^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha1	9.1063919	0.7129254	1.163184e+02	2.2089766
alpha2	1.4535591	0.0743938	2.840066e+01	0.3740151
beta	0.1793337	0.0404432	7.952033e-01	1.7185070
r	0.6107734	0.2020882	1.845947e+00	0.4930293
rc	1.7398392	0.9487021	3.190717e+00	0.5537927
rold	2.0502853	0.0840828	4.999441e+01	0.7179789
m	2291.6417943	2114.6075115	2.483497e+03	7.7370238
K	8635.3356122	3851.4348590	1.936136e+04	9.0636179
q1	0.0006661	0.0003914	1.133600e-03	7.3141141
q2	0.0163524	0.0090961	2.939710e-02	4.1133828
n	0.7021032	0.2747997	1.793848e+00	0.3536748
sdb	0.0628935	0.0052205	7.577063e-01	2.7663127
sdf	0.2246388	0.1544822	3.266563e-01	1.4932616
sdi1	0.5727327	0.4385589	7.479559e-01	0.5573362
sdi2	0.0914194	0.0489262	1.708185e-01	2.3922976
sdc	0.0402853	0.0107614	1.508077e-01	3.2117686

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	2634.3145191	1359.7118819	5103.737842	7.8763783
Fmsyd	0.8699196	0.4743511	1.595359	0.1393545
MSYd	2291.6417943	2114.6075115	2483.497332	7.7370238

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	2630.2300422	1352.5994632	5114.677525	7.8748266	0.0015528972

Fmsys	0.8700396	0.4744778	1.595373	0.1392165	0.0001379415
MSYs	2288.4048105	2104.1855646	2488.752259	7.7356103	-0.0014145154

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2016.50	3256.0948581	1696.5061604	6249.404790	8.0882839
F_2016.50	0.7474275	0.3846365	1.452405	0.2911179
B_2016.50/Bmsy	1.2379506	0.9532748	1.607639	0.2134573
F_2016.50/Fmsy	0.8590730	0.6280398	1.175095	0.1519014

Predictions w 95% CI (inp$msytype: s)

	prediction	cilow	ciupp	log.est
B_2017.00	3178.4669543	1599.8892524	6314.594691	8.0641543
F_2017.00	0.7462458	0.3675975	1.514925	0.2927003
B_2017.00/Bmsy	1.2084369	0.9282380	1.573217	0.1893277
F_2017.00/Fmsy	0.8577147	0.5882927	1.250525	0.1534837
Catch_2017.00	2339.3453683	1781.8445101	3071.276265	7.7576264
E(B_inf)	3041.4778653	NA	NA	8.0200988

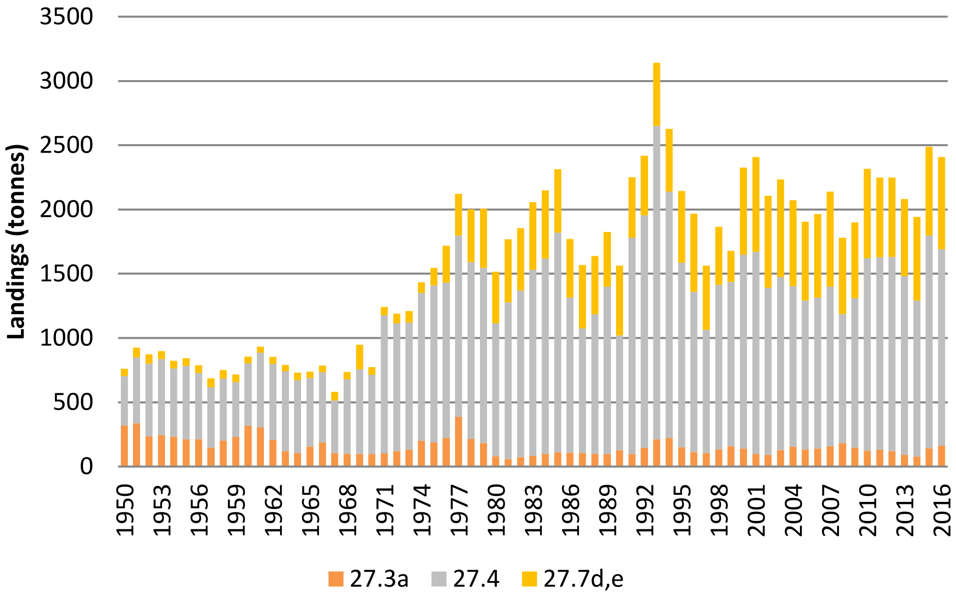


Figure 3.1. BLL 27.3a47de: Official landings (tons) over the period 1950–2016, as officially reported (Rec 12; ICES Fishstat).

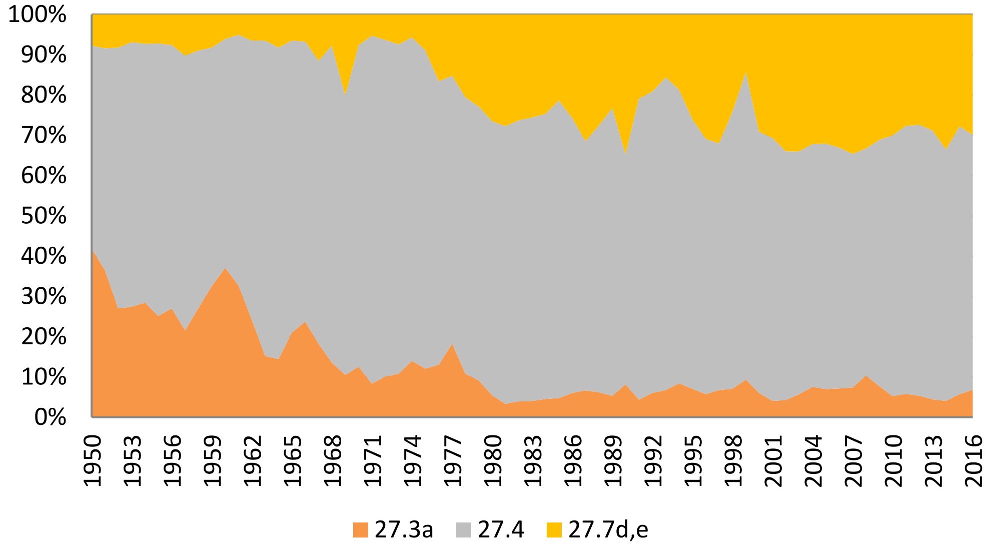


Figure 3.2. BLL 27.3a47de: Relative contribution to the official landings of brill from Subarea 27.4, Division 3.a and 27.7.d,e to the total international landings (tons) in the Greater North Sea over the period 1950–2016 (Source: ICES Fishstat).

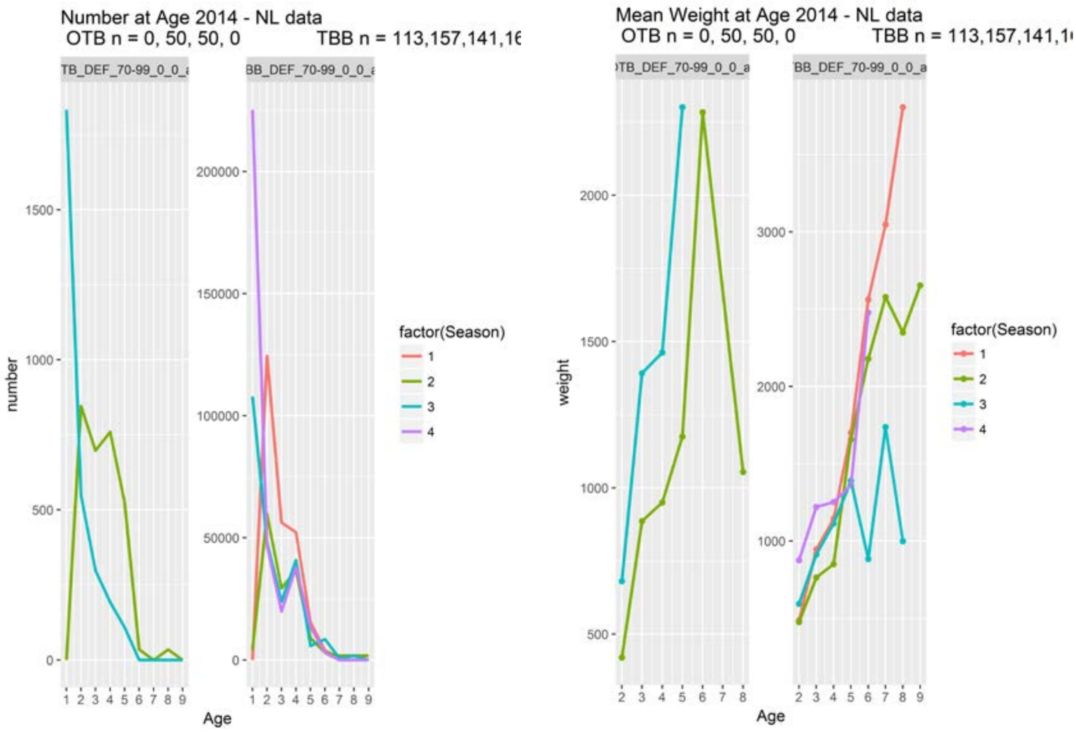


Figure 3.3. BLL 27.3a47de: Age data from 2014 provided through InterCatch (only the Netherlands provided age data).

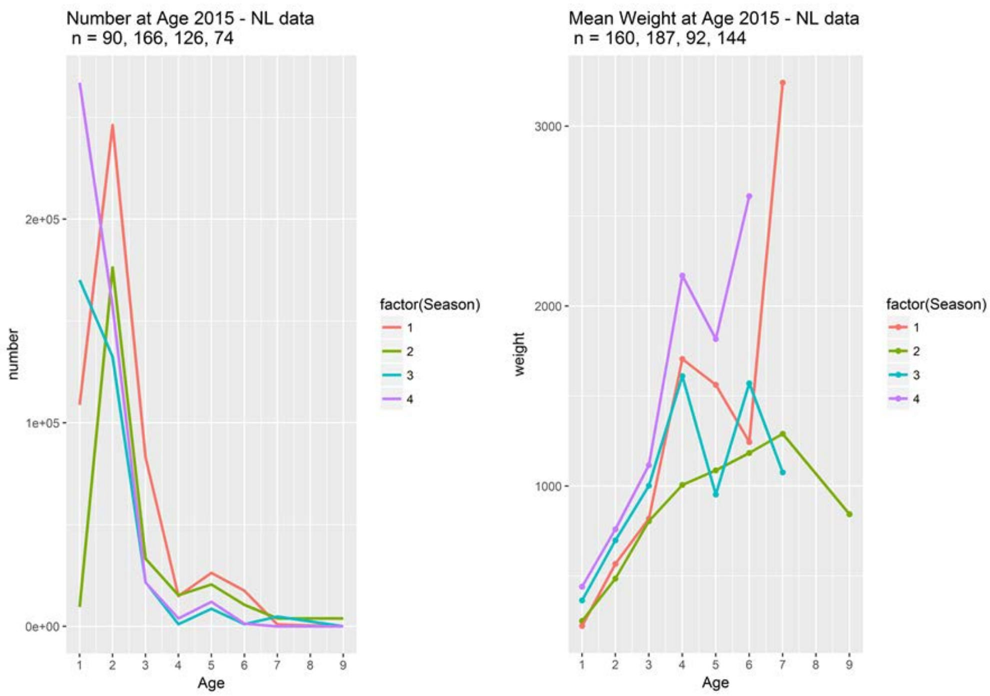


Figure 3.4. BLL 27.3a47de: Age data from 2015 provided through InterCatch (only the Netherlands provided age data).

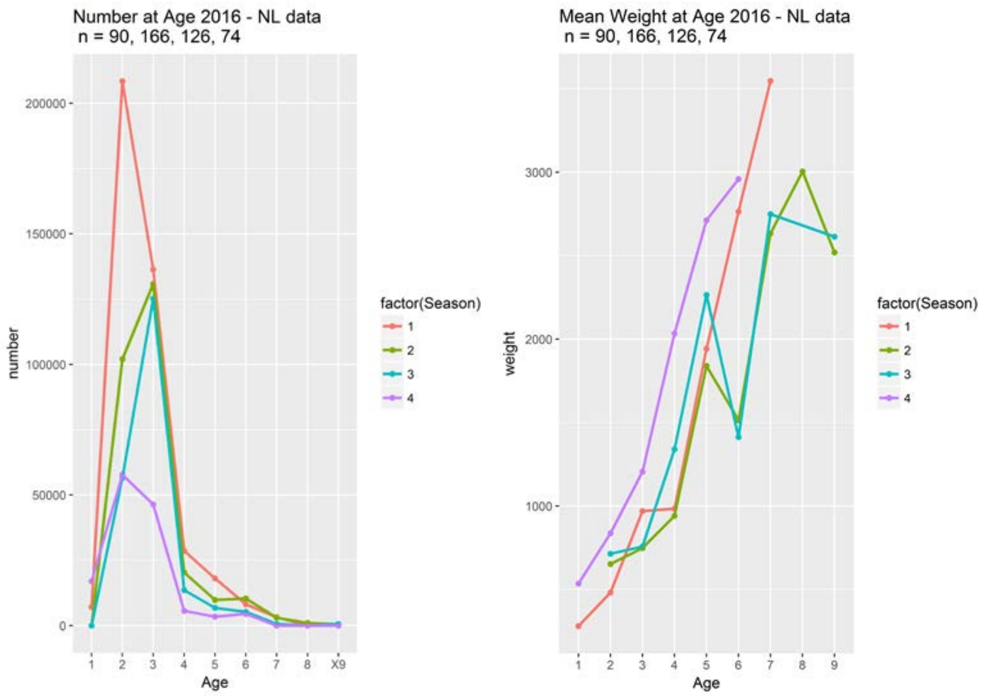


Figure 3.5. BLL 27.3a47de: Age data from 2016 provided through InterCatch (only the Netherlands provided age data).

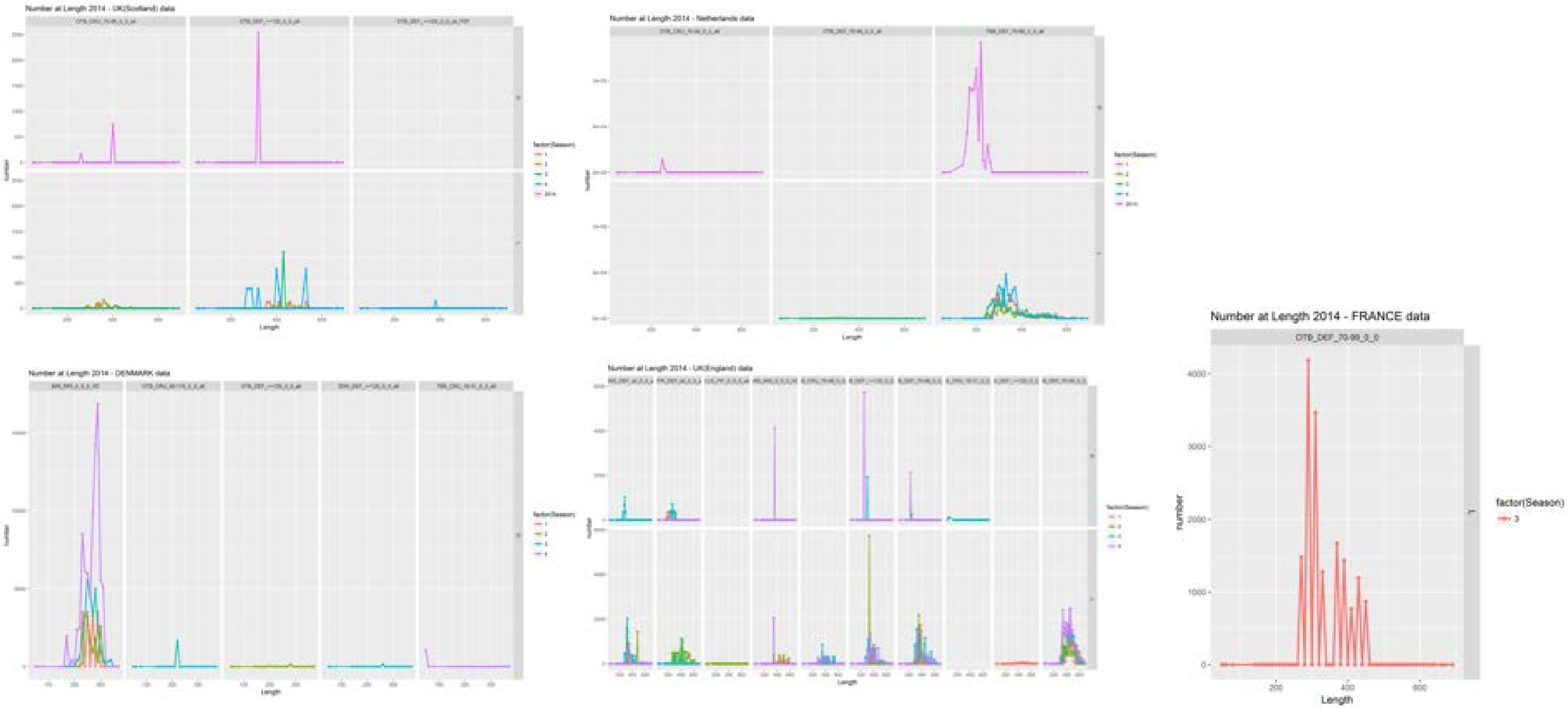


Figure 3.6. BLL 27.3a47de: Length data from 2014 provided through InterCatch.

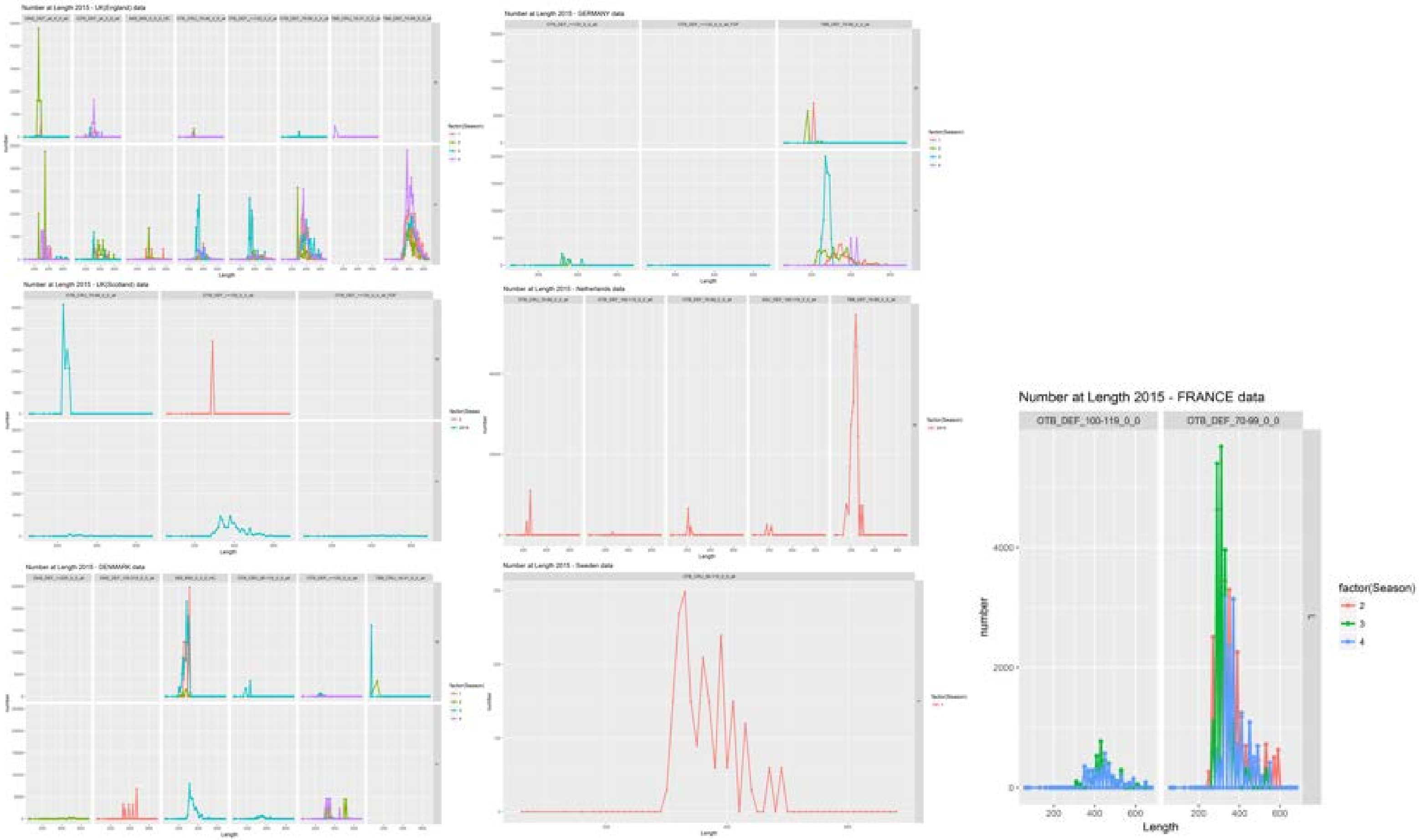


Figure 3.7. BLL 27.3a47de: Length data from 2015 provided through InterCatch.

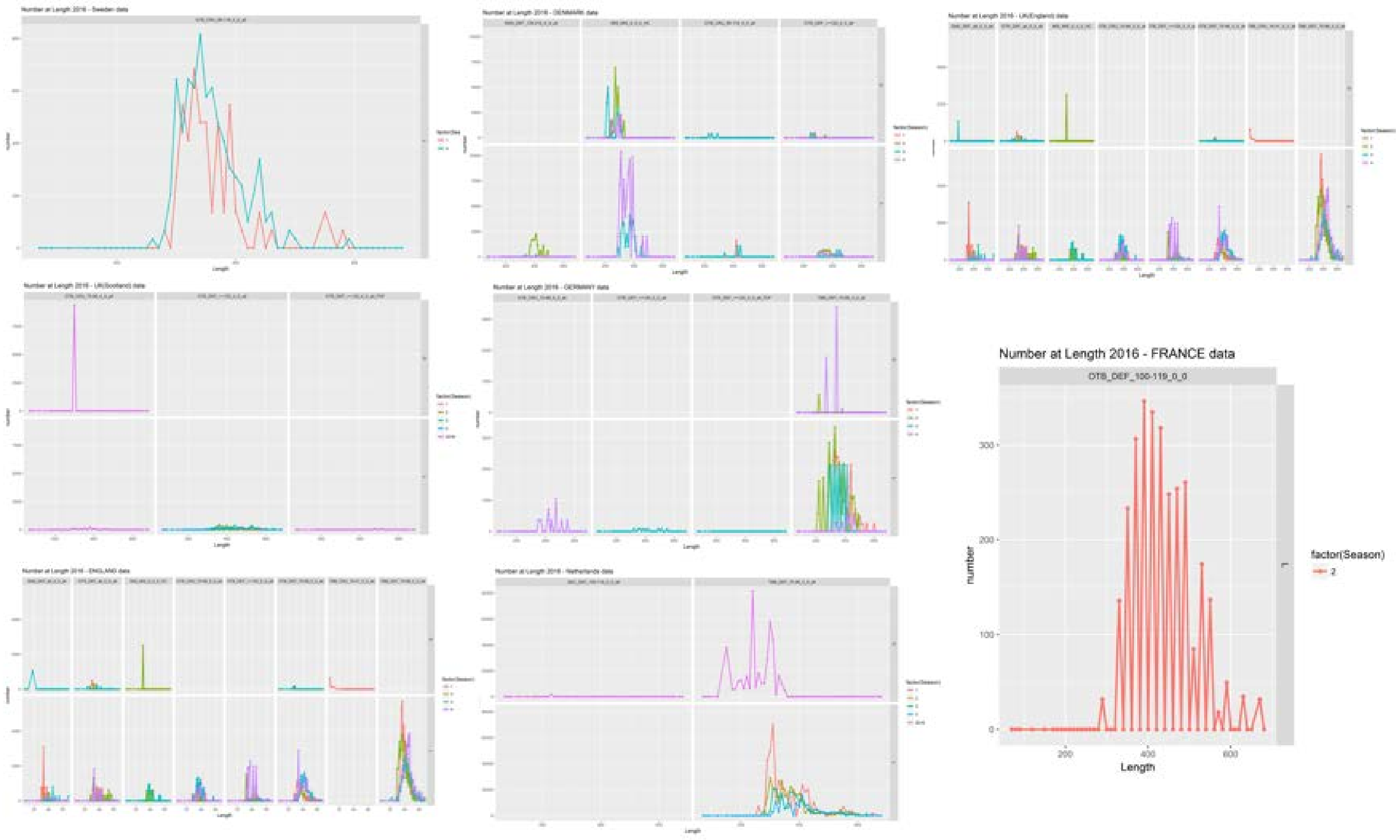


Figure 3.8. BLL 27.3a47de: Length data from 2016 provided through InterCatch.

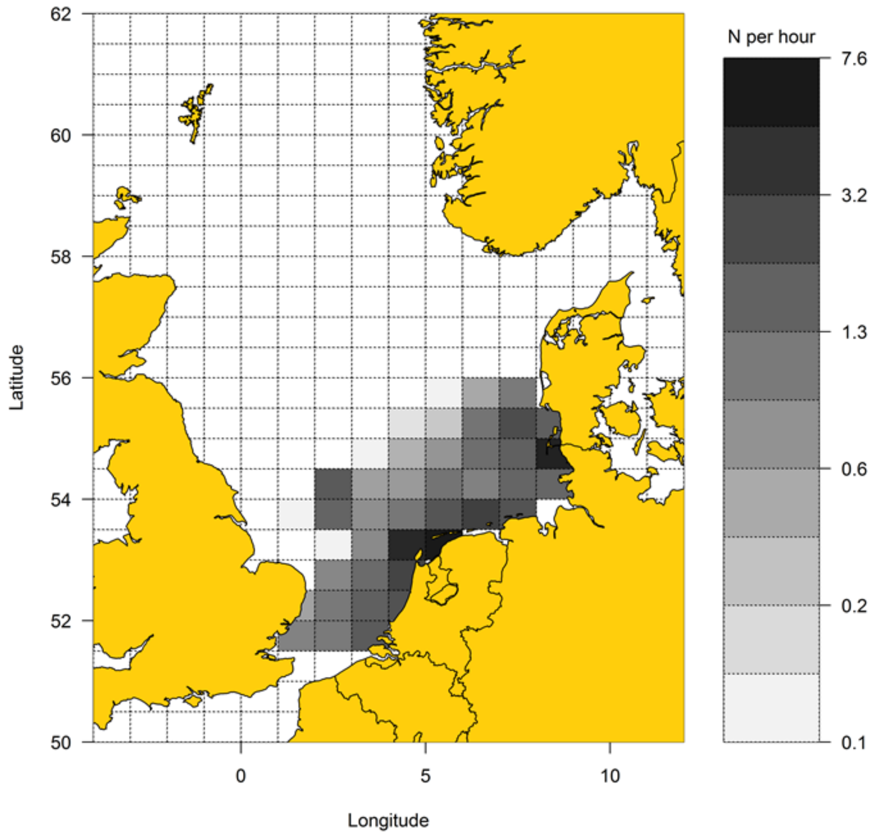


Figure 3.9. BLL 27.3a47de: Numbers of brill caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2016.

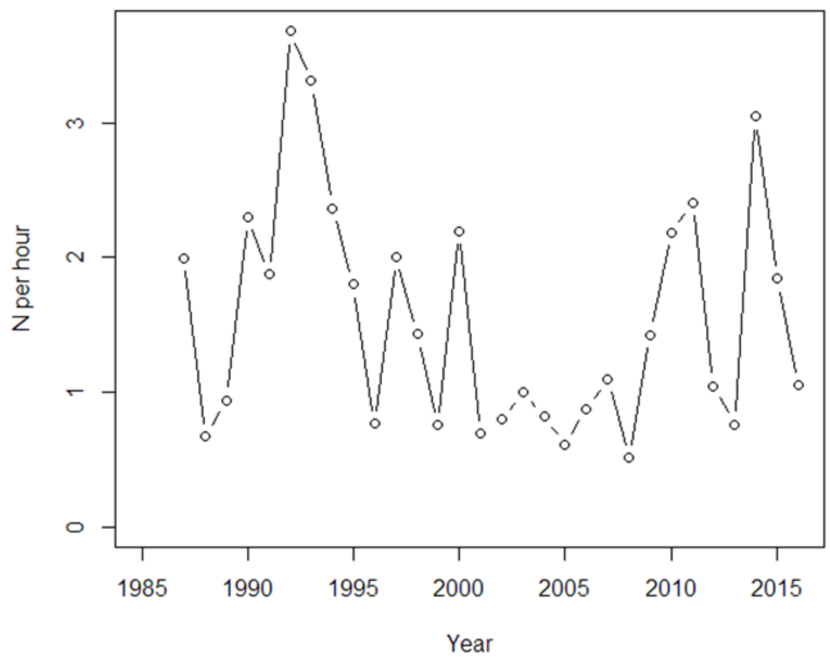


Figure 3.10. BLL 27.3a47de: Abundance index (numbers caught per hour) of brill for the BTS_ISI_Q3 in the North Sea (27.4) over the period 1987–2016.

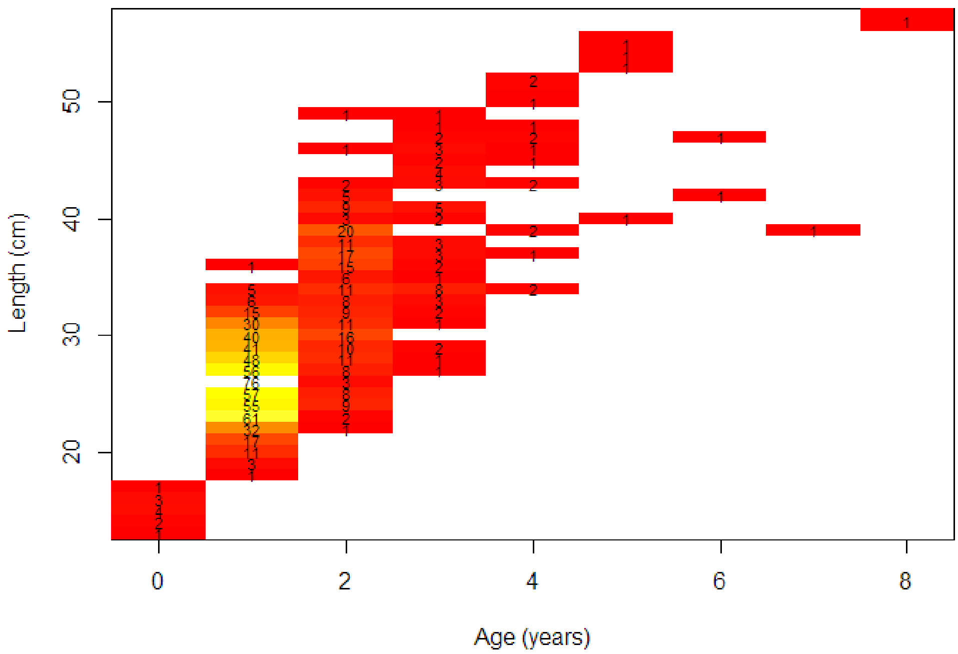


Figure 3.11. BLL 27.3a47de: Age–length key of brill in the North Sea (27.4) as documented by the BTS_ISI_Q3 (1987–2016).

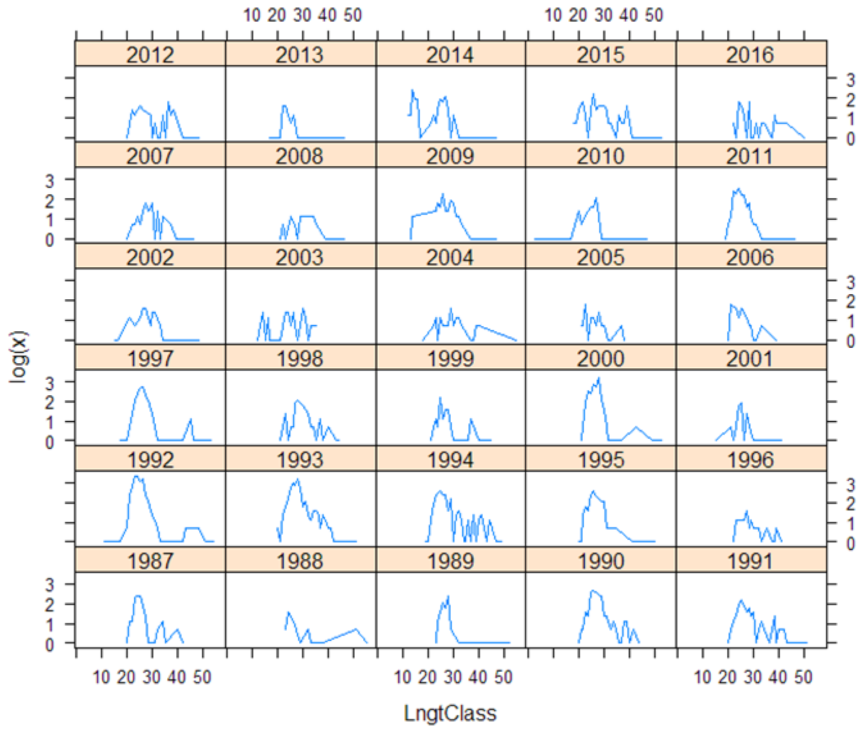


Figure 3.12. BLL 27.3a47de: Length distributions of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1987–2016).

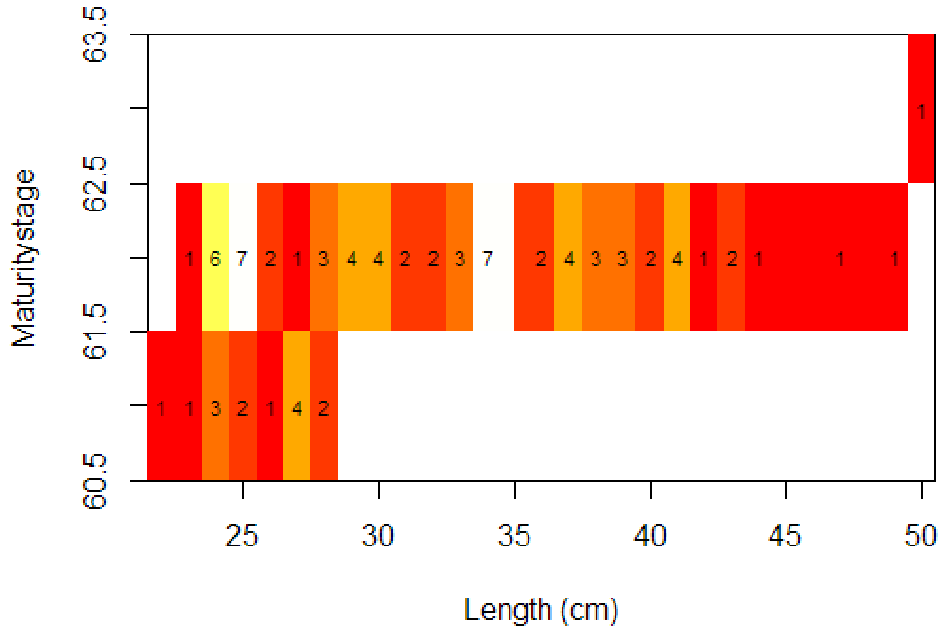


Figure 3.13. BLL 27.3a47de: Maturity at length of brill in the North Sea (27.4) as documented in the BTS_ISI_Q3 (1987–2016) (Maturity codes are 61 = juveniles/immature; 62 = Maturing; 63 = Spawning).

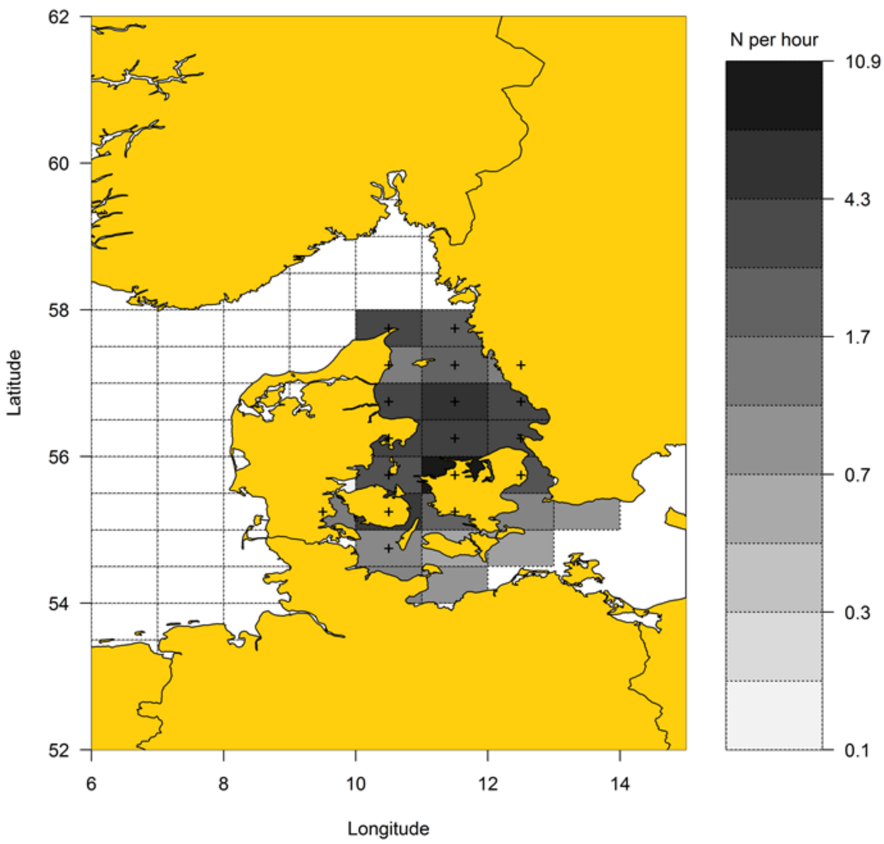


Figure 3.14. BLL 27.3a47de: Numbers of brill caught per hour and rectangle by BITS_HAF_Q1&4 in the Kattegat (27.3.a22) over the period 1996–2016.

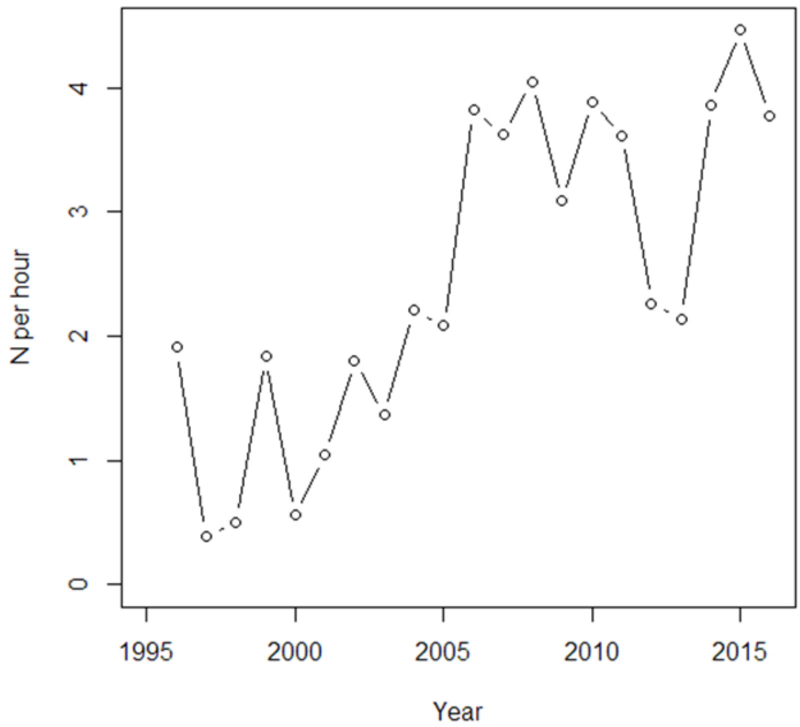


Figure 3.15. BLL 27.3a47de: Abundance index (numbers caught per hour) of brill for the BITS_HAF_Q1&4 in the Kattegat (27.3.a22) over the period 1996–2016.

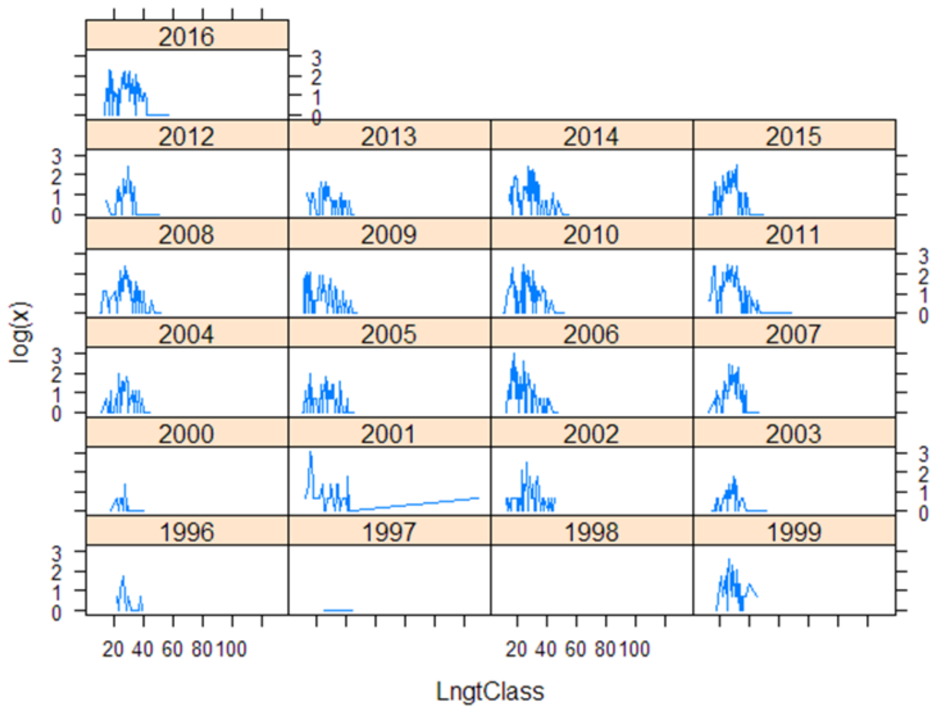


Figure 3.16. BLL 27.3a47de: Length distributions of brill in the Kattegat (27.3.a22) as documented in the BITS_HAF_Q1&4 (1996–2016).

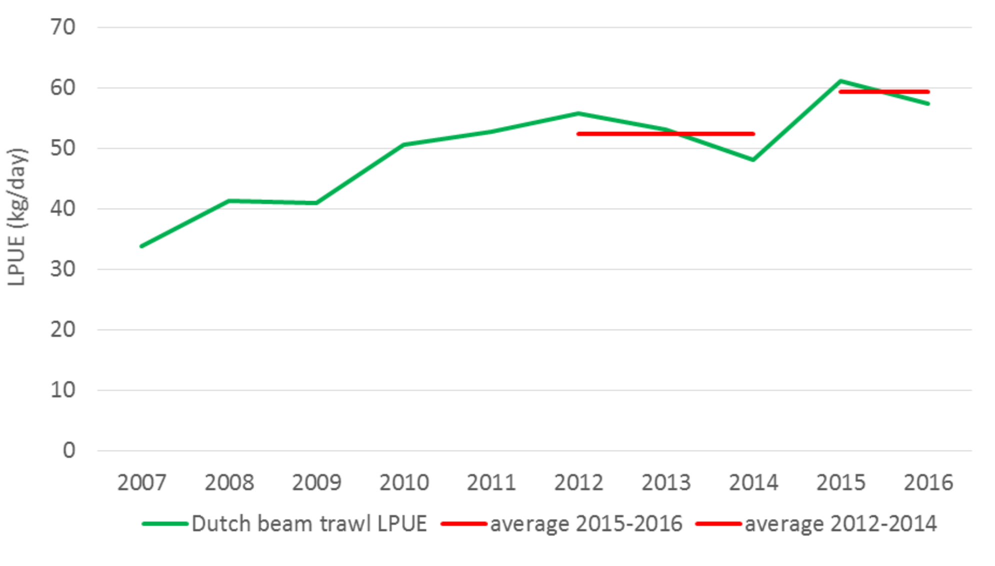


Figure 3.17. BLL 27.3a47de. Commercial lpue (kg/day) of brill in the Dutch beam trawl fleet > 221kW (standardized for engine power and corrected for targeting behaviour). The red lines are the averages of the last two (2015–2016) and the previous three (2012–2014) years.

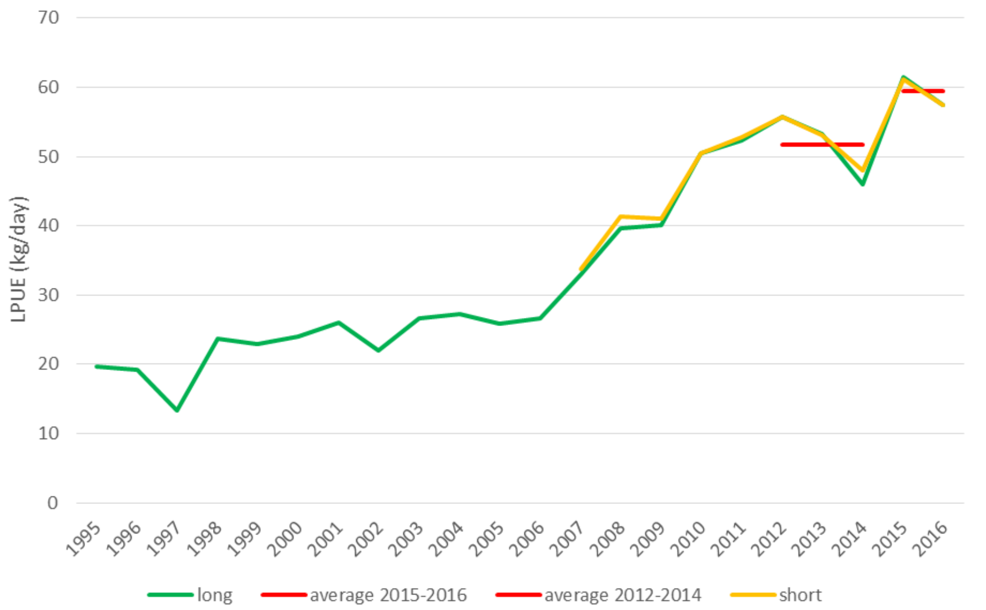


Figure 3.18. BLL 27.3a47de: Extended (long) commercial lpue (kg/day) of brill in the Dutch beam trawl fleet > 221kW (standardized for engine power and corrected for targeting behaviour) as used in the SPiCT runs (green line) and shorter lpue as used in the advice (yellow line). The red lines are the averages of the last two (2015–2016) and the previous three (2012–2014) years. Note that during the ADG North Sea it was decided to use the extended (long) Dutch commercial lpue for the advice.

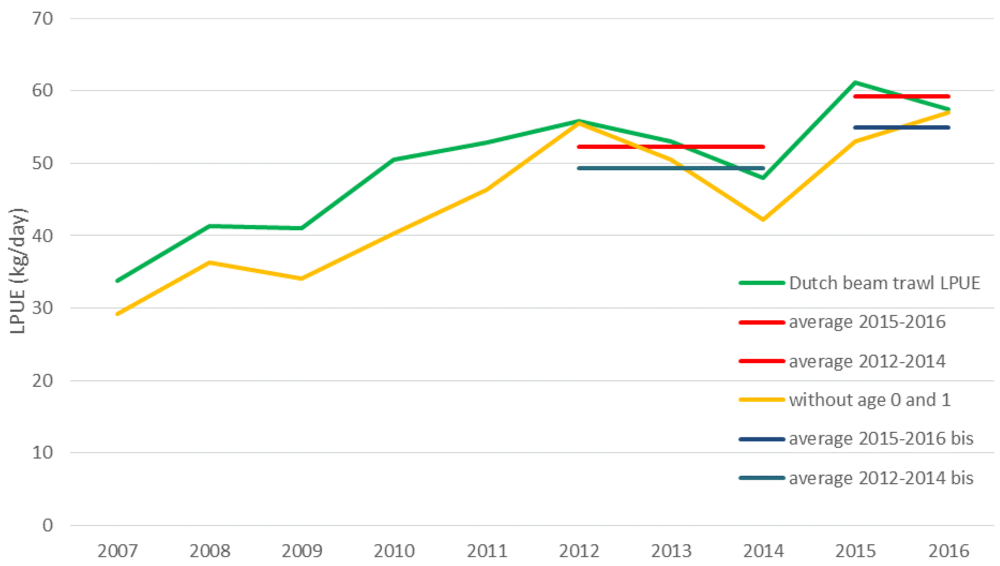


Figure 3.19. BLL 27.3a47de: Commercial lpue (kg/day) of brill in the Dutch beam trawl fleet > 221kW with (green line) and without (yellow line) ages 0 and 1 as used in one of the trial SPiCT runs. The red lines are the averages of the last two (2015–2016) and the previous three (2012–2014) years.

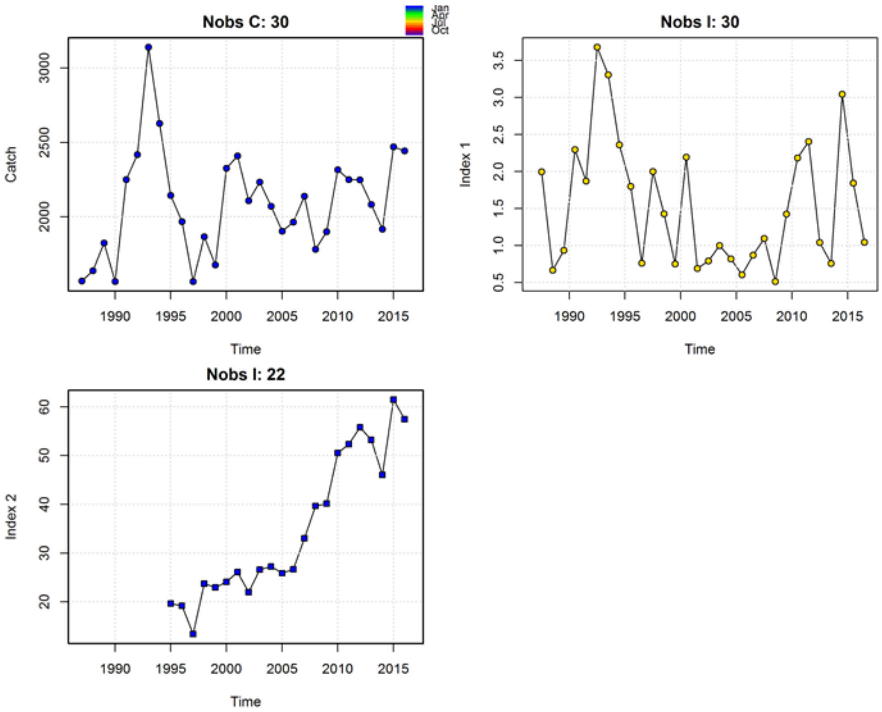


Figure 3.20. BLL 27.3a47de: Input data used for the final SPiCT assessment. Top left: Landings data from 1987 onwards. Top right: BTS–Q3 survey index (1987–2016). Bottom: standardized lpue index from the Dutch beam-trawl fleet (vessels > 221 kW) (1995–2016) (including age 0 and 1).

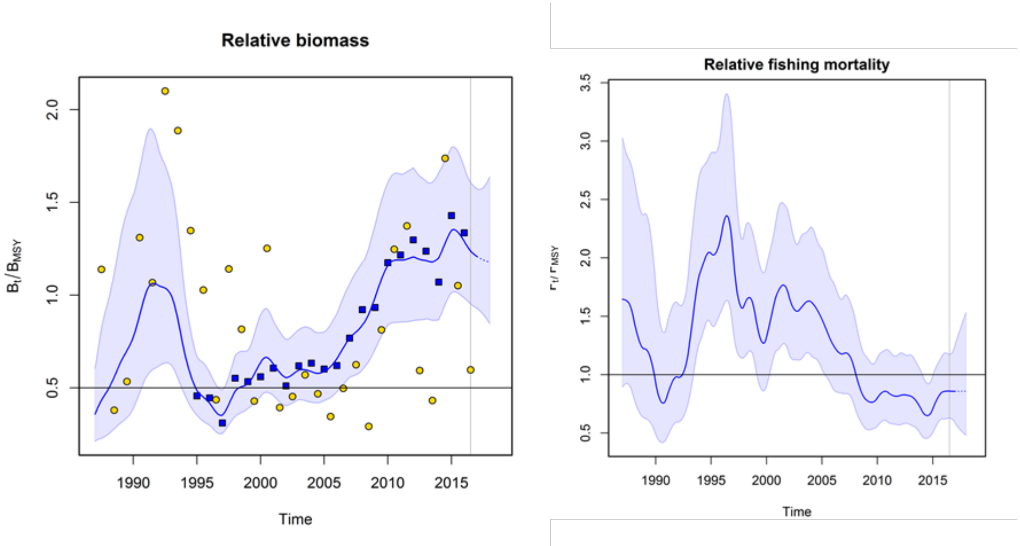


Figure 3.21. BLL 27.3a47de: SPiCT analysis showing exploitable biomass relative to BMSY (left) and fishing mortality relative to FMSY (right). The symbols in the relative biomass plot indicate observed biomass indices (blue squares = standardized lpue from the Dutch beam trawl fleet with vessels > 221 Kw, yellow dots = BTS_ISI_Q3). The shaded areas in both plots indicate 95% confidence intervals. The horizontal lines indicate levels relative to the F_{MSY} and BMSY $B_{trigger}$ proxies.

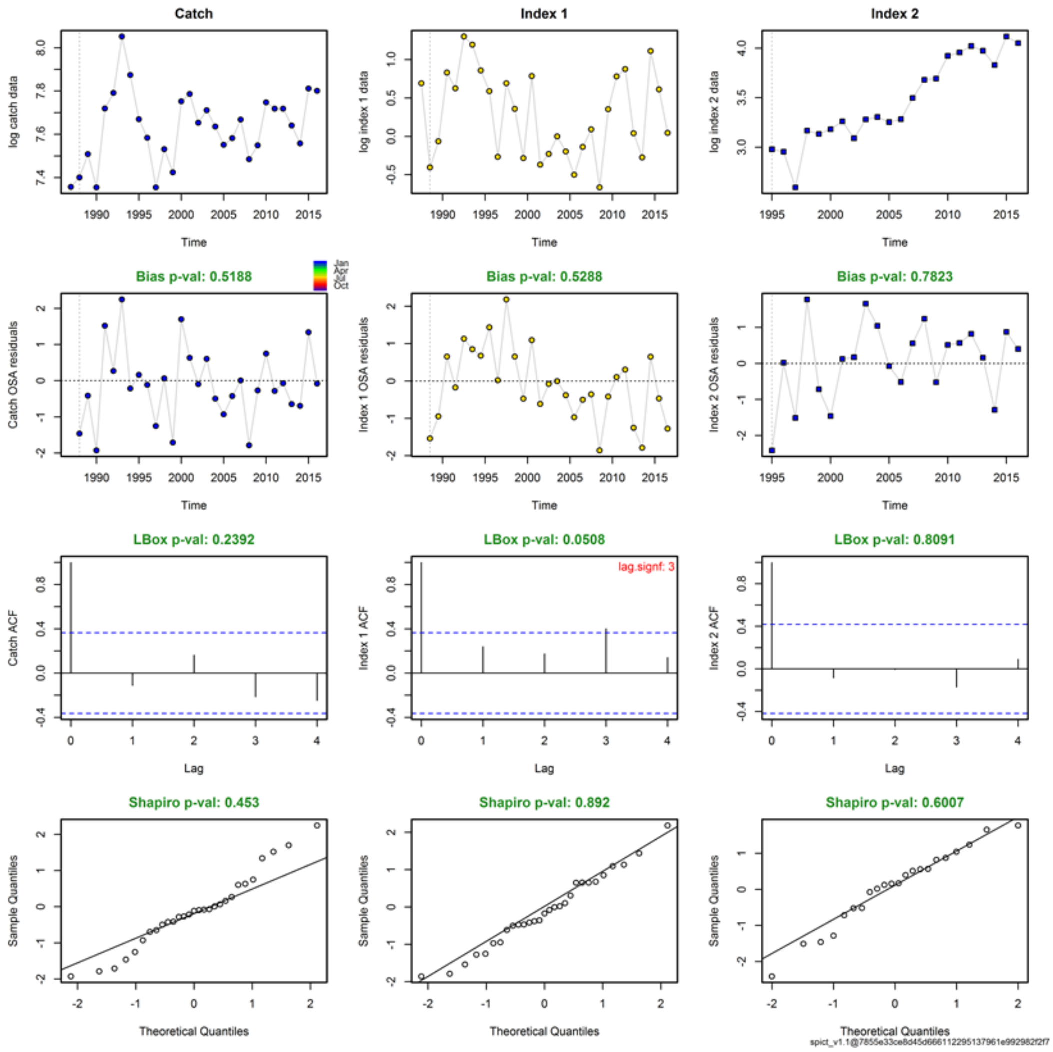


Figure 3.22. BLL 27.3a47de: SPiCT diagnostics: residuals (top), autocorrelation functions (middle), and QQ distribution plots (bottom).

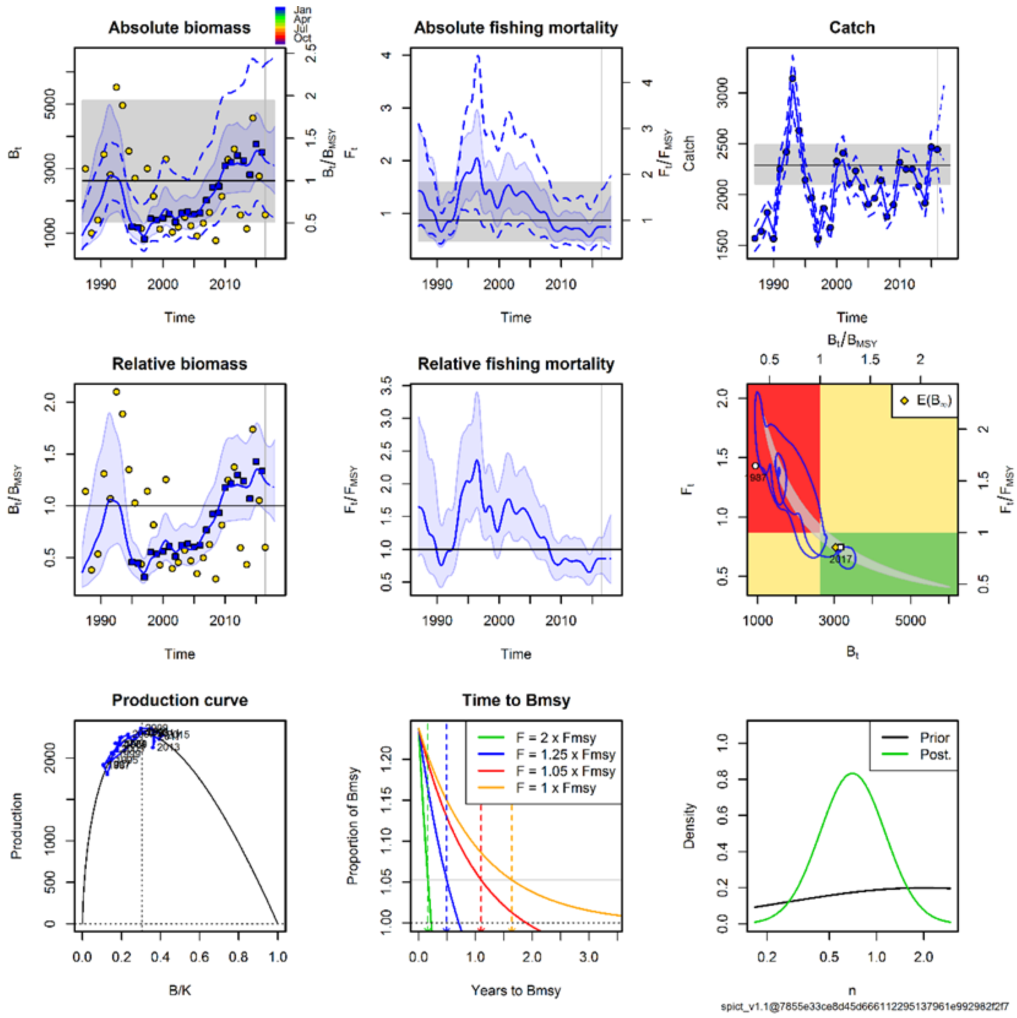


Figure 3.23. BLL 27.3a47de: SPiCT model results. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. Bottom row: production curve, estimated time to BMSY, and prior and posterior parameter distributions. The dashed lines are 95% CI bounds for absolute estimated values, shaded blue regions are 95% CIs for relative estimates, shaded grey regions are 95% CIs for estimated absolute reference points (horizontal lines). The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates.

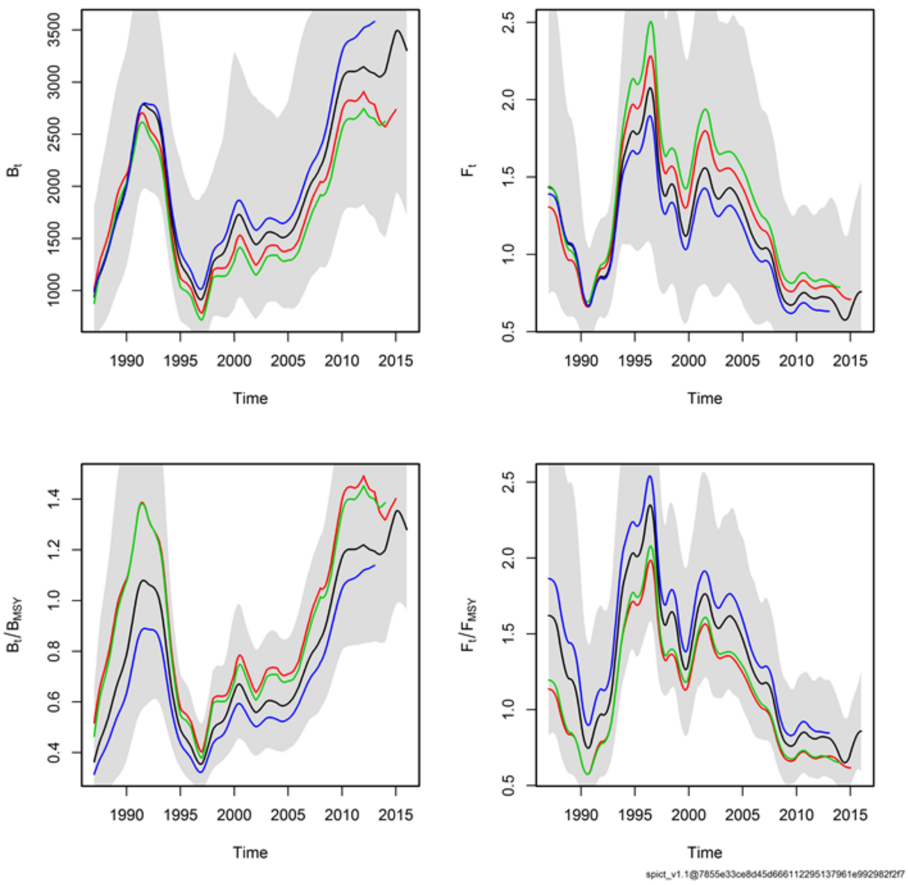


Figure 3.24. BLL 27.3a47de: SPiCT retrospective plots.

4 Cod (*Gadus morhua*) in Subarea 4, Divisions 7.d and Subdivision 20 (North Sea, Eastern English Channel, Skagerrak)

This assessment relates to the cod stock in the North Sea (Subarea 4), the Skagerrak (Division 20) and the eastern Channel (Division 7.d). This assessment is presented as an update from last year.

A stock annex records more detail and references historic information on the stock definition, ecosystem aspects and the fisheries. This report section records only recent developments and new information presented to WGNSSK.

4.1 General

4.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

4.1.2 Ecosystem aspects

The North Sea is characterised by episodic changes in productivity of key components of the ecosystem. Phytoplankton, zooplankton, demersal and pelagic fish have all exhibited such cycles in variability. Managers should expect long-term change, and ensure that management plans have the potential to respond to new circumstances. Examples of these changes include the gadoid outburst in the 1970s. The contracted range of the North Sea cod stock can be linked to reduced abundance as well as environmental factors. A summary of available information on ecosystem aspects is presented in the Stock Annex.

4.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Subarea 4 and Divisions 20 (Skagerrak) and 7.d, including beam trawls, otter trawls, seine nets, gill nets, trammel nets and lines. Most of these gears take a mixture of species. In some of them, cod are considered a bycatch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, some of the fixed gear fisheries). The main gears landing cod in the EU are primarily TR1 (mainly operated by Scotland, Denmark and Germany), but also GN1 (mainly Denmark), BT1 (mainly Denmark, Belgium and England), BT2 (mainly Netherlands, Belgium and Germany), and TR2. The overall effort by demersal trawls/seines has shown a reduction since 2003, especially in the North Sea. The effort by larger mesh (TR1) had remained relatively stable over the previous cod plan (2004–2009) but has been declining since the full implementation of the new cod plan in 2010 (STECF 2014). A summary of historic information on the directed and by-catch cod fisheries and past and current technical measures used for the management of cod is presented in the Stock Annex.

Technical Conservation Measures

In 2009 a new system of effort management, by setting effort ceilings (kilowatt–days), was introduced in accordance with the new cod management plan (EC 1342/2008). The number of kw–days utilized was estimated for the different metiers of the national fleets during a reference period selected by each nation (2004–2006 or 2005–2007). From these reference values, the effort in the primary métiers catching cod (with discard and bycatch taken into account) would be reduced in direct proportion to reductions in fishing mortality until the new cod management plan target fishing mortality of 0.4 was achieved for levels of SSB at or above Bpa. EC 1342/2008 specifies that the reductions in effort shall be applied to metiers using Otter Trawls, Danish Seines or similar gears with mesh size 80 mm and larger and Gill Nets. However, if certain national fleet segments can provide proof that they use highly selective gears and/or that their catches per fishing trip comprise less than 5% cod, the reductions will not pertain. National fleet segments with less than 1.5% cod catches could apply to be excluded from the effort management regime completely. There was no reduction in effort ceiling in 2013–2016 compared to 2012. The fishing effort regime was discontinued in 2017 (EC 2094/2016).

In 2008, Scotland introduced a voluntary programme known as "Conservation Credits", which involved seasonal closures, real-time closures (RTCs) and various selective gear options. This was designed to reduce mortality and discarding of cod. The scheme was incentivised by rewarding participating skippers with additional days at sea. The real-time closures system (15 were implemented in 2008) discouraged vessels from operating in areas of high cod abundance. In 2009, the number of closures implemented was increased substantially (to 144 for all areas subject to the cod management plan) and made mandatory, with up to 12 being implemented at any one time. Closures are determined by landings per unit effort, based on fine scale VMS data and daily logbook records and by on-board inspections. Based on new in-year information on cod movement from tagging, the dimensions of the RTCs were increased by just over four times (from 50 square nautical miles to 225) from July 2010. The use of more species and size selective gears (some trialled by the Marine Laboratory in Aberdeen) formed a further series of options within the scheme. These included the 'Orkney' trawl, the use of nets with 130mm cod ends and larger meshes in the square meshed panels of *Nephrops* trawls. The scheme delivered a total of 165, 185, 173, 166, 94, 97 and 114 closures in 2010, 2011, 2012, 2013 2014, 2015 and 2016 respectively, although the scheme was suspended on 20th November 2016 and there are no plans for its reintroduction. ICES notes that from the initial year of operation (2008) cod discarding rates in Scotland have decreased from 61% to 24% in 2012, but have increased again to 34% in 2015 and 33% in 2016; it is hypothesised that this recent increase may be due in part to FDF (fully documented fisheries) vessels putting upward pressure on the lease price of cod, resulting in non-FDF vessels increasing the amount of cod they discard because they are unwilling to pay an above-market price for cod quota.

The expansion of the closed-circuit TV (CCTV) and FDF programmes in 2010–2016 in Scotland, Denmark, Germany, England and the Netherlands is expected to have contributed to the reduction of cod mortality. Under this scheme, UK vessels are not permitted to discard any cod, while Danish, German and Dutch vessels are still permitted to discard undersized cod. For participating vessels, all cod caught are counted against the quota, and in return fishers are permitted additional catches of cod. Landings by FDF métiers comprised less than 2% of total landings in 2009, rising to 27% in 2012, but has since declined to 20% in 2016 (InterCatch data). The cod-specific FDF scheme terminated at the end of 2016.

Changes in national fleet dynamics

The ICES WGFTFB report now only provides a description of changes in EU fishing fleets and effort relevant to assessment working groups every second year; there is no such information in recent ICES WGFTFB (2015, 2016) reports.

The Fishers' North Sea Stock Survey

A fishers' North Sea stock survey for 2016 was not available at the time of the Working Group. Historic comparisons between the fishers' North Sea stock survey and the IBTS survey data are given in previous WGNSSK reports.

4.1.4 Management

Management of cod is by TAC and technical measures. The agreed TACs for Cod in Division 20 (Skagerrak), 7.d and Subarea 4 were as follows:

TAC(000t)	2009	2010	2011	2012	2013	2014	2015	2016	2017
20(Skagerrak)	4.1	4.8	3.8	3.8	3.8	4.0	4.2	4.8	5.7
2.a + 4	28.8	33.6	26.8	26.5	26.5	27.8	29.2	33.7	39.2
7.d	1.7	2.0	1.6	1.5	1.5	1.6	1.7	2.0	2.1

For 2009 Council Regulation (EC) N°43/2009 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size (see section 2.1.2 for more details). For 2010–2016, Council Regulations (EC) N°219/2010, N°57/2011, N°44/2012, N°297/2013, N°432/2014, N°2015/104 and N°2016/72 respectively updated Council Regulation (EC) N°43/2009 with new allocates, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009. The effort regime has now been discontinued, and the allocations for 2017 are given in Council Regulation (EC) N°2017/127.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

Cod recovery and management plans

A Cod Recovery Plan which detailed the process of setting TACs for the North Sea cod was in place until 2008. Details of it are given in EC 423/2004 and previous working group reports. ICES considered the recovery plan as not consistent with the precautionary approach because it did not result in a closure of the fisheries for cod at a time of very low stock abundance and until an initial recovery of the cod SSB had been proven.

In April 2008, the European Commission adopted a proposal to amend the cod recovery plan, based on input from stakeholders, and on scientific advice from both ICES and STECF that current measures have been inadequate to reduce fishing pressure on cod to enable stock recovery. The main changes proposed were replacing targets in terms of biomass levels with new targets expressed as optimum fishing rates intended to provide high sustainable yield, and introducing a new system of effort management by setting effort ceilings (kilowatt–days) for groups of vessels or fleet segments to be managed at a national level by Member States. The new system was intended to be simpler, more flexible and more efficient than the previous one, allowing effort reductions to be proportionate to targeted reductions in fishing mortality for the segments that contribute the most to cod mortality, while for other segments effort will be frozen at the average level for either 2004–2006 or 2005–2007.

In December 2008 the European Commission and Norway agreed on a new cod management plan that aimed to be consistent with the precautionary approach and was intended to achieve sustainable fisheries and high yield, leading to a target fishing mortality of 0.4. In addition to the EU–Norway agreement, the EU implemented effort restrictions, reducing KW-days available to EU vessels in the main métiers catching cod in direct proportion to reductions in fishing mortality until the long-term phase of the plan was reached, for which the target F is 0.4 if SSB is above Bpa. Details of European Commission plan are given in EC 1342/2008.

A joint ICES STECF group met during 2011 to conduct a historical evaluation of the effectiveness of these plans (ICES WKROUNDMP, 2011; Kraak *et al*., 2013), and concluded that for North Sea cod, although there had been a gradual reduction in F and discards, the plans had not controlled F as envisaged, and that following the current regime was unlikely to deliver Fmsy by 2015. However, there had been positive contributions under Article 13c of the EC plan towards achieving the cod plan targets.

In November 2016, the cod management plan was amended to discontinue the effort regime set out in EC 1342/2008 as it became an obstacle to the implementation of the landings obligation. Details of the amended cod management plan are given in EC 2016/2094. Since 2015 advice has been given according to the ICES MSY approach.

4.2 Data available

4.2.1 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given for each area separately and combined in Table 4.1.

The landings estimate for 2016 is 38 230 tons, split as follows for the separate areas (tons):

	TAC	Landings	Discards	BMS landings
20–Skagerrak	4807	4774	1704	0
4	33651	33035	10528	10
7.d	1961	421	72	0
Total	40419	38230	12304	10

WG estimates of discards and BMS landings are also shown in the above table.

Prior to the use of InterCatch for discard estimation, discard numbers-at-age were estimated for areas 4 and 7.d by applying the Scottish discard ogives to the international landings-at-age, and were based on observer sampling estimates for area 20–Skagerrak. Discard raising for 2002–2016 was performed in InterCatch, with the different nations providing information by area, quarter and métier. Prior to the reform of the EU's data collection framework in 2008 (see http://datacollection.jrc.ec.europa.eu/), sampling for discards and age compositions was poor in area 7.d, and this necessitated combining areas 4 and 7.d for 2002–2008 to facilitate computations in InterCatch. The provision of discard information has vastly improved since 2009 and covered 72% of the landings in 2016, with all nations (apart from Norway) now providing discard information. Figure 4.1a plots reported landings and estimated discards (including BMS landings) used in the assessment. Discard ratio sampling coverage by area and season for 2016 is provided in Table 4.2e, along with the contributions to total landings and discards from each area prior to raising.

Norwegian discarding is illegal, so although this nation has accounted for 7–14% of cod landings over the period 2002–2016 (InterCatch data), it does not provide discard estimates. Nevertheless, the agreed procedure applied in InterCatch is that discards raising should include Norway (i.e. Norway will be allocated discards associated with landings in reported métiers). Furthermore, tagging and genetic studies have indicated that Norwegian coastal cod are different to North Sea cod and do not generally move into areas occupied by North Sea cod. Therefore, Norwegian coastal cod data have been removed from North Sea cod data by uploading only North Sea cod data into InterCatch for 2002 onwards, and by adjusting catches prior to 2002 to reflect the removal of Norwegian coastal cod data (an annual multiplicative adjustment of no more than 2.5% was made using Norwegian coastal cod data (see ICES WKNSEA 2015 for more details).

For cod in 4, 20–Skagerrak and 7.d, ICES first raised concerns about the misreporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid–1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3 000 tons of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment (apart from the adjustment for Norwegian coastal cod).

For 1999 and 2000, the WG has no a priori reason to believe that there was significant under-reporting of landings. However, the substantial reduction in fishing effort implied by the 2001, 2002 and 2003 TACs is likely to have resulted in an increase in unreported catch in those years. Anecdotal information from the fisheries in some countries indicated that this may indeed have been the case, but the extent of the alleged under-reporting of catch varies considerably.

Marine Scotland-Compliance, a department in the Scottish government responsible for monitoring the Scottish fishing industry, operated a system intended to detect unreported or otherwise illegal fish landings (known as "blackfish"). Records show that blackfish landings have declined significantly since 2003, and is likely to be extremely low since 2006 (ICES WKCOD 2011). While the UK Registration of Buyers and Sellers regulation, introduced towards the end of 2005, may have had an important impact on the declining levels of blackfish landings, it is unlikely to be solely responsible, with other factors including large-scale decommissioning, and the development of targeting and monitoring systems that has substantially increased the pressure on the fleet.

The Danish Fisheries Directorate expressed the view that there is no indication of a lack of reporting of cod of any significance for vessels of ten meters and more. This view is based both on the analysis of six indicators of missing reports of landed cod, and a calculation of the difference between the total quantity of cod registered in logbooks and cod registered in sales receipts for Danish vessels over ten meters per quarter over the period 2008–2010, which has been shown to vary between approx. 0.5% and 2.5% (ICES WKCOD 2011).

Since the WG has no basis to judge the overall extent of under-reported catch over time, it has no alternative but to use its best estimates of landings, which in general are in line with the officially reported landings. An attempt is made to incorporate a catch multiplier to the sum of reported landings and discards data in the assessment of this stock for the period 1993–2005, but the figures shown in Table 4.2c and Figure 4.1a nevertheless comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations in 2016, although there are gaps from some nations in the years in 2002–2014 (e.g. France prior to 2009, Norway in 2011 and prior to 2005 and the Netherlands prior to 2015). The sampling coverage for landings and discards age compositions for 2016 are reported in Table 4.2e.

Landings in numbers at age for age groups 1–11+ and 1963–2016 are given in Table 4.2a. These data form the basis for the catch at age analysis but do not include industrial fishery bycatches landed for reduction purposes prior to 2002 (values from 2002 onwards were entered into InterCatch for all relevant nations except Norway, and were included in the raising, although the numbers were very small). Bycatch estimates are available for the total Danish small-meshed fishery in Division 3.a and Subarea 4 and separately for the Skagerrak (Table 4.1). During the last five years, an average of 71% of the international landings in number were accounted for by juvenile cod aged 1–3; this average rises to 85% when considering landings and discards combined. In 2016, age 1 cod comprised 14% of the total catch by number, age 2, 29% and age 3, 37%.

Discard numbers-at-age (including BMS landings) are shown in Table 4.2b. The proportions of the estimated numbers discarded for ages 1–4 are plotted in Figure 4.1b. The proportion of the estimated total discards by weight are shown in Figure 4.1c, and by number in Figure 4.1d. Estimated proportion of total numbers caught that were discarded (Figure 4.1d) has varied between 35 and 70% from 1995 to 2005, but has shown an increase to between 70 and 85% in 2006–2008, due to the stronger 2005 year class entering the fishery (estimated to be almost the size of the 1999 year class), and a mismatch between the TAC and effort. The total numbers discarded has decreased to below 50% since 2015. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% with no decline apparent after the introduction of the 120 mm mesh in 2002. Since 2003, it has been at or above 90%, except for a brief decrease to 78% in 2011 and again in 2014, rising to 86% in 2015 and 95% in 2016. At ages 2 to 4 discard proportions increased to a maximum around 2006–10, but have subsequently declined to give 71% for age 2, 36% for age 3 and 8% for 4-year-old cod in 2016. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 4.2c. Landings, discards (including BMS landings) and total catch numbers at age are given by season in Table 4.2d for 2016. Reported landings, estimated discards (including BMS landings) and total catch (sum of landings and discards), given in tonnage, are shown in Table 4.4.

InterCatch

InterCatch was used for estimation of landings, discards and total catch at age and mean weight at age in 2016, and updates performed for 2015 (due to data revisions by UK-England). Data co-ordinators from each nation were tasked to input data into InterCatch, disaggregated to quarter and métier. The data from Norway excluded Norwegian coastal cod. Allocations of discard ratios and age compositions for unsampled strata were then performed in order to obtain the data required for the assessment. This is the sixth year that InterCatch is used for this purpose for North Sea cod. The approach used for discard ratio allocations was to do it by area (20, 4 and 7.d) and treat FDF métiers separately, giving six broad categories. Annual discards were first matched to quarterly landings. Then, within each of these six categories, ignoring country and season, where métiers had some samples these were pooled and allocated to unsampled records within that métier. At the end of this process, any remaining métiers were allocated an all samples pooled discard ratio for the given category.

The landings and discards imported or raised for 2016 are as follows (tons; note any differences in landings and discards values to those given above are due to SOP correction):

Catch Category	Raised or Imported	CATON	Percentage
BMS landing	Imported	10	100
Discards	Raised	2417	20
Discards	Imported	9888	80
Landings	Imported	38229	100
Logbook Registered Discard	Imported	0	NA

A similar approach was used for allocating age compositions, except that there were 12 broad categories because discards (including BMS landings) were treated separately to landings.

The landings and discards imported or raised, with age distribution sampled or estimated for 2016 are as follows (tons; note any differences in landings and discards values to those given above are due to SOP correction):

Catch Category	Raised or Imported	Sampled or Estimated	CATON	Percentage
Logbook Registered Discard	Imported	Estimated	0	NA
Landings	Imported	Sampled	31836	84
Landings	Imported	Estimated	6261	16
Discards	Imported	Sampled	9353	76
Discards	Raised	Estimated	2417	20
Discards	Imported	Estimated	535	4
BMS landing	Imported	Estimated	10	100

InterCatch is discussed in section 1.2, and all results are available on the WGNSSK SharePoint. Further work is ongoing, analysing the InterCatch data (cf. ICES WGMIXFISH meeting during 2017).

4.2.2 Weight-at-age

Mean weight at age data for landings, discards (including BMS landings) and catch, are given in Tables 4.3a–c. Landings, discards and catch mean weights at age are given by season in Table 4.3d for 2016. Total catch mean weight values were also used as stock mean weights. Long-term trends in mean catch weight at age for ages 1–9 are plotted in Figure 4.2, which indicates that there have been short-term trends in mean weight at age and that the decline noted during the 90's at ages 3 and above now seems to have been reversed. Ages 1 and 2 show little absolute variation over the long-term.

4.2.3 Maturity and natural mortality

Until 2015 the maturity values applied to all years were left unchanged from year to year, and were based on NS–IBTS–Q1 data from 1981–1985. However, ICES WKNSEA (2015) noted a change in maturity-at-age in the North Sea cod stock, with fish maturing at a younger age and smaller size. In order to address these changes in the stock, an area-weighted maturity age key was constructed from NS–IBTS–Q1 data. As variation in sampling intensity added to the interannual variation, a smoother was applied to the maturity age key. This smoothed maturity age key was then applied to the estimation of spawning stock biomass. Maturity-at-age was re-estimated in 2017 to produce a time-series of maturity estimates that are calculated consistently over time in a manner that is transparent and reproducible, according to the methodology described by ICES WKNSEA (2015). The smoothed time-varying maturity ogive used in the assessment is given in Table 4.5a, and illustrated in Figure 4.2b.

Table 4.5b and Figure 4.2c show estimates of M, based on multi species considerations adopted for the assessment. ICES WKROUND (2009) noted that as new stomach data (e.g. on seal predation) become available, a revision of more recent M2 values to reflect the current status of the food web, should be considered. Estimates of natural mortality, derived from multispecies analyses, are updated by the Working Group on Multi Species Stock Assessment Methods (WGSAM) every three years in so called "key runs" to account for improved knowledge of predation on cod by other species (mainly seals, harbour porpoises and gurnards) and cannibalism; the last update occurred in 2014 with the new key run (ICES WGSAM 2014). The values presented in Table 4.5b are different to the ones presented by ICES WGSAM (2014) and ICES WKNSEA (2015) because an error in the input data to the multi species model was found after WKNSEA that led to a shift in parameters influencing the estimated natural mortalities for cod to a small extent. Between ICES WGSAM (2014) and ICES WKNSEA (2015) already unrealistically high predation mortalities on age 3 cod caused by harbour porpoise were corrected in an updated key run (see ICES WKNSEA 2015).

4.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of cpue. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable as it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed. The WG has previously argued that, although they are in general agreement with the survey information, commercial cpue tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES WGNSSK 2001), and also changes in gear design and usage, as discussed by ICES WGFTFB (2006, 2007). Therefore, although the commercial fleet series are available, only survey and combined commercial landings and discard information are analysed within the assessment presented.

ICES WKCOD (2011) analysed UK commercial landings per unit of effort (days fishing) to the northeast and west of Shetland compared to the south and east. Analyses were conducted by gear type and vessel length. Landings per unit of effort (lpue) do not contain discard information or allow for reductions in catch/landings rates resulting from changes in fisher behaviour as part of the Scottish Conservation Credits programme; recent values are therefore likely to be underestimates of the catches and potential catch rates. Vessels from 19–23 m had a slightly greater increase in their catch rates to the north and west of Shetland, by a factor of 4 compared to 3.5 in the east. When catch rates were averaged across other vessel lengths and across all vessels, the WKCOD analysis could not identify differing rates of increase to either side of the Shetlands but did demonstrate that all vessels have had strong increases in lpue around the Shetlands in recent years.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS–Q1): ages 1–6+, covering the period 1976–2017. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Quarter 3 international bottom-trawl survey (IBTS–Q3): ages 0–6+, covering the period 1991–2016. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Maps showing the IBTS distribution of cod are presented in Figures 4.3a–b (ages 1–3+). The recent dominant effect of the size and distribution of the 1996 and, to a lesser extent, the 1999, 2005, 2009 and 2013 year-classes are clearly apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 2000, 2002 and 2004 year classes, but have subsequently begun to increase, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels but is increasing. The 2014 and 2015 year classes appear to be weak (Figure 4.3a and b) but there are indications of a strong 2016 year class based on the 2017 IBTS Q1 survey (Figure 4.3a; Figure 4.6).

The 2011 benchmark of North Sea Cod resulted in the exclusion of the IBTS–Q3 survey index, because divergent trends in recent years were observed when the Q3 index was applied independently of the Q1 index (ICES WKCOD 2011). At that time it was decided that until the reasons for the discrepancies were resolved, the Q1 was more likely to reflect the stock, and hence the Q3 index was dropped from the assessment. The indices were calculated using the standard stratified mean methodology (mean by rectangle within year, followed by mean over rectangles by year), applied to an extended area (referred to below as the NS–IBTS extended index; ICES WKROUND 2009; Figure 4.3c). This simple design-based estimator is unable to account for systematic changes in experimental conditions (e.g. change of survey gear). Given these issues, an alternative methodology that calculates standardized age-based survey indices based on GAMs and Delta-distributions (see also Berg WD3, ICES WKNSEA 2015) has now been adopted (referred to as the NS–IBTS Delta–GAM index), and has led to both the Q1 and Q3 indices being incorporated into the assessment. The general methodology is described in Berg and Kristensen (2012) and Berg *et al*. (2014) and is implemented in R based on the DATRAS package (http://rforge.net/DATRAS/).

More details of the method used to produce the NS–IBTS Delta–GAM index is provided in the stock annex and can be found in ICES WKNSEA (2015), as well as the above mentioned publications. In summary the final Delta–GAM models selected for NS–IBTS–Q1 and Q3 comprised a stationary spatial model, and included ship, year, depth, and time-of-day and haul-duration effects. In addition, the Q3 model also included a gear effect (Q1 only has a single gear, GOV, so this effect is not an issue). The NS–IBTS Delta–GAM indices used in the assessment are given in Table 4.6. Figure 4.3d compares the Q1 and Q3 NS–IBTS extended indices to the corresponding NS–IBTS Delta–GAM indices.

4.3 Data analyses

4.3.1 Assessment audit

The assessment audit for North Sea cod was completed and no significant issues found. Additional checks on the forecast are carried out during the ICES WGMIXFISH meeting in 2017.

4.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 4.4a for the IBTS–Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS–Q3 survey in Figure 4.4b. The log-mean standardised curves indicate no obvious year effects (top-left plots), and track cohort signals well (top right). The log abundance curves for each survey series indicate consistent gradients (bottom left), with less steep gradients in recent years (bottom right).

Figures 4.5a and b show within-survey consistency (in cohort strength) for the NS-IBTS Q1 and Q3 Delta–GAM survey indices, while Figure 4.5c shows between survey consistencies (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning.

The SURBAR survey analysis model was fitted to both the Q1 and Q3 NS–IBTS Delta-GAM survey indices. The summary plots are presented in Figure 14.6.

Biomass Spawning stock biomass reached the lowest level in the time series in 2005 caused by a series of poor recruitments coupled with high fishing mortality and discard rates at the youngest ages, but SSB has subsequently increased again because of the stronger 2005, 2009 and 2013 year classes and recent reductions in fishing mortality. This increase can also be seen in the time series for total stock biomass.

Total mortality: the SURBAR analysis indicates an overall gradual decline in total mortality with a slight increase in 2016.

Recruitment: the SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, but that the 2016 year class is the strongest since then.

4.3.3 Exploratory catch-at-age-based analyses

Catch-at-age matrix

The total catch-at-age matrix (Table 4.2c) is expressed as numbers at age, and proportions-at-age, standardised over time in Figure 4.7. It shows clearly the contribution of the 1996, 1999, 2005 and 2009 year classes to catches in recent years, with the larger 1996 year class disappearing more rapidly from the catches compared to the 1999, 2005 and 2009 year classes. It also shows the greater proportion of older fish in the catches at the start of the time series relative to recent years, but with the most recent years indicating a relative increase in the number of older fish in the catches. The 2009 year class features strongly in the catch in the most recent period.

Catch curve cohort trends

The top panel of Figure 4.8 presents the log catch curve plot for the catch at age data. Through time there is an increase in the slope of the cohort plots indicating faster removal rates or high total mortality. In the most recent years there has been a gradual decrease in the slope at the youngest ages–a sign of decreased mortality rates. The bottom panel plots the negative slope of a regression fitted to the ages 2–4, the age range used as the reference for mortality trends. The decrease in the negative slope indicates that total mortality rates at the ages comprising the dominant ages within the fishery are declining, with the last value being the lowest in the time series.

Assessment model

SAM

SAM (State-space Assessment Model, Nielsen and Berg 2014) has been used as the assessment model for North Sea cod since 2011, following acceptance at the 2011 benchmark meeting held for the stock (ICES WKCOD 2011, ICES WGNSSK 2011). More details can be found in Nielsen and Berg (2014) and in the ICES WKCOD 2011 report, but essentially SAM models recruitment from a stock–recruitment relationship, with random variability estimated around it, or as a random walk in log space. Starting from recruitment, each cohort's abundance decreases over time following the usual exponential equation involving natural and fishing mortality. Instead of assuming catches to be known without error and simply subtracting those, SAM assumes that catches include observation noise, and that the survival process along cohorts is a random process. This has the consequence that estimated F-at-age paths display less interannual variability with SAM than with deterministic assessment models, because part of the observed fluctuations in catch-at-age are arising from observation noise instead of from changes in F.

SAM puts random distributions on the fishing mortalities F(y,a), where (y,a) denotes year and age. SAM considers a random walk over time for log [F(y,a)], for each age, allowing for correlation in the increments of the different ages. It has observation equations for both survey indices-at-age and observed catch-at-age, so catch-at-age data are never considered to be known without error. Additionally, in order to deal with the uncertain overall catch levels over the period 1993–2005, SAM estimates annual catch multipliers for this period.

An extension to allow for varying correlation between different ages is achieved by setting the correlation of the log F annual increments to be a simple function of the age difference (AR(1) process over the ages). By doing this, individual log F processes will develop correlated in time, but in such a way that neighbouring age classes have more similar fishing mortalities than more distant ones. This correlation structure does not introduce additional parameters to the model, and is referred to as an AR correlation structure (see Nielsen and Berg 2014 for more details).

SAM is considered more appropriate than VPA approaches such as B–Adapt, because the additional variability/uncertainty considered in various components of SAM seems realistic and gives rise to results that are less reactive to noise in the catch or survey data or to potential changes in survey catchability. The fact that SAM considers random variability of the annual survival process along cohorts separately from fishing mortality produces smoother estimated F paths over time. Because the current management regime for the North Sea cod stock is strongly focused on F estimates in the final assessment year, it is important that these estimates do not change too suddenly in response to some data values which may represent noise. Additionally, SAM utilizes the age structure of the observed catch even in years when the overall catch value is considered biased. SAM was considered by recent benchmarks of North Sea cod (ICES WKCOD 2011, ICES WKNSEA 2015) to be the most appropriate modelling approach for the stock assessment.

The assessment uses a time-varying maturity ogive, obtained by smoothing through an area-weighted maturity age key derived from the NS–BTS Q1 survey data. Maturity-at-age was re-estimated in 2017 to produce a time-series of maturity estimates that are consistently calculated over time in a manner that is transparent and reproducible. This affects estimates of SSB, but has no impact in the assessment because recruitment is modelled as a random-walk process independent of SSB.

Figure 4.9 shows the assessment, with the final assessment from 2016 (October update) given in light grey for comparison. When comparing to the final assessment from 2016

(October update) differences in Figure 4.9 are due to the addition of one year of catch and NS–IBTS–Q1 data, but for SSB it is both the inclusion of these data and revision of the maturity age key.

Normalised residual plots are shown in Figure 4.10, indicating no serious model mis-specification. Retrospective plots for SSB, average fishing mortality and recruitment at age 1 are shown with Mohn's r statistics in Figure 4.11, indicating no serious retrospective patterns. A summary of the SAM final assessment run in terms of population trends is provided in Figure 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 4.13.

4.3.4 Final assessment

The SAM update run is accepted as the final assessment. The data used in the assessment are given in Tables 4.2–3 and 4.5–6, and the model configuration in Table 4.7a. Model fitting diagnostics, parameter estimates and associated correlation matrix are given in Table 4.7b, while normalised residual plots and retrospective runs are shown in Figures 4.10 and 4.11 respectively. Estimates of fishing mortality at age, stock numbers at age and total removals at age are given in Tables 4.8–10 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, total removals and Fbar (2–4) are given in Table 4.11a (along with 95% confidence bounds), and estimates of landings, discards, catch, the catch multiplier and total removals (combining all these components) are given in Table 4.11b (and can be compared to the corresponding data in Table 4.4). Table 4.11c provides estimates of the catch multiplier along with 95% confidence bounds. Summary plots of the final assessment in terms of population trends is provided in Figure 4.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into age is shown in Figure 4.13. A comparison with last year's assessment (October update) is provided in Figure 4.14.

4.4 Historic Stock Trends

The historic stock and fishery trends are presented in Figures 4.12–13 and Table 4.11a–c.

Recruitment fluctuated at a relatively low level from 1998. The 1996-year class was the last large year class that contributed to the fishery, and subsequent year classes have been the lowest in the time series, apart from the 1999, 2005, 2009 and 2013 year classes. There are indications (from the IBTS Q1 survey only) of a strong 2016 year class; the largest since 1996 (not shown in Figure 4.12 or Table 4.11a).

Fishing mortality increased until the early 1980's, remained high until 2000 after which it declined, and is now below the precautionary reference points Flim and Fpa, but remains above FMSY.

SSB declined steadily during the 1970's and 80's. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the mid-1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline. SSB is estimated to have increased in recent years from the lowest level in the time series in 2006. TSB estimates have been increasing for slightly longer than SSB because of the 2005 year class, but have not experienced as rapid an improvement as SSB because of continued low recruitment.

Figure 4.15 indicates that the age structure in the population is gradually improving (number of fish aged 5 and older in the population appears to be increasing), and the survival of fish to age 5 is at its highest level in the time series.

Biomass indices by subregion (Figure 4.16a with subregions given in Figure 4.16c) highlight differing rates of change in cod biomass, with a general decline in all areas prior to the mid-2000s, and a general increase in all areas thereafter, apart from the southern area, where biomass has not increased following the decline. Recruitment indices by subregion (Figure 4.16b with subregions given in Figure 4.16c) show similar trends in all areas, but with indications of increased recruitment in the northern North Sea. Management measures ensuring sustainable exploitation of substocks may be needed in addition to management for the stock as a whole.

4.5 Recruitment estimates

The May forecast methodology ignores the SAM estimate of recruitment for the intermediate year (2017) and resamples from the 1997–2015 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005, 2009 and 2013 year classes. The SAM estimate of recruitment in 2017 is based on only the IBTS Q1 survey estimate for age 1, but is over three times larger than the median from the resampled recruitments. Given that there is a high correlation between the IBTS Q1 age 1 estimate and the IBTS Q3 age 1 estimate the same year (Figure 4.5c), and the IBTS Q1 age 2 estimate the next year (Figure 4.5a), the WG decided to implement the October forecast procedure, which uses the latest estimate of recruitment from SAM in the intermediate year and the resampled recruitments in subsequent years.

4.6 MSY estimation

MSY estimation is performed with the EQSIM software (ICES WGMG 2013), in accordance with the guidelines provided in ICES WKMSYREF3 (2014). MSY estimation for North Sea cod was performed during the WKMSYREF3 meeting in late 2014 (ICES WKMSYREF3 2014) and repeated during WKNSEA (ICES WKNSEA 2015) and WGNSSK (ICES WGNSSK 2015) in 2015. In 2017, the re-estimation of annually-varying maturities-at-age caused a rescaling of the SSB to an extent that necessitated the recalculation of reference points. MSY estimation was performed on the same basis as for ICES WKNSEA 2015 and ICES WGNSSK 2015; the Blim used in the analysis was taken as the SSB associated with the 1996 year class (the last reasonably-sized recruitment; Section 4.9).

Assessment error in the advisory year and associated autocorrelation was derived from MSE evaluations of the EU management plan for both assessments. There were three choices for recruitment periods, namely the full time series, only recruitment from 1988 onwards (reflecting the period of known productivity change in the North Sea), and only recruitment from 1998 onwards (reflecting the recent low period of recruitment for North Sea cod). The second of these (1988 onwards) was selected for the analysis because it was a period that included the SSB used for Blim, reflected the productivity change in the North Sea, and excluded the "gadoid outburst" of the 1960s and 1970s that could be considered an exception. Nevertheless, there are indications that recruitment from 1998 onwards has been lower than would be explained by SSB alone, so an EQSIM analysis based on the very low recruitment period of 1998 onwards was used as a precautionary check on the FMSY range. Further investigation is needed to evaluate whether this very low recruitment period is just due to short-term environmental effects, or whether it is likely to continue in the long term; such changes may influence both the recovery rate of SSB and the values for biomass reference points.

A summary of the resultant biological reference points (not including the advisory HCR in all but FP.05) is provided in the following table.

Stock	
FMSY	0.31
FMSY lower	0.198
FMSY upper	0.46
FP.05 (5% risk to Blim, with HCR included)	0.48
FMSY upper precautionary	0.46*
MSY	77 651 t
Median SSB at FMSY	346 032 t
Median SSB at FMSY upper precautionary	219 876 t
Median SSB at FMSY lower	510 886 t

*Note that the FP0.5 value is 0.48 for an EQSIM run (with HCR included) based on the recruitment period 1998–2016, so the FMSY upper value is not constrained.

4.7 Short-term forecasts

The May forecast

Forecasting takes the form of short-term stochastic projections. The usual May forecast procedure is to generate 1 000 samples from the estimated distribution of survivors, with recruitment being sampled with replacement from the year 1998 to the final year of catch data (a period during which recruitment has been low). These replicates are then simulated forward according to model and forecast assumptions (see Table below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios. Given that recruitment in the intermediate year (2017) is estimated to be over three times larger than the median of recruitments resampled from 1998–2016, the WG decided to implement the October forecast procedure, which uses the SAM estimate of recruitment in the intermediate year and recruitments resampled from 1998–2016 for subsequent years.

Forecasts are presented following both the October forecast procedure (using the SAM estimate of recruitment in the intermediate year; Table 4.12a) and the May forecast procedure (recruitment resampled from 1998–2016; Table 4.12b). Forecast assumptions are as follows. (Note that the values that appear in the catch options Tables 4.12a and b are medians from the distributions that result from the stochastic forecast).

Initial stock size	Starting populations are simulated from the estimated distribution at the start of the intermediate year (including co-variances).
Maturity	Maturity for the intermediate year is taken from the smoothed maturity ogive. Maturity for the TAC year onwards is the average of final four years of assessment data
Natural mortality	Average of final three years of assessment data.
F and M before spawning	Both taken as zero.
Weight at age in the catch	Average of final three years of assessment data.
Weight at age in the stock	Assumed to be the same as weight at age in the catch.
Exploitation pattern	Fishing mortalities taken as a three year average scaled to the final year.
Intermediate year assumptions	Multiplier reflecting intended changes in effort (and therefore F) relative to the final year of the assessment, assumed to be 1 to reflect a status quo intermediate year assumption.

Stock recruitment model used	Recruitment for the intermediate (the year the WG meets) is taken from the SAM assessment. Recruitment for the TAC year onwards is sampled, with replacement, from 1998 to the final year of catch data.
Procedures used for splitting projected catches	The final year landing fractions are used in the forecast period.

Large differences in SSB in the intermediate year between the assessment and the forecast presented itself in 2016, and resulted from assuming the final year of assessment data in the intermediate year for the assessment and the average of the final three years' assessment data for the forecast. This divergence had not presented itself to this extent in previous years, and was solved by using three year averages for stock weights and natural mortality to calculate SSB in the intermediate year for the assessment, and by using the smoothed maturity estimates to calculate SSB in the intermediate year for the forecast, so the two calculations are consistent.

This is the first year that maturity data has been available and used in the assessment year, and necessitated increasing the forecast assumption for maturity from a three to a four-year average. This is consistent with the start of the period over which the other data are averaged and allows inclusion of the most recent maturity estimate.

The October forecast

Since the NS–IBTS Q3 index has been re-introduced into the assessment, there is an opportunity to update the forecast in October following the NS–IBTS Q3 survey. ICES WKNSEA (2015) recommended that the usual procedure be used to establish whether to re-open advice in the autumn (as described in ICES AGCREFA 2008). Once it has been established that advice should be re-opened for North Sea cod, the recommended procedure is to then re-run the assessment and forecast with the new Q3 data included, but to use the actual SAM estimate of recruitment for the intermediate year (the year following the final year of catch data), with recruitment for the years following the intermediate year being re-sampled, with replacement, from the period 1998 to the final year of catch data.

The ICES WKNSEA (2015) recommendations on conducting the North Sea cod forecast deviated from the ICES norm in that the October forecast implies re-running the SAM assessment, and was therefore presented to the ICES ACOM leadership who have given it their approval. The forecasting procedure will therefore follow the ICES-WKNSEA (2015) recommended approach.

The current May forecast

Several scenarios were considered as follows (note, Btrigger = Bpa = 150 000 tons, and FMSY = 0.31; see Section 4.9):

1) EU Management plan: the long term Phase of the plan, applying the sliding rule with former Blim and Bpa values (70 000 tons and 150 000 tons respectively) (paragraph 4 of Article 8 of EC 1342/2008), ensuring that TAC (2018) is within 20% of TAC (2017)

2) EU-Norway agreement plan: the Long-term Phase of the plan, applying the same sliding rule as for the EU Management plan, but using the new Blim and Bpa values (107 000 tons and 150 000 tons respectively) (see Section 4.9), ensuring that TAC (2018) is within 20% of TAC (2017)

3) MSY framework: Fbar (2018) = FMSY×min{1; SSB2018/Btrigger}

4) Zero catch: Fbar (2018) = 0

5) MSY: Fbar (2018) = FMSY = 0.31

6) Fpa: Fbar (2018) = Fpa = Flim/1.4 = 0.39

7) Flim: Fbar (2018) = Flim = 0.54

8) SSB (2019) = Blim: F corresponding to SSB (2019) = Blim

9) SSB (2019) = Bpa: F corresponding to SSB (2019) = Bpa

10) SSB (2019) = Btrigger: F corresponding to SSB (2019) = Btrigger

11) Lower TAC constraint: Fbar (2018) such that TAC (2018) = 0.8×TAC (2017)

12) Rollover TAC 15%: Fbar (2018) such that TAC (2018) = 0.85×TAC (2017)

13) Rollover TAC 10%: Fbar (2018) such that TAC (2018) = 0.9×TAC (2017)

14) Rollover TAC 5%: Fbar (2018) such that TAC (2018) = 0.95×TAC (2017)

15) Rollover TAC: Fbar (2018) such that TAC (2018) = TAC (2017)

16) Rollover TAC + 5%: Fbar (2018) such that TAC (2018) = 1.05×TAC (2017)

17) Rollover TAC + 10%: Fbar (2018) such that TAC (2018) = 1.1×TAC (2017)

18) Rollover TAC + 15%: Fbar (2018) such that TAC (2018) = 1.15×TAC (2017)

19) Upper TAC constraint: Fbar (2018) such that TAC (2018) = 1.2×TAC (2017)

20) Status quo – constant F: Fbar (2018) = Fbar (2017)

21) FMSY lower: Fbar (2018) = FFMS lower = 0.20

22) FMSY upper: Fbar (2018) = FFMS upper with AR = 0.46

The reason two management plan options (1 and 2 above) are supplied is because both plans were based on Blim and Bpa as part of the sliding rule, but with the revision of these reference points in 2015 and again in 2017, the two plans now differ from one another. The EU management plan continued to be based on the previous values for Blim and Bpa (formerly 70 000 tons and 150 000 tons respectively) while the EU–Norway agreement has the flexibility to accommodate the revised values for these quantities (107 000 tons and 150 000 tons respectively). Both management plans switched into their long-term phases (when they were still based on the same values for Blim and Bpa) in 2013 but the effort regime was discontinued in 2017.

Forecasts using the SAM estimate of recruitment in the intermediate year (October forecast procedure) and associated scenarios are given in Table 4.12a. For completeness, Table 4.12b provides the corresponding forecasts using recruitments resampled from 1998–2016 (May forecast procedure), excluding options 21–22.

4.8 Medium-term forecasts

Medium-term projections are not carried out for this stock.

4.9 Biological reference points

In 2017, the re-estimation of annually-varying maturities-at-age caused a rescaling of the SSB to an extent that necessitated the recalculation of reference points. Biological reference points were calculated based on the SAM final assessment presented here, following the procedures of ICES WGNSSK 2015 and ICES WGNSSK 2016. The choice for Blim was to take the last SSB to have produced a reasonably-sized recruitment (the 1996 year class); the reason the change point in a segmented regression fitted to the whole-time period was not used was because this time period spans different environmental and recruitment regimes, and such a change point would therefore not be appropriate for deriving Blim. The SSB in 1996 produced the last outstanding year class (1 218 340 thousand recruits based on the assessment presented here) that was above the average observed between 1963 and 1996 (1 029 155 thousands based on the assessment presented here) when the stock produced relatively high recruitment compared to recently observed values. Therefore, it can be argued that a SSB above the one observed in 1996 has the potential to produce high recruitment under sufficiently good environmental conditions, and therefore impaired recruitment because of a too-low SSB is avoided. Bpa was simply calculated as 1.4×Blim.

Flim estimation was performed with the EQSIM software on the basis of the very low recruitment period from 1998, consistent with the calculation of FP.05 used as a precautionary check on the FMSY range (as opposed to the period 1988 onwards used for calculation of Blim and Bpa). The change point of the segmented regression was estimated rather than forced at Blim. This deviation from the ICES guidelines avoids use of a stock-recruit curve that falls below the majority of observed stock-recruit pairs and is consistent with the curve used for calculating the FP.05 value. Fpa was simply calculated as Flim/1.4. Biological reference points are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Btrigger	150 000 t.	The default option of Bpa.(=1.4×Blim)	
	FMSY	0.31	EQSim analysis based on recruitment period 1988–2016	2017 assessment
Precautionary approach	Blim	107 000 t.	SSB associated with the 1996 year class	2017 assessment
	Bpa	150 000 t.	Blim multiplied by 1.4. This is the current ICES default approach.	
	Flim	0.54	EQSim analysis based on recruitment period 1998–2016	2017 assessment
	Fpa	0.39	Flim/1.4	
EU Management plan	SSBlower	70 000 t.	Former Blim	EC 1342/2008
	SSBupper	150 000 t	Former Bpa	
	Flower	0.2	Fishing mortality when SSB <SSBlower.	
	Fupper	0.4	Fishing mortality when SSB>SSBupper	
EU–Norway agreement	SSBlower	107 000 t.	Revised Blim	2008 EU-Norway agreement
	SSBupper	150 000 t	Revised Bpa	
	Flower	0.2	Fishing mortality when SSB <SSBlower.	

Fupper	0.4	Fishing mortality when SSB>SSBupper

4.10 Quality of the assessment

The quality of the commercial landings and catch-at-age data for this stock deteriorated in the 1990s following reductions in the TAC without associated control of fishing effort. The WG considers the international landings figures from 1993 onwards to have inaccuracies that lead to retrospective underestimation of fishing mortality and over estimation of spawning stock biomass and other problems with an analytical assessment. The mismatch between reported and actual landings is assumed to be negligible since 2006.

Prior to 2002 estimates of discards for areas 4 and 7.d are taken from the Scottish discard sampling program and the average proportions across gears applied to raise the landings data from other areas. If the gear and fishery characteristics differ, this could introduce bias. This bias is likely to introduce sensitivity to the estimates of the youngest age classes (1 and 2) and will not affect estimates of SSB. InterCatch has been used to raise data for discards ratios and landings and discard age compositions from 2002 onwards. The provision of discard information has vastly improved since 2009.

Comparing the assessment this year with last year gives the following (Figure 4.14): historical SSB trends are similar, but there is a downscaling of SSB since the mid–1970s due to re-estimation of the time-varying maturity ogive; the stock is now above Bpa; fishing mortality continues to decline, and is now below the precautionary reference points Flim and Fpa, but still above Fmsy.

The estimated CVs for observed catch at age 1, for the NS–IBTS–Q1 and Q3 survey indices at age 1 and for the stock–recruitment relationship are all large: 60%, 47%, 33% and 81%, respectively. These large CVs suggest that these sources of information are somewhat ignored in the SAM recruitment estimation, which might therefore be more influenced by age 2 abundance estimates and model assumptions about F-at-age 1. The CV of the survival process is assumed to be the same for all non-recruiting ages (estimated at 12%) and this might have an impact on recruitment estimates (and, hence, age 1 catch and survey residuals) because it constraints the changes permitted between abundance at ages 1 and 2 of a cohort.

Finally, the high correlation (0.90) estimated for the increments of log[F(y,a)] across ages suggests that the model might react a bit slowly if different changes in selectivity start to happen for different ages (for example, as a consequence of discard reduction policies). Annual assessment results should be monitored closely, via retrospective analyses and other model diagnostics.

Changes to the assessment in 2015 include a reduction of the plus group from 7+ to 6+. This reduces the cohort information for ages 6+; these ages represent around 20% of the SSB (by weight), and if the SSB continues to increase, this proportion should also increase as more fish aggregate in the plus group, with an associated increasing loss in cohort signal for ages in the plus group, potentially undermining the assessment. Furthermore, this change introduced increasingly domed selection in the latter half of the time series that was not present in previous assessments; although there are reasons why such increasingly domed selection might occur, such as some evidence that larger cod inhabit less accessible rocky areas or simply move away from areas fishing vessels operate in, these reasons remain largely speculative.

The SAM model estimates the quantity of additional "unaccounted removals" that would be required to be added or removed from the catch-at-age data in order to remove any persistent trends in survey catchability. The unaccounted removals figures given by SAM could potentially include components due to increased natural mortality and discarding as well as misreported landings.

There is general agreement across all models presented (SAM and SURBAR) of an increasing SSB since the mid–2000s, declining fishing mortality (total mortality for SURBAR) since around 2000, and stronger 2005, 2009, 2013 and 2016 year classes in recent years. The decline in fishing mortality is evident from the shallower gradients of log-catch curves, and the stronger 2016 year class is evident from this year class being more widespread in the North Sea compared to other recent year classes at the same age.

Values for natural mortality were updated in 2015, following the key run conducted by WGSAM (ICES WGSAM 2014); they are smoothed annual model estimates from a multispecies model. The annually varying maturity-at-age estimates are derived from an area-weighted maturity age key based on NS–IBTS–Q1 data from the period 1978–2017, to which a smoother is applied to get rid of the effects of variations in sampling intensity. A Delta-GAM approach, assuming a stationary spatial model with ship effect, has been used to derive both Q1 and Q3 NS–IBTS indices.

4.11 Status of the Stock

There has been a strong improvement of the status of the stock in the last few years. SSB has increased from the historical low in 2006, and is now above Bpa. This increasing trend is expected to continue in the short term under current fishing mortality levels, because of improved survival of incoming year classes.

Fishing mortality has declined from 2000, and is now just below the precautionary reference points Flim and Fpa, but still estimated to be above the level that achieves the long-term objective of maximum yield.

Recruitment of 1 year old cod has varied considerably since the 1960s, but since 1998, average recruitment has been lower than any other time. There are indications from the IBTS Q1 survey that recruitment in 2017 is substantially higher than the low level observed since 1998. Recent sharp increases in the rate of discarding have been reversed are stabilising at lower levels.

4.12 Management considerations

The stock has begun to recover from the low levels to which it was reduced in early 2000, at which recruitment was impaired and the biological dynamics of the stock difficult to predict. Fishing mortality rates have been reduced from 2000 and in combination with the stronger 2005, 2009 and 2013 year classes, the stock has increased since 2006. The reduction in fishing mortality is allowing the recent series of poor recruitments to make an improved contribution to the stock.

Discarding currently contributes around a quarter of the total catch by weight, a substantial improvement compared to recent years (when the average was almost half of the total). There have been considerable efforts to reduce discards by some countries, and the impact of these reductions are starting to be felt (e.g. reduced discarding leading to improved survival of incoming year classes).

Cod is caught by a large variety of gears and together with many other species. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, in order to estimate the potential risks of quota over- and undershooting for the different stocks.

There is a need to reduce fishing induced mortality on North Sea cod further, particularly for younger ages, in order to allow more fish to reach maturity and increase the probability of good recruitment. Incidence of discarding remain high, with the proportion of fish discarded by number in 2016 being 94% of 1 year old (compared to 85% in 2015), 71% of 2 year old (58% in 2015), 36% of 3 year old (29% in 2015) and 8% of 4 year old cod (9% in 2015).

Because the fishery is at present so dependent on incoming year classes, fishing mortalities on these year classes remain high, and only a small proportion of 2 year olds currently survive to maturity. At the same time, the unbalanced age structure of the stock reduces its reproductive capacity even if a sufficient SSB were reached, as first-time spawners reproduce less successfully than older fish. Both factors are believed to have contributed to the reduction in recruitment of cod. However, there are indications that, although still low, survival to age 5 is improving, and is currently at the highest level in the time series.

The recruitment of the relatively more abundant year classes to the fishery may have no beneficial effect on the stock if they are caught and heavily discarded. The last substantial year class to enter the fishery was the 1996 year class. This year class was a prominent feature in all surveys, was heavily exploited and discarded by the fishery at ages 1–5, and disappeared relatively quickly from the fishery.

There are indications from the IBTS–Q1 survey that recruitment in 2017 is substantially higher than the low level observed since 1998. Therefore, the forecast uses the assessment estimate of recruitment in 2017 rather than assuming the continuation of the recent period of low recruitment. The 2017 recruitment remains to be confirmed by the IBTS Q3 survey and a reopening of the advice may be triggered in October. Despite this indication of improved recruitment, ICES advise a cut in TAC due to two weak year classes immediately preceding, which will form the majority of catches in 2018.

The availability of discard rate estimates has vastly improved since 2009, and catch estimates (landings and discards) are now provided by InterCatch from 2002 onwards.

Recent measures to improve survival of young cod, such as the Scottish Conservation Credits Scheme, and increased uptake of more selective gears such as the now widespread use of sorting grids in the Skagerrak, should be encouraged.

The reported landings in 2016 were 38 230 tons and the estimated discards and BMS landings in 2016 were 12 304 tons and 10 tons respectively, giving a total of 50 544 tons. Cod are taken by towed gears in mixed demersal fisheries, which include haddock, whiting, *Nephrops*, plaice, and sole. They are also taken in directed fisheries using fixed gears.

Table 4.1. Nominal landings (in tons) of COD in Subarea 4, Divisions 7.d and Subdivision 20, as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	4,642	5,799	3,882	3,304	2,470	2,616	1,482	1,627	1,722	1,309
Denmark	21,870	23,002	19,697	14,000	8,358	9,022	4,676	5,889	6,291	5,105
Faroe Islands	40	102	96	-	9	34	36	37	34	3
France	3,451	2,934	.	1,222	717	1,777	620	294	664	354
Germany	5,179	8,045	3,386	1,740	1,810	2,018	2,048	2,213	2,648	2,537
Greenland	.	.	.	.	.	.	.	.	35	23
Netherlands	11,807	14,676	9,068	5,995	3,574	4,707	2,305	1,726	1,660	1,585
Norway	5,814	5,823	7,432	6,410	4,369	5,217	4,417	3,223	2,900	2,749
Poland	31	25	19	18	18	39	35	-	-	0
Sweden	832	540	625	640	661	463	252	240	319	309
UK (E/W/NI)	13,413	17,745	10,344	6,543	4,087	3,112	2,213	1,890	1,270	1,491
UK (Scotland)	32,344	35,633	23,017	21,009	15,640	15,416	7,852	6,650	4,936	6,857
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Others	0	0	0	0	0	0	0	0	0	786
Danish industrial by-catch *	.	.	.	.	.	105	22	17	21	11
Norwegian industrial by-catch *	.	.	.	.	.	.	.	.	.	48
Total Nominal Catch	99,423	114,324	77,566	60,881	41,713	44,526	25,958	23,806	22,500	23,119
Unallocated landings	2,746	7,779	826	-1,114	-740	-226	-111	-1,277	356	-2,041
WG estimate of total landings	**102,169**	**122,103**	**78,392**	**59,767**	**40,973**	**44,300**	**25,847**	**22,529**	**22,855**	**21,078**
Agreed TAC	**115,000**	**140,000**	**132,400**	**81,000**	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**

Division VIId

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	310	239	172	110	93	51	54	47	51	80
Denmark	-	-	-	-	-	-	-	-	-	-
France	6,387	7,788	.	3,084	1,677	1,361	1,730	810	986	1,124
Netherlands	-	19	3	4	17	6	36	14	9	9
UK (E/W/NI)	478	618	454	385	249	145	121	103	184	267
UK (Scotland)	3	1	-	-	-	-	-	-	-	1
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total Nominal Catch	7,178	8,665	629	3,583	2,036	1,563	1,941	974	1,230	1,481
Unallocated landings	-135	-85	6,229	-1,258	-463	1,534	-707	40	29	-2
WG estimate of total landings	**7,043**	**8,580**	**6,858**	**2,325**	**1,573**	**3,097**	**1,234**	**1,014**	**1,259**	**1,479**

Division IIIa (Skagerrak)**

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	12,159	12,339	8,681	7,684	5,900	5,525	3,067	3,038	3,019	2,513
Germany	81	54	54	54	32	83	49	99	86	84
Norway	1,323	1,293	1,146	926	762	645	825	856	759	628
Sweden	2,173	1,900	1,909	1,293	1,035	897	510	495	488	372
Others	-	-	-	-	-	-	27	24	21	373
Danish industrial by-catch *	205	97	62	99	687	20	5	4	2	3
Total Nominal Catch	15,736	15,586	11,790	9,957	7,729	7,170	4,483	4,516	4,375	3,973
Unallocated landings	-790	-255	-816	-680	-643	298	-692	-602	-376	-715
WG estimate of total landings	**14,946**	**15,331**	**10,974**	**9,277**	**7,086**	**7,468**	**3,791**	**3,914**	**3,998**	**3,258**
Agreed TAC	**16,100**	**20,000**	**19,000**	**11,600**	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total Nominal Catch	122,337	138,575	89,985	74,421	51,478	53,260	32,382	29,296	28,104	28,573
Unallocated landings	1,821	7,439	6,240	-3,052	-1,846	1,605	-1,510	-1,839	9	-2,759
WG estimate of total landings	**124,158**	**146,014**	**96,225**	**71,369**	**49,632**	**54,865**	**30,872**	**27,457**	**28,113**	**25,815**

** Skaggerak/Kattegat split derived from national statistics

* The Danish (up to 2001) and Norwegian industrial bycatch are not included in the (WG estimate of) total landings

. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IV and IIIa (Skagerrak) landings not included in the assessment

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Danish industrial by-catch *	205	97	62	99	687	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	.	.	.	.	48
Total	**205**	**97**	**62**	**99**	**687**	**0**	**0**	**0**	**0**	**48**

Table 4.1 cont. Nominal landings (in tons) of COD in 20 (Skagerrak), 4 and 7.d, as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	1,009	894	946	666	653	862	1,076	1,257	1,187	1,103
Denmark	3,430	3,831	4,402	5,686	4,863	4,803	4,536	5,457	6,026	6,697
Faroe Islands	0	16	45	32	0	0	0	0	.	.
France	659	573	950	781	619	368	287	638	521	391
Germany	1,899	1,736	2,374	2,844	2,211	2,385	1,921	2,257	2,133	2,083
Greenland	17	17	11	0	0	0	0	0	.	2
Netherlands	1,523	1,896	2,649	2,657	1,928	1,955	1,344	1,242	1,349	1,365
Norway	3,057	4,128	4,234	4,496	4,898	4,601	4,079	4,590	5,486	5,592
Poland	1	2	3	0	2	0	0	0	.	.
Sweden	387	439	378	363	315	472	332	401	417	370
UK (E/W/NI)	1,588	1,546	2,384	2,553	2,169	1,630	2,129	2,963	.	.
UK (Scotland)	6,511	7,185	9,052	11,567	10,141	10,565	10,619	10,517	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	13,480	14,839	16,583
Others	0	0	0	0	0	0	0	0	0	0
Danish industrial by-catch	23	1	72	12	0	0	2	24	0	5
Norwegian indust by-catch *	101	22	4	201	1	.	.	.	.	.
Total Nominal Catch	20,104	22,264	27,500	31,657	27,799	27,641	26,325	29,346	31,959	34,192
Unallocated landings	-1,047	-607	134	-677	-1,124	-1,014	-1,010	-796	-715	-1,157
WG estimate of total landings	**19,056**	**21,657**	**27,634**	**30,980**	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**
Agreed TAC	**19,957**	**22,152**	**28,798**	**33,552**	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**39,220**

Division VIId										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	84	154	73	57	56	40	53	72	79	38
Denmark	.	.	.	.	.	.	.	.	.	.
France	1,743	1,326	1,779	1,606	1,078	885	768	1,270	1,100	279
Netherlands	59	30	35	45	51	40	38	50	47	40
UK (E/W/NI)	174	144	133	127	125	99	100	156	.	.
UK (Scotland)	12	7	3	1	1	0	0	0	.	.
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	156	161	101
Total Nominal Catch	2,072	1,661	2,023	1,836	1,311	1,064	959	1,548	1,387	459
Unallocated landings	75	-32	-136	-128	8	56	-43	-112	11	-38
WG estimate of total landings	**2,147**	**1,629**	**1,887**	**1,708**	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**
Agreed TAC			**1,678**	**1,955**	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**2,059**

Division IIIa (Skagerrak)**										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	2,246	2,553	3,024	3,286	3,118	3,178	3,033	3,430	3,344	3,695
Germany	67	52	55	56	60	78	69	84	87	94
Norway	681	779	440	375	421	615	575	528	499	549
Sweden	370	365	459	458	518	520	529	570	576	643
Others	385	13	2	26	0	0	33	28	24	25
Danish industrial by-catch	2	7	2	10	0	1	1	5	5	0
Total Nominal Catch	3,751	3,769	3,983	4,211	4,117	4,392	4,240	4,644	4,536	5,007
Unallocated landings	-731	-376	-188	-154	-161	-65	-85	43	28	-233
WG estimate of total landings	**3,020**	**3,393**	**3,794**	**4,057**	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**
Agreed TAC	**2,851**	**3,165**	**4,114**	**4,793**	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**5,744**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total Nominal Catch	25,927	27,694	33,506	37,705	33,227	33,097	31,524	35,538	37,882	39,657
Unallocated landings	-1,704	-1,015	-190	-959	-1,277	-1,024	-1,138	-865	-676	-1,427
WG estimate of total landings	**24,223**	**26,679**	**33,315**	**36,746**	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**

*** 2016 WG estimates of total landings do not include BMS landings
** Skaggerak/Kattegat split derived from national statistics
* The Norwegian industrial by-catch are not included in the (WG estimate of) total landings
. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IV and IIIa (Skagerrak) landings not included in the assessment										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Norwegian indust by-catch *	101	22	4	201	1	.	.	.	.	.
Total	**101**	**22**	**4**	**201**	**1**	**0**	**0**	**0**	**0**	**0**

Table 4.2a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Landings numbers at age (Thousands).

Landings numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	3198	5004	15734	18133	10749	5800	2932	54219	44599	3813	25836
2	42377	22373	51628	62202	70539	83416	22561	33747	154565	186744	31596
3	6995	20003	17557	29695	32529	42373	31419	18395	17132	47885	54655
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103
7	81	596	655	475	884	866	585	956	888	1671	1055
8	489	117	297	368	353	307	420	208	455	609	487
9	13	93	51	125	137	150	147	185	227	388	79
10	6	11	75	56	40	111	46	97	77	112	57
+gp	0	4	8	83	17	24	77	40	93	17	161
TOTALNUM	60659	56203	98460	121923	131671	152829	79251	129139	234508	252789	131226
TONSLAND	115893	125393	180120	220197	251687	286948	199746	224993	326492	352161	237874
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	15484	33210	5695	75130	29593	34627	62394	20131	66220	25488	64358
2	58624	46907	99779	50926	174912	91143	104356	187626	64755	128396	66026
3	11347	18849	18481	25525	17178	44384	34938	34567	59907	21456	31087
4	15745	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238
5	4601	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415
6	956	2057	3056	833	1103	708	1269	779	2048	1246	1013
7	436	447	920	1140	408	396	494	599	425	589	434
8	393	195	130	370	403	139	197	133	234	179	243
9	330	228	67	262	152	157	73	64	77	89	59
10	80	95	63	26	36	42	55	36	27	28	44
+gp	188	63	43	96	44	17	25	21	16	23	19
TOTALNUM	108183	114215	136672	161191	236214	178997	218034	256998	206643	192083	170937
TONSLAND	213215	204249	233007	208318	294640	266019	293753	333616	302365	257634	227070
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	8795	99841	24816	21362	22072	11629	13288	27162	4688	15366	15486
2	117383	32308	127774	55025	36084	53783	23145	31472	54171	24969	62650
3	18888	33973	9761	43712	18056	11795	16554	8523	11134	20885	12753
4	7779	5791	8689	3117	9791	4299	3267	4916	3126	3045	5223
5	1369	2981	1528	2543	994	2445	1372	1041	1546	859	790
6	1257	602	1071	652	1028	307	1039	482	426	513	282
7	371	554	234	293	249	307	222	323	200	140	148
8	172	170	215	66	139	54	137	51	106	57	41
9	78	69	55	63	27	60	27	39	17	32	14
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	9	9	13	16	5
TOTALNUM	156139	176355	174203	126873	88481	84698	59065	74034	75437	65889	97405
TONSLAND	214354	201279	216041	183202	139578	124835	101442	112740	119947	109915	136397
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4871	23443	1243	5831	8087	2164	4425	438	1470	1009	1286
2	36303	28793	80948	9549	22457	20309	8029	8893	3511	8175	4401
3	23046	18390	16794	31624	6310	6044	13831	3552	5453	3036	4410
4	3125	6409	5909	3959	6529	1114	2787	3072	1527	1714	969
5	1834	1221	2379	1419	996	1053	395	397	939	479	520
6	393	690	504	614	375	140	384	68	155	339	187
7	159	151	233	219	135	82	58	61	29	52	120
8	87	47	41	89	39	27	38	15	19	13	23
9	42	14	16	14	18	13	18	5	6	9	4
10	4	15	4	10	5	6	4	2	2	1	1
+gp	8	10	12	2	1	1	1	0	0	1	0
TOTALNUM	69872	79183	108083	53329	44952	30953	29971	16505	13111	14830	11921
TONSLAND	124721	122434	144637	94108	69567	48440	53152	30426	27748	28165	25665
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	776	338	519	1120	1099	665	683	2240	686	167
2	6334	3268	4833	5037	4540	2230	2688	4207	6384	2035
3	2264	4130	2839	4578	4046	5367	3063	4376	4903	5644
4	1562	1146	2888	1582	1408	1963	2592	1605	1933	3150
5	398	706	596	1315	610	633	865	1286	745	1012
6	137	213	237	198	451	248	190	332	584	277
7	40	70	44	65	48	139	84	64	144	188
8	39	26	19	16	27	15	38	38	22	44
9	6	13	17	6	5	4	5	6	6	9
10	1	1	8	4	2	4	1	2	1	5
+gp	1	1	3	2	2	1	1	0	2	2
TOTALNUM	11558	9911	12003	13923	12237	11269	10208	14156	15411	12534
TONSLAND	24215	26814	33177	36762	31979	32124	30474	34651	37373	38104
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 4.2b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Discard numbers at age (including BMS landings; Thousands).

Discards numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	16150	8049	97921	108375	50214	31115	2502	52958	258920	38250	85915
2	19902	6168	6599	22125	24736	22957	10279	8656	37224	59342	17387
3	33	115	89	71	160	197	113	152	47	177	246
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	36085	14332	104609	130570	75110	54268	12894	61766	296192	97768	103548
TONSDISC	12198.57	4655.611	28972.64	37861.71	23284.92	17468.34	4756.776	17662.66	84006.59	33602.62	29965.76
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	124151	136651	226781	472599	28908	581071	1185689	155732	181946	54949	537521
2	15878	16214	83210	48009	78114	5270	17692	34307	8377	11130	12518
3	71	0	192	464	0	0	0	79	98	25	5
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	140100	152866	310182	521072	107022	586341	1203381	190118	190421	66103	550043
TONSDISC	39532.68	36840.85	72396.83	139026.6	32433.69	162278.1	294208.1	57075.62	54007.83	21430.4	151003.9
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	63301	563506	24634	15376	176920	33875	47473	102410	33433	320725	44756
2	36573	5761	61948	17084	8685	48244	8383	9881	28538	16804	43434
3	115	303	0	216	489	78	448	2	11	160	30
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	99989	569571	86583	32676	186094	82197	56304	112293	61983	337689	88220
TONSDISC	31297.6	138603.8	27706.11	10504.47	61655.63	26747.11	18198.97	36192.59	21411.61	98208.27	31706.81
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	14254	86109	15458	30962	37031	5460	26267	5696	20336	10213	26890
2	23058	13701	90259	5630	5509	33094	13236	6082	8941	8303	35342
3	764	40	1500	8280	0	753	3181	775	2007	1795	1965
4	0	0	0	0	0	0	17	55	122	149	51
5	0	0	0	0	0	0	0	0	6	66	4
6	0	0	0	0	0	0	0	0	0	12	1
7	0	0	0	0	0	0	0	0	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	2	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	38075	99851	107216	44872	42540	39307	42702	12608	31413	20540	64253
TONSDISC	14030	33183.67	40102.32	13641.52	13359.94	13519.42	11900.56	4007.44	8721.211	9931.799	11923
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	16171	10847	9608	9867	3936	11149	6188	7756	3980	3067
2	23047	9331	9055	9151	7851	5190	6055	6504	8935	4942
3	2657	7591	2655	1254	925	1422	856	1434	1965	3110
4	481	223	650	65	81	115	397	163	180	257
5	52	14	50	30	6	5	83	58	55	31
6	24	11	17	0	4	1	40	5	64	1
7	0	0	9	0	1	1	16	0	15	0
8	2	0	0	0	1	0	0	0	5	0
9	0	0	0	0	0	0	0	0	3	0
10	0	0	2	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0
TOTALNUM	42433	28017	22047	20366	12804	17884	13635	15921	15201	11409
TONSDISC	30422	24984	20846	12341	8711	8638	10289	10538	12537	12203
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 4.2c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Catch numbers at age (Thousands).

Catch numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	19347	13052	113655	126508	60962	36915	5434	107177	303519	42062	111751
2	62280	28541	58227	84327	95275	106373	32840	42403	191789	246086	48983
3	7028	20118	17646	29766	32689	42569	31532	18547	17179	48062	54901
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103
7	81	596	655	475	884	866	585	956	888	1671	1055
8	489	117	297	368	353	307	420	208	455	609	487
9	13	93	51	125	137	150	147	185	227	388	79
10	6	11	75	56	40	111	46	97	77	112	57
+gp	0	4	8	83	17	24	77	40	93	17	161
TOTALNUM	96744	70535	203069	252494	206780	207098	92145	190905	530700	350558	234774
TONSLAND	128092	130049	209092	258059	274972	304417	204503	242656	410498	385764	267840
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	139635	169862	232476	547729	58501	615698	1248084	175863	248166	80437	601879
2	74502	63121	182989	98935	253025	96413	122048	221933	73132	139526	78543
3	11418	18849	18672	25989	17178	44384	34938	34646	60005	21480	31092
4	15745	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238
5	4601	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415
6	956	2057	3056	833	1103	708	1269	779	2048	1246	1013
7	436	447	920	1140	408	396	494	599	425	589	434
8	393	195	130	370	403	139	197	133	234	179	243
9	330	228	67	262	152	157	73	64	77	89	59
10	80	95	63	26	36	42	55	36	27	28	44
+gp	188	63	43	96	44	17	25	21	16	23	19
TOTALNUM	248283	267081	446854	682263	343235	765338	1421415	447116	397064	258186	720980
TONSLAND	252748	241089	305404	347345	327074	428297	587962	390691	356372	279065	378074
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	72096	663347	49451	36738	198992	45504	60761	129572	38121	336092	60242
2	153957	38069	189722	72109	44768	102027	31528	41353	82709	41773	106084
3	19003	34277	9761	43929	18544	11873	17002	8525	11145	21045	12783
4	7779	5791	8689	3117	9791	4299	3267	4916	3126	3045	5223
5	1369	2981	1528	2543	994	2445	1372	1041	1546	859	790
6	1257	602	1071	652	1028	307	1039	482	426	513	282
7	371	554	234	293	249	307	222	323	200	140	148
8	172	170	215	66	139	54	137	51	106	57	41
9	78	69	55	63	27	60	27	39	17	32	14
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	9	9	13	16	5
TOTALNUM	256129	745925	260786	159550	274574	166895	115368	186327	137419	403578	185625
TONSLAND	245651	339883	243747	193706	201233	151582	119641	148932	141358	208123	168104
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	19124	109552	16701	36793	45118	7624	30692	6135	21807	11222	28177
2	59360	42494	171206	15180	27965	53403	21265	14975	12452	16478	39743
3	23809	18430	18293	39904	6310	6797	17012	4328	7460	4831	6375
4	3125	6409	5909	3959	6529	1114	2805	3127	1650	1863	1020
5	1834	1221	2379	1419	996	1053	395	397	944	546	524
6	393	690	504	614	375	140	384	68	155	351	187
7	159	151	233	219	135	82	58	61	29	52	121
8	87	47	41	89	39	27	38	15	19	13	23
9	42	14	16	14	18	13	18	5	6	11	4
10	4	15	4	10	5	6	4	2	2	1	1
+gp	8	10	12	2	1	1	1	0	0	1	0
TOTALNUM	107947	179034	215299	98201	87491	70260	72673	29113	44524	35370	76174
TONSLAND	138751	155618	184740	107749	82927	61960	65053	34433	36469	38097	37589
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	16947	11185	10127	10987	5035	11815	6871	9995	4666	3234
2	29381	12599	13887	14188	12391	7420	8743	10711	15319	6977
3	4921	11721	5494	5831	4970	6789	3919	5810	6869	8754
4	2043	1369	3539	1646	1489	2077	2989	1768	2113	3408
5	451	720	646	1344	616	638	949	1345	800	1044
6	161	224	254	199	455	249	229	337	648	279
7	40	70	53	65	49	139	100	64	159	188
8	41	26	19	16	28	15	38	38	27	44
9	6	13	17	6	5	4	5	6	9	9
10	1	1	10	4	2	4	2	2	1	5
+gp	1	1	3	2	2	1	1	0	2	2
TOTALNUM	53992	37928	34050	34288	25041	29153	23844	30076	30612	23942
TONSLAND	54637	51798	54023	49103	40689	40762	40763	45190	49910	50307
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 4.2d. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch numbers at age (Thousands) by season (quarter or annual, depending on data stratification) from InterCatch for 2016.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	7	10	21	114	14	166
2	241	222	666	674	232	2035
3	1015	1075	1657	1344	553	5644
4	793	838	752	532	235	3150
5	246	314	227	188	37	1012
6	71	73	66	52	14	276
7	54	50	47	19	19	189
8	23	4	8	4	6	45
9	3	1	5	0	0	9
10	0	1	2	1	0	4
+gp	0	0	0	0	0	0
TOTALNUM	2453	2588	3451	2928	1110	12530

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	237	399	892	899	640	3067
2	676	1125	1655	802	683	4941
3	685	837	587	452	549	3110
4	46	69	61	79	2	257
5	10	6	4	11	0	31
6	0	0	1	1	0	2
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	1654	2436	3200	2244	1874	11408

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	244	409	913	1013	655	3234
2	917	1347	2322	1476	915	6977
3	1701	1911	2244	1796	1102	8754
4	839	907	814	611	237	3408
5	256	320	231	200	37	1044
6	71	74	67	53	14	279
7	54	50	47	19	19	189
8	23	4	8	4	6	45
9	3	1	5	0	0	9
10	0	1	2	1	0	4
+gp	0	0	0	0	0	0
TOTALNUM	4108	5024	6653	5173	2985	23943

Table 4.2e. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2016, calculated as the weight in each area–season–métier stratum covered by the relevant sampling, then summed over métiers and expressed as a proportion of the total for the area–season (note the country dimension is not used). Also provided is the contribution of landings and discards in each area (by weight) to the total for that catch category (before raising is conducted). BMS landings not included.

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
4	77%	72%	85%	78%	94%
3.a.20	69%	75%	62%	89%	-
7.d	66%	83%	70%	74%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
4	78%	80%	80%	83%	94%
3.a.20	98%	92%	88%	92%	-
7.d	53%	64%	7%	40%	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
4	99%	99%	97%	97%	100%
3.a.20	100%	42%	100%	100%	-
7.d	8%	92%	100%	-	-

Contribution to total (before raising)

Area/Type	Landings	Discards
4	86%	91%
3.a.20	12%	8%
7.d	1%	0%

Table 4.3a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Landings weights at age (kg).

Landings weights at age (kg)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.538	0.496	0.581	0.579	0.590	0.640	0.544	0.626	0.579	0.616	0.559
2	1.004	0.863	0.965	0.994	1.035	0.973	0.921	0.961	0.941	0.836	0.869
3	2.657	2.377	2.304	2.442	2.404	2.223	2.133	2.041	2.193	2.086	1.919
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.594	0.619	0.568	0.541	0.573	0.550	0.550	0.723	0.589	0.632	0.594
2	1.039	0.899	1.029	0.948	0.937	0.936	1.003	0.837	0.962	0.919	1.007
3	2.217	2.348	2.470	2.160	2.001	2.411	1.948	2.190	1.858	1.835	2.156
4	4.156	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972
5	6.174	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190
6	8.333	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362
7	9.889	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317
8	10.791	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352
9	12.175	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505
10	12.425	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408
+gp	13.731	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.590	0.583	0.635	0.585	0.673	0.737	0.670	0.699	0.699	0.677	0.721
2	0.932	0.856	0.976	0.881	1.052	0.976	1.078	1.146	1.065	1.075	1.021
3	2.141	1.834	1.955	1.982	1.846	2.176	2.038	2.546	2.479	2.201	2.210
4	4.164	3.504	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293
5	6.324	6.230	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220
6	8.430	8.140	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980
7	10.362	9.896	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282
8	12.074	11.940	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743
9	13.072	12.951	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107
10	14.443	13.859	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052
+gp	16.588	14.707	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.699	0.656	0.542	0.640	0.611	0.725	0.626	0.573	0.726	0.747	0.793
2	1.117	0.960	0.922	0.935	1.021	1.004	0.996	1.079	1.072	1.160	1.200
3	2.147	2.120	1.724	1.663	1.747	2.303	1.844	1.895	2.089	1.952	2.239
4	4.034	3.821	3.495	3.305	3.216	3.663	3.735	3.347	3.252	3.647	3.894
5	6.637	6.228	5.387	5.726	4.903	5.871	5.537	5.757	5.184	5.244	5.676
6	8.494	8.394	7.563	7.403	7.488	7.333	8.006	6.694	7.438	7.225	7.234
7	9.729	9.979	9.628	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.243
8	11.080	11.424	10.643	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477
9	12.264	12.300	11.499	11.600	10.894	12.062	11.888	11.518	11.857	12.015	12.325
10	12.756	12.761	13.085	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.830	1.06679	0.78826	0.71481	0.862	0.938	0.883	0.699	0.596	0.800
2	1.182	1.38884	1.41193	1.29224	1.328	1.369	1.240	1.213	1.206	1.315
3	2.365	2.45605	2.67433	2.67091	2.525	2.354	2.461	2.390	2.291	2.342
4	4.050	4.06299	4.14457	4.22308	4.596	4.175	4.164	4.180	4.112	3.862
5	6.053	6.22405	6.11913	6.04897	6.481	6.391	6.187	5.678	5.935	5.744
6	8.250	7.39317	7.48963	8.29925	7.843	8.115	8.347	7.435	6.920	7.342
7	9.262	9.65076	8.96797	9.47215	9.681	9.092	9.817	9.191	8.775	7.928
8	10.015	11.48868	11.44744	11.63072	9.629	11.799	9.486	9.180	9.622	8.717
9	12.282	11.38721	11.29135	12.82728	10.845	12.548	11.364	11.469	10.654	10.367
10	14.559	12.72507	11.71648	12.08332	14.436	11.436	10.935	16.456	13.838	11.926
+gp	17.522	15.38134	18.764	10.05238	12.421	20.644	29.764	34.656	30.079	19.623

Table 4.3b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Discard weights-at-age (includes BMS landings; kg).

Discards weights at age (kg)

AGE/YEAI	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.270	0.270	0.269	0.269	0.269	0.269	0.268	0.268	0.268	0.268	0.268
2	0.393	0.393	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
3	0.505	0.508	0.506	0.509	0.506	0.505	0.504	0.505	0.508	0.507	0.507
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.268	0.227	0.189	0.255	0.287	0.276	0.242	0.279	0.274	0.297	0.270
2	0.392	0.359	0.354	0.382	0.309	0.361	0.411	0.396	0.489	0.458	0.469
3	0.508	0.000	0.412	0.376	0.000	0.000	0.000	0.517	0.593	0.534	0.509
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.276	0.242	0.237	0.300	0.326	0.260	0.315	0.314	0.274	0.287	0.316
2	0.376	0.365	0.353	0.339	0.431	0.371	0.366	0.408	0.429	0.362	0.404
3	0.652	0.437	0.000	0.463	0.484	0.526	0.395	2.309	0.705	0.483	0.553
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.342	0.313	0.358	0.257	0.298	0.232	0.243	0.262	0.236	0.302	0.224
2	0.380	0.453	0.375	0.389	0.422	0.361	0.314	0.345	0.270	0.565	0.116
3	0.515	0.616	0.481	0.422	0.000	0.406	0.413	0.498	0.686	0.814	0.827
4	0.000	0.000	0.000	0.000	0.000	0.000	2.205	0.528	0.864	2.223	2.557
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.852	4.255	4.208
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.300	6.509	5.437
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.048
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.100	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.288	0.404	0.385	0.292	0.277	0.234	0.334	0.311	0.326	0.364
2	0.814	0.735	0.984	0.785	0.677	0.556	0.796	0.742	0.759	0.939
3	1.690	1.699	2.013	1.533	2.057	1.867	1.493	1.772	1.617	1.767
4	3.949	3.002	3.485	3.137	4.099	3.803	3.375	3.128	3.158	3.092
5	6.609	5.311	6.565	5.323	5.576	6.456	4.048	3.826	3.983	4.687
6	10.198	9.341	8.521	8.369	6.071	8.579	8.419	4.642	5.303	5.439
7	5.900	5.128	13.464	6.728	8.264	9.733	7.086	4.423	6.940	0.000
8	15.906	0.000	0.000	0.000	6.213	0.000	0.000	0.000	8.390	0.000
9	0.000	0.000	0.000	0.000	11.617	0.000	0.000	0.000	4.087	0.000
10	0.000	0.000	12.014	0.000	0.000	16.370	16.370	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.3c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Catch weights at age (kg), also assumed to represent stock weights-at-age.

Catch weights at age (kg)

AGE/YEAI	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.314	0.357	0.312	0.313	0.326	0.327	0.417	0.449	0.314	0.300	0.335
2	0.809	0.761	0.900	0.836	0.868	0.848	0.755	0.845	0.834	0.729	0.700
3	2.647	2.366	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.913
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886

AGE/YEAI	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.304	0.304	0.198	0.294	0.432	0.291	0.257	0.330	0.358	0.403	0.305
2	0.901	0.760	0.722	0.673	0.743	0.905	0.917	0.769	0.908	0.882	0.921
3	2.206	2.348	2.449	2.128	2.001	2.411	1.948	2.186	1.856	1.834	2.156
4	4.156	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972
5	6.174	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190
6	8.333	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362
7	9.889	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317
8	10.791	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352
9	12.175	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505
10	12.425	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408
+gp	13.731	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472

AGE/YEAI	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.314	0.293	0.437	0.466	0.364	0.382	0.393	0.395	0.326	0.305	0.420
2	0.800	0.782	0.773	0.753	0.932	0.690	0.889	0.970	0.846	0.788	0.768
3	2.132	1.822	1.955	1.975	1.810	2.165	1.995	2.546	2.477	2.188	2.206
4	4.164	3.504	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293
5	6.324	6.230	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220
6	8.430	8.140	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980
7	10.362	9.896	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282
8	12.074	11.940	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743
9	13.072	12.951	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107
10	14.443	13.859	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052
+gp	16.588	14.707	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954

AGE/YEAI	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.433	0.386	0.372	0.318	0.354	0.372	0.298	0.285	0.269	0.342	0.250
2	0.831	0.797	0.634	0.732	0.903	0.606	0.572	0.781	0.496	0.860	0.236
3	2.095	2.117	1.622	1.405	1.747	2.093	1.576	1.645	1.712	1.529	1.804
4	4.034	3.821	3.495	3.305	3.216	3.663	3.726	3.298	3.075	3.533	3.828
5	6.637	6.228	5.387	5.726	4.903	5.871	5.537	5.757	5.175	5.124	5.665
6	8.494	8.394	7.563	7.403	7.488	7.333	8.006	6.694	7.449	7.201	7.229
7	9.729	9.979	9.628	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.262
8	11.080	11.424	10.643	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477
9	12.264	12.300	11.499	11.600	10.894	12.062	11.888	11.518	11.857	11.384	12.325
10	12.756	12.761	13.085	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887

AGE/YEAI	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.313	0.424	0.406	0.33483	0.405	0.274	0.388	0.398	0.366	0.387
2	0.893	0.904	1.133	0.964822	0.915	0.800	0.932	0.927	0.945	1.049
3	2.001	1.966	2.355	2.426207	2.438	2.252	2.249	2.237	2.098	2.138
4	4.026	3.890	4.023	4.180381	4.569	4.154	4.060	4.083	4.031	3.803
5	6.117	6.207	6.154	6.032982	6.472	6.392	5.999	5.598	5.802	5.712
6	8.543	7.491	7.560	8.299303	7.829	8.117	8.360	7.392	6.761	7.332
7	9.255	9.644	9.733	9.47205	9.656	9.095	9.385	9.190	8.602	7.928
8	10.293	11.489	11.447	11.63072	9.461	11.799	9.486	9.180	9.410	8.717
9	12.282	11.387	11.291	12.82728	10.853	12.548	11.364	11.469	8.663	10.367
10	14.559	12.725	11.786	12.08332	14.436	11.754	11.680	16.456	13.838	11.926
+gp	17.522	15.381	18.764	10.05238	12.421	20.644	29.764	34.656	30.079	19.623

Table 4.3d. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch weights at age (kg) by season (quarter or annual, depending on data stratification) from InterCatch for 2016 (note, any differences in the +gp values between Tables 4.3a–c and Table 4.3d is due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.782	0.785	0.911	0.768	0.918	0.801
2	1.106	1.165	1.256	1.52	1.238	1.314
3	1.88	2.228	2.434	2.7	2.246	2.34
4	3.299	3.712	4.264	4.372	3.843	3.861
5	5.207	5.376	6.171	6.481	6.154	5.748
6	6.488	7.426	7.706	8.255	6.315	7.353
7	7.606	8.226	8.63	7.321	7.041	7.936
8	8.6	8.303	8.467	10.055	8.897	8.731
9	10.405	10.296	10.358	10.627	10.299	10.379
10	10.966	10.552	12.864	12.531	11.685	11.921
+gp	19.809	17.358	21.737	18.965	19.638	19.623

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.255	0.314	0.371	0.427	0.335	0.364
2	0.708	0.843	1.01	1.17	0.868	0.937
3	1.462	1.718	1.861	2.254	1.712	1.766
4	2.467	3.195	2.627	3.755	2.774	3.097
5	3.565	4.778	4.639	5.762	3.431	4.717
6	5.439	5.439	5.439	5.439	5.439	5.439
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0

Catch weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.27	0.326	0.383	0.466	0.348	0.386
2	0.813	0.896	1.08	1.33	0.961	1.047
3	1.712	2.005	2.284	2.588	1.98	2.136
4	3.253	3.673	4.14	4.293	3.832	3.803
5	5.143	5.365	6.147	6.44	6.143	5.717
6	6.486	7.418	7.688	8.226	6.315	7.342
7	7.606	8.226	8.63	7.321	7.041	7.936
8	8.6	8.303	8.467	10.055	8.897	8.731
9	10.405	10.296	10.358	10.627	10.299	10.379
10	10.966	10.552	12.864	12.531	11.685	11.921
+gp	19.809	17.358	21.737	18.965	19.638	19.623

Table 4.4. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Reported landings, estimated discards (including BMS landings) and total catch (landings + discards) in tons. Note any differences in values between Table 4.4 and those given in the report and advice are due to SOP correction.

year	landings	discards	catch
1963	115893	12199	128092
1964	125393	4656	130049
1965	180120	28973	209092
1966	220197	37862	258059
1967	251687	23285	274972
1968	286948	17468	304417
1969	199746	4757	204503
1970	224993	17663	242656
1971	326492	84007	410498
1972	352161	33603	385764
1973	237874	29966	267840
1974	213215	39533	252748
1975	204249	36841	241089
1976	233007	72397	305404
1977	208318	139027	347345
1978	294640	32434	327074
1979	266019	162278	428297
1980	293753	294208	587962
1981	333616	57076	390691
1982	302365	54008	356372
1983	257634	21430	279065
1984	227070	151004	378074
1985	214354	31298	245651
1986	201279	138604	339883
1987	216041	27706	243747
1988	183202	10504	193706
1989	139578	61656	201233
1990	124835	26747	151582
1991	101442	18199	119641
1992	112740	36193	148932
1993	119947	21412	141358
1994	109915	98208	208123
1995	136397	31707	168104
1996	124721	14030	138751
1997	122434	33184	155618
1998	144637	40102	184740
1999	94108	13642	107749
2000	69567	13360	82927
2001	48440	13519	61960
2002	53152	11901	65053
2003	30426	4007	34433
2004	27748	8721	36469
2005	28165	9932	38097
2006	25665	11923	37589
2007	24215	30422	54637
2008	26814	24984	51798
2009	33177	20846	54023
2010	36762	12341	49103
2011	31979	8711	40689
2012	32124	8638	40762
2013	30474	10289	40763
2014	34651	10538	45190
2015	37373	12537	49910
2016	38104	12203	50307

Table 4.5a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Proportion mature by age-group.

	Age					
	1	2	3	4	5	6+
1963	0.010	0.050	0.230	0.620	0.860	1.000
1964	0.010	0.050	0.230	0.620	0.860	1.000
1965	0.010	0.050	0.230	0.620	0.860	1.000
1966	0.010	0.050	0.230	0.620	0.860	1.000
1967	0.010	0.050	0.230	0.620	0.860	1.000
1968	0.010	0.050	0.230	0.620	0.860	1.000
1969	0.010	0.050	0.230	0.620	0.860	1.000
1970	0.010	0.050	0.230	0.620	0.860	1.000
1971	0.010	0.050	0.230	0.620	0.860	1.000
1972	0.010	0.050	0.230	0.620	0.860	1.000
1973	0.008	0.051	0.238	0.642	0.878	1.000
1974	0.008	0.053	0.229	0.617	0.846	1.000
1975	0.008	0.056	0.221	0.592	0.814	1.000
1976	0.007	0.057	0.214	0.567	0.784	1.000
1977	0.007	0.059	0.210	0.545	0.756	1.000
1978	0.007	0.060	0.207	0.525	0.731	1.000
1979	0.007	0.059	0.207	0.507	0.711	1.000
1980	0.007	0.059	0.207	0.494	0.697	1.000
1981	0.007	0.058	0.209	0.484	0.688	1.000
1982	0.006	0.057	0.213	0.479	0.686	1.000
1983	0.006	0.058	0.218	0.480	0.689	1.000
1984	0.006	0.061	0.227	0.487	0.698	1.000
1985	0.007	0.067	0.241	0.500	0.713	1.000
1986	0.007	0.075	0.262	0.518	0.731	1.000
1987	0.007	0.085	0.288	0.542	0.751	1.000
1988	0.007	0.095	0.320	0.570	0.774	1.000
1989	0.007	0.104	0.355	0.600	0.797	1.000
1990	0.007	0.111	0.389	0.632	0.819	1.000
1991	0.007	0.115	0.420	0.662	0.841	1.000
1992	0.008	0.115	0.444	0.691	0.860	1.000
1993	0.008	0.113	0.460	0.715	0.877	1.000
1994	0.008	0.111	0.468	0.736	0.893	1.000
1995	0.009	0.110	0.471	0.753	0.906	1.000
1996	0.010	0.115	0.471	0.767	0.916	1.000
1997	0.011	0.126	0.473	0.778	0.925	1.000
1998	0.012	0.144	0.481	0.787	0.933	1.000
1999	0.013	0.169	0.496	0.795	0.938	1.000
2000	0.015	0.198	0.520	0.802	0.943	1.000
2001	0.017	0.230	0.552	0.810	0.946	1.000
2002	0.019	0.261	0.591	0.818	0.949	1.000
2003	0.022	0.289	0.631	0.827	0.951	1.000
2004	0.024	0.313	0.671	0.835	0.952	1.000
2005	0.027	0.331	0.706	0.844	0.953	1.000
2006	0.031	0.344	0.734	0.852	0.954	1.000
2007	0.034	0.353	0.752	0.860	0.955	1.000
2008	0.037	0.360	0.762	0.867	0.956	1.000
2009	0.041	0.364	0.761	0.872	0.956	1.000
2010	0.045	0.367	0.752	0.876	0.955	1.000
2011	0.049	0.368	0.736	0.878	0.953	1.000
2012	0.052	0.367	0.712	0.877	0.951	1.000
2013	0.056	0.362	0.683	0.874	0.946	1.000
2014	0.060	0.355	0.649	0.868	0.941	1.000
2015	0.064	0.345	0.613	0.861	0.934	1.000
2016	0.067	0.333	0.575	0.852	0.927	1.000

Table 4.5b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Natural mortality by age-group.

	Age					
y	1	2	3	4	5	6
1963	1.215	0.777	0.221	0.2	0.2	0.2
1964	1.215	0.777	0.221	0.2	0.2	0.2
1965	1.215	0.777	0.221	0.2	0.2	0.2
1966	1.215	0.777	0.221	0.2	0.2	0.2
1967	1.215	0.777	0.221	0.2	0.2	0.2
1968	1.215	0.777	0.221	0.2	0.2	0.2
1969	1.215	0.777	0.221	0.2	0.2	0.2
1970	1.215	0.777	0.221	0.2	0.2	0.2
1971	1.215	0.777	0.221	0.2	0.2	0.2
1972	1.215	0.777	0.221	0.2	0.2	0.2
1973	1.215	0.777	0.221	0.2	0.2	0.2
1974	1.208	0.767	0.211	0.2	0.2	0.2
1975	1.233	0.746	0.211	0.2	0.2	0.2
1976	1.260	0.729	0.211	0.2	0.2	0.2
1977	1.286	0.715	0.211	0.2	0.2	0.2
1978	1.311	0.705	0.211	0.2	0.2	0.2
1979	1.332	0.701	0.211	0.2	0.2	0.2
1980	1.349	0.702	0.211	0.2	0.2	0.2
1981	1.360	0.706	0.211	0.2	0.2	0.2
1982	1.362	0.710	0.211	0.2	0.2	0.2
1983	1.357	0.715	0.212	0.2	0.2	0.2
1984	1.344	0.717	0.212	0.2	0.2	0.2
1985	1.325	0.718	0.213	0.2	0.2	0.2
1986	1.301	0.718	0.213	0.2	0.2	0.2
1987	1.274	0.718	0.214	0.2	0.2	0.2
1988	1.247	0.718	0.215	0.2	0.2	0.2
1989	1.220	0.720	0.215	0.2	0.2	0.2
1990	1.196	0.722	0.216	0.2	0.2	0.2
1991	1.174	0.723	0.216	0.2	0.2	0.2
1992	1.157	0.725	0.217	0.2	0.2	0.2
1993	1.144	0.727	0.217	0.2	0.2	0.2
1994	1.136	0.730	0.217	0.2	0.2	0.2
1995	1.129	0.734	0.218	0.2	0.2	0.2
1996	1.122	0.740	0.219	0.2	0.2	0.2
1997	1.115	0.748	0.220	0.2	0.2	0.2
1998	1.106	0.756	0.222	0.2	0.2	0.2
1999	1.097	0.767	0.224	0.2	0.2	0.2
2000	1.088	0.779	0.226	0.2	0.2	0.2
2001	1.084	0.795	0.229	0.2	0.2	0.2
2002	1.085	0.814	0.232	0.2	0.2	0.2
2003	1.091	0.835	0.235	0.2	0.2	0.2
2004	1.100	0.854	0.237	0.2	0.2	0.2
2005	1.112	0.871	0.238	0.2	0.2	0.2
2006	1.126	0.884	0.239	0.2	0.2	0.2
2007	1.141	0.893	0.238	0.2	0.2	0.2
2008	1.159	0.900	0.237	0.2	0.2	0.2
2009	1.180	0.907	0.236	0.2	0.2	0.2
2010	1.208	0.916	0.235	0.2	0.2	0.2
2011	1.242	0.929	0.234	0.2	0.2	0.2
2012	1.283	0.945	0.233	0.2	0.2	0.2
2013	1.326	0.962	0.233	0.2	0.2	0.2
2014*	1.326	0.962	0.233	0.2	0.2	0.2
2015*	1.326	0.962	0.233	0.2	0.2	0.2
2016*	1.326	0.962	0.233	0.2	0.2	0.2

***A new key run was performed in 2014 with data up to 2013 (ICES WGSAM 2014), so 2014–2016 M–values are assumed equal to 2013.**

Table 4.6. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Survey tuning indices for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices). Data used in the assessment are highlighted in bold font.

IBTS_Q1_gam							
1983	2017						
1	1	0	0.25				
1	5						
1	**4220.40**	**15101.08**	**1669.72**	**945.50**	**382.28**	392.64	1983
1	**12660.51**	**5915.62**	**2279.16**	**459.18**	**420.66**	186.86	1984
1	**587.27**	**15264.49**	**2031.00**	**790.08**	**220.93**	274.31	1985
1	**12460.11**	**2580.00**	**3284.99**	**976.50**	**411.11**	232.25	1986
1	**5117.07**	**14854.48**	**720.47**	**775.19**	**209.36**	201.54	1987
1	**2668.20**	**3628.00**	**3352.98**	**193.71**	**337.02**	218.21	1988
1	**9911.68**	**3455.08**	**2549.55**	**1153.73**	**166.94**	241.31	1989
1	**2003.38**	**7615.62**	**1110.60**	**427.35**	**463.34**	84.66	1990
1	**1688.78**	**2274.51**	**1878.34**	**497.87**	**266.58**	266.17	1991
1	**9397.05**	**3083.54**	**715.68**	**497.83**	**157.39**	68.24	1992
1	**3256.91**	**8071.12**	**954.55**	**337.85**	**249.70**	76.59	1993
1	**6977.64**	**2167.19**	**1531.42**	**469.75**	**230.70**	126.39	1994
1	**7097.39**	**9278.19**	**1752.55**	**507.37**	**182.70**	73.88	1995
1	**1821.62**	**4133.20**	**2278.84**	**382.63**	**255.43**	69.51	1996
1	**15374.10**	**2941.05**	**1172.68**	**521.77**	**151.57**	108.36	1997
1	**653.10**	**9956.82**	**1146.76**	**476.48**	**285.73**	108.92	1998
1	**1409.37**	**522.93**	**4045.88**	**565.34**	**283.97**	103.18	1999
1	**3521.01**	**2086.36**	**496.52**	**930.09**	**172.98**	107.89	2000
1	**848.19**	**3799.07**	**845.31**	**153.97**	**147.06**	56.05	2001
1	**2856.21**	**1543.76**	**1549.78**	**242.85**	**56.80**	60.21	2002
1	**357.56**	**1972.47**	**694.90**	**463.85**	**154.92**	31.79	2003
1	**2782.35**	**1237.20**	**1110.21**	**182.56**	**182.58**	70.44	2004
1	**1091.43**	**1460.96**	**475.74**	**386.57**	**68.45**	109.37	2005
1	**3880.07**	**872.16**	**745.96**	**149.54**	**86.01**	57.64	2006
1	**1440.08**	**2630.81**	**686.85**	**223.91**	**85.20**	66.39	2007
1	**2272.94**	**1065.76**	**1164.62**	**282.91**	**196.82**	50.76	2008
1	**1067.80**	**1759.51**	**805.16**	**381.55**	**123.54**	73.36	2009
1	**2855.36**	**1599.71**	**1131.84**	**314.15**	**201.29**	82.18	2010
1	**763.52**	**2904.98**	**605.13**	**330.66**	**209.76**	136.07	2011
1	**1545.33**	**1537.66**	**1870.05**	**412.38**	**224.30**	80.96	2012
1	**1623.41**	**1395.38**	**756.53**	**555.35**	**367.33**	100.03	2013
1	**2664.20**	**1721.43**	**740.43**	**284.46**	**345.36**	116.84	2014
1	**1672.34**	**3569.38**	**1244.41**	**445.51**	**195.97**	163.35	2015
1	**945.56**	**1089.25**	**1903.08**	**618.92**	**346.68**	136.67	2016
1	**8423.64**	**903.10**	**1246.49**	**1084.51**	**581.00**	149.33	2017
IBTS_Q3_gam							
1992	2016						
1	1	0.50	0.75				
1	4						
1	**17081.60**	**1666.24**	**379.69**	**337.26**	117.71	42.86	1992
1	**4431.27**	**4364.14**	**595.43**	**122.81**	91.54	7.68	1993
1	**17526.64**	**2254.95**	**939.10**	**159.35**	43.94	35.51	1994
1	**9506.04**	**6772.28**	**710.37**	**299.90**	34.23	18.85	1995
1	**5070.50**	**2895.85**	**1082.55**	**173.84**	141.43	12.65	1996
1	**29598.54**	**1981.85**	**731.26**	**264.97**	51.66	37.40	1997
1	**914.07**	**8896.76**	**713.86**	**191.80**	117.62	41.88	1998
1	**3427.58**	**472.96**	**2453.00**	**152.39**	41.83	18.11	1999
1	**6483.26**	**946.43**	**115.56**	**334.77**	37.94	33.38	2000
1	**1408.58**	**2162.29**	**373.44**	**75.50**	58.17	36.55	2001
1	**3989.91**	**874.65**	**759.18**	**191.76**	52.22	24.32	2002
1	**988.76**	**1279.93**	**247.11**	**176.27**	85.65	59.36	2003
1	**3214.66**	**778.98**	**479.20**	**92.26**	69.92	24.53	2004
1	**1103.80**	**741.99**	**285.82**	**117.04**	25.98	44.90	2005
1	**5571.79**	**708.41**	**603.26**	**117.52**	29.42	17.24	2006
1	**1890.11**	**2340.89**	**435.15**	**171.45**	99.38	46.17	2007
1	**2503.93**	**1201.73**	**1113.89**	**222.17**	121.23	31.43	2008
1	**1966.83**	**969.76**	**296.28**	**236.18**	52.55	25.80	2009
1	**4655.00**	**1691.04**	**544.13**	**178.92**	110.86	22.46	2010
1	**1232.77**	**2822.04**	**871.38**	**362.63**	103.88	98.37	2011
1	**2130.48**	**993.82**	**1236.00**	**367.43**	102.12	18.50	2012
1	**3204.62**	**1059.63**	**499.35**	**517.80**	139.06	63.33	2013
1	**3496.81**	**1477.29**	**610.79**	**293.73**	194.52	94.88	2014
1	**1899.50**	**3113.62**	**1082.07**	**459.08**	136.91	134.33	2015
1	**1449.41**	**1151.48**	**1703.03**	**830.31**	200.77	132.24	2016

Table 4.7a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run model specification (model.cfg file).

```
# Min Age (should not be modified unless data is modified accordingly)
1
 # Max Age (should not be modified unless data is modified accordingly)
6
 # Max Age considered a plus group (0=No, 1=Yes)
1
 # The following matrix describes the coupling
 # of fishing mortality
 # Rows represent fleets.
 # Columns represent ages.
1	2	3	4	5	6
0	0	0	0	0	0
0	0	0	0	0	0
# Use correlated random walks for the fishing mortalities
 # ( 0 = independent, 1 = correlation estimated)
2
 # Coupling of catchability PARAMETERS
0	0	0	0	0	0
1	2	3	4	5	0
6	7	8	9	0	0
 # Coupling of power law model EXPONENTS (if used)
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
 # Coupling of fishing mortality RW VARIANCES
1	2	2	2	2	2
0	0	0	0	0	0
0	0	0	0	0	0
 # Coupling of log N RW VARIANCES
1	2	2	2	2	2
 # Coupling of OBSERVATION VARIANCES
1	2	3	3	3	3
4	5	5	5	5	0
6	7	7	7	0	0
 # Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
0
 # Years in which catch data are to be scaled by an estimated parameter
 # first the number of years
13
 # Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
 # Them the model config lines years cols ages
 1  1  1  1  1  1
 2  2  2  2  2  2
 3  3  3  3  3  3
 4  4  4  4  4  4
 5  5  5  5  5  5
 6  6  6  6  6  6
 7  7  7  7  7  7
 8  8  8  8  8  8
 9  9  9  9  9  9
10 10 10 10 10 10
11 11 11 11 11 11
12 12 12 12 12 12
13 13 13 13 13 13
 # Define Fbar range
2	4
```

Table 4.7b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run model fitting diagnostics, parameter estimates and correlation matrix (.par and .cor files).

Number of parameters = 34 Objective function value = 158.690 Maximum gradient component = 0.0143493

The logarithm of the determinant of the hessian = 165.759

index	name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	logq Q1_1	-4.7852	0.089503	1																																	
2	logq Q1_2	-3.3108	0.052697	0.23	1																																
3	logq Q1_3	-2.6783	0.051348	0.17	0.31	1																															
4	logq Q1_4	-2.6277	0.057215	0.18	0.31	0.39	1																														
5	logq Q1_5	-2.3251	0.071925	0.18	0.33	0.41	0.54	1																													
6	logq Q3_1	-3.5869	0.081043	0.23	0.3	0.23	0.24	0.24	1																												
7	logq Q3_2	-2.9276	0.065918	0.2	0.37	0.33	0.34	0.35	0.28	1																											
8	logq Q3_3	-2.6469	0.069334	0.18	0.31	0.4	0.43	0.45	0.24	0.34	1																										
9	logq Q3_4	-2.622	0.080096	0.18	0.32	0.4	0.53	0.59	0.24	0.35	0.45	1																									
10	logSdLogF1	-1.9174	0.21298	-0	-0	-0	-0.1	-0.1	-0	-0	-0	-0.1	1																								
11	logSdLogF2+	-2.4159	0.13205	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	0.43	1																							
12	logSdLogN1	-0.21591	0.11504	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	1																						
13	logSdLogN2+	-2.108	0.13849	-0	0.01	-0	0.01	0.06	-0	0.02	-0	0	-0.1	-0.1	0.26	1																					
14	logSdLogC1	-0.5147	0.11311	0	0	0.01	0.02	0.02	-0	0.01	0.01	0.02	-0.1	-0	-0.1	-0.1	1																				
15	logSdLogC2	-1.4601	0.13406	0.01	0.01	0.03	0.03	0.03	0.02	0.03	0.03	0.03	-0	-0	-0	-0.1	0.06	1																			
16	logSdLogC3+	-2.7423	0.25919	-0	-0	-0	-0.1	-0.1	-0	-0	-0.1	-0.1	-0	-0	-0.1	-0.5	0.06	-0	1																		
17	logSdLogQ1_1	-0.76044	0.14213	0.05	0.02	0.03	0.03	0.02	0.05	0.03	0.03	0.03	0.02	0.01	-0.2	-0.2	0.03	0.02	0.08	1																	
18	logSdLogQ1_2+	-1.4359	0.070435	0.05	0.09	0.1	0.11	0.11	0.05	0.08	0.12	0.13	0.02	-0	-0.1	-0.1	0.02	-0	-0	0.05	1																
19	logSdLogQ3_1	-1.0963	0.17533	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.03	0.01	-0.2	-0.2	0.04	-0	0.09	0.18	0.09	1															
20	logSdLogQ3_2+	-1.3603	0.097628	0.02	0.03	0.04	0.07	0.09	0.02	0.03	0.06	0.09	0	-0.1	-0.1	-0.1	-0	-0	-0.1	0.04	0.06	0.06	1														
21	rho	0.90312	0.051382	-0	-0	0	0.01	0.05	-0	0.02	-0	0.01	-0	0.14	0.06	0.25	0.11	0.05	0.12	-0	-0.1	-0.1	-0.1	1													
22	logCmult 93	-0.06328	0.090792	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	0.02	0.07	0.02	0.02	-0	-0	0.05	-0	-0.1	-0.1	0.01	0.03	1												
23	logCmult 94	0.035855	0.097924	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.04	0.09	0.03	0.04	0	-0	0.02	-0	-0.1	-0.1	0.02	0.03	0.4	1											
24	logCmult 95	0.16545	0.10062	-0.2	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.03	0.14	0.02	0.01	0	-0	0.04	-0	-0.1	-0.1	-0	0.05	0.21	0.44	1										
25	logCmult 96	0.031797	0.10051	-0.1	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.01	0.13	0.03	0.02	-0	-0	0.03	-0	-0.1	-0.1	-0	0.04	0.14	0.22	0.45	1									
26	logCmult 97	-0.13804	0.097953	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0	0.05	0.01	-0	-0	-0	0.04	-0	0.01	-0.1	0.02	-0.1	0.1	0.13	0.2	0.41	1								
27	logCmult 98	-0.29607	0.098675	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.04	0.12	0.02	-0	-0	-0	0.02	-0	-0.1	-0.1	-0	-0	0.12	0.14	0.16	0.22	0.42	1							
28	logCmult 99	-0.11432	0.10182	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.09	0.24	0.04	0.08	-0	-0	-0	-0	-0.2	-0.1	-0	0.03	0.13	0.15	0.16	0.16	0.19	0.42	1						
29	logCmult 00	-0.06994	0.10052	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.06	0.19	0	-0	-0	-0	0.03	-0	-0.2	-0	0.04	-0	0.13	0.16	0.17	0.15	0.13	0.21	0.43	1					
30	logCmult 01	0.23521	0.098679	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0	0.05	0	-0	-0	0.03	0.02	-0	-0.1	-0	0.08	-0.1	0.12	0.15	0.16	0.15	0.15	0.13	0.14	0.19	0.41	1				
31	logCmult 02	-0.13818	0.097877	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	0.02	0.05	0.02	0.04	-0	-0	-0	-0	-0.1	-0	0.05	-0	0.11	0.14	0.15	0.14	0.15	0.14	0.13	0.12	0.14	0.2	0.41	1			
32	logCmult 03	0.40592	0.10106	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	0.04	0.14	-0	-0	-0	-0	0.07	-0	-0.1	0	0.05	-0	0.14	0.16	0.18	0.18	0.18	0.15	0.16	0.16	0.17	0.22	0.42	1		
33	logCmult 04	0.10979	0.098902	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	0.05	0.12	0	-0	-0	-0	0.04	-0	-0.1	0	0.05	0.02	0.12	0.15	0.17	0.16	0.14	0.15	0.15	0.15	0.15	0.14	0.2	0.44	1	
34	logCmult 05	-0.03937	9.06E-02	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	0.02	0.09	0.01	0.03	-0	-0.1	0.02	-0	-0.1	0	0.04	0.05	0.08	0.1	0.11	0.11	0.1	0.1	0.12	0.11	0.09	0.11	0.19	0.39	1

Table 4.8. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated fishing mortality at age.

Fishing mortality (F) at age

Year\Age	1	2	3	4	5	6+	Fbar 2-4
1963	0.080	0.446	0.514	0.465	0.461	0.465	0.475
1964	0.089	0.479	0.561	0.504	0.497	0.499	0.515
1965	0.104	0.528	0.620	0.546	0.529	0.524	0.565
1966	0.109	0.541	0.630	0.543	0.528	0.525	0.571
1967	0.119	0.575	0.669	0.577	0.567	0.562	0.607
1968	0.131	0.611	0.706	0.610	0.597	0.584	0.642
1969	0.124	0.588	0.671	0.579	0.572	0.561	0.613
1970	0.144	0.640	0.711	0.601	0.585	0.565	0.651
1971	0.183	0.738	0.800	0.668	0.643	0.613	0.735
1972	0.215	0.810	0.859	0.714	0.688	0.653	0.794
1973	0.221	0.813	0.837	0.691	0.662	0.622	0.780
1974	0.219	0.794	0.796	0.655	0.633	0.598	0.748
1975	0.250	0.860	0.854	0.699	0.675	0.630	0.804
1976	0.286	0.932	0.913	0.731	0.705	0.651	0.859
1977	0.272	0.897	0.874	0.691	0.679	0.632	0.821
1978	0.305	0.969	0.971	0.770	0.755	0.691	0.903
1979	0.281	0.908	0.921	0.721	0.694	0.633	0.850
1980	0.312	0.973	1.006	0.790	0.744	0.674	0.923
1981	0.311	0.979	1.029	0.810	0.748	0.677	0.939
1982	0.348	1.066	1.152	0.919	0.839	0.753	1.046
1983	0.339	1.056	1.146	0.924	0.836	0.747	1.042
1984	0.307	0.990	1.072	0.880	0.797	0.713	0.981
1985	0.286	0.950	1.028	0.860	0.777	0.694	0.946
1986	0.298	0.983	1.082	0.927	0.831	0.738	0.997
1987	0.282	0.958	1.063	0.923	0.824	0.731	0.981
1988	0.284	0.968	1.088	0.944	0.834	0.734	1.000
1989	0.289	0.981	1.104	0.965	0.852	0.747	1.017
1990	0.262	0.922	1.027	0.895	0.784	0.684	0.948
1991	0.250	0.898	1.016	0.900	0.797	0.691	0.938
1992	0.240	0.879	1.009	0.899	0.793	0.675	0.929
1993	0.237	0.880	1.032	0.918	0.805	0.674	0.943
1994	0.237	0.884	1.065	0.938	0.820	0.676	0.962
1995	0.242	0.909	1.122	0.978	0.852	0.689	1.003
1996	0.228	0.885	1.133	1.002	0.898	0.721	1.007
1997	0.208	0.839	1.109	0.999	0.907	0.717	0.982
1998	0.209	0.843	1.147	1.044	0.947	0.733	1.011
1999	0.216	0.867	1.222	1.129	1.031	0.782	1.073
2000	0.211	0.857	1.223	1.142	1.040	0.769	1.074
2001	0.190	0.797	1.137	1.071	0.973	0.704	1.002
2002	0.176	0.756	1.085	1.023	0.928	0.662	0.955
2003	0.174	0.747	1.079	1.002	0.897	0.625	0.943
2004	0.167	0.721	1.040	0.939	0.844	0.580	0.900
2005	0.153	0.678	0.974	0.861	0.793	0.540	0.838
2006	0.135	0.621	0.877	0.761	0.717	0.484	0.753
2007	0.120	0.569	0.816	0.705	0.666	0.441	0.697
2008	0.109	0.534	0.780	0.673	0.648	0.427	0.662
2009	0.104	0.517	0.769	0.670	0.646	0.415	0.652
2010	0.085	0.449	0.671	0.587	0.566	0.359	0.569
2011	0.063	0.368	0.55	0.487	0.473	0.301	0.468
2012	0.056	0.335	0.503	0.448	0.43	0.268	0.429
2013	0.052	0.322	0.489	0.435	0.412	0.251	0.415
2014	0.051	0.315	0.485	0.43	0.403	0.242	0.410
2015	0.046	0.295	0.454	0.408	0.388	0.234	0.386
2016	0.041	0.271	0.413	0.371	0.349	0.208	0.352

Table 4.9. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated population numbers at age. (Note, the recruitment value in the final year relies on a single data point only, and is therefore considered preliminary only).

Stock numbers at age (start of year) (thousands)

Year\Age	1	2	3	4	5	6+	Total
1963	483110	187025	20163	10340	8263	5299	714200
1964	788589	132455	51896	11569	5281	7169	996959
1965	1053891	226613	40457	23063	6247	5653	1355924
1966	1278247	277340	67846	16488	9481	6275	1655677
1967	1074107	338405	73057	28767	8084	8341	1530761
1968	537132	290106	90310	28941	14448	7220	968157
1969	469771	139386	72475	34235	11488	10227	737582
1970	1572221	129444	38793	32338	15452	8570	1796818
1971	2053385	418319	33557	14965	16071	10757	2547054
1972	505347	522301	90762	12156	5981	12966	1149513
1973	741181	118539	105873	29971	4963	7221	1007748
1974	725053	177371	23695	36498	11016	5660	979293
1975	1246687	168384	36754	9660	16436	7229	1485150
1976	861129	288370	33860	13623	3794	9922	1210698
1977	2115919	173859	50970	10803	5107	6197	2362855
1978	1298863	448202	30730	18770	5627	4650	1806842
1979	1639661	266999	80338	8918	7335	3541	2006792
1980	2655119	311763	58689	24563	3960	4687	3058781
1981	1043405	497325	58689	17608	8777	3626	1629430
1982	1723728	189094	92503	17007	6564	5608	2034504
1983	946002	321258	33024	21203	5393	4490	1331370
1984	1744537	178260	51689	7992	6713	3841	1993032
1985	416649	337392	32893	14746	2758	4202	808640
1986	1901208	85819	57642	10230	5598	2998	2063495
1987	714258	393958	16367	15434	2998	3369	1146384
1988	485046	152818	70263	5256	4926	2369	720678
1989	853414	107152	30303	17426	1836	2959	1013090
1990	328733	184979	20157	7914	5135	1691	548609
1991	377755	75358	30516	6057	2706	2998	495390
1992	883812	91491	14843	8892	2044	2084	1003166
1993	430198	204638	18090	5066	2886	1617	662495
1994	1056001	107259	36498	5592	1755	1749	1208854
1995	604405	255506	23624	10463	1831	1341	897170
1996	382697	142914	40538	5762	3395	1440	576746
1997	1218340	100308	26291	9735	1882	1713	1358269
1998	121176	313013	21677	7255	3143	1282	467546
1999	248699	33124	55715	5751	2152	1631	347072
2000	456343	66703	8403	10289	1552	1102	544392
2001	162592	127389	13996	2248	2342	760	309327
2002	248699	48339	25413	4030	619	981	328081
2003	119253	67643	10757	7488	1138	549	206828
2004	202197	37049	14066	3158	2086	594	259150
2005	153430	53210	8027	3513	1025	1073	220278
2006	360411	45844	12247	2251	1116	931	422800
2007	168721	100308	9912	4239	993	813	284986
2008	195243	46305	23365	3292	1673	999	270877
2009	190042	53370	11166	7793	1438	1156	264965
2010	294490	54394	12967	4072	3309	1100	370332
2011	143631	79459	13318	4478	1806	2216	244908
2012	201189	40619	20173	6238	2035	1954	272208
2013	265136	52052	11255	9211	3094	1908	342656
2014	380408	67373	15626	5392	4517	2417	475733
2015	184979	101926	20948	7126	2673	4211	321863
2016	134592	46537	29231	11717	3879	3304	229260
2017	690382	33124	14641	15480	6566	4438	764631

Table 4.10. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated total removals at age (including catches due to unaccounted mortality).

Total removals at age (thousands)

Year\Age	1	2	3	4	5	6+
1963	21692	48378	7372	3512	2786	1801
1964	39226	36305	20292	4187	1891	2574
1965	61102	67131	17036	8870	2347	2108
1966	77234	83726	28889	6323	3554	2345
1967	70856	107194	32500	11545	3201	3282
1968	38735	96240	41719	12095	5942	2923
1969	32190	44909	32290	13775	4579	4019
1970	124008	44471	18011	13372	6267	3384
1971	202481	159500	16890	6683	6985	4512
1972	57890	212862	47863	5690	2726	5697
1973	87317	48417	54929	13721	2201	3064
1974	84466	71303	11881	16074	4732	2332
1975	162413	72049	19307	4452	7394	3095
1976	125455	131046	18565	6480	1759	4351
1977	291589	77428	27176	4942	2308	2658
1978	196438	210681	17499	9249	2737	2127
1979	228845	120536	44285	4201	3366	1521
1980	403689	147178	34146	12319	1907	2106
1981	157613	235414	34617	8978	4242	1635
1982	287104	94268	58157	9403	3425	2723
1983	154338	158991	20715	11770	2808	2167
1984	262630	84643	31201	4301	3386	1796
1985	59249	155998	19376	7821	1367	1929
1986	282745	40542	34954	5686	2903	1436
1987	102120	183157	9826	8556	1545	1603
1988	70523	71489	42758	2957	2560	1130
1989	127313	50514	18569	9930	968	1429
1990	45324	83684	11852	4304	2562	768
1991	50383	33493	17828	3305	1365	1372
1992	114234	40059	8632	4850	1027	938
1993	55354	89608	10660	2800	1465	727
1994	136162	47061	21907	3133	902	788
1995	79682	113971	14608	6010	965	612
1996	47868	62499	25175	3360	1850	678
1997	140787	42193	16130	5667	1032	804
1998	14075	131623	13542	4334	1771	611
1999	29956	14139	36001	3593	1276	812
2000	53992	28133	5427	6468	925	543
2001	17427	50782	8674	1363	1341	352
2002	24907	18440	15318	2379	344	435
2003	11770	25369	6458	4366	620	234
2004	19088	13440	8260	1770	1093	239
2005	13317	18345	4528	1864	515	409
2006	27678	14707	6473	1100	524	327
2007	11487	29992	4999	1966	442	265
2008	12088	13136	11447	1477	731	317
2009	11148	14708	5417	3486	627	358
2010	13997	13310	5726	1654	1308	302
2011	5087	16368	5079	1576	622	524
2012	6164	7668	7180	2056	650	419
2013	7528	9420	3923	2968	954	386
2014	10498	11985	5408	1722	1368	473
2015	4646	17120	6880	2178	784	798
2016	2980	7235	8893	3311	1042	564

Table 4.11a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated stock and management metrics, together with the lower and upper bounds of the point-wise 95% confidence intervals.

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), total removals (including catches due to unaccounted mortality) and average fishing mortality for ages 2 to 4 (Fbar 2-4).

Year	Recruits age 1 ('000)	Low	High	TSB (tons)	Low	High	SSB (tons)	Low	High	Total removals (tons)	Low	High	Fbar 2-4	Low	High
1963	483110	349319	668145	513497	438137	601819	152665	117109	199016	118658	105216	133817	0.475	0.41	0.551
1964	788589	571249	1088618	658026	556859	777572	164226	128553	209798	144640	131123	159549	0.515	0.45	0.589
1965	1053891	766446	1449139	836515	715290	978285	200186	161814	247657	198789	177447	222698	0.565	0.495	0.645
1966	1278247	930651	1755668	1001491	857474	1169695	222348	180849	273370	241591	216177	269992	0.571	0.503	0.649
1967	1074107	781773	1475755	1054946	914284	1217249	251954	205241	309298	287506	256837	321838	0.607	0.537	0.687
1968	537132	390155	739478	880284	781792	991185	263024	221204	312750	293608	266523	323446	0.642	0.567	0.727
1969	469771	339069	650854	731608	644661	830281	259367	215924	311550	225934	208754	244529	0.613	0.543	0.691
1970	1572221	1142786	2163029	1196606	984137	1454947	270493	226492	323041	252458	221947	287184	0.651	0.58	0.73
1971	2053385	1487340	2834851	1339759	1125412	1594929	274855	230529	327704	351512	302149	408941	0.735	0.658	0.821
1972	505347	365668	698381	924492	815687	1047811	244263	204784	291352	363669	318371	415412	0.794	0.711	0.888
1973	741181	536660	1023645	738222	651018	837108	215130	186622	247995	259367	236223	284779	0.781	0.699	0.872
1974	725053	524101	1003054	709276	624613	805414	230499	199858	265837	235861	210833	263861	0.748	0.67	0.836
1975	1246687	894124	1738268	808552	684352	955292	207939	178737	241912	245242	213987	281062	0.804	0.723	0.895
1976	861129	613429	1208850	640497	560241	732251	177194	150206	209031	246225	213817	283545	0.859	0.77	0.957
1977	2115919	1516082	2953082	994505	803619	1230732	150091	127632	176504	260928	214756	317026	0.821	0.737	0.914
1978	1298863	927307	1819296	1115708	926223	1343959	149492	131526	169913	353274	291578	428025	0.903	0.813	1.003
1979	1639661	1174579	2288896	1036127	876516	1224802	147561	130986	166234	338405	289778	395193	0.85	0.766	0.944
1980	2655119	1893467	3723148	1260476	1037421	1531490	161135	143915	180416	391601	324651	472359	0.923	0.834	1.021
1981	1043405	746208	1458968	1034057	891574	1199309	168890	152127	187499	396329	338119	464561	0.939	0.851	1.036
1982	1723728	1248533	2379783	1129177	939298	1357441	168384	150984	187789	384616	326361	453269	1.046	0.949	1.152
1983	946002	696205	1285425	884697	757607	1033106	137861	123131	154352	324811	277035	380828	1.042	0.947	1.147
1984	1744537	1285965	2366636	918043	763897	1103295	119970	106804	134760	280688	238026	330997	0.981	0.891	1.079
1985	416649	302090	574652	589482	519522	668864	118777	105647	133539	244263	211398	282237	0.946	0.859	1.043
1986	1901208	1404202	2574124	829020	674617	1018763	109426	98260	121860	230268	192352	275658	0.997	0.907	1.096
1987	714258	529199	964032	755398	646841	882173	113210	101455	126327	261189	220411	309512	0.981	0.893	1.079
1988	485046	358807	655701	548532	477467	630173	111413	101393	122423	206489	183197	232741	1	0.91	1.099
1989	853414	628191	1159385	563544	472398	672274	103363	93549	114207	180412	155151	209787	1.017	0.924	1.118
1990	328733	244019	442856	373996	327992	426452	92503	83334	102682	139665	122035	159842	0.948	0.859	1.046
1991	377755	282044	505943	342833	297585	394962	90219	80708	100851	118539	105266	133487	0.938	0.851	1.034
1992	883812	664414	1175660	545796	451988	659073	86250	77644	95809	141775	119560	168118	0.929	0.844	1.022
1993	430198	327958	564311	414986	364451	472528	89054	80852	98089	149194	128861	172735	0.943	0.857	1.038
1994	1056001	795941	1401032	540365	453917	643277	94940	86746	103908	154199	132927	178875	0.962	0.876	1.057
1995	604405	458282	797120	573206	493326	666019	107474	98649	117087	191952	164729	223673	1.003	0.913	1.101
1996	382697	291571	502304	428480	377604	486212	107259	98508	116787	157629	140082	177375	1.007	0.918	1.104
1997	1218340	905588	1639103	669978	542151	827943	96568	88463	105415	157472	131735	188236	0.982	0.896	1.077
1998	121176	91006	161348	331705	291364	377631	92689	84209	102022	140505	120651	163626	1.011	0.924	1.107
1999	248699	189932	325651	226160	202375	252741	83784	76479	91787	96182	88076	105035	1.073	0.979	1.175
2000	456343	348210	598056	286359	243080	337342	64926	58876	71597	83868	72722	96722	1.074	0.98	1.177
2001	162592	123656	213788	195438	172816	221022	61145	55396	67491	71254	62870	80755	1.002	0.911	1.101
2002	248699	189639	326152	168552	147640	192427	56162	50994	61855	56557	51183	62495	0.955	0.867	1.051
2003	119253	90396	157320	140365	125831	156578	58454	53149	64289	53745	48264	59847	0.943	0.851	1.044
2004	202197	154492	264633	122149	106713	139818	46397	41772	51536	38949	35445	42799	0.9	0.811	0.999
2005	153430	115696	203471	136489	118721	156917	49021	43284	55518	39656	35120	44778	0.838	0.753	0.932
2006	360411	275714	471126	145656	122152	173682	43739	38216	50061	31952	28380	35975	0.753	0.671	0.845
2007	168721	129578	219687	192721	169553	219055	76191	67373	86184	53423	46803	60980	0.697	0.618	0.785
2008	195243	149669	254694	202197	176702	231372	82619	73230	93213	52470	47726	57686	0.663	0.584	0.752
2009	190042	145717	247850	213844	187226	244246	90853	79736	103520	54885	49657	60664	0.652	0.57	0.745
2010	294490	224520	386265	229349	196905	267139	91126	78306	106045	48923	44469	53822	0.569	0.491	0.659
2011	143631	109811	187865	213416	184324	247101	100609	84147	120292	44936	40614	49719	0.468	0.4	0.548
2012	201189	154378	262194	188905	162530	219561	99211	81972	120074	40336	37320	43595	0.428	0.364	0.504
2013	265136	203138	346057	249447	212920	292239	107689	89078	130187	41731	38379	45376	0.415	0.355	0.486
2014	380408	290355	498391	315212	266688	372564	115960	96335	139583	45798	41673	50331	0.41	0.353	0.477
2015	184979	138890	246363	282660	242903	328925	134323	110731	162941	51431	46702	56639	0.386	0.331	0.45
2016	134592	93584	193567	255761	217702	300474	139804	114984	169982	50716	46948	54786	0.352	0.296	0.418
2017							167711	132341	212535						

Table 4.11b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated landings, discards, catch (=landings + discards) and total removals in tons. Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch (after removing unaccounted mortality), while total removals are the SAM estimate of catch, including a catch multiplier incorporated from 1993 to 2005 only.

Year	Landings	Discards	Catch	Catch multiplier	Total Removals
1963	107581	10982	118658		118658
1964	134996	9673	144640		144640
1965	181498	17187	198789		198789
1966	215130	26450	241591		241591
1967	260928	26689	287506		287506
1968	276509	17021	293608		293608
1969	216425	9541	225934		225934
1970	232582	20054	252458		252458
1971	293021	58454	351512		351512
1972	329062	34303	363669		363669
1973	234451	24860	259367		259367
1974	209609	26134	235861		235861
1975	208772	36316	245242		245242
1976	201995	44312	246225		246225
1977	182408	78669	260928		260928
1978	305285	47954	353274		353274
1979	276509	62007	338405		338405
1980	290396	101620	391601		391601
1981	342833	53370	396329		396329
1982	321579	63007	384616		384616
1983	287506	37123	324811		324811
1984	210871	69633	280688		280688
1985	215777	28368	244263		244263
1986	169736	60476	230268		230268
1987	227977	33157	261189		261189
1988	191760	14694	206489		206489
1989	138968	41357	180412		180412
1990	116192	23482	139665		139665
1991	102642	15845	118539		118539
1992	109426	32273	141775		141775
1993	130651	28319	158940	0.94	149194
1994	106101	42665	148768	1.04	154199
1995	130947	31842	162682	1.18	191952
1996	131426	21159	152696	1.03	157629
1997	133926	46866	180781	0.87	157472
1998	146983	41985	188918	0.74	140505
1999	94781	13085	107831	0.89	96182
2000	73272	16670	89944	0.93	83868
2001	44747	11577	56319	1.27	71254
2002	53486	11480	64937	0.87	56557
2003	31104	4688	35813	1.50	53745
2004	27316	7595	34899	1.12	38949
2005	29863	11377	41248	0.96	39656
2006	22697	9256	31952		31952
2007	24077	29319	53423		53423
2008	27092	25387	52470		52470
2009	33223	21627	54885		54885
2010	36279	12655	48923		48923
2011	34441	10489	44936		44936
2012	32696	7637	40336		40336
2013	30853	10872	41731		41731
2014	34752	11049	45798		45798
2015	38139	13317	51431		51431
2016	38330	12352	50716		50716

Table 4.11c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM final run estimated catch multipliers, together with the lower and upper bounds of the point–wise 95% confidence intervals.

year	Catch multiplier	Low	High
1993	0.94	0.78	1.13
1994	1.04	0.85	1.26
1995	1.18	0.96	1.44
1996	1.03	0.84	1.26
1997	0.87	0.72	1.06
1998	0.74	0.61	0.91
1999	0.89	0.73	1.09
2000	0.93	0.76	1.14
2001	1.27	1.04	1.54
2002	0.87	0.72	1.06
2003	1.50	1.23	1.84
2004	1.12	0.92	1.36
2005	0.96	0.80	1.15

Table 4.12a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Catch options using the SAM estimate of recruitment in the intermediate year (October forecast procedure). Units are '000t (SSB, landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2017) = F(2016) =	**0.35**
SAM estimate of recruitment =	**692**
SSB(2018) =	**204267**
HC landings (2017) =	**41939**
Discards (2017) =	**13268**

Rationale	Catch (2018)	Landings (2018)	Discards (2018)	Basis	Ftotal (2018)	F land (2018)	F disc (2018)	SSB (2019)	SSB 5% (2019)	%SSB change	%TAC change
Management Plan	74748	51393	23355	EU MP	0.40	0.26	0.14	202395	148739	-1	9
Management Plan	74748	51393	23355	EU-Norway	0.40	0.26	0.14	202395	148739	-1	9
MSY approach	59888	41309	18579	FMSY *SSB2017/Btrigger	0.31	0.20	0.11	216473	160410	6	-12
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	275777	207436	35	-100
MSY	59888	41309	18579	FMSY	0.31	0.20	0.11	216473	160410	6	-12
Fpa	73133	50297	22836	Flim/1.4	0.39	0.25	0.14	203811	149971	0	7
Flim	95963	65753	30210	Flim	0.54	0.35	0.19	182048	133287	-11	40
SSB(2019)=Blim	178836	119859	58977	SSB(2019)=Blim	1.29	0.84	0.45	107000	75658	-48	155
SSB(2019)=Bpa	130185	88465	41720	SSB(2019)=Bpa	0.80	0.52	0.28	150000	108828	-27	88
SSB(2019)=Btrigger	130185	88465	41720	SSB(2019)=Btrigger	0.80	0.52	0.28	150000	108828	-27	88
TAC constraint	55135	37618	17517	TAC2017 - 20%	0.28	0.18	0.10	220655	156450	8	-20
TAC constraint	58613	39970	18643	TAC2017 - 15%	0.30	0.19	0.11	217094	153255	6	-15
TAC constraint	62089	42321	19768	TAC2017 - 10%	0.32	0.21	0.11	213494	150030	5	-10
TAC constraint	65567	44672	20895	TAC2017 - 5%	0.34	0.22	0.12	210182	146909	3	-5
TAC constraint	69046	47023	22023	TAC2017	0.36	0.24	0.12	206804	143867	1	0
TAC constraint	72530	49374	23156	TAC2017 + 5%	0.38	0.25	0.13	203532	140829	0	5
TAC constraint	76018	51725	24293	TAC2017 + 10%	0.40	0.26	0.14	200116	137793	-2	10
TAC constraint	79508	54076	25432	TAC2017 + 15%	0.42	0.28	0.14	196951	134710	-4	15
TAC constraint	83010	56428	26582	TAC2017 + 20%	0.45	0.29	0.16	193442	131411	-5	20
Status quo	66900	46061	20839	Fsq	0.35	0.23	0.12	209849	154899	3	-2
FMSY lower	40280	27842	12438	FMSY lower	0.20	0.13	0.07	235401	175094	15	-41
FMSY upper with AR	84146	57763	26383	FMSY upper with AR	0.46	0.30	0.16	193223	141819	-5	23

Rationale	Ftotal (2019)	Ftotal (2020)	Catch (2019)	Catch (2020)	Landings (2019)	Landings (2020)	Discards (2019)	Discards (2020)	SSB (2020)	SSB (2021)	%change SSB 20:18	%change SSB 21:18
Management Plan	0.40	0.40	75799	71689	56353	58283	19446	13406	209498	197462	3	-3
Management Plan	0.40	0.40	75799	71689	56353	58283	19446	13406	209498	197462	3	-3
MSY approach	0.31	0.31	64950	65740	48963	54479	15987	11261	241628	239683	18	17
Zero Catch	0.00	0.00	0	0	0	0	0	0	397724	499363	95	144
MSY	0.31	0.31	64950	65740	48963	54479	15987	11261	241628	239683	18	17
Fpa	0.39	0.39	74746	71284	55665	58058	19081	13226	212541	201560	4	-1
Flim	0.54	0.54	87314	75321	64202	59178	23112	16143	170192	147916	-17	-28
SSB(2019)=Blim	1.29	1.29	96613	60877	64827	37665	31786	23212	65413	47194	-68	-77
SSB(2019)=Bpa	0.80	0.80	97334	73178	69584	53460	27750	19718	117475	91582	-42	-55
SSB(2019)=Btrigger	0.80	0.80	97334	73178	69584	53460	27750	19718	117475	91582	-42	-55
TAC constraint	0.22	0.18	50015	44707	37618	37618	12397	7089	266587	293577	31	44
TAC constraint	0.24	0.20	53238	47678	39970	39970	13268	7708	258615	280671	27	37
TAC constraint	0.26	0.23	56450	50671	42321	42321	14129	8350	250735	267939	23	31
TAC constraint	0.29	0.25	59693	53699	44672	44672	15021	9027	242540	255515	19	25
TAC constraint	0.31	0.27	62944	56771	47023	47023	15921	9748	233903	242036	15	18
TAC constraint	0.34	0.30	66206	59890	49374	49374	16832	10516	225301	228452	10	12
TAC constraint	0.36	0.33	69466	63014	51725	51725	17741	11289	217435	215626	6	6
TAC constraint	0.39	0.37	72761	66209	54076	54076	18685	12133	209168	201237	2	-1
TAC constraint	0.42	0.41	76073	69493	56428	56428	19645	13065	201124	188344	-2	-8
Status quo	0.35	0.35	70309	69069	52790	56786	17519	12283	226025	218394	11	7
FMSY lower	0.20	0.20	47685	52549	36254	44407	11431	8142	286697	308835	40	51
FMSY upper with AR	0.46	0.46	81584	73771	60150	59101	21434	14670	190938	174096	-7	-15

Table 4.12b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Catch options using recruitments resampled from 1998–2016 in the intermediate year (May forecast procedure). Units are '000t (SSB, landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2017) = F(2016) =	**0.35**
Recruitment resampled from 1998-2016 =	**195**
SSB(2018) =	**159676**
HC landings (2017) =	**40648**
Discards (2017) =	**9029**

Rationale	Catch (2018)	Landings (2018)	Discards (2018)	Basis	Ftotal (2018)	F land (2018)	F disc (2018)	SSB (2019)	SSB 5% (2019)	%SSB change	%TAC change	Ftotal (2019)	Ftotal (2020)	Catch (2019)	Catch (2020)	Landings (2019)	Landings (2020)	Discards (2019)	Discards (2020)	SSB (2020)	SSB (2021)	%change SSB 20:18	%change SSB 21:18
Management Plan	52832	42088	10744	EU MP	0.40	0.26	0.14	153191	118215	-4	-10	0.40	0.40	49786	49698	38030	37522	11756	12176	148796	146938	-7	-8
Management Plan	52832	42088	10744	EU-Norway	0.40	0.26	0.14	153191	118215	-4	-10	0.40	0.40	49786	49698	38030	37522	11756	12176	148796	146938	-7	-8
MSY approach	42362	33814	8548	FMSY *SSB2017/Btrigger	0.31	0.20	0.11	164073	127533	3	-28	0.31	0.31	42607	44610	32959	34512	9648	10098	168244	174249	5	9
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	210542	165923	32	-100	0.00	0.00	0	0	0	0	0	0	266027	330706	67	107
MSY	42362	33814	8548	FMSY	0.31	0.20	0.11	164073	127533	3	-28	0.31	0.31	42607	44610	32959	34512	9648	10098	168244	174249	5	9
Fpa	51709	41204	10505	Flim/1.4	0.39	0.25	0.14	154367	119086	-3	-12	0.39	0.39	49061	49260	37538	37280	11523	11980	150773	149647	-6	-6
Flim	67683	53714	13969	Flim	0.54	0.35	0.19	137768	105221	-14	14	0.54	0.54	57944	53833	43357	39542	14587	14291	123632	114943	-23	-28
SSB(2019)=Blim	98063	77196	20867	SSB(2019)=Blim	0.89	0.58	0.31	107000	79431	-33	64	0.89	0.89	67064	54813	47712	36381	19352	18432	81547	68006	-49	-57
SSB(2019)=Bpa	55888	44494	11394	SSB(2019)=Bpa	0.43	0.28	0.15	150000	115847	-6	-5	0.43	0.43	51684	50885	39282	38189	12402	12696	143215	139707	-10	-13
SSB(2019)=Btrigger	55888	44494	11394	SSB(2019)=Btrigger	0.43	0.28	0.15	150000	115847	-6	-5	0.43	0.43	51684	50885	39282	38189	12402	12696	143215	139707	-10	-13
TAC constraint	47042	37618	9424	TAC2017 - 20%	0.35	0.23	0.12	159016	118201	0	-20	0.38	0.38	48808	48799	37618	37618	11190	11181	155916	154735	-2	-3
TAC constraint	50014	39970	10044	TAC2017 - 15%	0.37	0.24	0.13	155857	115308	-2	-15	0.42	0.43	52030	52334	39970	39970	12060	12364	148714	143437	-7	-10
TAC constraint	52988	42321	10667	TAC2017 - 10%	0.40	0.26	0.14	152671	112349	-4	-10	0.46	0.49	55259	55998	42321	42321	12938	13677	142138	132279	-11	-17
TAC constraint	55961	44672	11289	TAC2017 - 5%	0.43	0.28	0.15	149413	109387	-6	-5	0.50	0.56	58565	59703	44672	44672	13893	15031	135291	121702	-15	-24
TAC constraint	58941	47023	11918	TAC2017	0.46	0.30	0.16	146327	106405	-8	0	0.55	0.64	61890	63475	47023	47023	14867	16452	128497	110159	-20	-31
TAC constraint	61922	49374	12548	TAC2017 + 5%	0.48	0.32	0.16	143192	103339	-10	5	0.60	0.75	65272	67574	49374	49374	15898	18200	121640	98199	-24	-39
TAC constraint	64908	51725	13183	TAC2017 + 10%	0.51	0.33	0.18	140095	100332	-12	10	0.66	0.87	68731	71868	51725	51725	17006	20143	114715	87063	-28	-45
TAC constraint	67900	54076	13824	TAC2017 + 15%	0.54	0.35	0.19	136978	97333	-14	15	0.72	1.02	72229	76373	54076	54076	18153	22297	107893	75742	-32	-53
TAC constraint	70898	56428	14470	TAC2017 + 20%	0.57	0.37	0.20	133893	94345	-16	20	0.79	1.22	75741	81237	56428	56428	19313	24809	101474	64134	-36	-60
Status quo	47446	37855	9591	Fsq	0.35	0.23	0.12	158698	123079	-1	-19	0.35	0.35	46253	47327	35621	36202	10632	11125	158528	160423	-1	0

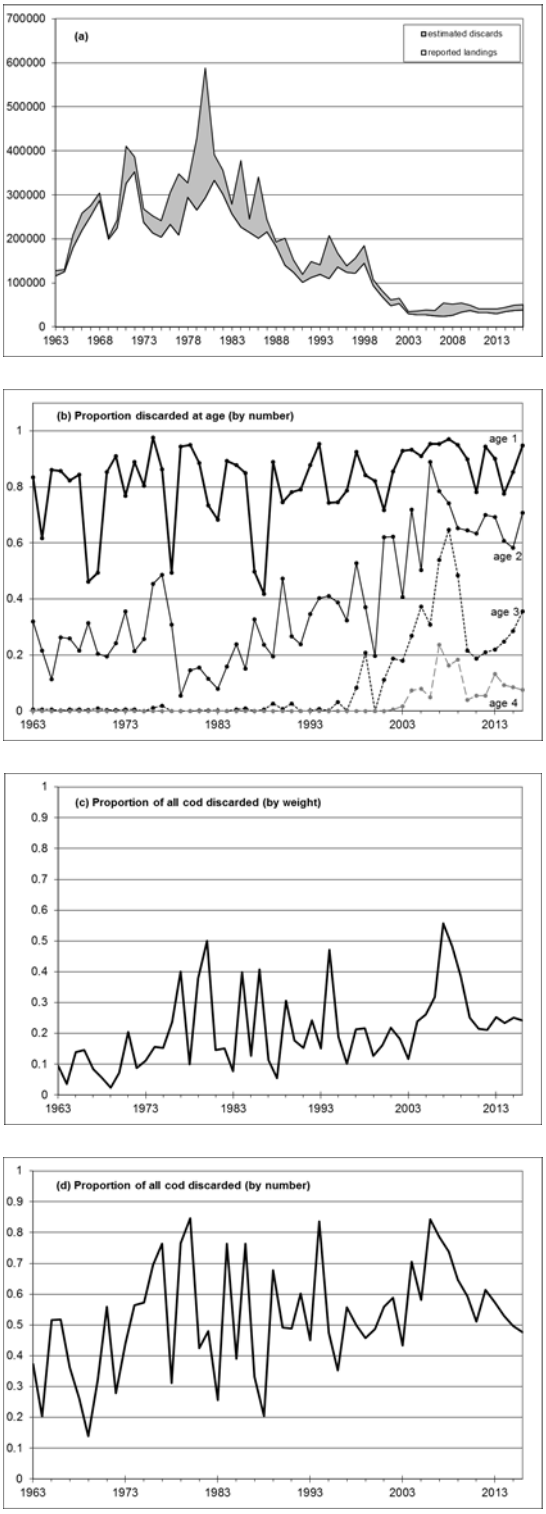


Figure 4.1. Cod in Subarea 4, Divisions 7.d and Subdivision 20: (a) stacked area plot of reported landings and estimated discards (including BMS landings; in tons); (b) proportion of total numbers caught at age that are discarded; (c) proportion of total weight caught that is discarded; (d) and proportion of the total numbers caught that are discarded.

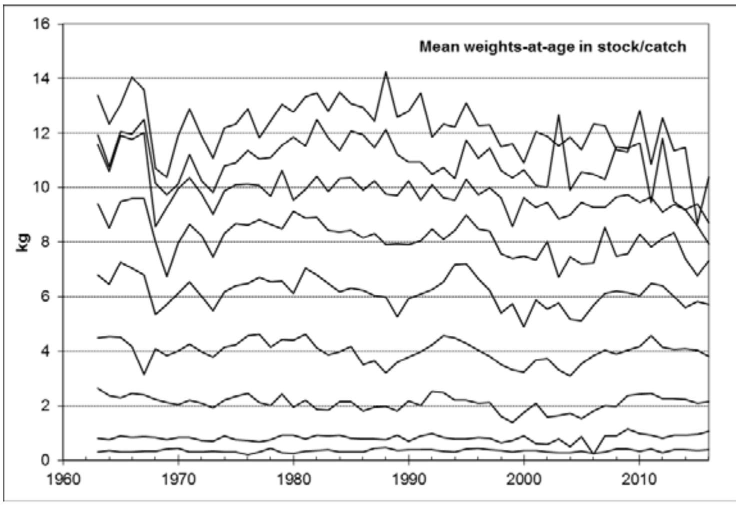


Figure 4.2a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Mean weight at age in the catch for ages 1–9.

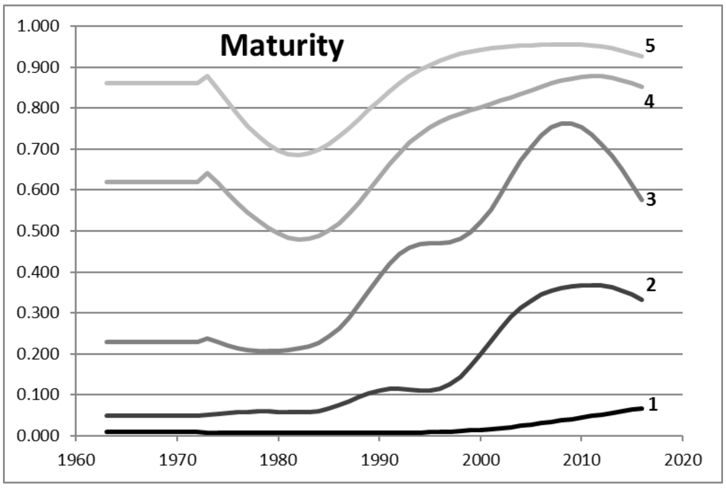


Figure 4.2b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Annually varying maturity-at-age. Values for 1963–1972 are the former constant maturity values used for cod.

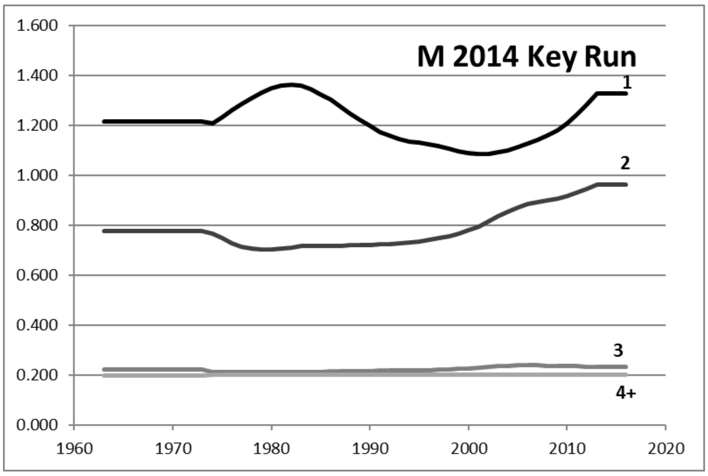


Figure 4.2c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2014 key run (ICES WGSAM 2014). Values for 1963–1972 are set equal to the 1973 value, while 2014–2016 are set equal to 2013.

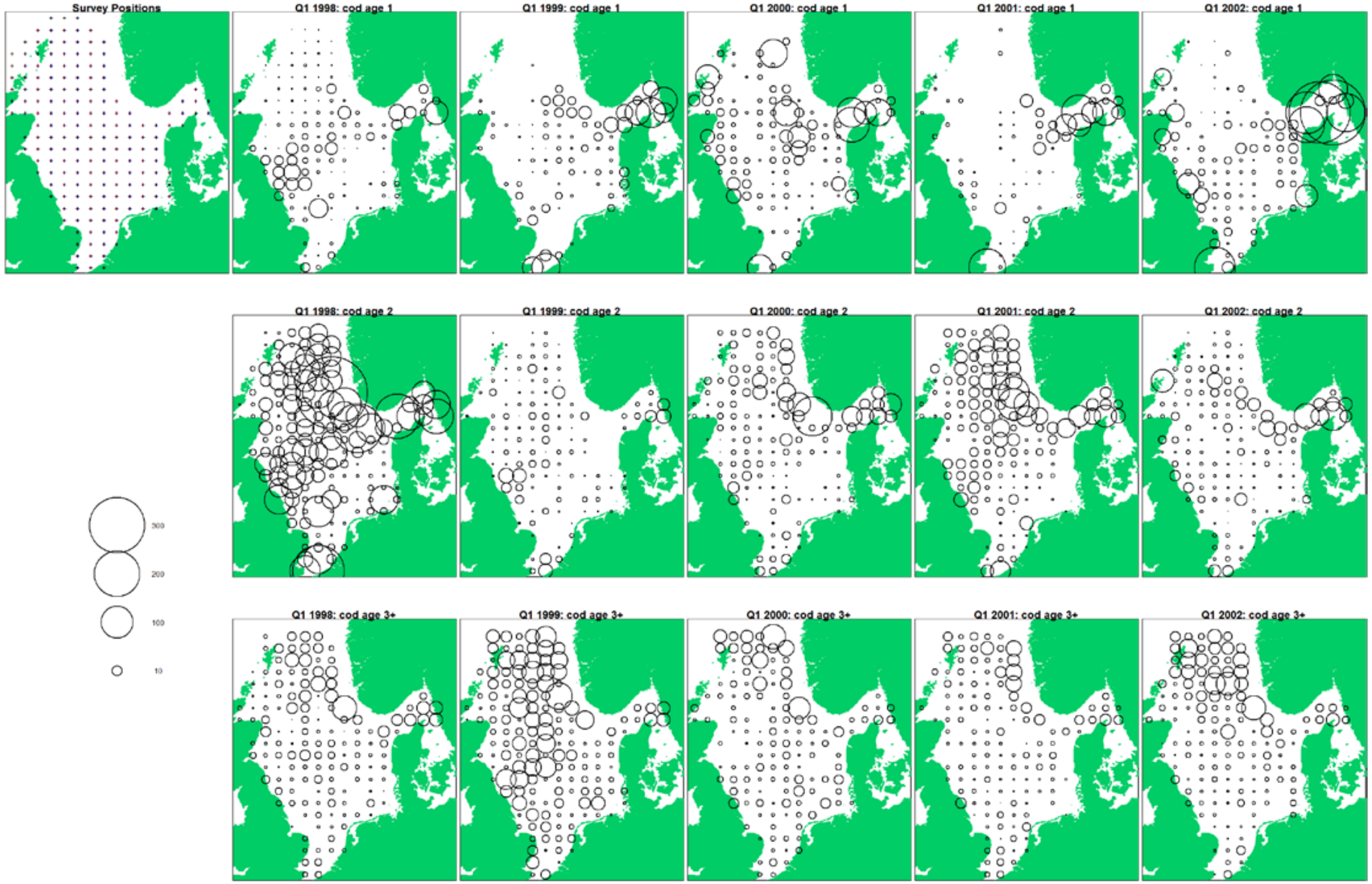


Figure 4.3a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1998–2017 in the North Sea.

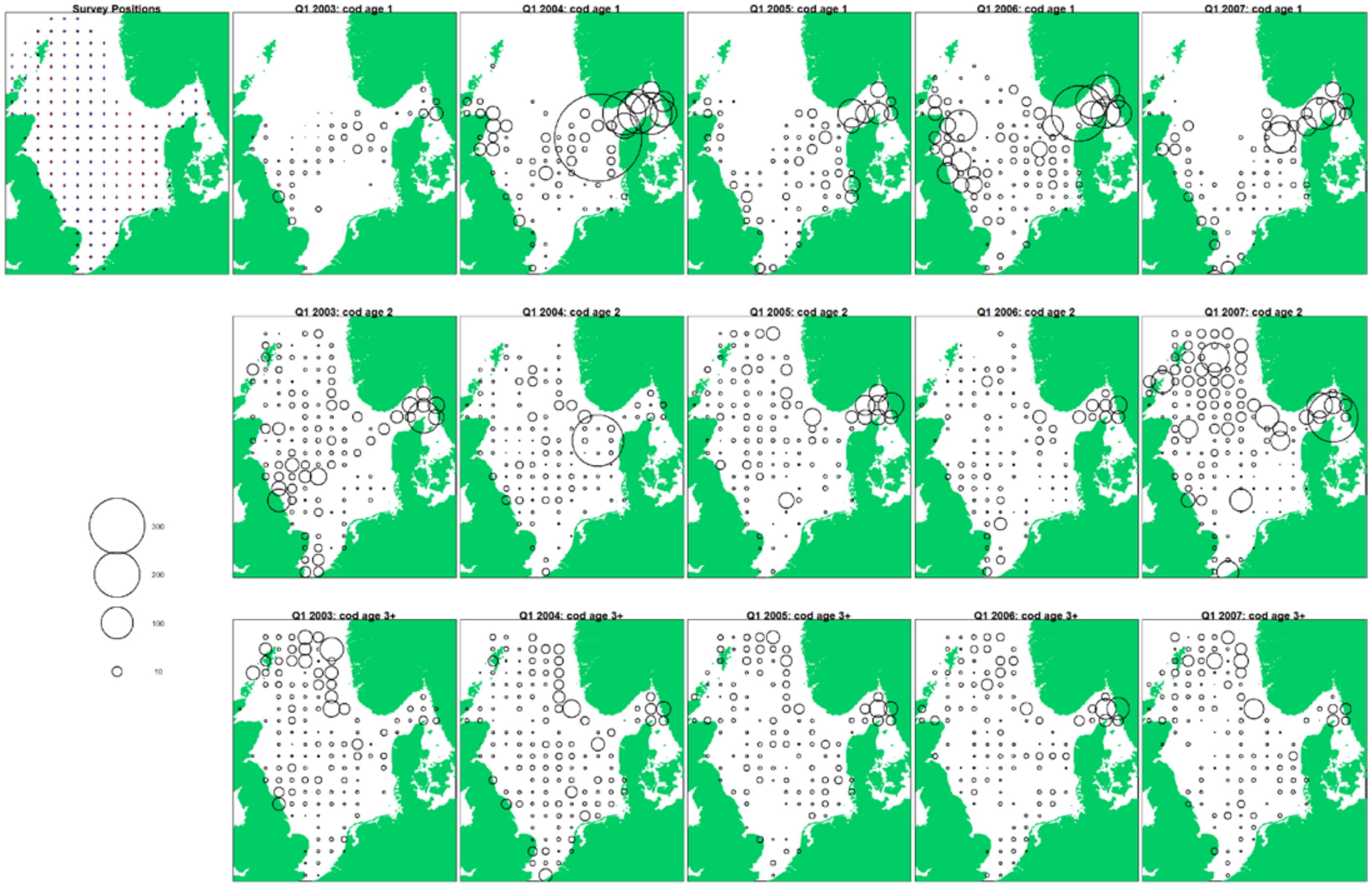


Figure 4.3a contd. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1998–2017 in the North Sea.

Figure 4.3b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1998–2016 in the North Sea.

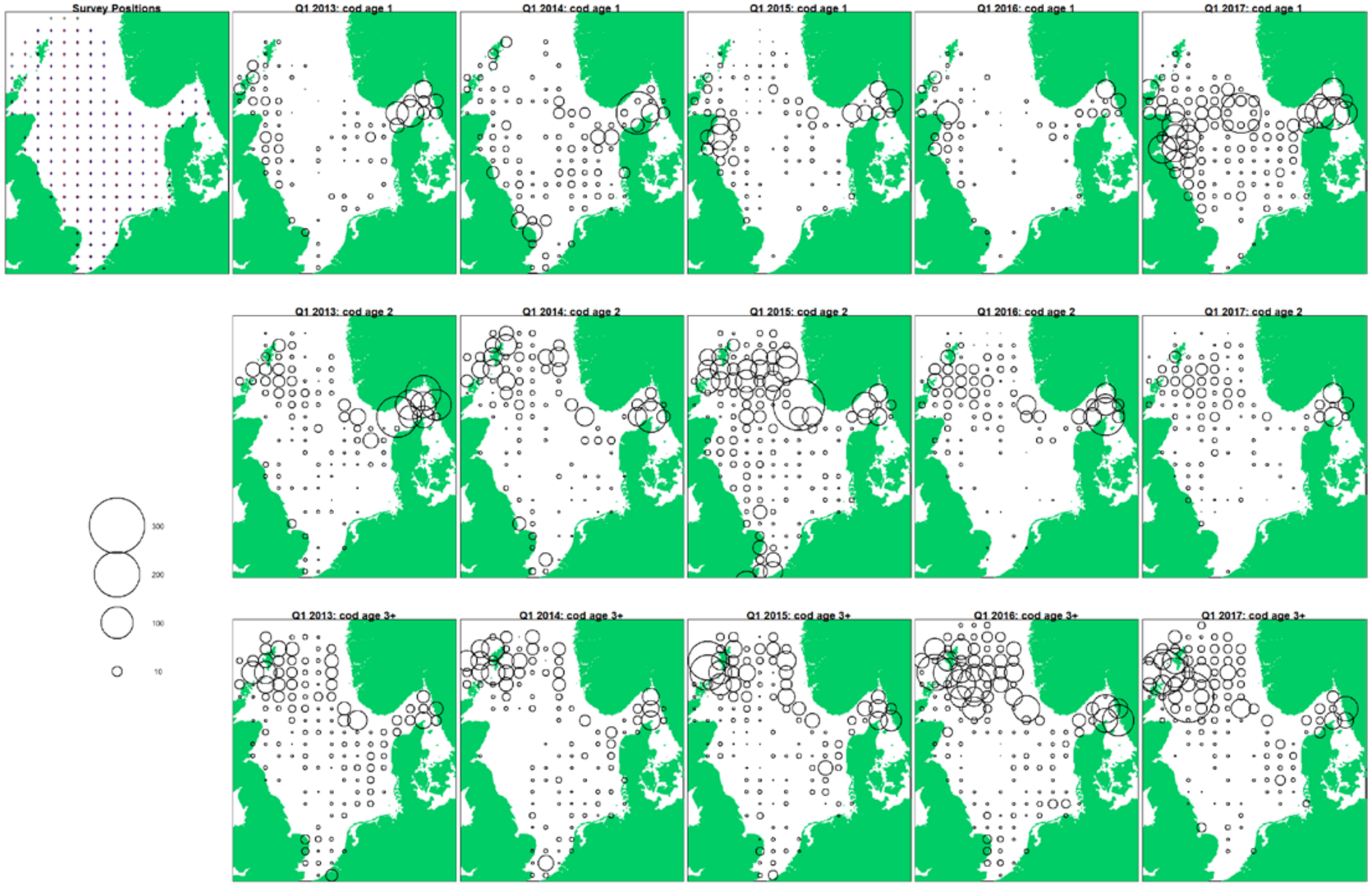


Figure 4.3a contd. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 1998–2017 in the North Sea.

Figure 4.3b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1998–2016 in the North Sea.

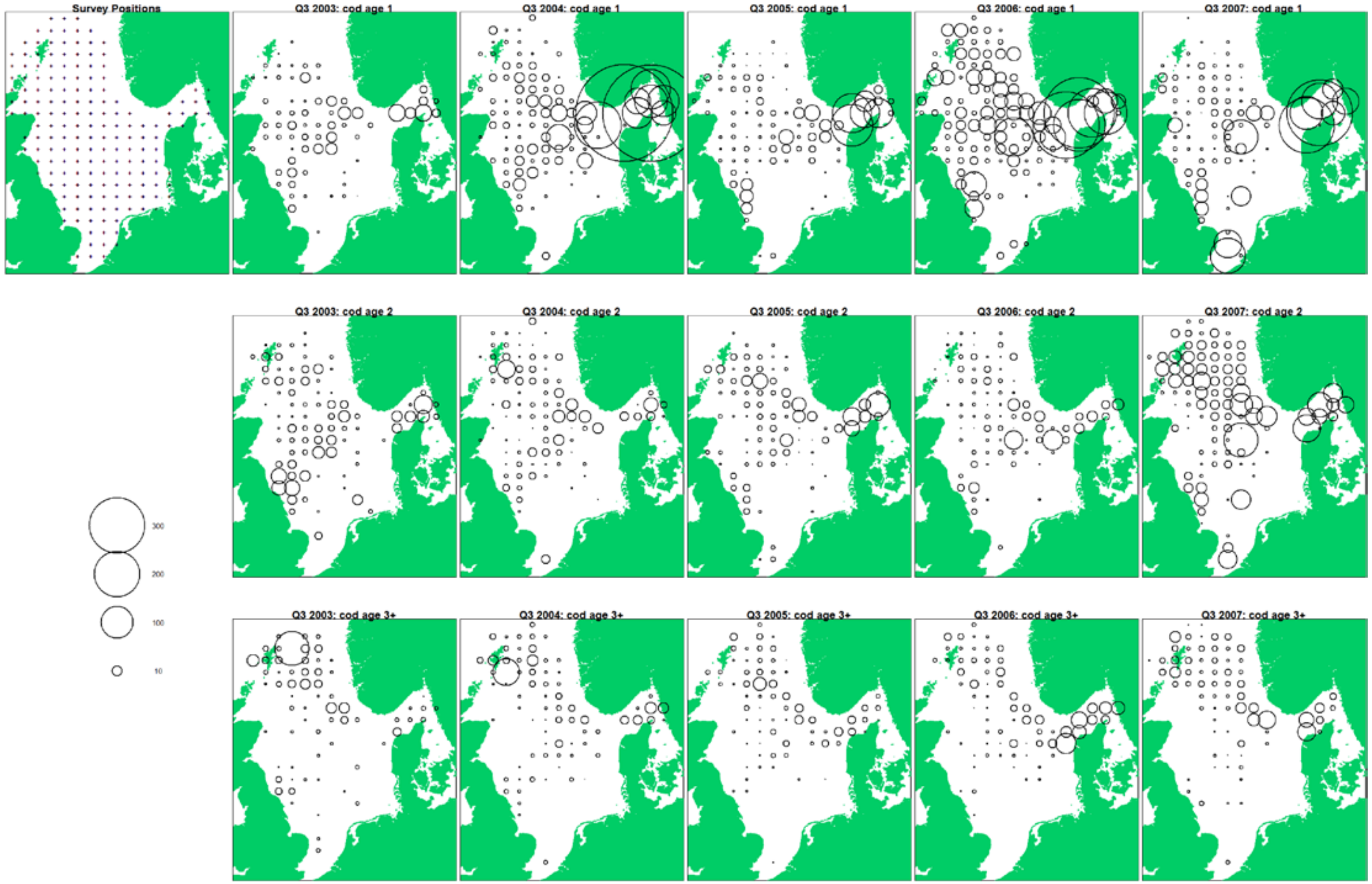


Figure 4.3b contd. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1998–2016 in the North Sea.

Figure 4.3b contd. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1998–2016 in the North Sea.

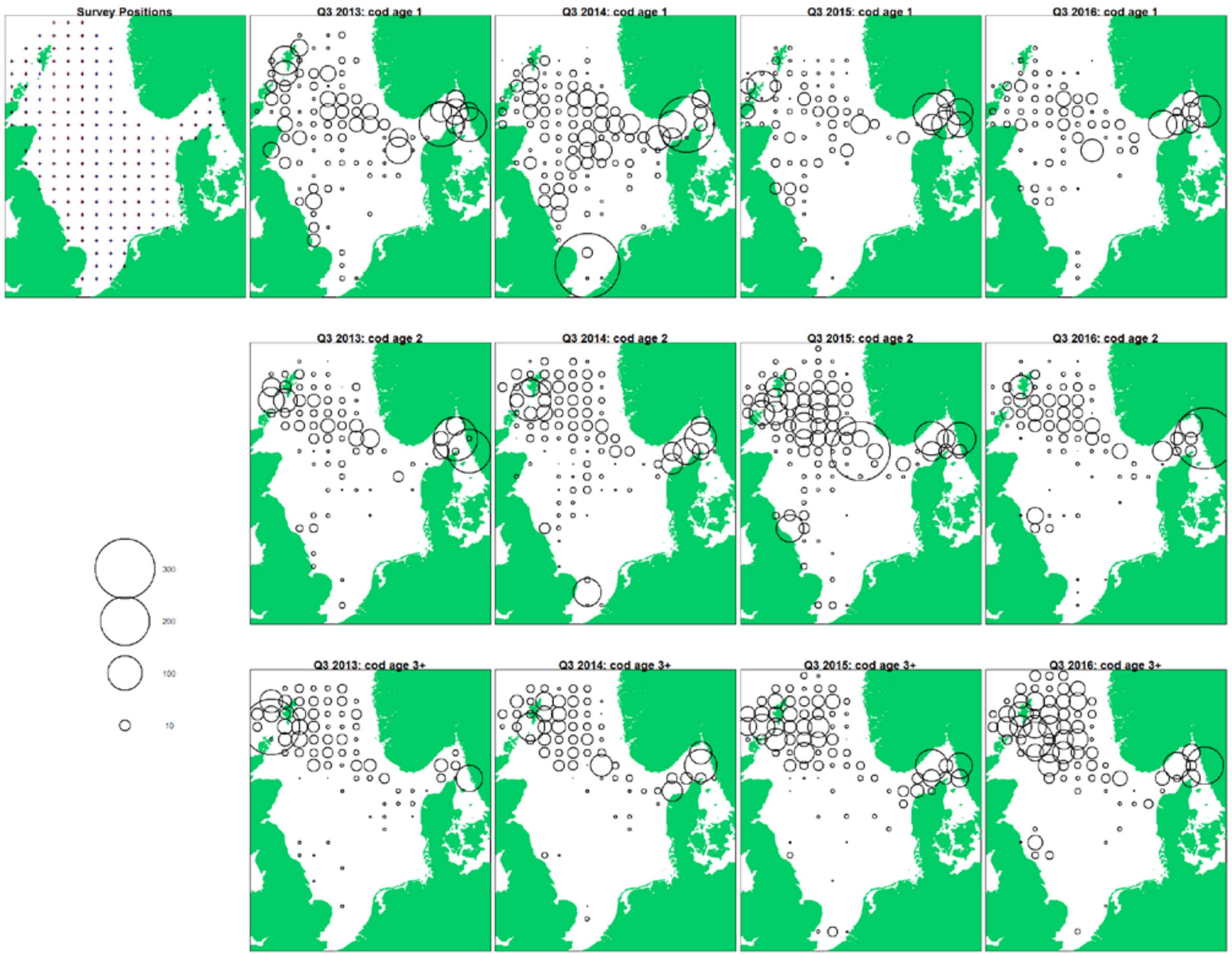


Figure 4.3b contd. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 1998–2016 in the North Sea.

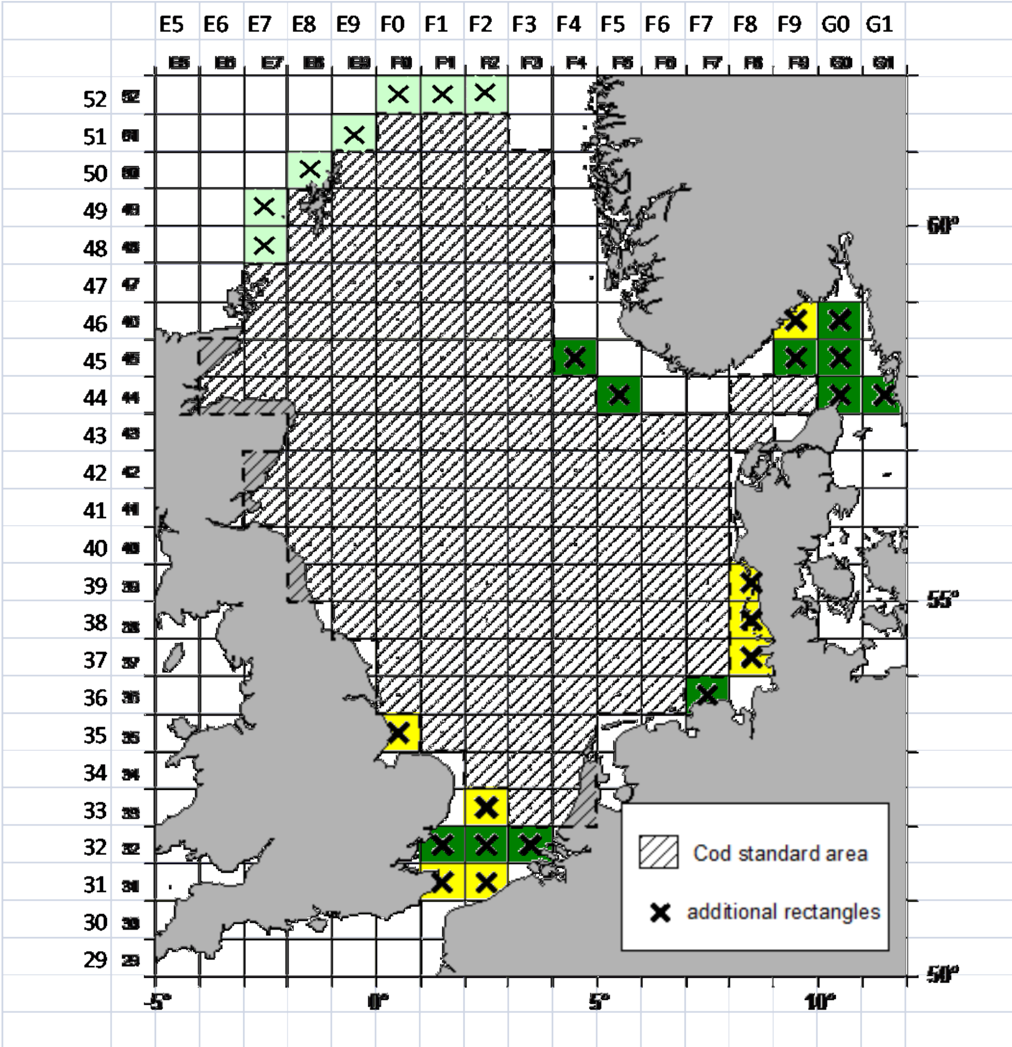


Figure 4.3c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND 2009; ICES WKCOD 2011); green squares (light and dark) indicate where the IBTS group indicate data is available; yellow squares indicate where intermittent coverage does not allow inclusion and the IBTS WG considered should be omitted; light green squares indicate the recommended extension around Shetland (ICES WKCOD 2011).

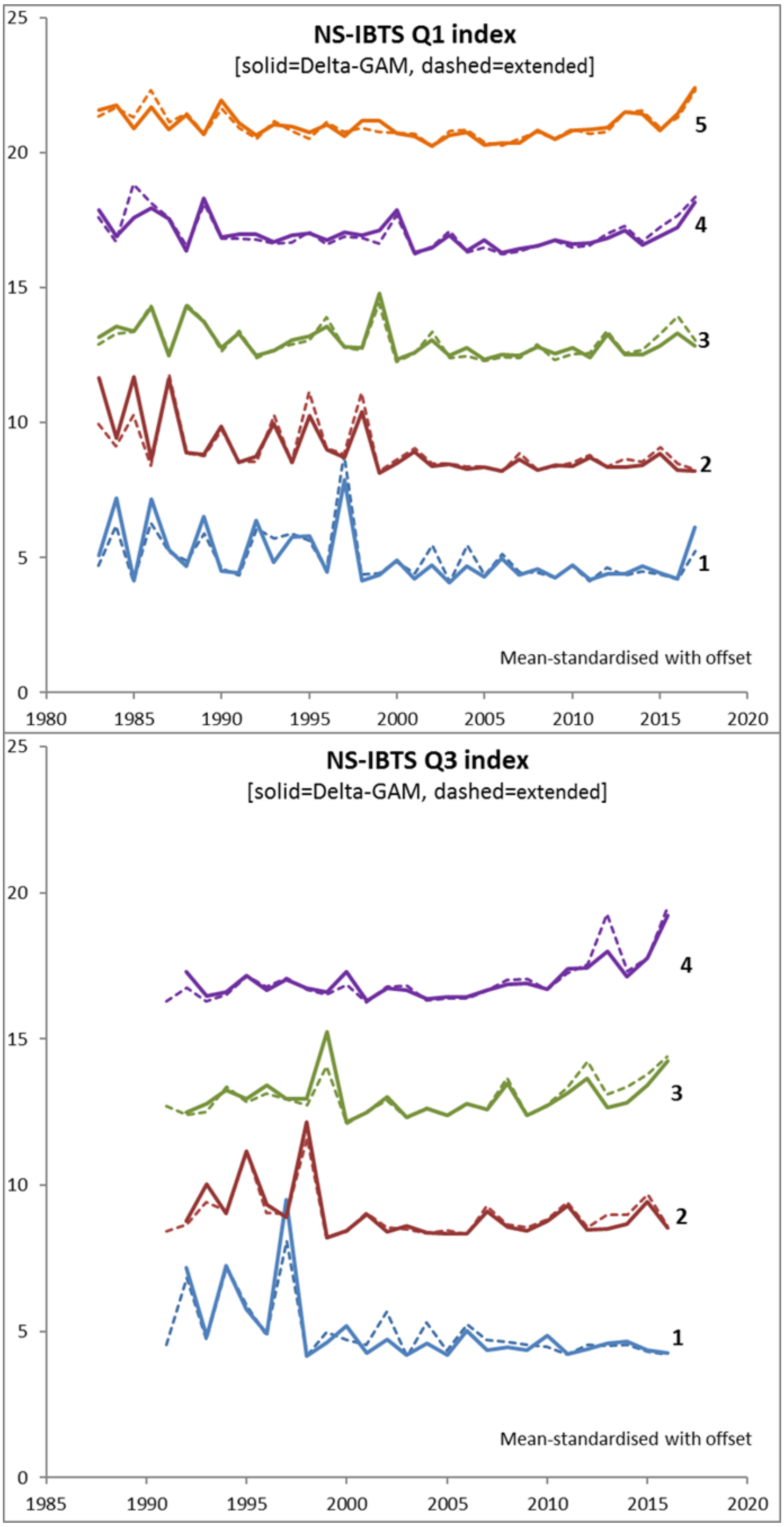


Figure 4.3d. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS extended indices to the corresponding NS–IBTS Delta–GAM indices used in the assessment. The indices are mean-standardised with an offset for ease of presentation.

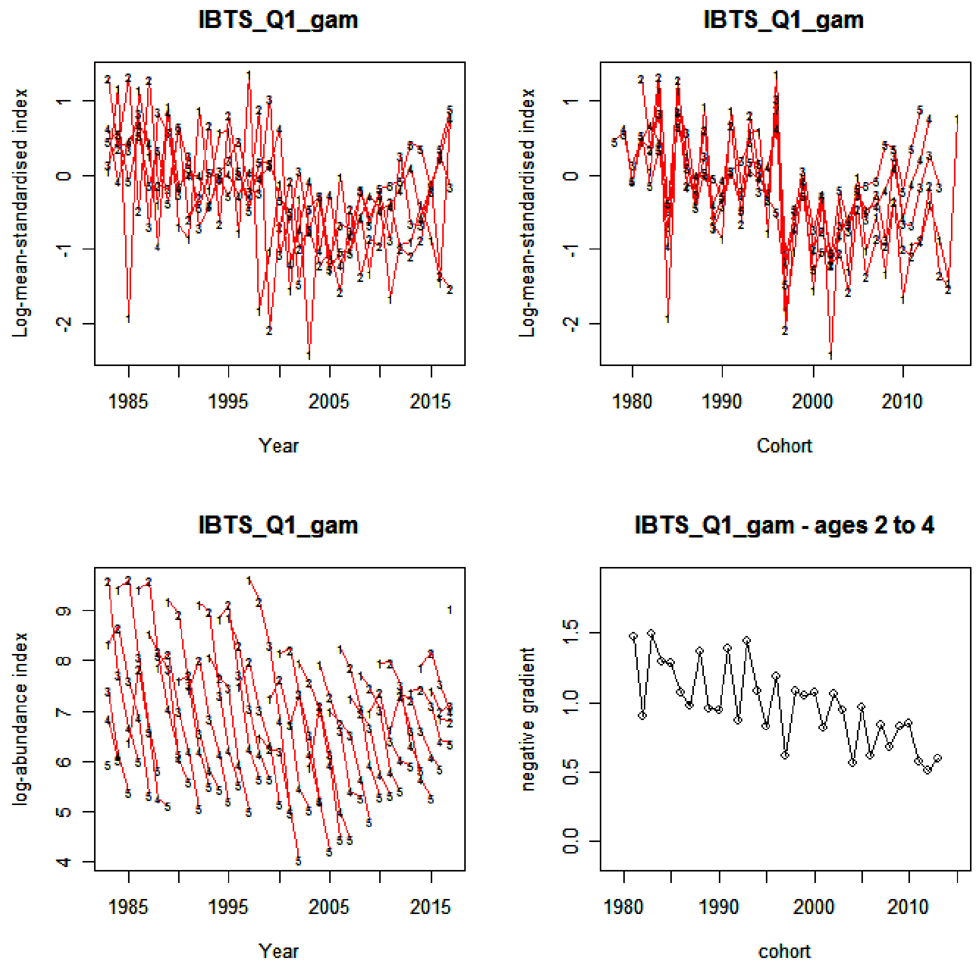


Figure 4.4a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta–GAM index).

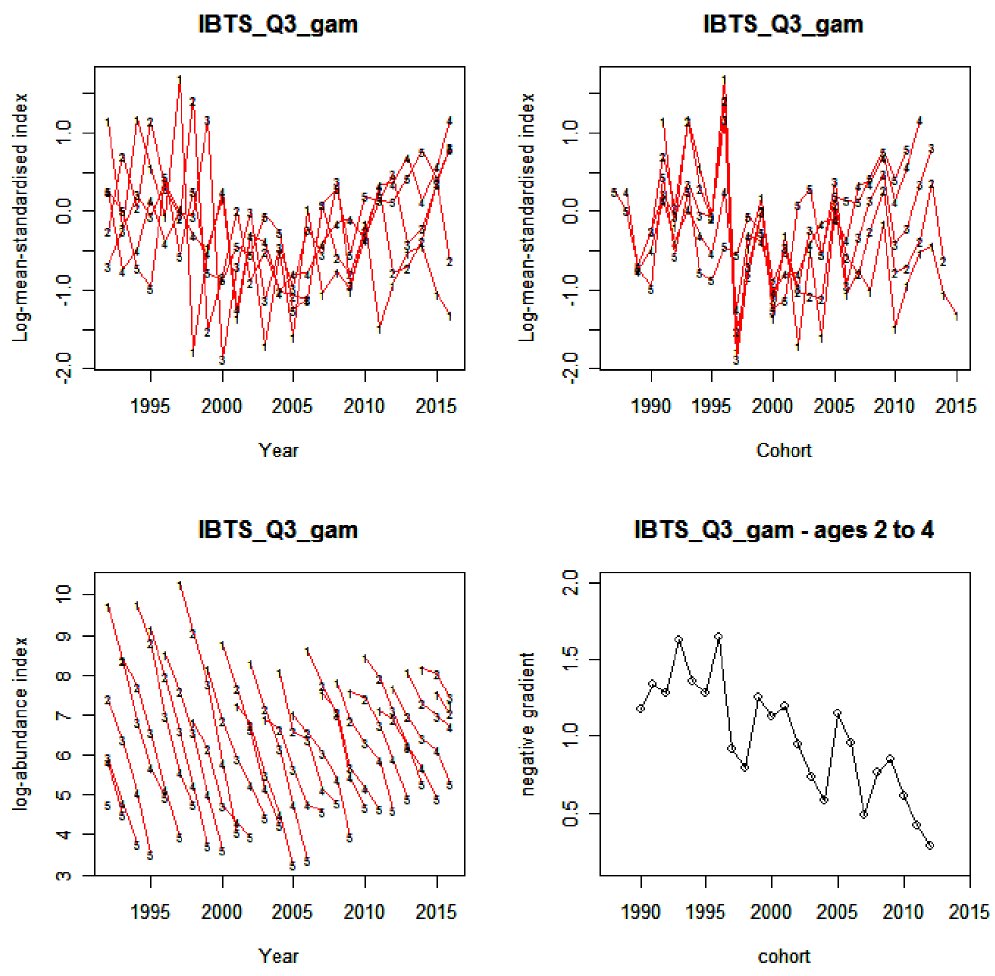


Figure 4.4b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

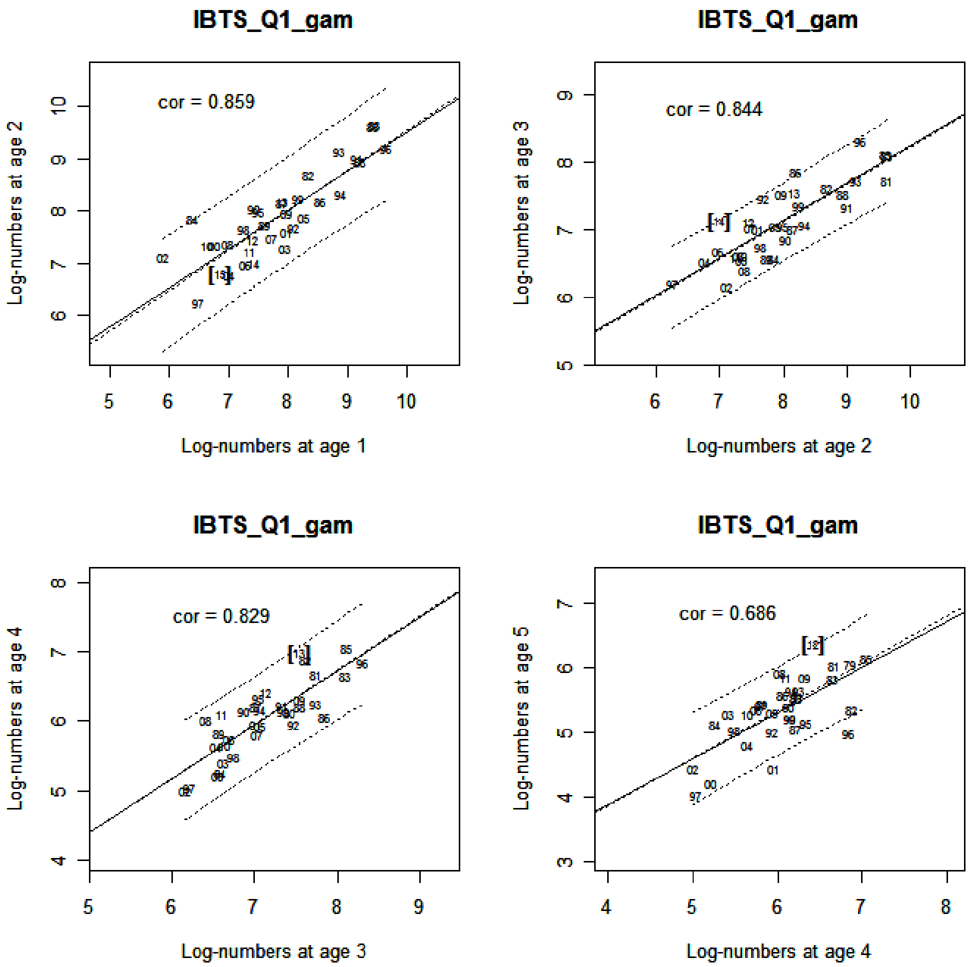


Figure 4.5a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2017. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in square brackets.

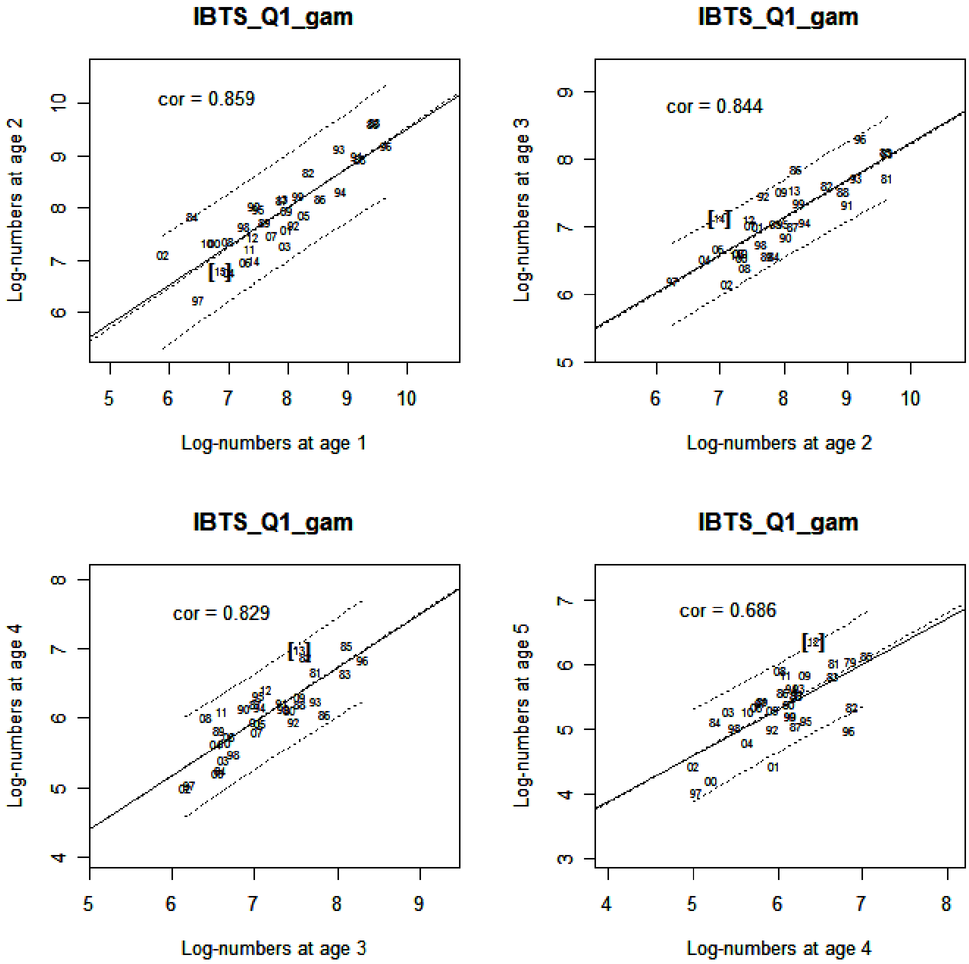


Figure 4.5b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2016. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in square brackets.

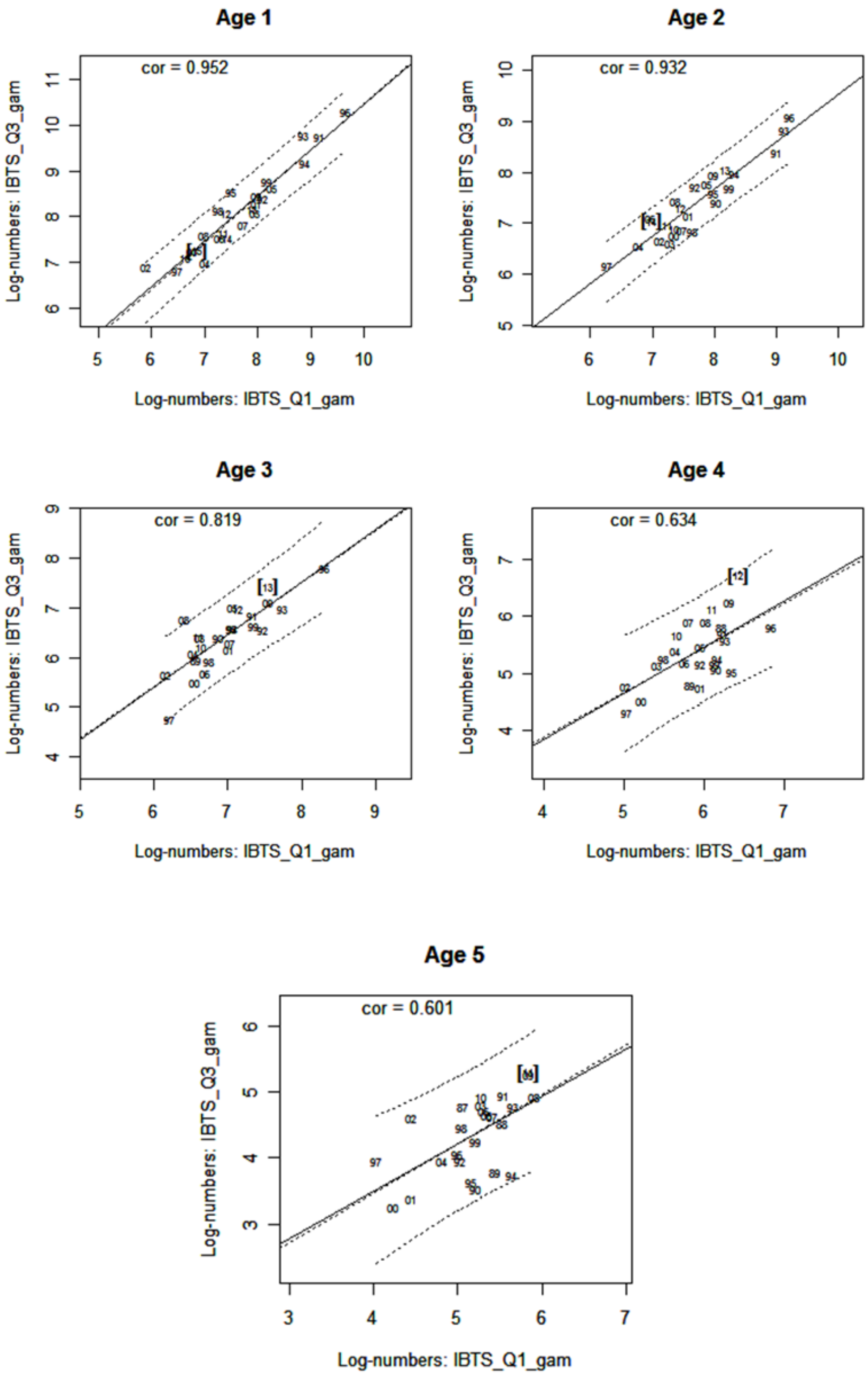


Figure 4.5c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2016. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data appear in square brackets.

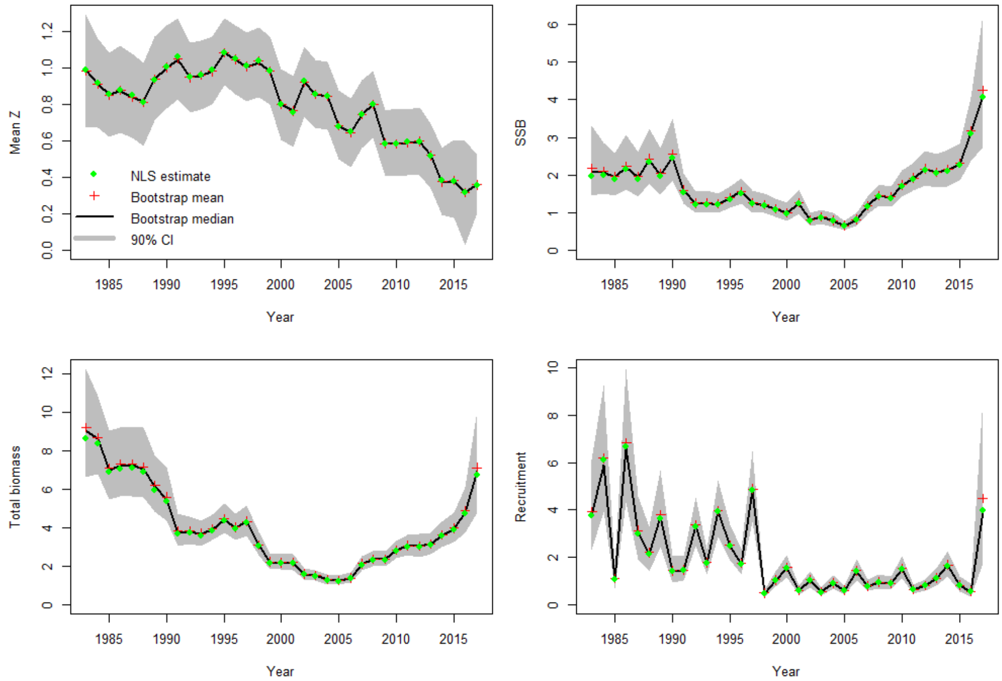


Figure 4.6. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (IBTS–Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3. The shaded area represents 90% confidence bounds.

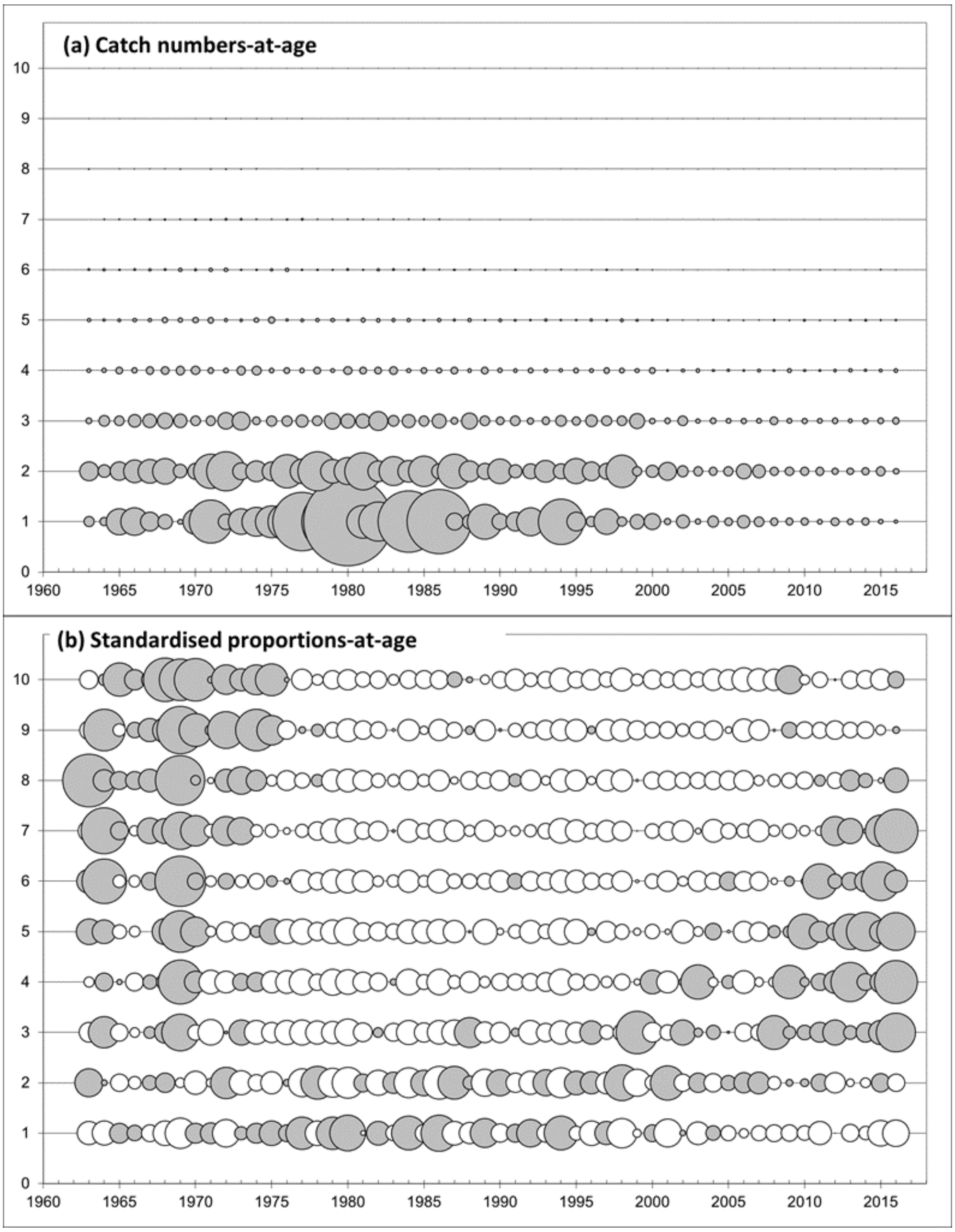


Figure 4.7. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

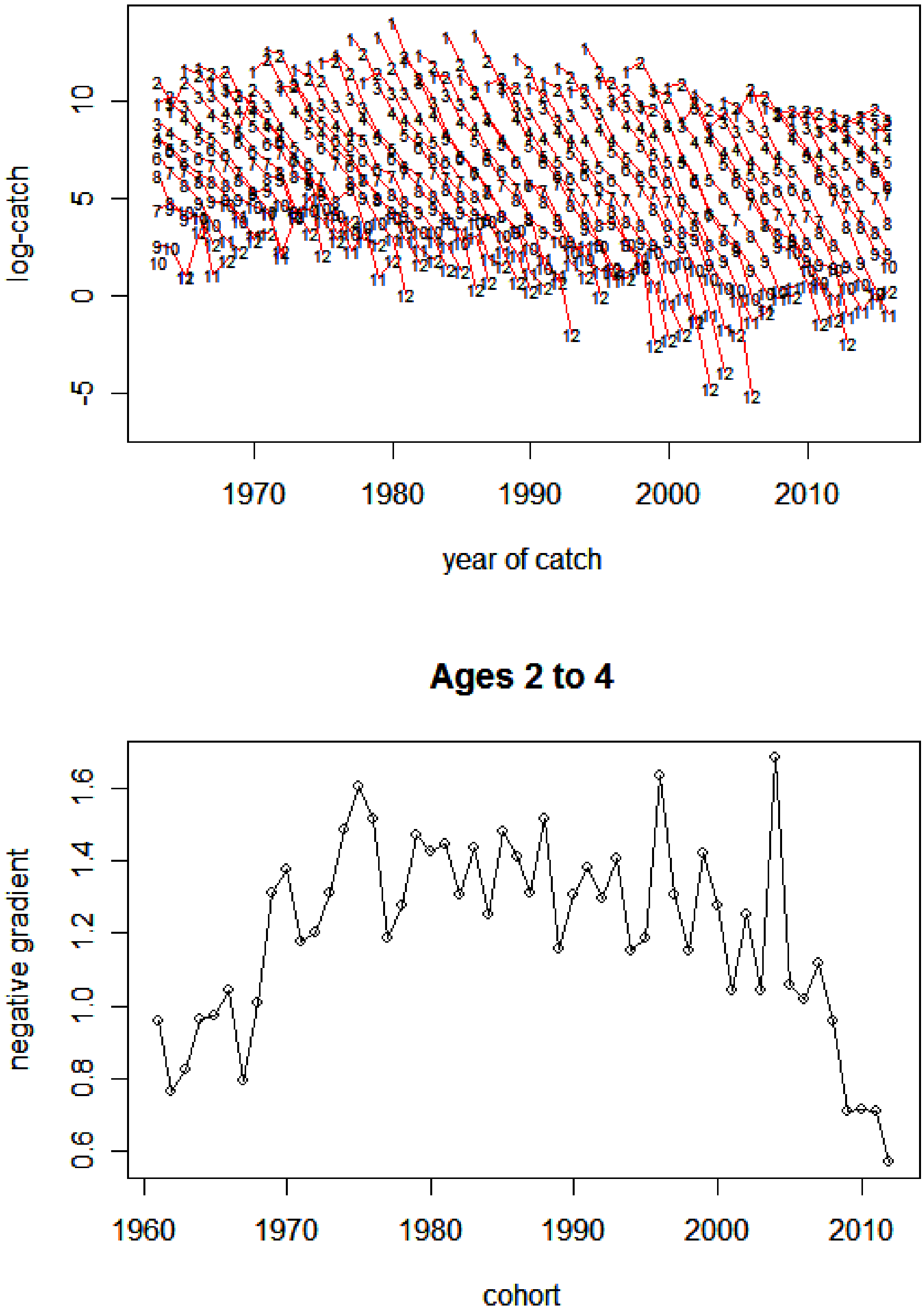


Figure 4.8. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

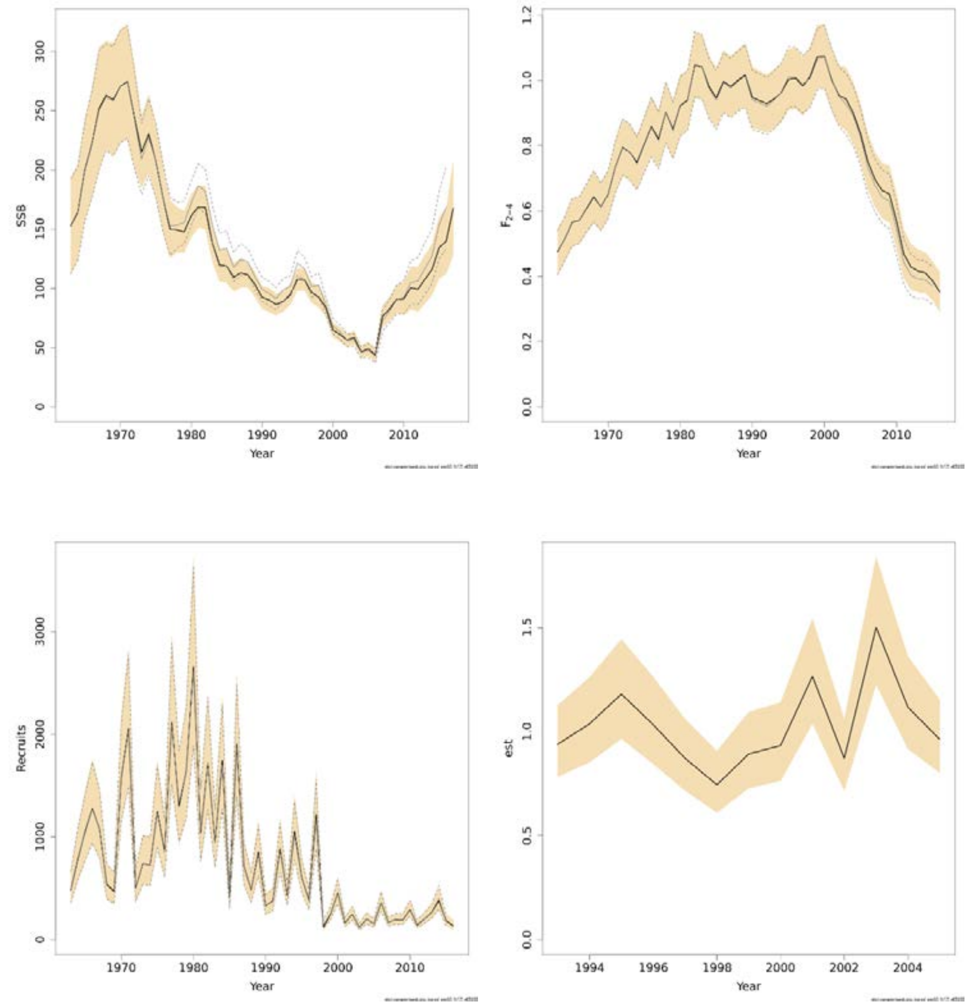


Figure 4.9. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and the catch multiplier from the SAM assessment (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The final SAM assessment from the October update (2016) is plotted in light grey for the SSB, F and recruitment plots for comparison.

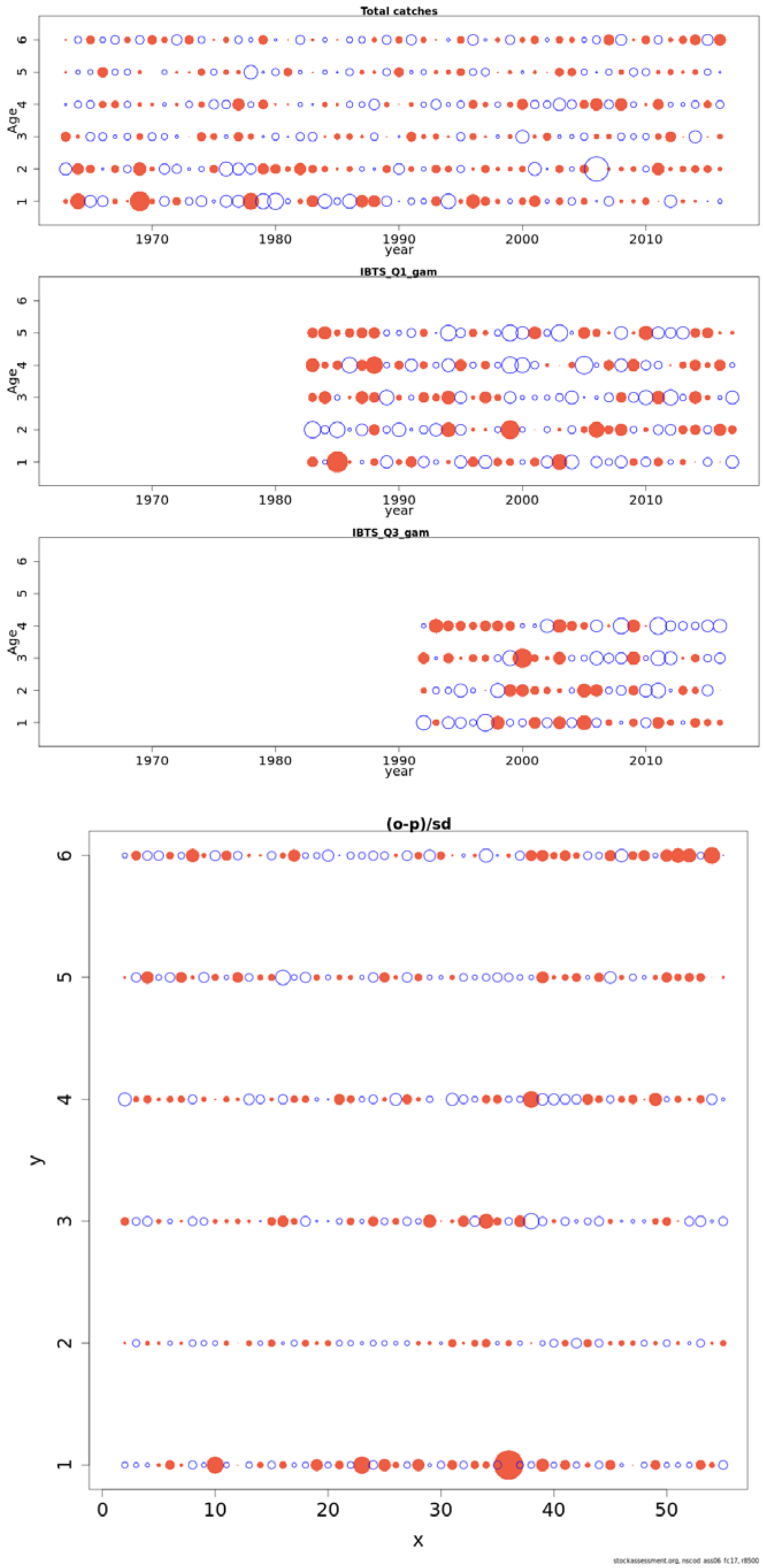


Figure 4.10. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Normalized residuals for the SAM assessment, for total catch, IBTS–Q1, IBTS–Q3, and the recruitment and survival process error. Empty circles indicate a positive residual and filled circles negative residual.

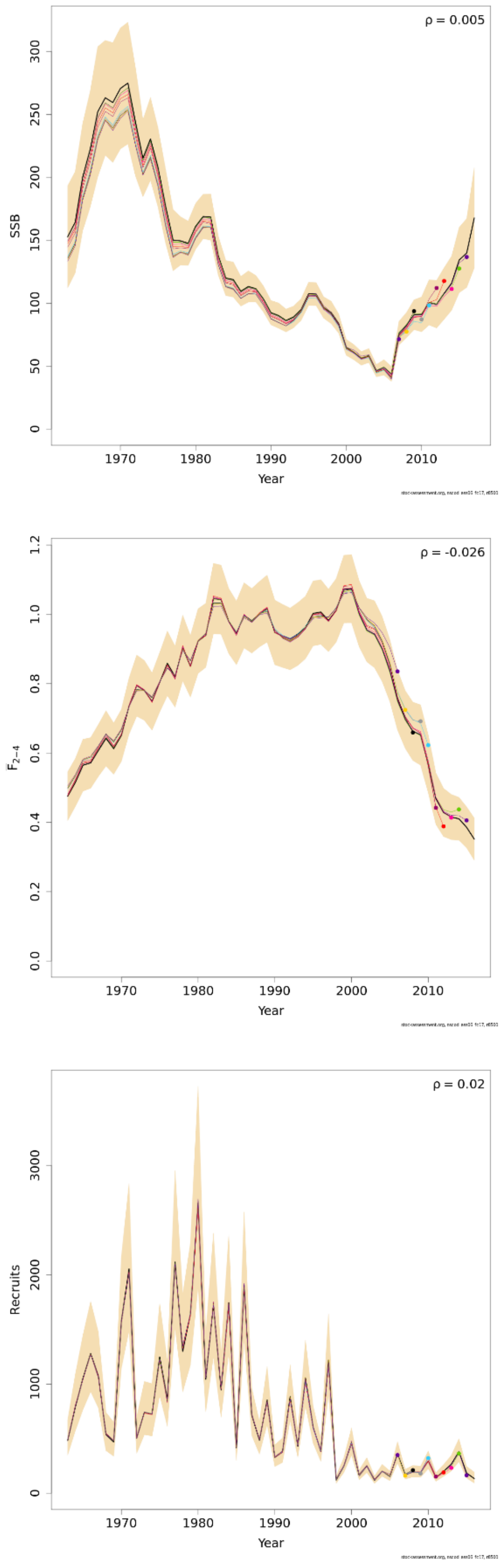


Figure 4.11. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Retrospective estimates (10 years) from the SAM assessment. Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals. Mohn's r given in each plot is calculated as: =□(1/n) ∑_(y=Y-n)^(Y-1)▒〖(1–X_(y,y)/X_(y,Y))〗 , where the first subscript indicates the year X (SSB, F or R) pertains to, and the second subscript the final full data year for the given assessment, with Y indicating the most recent assessment.

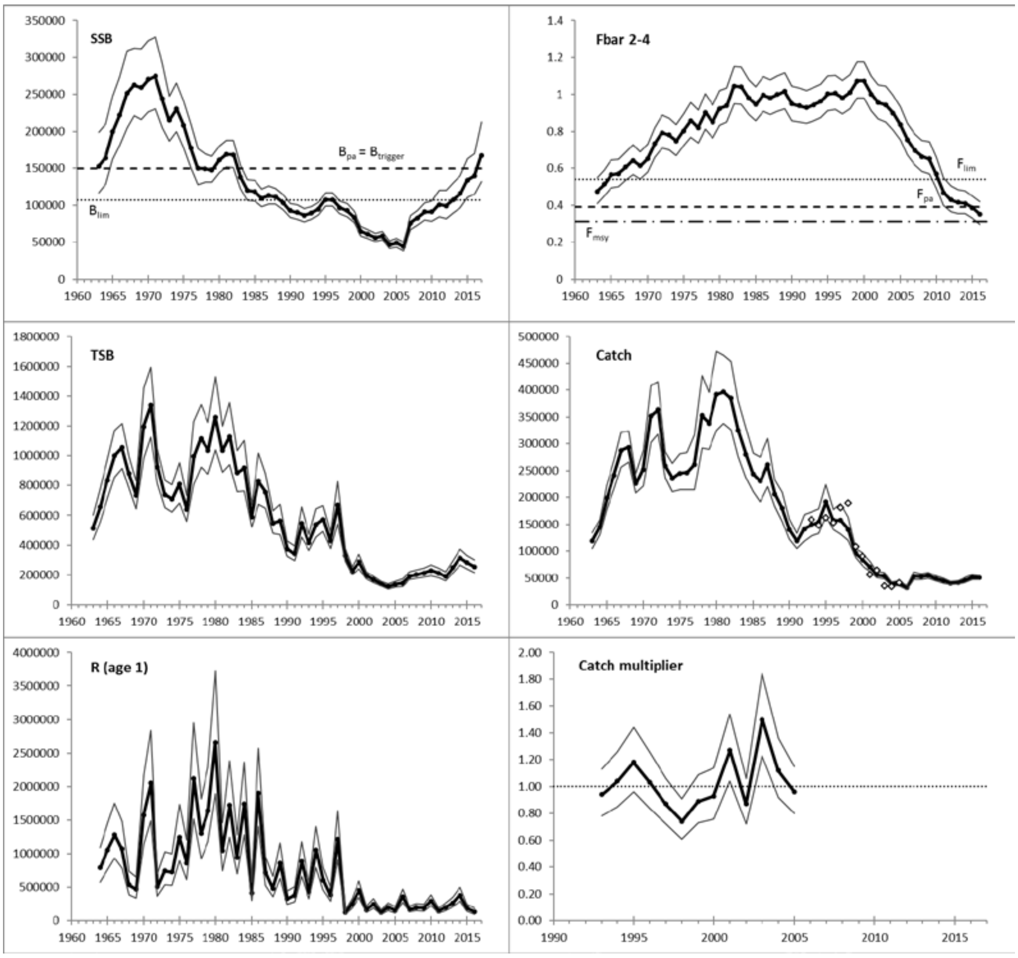


Figure 4.12. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Anticlockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2–4 (F(2–4)), from the SAM final run (catch multiplier estimated for 1993–2005 only). The heavy lines represent the point-wise estimate, and the light lines point-wise 95% confidence intervals. The open diamonds given in the catch plot represent model estimates of the total catch excluding unaccounted mortality, while the solid lines represent the total catch including unaccounted mortality for 1993–2005. The horizontal broken lines in the SSB plot indicate Blim=107 000t and Bpa=150 000t, and in the Fbar plot Flim=0.54, Fpa=0.39 and Fmsy=0.31. The horizontal broken line in the catch multiplier plot indicates a multiplier of 1. Catch, SSB and TSB are in tons, and R in thousands.

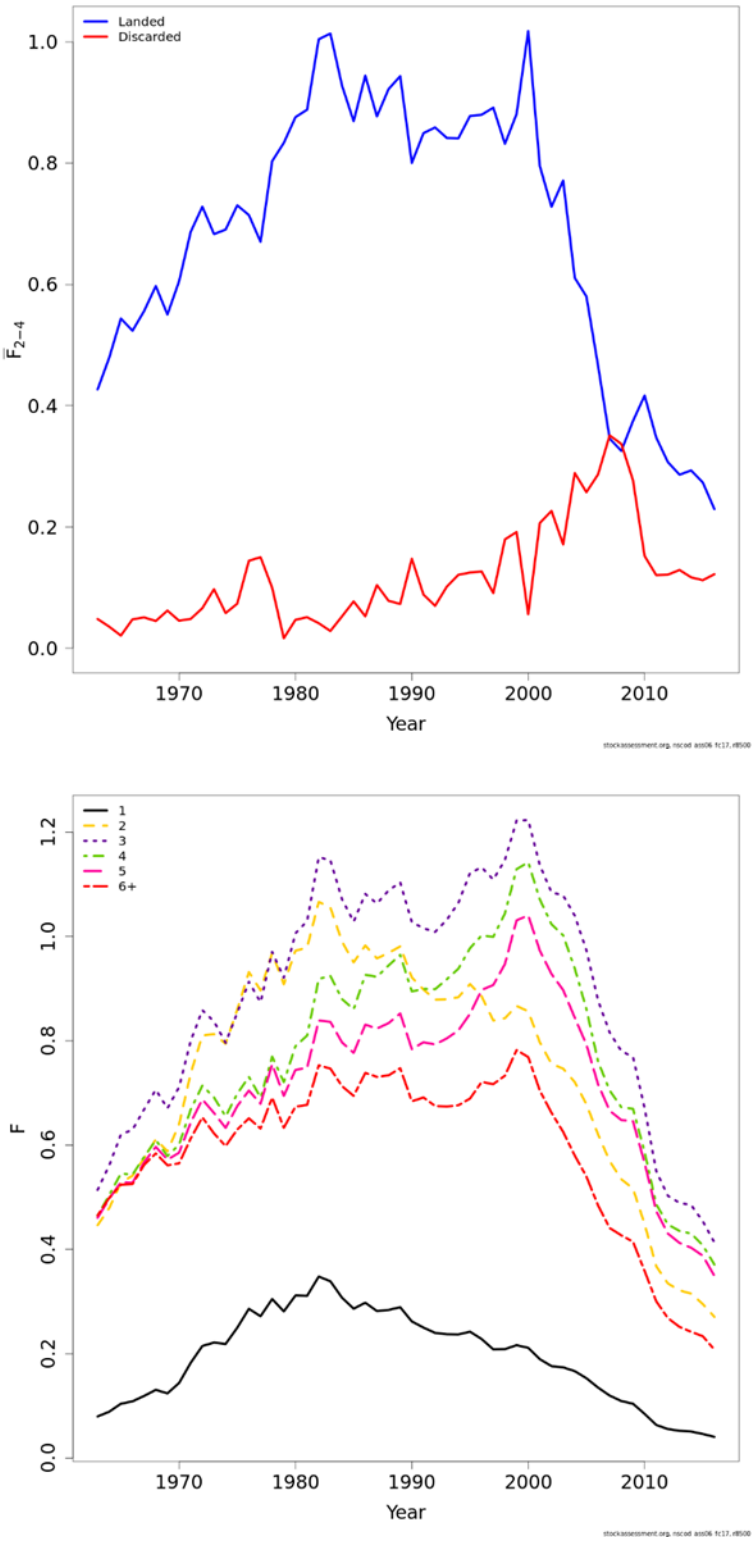


Figure 4.13. Cod in Subarea 4, Divisions 7.d and Subdivision 20: SAM estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

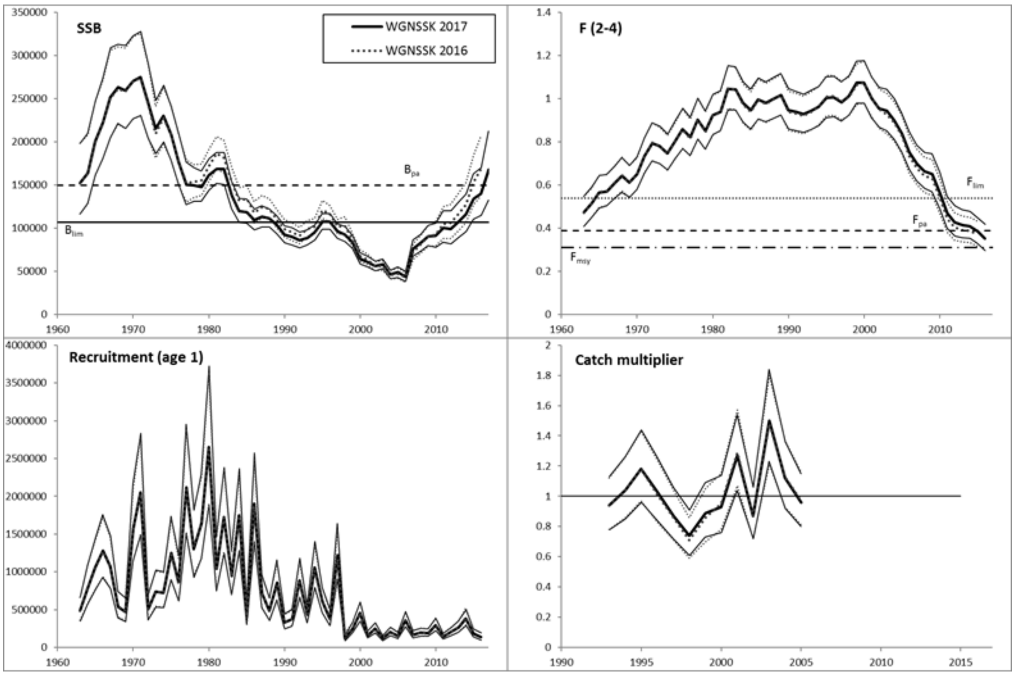


Figure 4.14. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Comparison of final SAM assessment for 2017 with the final SAM assessment for 2016 (October update). Plots are as described in Figure 4.12.

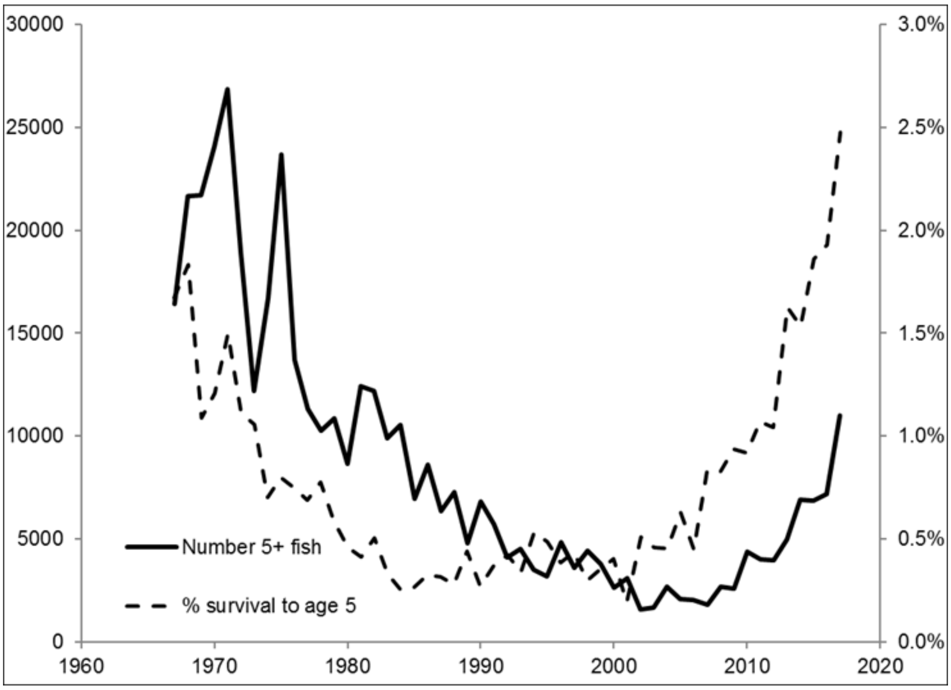
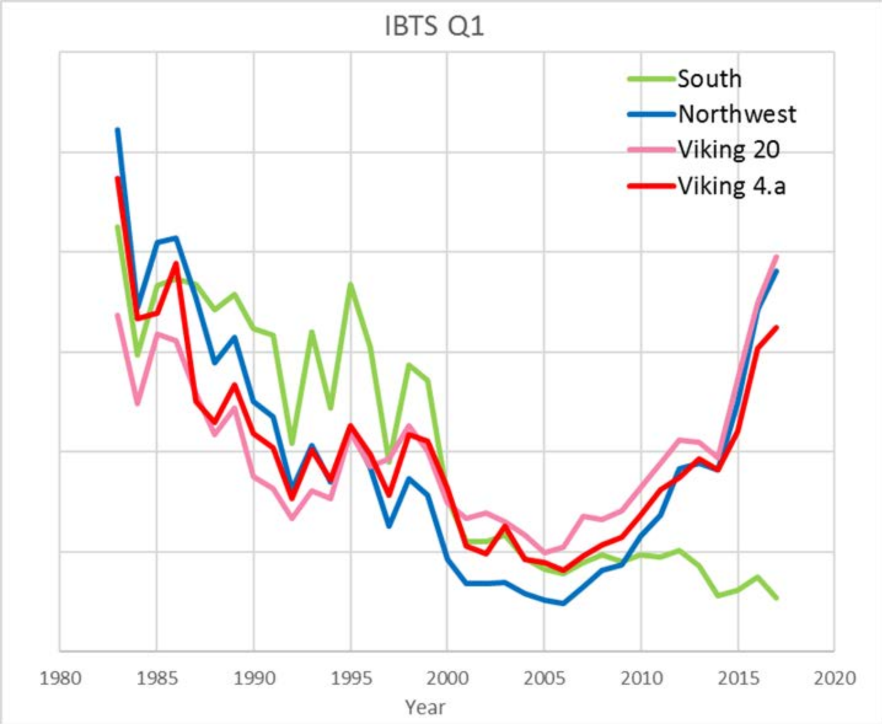


Figure 4.15. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Estimates of the number of 5-year-old and older cod in the population (solid line; thousands) and the percentage of 1 year olds by number that have survived to age 5 in the given year (hashed line).



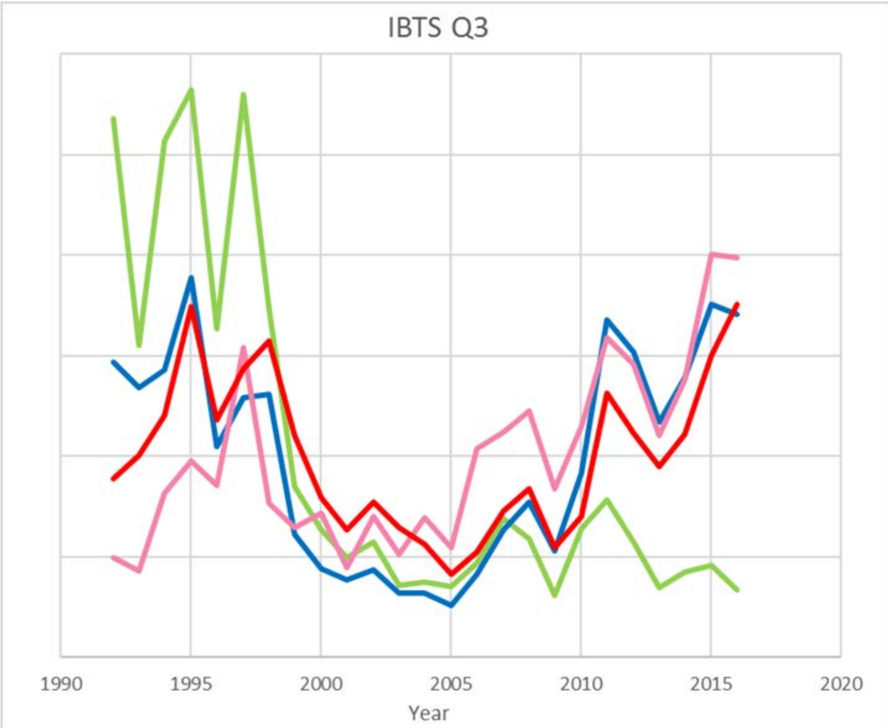


Figure 4.16a. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model (including ship effects) to numbers-at-age for the entire dataset and integrating the fitted abundance surface over each of the Subareas to obtain indices-at-age by area. These are then multiplied by smoothed weight-at-age estimates and summed to get the biomass indices.

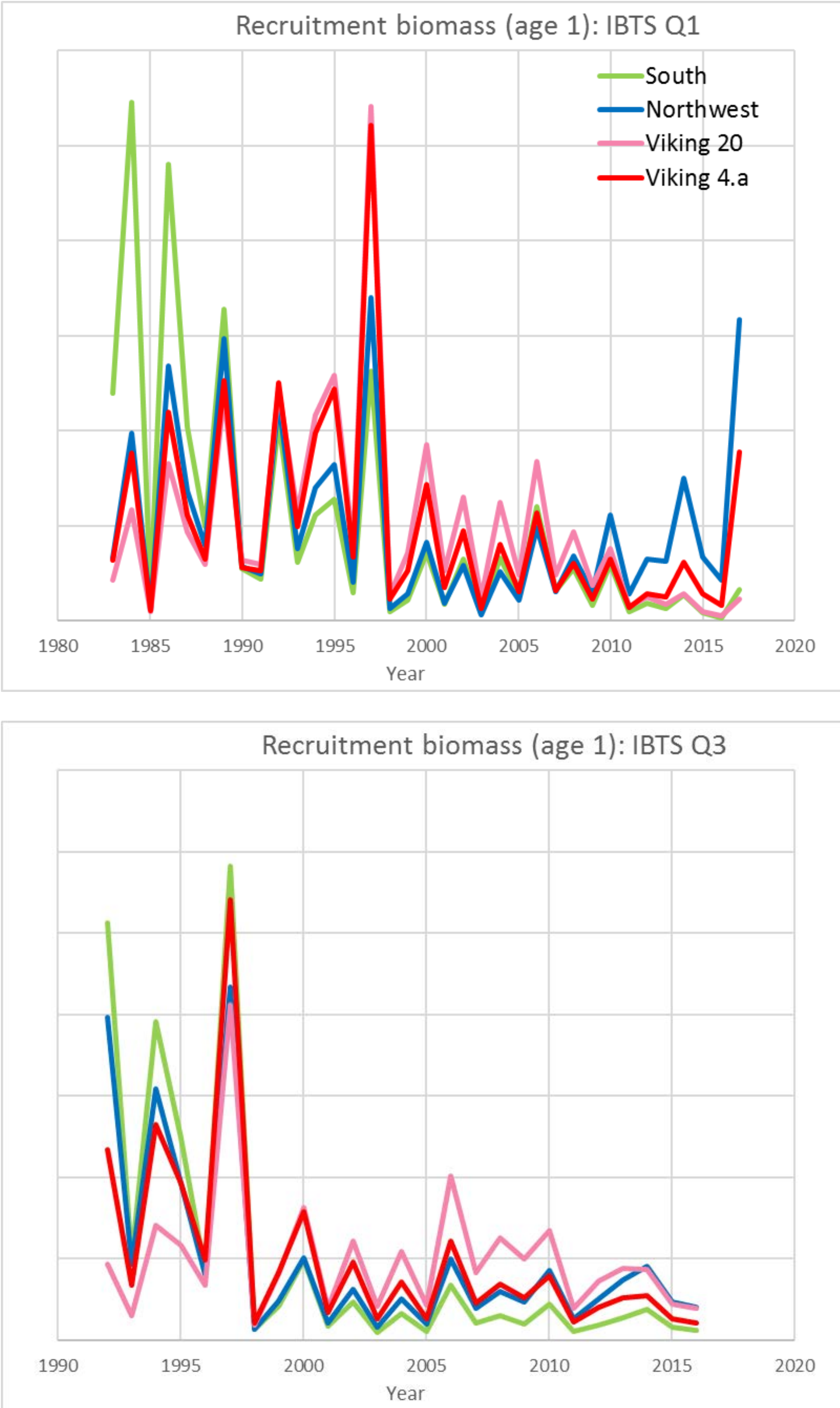


Figure 4.16b. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data.

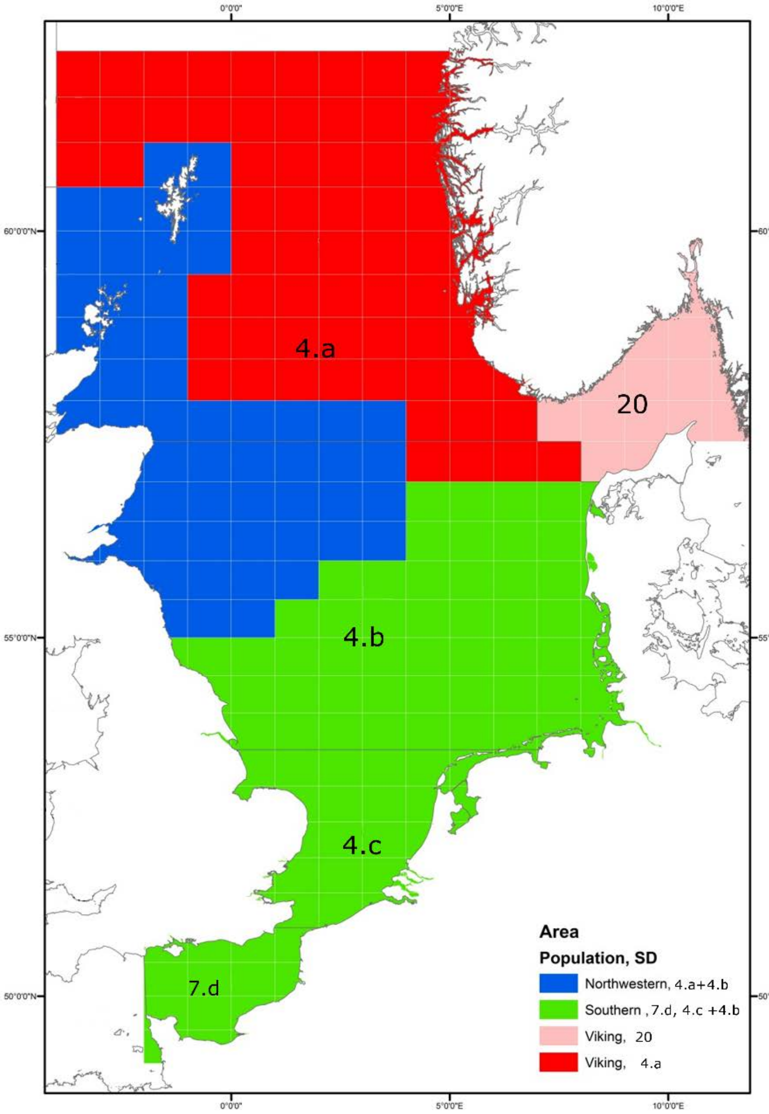


Figure 4.16c. Cod in Subarea 4, Divisions 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

5 Dab in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat)

5.1 General

Dab (*Limanda limanda*) was assessed for the first time by the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) in 2014. Until 2013 it was assessed by the Working Group on Assessment of New MoU Species (ICES 2013a). This group was dissolved in 2014. Because only official landings and survey data were available at that time, dab was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES 2012). Since 2015 dab was included in the official data call for the WGNSSK and discard estimates were included into the dab assessment. Based on survey trends and total catch data (2012–2014) biennial advice for dab was given in 2015 (ICES 2015). In 2016 a benchmark assessment of dab was conducted by ICES. For this benchmark assessment catch data from 2002 were requested and uploaded into the InterCatch data portal by all relevant countries (ICES 2016). The benchmark agreed on the use of a survey based assessment model (SURBA; Needle, 2015) to inform stock status of North Sea dab (ICES 2016). This model provides relative estimates of the spawning stock, recruitment, and total mortality. The trend based data limited approach for category 3.2 stocks (2 over 3 rule; ICES 2012) is then applied to the achieved relative trends in spawning stock biomass. During the WGNSSK 2017 an update assessment was conducted following the stock annex and MSY proxy reference points were determined applying the Surplus Production Model in Continuous Time (SPiCT, Pedersen & Berg, 2017) in order to inform a new advice for this stock. Further, length based methods to analyse MSY proxies were tested.

5.1.1 Biology and ecosystem aspects

Dab is a widespread demersal species on the Northeast Atlantic shelf and distributed from the Bay of Biscay to Iceland and Norway, including the Barents Sea and the Baltic. In the North Sea it is one of the most abundant species distributed over the whole area in depths down to 100 m, but it was also found occasionally down to depths of 150m. The main concentration of dab can be found in the south eastern North Sea especially that of the younger age groups 1–2. Older age groups are more distributed in the central and more Northern parts of the North Sea (Fig. 5.14). Generally, dab abundance decreases towards the northern parts of the North Sea. Dab feeds on a variety of small invertebrates, mainly polychaete worms, shellfish and crustaceans. Early sexual maturation was reported for dab, maturing at ages of 2 to 3 years corresponding to approximately 11 cm to 14 cm total length. Peak spawning in the south eastern North Sea occurs from February to April.

5.1.2 Stock ID and possible assessment areas

The several spawning grounds and the wide distribution of dab indicate the presence of more than one stock. Meristic data (Lozán, 1988) corroborate the hypothesis of several stocks for dab, distinguishing significantly between populations from western British waters, the North Sea and the Baltic Sea.

5.1.3 Management regulations

Dab is mainly a bycatch species in fisheries for plaice and sole. The discard rates for dab can be extremely high (~90%). No minimum landing size is defined for dab. According to EU–Regulations a precautionary TAC was given in EU waters of Division

2a and Subarea 4 together with flounder (*Plathichthys flesus*). This combined TAC was never fully utilized. In 2017 the European Commission requested ICES to evaluate the possible effects on the stocks of dab and flounder having no TAC. ICES advised that given the current fishing patterns of the main fleets catching dab and flounder, which are the same fleets targeting plaice and sole, the risk of having no TAC for dab and flounder is considered to be low (ICES 2017a). Therefore, the European Commission removed the combined TAC for these two stocks (EU COM, 2017/595).

5.2 Fisheries data

5.2.1 Historical landings

Dab is a bycatch species mainly in the fisheries for plaice and sole but also in fisheries targeting demersal round fish. According to ICES catch statistics, annual landings of dab in ICES Subarea 4 and Division 3.a has been well above 10 000 tons since 1973 (Figure 5.2, Table 5.13). The apparent decrease in official landings in the 1980's and 1990's are due to unreported landings by the Netherlands and Norway. However, since 1999 total landings for both areas (Subarea 4 and Division 3.a) steadily decreased. This trend continued until 2015 with total official landings of 4 512 tons. In 2016 official landings for both areas increased slightly and resulted in total landings of 4 953 tons.

The main fishing gear in the North Sea is the beam trawl with mesh sizes between 80 and 100 mm. Large effort reductions took place in this fishery over the last decade. The largest part of the landings in Subarea 4 is taken by the Netherlands, followed by UK and Denmark (Figure 5.3, Table 5.14). In Division 3.a Denmark lands the largest amount of dab (Figure 5.4, Table 5.15). Dab is among the most discarded fish species in ICES Subarea 4. In the beam trawl fishery on plaice and sole and the otter trawl fishery on plaice up to 95% of dab catches are discarded (e.g. van Helmond *et al*., 2012).

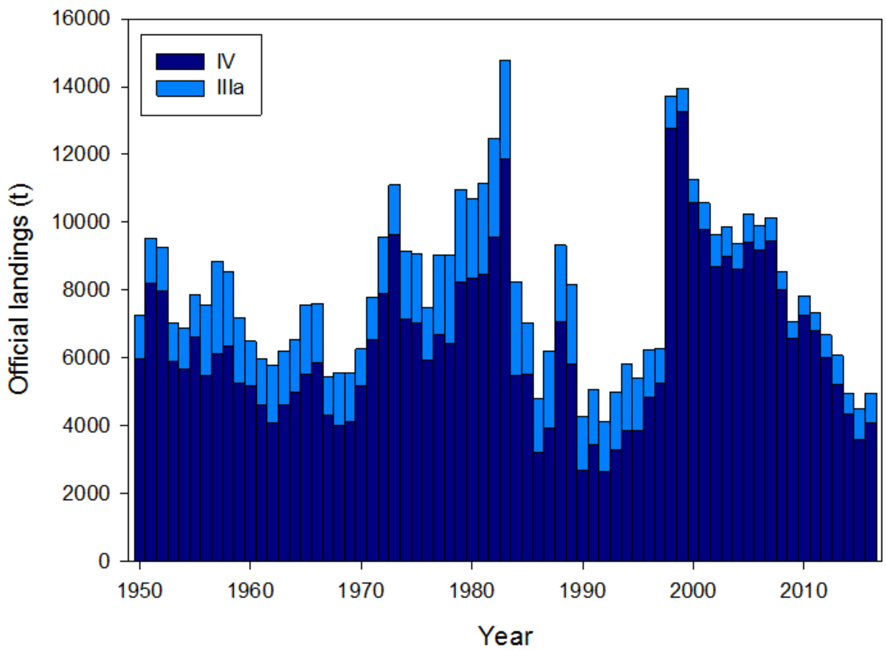


Figure 5.1. Dab in Subarea 4 and Division 3.a: Total official landings of dab in Subarea 4 and Division 3.a in 1950–2016.

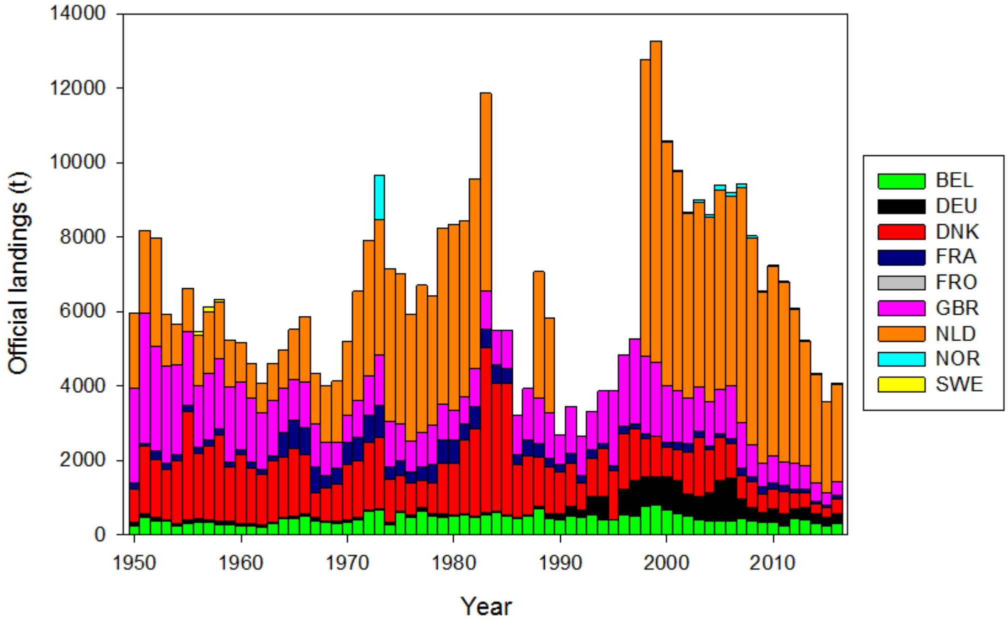


Figure 5.2. Dab in Subarea 4 and Division 3.a: Official landings of dab in Subarea 4 by country 1950 to 2016.

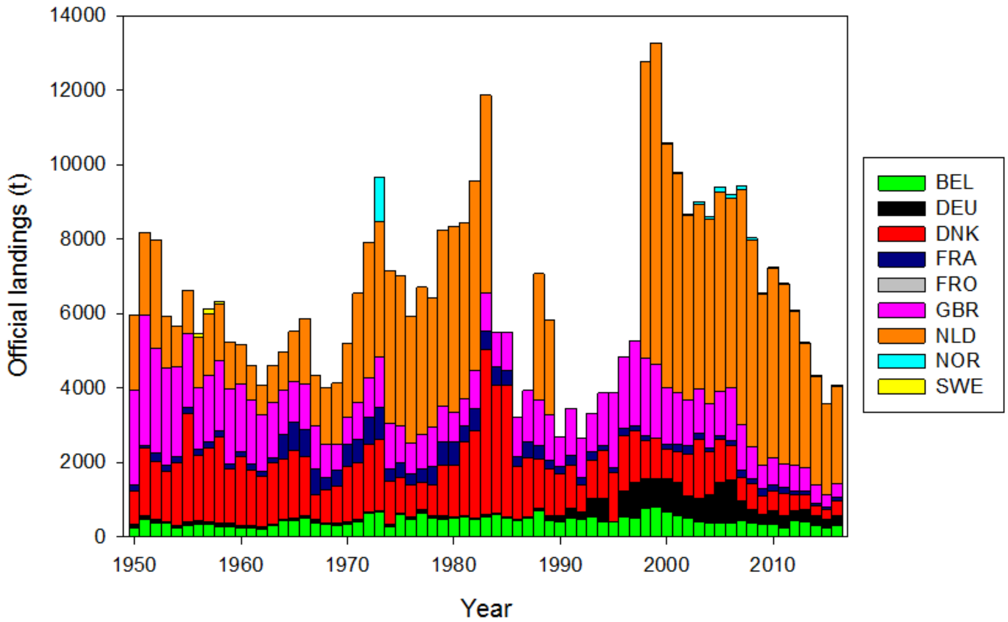


Figure 5.3. Dab in Subarea 4 and Division 3.a: Official landings of dab in Division 3.a by country 1950–2016.

5.2.2 InterCatch

For the WGNSSK2017 dab landing and discard data from 2002–2016 were available in the InterCatch system. Norway did not report any discards because of the official discard ban for the Norwegian fleet. Discard information in 2017 was provided for 78% of total landings in relation to weight.

In 2016 the largest amount of landings and discards was again reported by The Netherlands for the TBB_DEF_70-99_0_0_all metier (Fig. 5.4 and Fig. 5.6). Consequently, by far the largest catch is taken by The Netherlands (32 435 tons in total). All other countries catch less than 10 000 tons (Figure 5.7). The total dab catch estimated with InterCatch for 2016 was 46 896 tons from which 5 085 tons were landings and 44 811 tons discards (90% of total catch). It should be noted that not all metiers were sampled in every quarter and that the raising procedure with the InterCatch tool may not be adequate in all cases. Further, there are a number of metiers for which zero landings are reported and a discard raising for these fleets is not possible with the InterCatch tool, which is based on a discard ratio between landings and observed discards. Especially for bycatch species without economic interest zero landings do not necessarily imply zero discards. However, the Dutch TBB_DEF_70-99_0_0_all metier is by far the most important one in terms of landings and information on discard weights was provided for every quarter.

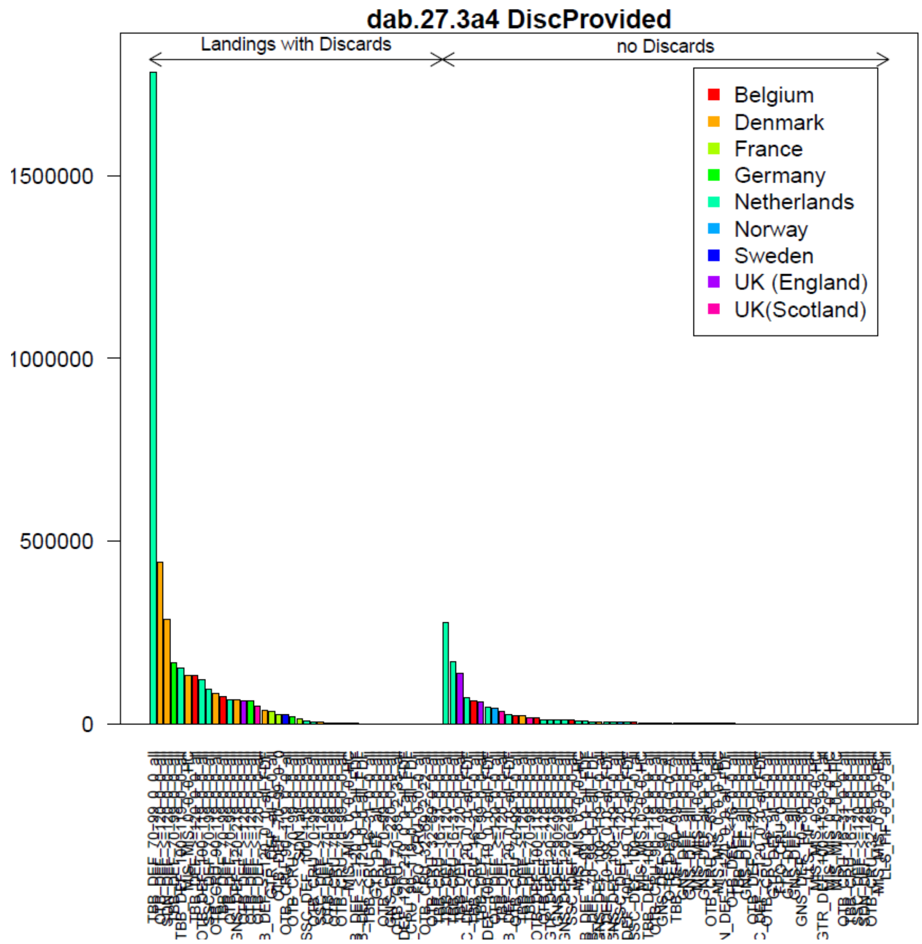


Figure 5.4. Dab in Subarea 4 and Division 3.a: Dab landings and discards (kg) provision for Subarea 4 and Division 3.a by métier and country in 2016 as uploaded into InterCatch.

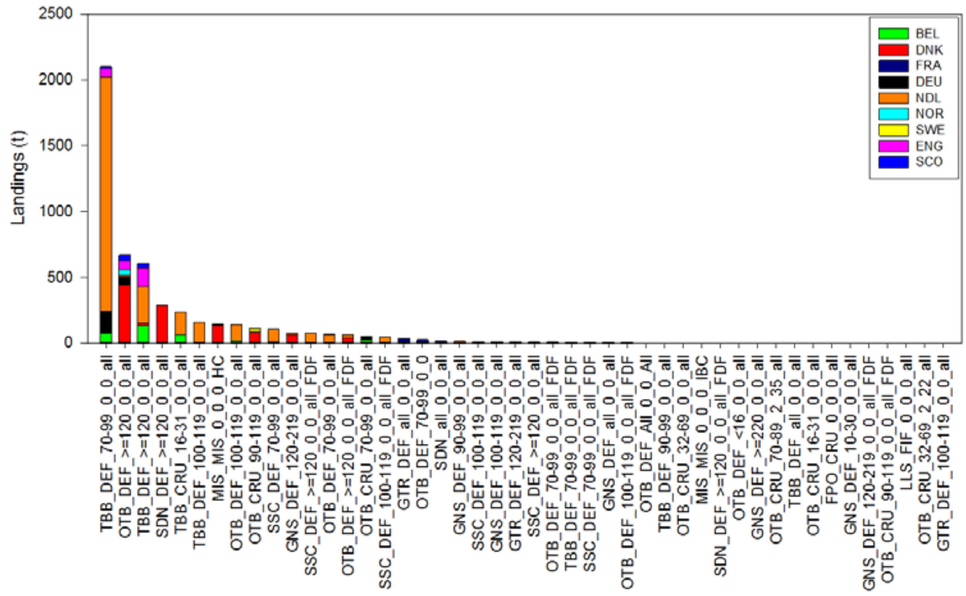


Figure 5.5. Dab in Subarea 4 and Division 3.a: Dab landings (tons) for Subarea 4 and Division 3.a by métier and country in 2016 as uploaded to InterCatch.

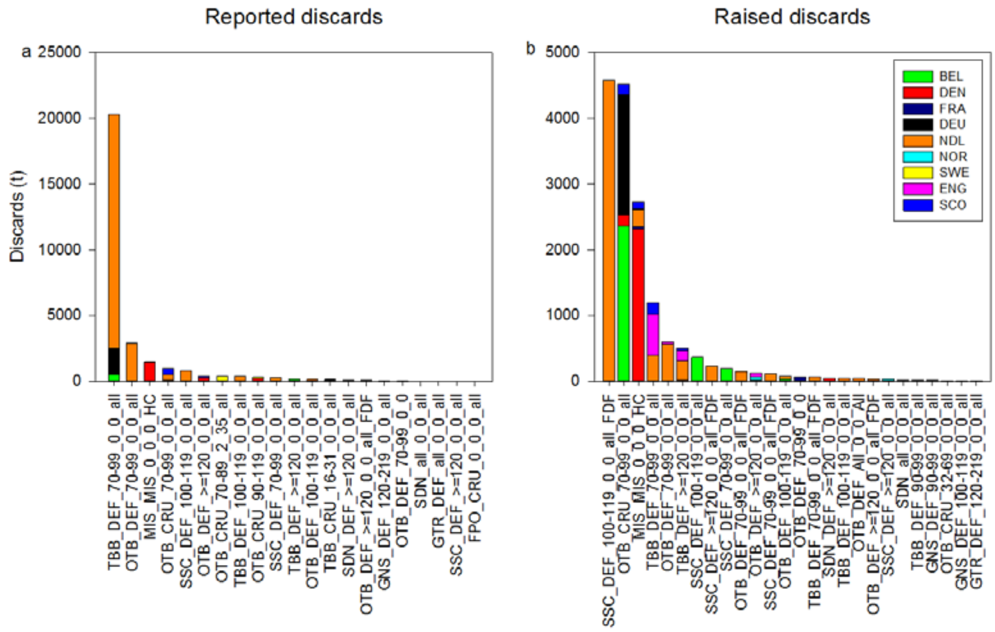


Figure 5.6. Dab in Subarea 4 and Division 3.a: Dab discards for Subarea 4 and Division 3.a by métier and country in 2016. Reported discards (a), raised discards (b).

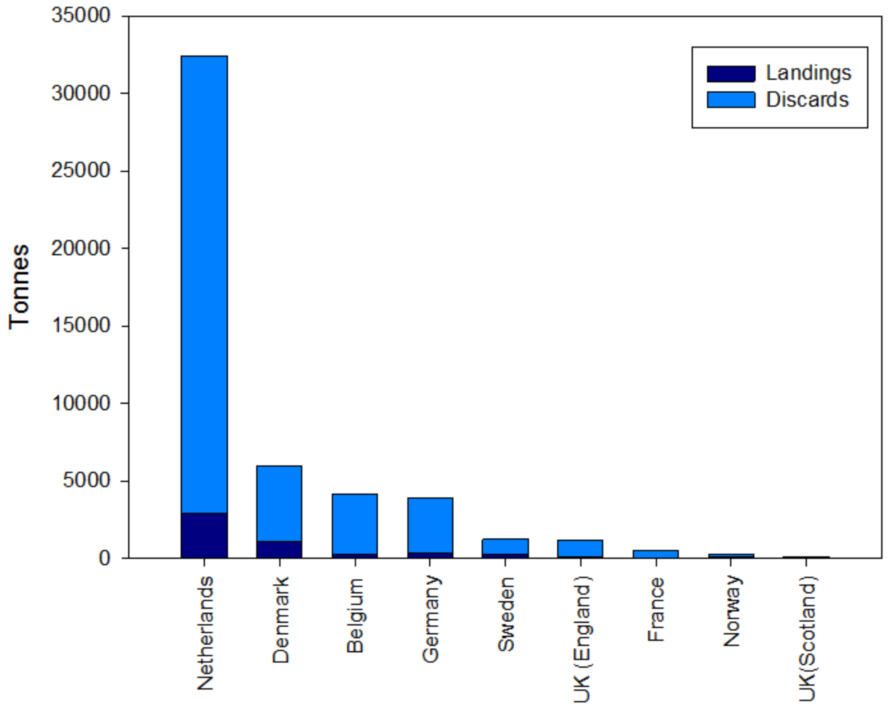


Figure 5.7. Dab in Subarea 4 and Division 3.a: Dab landings and estimated discards for Subarea 4 and Division 3.a by countries in 2015.

5.3 Survey data/recruit series

Surveys providing information on distribution, abundance and length frequency for dab in Subarea 4 and Division 3.a are the several Beam Trawl Surveys (BTS) in quarter 3 (Fig. 5.8 and Fig. 5.9) and the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3 (Figure 5.10).

The longest beam trawl survey time series exist for the RV Isis covering the south eastern part of the North Sea (Fig. 5.9). This index showed high dab abundance in the early years (1987–1990) followed by a sharp decline until 1995. After a second peak in abundance in 1998 the abundance declined again until 2006, and afterwards increased again to such high values as were observed for the time period 1997–1999. The increasing abundance trend from 2005/2006 onwards was also observed for the RV Tridens beam trawl survey, and since 2010 also for the RV Solea beam trawl survey. No trend is visible in the RV Belgica survey data, probably because the time series is too short. The two Dutch time series showed a decrease in abundance for the most recent year. A strong decrease was also observed for the RV Solea survey but already for the year 2015. Also the Belgium time series shows observed a lower value for 2016.

The International Bottom Trawl Survey in quarter 1 (IBTS–Q1) showed an increasing abundance trend from 1983 to 1990 and fluctuated since then without a clear trend until 2013. From 2013 to 2015 a rather strong increase in abundance was observed, followed by a strong decrease again in 2017 (Fig. 5.10). The abundance trends for the IBTS Q3 also showed highly variable abundance trend with a slight increase from the beginning of the time series in 1991 until 2016 (Fig. 5.11).

In order to estimate a mature biomass index a length weight relationship and maturity data derived from IBTS–Q1 data was estimated in previous years to apply the DLS 3.2. method. The obtained length weight relationship and the maturity ogive (Fig. 5.11) were then applied to estimate the mature biomass index in kg per hour. The mature biomass indices in kg/h (Fig. 5.12) show the same trends as the IBTS abundance indices.

Only the beam trawl surveys provide data on age and weight for dab. During the benchmark in 2016 it was agreed to use an age based survey index combining data from the Dutch and German beam trawl surveys taking into account a possible ship effect (i.e. gear effect; Berg *et al*., 2014). For age group 0 the index is highly variable and does not show any trends, probably due to the low catchability of the offshore surveys to catch the 0–group. For the age groups 1–8 an increase of the index is observed, especially since 2010. The indices for age group 9 and 10 also show a slight increase but are extremely variable for the most recent years. For age groups 3–8 a decrease of the index was observed for the last year (the same for age group 10). This index served as an input for a survey based assessment model (SURBA) to inform the stock status of North Sea dab (Fig. 5.13). The spatial distribution of dab age groups follows a clear pattern with the youngest age groups (0 and 1) located near the coast of the south eastern North Sea and the older age groups more distributed in the central North Sea (Fig. 5.14). The weight at age data show a slightly decreasing trend for all age groups from 2002 to 2015, but a rather sharp increase for the last year for the age groups 1–5 (Fig. 5.15).

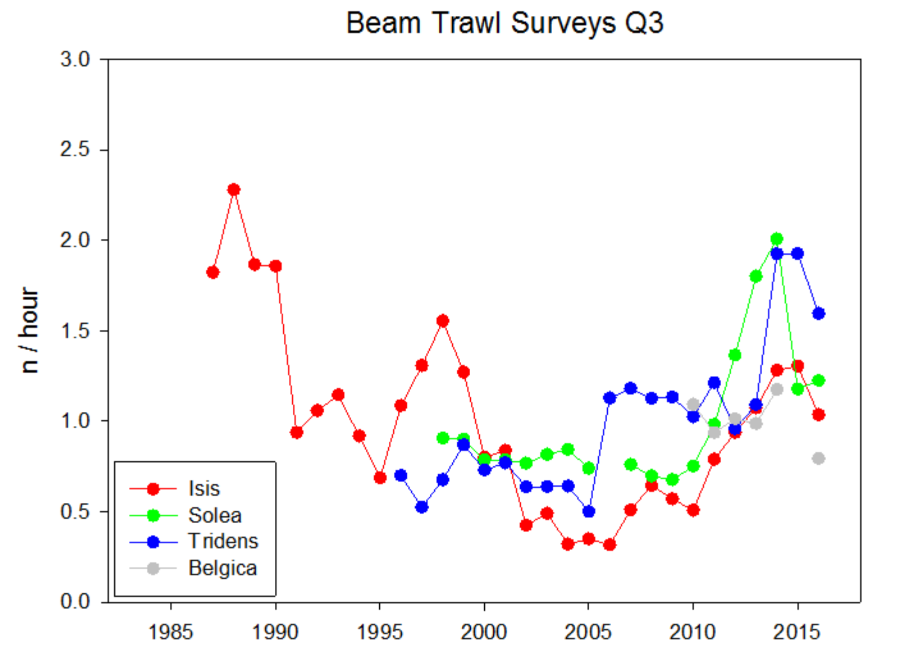


Figure 5.8. Dab in Subarea 4 and Division 3.a: Standardized dab beam trawl survey indices (n/hour) in Subarea 4 from the participating research vessels.

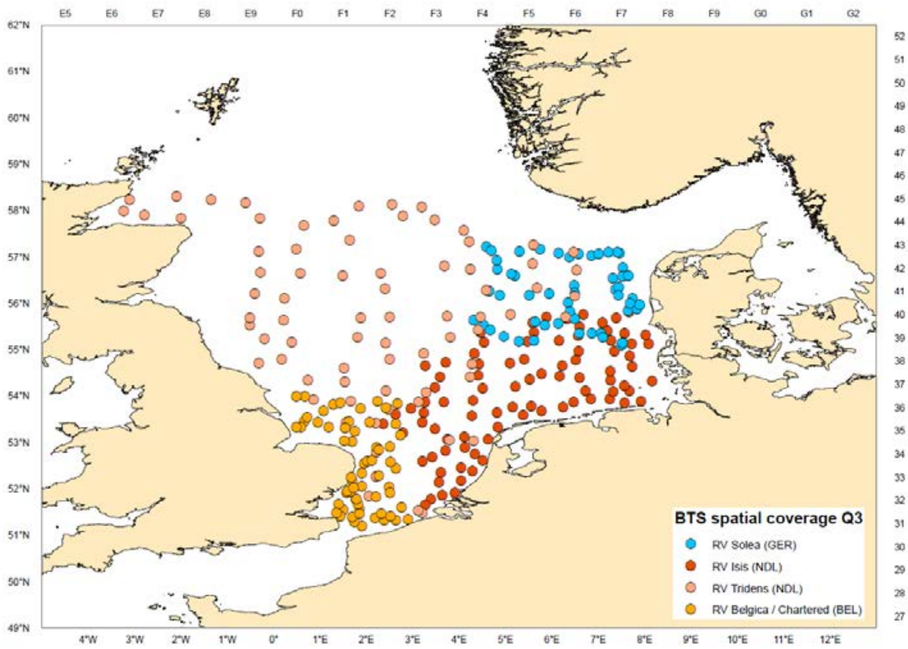


Figure 5.9. Dab in Subarea 4 and Division 3.a: Spatial coverage of the different beam trawl surveys in the North Sea.

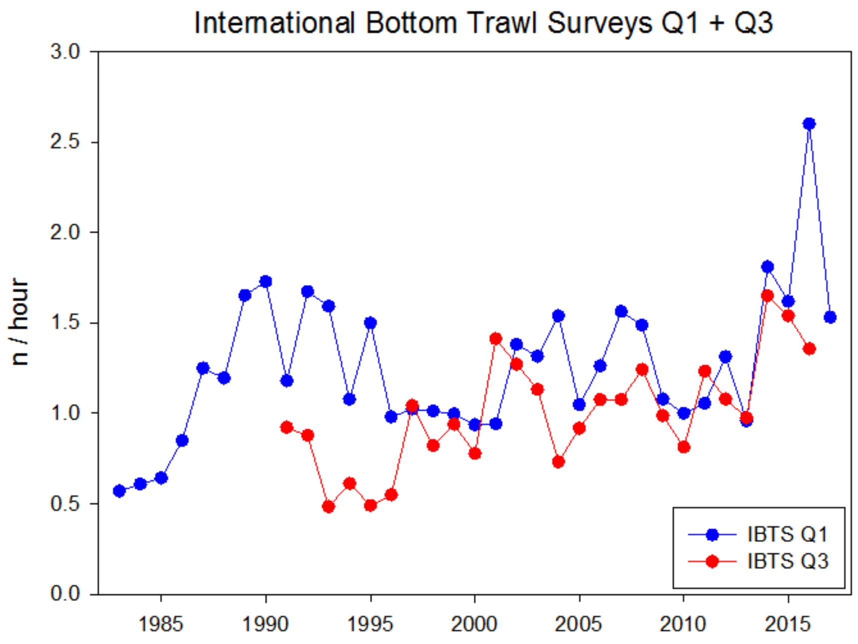


Figure 5.10. Dab in Subarea 4 and Division 3.a: Standardized dab survey indices (n/hour) from the International Bottom Trawl Survey.

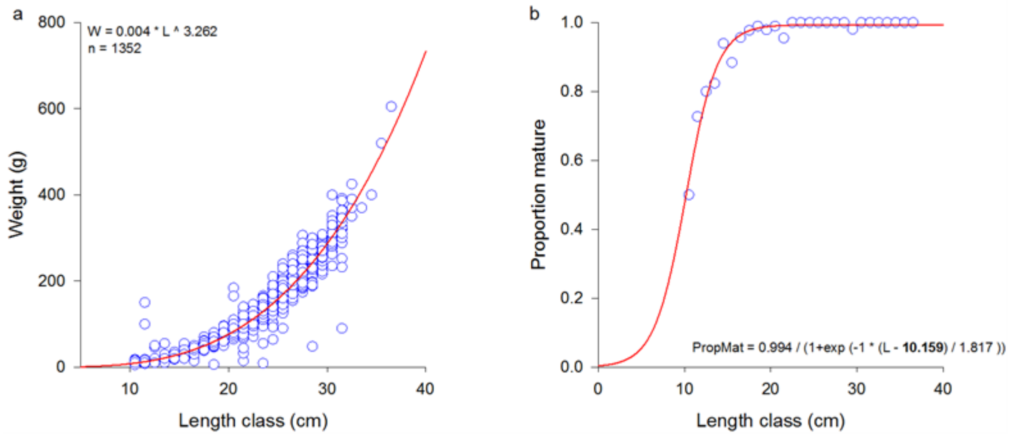


Figure 5.11. Dab in Subarea 4 and Division 3.a: Length weight relation (a) and length based maturity ogive (b) obtained from survey data (IBTS–Q1).

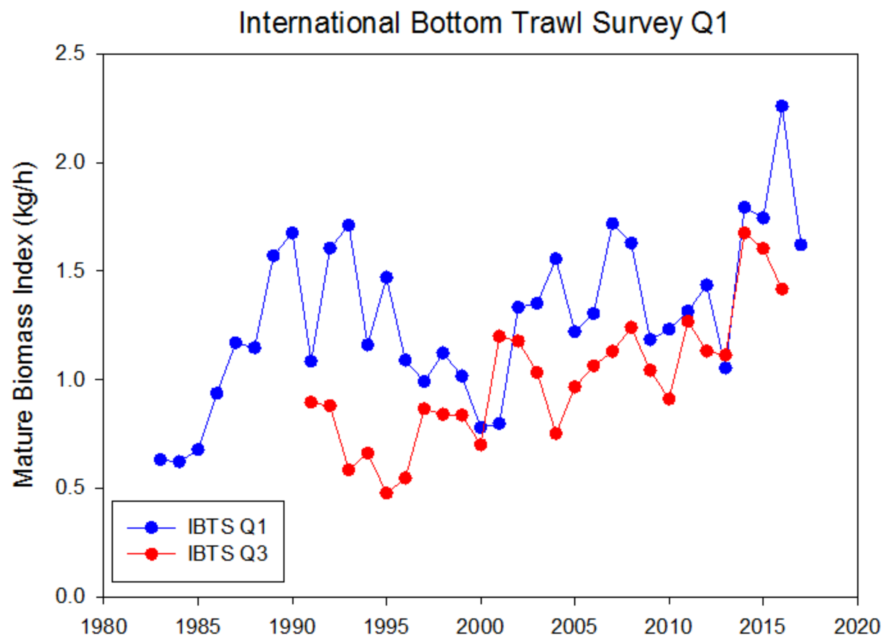


Figure 5.12. Dab in Subarea 4 and Division 3.a: Mature biomass index IBTS–Q1.

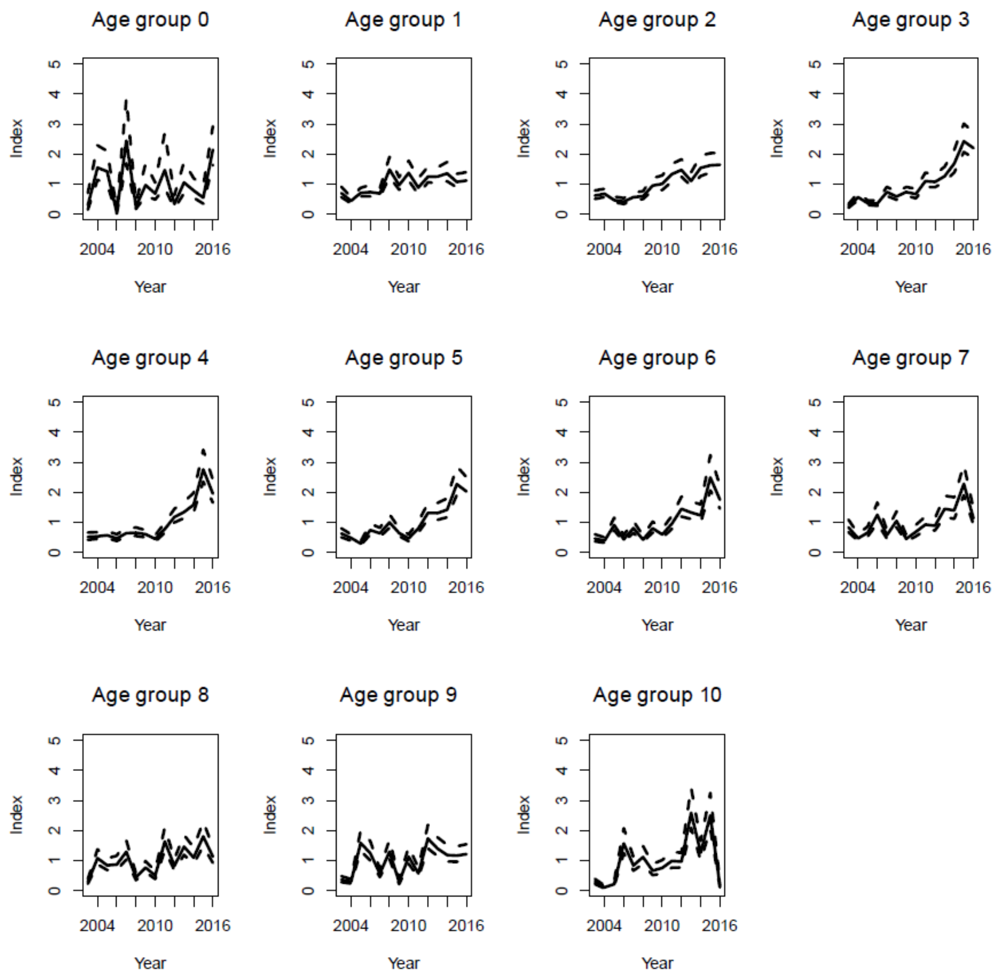


Figure 5.13. Dab in Subarea 4 and Division 3.a: Combined beam trawl index by age groups.

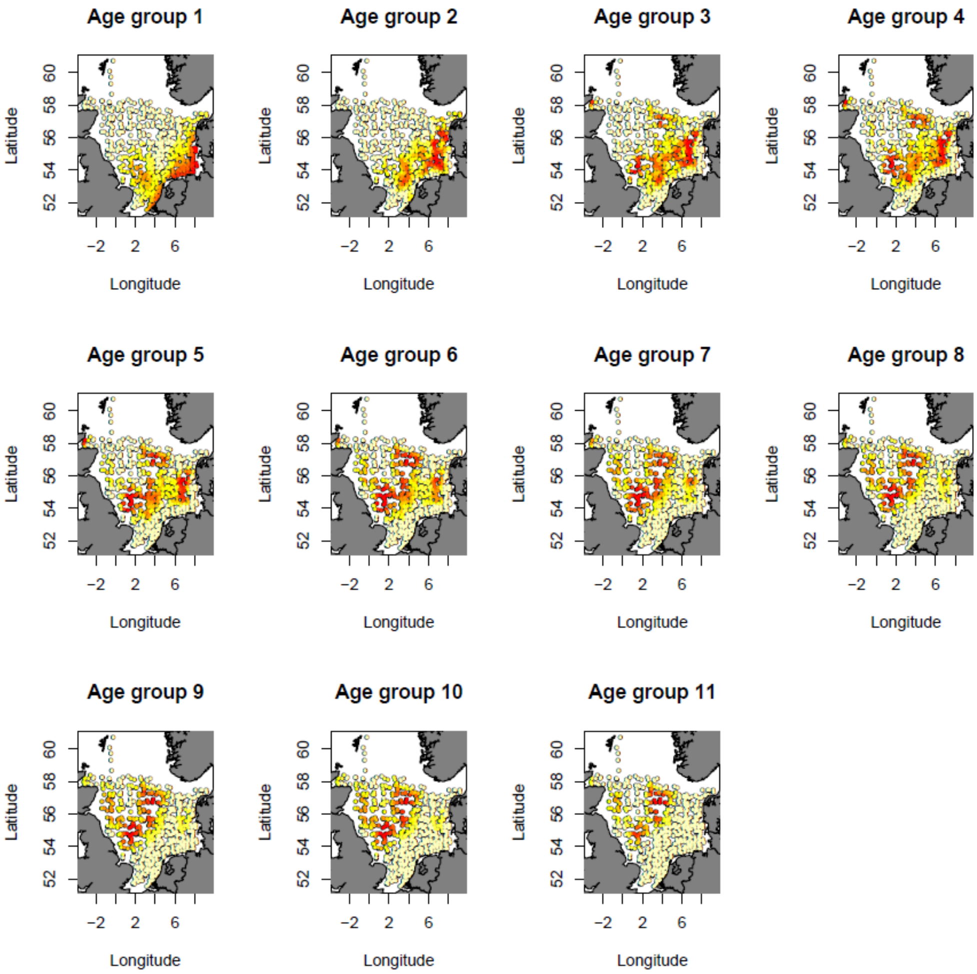


Figure 5.14. Dab in Subarea 4 and Division 3.a: Dab distribution in the North Sea by age group obtained by the Dutch and German Beam Trawl Surveys (age–1).

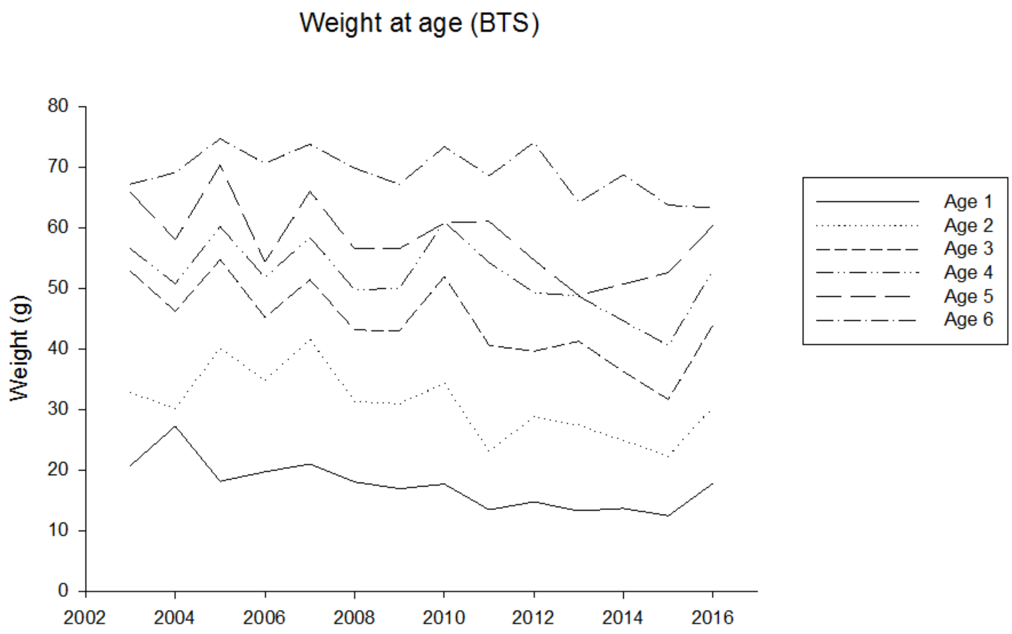


Figure. 5.15 Dab in Subarea 4 and Division 3.a: Weight at age derived from beam trawl survey data 2003–2016).

5.4 Survey Based Assessment (SURBA)

In 2016 a benchmark assessment was carried out for dab (ICES 2016). During this benchmark it was agreed to make use of the available data from the beam trawl surveys and to run a survey based assessment model (SURBAR; Needle, 2015) taking the age structure of dab into account. The SURBAR results of the update assessment showed an overall decreasing trend in total mortality (Fig. 5.16, upper left panel) while the spawning stock biomass (relative biomass) continued to increase (Fig. 5.16, upper right panel). The recruitment showed a decreasing trend for the last two years (Fig. 5.16, lower right panel). The recruitment increased by a factor of 2.6 from 2003 to 2014 but dropped for the last two years. However, there is a strong retrospective pattern in recruitment with a general underestimation of recruitment for the terminal years (Fig. 5.21). This might indicate a lower catchability of the survey for the youngest age group and a lower capability of the SURBA model to track the young age groups. No pattern was detected in the log residual pattern of the age based survey indices (Fig. 5.17).

Table 5.1. Dab in Subarea 4 and Division 3.a: Settings and input data used for the final SURBA assessment run.

Setting/Data	Values/source
Survey index	Combined beam trawl survey index 2003 - current assessment year (BTS-Isis, BTS-Tridens, German BTS) . Delta GAM Method by Berg *et al.*, 2014.
Ages	1 – 6
Lambda	3
zbar	1 - 6
Spawning time	0.4
Maturity ogive	Fixed ogive, age 1 = 60%, age 2 = 80%, age 3 and older 100%
Weight at age	Data from Dutch Beam Trawl Surveys (2003 - current assessment year)

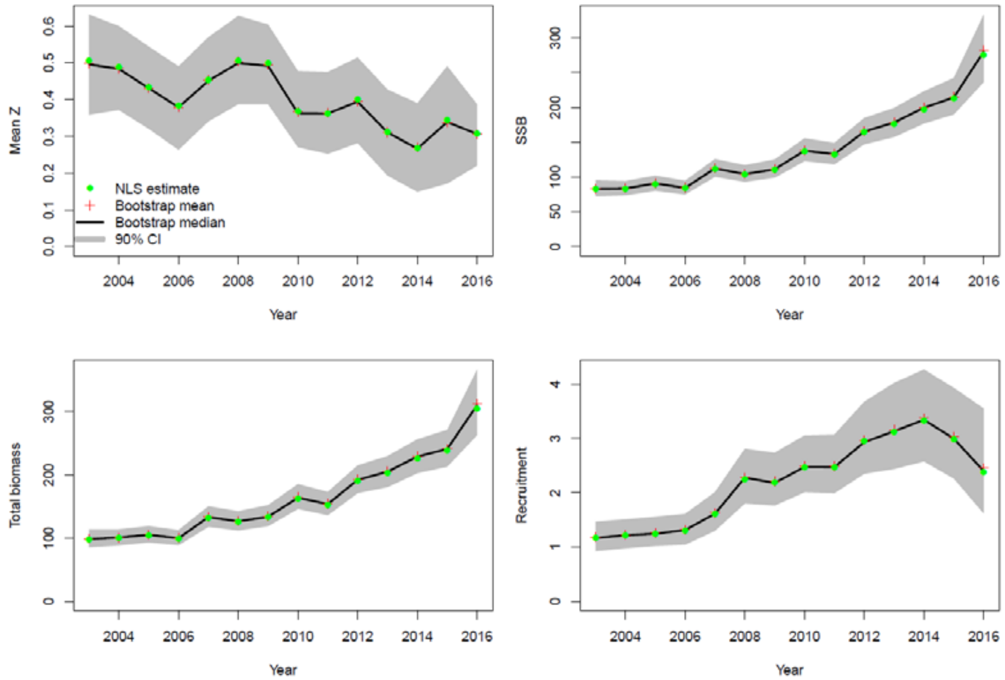


Figure 5.16. Dab in Subarea 4 and Division 3.a: SURBA model results for dab total mortality (z), spawning stock biomass (SSB), total stock biomass (TSB) and recruitment.

Figure 5.17. Dab in Subarea 4 and Division 3.a: SURBA model results of log residuals.

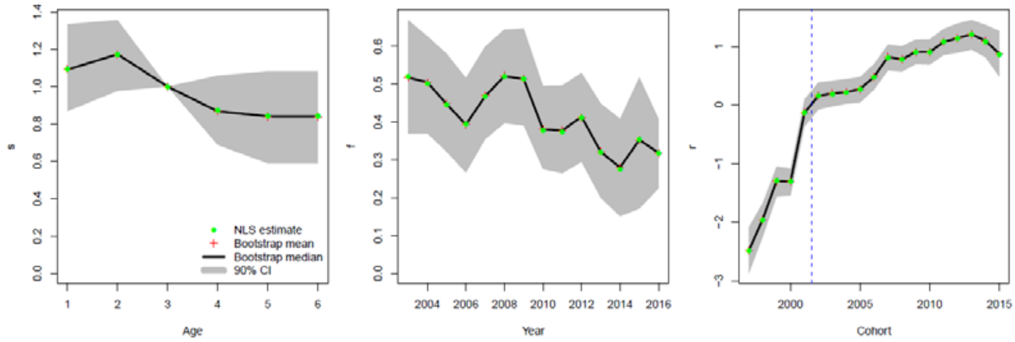


Figure 5.18. Dab in Subarea 4 and Division 3.a: SURBA model results displaying the age, year and cohort effects.

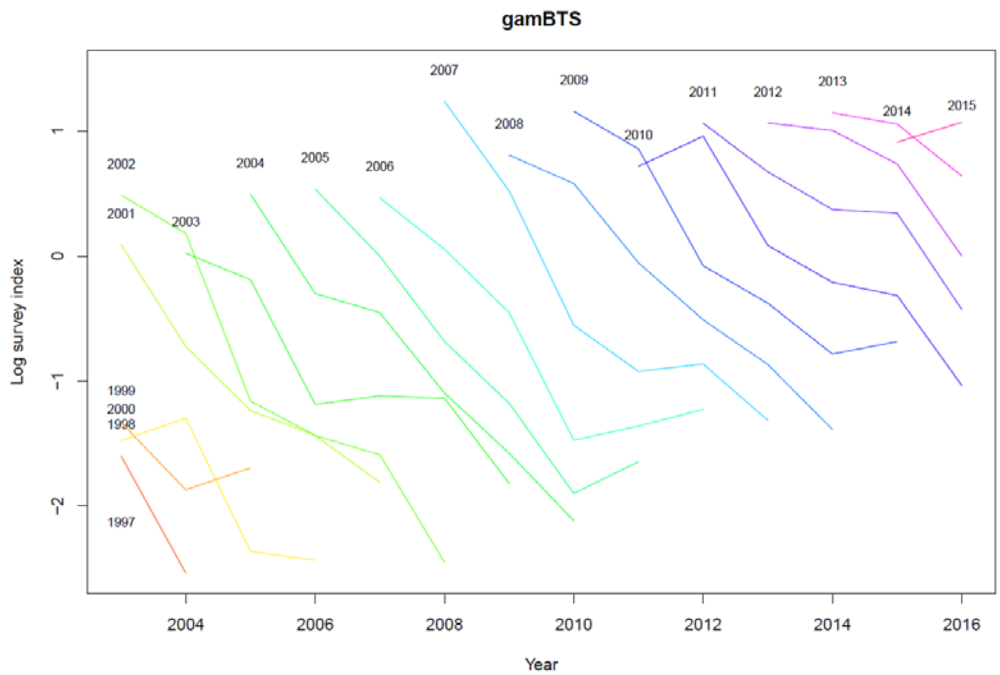


Figure 5.19. Dab in Subarea 4 and Division 3.a: SURBA model results: catch curves.

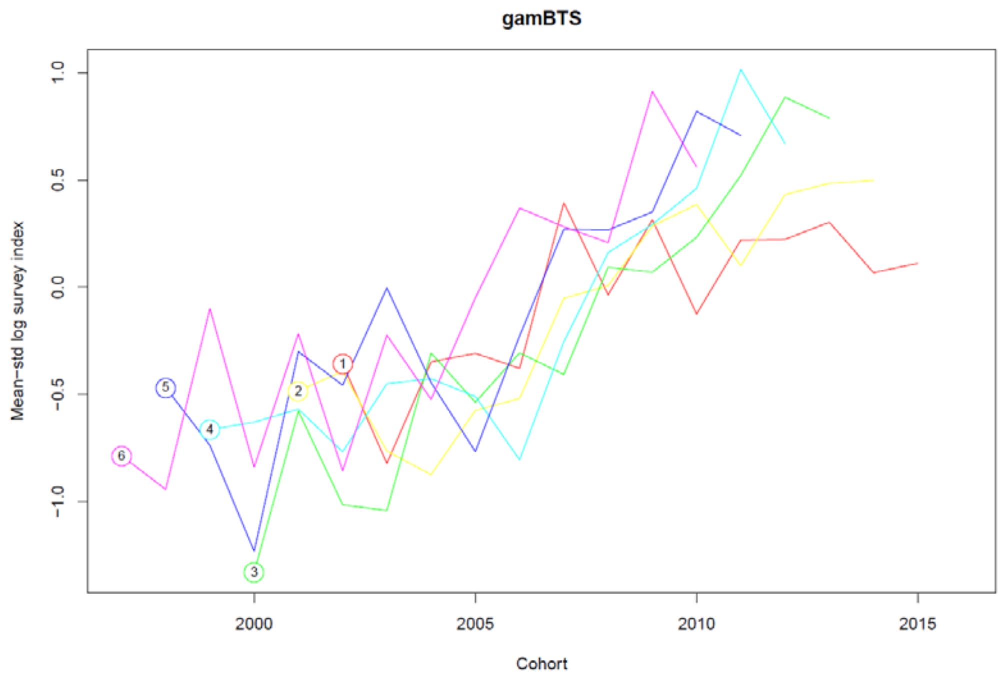


Figure 5.20. Dab in Subarea 4 and Division 3.a: SURBA mean-standardized log survey index.

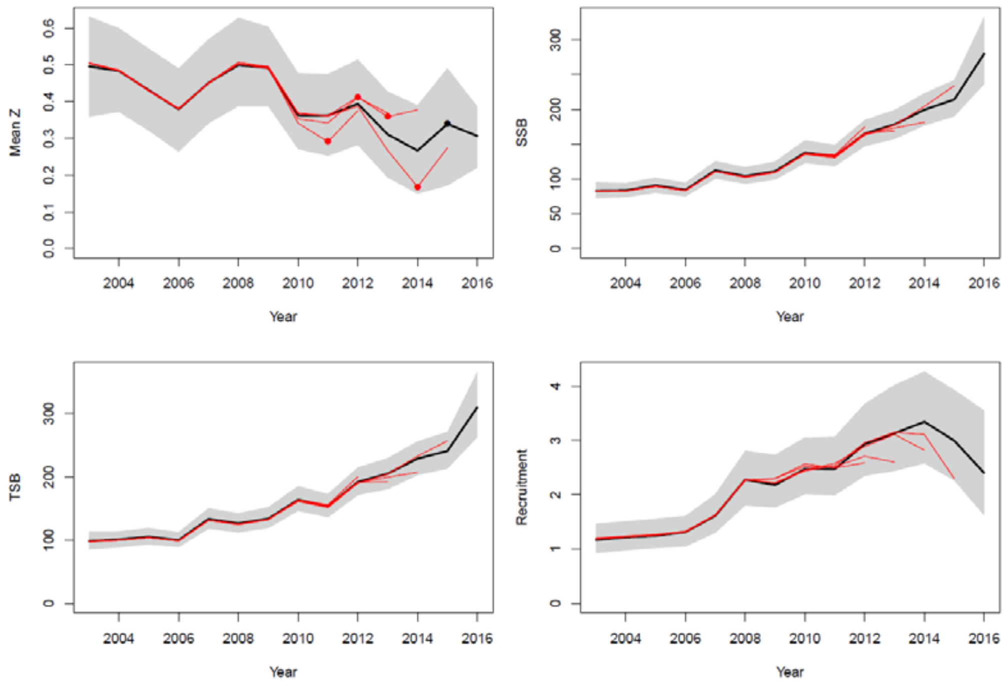


Figure 5.21. Dab in Subarea 4 and Division 3.a: SURBA Retrospective runs.

5.5 Analysis of stock trends

Dab is defined as a category 3 species following the ICES guidelines for data limited stocks (ICES 2013). Consequently, the basis of the advice is a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and *I* is the stock index. By default x=2 and z=5.

Table 5.2 displays the summary of the DLS 3.2. approach using the results of the updated assessment.

Table 5.2. Results of applying the DLS 3.2.

Indicator (2015–2016)	244.07
Indicator (2012–2014)	179.01
Indicator ratio	1.36
Uncertainty cap	Applied
Average catch (2014–2016)	53 710 tons
Discard rate (2014–2016)	0.91
Precautionary buffer	Not applied
Catch advice*	64 452 tons
Landings corresponding to catch advice**	6 116 tons

* average catch x uncertainty cap

** average catch x uncertainty cap x (1–discard rate)

Table 5.3. Summary of the assessment.

Year	Official landings	ICES Landings	ICES catches	ICES discards	SURBA SSB	Discard rate
1983	14771					
1984	8251					
1985	7047					
1986	4813					
1987	6189					
1988	9321					
1989	8162					
1990	4275					
1991	5057					
1992	4101					
1993	5004					
1994	5822					
1995	5395					
1996	6239					
1997	6271					
1998	13720					

1999	13949					
2000	11249					
2001	10564					
2002	9655	8588	35219	26631		0.76
2003	9873	9433	54363	44930	82.52	0.83
2004	9387	8647	42920	34273	82.65	0.80
2005	10238	9537	44828	35291	89.64	0.79
2006	9914	10236	48214	37977	83.55	0.79
2007	10127	9881	43208	33328	111.08	0.77
2008	8551	8645	36024	27379	103.03	0.76
2009	7060	7040	40461	33421	109.84	0.83
2010	7830	8279	50765	42486	136.34	0.84
2011	7372	7422	51882	44460	131.52	0.86
2012	6749	7047	59679	52632	163.85	0.88
2013	6084	6611	60087	53476	176.04	0.89
2014	4957	5047	58780	53733	197.14	0.91
2015	4512	5082	52454	47372	212.75	0.90
2016	4953	5085	49896	44811	275.39	0.90

5.6 MSY Proxy analyses for dab in Subarea 4 and Division 3.a.

5.6.1 Dab 27.3a4 Surplus Production Model in Continuous Time (SPiCT)

In order to estimate MSY proxy reference points for dab a Surplus Production Model in Continuous Time (SPiCT, Pedersen & Berg, 2017) was applied. Three fishery independent survey time series and a catch time series (2002–2016) were used as input for the model (details of model input and settings given in table 5.2). The survey time series were reduced by the recruits (i.e. >12 cm or >age 1) in order to obtain a better proxy for the exploitable biomass, which is a prerequisite for any production model.

Table 5.3. Dab in Subarea 4 and Division 3.a. SPiCT settings and input data.

SETTING/DATA	VALUES/SOURCE
Catch time series	InterCatch data 2002–2016
BTS Isis	1987–2002, >12 cm
BTS Tridens	1996–2002, >12 cm
Combined BTS (Isis, Tridens, Solea)	2003–2016, Age > 1yr
SPiCT settings	Default from stockassessment.org, no priors

The results of the SPiCT assessment for dab in Subarea 4 and Division 3.a showed that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is above the reference B_{MSY}* 0.5 proxy. Also the estimated uncertainty boundaries around the relative F values show that these are below the reference F_{MSY} proxy for the last four years, and those estimated for the relative biomass are above the reference B_{MSY}* 0.5 for the last six years. These results show that the SPiCT assessment was able to give robust results in the case of dab in Subarea 4 and Division 3.a with regard to MSY proxies. Therefore, the Precautionary Approach Buffer (PA Buffer) was not applied for the advice for this stock. However, it has to be noted here that the absolute F and biomass estimates are highly uncertain and must not be used for any further analyses or conclusions. All results of the SPiCT assessment are given in figures 5.22–5.28 and in tables 5.4–5.8.

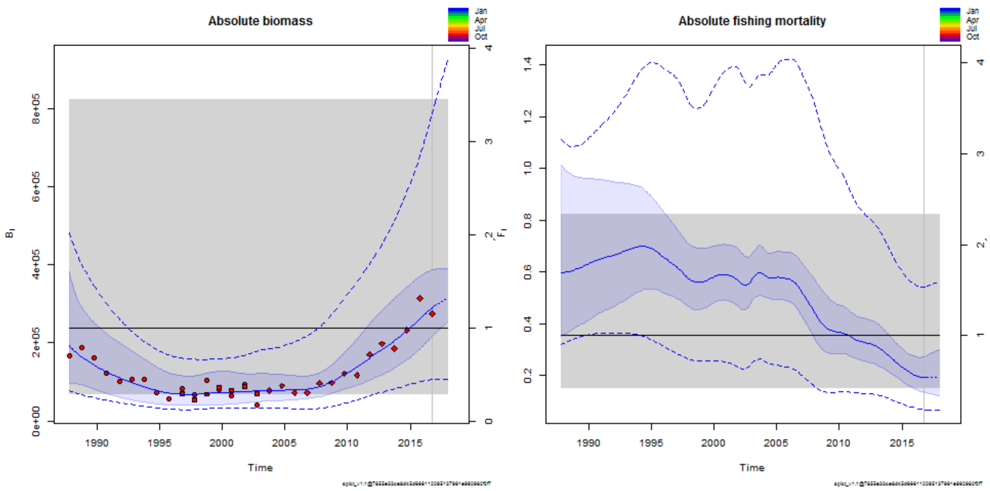


Figure 5.22. Dab in Subarea 4 and Division 3.a: SPiCT results. Absolute biomass (left panel) and absolute fishing mortality (right panel).

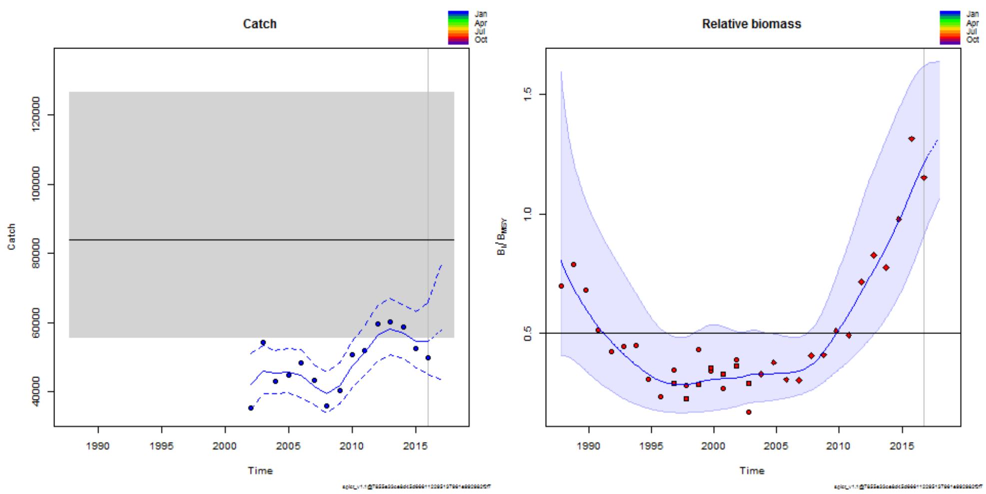


Figure 5.23. Dab in Subarea 4 and Division 3.a: SpiCT results. Catch time series (left panel) and relative fishing mortality (right panel).

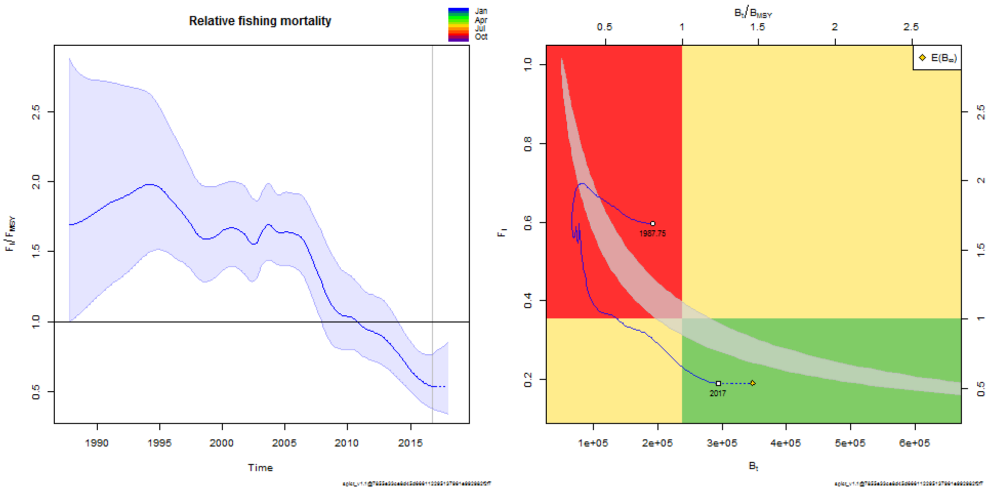


Figure 5.24. Dab in Subarea 4 and Division 3.a: SpiCT results. Relative fishing mortality (left panel) and Kobe plot of relative fishing mortality over biomass estimate (right panel).

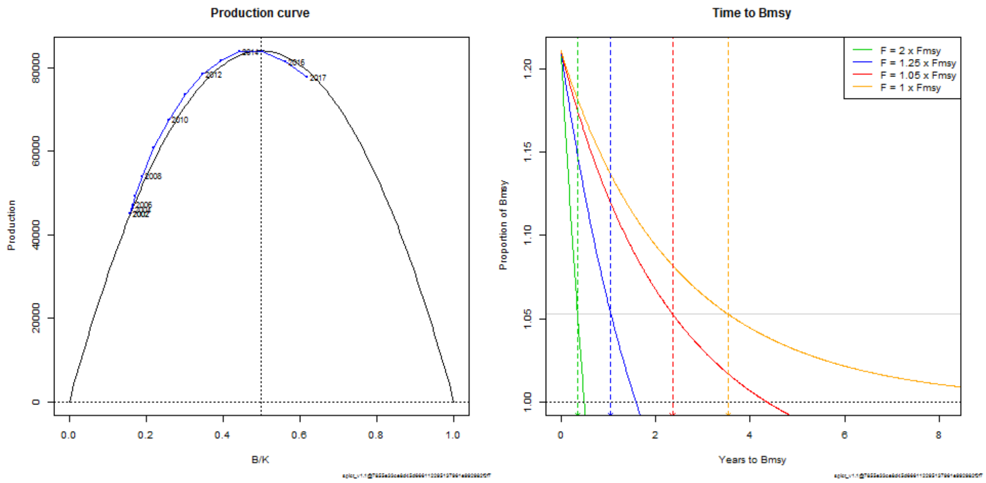


Figure 5.25. Dab in Subarea 4 and Division 3.a: SpiCT results. Production curve (left panel) and estimated time to BMSY (right panel).

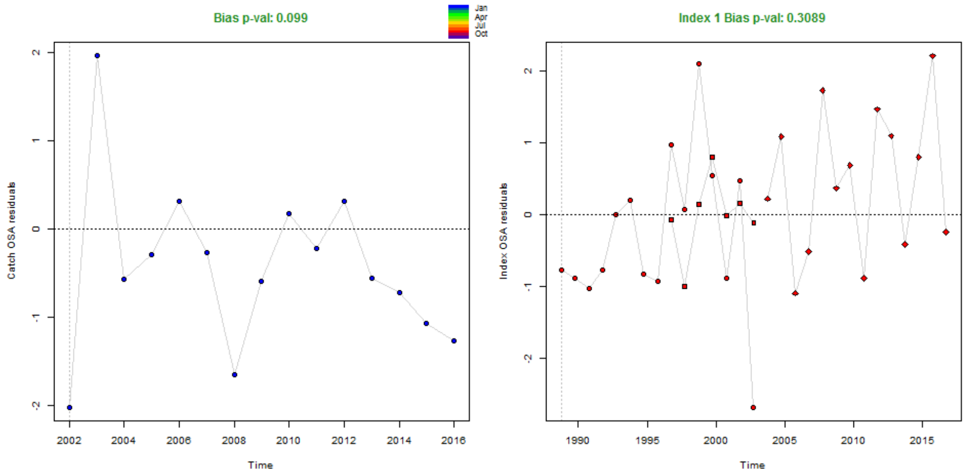


Figure 5.26. Dab in Subarea 4 and Division 3.a: SpiCT results. Catch residuals (left panel) and survey residuals (right panel).

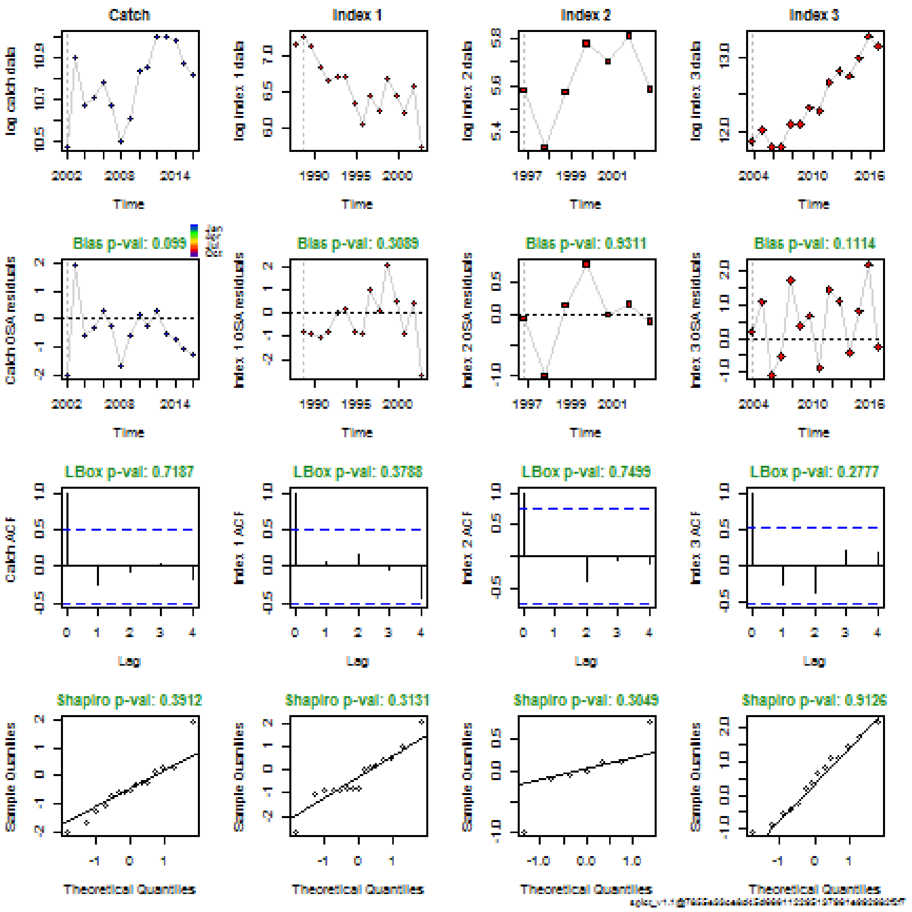


Figure 5.27. Dab in Subarea 4 and Division 3.a: SpiCT diagnostics.

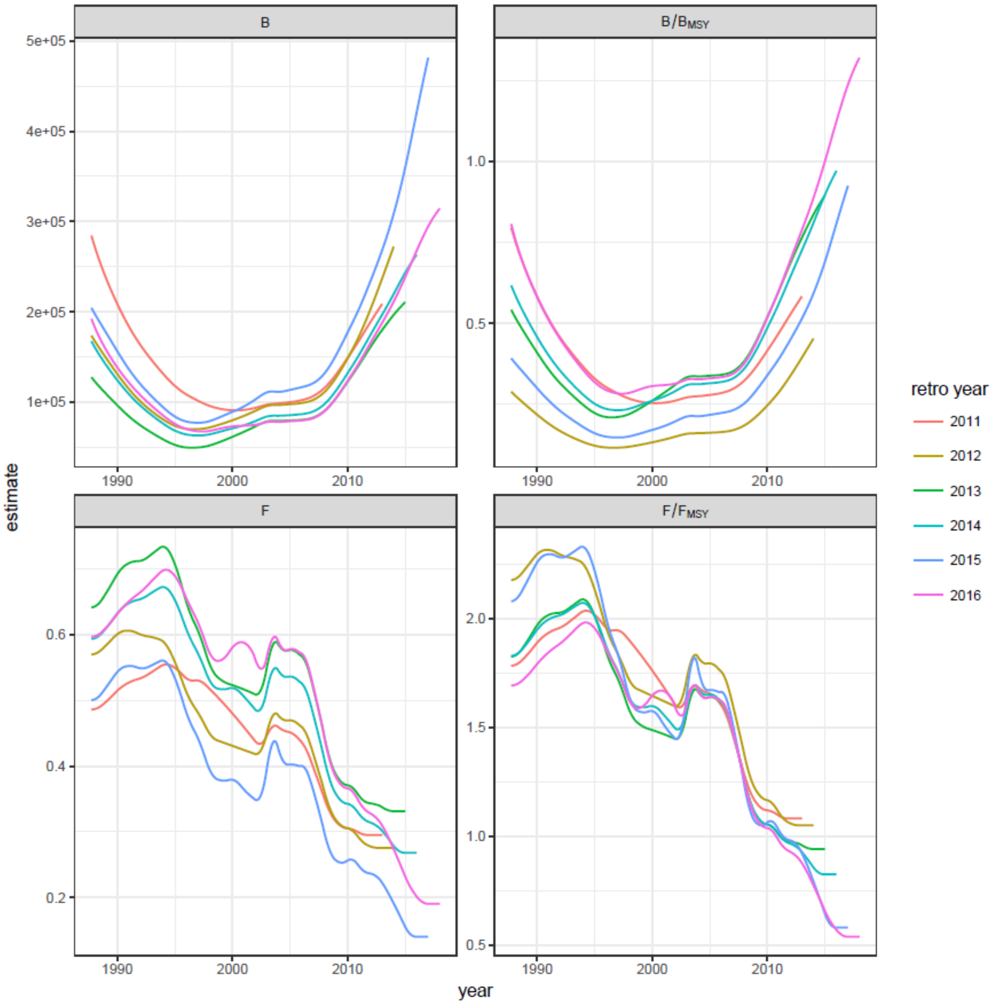


Figure 5.28. Dab in Subarea 4 and Division 3.a: SpiCT retrospective plots.

Table 5.4. Dab in Subarea 4 and Division 3.a: Parameter estimates of the SPiCT assessment.

Parameter	estimate	cilow	ciupp	log.est
alpha1	23.476	0.243	2264.898	3.156
alpha2	12.834	0.127	1293.423	2.552
alpha3	9.921	0.104	946.177	2.295
beta	0.787	0.311	1.991	-0.239
r	0.705	0.302	1.645	-0.349
rc	0.705	0.302	1.645	-0.349
rold	0.705	0.302	1.645	-0.349
m	83987.985	55769.979	126483.490	11.338
K	476289.598	137828.456	1645899.457	13.074
q1	0.008	0.003	0.018	-4.857
q2	0.004	0.002	0.009	-5.559
q3	1.861	0.726	4.771	0.621
sdb	0.011	0.000	1.023	-4.523
sdf	0.133	0.077	0.230	-2.021
sdi1	0.255	0.172	0.378	-1.367
sdi2	0.139	0.073	0.265	-1.971
sdi3	0.108	0.071	0.163	-2.228
sdc	0.104	0.057	0.191	-2.260

Table 5.5. Dab in Subarea 4 and Division 3.a: Deterministic reference points of the SPiCT assessment.

Reference point	estimate	cilow	ciupp	log.est
Bmsyd	238144.799	68914.228	822949.729	12.381
Fmsyd	0.353	0.151	0.823	-1.042
MSYd	83987.985	55769.979	126483.490	11.338

Table 5.6. Dab in Subarea 4 and Division 3.a: Stochastic reference points of the SPiCT assessment.

Reference point	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	238115.455	68906.853	822834.997	12.381	0.000
Fmsys	0.353	0.151	0.823	-1.042	0.000
MSYs	83970.937	55760.373	126453.928	11.338	0.000

Table 5.7. Dab in Subarea 4 and Division 3.a: Estimated states of the SPiCT assessment.

	estimate	cilow	ciupp	log.est
B_2016.75	288297.866	105861.884	785133.009	12.572
F_2016.75	0.191	0.067	0.541	-1.657
B_2016.75/Bmsy	1.211	0.905	1.620	0.191
F_2016.75/Fmsy	0.541	0.381	0.768	-0.614

Table 5.8. Dab in Subarea 4 and Division 3.a: Estimated forecast of the SPiCT assessment.

	prediction	cilow	ciupp	log.est
B_2017.00	294515.123	106572.973	813894.511	12.593
F_2017.00	0.190	0.067	0.544	-1.659
B_2017.00/Bmsy	1.237	0.939	1.629	0.213
F_2017.00/Fmsy	0.540	0.372	0.783	-0.616
Catch_2017.00	57840.162	43637.562	76665.243	10.965
E(B_inf)	347643.823			12.759

5.6.2 Exploration of length based methods for dab 27.3a4

Length distribution from commercial landings and discards were available for three years in InterCatch (2014–2016). These data were used for the analyses of MSY proxies applying the Mean Length Z Estimator (Gedamke and Hoenig 2006, Then *et al.*, 2011) and Length Based Indicators. For most of the years only a small part of the total catch was sampled (Fig. 5.29 and Fig. 5.30). Especially for the discards the data availability was limited because data for the Dutch fleets, which are the most important ones for this stock in terms of total catch, were not provided. The same was the case for landings in 2014 and 2015. The sample coverage of landings was around 20% for these two years (Fig. 5.30). In 2016 the sample coverage for landings was better with ca. 60%, because for this year also Dutch data were available (Fig. 5.30 lower panel). Further, Belgium and England provided length data in cm units for dab. Since most of the data were provided in mm units, Belgian and English data were not used for the allocation schemes in InterCatch. In order to obtain a sufficient number of length samples all gears were grouped together by landings and discards and by quarter. Both methods also require growth parameters and length weight relationships, which were taken from literature (Froese and Sampang, 2013; Table 5.9).

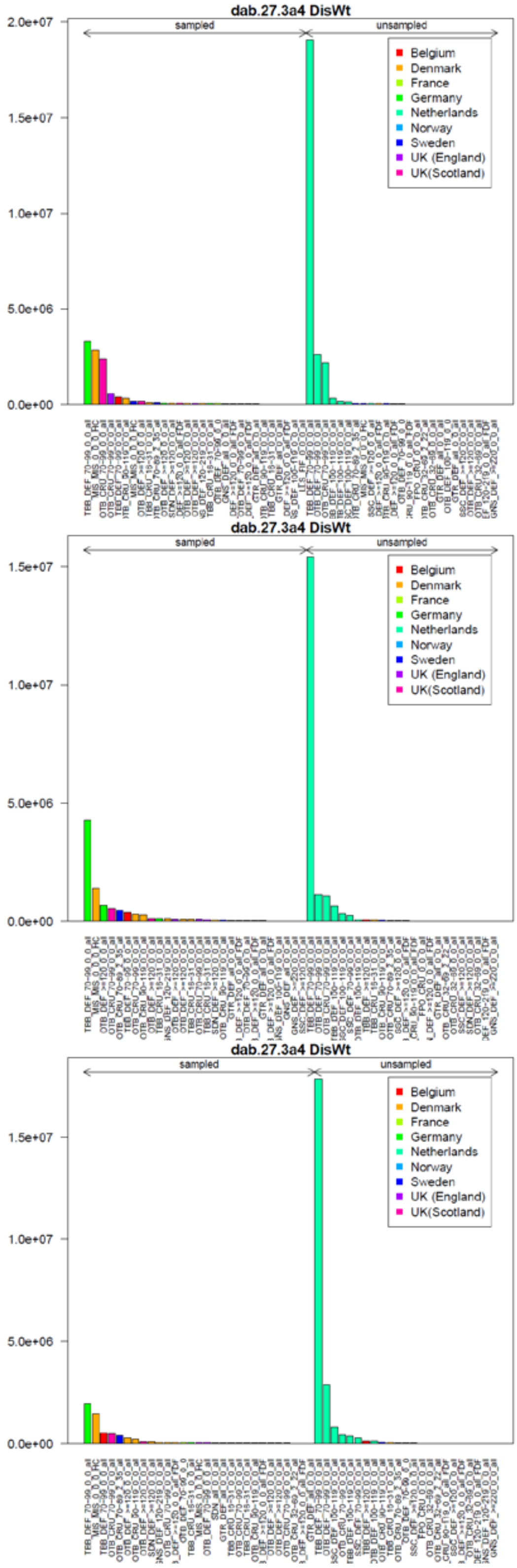


Figure 5.29. Dab in Subarea 4 and Division 3.a: Sampled and unsampled discards by métier and country in terms of catch weight (2014–2016).

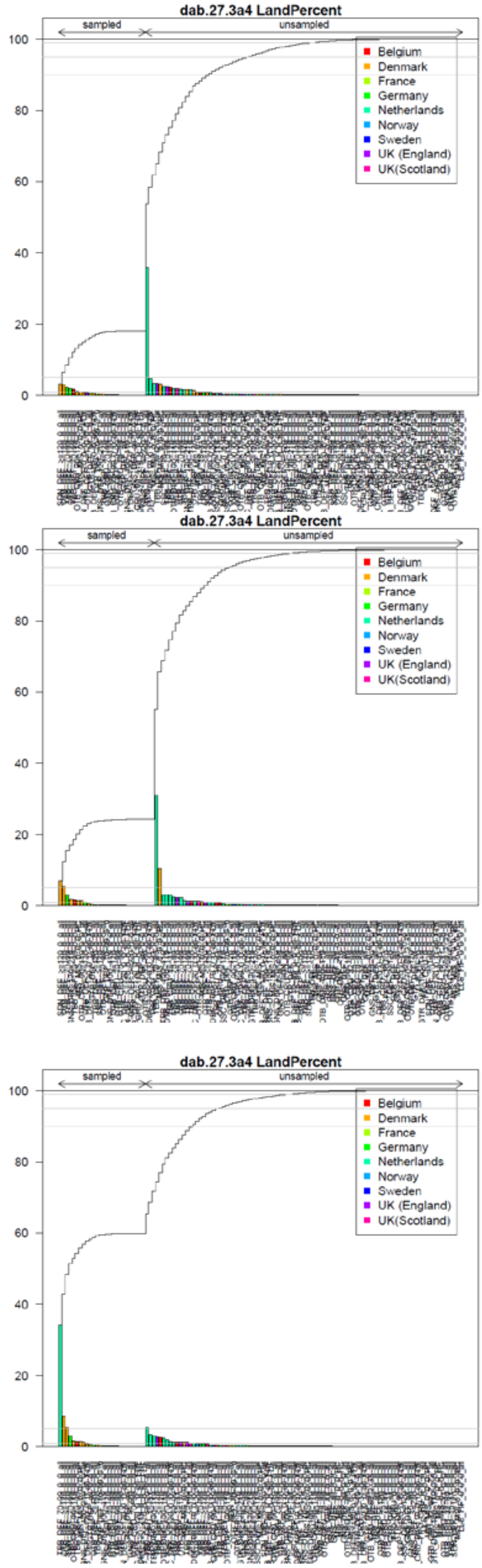


Figure 5.30. Dab in Subarea 4 and Division 3.a: Sampled and unsampled landings by métier and country in percent of total landings (2014–2016).

Table 5.9 Dab in Subarea 4 and Division 3.a: Parameters used as input for the length based methods (Source Froese & sampan, 2013; *fishbase.org).

PARAMETER	SEX COMBINED
von Bertalanffy L∞ (cm)	33
von Bertalanffy k (yr-1)	0.21
Length-weight a	0.0068
Length weight b	3.14
Natural mortality M (yr-1)	0.25
Length-at-maturity (mm)	13
Max Age	12*

Mean Length Z estimator

Data

Length distribution time series: Landings and discards length distribution sex combined for the years 2014–2016 (InterCatch). Fishing effort: InterCatch effort data for the most important metier catching dab 2014–2016 (TBB_DEF_70-99_0_0_all; effort data from UK (England) were not provided).

Results

The length frequency distributions show a bimodal distribution for all three years (Fig. 5.31). Therefore, two runs were performed: (i) including all data, (ii) removing the left mode, i.e. recruits. In the following only one run is described, since both runs revealed exactly the same results. The mean length differed only slightly between the last three years and were around 19 cm (Fig. 5.32). The Gedamke and Hoenig model revealed a total mortality of 0.65 for dab. Assuming a natural mortality of 0.25 for dab this would result in F=0.40 which is higher than the $F_{0.1}$=0.19 obtained by the YPR analysis. This result would suggest that dab is exploited at or above F_{MSY}. However, for the YPR analysis the hessian matrix was not definite positive and the results seem not to be reliable. Estimating M by the THoG model did not provide reliable results either, since M was estimated to be negative. With a fixed M of 0.25 the THoG model revealed similar results as the Gedamke and Hoenig model with an average F of 0.37 for the last three years (Fig. 5.33).

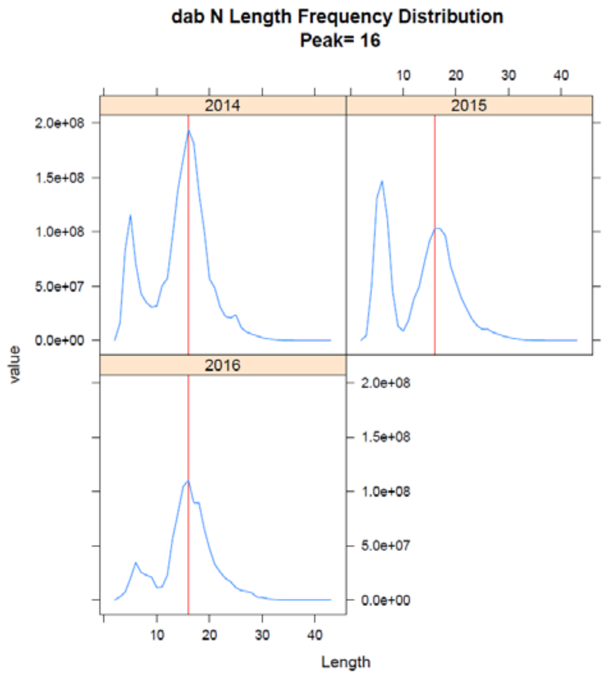


Figure 5.31. Dab in Subarea 4 and Division 3.a: Length distributions obtained by the InterCatch data (2014–2016).

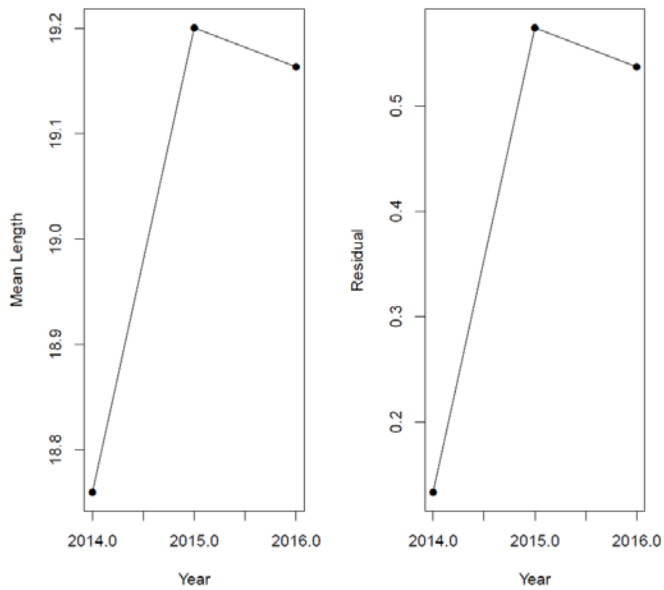


Figure 5.32. Dab in Subarea 4 and Division 3.a: Mean length and residuals 2014–2016 (InterCatch).

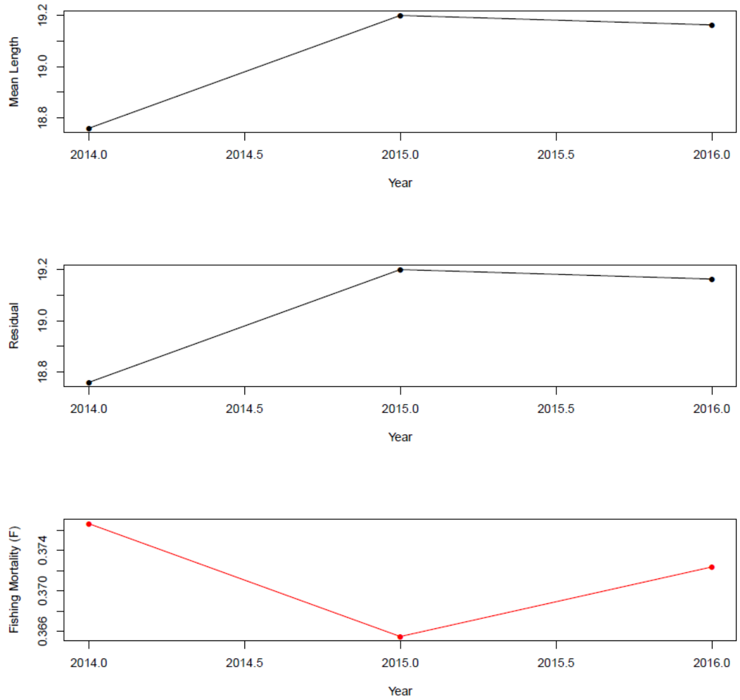


Figure 5.33. Dab in Subarea 4 and Division 3.a: Results of the THoG model with fixed M=0.25.

Conclusion

It was not possible to estimate M with the THoG Model and the available data. The obtained results by using the mean length only model and the THoG model with a fixed M revealed higher F compared to the $F_{0.1}$ value. However, also the $F_{0.1}$ value was not reliable since the model of the YPR analysis did not converge. Further, the effort data provided by InterCatch were not complete and might be highly uncertain. Therefore, and because the SPiCT revealed robust results, it was concluded not to use the Mean Length Z analyses and results as a basis for the decision on applying the Precautionary Buffer (PA Buffer) for the 2:3 rule on dab.

Length Based Indicators

Data

Length distribution time series: Landings and discards length distribution sex combined for the years 2014–2016 (InterCatch). Growth parameters were taken from literature (Tab. 5.10).

Table 5.10. Dab in Subarea 4 and Division 3.a: Input parameters for analysis of Length Based Indicators 2014–2016.

Data Type	Value/Year	Source
Length at maturity (Lm50%)	130 130 130	Froese, R. and A. Sampang, 2013. Potential indicators and reference points for good environmental status of commercially exploited marine fishes and invertebrates in the German EEZ. http://oceanrep.geomar.de/22079/
von Bertalanffy growth parameter	330 330 330	Froese, R. and A. Sampang, 2013. Potential indicators and reference points for good environmental status of commercially exploited marine fishes and invertebrates in the German EEZ. http://oceanrep.geomar.de/22079/
Catch at length by year	2014 2016	Length data from InterCatch (2014-2016)
Length-weight relationship parameters for landings and discards	2014 2016	Mean weight at length from IC

Results

The length frequency distributions show that a bimodal distribution with the first mode around 50–60mm is obvious for all three years. These length classes are caught only in the TBB_CRU_16-32_0_0_all métier (coastal near shrimper fleet) and to a much lesser extent also in the TBB_DEF_70-99_0_0_all métier (flat fish beam trawler). Therefore, two runs were performed for the Length Based Indicator method: (i) including all data (Fig. 5.34, Tab. 5.11), (ii) excluding recruits ≤ 100mm (Fig. 5.35, Tab. 5.12). Both runs revealed that the obtained P_{mega} values are clearly below the reference of 30% for the last three years. This is also the case for the L_{mean} values, which are logically closer to the reference point for the run excluding small recruits. This suggests that the yield is currently not optimized and that the stock might be growth overfished. However, since dab is no target species this is no major issue form a management point of view. The run excluding recruits further shows that the obtained values with respect to conservation are all above the respective reference points for all three years and the $F_{mean}/F_{F=M}$ (MSY proxy) are just slightly below the reference point. For the run including all data only the $L_{25\%}/L_{mat}$ and the $L_{max5\%}/L_{inf}$ are above the reference points for the last year. However, for all three years the $F_{mean}/F_{F=M}$ values are above the reference for this run.

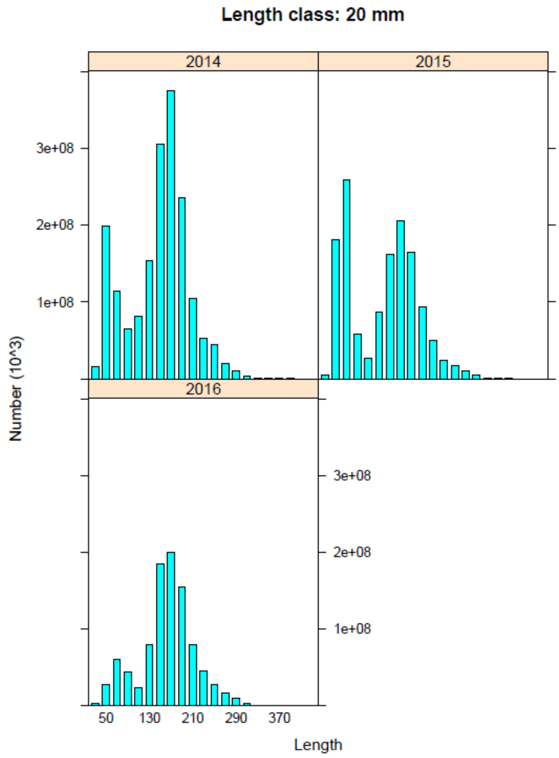


Figure 5.34. Dab in Subarea 4 and Division 3.a: Length distribution of commercial sampling in 20 mm length classes (InterCatch 2014–2016).

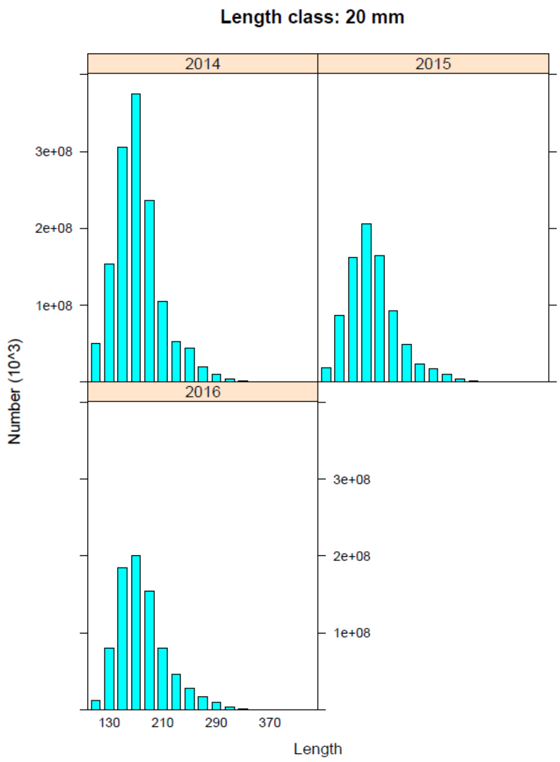


Figure 5.35. Dab in Subarea 4 and Division 3.a: Length distribution of commercial sampling in 20mm length classes without recruits <=100 mm (InterCatch 2014–2016).

Table 5.11. Dab in Subarea 4 and Division 3.a: Length based reference points and indicators based on landings and discards sampling (InterCatch data 2014–2016).

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	Lc	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	L_{max5}
2014	185	115	155	215	235	153.6	50	120	175	130	220	330	260.7
2015	185	75	145	215	235	140.1	50	120	185	130	220	330	264.0
2016	195	145	165	225	245	170.4	70	135	185	130	220	330	270.7

	Conservation				Optimizing Yield	MSY
	LC/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	>1	>1	>0.8	>30%	~1(>0.9)	≥1
2014	0.38	0.88	0.79	0.04	0.70	1.28
2015	0.38	0.58	0.80	0.04	0.64	1.17
2016	0.54	1.12	0.82	0.06	0.77	1.26

Table 5.12. Dab in Subarea 4 and Division 3.a: Length based reference points and indicators based on landings and discards sampling; without recruits <=100 mm (InterCatch data 2014–2016).

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	Lc	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	L_{max5}
2014	185	145	165	215	245	186.4	150	195	175	130	220	330	267.1
2015	195	155	175	225	255	191.2	150	195	185	130	220	330	277.5
2016	195	155	175	225	255	189.9	150	195	185	130	220	330	275.0

	Conservation				Optimizing Yield	MSY
	LC/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	>1	>1	>0.8	>30%	~1(>0.9)	≥1
2014	1.15	1.12	0.81	0.06	0.85	0.96
2015	1.15	1.19	0.84	0.07	0.87	0.98
2016	1.15	1.19	0.83	0.07	0.86	0.97

Conclusion

The results show that there seem to be no major issues with the exploitation pattern of dab in Subarea 4 and Division 3.a as it is not exploited above or very close to the length-based indicator of MSY. This is in accordance with the results of the SPiCT model which suggest exploitation below F_{MSY}. However, there were some major limitations with the provided InterCatch length data, as described above, and the results might not be representative for the whole fishery.

Table 5.13. Official dab landings by ICES Subarea 4 and Division 3.a.

Year	Subarea 4	Division 3.a	Total
1950	5971	1287	7258
1951	8190	1332	9522
1952	7976	1294	9270
1953	5915	1123	7038
1954	5652	1237	6889
1955	6623	1257	7880
1956	5468	2081	7549
1957	6127	2724	8851
1958	6342	2210	8552
1959	5239	1943	7182
1960	5168	1314	6482
1961	4602	1367	5969
1962	4082	1683	5765
1963	4615	1565	6180
1964	4982	1575	6557
1965	5519	2052	7571
1966	5862	1755	7617
1967	4324	1115	5439
1968	3995	1548	5543
1969	4122	1430	5552
1970	5183	1079	6262
1971	6546	1242	7788
1972	7901	1669	9570
1973	9657	1449	11106
1974	7146	2003	9149
1975	7033	2049	9082
1976	5917	1583	7500
1977	6702	2318	9020
1978	6407	2630	9037
1979	8243	2716	10959
1980	8357	2333	10690
1981	8454	2679	11133
1982	9565	2902	12467
1983	11865	2906	14771
1984	5482	2769	8251
1985	5502	1545	7047
1986	3205	1608	4813
1987	3931	2258	6189
1988	7067	2254	9321
1989	5816	2346	8162
1990	2701	1574	4275
1991	3448	1609	5057
1992	2647	1454	4101
1993	3309	1695	5004

Year	**Subarea 4**	**Division 3.a**	**Total**
1994	3861	1961	5822
1995	3865	1530	5395
1996	4834	1405	6239
1997	5259	1012	6271
1998	12759	961	13720
1999	13276	673	13949
2000	10595	654	11249
2001	9799	765	10564
2002	8678	977	9655
2003	9008	865	9873
2004	8608	779	9387
2005	9402	836	10238
2006	9190	725	9915
2007	9434	694	10128
2008	8029	522	8551
2009	6561	498	7059
2010	7240	589	7829
2011	6824	545	7369
2012	6095	653	6748
2013	5214	871	6085
2014	4344	611	4955
2015*	3595	917	4512
2016*	4070	883	4953

*** preliminary catch statistics**

Table 5.14. Official dab landings by country in Subarea 4.

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Subarea 4
1950	254	92	900	139	0	2555	2031	0	0	5971
1951	462	114	1800	90	0	3503	2221	0	0	8190
1952	386	74	1562	227	0	2823	2904	0	0	7976
1953	357	58	1337	189	0	2591	1383	0	0	5915
1954	255	62	1666	177	0	2393	1099	0	0	5652
1955	305	92	2923	161	0	1993	1149	0	0	6623
1956	338	99	1766	138	0	1660	1368	0	99	5468
1957	336	73	1983	154	0	1785	1669	0	127	6127
1958	290	71	2320	175	0	1885	1517	0	84	6342
1959	285	93	1433	146	0	2011	1265	0	6	5239
1960	246	70	1833	154	0	1813	1052	0	0	5168
1961	227	67	1497	161	0	1734	916	0	0	4602
1962	205	54	1357	147	0	1524	795	0	0	4082
1963	306	40	1660	128	0	1481	1000	0	0	4615
1964	424	48	1612	672	0	1177	1049	0	0	4982
1965	432	64	1841	734	0	1099	1349	0	0	5519
1966	507	65	1589	719	0	1215	1767	0	0	5862
1967	384	77	659	716	0	1147	1341	0	0	4324
1968	334	57	861	350	0	877	1516	0	0	3995
1969	302	69	984	448	0	689	1630	0	0	4122
1970	338	71	1476	588	0	752	1958	0	0	5183
1971	409	46	1546	618	0	986	2941	0	0	6546
1972	638	46	1816	727	0	1057	3617	0	0	7901
1973	678	41	1899	873	0	1349	3638	1179	0	9657
1974	281	59	1168	310	0	1227	4101	0	0	7146
1975	600	45	944	418	0	992	4031	0	3	7033
1976	489	52	852	306	0	816	3402	0	0	5917
1977	652	70	743	371	0	907	3959	0	0	6702
1978	520	64	799	513	0	1038	3473	0	0	6407
1979	484	87	1366	630	0	951	4724	0	1	8243
1980	518	24	1376	639	0	777	5023	0	0	8357
1981	542	31	1968	447	0	737	4729	0	0	8454
1982	460	42	2356	594	0	1002	5111	0	0	9565
1983	541	49	4428	495	0	1034	5318	0	0	11865
1984	603	35	3438	486	0	920	0	0	0	5482
1985	509	24	3535	404	0	1030	0	0	0	5502
1986	445	34	1400	289	0	1036	0	0	1	3205
1987	514	36	1574	434	0	1373	0	0	0	3931
1988	697	72	1324	349	0	1221	3404	0	0	7067
1989	443	117	1280	223	0	1232	2521	0	0	5816
1990	416	162	1103	214	0	802	0	0	4	2701
1991	491	290	1160	258	0	1249	0	0	0	3448
1992	464	218	699	217	0	1049	0	0	0	2647
1993	548	493	1016	235	0	1017	0	0	0	3309

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Subarea 4
1994	397	626	1307	133	0	1398	0	0	0	3861
1995	410	0	1306	155	1	1993	0	0	0	3865
1996	527	718	1484	177	0	1928	0	0	0	4834
1997	507	945	1399	124	0	2284	0	0	0	5259
1998	757	796	1024	126	0	2085	7971	0	0	12759
1999	802	758	1101	0	0	1964	8651	0	0	13276
2000	684	892	785	124	0	1534	6527	49	0	10595
2001	575	878	839	206	0	1368	5886	47	0	9799
2002	516	582	1126	228	0	1224	4951	51	0	8678
2003	396	642	1580	154	0	1204	4955	77	0	9008
2004	382	767	1136	121	0	1158	4989	55	0	8608
2005	372	1105	1128	121	0	1193	5352	131	0	9402
2006	369	1149	949	130	0	1415	5071	107	0	9190
2007	436	526	634	195	0	1212	6313	118	0	9434
2008	371	375	670	161	0	847	5544	61	0	8029
2009	349	262	489	196	0	648	4588	29	0	6561
2010	337	365	523	178	0	724	5097	16	0	7240
2011	243	312	622	165	0	645	4808	29	0	6824
2012	454	252	421	126	0	665	4136	41	0	6095
2013	404	333	404	84	0	647	3316	26	0	5214
2014	299	282	253	73	0	505	2910	23	0	4344
2015*	242	244	250	75	0	336	2438	10	0	3595
2016*	321	244	412	75	0	372	2611	35	0	4070

* preliminary catch statistics

Table 5.15. Official dab landings in ICES Division 3.a.

YEAR	BEL	DEU	DNK	FRA	NLD	NOR	SWE	Division 3.a
1950	0	34	1253	0	0	0	0	1287
1951	0	17	1315	0	0	0	0	1332
1952	0	21	1273	0	0	0	0	1294
1953	0	9	1114	0	0	0	0	1123
1954	0	4	1233	0	0	0	0	1237
1955	0	3	1254	0	0	0	0	1257
1956	0	5	1462	0	0	0	614	2081
1957	0	5	2025	0	0	0	694	2724
1958	0	4	1578	0	0	0	628	2210
1959	0	2	1307	0	0	0	634	1943
1960	0	1	1313	0	0	0	0	1314
1961	0	0	1367	0	0	0	0	1367
1962	0	2	1681	0	0	0	0	1683
1963	0	0	1565	0	0	0	0	1565
1964	0	1	1574	0	0	0	0	1575
1965	0	1	2051	0	0	0	0	2052
1966	0	0	1755	0	0	0	0	1755
1967	0	0	1115	0	0	0	0	1115
1968	0	0	1535	13	0	0	0	1548
1969	0	0	1430	0	0	0	0	1430
1970	0	0	1079	0	0	0	0	1079
1971	0	0	1242	0	0	0	0	1242
1972	0	0	1669	0	0	0	0	1669
1973	0	0	1449	0	0	0	0	1449
1974	0	0	2003	0	0	0	0	2003
1975	0	0	1959	0	2	0	88	2049
1976	10	0	1493	0	80	0	0	1583
1977	11	0	2105	0	142	0	60	2318
1978	2	0	2515	0	39	0	74	2630
1979	3	0	2616	0	15	0	82	2716
1980	3	0	2218	0	3	0	109	2333
1981	0	0	2574	0	5	0	100	2679
1982	1	0	2823	0	22	0	56	2902
1983	1	0	2759	0	34	0	112	2906
1984	0	0	2695	0	0	0	74	2769
1985	1	0	1486	0	0	0	58	1545
1986	5	0	1551	0	0	0	52	1608
1987	19	0	2182	0	0	0	57	2258
1988	13	0	2150	0	15	0	76	2254
1989	4	0	2302	0	0	0	40	2346
1990	3	0	1535	0	0	0	36	1574
1991	5	1	1556	0	0	0	47	1609
1992	10	0	1412	0	0	0	32	1454
1993	7	0	1656	0	0	0	32	1695

YEAR	BEL	DEU	DNK	FRA	NLD	NOR	SWE	Division 3.a
1994	9	0	1917	0	0	0	35	1961
1995	3	0	1482	0	0	0	45	1530
1996	0	0	1387	0	0	0	18	1405
1997	0	0	990	0	0	0	22	1012
1998	0	0	942	0	0	0	19	961
1999	0	0	661	0	0	0	12	673
2000	0	0	647	0	0	1	6	654
2001	0	0	751	0	0	7	7	765
2002	0	0	968	0	0	3	6	977
2003	0	0	674	0	173	14	4	865
2004	0	0	637	0	138	1	3	779
2005	0	0	738	0	95	0	3	836
2006	0	20	566	0	117	18	4	725
2007	0	9	547	0	126	3	9	694
2008	0	12	475	0	26	2	7	522
2009	0	4	478	0	3	1	12	498
2010	0	4	426	0	151	0	8	589
2011	0	10	517	0	0	11	7	545
2012	0	5	632	0	0	10	6	653
2013	0	11	654	0	174	26	6	871
2014	0	12	501	0	75	2	21	611
2015*	0	8	687	0	191	8	23	917
2016*	0	9	647	0	189	14	24	883

* preliminary catch statistics

6 Flounder in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat)

6.1 General

Flounder (*Platichthys flesus*) in Subarea 4 and Division 3.a was assessed until 2013 in the Working Group on Assessment of New MoU Species (ICES, 2013a). Because only official landings and survey data were available, flounder was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for flounder is given for flounder since 2013 by ICES (ICES, 2013b) based on survey trends. Since 2015 flounder was included in the official data call for the WGNSSK and discard estimates were included into the dab assessment. Based on survey trends and total catch data (2012–2014) the last biennial advice for dab was given in 2015 (ICES, 2015). During the WGNSSK 2017 the official landings data, InterCatch data, and the survey indices for flounder were updated and further, a SPiCT assessment and length-based methods in relation to MSY proxies were tested in order to inform a new biennial advice for this stock.

The assessment for flounder in Subarea 4 and Division 3.a will be benchmarked in 2018.

6.1.1 Biology and ecosystem aspects

Flounder is a euryhaline flatfish: the life cycle of each individual usually includes marine, brackish, and freshwater habitats. It has a coastal distribution in the Northeast Atlantic, ranging from the White Sea and the Baltic in the north, to the Mediterranean and Black Sea in the south. Flounder can live in low salinity water but they reproduce in water of higher salinity.

Flounder feeds on a wide variety of small invertebrates (mainly polychaete worms, shellfish, and crustaceans), but locally the diet may include small fish species like smelt and gobies. The most intensive feeding occurs in the summer, while food is sparse in the winter.

In the North Sea, Skagerrak and Kattegat flounder spawn between February and April. The adults move further offshore to the 25–40 m deep spawning grounds, the most important of which are situated along the coasts of Belgium, the Netherlands, Germany, and Denmark. During autumn, both mature and immature flounder withdraw from the inshore and estuarine feeding areas. Juvenile flounder migrate into coastal areas, where they spend the winter.

More details on available data and knowledge can be found in the flounder Stock Annex.

6.1.2 Stock ID and possible assessment areas

There is no information about stock identity and possible stock assessment areas in the North Sea, Skagerrak and Kattegat. Within the North Sea there may exist a number of sub-populations (WGNEW, 2013).

6.1.3 Management regulations

There is no minimum landing size for this species in EU waters.

Flounder is mainly a bycatch species in fisheries for plaice and sole. The discard rates for flounder can be (~40%). No minimum landing size is defined for flounder. According to EU-Regulations a precautionary TAC was given in EU waters of Division 2a and

Subarea 4 together with dab (*Limanda limanda*). This combined TAC was never fully utilized. In 2017 the European Commission requested ICES to evaluate the possible effects on the stocks of flounder and dab having no TAC. ICES advised that given the current fishing patterns of the main fleets catching flounder and dab, which are the same fleets targeting plaice and sole, the risk of having no TAC for the flounder and dab stock is considered to be low (ICES, 2017a). Therefore, the European Commission removed the combined TAC for these two stocks (EU COM, 2017/595).

6.2 Fisheries data

6.2.1 Historical landings

In the North Sea and in the Skagerrak and Kattegat flounder is mainly a bycatch in the fishery for commercially more important flatfish such as sole and plaice and in the mixed demersal fisheries. The largest part of official landings is reported for Subarea 4, especially for the last decade (Figure 6.1; Table 6.7). Landings in ICES Subarea 4 and Division 3.a by country are shown in figures 6.2 and 6.3 and in tables 6.7 and 6.8. The apparent decrease in official landings between 1984 and 1997 is due to unreported landings by the Netherlands.

Since 1950, annual landings from the North Sea have fluctuated, without any clear pattern (Figure 6.1). During the last decade, landings declined considerably. This decline goes hand in hand with a reduction in fishing effort of bottom trawl fleets in the North Sea. For 2016, total official landings were reported with 1783 tonnes, compared to 1883 tonnes in 2015. In Area 3.a, annual landings in general have decreased sharply from mid of the 1980s until 2016. Although official landings increased slightly in 2016 they are still on historical low levels (108 tonnes in 2016; 77 tonnes in 2015; Figure 6.3).

Flounder is of relatively little commercial importance in the North Sea and the Skagerrak/Kattegat. Landings data may have been misreported in previous years. However, the amount of misreporting is not known. In addition, the official landings may not reflect the total catches, because flounder is often discarded and discarding is influenced by the prices and the availability of other, commercially more important species and therefore cannot be estimated for years without observations.

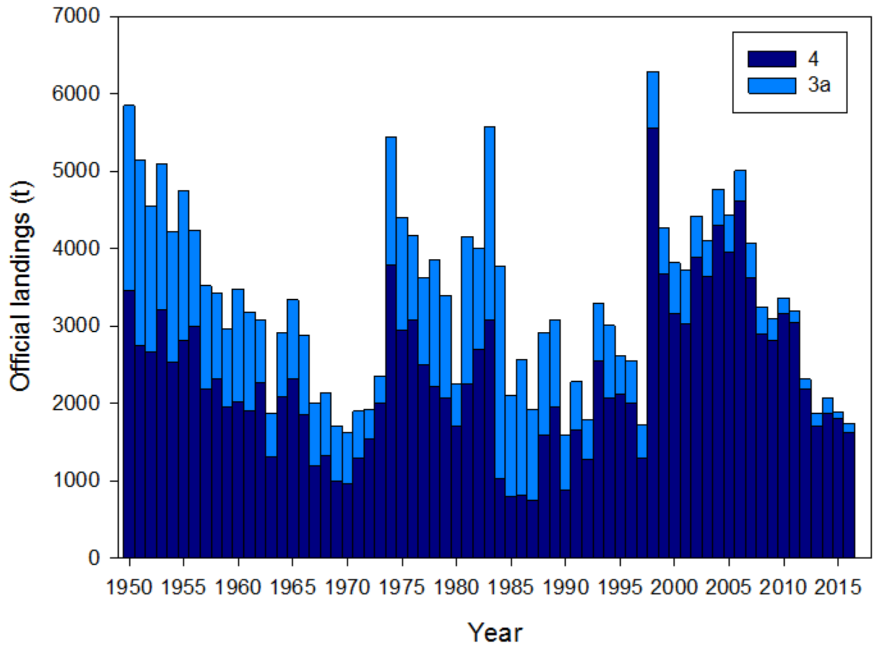


Figure. 6.1. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder by area.

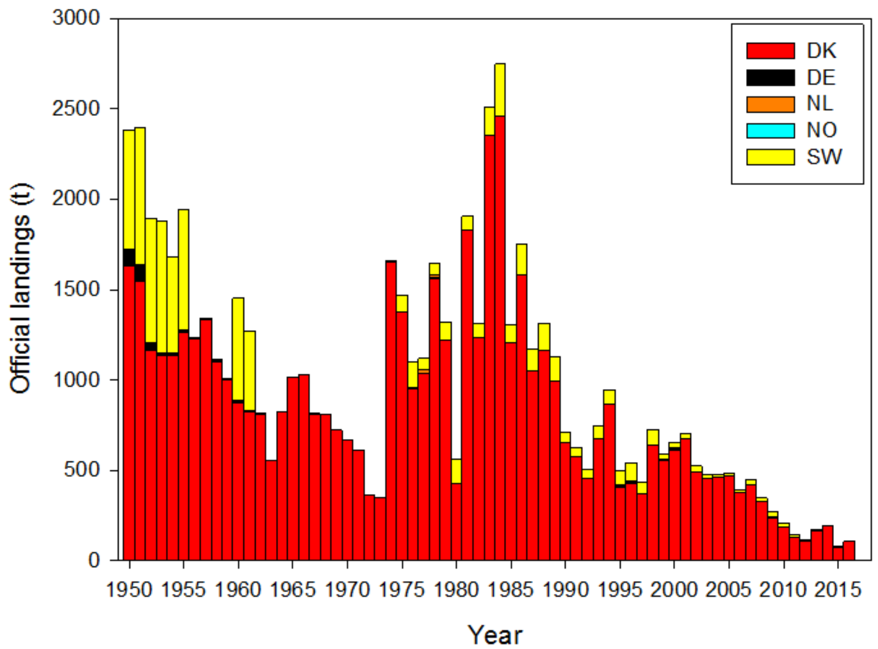


Figure 6.2. Flounder in Subarea 4 and Division 3.a: Official landings in tonnes of flounder in ICES Division 3.a by country.

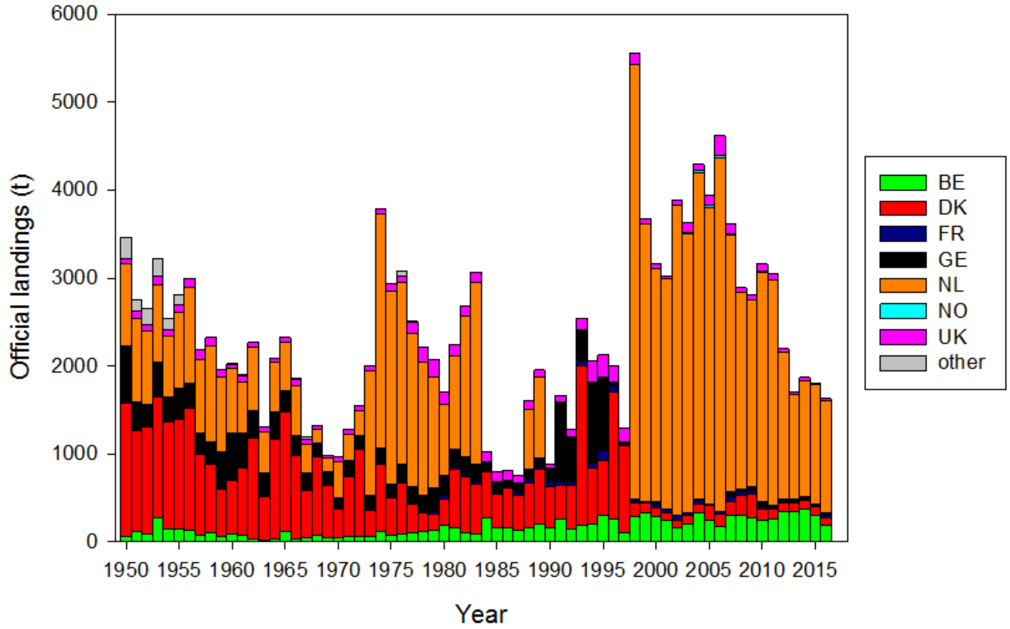


Figure 6.3. Flounder in Subarea 4 and Division 3.a: Official landings of flounder in ICES Subarea 4 by country.

6.2.2 InterCatch

For the WGNSSK 2017 flounder landings and discards data from 2012–2016 were available in the InterCatch system. For the years 2014–2016 also length sampling data were uploaded by most countries. Norway did not report any discards because of the official discard ban for the Norwegian fleet. For the year 2012 The Netherlands provided only discard data, therefore official landings were added for this case.

In general it was tried only to use equivalent or similar métiers for the discard raising procedure in InterCatch. Discard information was provided for 90% of total landings in relation to weight in 2016 (Figure 6.4). However, for a number of métiers zero landings were reported. For these no raising with InterCatch was possible.

In 2016 by far the largest proportion of landings (1102 tonnes, ~63% of total landings) was reported by Dutch beam trawlers (TBB_DEF_70_99_0_0_all), followed by the Danish MIS_MIS_0_0_0_HC métier which landed 101 tonnes. Other métiers landing flounder in considerable amounts did not land more than 100 tonnes and these métiers were also dominated mainly by Dutch landings (Figure 6.5). The highest amount of discards in 2016 was reported for the Scottish OTB_DEF_>=120_0_0_all (207 tonnes) and Scottish OTB_CRU_70-99_0_0_all (87 tonnes) métiers, followed by the Dutch TBB_DEF_70-99_0_0_all métier with 63 tonnes (Figure 6.6). Remarkable is the large deviation between the discards reported for the Scottish OTB_DEF_>=120_0_0_all métier for 2015 and 2016: the discards for this métier were reported with 633 tonnes in 2015, which is a threefold difference. This deviation alone caused a drop in the overall discard rate from 42% in 2015 to 28% in 2016.

A problem in the estimation of total flounder discards maybe the TBB_CRU_16-32_0_0_all métier targeting brown shrimps in more coastal areas. For this métier relatively high discards but extremely low landings were reported by Germany. The Netherlands and Belgium reported landings but no discards. It was not meaningful to use the German fleet to raise the Belgium and Dutch landings which would probably have resulted in unrealistic high discards for these fleets. However, given the amount discarded by Germany and the similar effort in this métier by The Netherlands this might lead to a substantial underestimation of the total discard estimation. It might be useful in the future to raise discard by effort for these fleets and also for some métiers with zero landings for which no discards can be raised although they might occur in these métiers.

The largest total catch is taken by the Netherlands, followed by Scotland (nearly all reported discards for Scotland), Belgium and Denmark. All other countries catch less than 100 tonnes (Figure 6.7). The total catch estimated with InterCatch was 2436 tonnes from which 1750 tonnes were landings (compared to 1783 tonnes reported official landings) and 686 tonnes discards (28% of total catches which is lower compared to the previous three years average of 44%). However, it should be noted that not all métiers were sampled in every quarter and that the raising procedure may not be adequate for all cases.

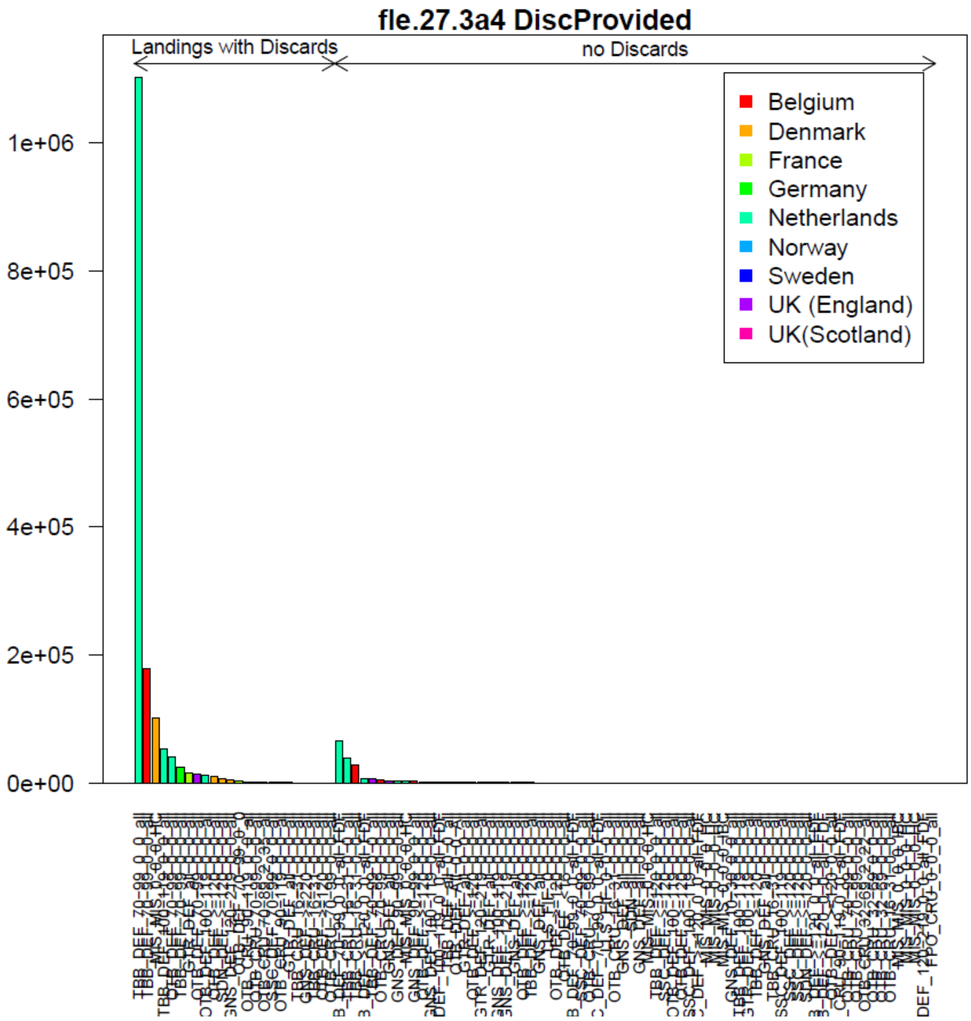


Figure 6.4. Flounder in Subarea 4 and Division 3.a: Provision of discards information by country and fleets.

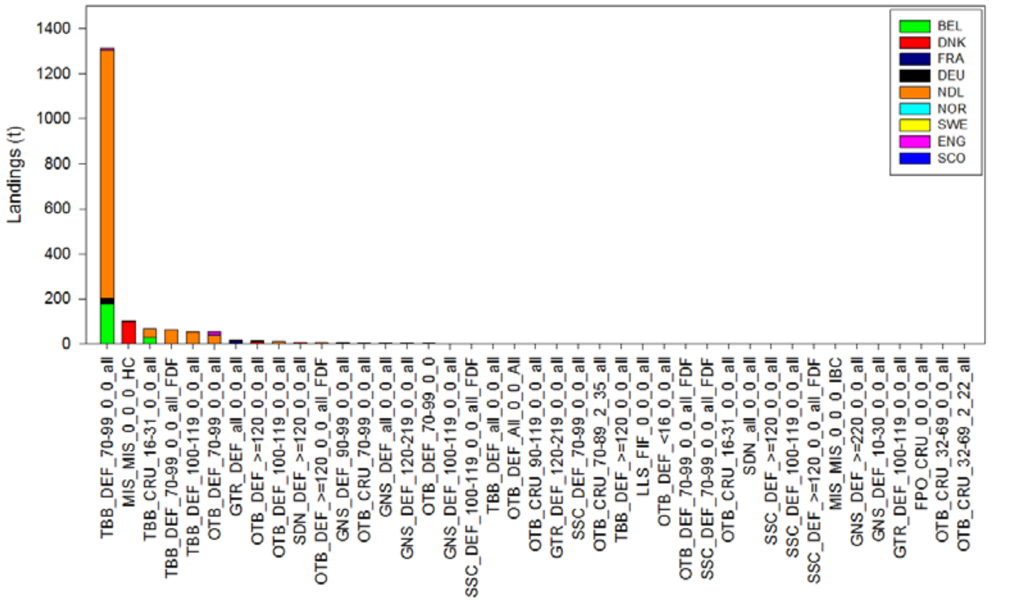


Figure 6.5. Flounder in Subarea 4 and Division 3.a: Flounder landings by métier and country in 2016 as uploaded to InterCatch.

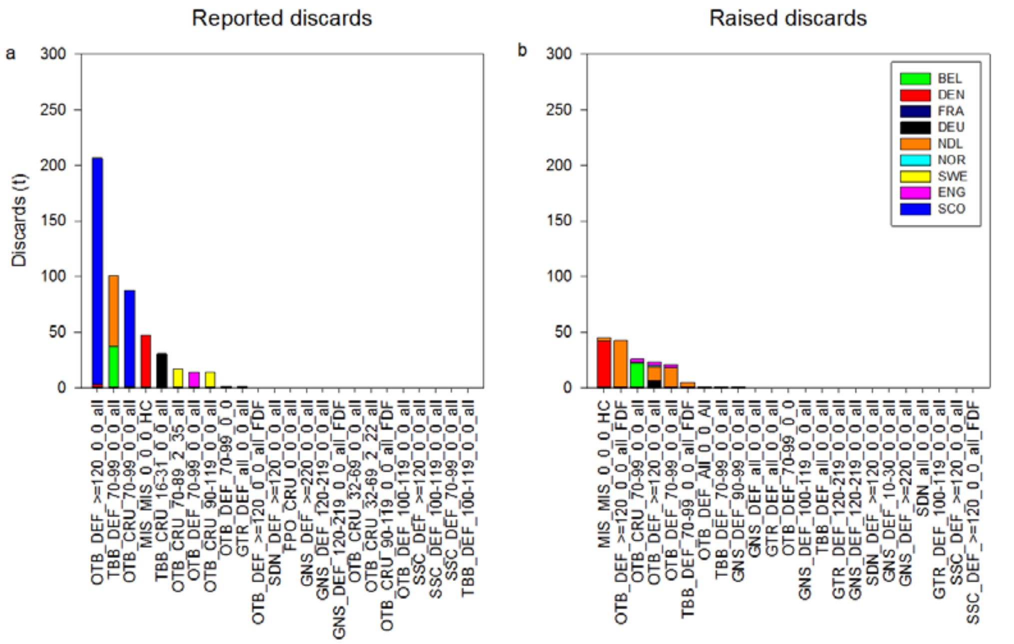


Figure 6.6. Flounder in Subarea 4 and Division 3.a: Flounder discards by métier and country in 2016. Reported discards panel (a), raised discards panel (b).

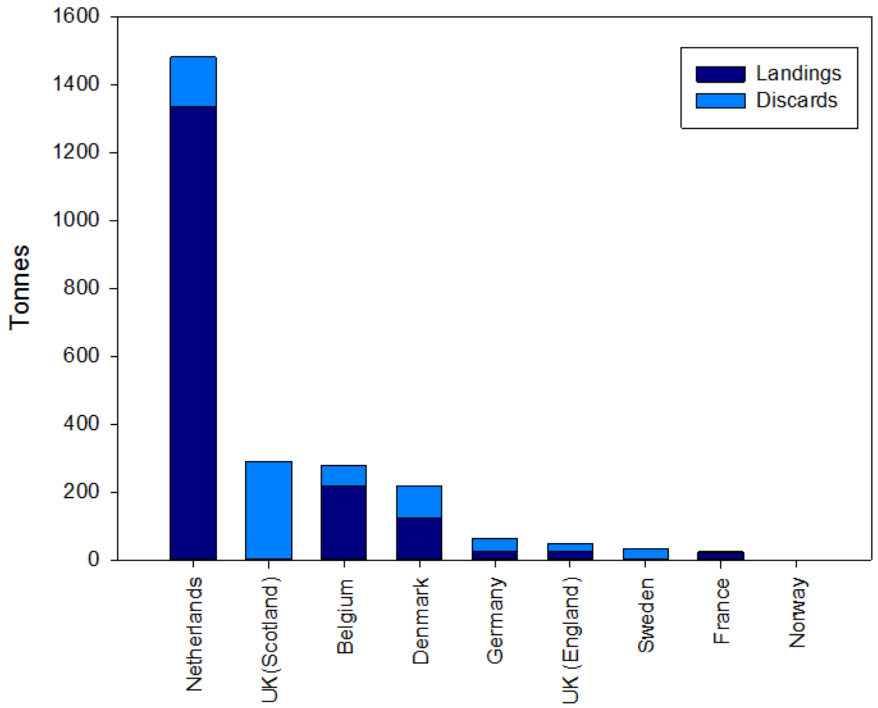


Figure 6.7. Flounder in Subarea 4 and Division 3.a: Flounder landings and discards by country in 2016 estimated with InterCatch.

6.3 Survey data/recruit series

Several surveys in the North Sea, Skagerrak and Kattegat provide information on distribution, abundance and length composition of flounder. The most relevant survey for flounder is probably the International Bottom Trawl Survey IBTS in quarter 1 (Figure 6.8 and Figure 6.11) because it covers the whole distribution area of the stock and shows a higher catchability compared to the beam trawl surveys. However, the IBTS–Q1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. The BTS surveys use a beam trawl, but they are carried out in quarter 3, in a time of year in which flounder is usually distributed in more coastal, shallow and brackish waters. Therefore, it was decided by WGNEW 2013 to use the IBTS–Q1 to analyse survey trends for this species. It should be noted here that the IBTS was not fully standardized before 1983. Therefore, index data before this year should be interpreted with caution and are not presented in this report.

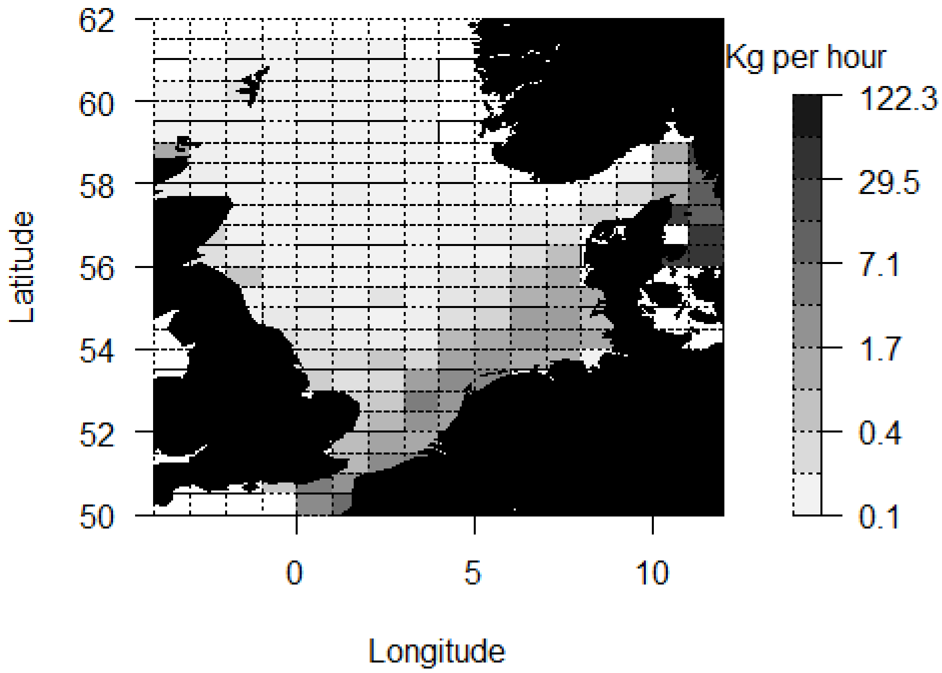


Figure 6.8. Flounder in Subarea 4 and Division 3.a: Distribution of flounder derived from the IBTS–Q1 survey in Subarea 4 and Division 3.a for the whole time series.

6.4 Analysis of stock trends/assessment

Only catch data and survey trends were available for this species. Therefore, flounder was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2012). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and *I* is the stock index. By default x=2 and z=5.

The mature biomass index (kg/hour) was based on the IBTS–Q1 survey which covers most of the distribution area of flounder in Subarea 4 and Division 3.a. Roundfish areas 1 and 2 were excluded from the analyses because flounder does only occur very occasionally in these areas (Figure 6.8). To estimate a mature biomass index (kg/hour) a length weight relationship derived from IBTS–Q1 data was applied (Figure 6.9). The same data set shows that above 20 cm probably most flounder are mature (Figure 6.10). Therefore, only data >20 cm were taken into account to calculate the index.

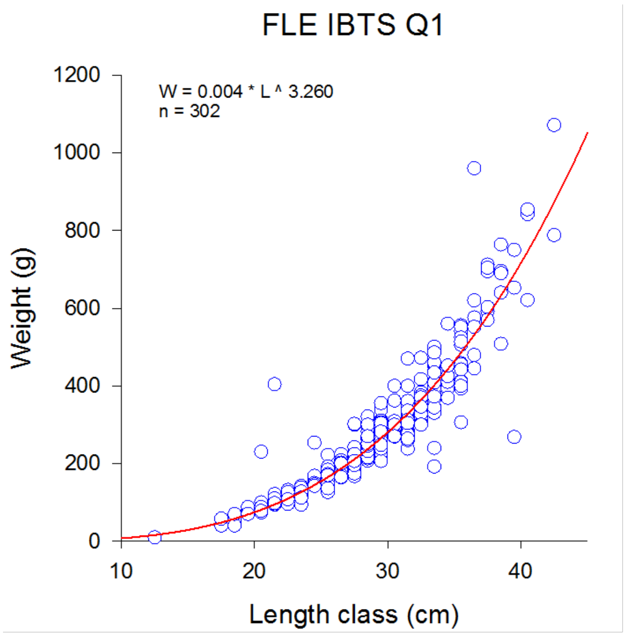


Figure 6.9. Flounder in Subarea 4 and Division 3.a: Length weight relationship of flounder derived from IBTS–Q1 data.

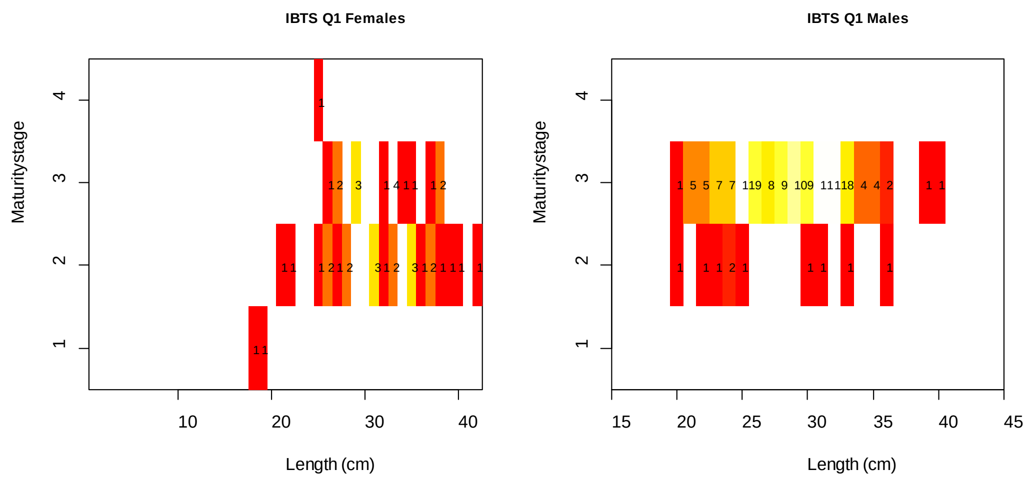


Figure 6.10. Flounder in Subarea 4 and Division 3.a: Maturity at length of female and male flounder derived from IBTS–Q1 data.

The biomass index shows a rather stable trend from 1983 onwards with two major peaks between 1985 and 1995 (Figure 6.11). From 1997 to 2002 the index declined, followed by an increase until 2005. Since then it fluctuated without a clear trend up to 2010. A declining trend can be observed from 2010 to 2014, while the values from 2015 to 2017 are again somewhat higher. Table 6.1 displays the summary of the DLS approach using the results of the updated assessment.

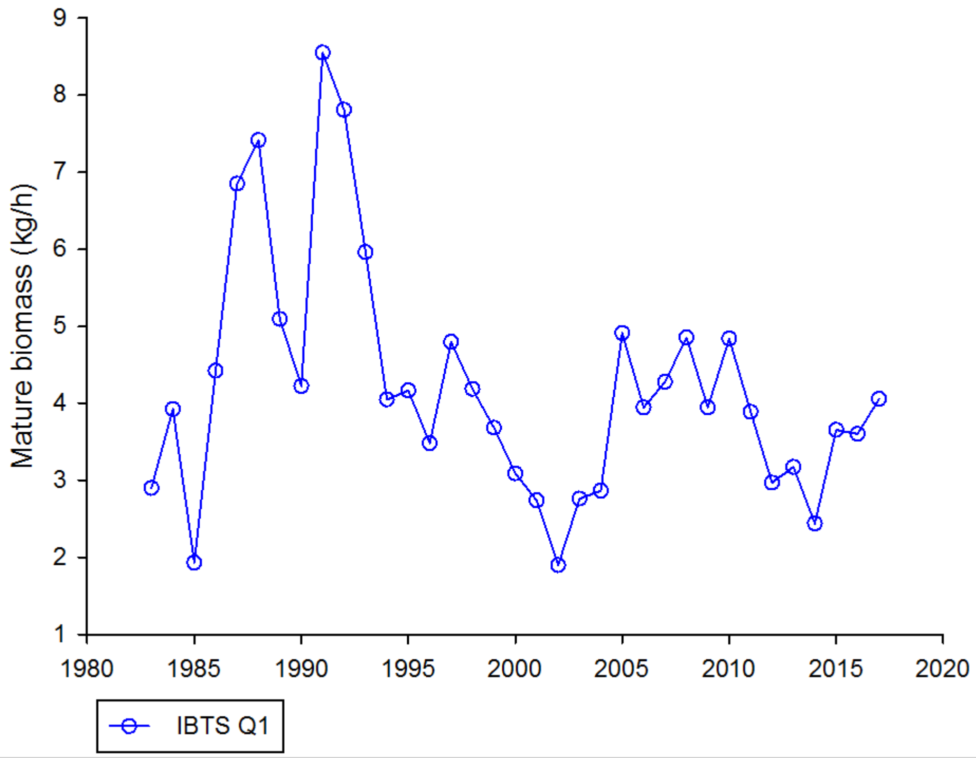


Figure 6.11. Flounder in Subarea 4 and Division 3.a: Mature biomass index of flounder in Subarea 4 and Division 3.a derived from IBTS–Q1 data 1983–2017.

Table 6.1. Flounder in Subarea 4 and Division 3.a: Results of applying the DLS 3.2. method with two options: advice based on (1) recent advised catch, and (2) based on average catch of the most recent three years.

Index A (2016–2017)		3.83 kg/h
Index B (2013–2015)		3.09 kg/h
Index ratio (A/B)		1.24
Uncertainty cap	Applied	1.2
Advised catch for 2016 and 2017 or Average catch (2014–2016)		5228 tonnes 2931 tonnes
Discard rate (2014–2016)		0.38
Precautionary buffer	Not applied	-
Catch advice* (recent advised catch) or Catch advice* (Average catch)		6274 tonnes 3517 tonnes
Landings corresponding to the catch advice**		3890 tonnes 2181 tonnes

* Advised catch for 2016–2017 x uncertainty cap
* Average catch for 2014–2016 x uncertainty cap
** (Advised catch for 2016–2017 × uncertainty cap) × (1 - discard rate)
** (Average catch for 2014–2016 × uncertainty cap) × (1 - discard rate)

6.5 MSY Proxy analyses for flounder in Subarea 4 and Division 3.a.

6.5.1 Surplus Production Model in Continuous Time (SPiCT)

In order to estimate MSY proxy reference points for flounder a Surplus Production Model in Continuous Time (SPiCT, Pedersen and Berg, 2017) was applied. One fishery independent survey time series and a reconstructed catch time series was used as input for this model. The index was the same as was used to inform stock status with the DLS approach, a mature biomass index based on IBTS–Q1 data for the years 1983–2016 (see paragraph 6.4). Information on landings and discards were only available for the years 2012–2016. Therefore, total catches of previous years (1983–2011) had to be reconstructed (Figure 6.12). This was done by (i) adding the average Dutch landings to that total landings for which Dutch data were missing in the official landings data (1984–1987, 1990–1997), and (ii) by applying an average discard rate on these reconstructed catches, based on the years for which discard data were available (average discard rate 2012–2016 = 41%).

The results of the SPiCT assessment revealed declining trends in absolute and relative fishing mortalities (Figures 6.13–6.15). However, the uncertainties are far too large to draw any meaningful conclusions based on these results. Consequently the SPiCT assessment was not used in order to decide if the Precautionary Buffer (PA Buffer) has to be applied or not for the advice and length based methods were explored instead (see next paragraph). All SPiCT results are displayed in figures 6.13–6.19.

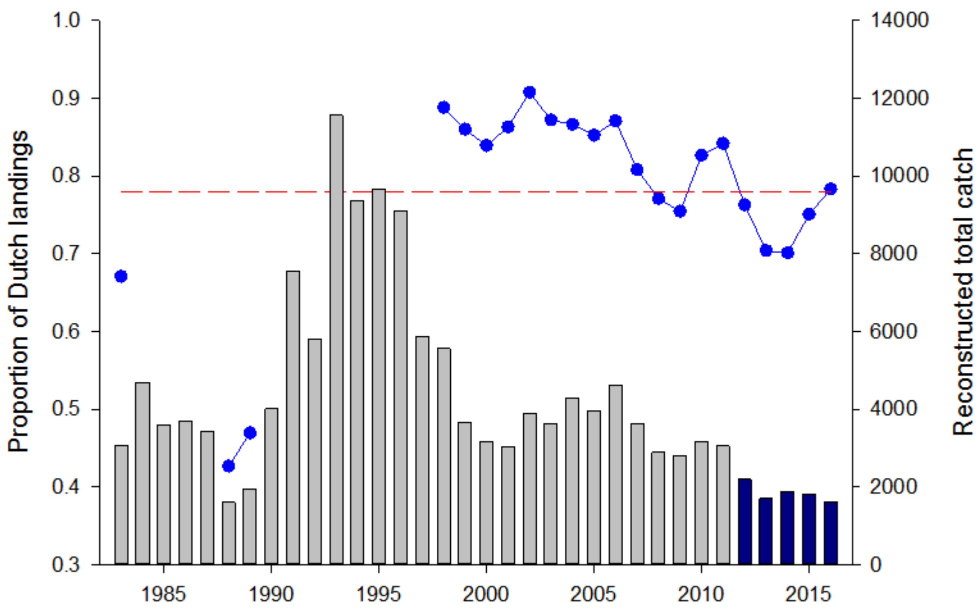


Figure 6.12. Flounder in Subarea 4 and Division 3.a: Proportion of Dutch landings of total official landings (blue dots), average Dutch landings proportion (red line), reconstructed total catch (grey bars), and observed total catch (blue bars).

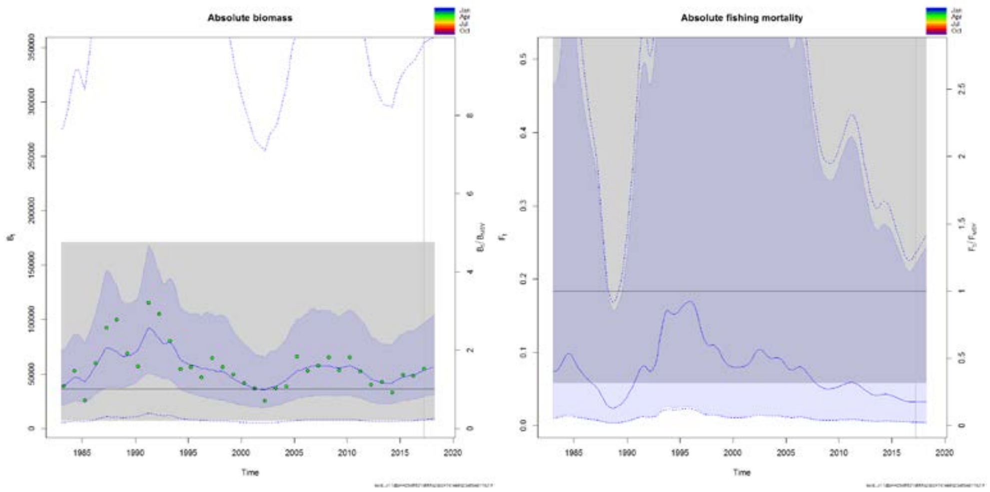


Figure 6.13. Flounder in Subarea 4 and Division 3.a: Absolute biomass (left panel) and absolute fishing mortality (right panel) obtained by the SPiCT model.

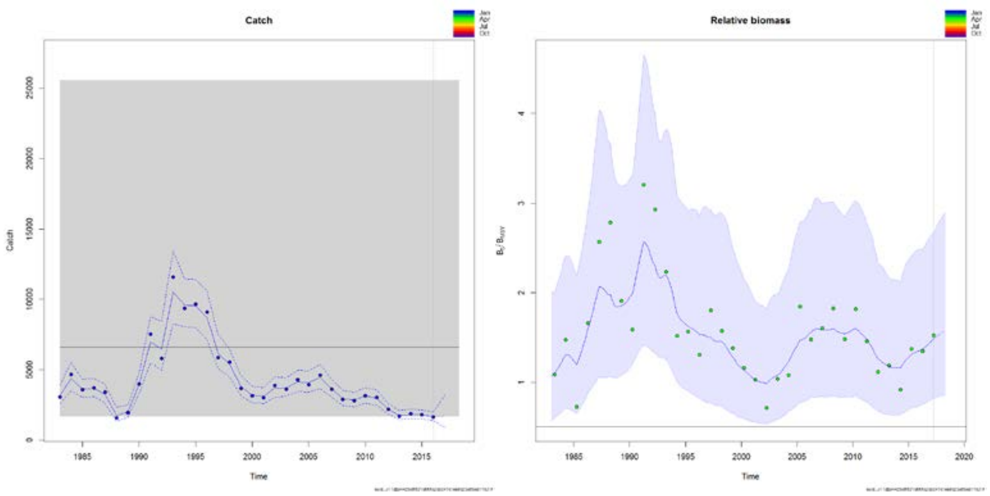


Figure 6.14. Flounder in Subarea 4 and Division 3.a: Total catch (left panel) and relative biomass (right panel) obtained by the SPiCT model.

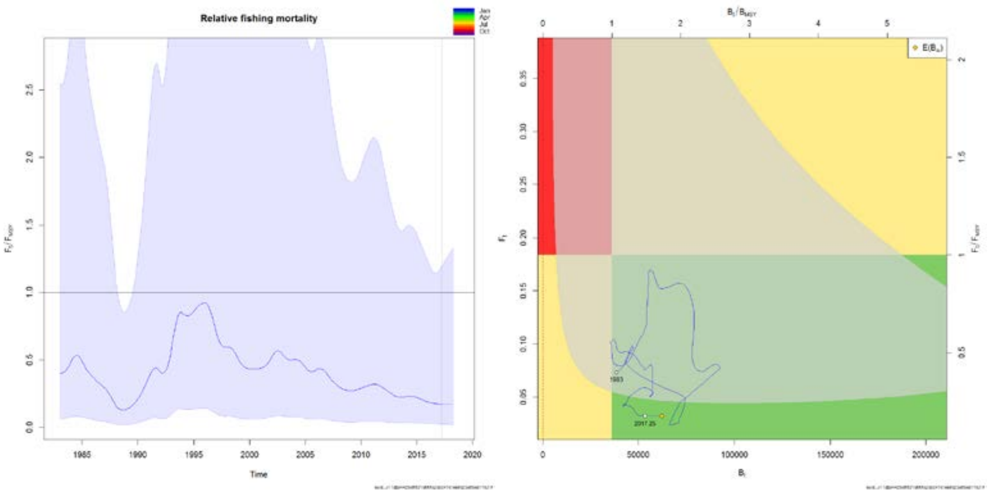


Figure 6.15. Flounder in Subarea 4 and Division 3.a: Relative fishing mortality (left panel) and Kobe plot (right plot).

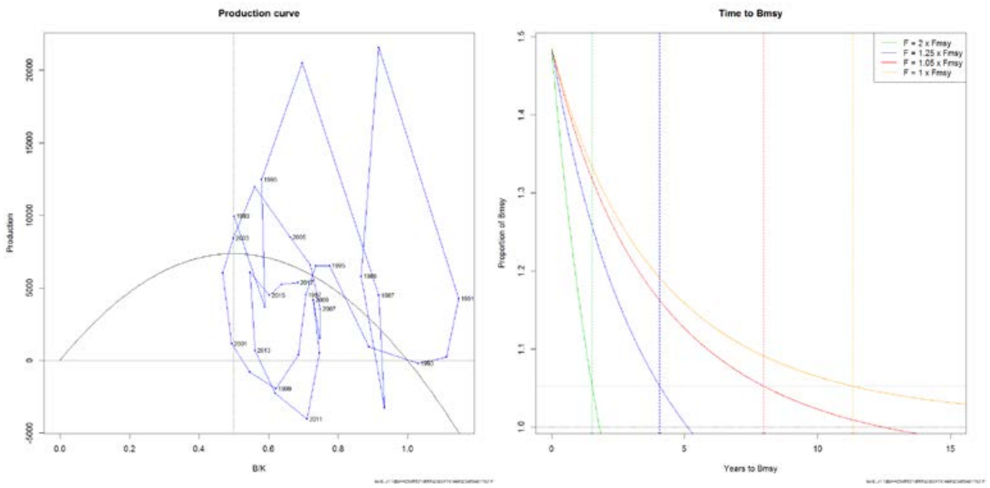


Figure 6.16. Flounder in Subarea 4 and Division 3.a: Production curve (left panel) and time to BMSY (right panel) obtained by the SPiCT model.

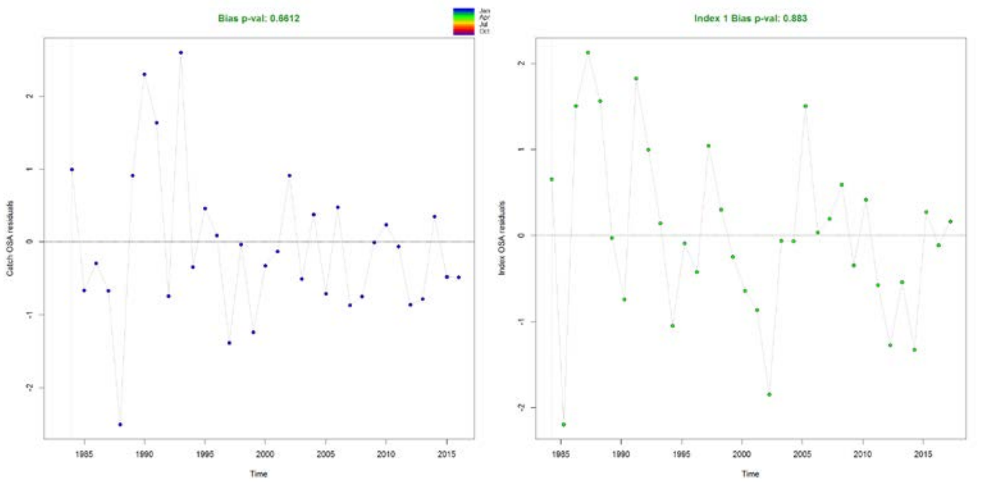


Figure 6.17. Flounder in Subarea 4 and Division 3.a: Catch (left panel) and index (right panel) residuals.

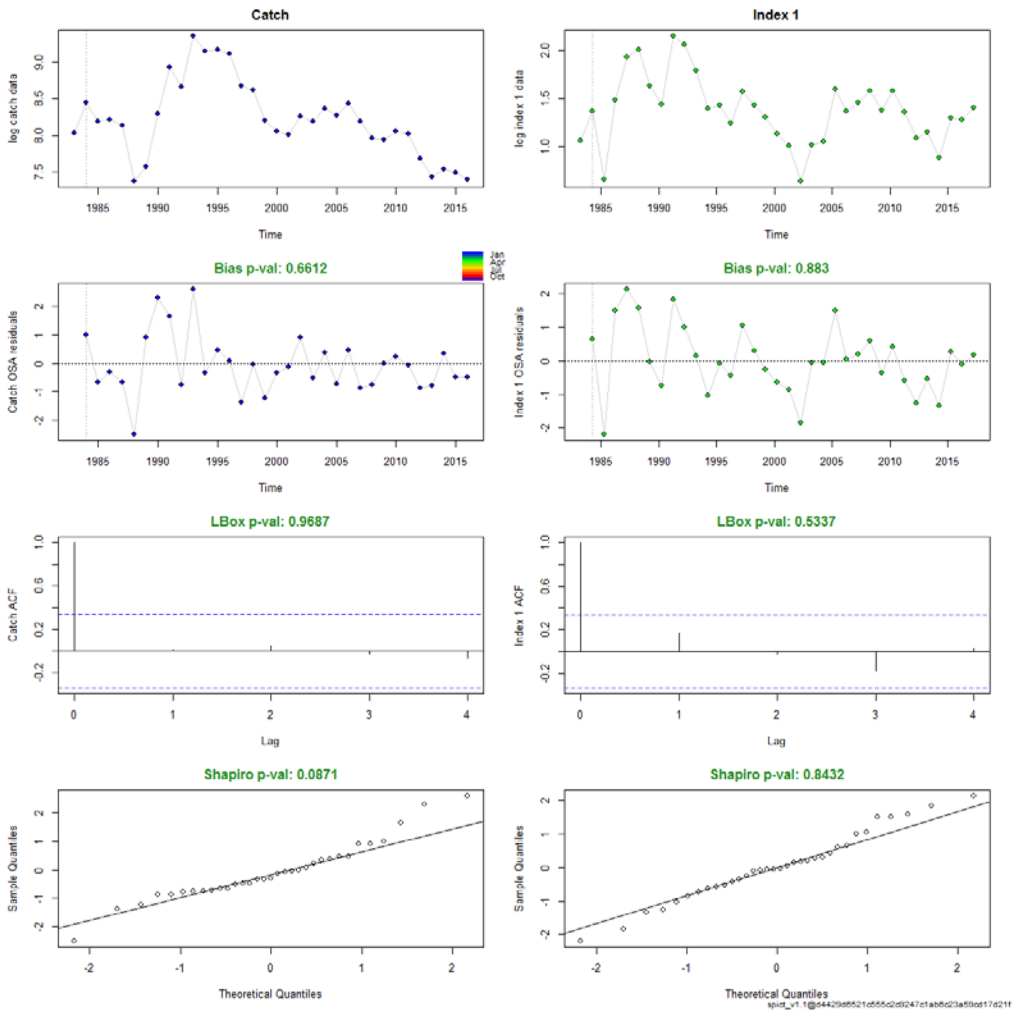


Figure 6.18. Flounder in Subarea 4 and Division 3.a: SPiCT diagnostics.

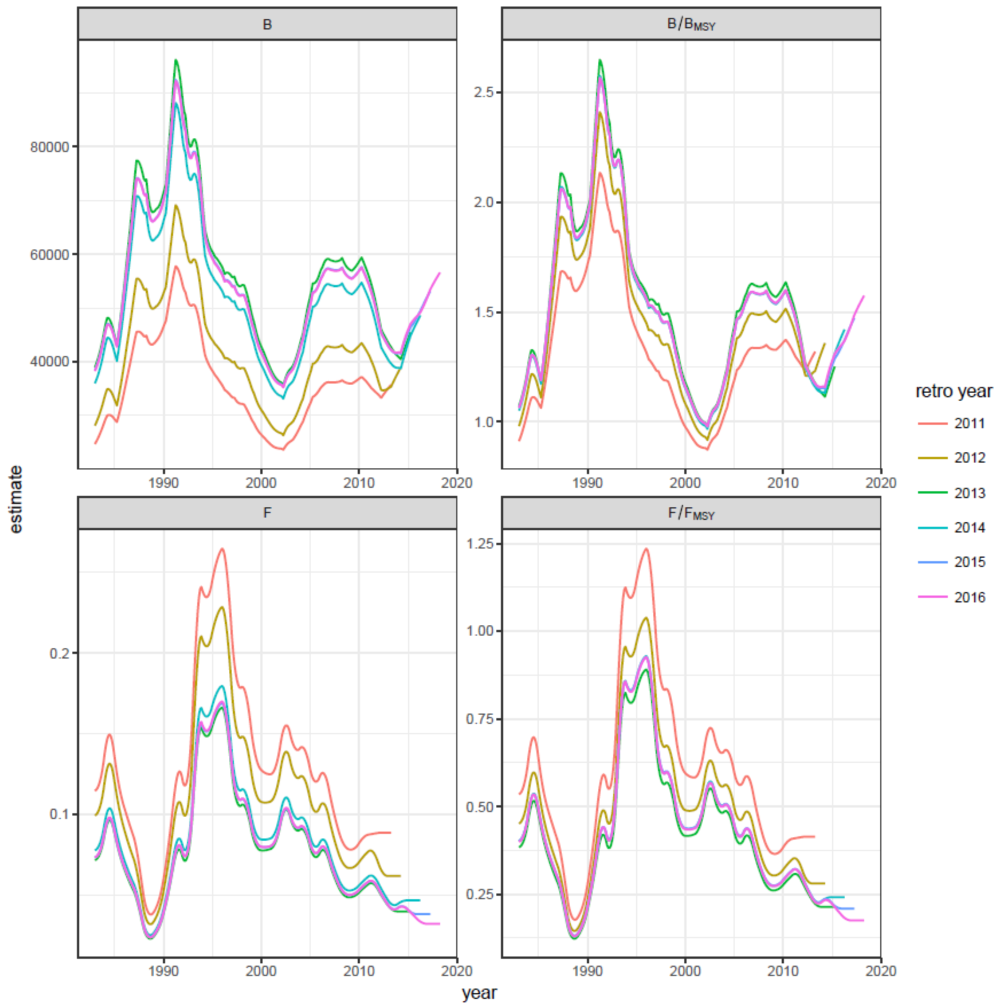


Figure 6.19. Flounder in Subarea 4 and Division 3.a: SPiCT retrospective plots.

6.5.2 Length-Based Methods

Flounder length samples from commercial catches were provided in InterCatch format for the years 2014–2016. These data were used for the analyses of MSY proxies applying the Mean Length Z Estimator (Gedamke and Hoenig, 2006) and Length Based Indicators. Besides the InterCatch data also survey length data were analysed. The commercial length data show incoming recruitment for 2014, but not for the other two years (Figure 6.20). In the survey data also strong recruitment can be observed occasionally, e.g. for the year 2011 (Figure 6.21). Since both length based methods assume constant recruitment, both data sets were reduced by length classes below 16 cm (corresponding to ages below 2 years). Both methods also require growth parameters and length weight relationships, which were taken from literature (Froese and Sampang, 2013; Table 6.2).

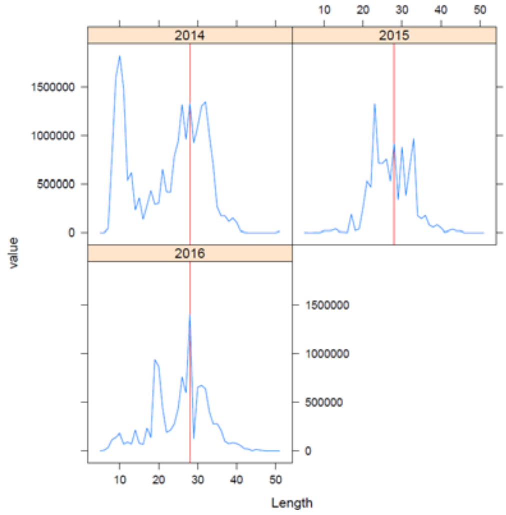


Figure 6.20. Flounder in Subarea 4 and Division 3.a: Length distribution of commercial sampling by year (InterCatch 2014–2016). Red vertical line display Lc value (28 cm).

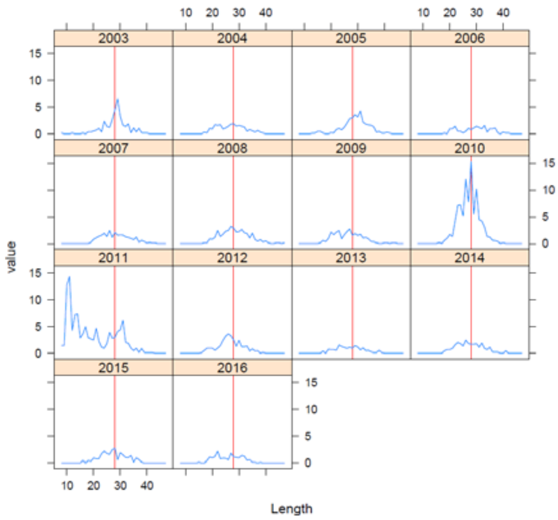


Figure 6.21. Flounder in Subarea 4 and Division 3.a: Length distribution of survey data by year (Beam Trawl Survey RV Isis 2003–2016). Red vertical line display Lc value (28 cm).

6.5.2.1 Mean Length Z Estimator

Data

Length distribution time series: Landings and discards length distribution sex combined for the years 2014–2016. Survey length distribution data (BTS RV "Isis" 1991–2016).

Fishing effort: InterCatch effort data for the most important métier catching flounder 2014–2016 (TBB_DEF_70-99_0_0_all; effort data from UK (England) were not provided). STECF effort data time series (2003–2015; assuming effort in 2016 is equal to effort in 2015).

Table 6.2. Flounder in Subarea 4 and Division 3.a: Parameters used as input for the length based methods.

Parameter	Sex combined
von Bertalanffy L∞ (cm)	41
von Bertalanffy k (yr-1)	0.36
Length-weight a	0.00867
Length weight b	3.06
Natural mortality M (yr-1)	0.2
Length-at-maturity (mm)	21
Natural mortality M	0.2

Runs

Four different runs were performed using the Mean Length Z Estimator method: (i) InterCatch data all length classes and InterCatch effort data, (ii) InterCatch data ≤16 cm (without recruits) and InterCatch effort data, (iii) beam trawl survey data all length classes with STECF effort data (2003–2015), (iv) beam trawl survey data ≤16 cm (without recruits) with STECF effort data (2003–2015).

Table 6.3. Flounder in Subarea 4 and Division 3.a: Summary of Mean Length Z results.

Run	Lc (cm)	mean Length	Gedamke & Hoenig		THoG (estimated M)				THoG (fixed M=0.2)		YPR analysis	
			Z	StdError	q	Std. dev	M	Std. dev	q	Std. dev	F0.1	F
InterCatch	28	20.3	0.580	0.004	0.137	0.023	0.282	0.046	0.175	0.002	0.230	0.420*
InterCatch_wo	28	27.7	0.580	0.004	0.137	0.023	0.282	0.046	0.175	0.002	0.230	0.366*
Survey Data	28	26.1	0.594	0.032	-0.344	0.256	0.755	0.127	0.845	0.116	0.230	0.394
Survey Data_wo	28	27.5	0.594	0.032	-0.344	0.256	0.755	0.127	0.845	0.116	0.230	0.394

*"Hessian matrix is not positive definite"

Results

For all four different runs the Lc was 28 cm (Table 6.3). The mean length was lowest for the InterCatch data set including all length classes. For the other three runs the mean length ranged between 27.7 cm and 27.5 cm. The Mean Length Z method by Gedamke and Hoenig (2006) resulted in a total Z of 0.580 using the length distribution of commercial catches. The same results were obtained by excluding the recruits from this data set. Given an assumed M of 0.2 the fishing mortality would be higher than $F_{0.1}$ (0.23). However, the YPR analysis did not result in meaningful F estimates because the Hessian matrix was not positive definite (Table 6.3). The THoG model resulted in q=0.137 and estimated M=0.282 for the InterCatch length distribution. This model resulted in a lower F compared to the mean length only method, but the resulting F is still higher than the YPR proxy $F_{0.1}$ (Figure 6.22). Using the survey data resulted in a very similar Z (0.594) compared to the InterCatch data length distribution by applying the mean length only model. No reliable results were obtained by applying the THoG model when using the survey data. When M was estimated by the model even negative q values (and therefore negative F) were obtained. With a fixed M of 0.2 the THoG model resulted in q values of 0.8 Estimated F (i.e. fishing effort) showed a decreasing trend over the whole time series (Figure 6.23) and for the last two years F was estimated with slightly below 0.23 (Table 6.4). This result would suggest exploitation at or below the F_{MSY} proxy.

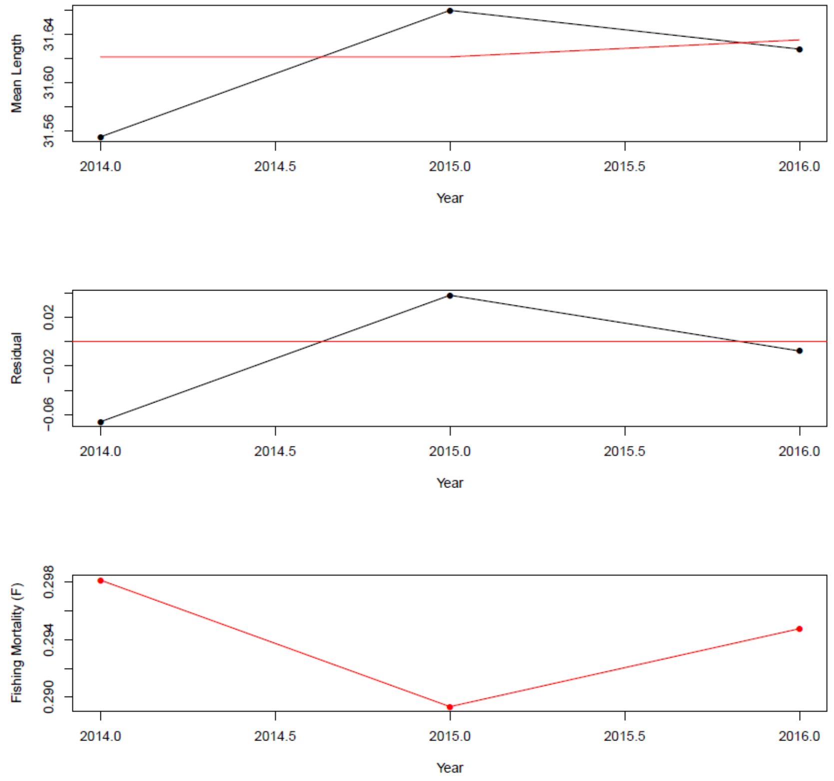


Figure 6.22. Flounder in Subarea 4 and Division 3.a: THoG model taking effort into account (InterCatch data).

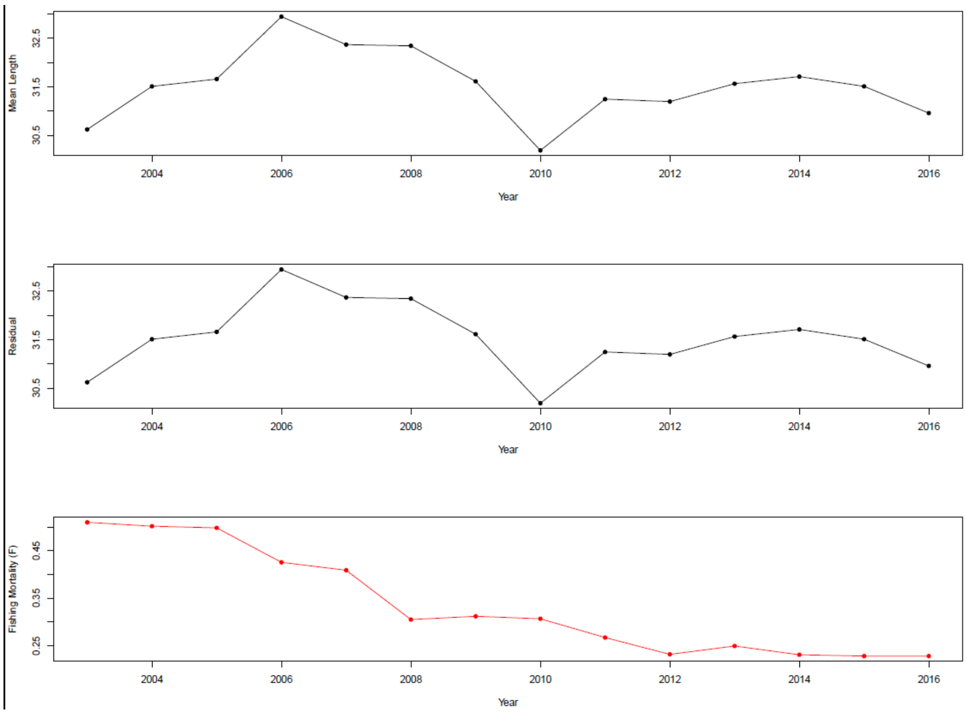


Figure 6.23. Flounder in Subarea 4 and Division 3.a: THoG model taking effort into account (InterCatch data).

Table 6.4. Flounder in Subarea 4 and Division 3.a: THoG model output using survey data and STECF effort data (2003–2016).

year	observed	predicted	residual	F
2003	30.620	0	30.620	0.510
2004	31.509	0	31.509	0.502
2005	31.659	0	31.659	0.498
2006	32.947	0	32.947	0.426
2007	32.370	0	32.370	0.409
2008	32.345	0	32.345	0.305
2009	31.613	0	31.613	0.312
2010	30.189	0	30.189	0.306
2011	31.246	0	31.246	0.267
2012	31.195	0	31.195	0.231
2013	31.564	0	31.564	0.249
2014	31.710	0	31.710	0.231
2015	31.509	0	31.509	0.228
2016	30.957	0	30.957	0.228

Conclusion

Using the mean length z method resulted in contradicting results. The results obtained by using the mean length only model with an assumed M (0.2) all showed exploitation above the YPR F_{MSY} proxy. Also both THoG models using InterCatch length distributions (models with estimated and fixed M) revealed F values above the obtained $F_{0.1}$ value and suggested exploitation above F_{MSY}. However, the effort data provided by InterCatch were not complete and results should be interpreted with caution. Further, only length and effort data for three years were available and the decreasing trend in fishing effort of the past years was not shown by the effort data. The THoG model estimating M and using survey data revealed non reliable results since the catchability (and hence also F) was estimated to be negative. The THoG model with a fixed M (0.2) resulted in F values below the $F_{0.1}$ value. However, these more positive results are solely dependent on the assumption of M=0.2, which might not be true. It was therefore concluded not to use the results of the mean length z methods as a basis for the decision on applying the Precautionary Buffer for the DLS approach.

6.5.2.2 Length Based Indicators

Data

Length distribution time series: Landings and discards length distribution sex combined for the years 2014–2016 (InterCatch).

Table 6.5. Flounder in Subarea 4 and Division 3.a: Input parameters for analysis of Length Based Indicators 2014–2016.

Data Type	Value/Year	Source
Length at maturit	210 210 210	Froese, R. and A. Sampang, 2013. Potential indicators and reference points for good environmental status of commercially exploited marine fishes and invertebrates in the German EEZ. http://oceanrep.geomar.de/22079/
von Bertalanffy growth parameter	410 410 410	Froese, R. and A. Sampang, 2013. Potential indicators and reference points for good environmental status of commercially exploited marine fishes and invertebrates in the German EEZ. http://oceanrep.geomar.de/22079/
Catch at length by year	2014 2016	Length data from InterCatch (2014-2016)
Length-weight relationship parameters for landings and discards	2014 2016	Mean weight at length from IC

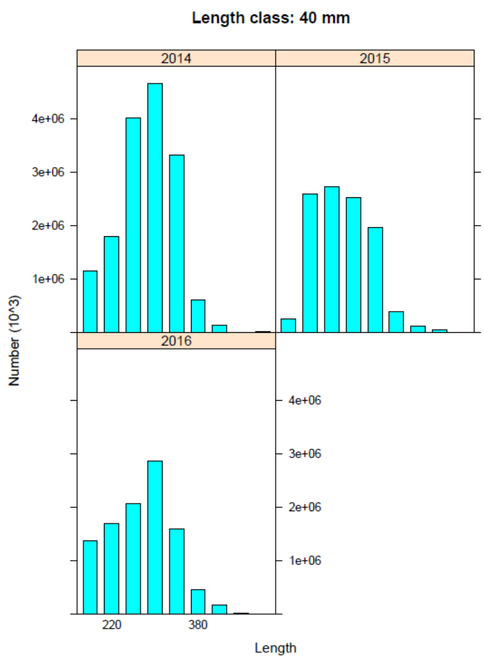


Figure 6.24. Flounder in Subarea 4 and Division 3.a: Length distribution of commercial sampling in 40mm length classes without recruits (InterCatch 2014–2016).

Table 6.6. Flounder in Subarea 4 and Division 3.a: Length based reference points and indicators based on InterCatch data 2014–2016.

Year	L_{75}	L_{25}	L_{med}	L_{90}	L_{95}	L_{mean}	Lc	$L_{F=M}$	L_{maxy}	L_{mat}	L_{opt}	L_{inf}	L_{max5}
2014	325	255	285	345	355	309.89	260	297.5	285	210	273.33	410	384.26
2015	315	235	275	335	355	286.95	220	267.5	335	210	273.33	410	389.22
2016	315	215	275	345	365	300.71	220	267.5	285	210	273.33	410	396.28

	Conservation				Optimizing Yield	MSY
	LC/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1(>0.9)**	**≥1**
2014	1.24	1.21	0.94	0.41	1.13	1.04
2015	1.05	1.12	0.95	0.36	1.05	1.07
2016	1.05	1.02	0.97	0.35	1.10	1.12

Results

The indicator series for flounder in Subarea 4 and Division 3.a do not give any signs of concern. All indicators are above the respective reference points (Table 6.6). Even the P_{mega} (mega-spawners) is above the reference for all three previous years, although somewhat decreasing since 2014. The length based indicators were also analysed for the survey data and revealed also all indicators above the respective reference points (detailed results not presented here).

Conclusion

The length based indicators showed that for the last three years all indicators are above the reference points. This suggests that the exploitation for this stock is at or below F_{MSY}. Based on these results and the obvious decrease in fishing effort of the main fisheries catching flounder it was concluded not to apply the Precautionary Buffer for the DLS approach.

Table 6.7. Flounder in Subarea 4 and Division 3.a: Flounder official landings by country in ICES Subarea 4.

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1950	67	1514	0	641	937	0	67	241	3467
1951	119	1143	0	329	949	0	81	127	2748
1952	91	1210	0	257	841	0	71	186	2656
1953	270	1372	0	397	886	0	92	203	3220
1954	142	1225	0	281	696	0	71	121	2536
1955	145	1244	0	353	871	0	88	109	2810
1956	132	1389	0	277	1097	0	102	2	2999
1957	81	910	0	250	825	0	112	0	2178
1958	99	784	0	257	1088	0	94	0	2322
1959	62	533	0	424	857	0	79	1	1956
1960	82	614	0	540	733	0	49	8	2026
1961	68	776	0	390	579	0	81	13	1907
1962	37	1146	0	313	717	0	53	2	2268
1963	16	501	0	263	467	0	65	0	1312
1964	30	1141	0	305	563	0	48	6	2093
1965	121	1349	0	248	549	0	54	3	2324
1966	32	946	0	229	573	0	71	2	1853
1967	43	540	0	193	331	0	57	25	1189
1968	75	894	0	152	160	0	43	1	1325
1969	54	582	0	158	161	0	33	0	988
1970	50	316	0	135	405	0	57	0	963
1971	60	685	0	173	297	0	70	0	1285
1972	63	991	0	159	275	0	60	0	1548
1973	63	290	0	172	1424	0	53	0	2002
1974	115	766	0	190	2661	0	58	0	3790
1975	68	437	0	155	2191	0	87	1	2939
1976	94	575	0	209	2077	0	70	54	3079
1977	107	320	0	208	1732	0	127	11	2505
1978	122	203	0	198	1519	0	169	0	2211
1979	129	181	31	275	1260	0	201	0	2077
1980	190	300	33	229	806	0	140	0	1698
1981	164	669	14	200	1068	0	133	0	2248
1982	110	630	31	200	1597	0	121	0	2689
1983	88	564	36	197	2059	0	125	0	3069
1984	272	518	15	103	0	0	122	0	1030
1985	163	379	14	128	0	0	109	0	793
1986	155	456	1	91	0	0	111	0	814
1987	132	394	32	106	0	0	90	0	754
1988	160	509	44	105	682	0	98	0	1598
1989	200	632	28	95	916	0	80	0	1951
1990	153	467	69	147	0	0	45	0	881
1991	260	377	51	902	0	0	69	0	1659
1992	152	492	35	521	0	0	76	0	1276

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1993	194	1812	47	356	0	0	136	0	2545
1994	196	642	57	921	0	0	247	0	2063
1995	301	628	103	843	0	0	250	0	2125
1996	262	1439	68	43	0	0	193	0	2005
1997	110	988	10	25	0	0	157	0	1290
1998	283	154	40	13	4938	0	132	0	5560
1999	326	123	0	11	3158	0	54	0	3672
2000	289	100	46	17	2656	5	52	0	3165
2001	241	92	42	4	2608	3	32	0	3022
2002	165	83	51	2	3531	3	55	0	3890
2003	206	94	33	3	3172	9	120	0	3637
2004	335	96	46	5	3720	18	74	0	4294
2005	241	171	17	5	3363	38	111	0	3946
2006	168	152	19	2	4020	39	216	0	4616
2007	298	166	56	45	2925	11	119	0	3620
2008	306	228	30	39	2231	3	57	0	2894
2009	272	273	38	46	2124	3	59	0	2815
2010	251	126	20	58	2612	6	87	0	3160
2011	262	112	17	25	2566	1	65	0	3048
2012	348	100	11	23	1672	0	38	0	2192
2013	346	93	13	28	1199	0	24	0	1703
2014	366	107	15	30	1318	1	31	0	1868
2015*	301	97	18	19	1356	15	0	0	1806
2016*	194	87	20	27	1277	0	25	0	1630

***Preliminary catch statistics**

Table 6.8. Flounder in Subarea 4 and Division 3.a: Flounder official landings by country in ICES Division 3.a.

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
1950	1632	92	0	0	657	2381
1951	1548	88	0	0	759	2395
1952	1161	48	0	0	683	1892
1953	1135	17	0	0	724	1876
1954	1138	13	0	0	528	1679
1955	1265	11	0	0	667	1943
1956	1229	6	0	0	0	1235
1957	1331	12	0	0	0	1343
1958	1099	12	0	0	0	1111
1959	1003	3	0	0	0	1006
1960	875	10	0	0	566	1451
1961	821	9	0	0	442	1272
1962	812	3	0	0	0	815
1963	554	0	0	0	0	554
1964	822	1	0	0	0	823
1965	1016	0	0	0	0	1016
1966	1027	0	0	0	0	1027
1967	811	3	0	0	0	814
1968	808	2	0	0	0	810
1969	721	0	0	0	0	721
1970	667	0	0	0	0	667
1971	611	1	0	0	0	612
1972	365	0	0	0	0	365
1973	346	0	0	0	0	346
1974	1656	2	0	0	0	1658
1975	1377	1	0	0	89	1467
1976	949	2	4	0	144	1099
1977	1036	0	19	0	64	1119
1978	1560	10	14	0	64	1648
1979	1219	0	0	0	100	1319
1980	426	0	0	0	135	561
1981	1831	0	0	0	74	1905
1982	1236	0	0	0	75	1311
1983	2352	0	0	0	160	2512
1984	2463	0	0	0	283	2746
1985	1203	0	0	0	102	1305
1986	1585	0	0	0	166	1751
1987	1050	0	0	0	119	1169
1988	1164	0	0	0	149	1313
1989	996	0	0	0	133	1129
1990	650	1	0	0	57	708
1991	574	0	0	0	50	624
1992	455	0	0	0	52	507

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
1993	673	3	0	0	67	743
1994	865	1	0	0	77	943
1995	403	19	0	0	76	498
1996	429	9	0	0	104	542
1997	367	2	0	0	68	437
1998	637	5	0	0	83	725
1999	558	6	0	0	24	588
2000	609	17	0	0	30	656
2001	672	2	0	1	30	705
2002	493	0	0	1	30	524
2003	452	3	0	0	18	473
2004	462	2	0	0	14	478
2005	467	0	0	0	15	482
2006	380	0	0	0	13	393
2007	419	3	1	0	22	445
2008	326	4	0	0	16	346
2009	238	2	0	0	33	273
2010	188	0	0	0	17	205
2011	129	0	0	0	16	145
2012	110	0	0	0	8	118
2013	162	0	0	0	11	173
2014	190	0	0	0	4	194
2015*	74	0	0	0	3	77
2016*	105	0	0	0	3	108

*preliminary catch statistics

Table 6.9. Flounder in Subarea 4 and Division 3.a: Flounder total official landings by ICES areas.

Year	Division 3.a	Subarea 4	Total
1950	2381	3467	5848
1951	2395	2748	5143
1952	1892	2656	4548
1953	1876	3220	5096
1954	1679	2536	4215
1955	1943	2810	4753
1956	1235	2999	4234
1957	1343	2178	3521
1958	1111	2322	3433
1959	1006	1956	2962
1960	1451	2026	3477
1961	1272	1907	3179
1962	815	2268	3083
1963	554	1312	1866
1964	823	2093	2916
1965	1016	2324	3340
1966	1027	1853	2880
1967	814	1189	2003
1968	810	1325	2135
1969	721	988	1709
1970	667	963	1630
1971	612	1285	1897
1972	365	1548	1913
1973	346	2002	2348
1974	1658	3790	5448
1975	1467	2939	4406
1976	1099	3079	4178
1977	1119	2505	3624
1978	1648	2211	3859
1979	1319	2077	3396
1980	561	1698	2259
1981	1905	2248	4153
1982	1311	2689	4000
1983	2512	3069	5581
1984	2746	1030	3776
1985	1305	793	2098
1986	1751	814	2565
1987	1169	754	1923
1988	1313	1598	2911
1989	1129	1951	3080
1990	708	881	1589
1991	624	1659	2283
1992	507	1276	1783
1993	743	2545	3288

Year	Division 3.a	Subarea 4	Total
1994	943	2063	3006
1995	498	2125	2623
1996	542	2005	2547
1997	437	1290	1727
1998	725	5560	6285
1999	588	3672	4260
2000	656	3165	3821
2001	705	3022	3727
2002	524	3890	4414
2003	473	3637	4110
2004	478	4294	4772
2005	482	3946	4428
2006	393	4616	5009
2007	445	3620	4065
2008	346	2894	3240
2009	273	2815	3088
2010	205	3160	3365
2011	145	3048	3193
2012	118	2192	2310
2013	173	1703	1876
2014	194	1868	2062
2015*	77	1806	1883
2016*	108	1630	1738

*preliminary catch statistics

7 Grey gurnard (*Eutrigla gurnardus*) in Subarea 4, Divisions 7.d and 3.a (North Sea, Eastern English Channel, Skagerrak and Kattegat)

7.1 General

Grey gurnard (*Eutrigla gurnardus*) was assessed in the Working Group on the Assessment of New MoU Species (ICES 2014) until 2014. Since 2015 the stock was assessed by the WGNSSK. Biennial advice is given by ICES for grey gurnard in Subarea 4 and Divisions 7.d and 3.a. For this stock several survey data are available. Available official landings data are incomplete or were not reported specifically for grey gurnard in the past. Only survey trends were used as a stock indicator (mature biomass index IBTS–Q1). Based on the assessment by WGNSSK 2016 the advised total catch should not be more than 8 813 tons for 2017 and 2018. This corresponds to landings not higher than 1 763 tons if the average discard rate (~80%) does not change. During the WGNSSK 2017 new available discard and landings data and the IBTS–Q1 index was updated. The updated index did not change the perception of this stock and the working group concluded that there was no need to reopen the advice.

7.1.1 Biology and ecosystem aspects

Grey gurnard occurs in the Eastern Atlantic from Iceland, Norway, southern Baltic, and North Sea to southern Morocco and Madeira. It is also found in the Mediterranean and Black Seas. In the North Sea and in Skagerrak/Kattegat, grey gurnard is an abundant demersal species. In the North Sea, the species may form dense semi-pelagic ag-aggregations in winter to the northwest of the Dogger Bank, whereas in summer it is more widely distributed. The species is less abundant in the Channel, the Celtic Sea and in the Bay of Biscay.

Spawning takes place in spring and summer. There do not seem to be clear nursery areas. Grey gurnard can reach a maximum length of approximately 50 cm.

Grey gurnard is considered a predator on young age groups of a number of commercially important demersal stocks (cod, whiting, haddock, sandeel, and Norway pout) in the North Sea (de Gee & Kikkert, 1993). The steep increase in abundance of grey gurnard has led to an increase in mortality especially of North Sea cod (age–0) and whiting (age–0 and age–1) in recent years (ICES 2011). The multispecies model SMS estimated that grey gurnard can cause up to 50% of the predation mortality on 0–group cod and whiting. Therefore, the abundance and distribution pattern of grey gurnard and its prey size preferences are highly relevant from an ecological point of view (Floeter and Temming, 2005, Kempf *et al*., 2013).

7.1.2 Stock ID and possible assessment areas

No studies are known of the stock ID of grey gurnard. In a pragmatic approach for advisory purposes and in order to facilitate addressing ecosystem considerations, the population is currently split among 3 ecoregions: North Sea including Division 7.d, Celtic Seas and South European Atlantic. This proposal should be discussed considering the low levels of catches reported in recent years in Celtic Seas and South European Atlantic (ICES 2011, ICES 2012).

7.1.3 Management regulations

There is no minimum landing size for this species and there is no TAC.

7.2 Fisheries data

7.2.1 Historical landings

Historically, grey gurnard is taken as a by-catch species in mixed demersal fisheries for flatfish and roundfish. Grey gurnard from the North Sea is mainly landed for human consumption purposes. A high amount of grey gurnard is landed as industrial bycatch in the Danish fishery for sandeel and sprat (MIS_MIS_0_0_0_IBC). However, the market is limited and the largest part of the catch is discarded (see also stock Annex). Owing to the low commercial value of this species, landings data do not reflect the actual catches.

In the past, gurnards were often not sorted by species when landed and were reported as one generic category of "gurnards". Further, catch statistics are incomplete for some years, e.g. the Netherlands did not report gurnards during the years 1984–1999. In recent years, the official statistics seem to improve gradually. However, some countries continue to report "gurnards" landings and do not provide information on grey gurnard separately (e.g. Germany) or the data imported into InterCatch are based on a gurnard mix raised by survey information on the proportion of the specific gurnard species (e.g. UK England).

Since the early 1980s specific landings data for grey gurnard are available from the official catch statistics. Before that, these data occurred only sporadically in the statistics. Most of gurnard catches are taken in Subarea 4 and to a much lesser extent in Divisions 7.d and 3.a (Fig. 7.1–7.3; Table 7.1–7.2). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46 598 tons in 1987 (Fig. 7.2; Table 7.2) because of Danish landings for reduction purposes. After this peak, the Danish landings dropped again to a low level. Recent international official landings for the last 5 years have been low ranging between 500 tons to 777 tons per year. Com-pared to 2015 the official landings in 2016 decreased to 681 tons. The average official landings for the last ten years (2007–2016) was 481 tons. Data from 1950 to 2005 were taken from the "ICES catch statistics 1950 to 2010". Data from 2006 to 2014 were taken from the "ICES catch statistics 2006 to 2014". Data for 2015 and 2016 were taken from the preliminary catch statistics provided by ICES (http://data.ices.dk/rec12/login.aspx).

7.2.2 InterCatch data

InterCatch contains now data for the years 2012–2016. Similar as for 2015, the largest amount of landings in 2016 was reported by Denmark for the MIS_MIS_0_0_0_IBC metier (1 157 tons), which is mainly industrial fishery for sand eel and sprat. These landings are not included in the official landings which is the main reason for the large discrepancy between the official landings and the InterCatch estimate. Considerable amounts of landings were also reported by Scotland (263 tons, OTB_DEF_>=120_0_0_all). For all other metiers the landings were below 100 tons (Fig. 7.4). For all countries the amount of discards exceeded by far the amount of landings, with the exception of Denmark (Fig. 7.5). The largest amounts of discards were reported for the Scottish OTB_DEF_>=120_0_0_all (1 179 tons), the Dutch TBB_DEF_70–99_0_0_all (962 tons), the Belgium SSC_DEF_100-119_0_0_all (616 tons), and the English TBB_DEF_70–99_0_0_all (459 tons). Norway, Belgium, and Germany did not report any grey gurnard discards. The largest amount of discards was estimated for the OTB_DEF_>120_0_0_all fleet (2 357 tons reported plus raised discards). The total catch estimated with InterCatch for the year 2016 was 8 455 tons from which 1 918 tons were landings (23%) and 6 538 tons estimated discards (77% of total catch). In total The Netherlands take the largest proportion of the total catch with a high amount of discards, followed by Scotland. In 2016 landings were 4% lower compared to 2015 and total catches were 15% higher.

The estimate of the InterCatch landings and discards were revised by including German data and splitting UK England data to get an estimate for grey gurnard only. Germany does not report officially grey gurnard data separately, but rather reports a combined group of gurnards. Thus, it was not possible to upload German data on grey gurnard into InterCatch. The uploaded InterCatch data from UK England were based on a gurnard mix for which a ratio obtained by survey data was applied. This latter approach will lead to a bias because gurnard landings are usually dominated by tub gurnards (*Chelidonichthys lucerna*) while the largest part of grey gurnard is discarded. In order to estimate the grey gurnard proportion of these data the grey gurnard proportion of all gurnards from Dutch and Belgian official landings was used. This resulted in an average of 20% grey gurnards in landings for the years 2012–2014. This ratio was then applied to the German and UK England data. Table 7.4 displays the change in total catch due to this correction.

7.2.3 Other information on Discards

In Table 7.5 the numbers per hour of discarded grey gurnard in Dutch bottom-trawl fisheries in North Sea and Eastern Channel are shown for 2006–2012 (Uhlmann *et al.*, 2013). The rates are highly variable depending on the specific métiers, with highest values observed for the SSC_DEF métiers. German discard data from an observer programme indicate that the proportion of discarded gurnard in German demersal trawl fisheries ranges between 76.6% and 93.0% (Ulleweit *et al.*, 2010).

7.3 Survey data/recruit series

For the North Sea and Skagerrak/Kattegat, data are available from the International Bottom Trawl survey. The IBTS–Q1 and IBTS–Q3 can provide information on distribution and the length composition of the catches. Grey gurnard occurs throughout the North Sea and Skagerrak/Kattegat. During winter, grey gurnards are concentrated to the northwest of the Dogger Bank at depths of 50–100 m, while densities are lower off the Danish coast, in the German Bight and eastern part of the Southern Bight (Figure 7.6 and 7.7). The distribution pattern changes substantially in spring, when the whole area south of 56°N becomes densely populated and the high concentrations in the central North Sea disappear until the next winter (Daan *et al.*, 1990).

The nearly absence of grey gurnard in the southern North Sea during winter and the marked shift in the centre of distribution between winter and summer suggests a preference for higher water temperatures (Hertling, 1924; Daan *et al.*, 1990).

During winter, grey gurnard occasionally form dense aggregations just above the sea bed (or even in midwater, especially during night time) which may result in extremely large catches. Within one survey, these large hauls may account for 70% or more of the total catch of all species. Bottom temperatures in high density areas usually range from 8 to 13°C (Sahrhage, 1964).

7.4 Biological sampling

Individual biological data for this species are still scarce (see also the stock annex). In the North Sea, individual data have been collected sporadically during some years of the IBTS–Q1 and IBTS–Q3 survey. The age readings done on collected otoliths from

IBTS–Q1 resulted in an age range from 2 to 14, but not many individuals were aged (n=469, years 2012–2014).

Available data on grey gurnard individual weights and maturity were analysed in order to estimate a mature biomass index. A maturity ogive based on all the available grey gurnard maturity data from IBTS–Q1 was used to calculate this mature biomass index. The obtained maturity ogive shows that above 19.5 cm more than 90% of all the individuals can be considered mature (Figure 7.8a). The corresponding Lmat50% value was 15.6 cm. Proportion mature at length was calculated by the obtained model PropMat = 0.995/(1+exp(-1*(LngtClass-15.611)/2.073)). The obtained weight–length relation was Weight = (0.007* LngtClass 3.062; Figure 7.8b).

The available age and maturity data suggest that grey gurnard is early maturing in North Sea and a certain proportion of fish at age 1 are mature.

7.5 Analysis of stock trends/assessment

Information from landings is very poor, due to poor reporting (gurnard species are not always identified in the data, and probably also misreporting has occurred) and also because the low value of the species leads to massive discarding.

The status of the populations in the Ecoregions which cover the Northern European Shelf is not known but some indications of trend are delivered by the survey series available.

To analyse stock trends a mature biomass index was calculated applying a length weight relationship and a maturity ogive which were obtained from all data available.

According to van Heesen and Daan (1996), outliers were excluded from the IBTS–Q1 time series since grey gurnards tend to form dense concentrations during winter. Outliers were defined as hauls which accounted for more than 90% of the total gurnard weight caught in the respective year. However, such extreme outliers were only identified in the time period before 1983 which is not displayed here. The time series of mature biomass index of grey gurnard of the IBTS–Q1 survey has shown a strong increase pattern from the beginning of 90's (Figure 7.9; Table 7.6). Since then it was fluctuating on a high level. The mature biomass index for the IBTS–Q3 does not show this pronounced increasing trend but the 2014 value was the highest observed in the time series ever. In 2015 the IBTS–Q3 index dropped quite sharply again. In general lower biomass and abundance values were observed for the IBTS–Q3 survey time series. Com-pared to the North Sea/Skagerrak (Subarea 4/Division 3.a) the mature biomass values recorded by the Channel Ground Fish Survey (CGFS) in the Eastern Channel (Division 7.d) were extremely low (not shown in this report). No trend could be detected in the CGFS index. Therefore, the advice for grey gurnard in area 4, 3.a and 7.d should be based on the IBTS survey, which covers by far the largest part of the stock. The updated index did not change the perception of this stock.

7.6 Data requirements

For management purposes, information should be available on catches and landings. Traditionally the quality of landings data has been poor for this species because in the past often only landings of "gurnards" were reported which is still the case for some countries today (e.g. Germany, UK England). Further, this species is highly discarded and discard data are only available for the recent years (2012–2016).

Given the high level of discarding, observation at sea under DCF is the main source of information to better estimate the total catches.

For a better understanding of this species an increase in our knowledge of biological parameters is required. In the context of ecosystem considerations, it would be useful to obtain more information on age composition of the stock and its diet composition.

From the information presented here, it can be concluded that grey gurnard is currently of very limited commercial interest.

Table 7.1. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 3.a.

Year	BE	DK	NL	NO	SE	Total
1980	0	0	0	0	36	36
1981	0	0	0	0	46	46
1982	0	86	0	0	43	129
1983	0	29	0	0	7	36
1984	0	62	0	0	6	68
1985	0	3	0	0	9	12
1986	0	6	0	0	10	16
1987	1	13	0	0	6	20
1988	0	59	0	0	2	61
1989	0	19	0	0	4	23
1990	0	34	0	0	3	37
1991	0	25	0	0	5	30
1992	0	22	0	0	10	32
1993	0	18	0	0	9	27
1994	0	12	0	0	12	24
1995	0	10	0	0	5	15
1996	0	18	0	0	3	21
1997	0	13	0	0	5	18
1998	0	27	0	0	8	35
1999	0	23	0	0	5	28
2000	0	32	0	0	5	37
2001	0	30	0	0	3	33
2002	0	18	0	0	1	19
2003	0	32	0	0	1	33
2004	0	24	2	0	2	28
2005	0	21	4	0	1	26
2006	0	19	0	0	2	21
2007	0	21	1	0	3	25
2008	0	24	0	0	5	29
2009	0	15	0	0	3	18
2010	0	10	1	0	2	13
2011	0	5	0	0	1	6
2012	0	5	0	0	1	6
2013	0	5	0	0	1	6
2014	0	3	0	0	1	4
2015	0	4	0	1	2	7
2016	0	9	1	0	2	12

Table 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Subarea 4.

Year	BE	DK	FR	NL	NO	SE	UK	Total
1980	0	0	43	0	0	0	0	43
1981	0	0	0	0	0	0	0	0
1982	0	0	100	0	0	0	0	100
1983	0	0	64	0	0	0	0	64
1984	0	0	71	0	0	0	0	71
1985	88	0	85	0	0	0	0	173
1986	0	27	66	0	0	0	0	93
1987	63	44205	56	0	0	0	0	44324
1988	72	36887	43	0	0	0	22	37024
1989	73	26230	45	0	0	0	0	26348
1990	85	22041	42	0	0	0	0	22168
1991	70	14514	28	0	0	0	0	14612
1992	98	8113	21	0	0	0	10	8242
1993	106	822	27	0	0	0	24	979
1994	63	87	21	0	0	0	22	193
1995	43	63	26	0	0	0	21	153
1996	108	52	18	0	0	0	54	232
1997	49	23	22	0	0	0	57	151
1998	33	29	13	0	0	0	0	75
1999	35	63	0	0	0	127	0	225
2000	28	63	5	452	0	0	0	548
2001	22	258	20	277	0	1	33	611
2002	23	45	10	285	0	1	29	393
2003	16	60	5	307	0	6	26	420
2004	21	59	6	264	0	3	23	376
2005	16	52	5	213	0	8	22	316
2006	10	46	2	133	2	0	7	200
2007	11	16	4	155	5	0	14	205
2008	8	24	2	104	5	3	12	158
2009	15	6	2	154	1	1	22	201
2010	14	8	10	218	1	0	13	264
2011	26	6	7	263	1	0	31	334
2012	49	3	4	467	2	0	77	602
2013	30	4	2	268	34	0	131	469
2014	35	4	3	252	56	0	128	478
2015	20	7	2	209	172	4	345	760
2016	31	7	6	232	83	5	297	660

Table 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official grey gurnard landings in Division 7.d.

Year	BE	FR	NL	UK	Total
1980	0	950	0	0	950
1981	0	0	0	0	0
1982	0	380	0	0	380
1983	0	489	0	0	489
1984	0	126	0	0	126
1985	14	102	0	0	116
1986	0	217	0	0	217
1987	12	66	0	0	78
1988	14	346	0	0	360
1989	9	90	0	0	99
1990	6	92	0	0	98
1991	5	94	0	0	99
1992	6	85	0	0	91
1993	7	47	0	0	54
1994	4	33	0	0	37
1995	7	36	0	0	43
1996	4	44	0	0	48
1997	3	81	0	0	84
1998	1	34	0	0	35
1999	1	0	0	0	1
2000	9	67	0	0	76
2001	6	40	0	0	46
2002	32	54	1	0	87
2003	18	42	12	0	72
2004	14	3	31	0	48
2005	13	2	21	0	36
2006	8	2	22	14	46
2007	3	1	9	36	49
2008	1	3	16	66	86
2009	1	1	3	61	66
2010	6	2	39	64	111
2011	11	5	53	33	102
2012	11	5	11	23	50
2013	23	4	11	14	52
2014	7	5	4	2	18
2015	2	6	2	0	10
2016	1	6	2	0	9

Table 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Revisions of the total catch (InterCatch) and update of total catch for 2016.

YEAR	CATCH WGNSSK 2015	UPDATE WGNSSK 2016 (CHANGE)	UPDATE WGNSSK 2017
2012	8345	7262 (-13%)	7262
2013	10230	8710 (-15%)	8710
2014	8596	8009 (-7%)	8009
2015	n.a.	7316	7316
2016	n.a.	n.a.	8455

Table 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Discards per hour of grey gurnard by different metiers in the Netherlands 2006–2012.

Métier	TBB_DEF	TBB_DEF*	TBB_DEF	SSC_DEF	SSC_DEF	OTB_MCD	OTB_DEF	OTB_DEF
Mesh	70-99	70-99	100-119	100-119	>120	70-99	70-99	100-119
2006	68.3							
2007	60.2							
2008	34.3							
2009	55	17	37			111	77	15
2010	81	10	109			47	52	110
2011	61	27	10	NA	119	27	55	70
2012	41	24	30	317	307	110	75	12

*≤300 hp segment

Table 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Mature biomass indices (kg/hour) from IBTS–Q1 and IBTS–Q3.

Year	IBTS–Q1	IBTS–Q3
1983	5.00	
1984	14.31	
1985	3.75	
1986	9.42	
1987	4.61	
1988	2.61	
1989	6.85	
1990	9.04	
1991	8.74	6.69
1992	9.76	10.66
1993	11.19	7.64
1994	10.61	10.76
1995	11.73	9.14
1996	18.71	15.14
1997	25.75	12.15
1998	21.45	20.37
1999	45.24	22.22
2000	25.83	16.28
2001	20.34	22.47
2002	24.85	16.25
2003	20.35	16.23
2004	21.29	8.86
2005	23.97	9.31
2006	22.24	9.83
2007	25.42	11.66
2008	24.68	15.14
2009	20.18	14.67
2010	30.87	12.97
2011	29.86	20.80
2012	32.47	13.04
2013	25.47	17.28
2014	25.63	25.99
2015	28.96	16.47
2016	33.20	18.18
2017	33.20	

Table 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Summary of the assessment done during the WGNSSK 2016 (ICES 2016) with updated values.

Year	Official landings	ICES Landings	ICES catches	ICES discards	Discard rate	Index
1983	589					5.00
1984	265					14.31
1985	301					3.75
1986	326					9.42
1987	44422					4.61
1988	37445					2.61
1989	26470					6.85
1990	22303					9.04
1991	14741					8.74
1992	8365					9.76
1993	1060					11.19
1994	254					10.61
1995	211					11.73
1996	301					18.71
1997	253					25.75
1998	145					21.45
1999	254					45.24
2000	661					25.83
2001	690					20.34
2002	499					24.85
2003	525					20.35
2004	452					21.29
2005	378					23.97
2006	267					22.24
2007	279					25.42
2008	273					24.68
2009	285					20.18
2010	388					30.87
2011	440					29.86
2012	632	904	7262	6358	0.88	32.47
2013	526	975	8710	7735	0.89	25.47
2014	499	1761	8009	6248	0.78	25.63
2015	777	2026	7316	5290	0.72	28.96
2016	681	1918	8455	6538	0.77	33.20

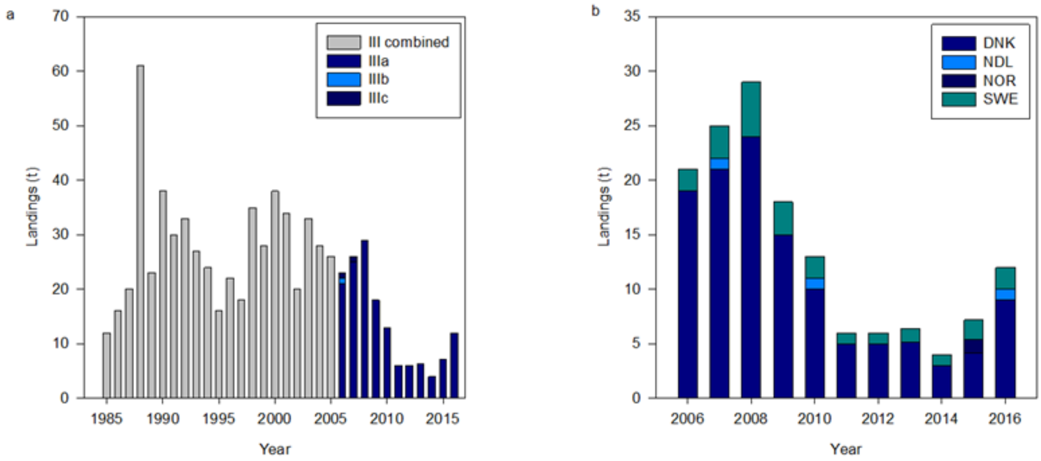


Figure 7.1. Grey gurnard in Subarea 4, Division 3.a and Division 7.d: Official landings of grey gurnard in Divisions 3.a, 3b and 3c 1985–2016 (a), official grey gurnard landings by country only in Division 3.a 2006–2015 (b).

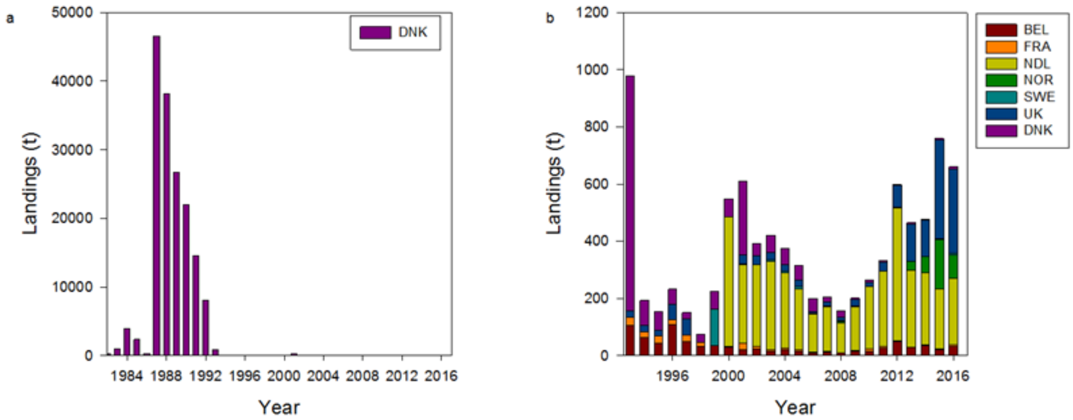


Figure 7.2. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Subarea 4 for Denmark only(a), official landings of grey gurnards by country in area IV since 1993 (b).

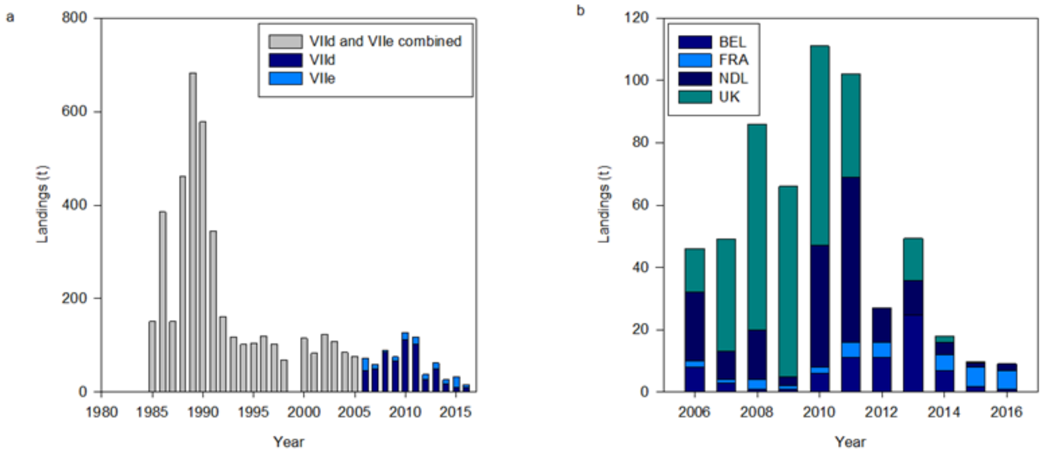


Figure 7.3. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Official landings of grey gurnard in Divisions 7.d and 7e (a), official landings of grey gurnards by country only in area 7.d since 2006 (b).

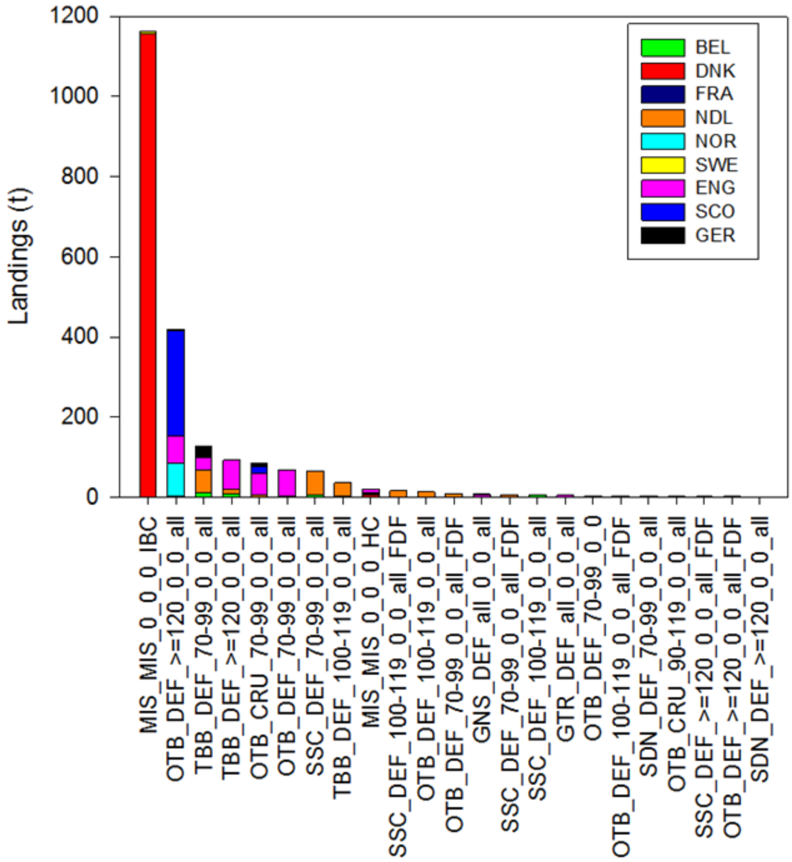


Figure 7.4. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Grey gurnard landings in 2016 by metier and country as uploaded into InterCatch.

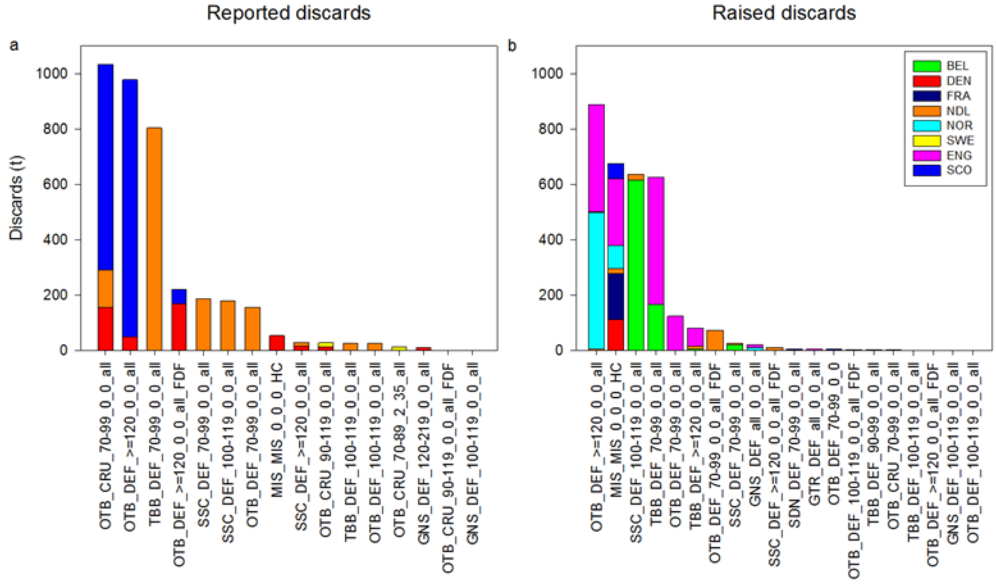


Figure 7.5. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Grey gurnard discards in 2016 by metier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

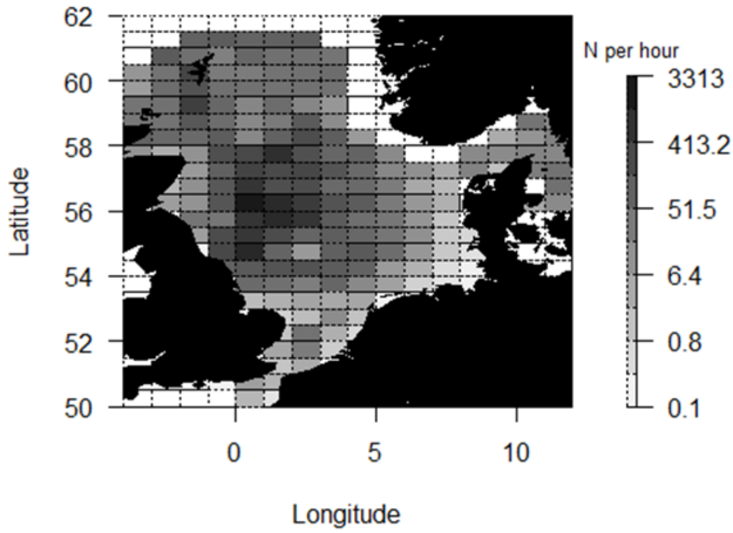


Figure 7.6. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q1 survey in Subarea 4 and Division 3.a.

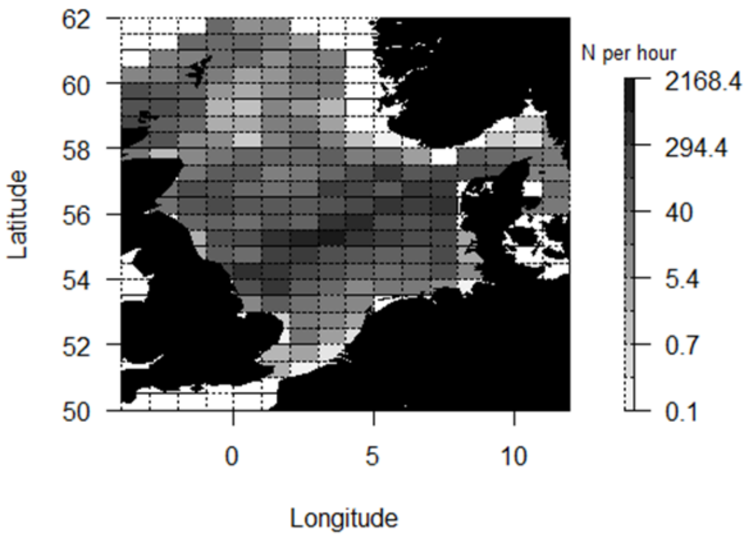


Figure 7.7. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: Spatial distribution of grey gurnard from IBTS–Q3 survey in Subarea 4 and Division 3.a.

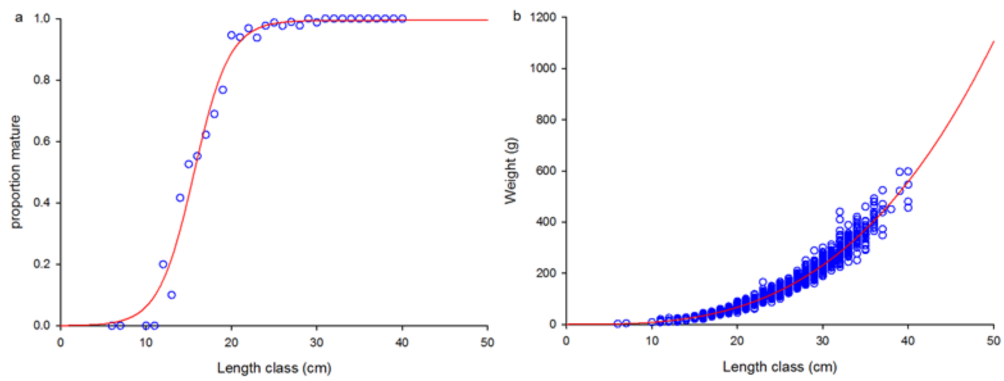


Figure 7.8. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: (a) Maturity ogive of Grey gurnard sampled during IBTS–Q1 surveys (n=1501), (b) length weight relationship of Grey gurnard sampled during IBTS–Q1 surveys.

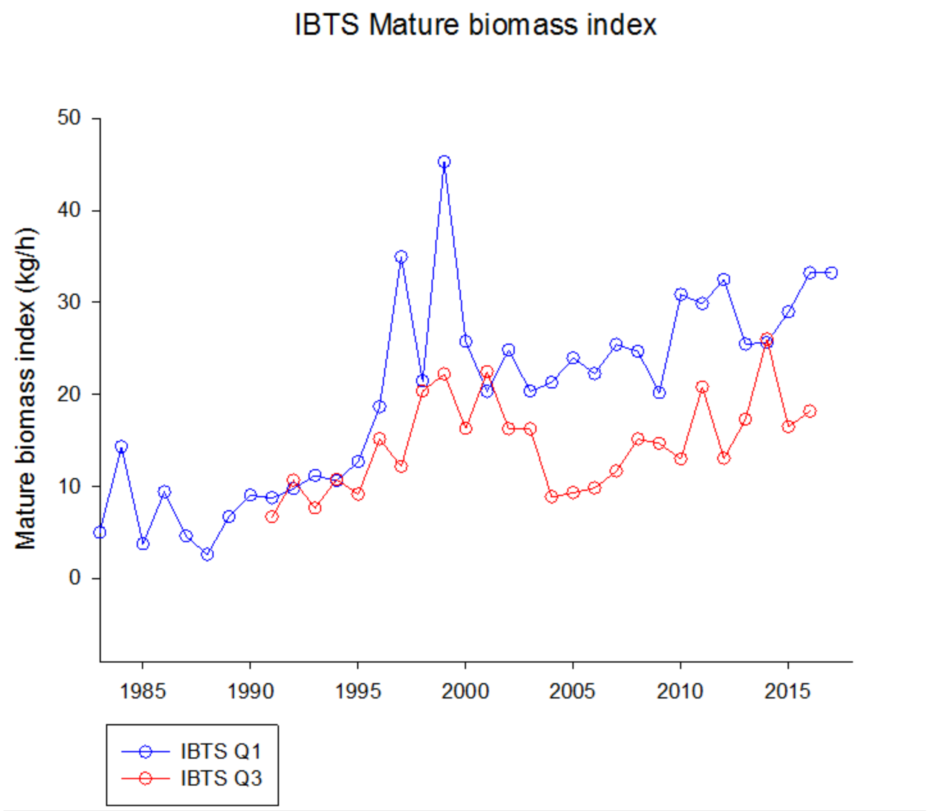


Figure 7.9. Grey gurnard in Subarea 4, Division 3.a. and Division 7.d: IBTS–Q1 and IBTS–Q3 grey gurnard mature biomass index.

8 Haddock in Subarea 4, Division 6.a and Subdivision 20 (North Sea, West of Scotland and Skagerrak)

Until 2014, haddock in Subarea 4, Division 6.a and Subdivision 20 (referred to hereafter as Northern Shelf haddock) were assessed as two separate stocks: Subarea 4 and Subdivision 20 by WGNSSK, and Division 6.a by WGCSE. The 2014 Benchmark Workshop for Northern Haddock Stocks (ICES WKHAD 2014) concluded that the two notional haddock stocks should be assessed as one stock.

During the 2016 WGNSSK meeting, problems were identified with the update haddock assessment. These could not be rectified during the meeting, and a separate inter-benchmark Group (IBP Haddock) was convened to address the issue during the summer of 2016 (ICES IBP Haddock 2016). IBP Haddock concluded that a) the existing TSA model code contained an error (and had done so since 2015), and that b) the corrected code produced a retrospective bias, which was addressed by modifying the treatment of recent above average year-classes. The results of the corrected model produced during the IBP Haddock process was used as the basis for the 2017 advice (and revised 2016 advice) published in November 2016. This section presents the fourth annual ICES assessment of Northern Shelf haddock which was conducted as an update assessment following the corrections made as a result of the IBP Haddock process.

8.1 General

8.1.1 Ecosystem aspects

Ecosystem aspects are summarised in the Stock Annex.

8.1.2 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex. Most of the information presented below and in the Stock Annex pertains to the Scottish fleet, which takes the largest proportion of the haddock stock. This fleet is not just confined to the Northern Shelf area, as vessels will sometimes operate in Divisions 6.b (Rockall) and 5.b (Faroes).

8.1.2.1 Changes in fleet dynamics

There have been no decommissioning schemes affecting haddock fisheries since the major rounds in 2002 and 2004. A number of Scottish vessels have been taking up opportunities for oil support work during recent years with a view to saving quota and days at sea.

With the relatively limited cod and whiting quotas in recent years, many vessels have tended to concentrate more on the haddock fishery, with others taking the opportunity to move between the *Nephrops* and demersal fisheries (particularly during 2006 and 2007, there may have been fewer boats changing focus in this way from 2008 to 2015). Accompanying the change in emphasis towards the haddock fishery, there has also been a tendency to target smaller fish in response to market demand. Some trawlers operating in the east of the North Sea have used 130 mm mesh and this is likely to have improved selectivity for haddock. Fish from the 2009 and 2014 year-classes form the bulk of haddock catches in 2016, and discarding rates for the 2009 year-class fish declined during 2012 and 2013 as they grew beyond the minimum landings size. The decline may also have been due to other measures related to the Scottish Conservation

Credits scheme (CCS; see Section 8.1.4). Discard rates in 2016 increased once again, possibly due to the entry of the modestly large 2014 year class to the fishery.

Specific information on changes in the Scottish fleet during 2011–2016 was not provided to WGNSSK in 2017. It is difficult to reach a firm conclusion on the likely effect of recent fishery changes on haddock mortality. Changes in gear that were required to qualify for the Scottish CCS are likely to have reduced bycatch (and therefore discards) of haddock in the *Nephrops* fishery in particular. The inclusion of Scottish vessels in the CCS has been mandatory since the beginning of 2009, and compliance has been close to 100%. Cod avoidance under the real-time closures scheme (which is a component of the CCS) could also have moved vessels away from haddock concentrations, but the extent of this depends on how closely cod and haddock distributions are linked, and on how successful the avoidance strategies have been. On the other hand, vessels catching fewer cod may have increased their exploitation of haddock in order to maintain economic viability. It is unclear what changes in fleet dynamics and fishing behaviour have been caused by the EU landings obligation which was implemented for the majority of fleets catching Northern Shelf haddock in January 2016.

Following trials during 2010–2013, 26 Scottish demersal whitefish vessels participated in the 2014 Fully Documented Fishery (FDF) scheme (although 3 vessels left the scheme during the year). Similar trials have been conducted during various periods by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on haddock fisheries of an enforceable discard ban for cod, and in data collation for the haddock assessment it was assumed that FDF vessels would have similar haddock discard patterns as other vessels, but this remains to be verified. It should be noted that the Scottish FDF schemes implemented to date have all been restricted to the North Sea: cod discarding from CCTV vessels has remained legal in Division 6.a, and indeed has been mandatory for over-quota cod. The Scottish FDF scheme for 2015 continued without a break from the end of 2014, and included 24 vessels (although 6 left during the year). In 2016, 14 vessels participated in the scheme: the uptake of the scheme declined due to concerns about monitoring of discards under the EU landing obligation. The cod-specific FDF scheme terminated at the end of 2016, due to the suspension of most aspects of the EU Cod Recovery plan which removed the opportunity for countries to provide additional quota for participants. However, a new Scottish FDF scheme has commenced, which is being run along similar lines and which is intended to monitor discarding of saithe and monkfish: there are currently 3 vessels participating in this new scheme in 2017.

8.1.2.2 Additional information provided by the fishing industry

Haddock are still the mainstay of the Scottish whitefish fleet, and have become increasingly so following cod-avoidance initiatives under the Scottish Conservation Credits scheme.

8.1.3 ICES advice

8.1.3.1 ICES advice for 2016

8.1.3.1.1 Subarea 4, Division 6.a and Subdivision 20

In November 2016, the advice for 2016 was revised following the IBPHaddock process. ICES concluded the following:

"ICES advises that when the MSY approach is applied, catches in 2016 should be no more than 59 945 tons. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from the average (2012–2014), this implies landings of no more than 48 621 tons."

8.1.3.2 ICES advice for 2017

8.1.3.2.1 Subarea 4, Division 6.a and Subdivision 20

The advice for 2017 was delayed until November 2016 due to the issues found in the update assessment at WGNSSK 2016 and the need to initiate the IBPHaddock process. In November 2016, ICES concluded the following:

"ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 39 461 tons."

8.1.4 Management

Until 2014, North Sea haddock (Subarea 4 and Subdivision 20) were jointly managed by the EU and Norway under an agreed management plan, the details of which are given in the Stock Annex. However, the validity and sustainability of the management plan when applied to the wider Northern Shelf area had not been evaluated by ICES, and advice could not be provided on the basis of the plan as a consequence. A separate management plan for Division 6.a was evaluated by ICES in 2008 to be precautionary, but similarly cannot be used to provide advice for the full stock area. A management plan for Northern Shelf haddock was to have been developed during 2015, but this has not yet occurred as the basis for management of shared EU–Norway stocks has still to be agreed. In the meantime the stock is managed according to advice based on the ICES MSY approach.

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), 166 (2013), 94 (2014) and 97 (2015). 114 closures were implanted during 2016, although the scheme was suspended on 20th November and there are no plans for its reintroduction. The CCS had two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts were also being made to reduce discards generally. Although the scheme was intended to reduce mortality on cod, it undoubtedly had an effect on the mortality of associated species such as haddock.

Studies tracking Scottish vessels during 2009–2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the haddock stock is still under investigation.

In early 2008, a one-net rule was introduced in Scotland as part of the CCS. This is likely to have improved the accuracy of reporting of landings to the correct mesh size range. The remaining technical conservation measures in place for the haddock fisheries in Subarea 4, Division 6.a and Subdivision 20 are summarised in the Stock Annex.

Annual management of the fishery operates through TACs for three discrete areas. The first is Subarea 4 (and EU Waters of 2.a). The 2016 and 2017 TACs for haddock in this area were 61 933 tons and 33 643 tons respectively. The second is Division 3.a (EU waters), for which the TACs for 2016 and 2017 were 3 926 tons and 2 069 tons respectively. The third is Division 6.a, for which the TACs in 2016 and 2017 were 6 462 tons and 3 697 tons respectively.

8.2 Data available

8.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 8.2.1, together with the corresponding WG estimates and the agreed international quota (listed as "total allowable catch" or TAC). Since 2012, international data on landings and discards have been collated through the InterCatch system (see Section 1.2). International data for below minimum size (BMS) landings and logbook registered discards (LRD) for Northern Shelf haddock have been collated through the InterCatch system from 2016. Figure 8.2.1 and Tables 8.2.2 to 8.2.4 summarise the proportion of landings in the combined Northern Shelf area, for which samples have been provided. While there are a large number of fleets for which landings have not been sampled, the overall contribution of these fleets to total landings is small and 94% of landings by weight have been sampled appropriately. Age compositions for the remaining landings have therefore been determined by averaging across the available sampling (as for last year), without consideration of quarter, country or gear type. Similarly, discard observations are available for the fleets landing the vast majority of haddock (see Figure 8.2.2), so discard rates for the remaining fleets have also been inferred using simple averaging.

The collation of BMS landings and logbook registered discards in InterCatch was introduced in 2016 in accordance with the implementation of the EU landing obligation. Similar to the landings, a large proportion (81%) of the BMS landings by weight has been sampled appropriately (see Figure 8.2.3). Age compositions for the BMS landings were determined in a similar way to the landings without consideration of quarter, country or gear. Logbook registered discard observations were not available in 2016.

The full time series of landings, discards, BMS landings and industrial bycatch (IBC) is presented in Table 8.2.5. These data are illustrated further in Figure 8.2.4. The total landed yield of the international fishery has been relatively stable since 2007. The WG estimates (Table 8.2.5) suggest that haddock discarding (as a proportion of the total catch) decreased significantly during 2013, and the discard rate for that year was the lowest in the time series at 7.2% by weight. This may have been due in part to fleet behaviour changes related to cod avoidance measures, but also to the weak year-classes since 2009 (implying that the bulk of the catch was large, mature fish that are less likely to be discarded). The discard rate increased once more to around 11% by weight in 2014, 15% in 2015 and around 18% in 2016, although the reasons for this are not known. The recent changes in discarding are not consistent across ages (Figure 8.2.5).

It would be expected that under the EU landing obligation fish caught under the minimum conservation reference size (MCRS) would be landed and recorded as BMS landings in log books rather than discarded as happened before the landing obligation. The log book records of BMS landings would then be reported to ICES. However, low BMS values may be seen if the fish caught below MCRS are either not landed, not recorded in log books, not reported to ICES or a mixture of the three. BMS landings reported to ICES in 2016 are 0.47% of the total catch which is significantly lower than the discard estimate of 17.97% of total catch. This suggests that fish caught below MCRS are not being reported as BMS. The majority of the catch for Northern Shelf haddock comes from the Scottish fleet where all recorded BMS landings have been reported to ICES. This indicates that the primary reason for the low value of BMS landings is that fish caught below MCRS are either not being landed or not being properly recorded in log books.

Subarea 4 discard estimates are derived from data submitted by Denmark, Germany, England and Scotland. As Scotland is the principal haddock fishing nation in that area, Scottish discard practices dominate the overall estimates. DCF regulations oblige only the UK (Scotland and England) and Denmark to submit discard age-composition data for Subarea 4. Subdivision 20 discard estimates are derived from data submitted by Denmark and Germany. Division 6.a discard estimates are provided by UK (Scotland). BMS landing estimates were provided for area Subarea 4 and Subdivision 20 by UK (Scotland). Industrial bycatch (IBC) has declined considerably from the high levels observed until the late 1970s.

Estimated discard rates can be calculated using video data from Scottish vessels carrying cameras (as part of the FDF scheme described in Section 8.1.2). Neither fish ages nor weights can be measured directly using video, but a method has been developed in Scotland for estimating discard rates by measuring numbers and lengths of discarded fish and applying existing weight-length relationships to obtain a discarded weight, which can then be compared with the total landed weight (see Needle et al 2015). The lack of age information currently impedes the use of these estimates in the ICES assessment process, but work is underway in Scotland and elsewhere to address this.

8.2.2 Age compositions

Total catch-at-age data are given in Table 8.2.6, while catch-at-age data for each catch component are given in Tables 8.2.7 to 8.2.10. The fishery in 2016 (landings for human consumption) was strongly reliant on the 2009, 2012 and 2014 year-classes. In the past, vessels have very seldom exhausted their quota in this fishery, and previous discarding behaviour is thought to be driven by a complicated mix of economic and other market-driven factors. From 2016 onwards, haddock fishing is covered by the EU landing obligation.

8.2.3 Weight-at-age

Weight-at-age for the total catch in the North Sea is given in Table 8.2.11. Weight-at-age in the total catch is a number-weighted average of weight-at-age in the human consumption landings, discards, BMS landings and industrial bycatch components. Weight-at-age in the stock is assumed to be the same as weight-at-age in the total catch. The mean weights-at-age for the separate catch components are given in Tables 8.2.12 to 8.2.15 and are illustrated in Figure 8.2.6: this shows the declining trend in weights-at–age for older ages in total catch and landings, as well as increasing trends for younger ages and some evidence for reduced growth rates for large year classes. Jaworski (2011) concluded that linear cohort–based growth models are the most appropriate method for characterising haddock growth, and these are used in the short-term forecast (Section 8.6).

8.2.4 Maturity and natural mortality

Maturity is assumed to be fixed over time and knife-edged at age 3 (that is, all fish aged 0–2 are assumed to be immature, all fish aged 3 and older are assumed to be fully mature). Natural mortality varies with age and year as shown in Figure 8.2.7 and Table 8.2.16. The general basis for these estimates is described in the Stock Annex, and these values shown here are derived from the WGSAM 2014 key run (as revised in 2015).

8.2.5 Catch, effort and research vessel data

The survey data available are summarised in the following table: data used in the final assessment are highlighted in bold.

Area	Country	Quarter	Code	Year range	Age range
Subarea 4	Scotland	Q3	ScoGFS Aberdeen Q3	1982–1997	0–8
Subarea 4	Scotland	Q3	ScoGFS Q3 GOV	1998–present	0–8
Subarea 4	England	Q3	EngGFS Q3 GRT	1977–1991	0–9
Subarea 4	England	Q3	EngGFS Q3 GOV	1992–present	0–9
Subarea 4 and Division 3.a	International	Q1	IBTS–Q1	1983–present	1–5
Subarea 4 and Division 3.a	International	Q3	IBTS–Q3	1991–present	0–5
Subarea 6.a	Scotland	Q1	ScoGFS–WIBTS Q1	1985–2010	1–8
Subarea 6.a	Scotland	Q1	New ScoGFS–WIBTS Q1	2011–present	1–8
Subarea 6.a	Scotland	Q4	ScoGFS–WIBTS Q4	1996–2009	0–7
Subarea 6.a	Scotland	Q4	New ScoGFS–WIBTS Q4	2011–present	0–7
Subarea 6.a	Ireland	Q4	IGFS–WIBTS Q4	1993–2002	0–8
Subarea 6.a	Ireland	Q4	New IGFS–WIBTS Q4	2003–present	0–8

The 2014 benchmark meeting (ICES WKHAD 2014) concluded that only the North Sea IBTS–Q1 and Q3 survey indices should be used to tune the Northern Shelf assessment. The West of Scotland surveys conducted by Scotland and Ireland covered too small a proportion of the overall stock area to be considered reliable indicators of overall stock dynamics, and the separate English and Scottish North Sea indices were only used previously because of the historical timing of the working group (WGNSSK met in early October when IBTS–Q3 was not yet available). ICES-WKHAD (2014) recommended that the IBTS working group consider whether the North Sea IBTS–Q1 and West of Scotland ScoGFS–Q1 indices could be combined, but this is for future consideration.

Data used for the calibration of the assessment are presented in Table 8.2.17. Survey-based abundance distributions by age and year are given in Figures 8.2.8 (North Sea IBTS–Q1), 8.2.9 (North Sea IBTS–Q3) and 8.2.10 (Scottish West Coast IBTS–Q4)). These demonstrate the concentration of North Sea haddock towards the north and west of the North Sea, quite widely along the continental shelf to the west of Scotland. The modestly large 2014 year-class is evident in all three surveys. Abundance trends in survey indices are shown in Figure 8.2.11. These indicate reasonably good consistency in stock signals from the two North Sea surveys, and support the perception of a modestly large 2014 year-class.

8.3 Data analyses

The assessment has been carried out using TSA (Fryer 2002) as the main assessment method. The results of SURBAR and SAM analyses are also shown, to corroborate (or otherwise) the main assessment.

8.3.1 Exploratory catch-at-age-based analyses

The catch-at-age data, in the form of log-catch curves linked by cohort (Figure 8.3.1), indicates partial recruitment to the fishery for most cohorts up to age 2. Gradients between consecutive values within a cohort have reduced considerably for some recent cohorts, reflecting a reduction in fishing mortality, although catch curves are considerably more variable in recent years suggesting less consistent catch data (which may reflect the lower sample size available from reduced landings). Figure 8.3.2 plots the negative gradient of straight lines fitted to each cohort over the age range 2–4, which can be viewed as a rough proxy for average total mortality for ages 2–4 in the cohort. These negative gradients are also lower in most recent cohorts, and the negative gradient measure for the 2010 cohort is the lowest in the time-series: it is itself negative, which in the absence of other information would indicate that the 2010 was increasing in size over time. As this cannot be the case, it suggests potential problems with recent catch data. It can also be seen that the negative gradient for the 2010 cohort (from ages 2–4) rises sharply, which suggests that fishing mortality may have increased in the most recent time-period.

Cohort correlations in the catch-at-age matrix (plotted as log numbers) are shown in Figure 8.3.3. These correlations show good consistency within cohorts up to the plus-group, verifying the ability of the catch-at-age data over the full time-series to track relative cohort strengths (although data for ages 0 and 1 are slightly more variable, and recent years may be problematic as discussed above).

An exploratory SAM assessment was conducted, using the run settings stipulated in ICES WKHAD (2014). The stock summary and residual plots from this run are given in Figure 8.3.4. The SAM assessment follows similar trends to the final TSA assessment, although the F estimates are less variable (see also Figure 8.3.10). There is evidence of some retrospective underestimation of mean F in the SAM runs, with a corresponding retrospective overestimation of SSB.

8.3.2 Exploratory survey-based analyses

A SURBAR run (ICES WKADSAM 2010, Needle 2015) was carried out using the same combination of tuning indices as the TSA and SAM assessments. The summary plot from this run is given is Figure 8.3.5, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The SURBAR residual plot in Figure 8.3.6 shows that the surveys agree more closely in recent years than was the case at the 2014 WGNSSK meeting, although there remains an indication of some conflict (mostly negative residuals for Q1 and a more even spread for Q3. The plot of survey catch curves also shows reasonable consistency (Figure 8.3.7). The plots of mean standardised log survey indices by age and cohort (Figure 8.3.8) and the pairwise within-survey correlations (Figure 8.3.9) show that both surveys track year-class strength well through the population overall. The results are discussed further in Section 8.3.4 below.

8.3.3 Conclusions drawn from exploratory analyses

Mean-standardising SSB and recruitment estimates (using a common year-range for the mean) and generating TSA and SAM estimates of Z by adding F and M enables the comparison between TSA, SAM and SURBAR shown in Figure 8.3.10. SSB and recruitment estimates are very similar from the three models, although it is noticeable that the SURBAR estimates for large year-classes in particular tend to be higher, and the swings between high and low SURBAR SSB estimates are more pronounced than for TSA and SAM: the final year SSB estimate from SAM is very similar to that from TSA. The mean Z time-series from SURBAR is consistent with that from TSA, while the SAM mean Z estimates tend to be smoother, but the overall trends are not significantly different: again, we note that the final year mean Z estimate from SAM is lower than that from TSA. Overall, the SAM and SURBAR assessments concur with and support the final TSA assessment, with some relatively minor variations.

8.3.4 Final assessment

Table 8.3.1 gives the final TSA assessment settings, while Table 8.3.2 gives the corresponding parameter estimates from the completed run. A full description of the TSA method and the purposes of each parameter are given in the Stock Annex, and the ICES WKHAD (2014) report. Note that, for assessment purposes, total catch is divided into human consumption landings (referred to as "landings") and a composite of discards, BMS landings and industrial bycatch (referred to as "discards" or "discards + bycatch + BMS"), as the selectivity characteristics of these latter components are similar.

The stock summary is given in Figure 8.3.11, with the stock-recruit plot in Figure 8.3.12 and the recruitment time-series in Figure 8.3.13. The latter plot shows that the underlying mean level of recruitment has declined from the early seventies until today, and recruitment remains low in general. Furthermore, the size of sporadic, larger year classes has diminished since the large 1999 year-class. Figure 8.3.14 summarises the observed and fitted discards (discard + bycatch + BMS) proportions by age, from which the decline in discard (discard + bycatch + BMS) rates across ages 2 to 4 in recent years can be seen.

Standardised prediction errors are given in Figures 8.3.15 (landings), 8.3.16 (discard + bycatch + BMS), 8.3.17 (the IBTS–Q1 survey) and 8.3.18 (the IBTS–Q3 survey). These are the principal diagnostic tools for fitting time-series Kalman filter models like TSA, and indicate the discrepancy between the model prediction and observation as the model steps through the data from the start to the end. They are a useful guide to suggest observations which might need to be down weighted, but as TSA also includes a backwards smoothing step they cannot be considered to be residuals in the usual sense.

The time-series of observed and fitted values for total catch (Figure 8.3.19), the IBTS–Q1 survey (Figure 8.3.20) and the IBTS–Q3 survey (Figure 8.3.21) are more interpretable in that context. The estimate of total catch at age–0 prior to 1991 is based on quite noisy discard + bycatch + BMS data where they are available, or on model inference where they are not (1973–1977), so for the earlier period model fits are not necessarily very close to observations. The other notable feature is that total catch tends to be overestimated for larger year-classes, whereas survey indices tend to be slightly underestimated for these year-classes: the TSA model fit is a compromise between the two.

Figure 8.3.22 summarises the results of TSA retrospective analyses for Northern Shelf haddock. There is very little retrospective noise or bias: only one retrospective run falls outside an approximate pointwise 95% confidence intervals of the full time-series assessment, specifically in the mean *F* estimates. It may be hypothesized that the strong population signals from occasional large year–classes provide sufficient data contrast to obviate against retrospective noise.

Fishing mortality estimates for the final TSA assessment are presented in Table 8.3.3, the stock numbers in Table 8.3.4, and the assessment summary in Table 8.3.5.

8.4 Historical stock trends

The historical stock and fishery trends are presented in Figure 8.3.11.

Landings yields have stabilised since 2000, partly due (until 2014) to the limitation of inter-annual TAC variation to ±15% in the EU–Norway management plan for the North Sea. Discards have fluctuated in the same period due to the appearance and subsequent growth of the 1999, 2005, 2009 and 2014 year-classes, while industrial bycatch (IBC) is now at a very low level for haddock (see also Figure 8.2.3).

Estimated fishing mortality for 2008 to 2016 appears to fluctuate between 0.2 and 0.4 and remains above the F(msy) value of 0.19 in 2016 (see Section 8.7). Fluctuations around the previous target-F rate (0.3) of the management plan are an expected consequence of the lag between data collection and management action, and should not be taken to indicate that the plan did not work. The 2006–2008 and 2010–2013 year-classes are estimated to have been very weak, and the fishery has been sustained in recent years by the 2005 and 2009 year-classes. The 2014 year-class is modest in size compared to the previous sporadic larger year classes and is below the long-term average for recruitment. Therefore, it is expected to make a smaller contribution to the stock compared to other recent "large" year classes over the next few years.

8.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2017) and in the quota year (IY + 1 = 2018) are based on the TSA estimate of forecasted recruits at age 0 in the intermediate year, as this ensures consistency between assessment and forecast.

The following table summarises the recruitment, age 1 and age 2 assumptions for the short term forecast.

Year class	**Age in 2017**	**TSA estimate (millions)**	**TSA forecast (millions)**
2015	2	173	
2016	1	1079	
2017	0		4236
2018	Age 0 in 2018		4236
2019	Age 0 in 2019		4236

8.6 Short-term forecasts

Weights-at-age

Mean weights-at-age are forecast using the method proposed by Jaworski (2011) and discussed by ICES WKHAD (2014). The method is also summarised in the Stock Annex, and involves fitting straight lines to cohort-based weight estimates and extrapolating forward in time.

The outcomes for the total catch and the landings (also referred to as wanted catch) are summarized in Figures 8.6.1 and 8.6.2 respectively. The weights-at-age for discards and BMS were combined into an unwanted catch category using the relative contribution of each component (in 2016) to the total catch. These combined weights were used in the extrapolation to calculate the forecast weights and are shown in Figure 8.6.3. There is insufficient data to allow for cohort-based modeling of weights-at-age in the industrial bycatch component, so simple three year (2014–2016) means by age are used for all forecast years.

Fishing mortality

ICES WKHAD (2014) concluded that fishing mortality estimates for the intermediate year should be taken to be the same as the final year, considering that F is smoothed within the TSA model. When this approach results in landings that overshoot the TAC, a TAC constraint should be considered. A TAC constraint was needed for the 2017 intermediate year as a combined-area TAC overshoot of approximately 22 000 tons would have occurred if a similar level of effort to 2016 was assumed for the intermediate year. The combined-area TAC for 2017 was 39 409 tons.

Given the choice of fishing-mortality rates discussed above, partial fishing mortality values were obtained for each catch component (wanted catch (human consumption landings), unwanted catch (discards and BMS landings) and bycatch) by using the relative contribution (averaged over 2014–2016) of each component to the total catch.

Splitting catch forecasts between management units

The haddock assessment presented in this section is for the combined Northern Shelf stock, following the conclusion from ICES-WKHAD (2014) that this was biologically appropriate. However, catch advice is still required for the extant management units. ICES-WKHAD (2014) proposed a survey-based method for splitting forecast catch into subunits on the basis of a time-smoothed survey-based estimate of the proportion of the fishable stock in each area in each year. This is summarised in the Stock Annex.

However, the survey-based proportions were not accepted by ACOM (in June 2014) as the basis for advice, due to concerns over the comparability of survey catchability between the three management areas covered by the assessment area. As a consequence, the catch forecasts provided in Table 8.6.2 are provided for the full stock area only (Subarea 4, Division 6a and Subdivision 20).

Forecast results

The inputs to the short-term forecast (conducted using the MFDP program) are presented in Table 8.6.1. Results for the short-term forecasts are presented in Table 8.6.2. Assuming a F of 0.183 (derived from the combined-area TAC constraint) in 2017, SSB is expected to increase to 237 756 tons in 2017, before decreasing in 2018 to 229 910 tons. In this case, wanted catch (human consumption yield) in 2017 would be 39 409 tons with associated unwanted catch (discards + BMS) of 5 675 tons.

Several alternative options for 2018 have been highlighted in Table 8.6.2. These are based on various reference points including F_{msy}, F_{pa}, F_{lim}, B_{pa}, B_{lim}, $B_{trigger}$ as well as F_{2017}. Under the assumption of F_{msy}, the 2018 total catch is forecast to be 51 037 tons, which corresponds (if 2016 discard+BMS rates remain unchanged) to a wanted–catch yield of 43 555 tons and unwanted catch of 7 482 tons. This exploitation is forecast to lead in turn to a SSB in 2019 of 266 941 tons, an increase of 16% on the 2017 forecast.

8.7 Medium-term forecasts

No specific medium-term forecasts have been carried out for this stock. Management simulations over the medium-term period were performed for North Sea haddock (Needle 2008a, b) and West of Scotland haddock (Needle 2010), as discussed briefly in Section 8.1.4 above.

8.8 Biological reference points

Following the estimation of revised F_{MSY} reference points at the 2014 WKMSYREF3 meeting, WGNSSK 2016 conducted further analysis using the EqSIM software to check that the estimated points remained valid following the update assessment. These analyses were repeated by the IBP following the modifications made to the assessment (ICES-IBPHaddock 2016). Figure 8.8.1 summarises the output from this analysis, which indicates that an appropriate value of F_{MSY} for Northern Shelf haddock is now 0.19. This is a reduction from the value set at WKMSYREF3 (0.37): the key difference in the estimates is that the calculation is based on the recruitment time-series from 2000–2015, rather than the full 1972–2015 time series. WGNSSK proposes that the former period is more appropriate, as recruitment does appear to be declining (see Figure 8.3.11) and it would be unwise to assume that a very large recruitment is likely in the near future.

Using the ICES guidelines for sporadic spawners, B_{lim} was revised to 94 kt (the estimated SSB for 1979, the smallest stock size to produce a good recruitment), and B_{pa} was revised to 1.4 x Blim = 132 kt (which was also used as the MSY $B_{trigger}$ value). An EqSim run with no advice error or rule generated $F_{lim} = F_{p50} = 0.38$, and $F_{pa} = F_{lim}/1.4 = 0.27$. A second EqSim run with advice error but no advice rule produced an estimate of F_{MSY} = 0.24 with the range of 0.18 to 0.30 (Figure 8.8.1, top plot). However, an EqSim run with advice error and rule showed that $F_{p05} = 0.19 < F_{MSY}$ (Figure 8.8.1, bottom plot) so both F_{MSY} and the upper limit of the F_{MSY} range were constrained resulting in an F_{MSY} estimate of 0.19 and associated range of 0.18–0.19.

The EqSim analysis was repeated by WGNSSK 2017 following the issuing of new guidelines (WKMSYREF4) that stated that the lower limit of the F_{MSY} range should be redefined when the F_{MSY} range is constrained by F_{p05}. The new guidelines define the lower limit of the F_{MSY} range as the F that delivers 95% of the yield at $F_{MSY} = F_{p05}$. The new EqSim run followed the same procedure as used in the IBP though with the new definition for the lower limit of the F_{MSY} range and resulted in a F_{MSY} range of 0.167–0.194. This rerun resulted in minor differences in the estimation of F_{MSY} (0.194 versus 0.193 from the IBP) which is thought to result from rounding.

The reference points in full from this analysis are given below:

Variable	WKHAD (2014)	IBPHaddock (2016)	WGNSSK 2017
B_{lim}	63 kt	94 kt	94 kt
B_{pa}	88 kt	132 kt	132 kt
F_{lim}	n/a	0.38	0.384
F_{pa}	n/a	0.27	0.274
F_{MSY}	0.37	0.19	0.194
$F_{MSY\ lower}$	n/a	0.18	0.167
$F_{MSY upper}$	n/a	0.19	0.194

8.9 Quality of the assessment

Survey data are consistent both within and between surveys, and the catch data are internally consistent. Trends in mortality from catch data and survey indices are similar. Retrospective bias in the TSA model has been significantly reduced in the current implementation, and a previous coding error has been identified and removed (ICES-IBPHaddock 2016).

8.10 Status of the Stock

Fishing mortality is now estimated to have remained at a relatively low level in 2016 and is now fluctuating around the historical minimum, although this remains above the estimate of F_{msy} (0.19). Discard rates have increased slightly above the historical minimum observed in 2013, but remain low. The 2010–2013 year-classes were estimated to be weak, following the relatively strong 2009 year-class, but the 2014 year-class is slightly larger than the recent average. Recruitment since the very large 1999 year-class has generally been low, compared with the historical time series. Spawning stock biomass is predicted to increase during 2017 to well above B_{pa} (132 kt) as the 2014 year-class matures.

8.11 Management considerations

The previous EU–Norway management plan for North Sea haddock, and the EU management plan for Division 6.a haddock, are not appropriate for the Northern Shelf stock, as they relate to only a part of the full stock area. Discussions are ongoing between the EU and Norway which may establish a new management strategy on the basis of the Northern Shelf stock. However, even if agreed this will require evaluation, and in the meantime the principal basis for management of this haddock stock is the MSY approach. The survey-based proposal for splitting catch advice into management subunits, which was proposed by WGNSSK in 2014, has not been agreed by ACOM, and the split of quota into management units remains based on historical landings. It is unlikely, therefore, to follow any future changes in stock distribution across the Northern Shelf.

Considering the Northern Shelf as a whole, fishing mortality declined significantly in the early 2000s and has fluctuated around a relatively low level since. However, the current estimate remains above F_{msy}. Spawning stock biomass is estimated to have reached a historical peak in 2002 with the growth of the large 1999 year-class, but declined again rapidly and is now driven strongly by occasional moderate year-classes. The most recent of these occurred in 2005, 2009 and 2014: other recent cohorts have been very weak. SSB is expected to increase in 2017 as the 2014 year-class matures. However, the impact on SSB of the 2014 year class is expected to be less than previous moderate year classes.

Keeping fishing mortality close to the target MSY level would be preferable to encourage the sustainable exploitation of the 2009 and 2014 year-classes. Estimated discard rates are now low, which may be due partly to the lack of small fish in the population, and partly due to an increased awareness of discard problems following public campaigns and (particularly) the installation of CCTV monitoring cameras on a number of vessels. However, discard rates do remain high in certain small-mesh fisheries (such as the TR2 *Nephrops* fleets in Division 6.a). Further improvements to gear selectivity measures, allowing for the release of small fish, would be highly beneficial not only for the haddock stock, but also for the survival of juveniles of other species that occur in mixed fisheries along with haddock. Similar considerations also apply to spatial management approaches (such as real-time closures), and other measures intended to reduce unwanted bycatch and discarding of various species (such as the Scottish Conservation Credits scheme; see Section 8.1.4). Haddock is included in the EU Landings Obligation regulation from 2016, though the impacts on fishing and on the stock are as yet unknown.

Haddock is a specific target for some fleets, but is also caught as part of a mixed fishery catching cod, whiting and *Nephrops*. It is important to consider both the species-specific assessments of these species for effective management, as well as the latest developments in the mixed fisheries approach. This is not straightforward when stocks are managed via a series of single-species, single-area management plans that do not incorporate mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another and the implications of any change need to be considered carefully.

8.12 Assessment frequency

Regarding the Northern Shelf haddock assessment, the following summarises the WGNSSK responses to each of the criteria:

- Stocks are considered candidates for biennial assessment if the advice for the stock has been 0–catch or equivalent for the latest three advice years. This **does not apply** for haddock.

Stocks are considered candidates for biennial assessment if the following criteria are fulfilled simultaneously.

- Life span (i.e. maximum normal age) of the species is larger than 5 years.

  This **applies** to haddock.
- The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) <= 1.1 x Fmsy OR if Fmsy range has been defined: F(latest assessment year) is <= Fupper (upper bound in F range) AND SSB(start of intermediate year) >= MSY Btrigger

  This **does not apply** to haddock.
- The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers. Should be calculated as the average over the latest five years of the catch in numbers of first age divided by the total catch in number by year.

  The first age in the assessment of haddock is zero. Applying the method given here, 2% of the catch is at age zero. Using age–1 instead (which would be the recruiting age for most comparable stocks) gives 3%. So the criterion **applies** to haddock as given.
- The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently underestimated by more than 20%. The formula to be used in the calculations is: $\rho = \frac{1}{7}\sum_{u=Y-7}^{Y-1}\left(1 - \frac{F_{u,u}}{F_{u,Y}}\right)$. The result should be < 0.20, where F_(u,u) is F in year u estimated from an assessment that ends in year u, and F_(u,Y) is the F in year u estimated from the most recent assessment (which ends in year Y)

  Mohn's rho for haddock is 0.22, so this criterion **does not apply**.

The stability table is difficult to complete for this stock, because the stock definition changed in 2014 and the predicted catch from original component stocks is not directly comparable. In addition, neither the 2011 nor the 2012 advice included a catch prediction for 2014, such a prediction was not made until the 2013 advice. A further complication for haddock is that the forecast must still be run using the MFDP program, because the corresponding FLR function does not yet allow for a third catch component (industrial bycatch, in this case). This should be possible within FLR, but the required development work has not yet been completed and MFDP is the only option in the meantime. The problem for this exercise is that MFDP can only carry out a standard one-year ahead forecast, rather than the two-year ahead forecast required for the frequency analysis.

Therefore, Northern Shelf haddock does not pass all the given criteria. In 2015, the stock did pass all the criteria, but WGNSSK argued that it still may not be a good candidate for less frequent assessment in any case. The reason is that stock dynamics are driven very strongly by the occasional (and completely unpredictable) appearance of large year-classes, and an assessment schedule that was unable to respond sufficiently quickly to these recruitment events would rapidly lead to a serious disjunction between the stock abundance and the available quota. In the context of the EU Landings Obligation, this would be particularly problematic. On the other hand, it generally takes two years for the recruits observed at age 0 in the IBTS–Q3 survey to fully recruit to the human consumption fishery, so a two-year quota may be sufficient to account for large incoming year–classes. It is hard to be certain what the outcome would be, however, without more comprehensive risk analyses.

This leads to the more general point. One further opinion expressed during the WGNSSK discussion on this issue was that relatively simple tests would generally be insufficient to determine the risk of unwanted outcomes, should the frequency of assessments for a particular stock be reduced. Such an exercise would require a simulation analysis of the type used to evaluate management plans and strategies. An approach of this kind would take considerable time that would not be available during the WG meeting itself, and would thus require the implementation of a directed Expert Group or coordinated intersessional work. Several members of WGNSSK have tried to set up such a Group within ICES in recent years to no avail, and the difficulty of instigating this work should not be underestimated. There remains a real concern that the simple application of the criteria could lead rapidly to very undesirable outcomes which cannot be predicted without a more robust risk analysis.

Table 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20: Nominal landings (000t) during 2007–2016, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2016 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota before 2016. Quota uptake from 2016 is calculated as the WG estimates of total catch divided by available quota following the implementation of the Landing Obligation. Note that the United Kingdom did not provide official landings for 2012. Reporting of BMS landings started in 2016.

Subdivision 20										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
DE	206	87	105	65	102	120	90	114	103	125
DK	1054	1052	1263	1139	1661	1916	1456	1763	1057	973
NL	0	0	0	1	0	0	5	6	4	2

NO	152	170	121	81	125	239	223	81	63	70
PT	37	0	0	0	0	0	0	0	0	0
SE	278	276	166	126	198	210	217	219	202	129
UK	0	0	0	0	0	0	3	0	0	0
Subarea 4										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
BE	178	112	108	78	106	78	78	98	45	53
DE	727	393	657	634	575	548	677	677	599	554
DK	645	501	552	725	697	947	1283	1079	1426	1213
ES	0	0	0	0	0	0	0	0	0	0
FO	0	3	32	5	0	0	0	0	0	0
FR	498	448	135	276	320	175	177	209	101	121
GL	8	0	4	0	0	0	0	0	0	0
IE	0	0	0	0	0	0	0	0	0	0
IS	0	0	0	0	0	0	0	0	0	0
NL	55	29	24	41	71	191	172	99	43	146
NO	1706	1482	1278	1126	1195	1069	1661	2705	2004	1484
PL	8	16	0	0	0	0	0	0	0	0
PT	0	0	0	0	0	0	0	0	0	0
SE	130	83	141	90	128	103	113	154	135	117
UK	26717	27365	28393	24983	23343	0	32993	29758	25852	26374
Division 6.a										
Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
DE	0	1	0	1	0	0	0	0	0	0
DK	0	0	0	0	0	0	0	0	0	2
ES	5	10	21	28	36	15	0	19	9	33
FO	2	0	0	0	0	0	0	0	0	0
FR	211	151	136	89	73	32	51	67	41	62
IE	759	879	297	396	290	845	746	653	768	1033
NL	0	0	0	0	0	0	0	0	0	28
NO	16	28	18	9	4	0	6	15	7	5
UK	2780	1776	2380	2415	1364	0	3878	3230	3051	3090
Northern Shelf										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Official landings	36172	34862	35831	32308	30288	6488	43830	40945	35520	35238
ICES landings	34672	33058	35590	31940	36570	38162	43681	41143	35316	35058
ICES discards	32651	14503	12326	13071	13067	5032	3038	5090	6255	7449
ICES IBC	48	199	52	431	24	1	54	65	21	37
ICES BMS										201
ICES total catch	67371	47759	47968	45442	49661	43195	46772	46295	41571	42745
TAC 4	54640	46444	42110	35794	34057	39000	45041	38284	40711	61933
TAC 3.a	3360	2856	2590	2201	2100	2095	2770	2355	2504	2069
TAC 6.a	7200	6120	3520	2670	2005	6015	4211	3988	4536	6462
Total TAC	65200	55420	48220	40665	38162	47110	52022	44627	47751	72321
ICES quota uptake	53%	60%	74%	79%	96%	81%	84%	92%	74%	59%

Table 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20: Proportion of sampling strata for discards imported into InterCatch and proportion of discards raised from averaged discard rates.

Catch category	Raised or imported	Weight (tonnes)	Proportion
BMS LANDINGS	IMPORTED	190.27	100
DISCARDS	RAISED	596.61	8
DISCARDS	IMPORTED	7089.86	92
LANDINGS	IMPORTED	35273.87	100

Table 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20: Proportion of age distributions for landings, BMS landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Weight (tonnes)	Proportion
LANDINGS	IMPORTED	SAMPLED	32901.13	94
LANDINGS	IMPORTED	ESTIMATED	2281.07	6
DISCARDS	IMPORTED	SAMPLED	7003.72	90
DISCARDS	RAISED	ESTIMATED	601.51	8
DISCARDS	IMPORTED	ESTIMATED	144.29	2
BMS LANDINGS	IMPORTED	SAMPLED	162.99	81
BMS LANDINGS	IMPORTED	ESTIMATED	37.90	19

Table 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20: Proportion by area of distributions for landings, BMS landings and discards either imported or raised in InterCatch and either sampled or estimated.

Catch category	Raised or imported	Sampled or estimated	Area	Weight (tonnes)	Proportion
Landings	Imported	Sampled	27.6.a	4096.31	96
Landings	Imported	Estimated	27.6.a	150.74	4
Discards	Imported	Sampled	27.6.a	1491.85	96
Discards	Imported	Estimated	27.6.a	39.02	3
Discards	Raised	Estimated	27.6.a	35591.27	1
BMS landings	Imported	Sampled	27.6.a	9.39	100
BMS landings	Imported	Estimated	27.6.a	0.00	0
Landings	Imported	Sampled	27.4	27893.64	94
Landings	Imported	Estimated	27.4	1822.32	6
Discards	Imported	Sampled	27.4	5491.43	90
Discards	Raised	Estimated	27.4	516.53	8
Discards	Imported	Estimated	27.4	91.37	1
BMS landings	Imported	Sampled	27.4	153.60	80
BMS landings	Imported	Estimated	27.4	37.48	20
Landings	Imported	Sampled	27.3.a.20	911.18	75
Landings	Imported	Estimated	27.3.a.20	308.01	25
Discards	Raised	Estimated	27.3.a.20	62.55	65
Discards	Imported	Sampled	27.3.a.20	20.44	21
Discards	Imported	Estimated	27.3.a.20	13.91	14
BMS landings	Imported	Estimated	27.3.a.20	0.41	100

Table 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20: Working Group estimates of catch components by weight (000t). *Note that Subarea 4 and Subdivision 20 data are collated together in 2013, and are listed here only in the Subarea 4 section.

	Subarea 4					Subdivision 20				Division 6.a				Combined				
Year	Landings	Discards	BMS landings	IBC	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	Total	Landings	Discards	BMS landings	IBC	Total
1965	161.7	62.3		74.6	298.6	0.7			0.7	32.5	3.4		35.9	194.9	65.7		74.6	335.2
1966	225.6	73.5		46.7	345.8	0.6			0.6	29.9	0.7		30.6	256.1	74.2		46.7	377.0
1967	147.4	78.2		20.7	246.3	0.4			0.4	20.3	7.4		27.7	168.1	85.6		20.7	274.4
1968	105.4	161.8		34.2	301.4	0.4			0.4	20.5	25.3		45.8	126.3	187.1		34.2	347.6
1969	331.1	260.1		338.4	929.5	0.5			0.5	26.3	25.2		51.5	357.9	285.3		338.4	981.6
1970	524.1	101.3		179.7	805.1	0.7			0.7	34.1	6.2		40.3	558.9	107.5		179.7	846.1
1971	235.5	177.8		31.5	444.8	2			2	46.3	12.2		58.5	283.8	190.0		31.5	505.3
1972	193	128		29.6	350.5	2.6			2.6	41.1	16.4		57.5	236.7	144.4		29.6	410.7
1973	178.7	114.7		11.3	304.7	2.9			2.9	28.8	11.4		40.2	210.4	126.1		11.3	347.8
1974	149.6	166.4		47.5	363.5	3.5			3.5	18.0	15.4		33.3	171.1	181.8		47.5	400.3
1975	146.6	260.4		41.5	448.4	4.8			4.8	13.7	33.0		46.6	165.1	293.4		41.5	499.9
1976	165.7	154.5		48.2	368.3	7			7	18.8	15.3		34.1	191.5	169.8		48.2	409.5
1977	137.3	44.4		35	216.7	7.8			7.8	19.3	4.4		23.7	164.4	48.8		35	248.2
1978	85.8	76.8		10.9	173.5	5.9			5.9	17.2	1.1		18.3	108.9	77.9		10.9	197.7
1979	83.1	41.7		16.2	141	4			4	14.8	6.5		21.3	101.9	48.2		16.2	166.3
1980	98.6	94.6		22.5	215.7	6.4			6.4	12.8	4.8		17.5	117.8	99.4		22.5	239.6
1981	129.6	60.1		17	206.7	6.6			6.6	18.2	7.1		25.3	154.4	67.2		17	238.6
1982	165.8	40.6		19.4	225.8	7.5			7.5	29.6	7.7		37.3	202.9	48.3		19.4	270.6
1983	159.3	66		12.9	238.2	6			6	29.4	3.4		32.8	194.7	69.4		12.9	277.0
1984	128.2	75.3		10.1	213.6	5.4			5.4	30.0	8.1		38.1	163.6	83.4		10.1	257.1
1985	158.6	85.2		6	249.8	5.6			5.6	24.4	10.7		35.1	188.6	95.9		6	290.5
1986	165.6	52.2		2.6	220.4	2.7			2.7	19.6	5.2		24.7	187.9	57.4		2.6	247.8
1987	108	59.1		4.4	171.6	2.3			2.3	27.0	11.1		38.1	137.3	70.2		4.4	211.9
1988	105.1	62.1		4	171.2	1.9			1.9	21.1	5.0		26.1	128.1	67.1		4	199.2
1989	76.2	25.7		2.4	104.2	2.3			2.3	16.7	2.5		19.2	95.2	28.2		2.4	125.8
1990	51.5	32.6		2.6	86.6	2.3			2.3	10.1	0.8		11.0	63.9	33.4		2.6	100.0
1991	44.7	40.2		5.4	90.2	3.1			3.1	10.6	4.8		15.3	58.4	45.0		5.4	108.7
1992	70.2	47.9		10.9	129.1	2.6			2.6	11.3	3.5		14.9	84.1	51.4		10.9	146.5
1993	79.6	79.6		10.8	169.9	2.6			2.6	19.1	7.0		26.1	101.3	86.6		10.8	198.7
1994	80.9	65.4		3.6	149.8	1.2			1.2	14.2	5.0		19.2	96.3	70.4		3.6	170.3
1995	75.3	57.4		7.7	140.4	2.2			2.2	12.4	7.7		20.0	89.9	65.1		7.7	162.6
1996	76	72.5		5	153.5	3.1			3.1	13.5	7.8		21.3	92.6	80.3		5	177.9
1997	79.1	52.1		6.7	137.9	3.4			3.4	12.9	7.5		20.4	95.4	59.6		6.7	161.7
1998	77.3	45.2		5.1	127.6	3.8			3.8	14.4	7.0		21.4	95.5	52.2		5.1	152.8
1999	64.2	42.6		3.8	110.7	1.4			1.4	10.4	3.9		14.3	76.0	46.5		3.8	126.3
2000	46.1	48.8		8.1	103	1.5			1.5	7.0	6.3		13.2	54.6	55.1		8.1	117.7
2001	39	118.3		7.9	165.2	1.9			1.9	6.7	8.5		15.2	47.6	126.8		7.9	182.3
2002	54.2	45.9		3.7	103.8	4.1			4.1	7.1	9.4		16.5	65.4	55.3		3.7	124.4
2003	40.1	23.5		1.1	64.8	1.8	0.2		2	5.3	4.5		9.8	47.2	28.2		1.1	76.5
2004	47.3	15.4		0.6	63.2	1.4	0.1		1.6	3.2	4.5		7.7	51.9	20.0		0.6	72.5
2005	47.6	8.4		0.2	56.2	0.8	0.2		1	3.1	3.8		6.9	51.5	12.4		0.2	64.1
2006	36.1	16.9		0.5	53.6	1.5	1		2.5	5.7	5.2		10.9	43.3	23.1		0.5	66.9
2007	29.4	27.8		0	57.3	1.5	0.8		2.3	3.7	4.0		7.8	34.6	32.6		0	67.3
2008	28.9	12.5		0.2	41.6	1.4	0.6		2	2.8	1.3		4.1	33.1	14.4		0.2	47.7
2009	31.3	10		0.1	41.3	1.5	0.6		2.1	2.8	1.8		4.6	35.6	12.4		0.1	48.1
2010	27.8	9.5		0.4	37.7	1.3	0.6		1.9	2.9	2.9		5.8	32.0	13.0		0.4	45.4
2011	26.3	10.2		0	36.5	9.9	1.7		11.6	1.7	1.5		3.3	37.9	13.4		0	51.4
2012	30.3	3.7		1.2	35.0	2.6	0.7		3.4	5.1	0.5		5.6	38.0	4.9		1.2	44.1
2013*	38.9	2.0		0.1	41.0					4.7	1.1		5.8	43.7	3.0		0.1	46.8
2014	34.9	4.1		0.1	39.1	2.3	0.1		2.4	4.0	0.8		4.8	41.1	5.1		0.1	46.3
2015	30.2	4.2		0.0	34.3	1.4	0.1		1.5	3.9	1.3		5.2	35.3	6.3		0.0	41.6
2016	29.8	5.5	0.2	0.0	35.5	1.2	0.0	0.0	1.2	4.2	1.5	0.0	5.8	35.2	7.1	0.2	0.0	42.6

Table 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20: Numbers at age data (thousands) for total catch. Ages 0–7 and 8+ and years 1972–2016 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	650218	368560	16491	721514	36301	4954	2245	626	118	97	47	0	0	0	0	0	262
1966	1672925	1007517	26186	7536	459941	11903	1109	633	222	90	23	2	0	0	0	0	337
1967	345371	856339	108401	5814	3850	202830	2843	223	231	61	34	0	0	0	0	0	326
1968	11133	1226448	477603	22671	2303	3210	60034	1052	84	22	5	0	0	0	0	0	111
1969	75301	20554	3736629	313593	9029	2678	2894	23704	392	32	7	0	0	0	0	0	431
1970	941790	272467	218881	2003201	60200	1350	1285	401	6539	81	13	19	0	0	0	0	6652
1971	337277	1881729	74866	50845	480381	10916	589	201	167	1767	176	3	5	0	0	0	2119
1972	255110	696714	671965	43309	23547	211817	4067	241	53	27	475	11	0	0	0	0	566
1973	79461	412305	587335	260080	6450	5689	72652	1406	140	34	234	49	5	0	0	0	462
1974	665110	1283252	187149	342628	60523	1956	1795	22380	345	57	63	4	7	4	0	0	480
1975	51796	2276937	673960	62175	112242	17691	1078	718	6168	339	70	11	0	8	0	0	6596
1976	171400	192030	1127520	225532	11538	32677	5864	228	84	1863	64	3	5	0	0	0	2019
1977	119506	263702	109480	426291	45756	4984	6757	1608	163	40	460	8	0	1	0	0	672
1978	281785	223294	130963	31141	144703	11791	1582	2322	740	122	33	275	16	2	0	0	1188
1979	844410	261156	220200	45487	7978	38097	3069	377	629	181	57	13	52	3	0	0	935
1980	374573	439674	374310	80225	11364	2040	11143	827	143	168	96	34	9	7	1	0	457
1981	645352	116229	430149	180553	17044	2225	497	3320	164	78	26	32	5	1	4	0	311
1982	275508	217834	89989	390347	49835	4275	820	551	1072	60	28	8	2	2	0	0	1172
1983	513034	148158	222772	83199	166812	20055	2365	338	255	385	93	21	4	4	0	0	763
1984	95862	483045	139887	143821	29321	56077	6238	967	127	84	185	19	5	1	1	0	423
1985	127003	161400	441785	80605	41508	7082	18393	1929	296	56	29	144	9	0	0	1	535
1986	45703	137091	144075	328016	29497	10595	1686	4421	581	156	56	47	37	16	4	1	898
1987	10249	253236	259369	56407	92705	6214	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	16679	33092	424014	96795	17161	27728	2030	874	368	1076	95	21	12	13	17	1	1603
1989	19587	51743	43162	216359	21015	4189	7671	763	285	170	469	69	8	3	2	1	1007
1990	19286	82571	78881	17811	60888	4373	1104	1839	254	100	54	13	12	1	4	2	439
1991	128703	188087	101425	24822	4706	17618	1388	684	1024	171	65	11	11	1	2	2	1287
1992	277933	166550	255051	43257	7162	1486	6376	611	337	401	149	22	6	2	0	0	918
1993	136841	302610	269220	123469	11822	1986	669	2050	215	210	188	84	4	4	0	0	706
1994	89104	91674	339428	106673	35056	3381	601	366	746	132	48	36	26	5	0	0	992
1995	200151	336460	119210	182969	33802	9237	898	161	155	151	21	8	6	2	1	0	345
1996	167032	46797	505401	73987	66245	11159	4058	1080	75	72	37	9	8	3	1	0	205
1997	36954	162449	107657	251339	18037	18288	2762	937	121	16	18	5	4	4	2	0	170
1998	21919	88387	224037	60861	128348	7110	4590	850	263	60	7	8	3	2	1	1	345
1999	90634	69455	119094	110046	28510	45221	2700	2047	438	53	8	3	3	2	0	0	507
2000	12630	397390	110381	61263	33137	7254	9935	765	367	53	13	2	1	1	0	0	438
2001	3518	95086	633162	34548	12078	5573	2094	1611	257	89	28	3	4	0	0	0	382
2002	50927	36063	99685	372036	7812	2801	1615	729	603	283	25	8	5	0	0	0	923
2003	7082	13136	15234	48729	127241	2166	786	339	144	100	48	5	1	0	0	0	299
2004	3758	25698	24627	8958	38784	97827	1010	248	82	42	37	12	1	0	0	0	174
2005	8779	17695	24596	15085	5446	27745	61457	371	132	38	11	8	4	1	0	0	193
2006	3229	122537	30995	20657	11284	6078	16415	32978	156	56	20	7	4	1	0	0	243
2007	2046	20565	171600	16796	8187	4782	2237	6876	7254	75	8	14	3	1	0	0	7355
2008	3780	15005	31864	75341	4757	2050	1516	566	1432	2570	5	8	1	1	0	0	4017
2009	10483	11042	15303	20764	78513	1860	845	567	239	276	569	6	2	0	0	0	1092
2010	2930	108139	17377	17834	11301	38134	853	416	160	83	85	148	9	0	0	3	488
2011	3003	6082	66355	17091	14138	11495	23124	677	282	95	17	5	60	0	0	0	459

2012	1319	3389	5260	66109	5388	3670	2416	7900	157	178	68	44	57	24	4	0	532
2013	1285	11998	4394	4838	68899	2269	1539	879	3896	37	7	8	2	2	2	0	3954
2014	3537	7504	19838	4818	7799	46760	1104	980	390	1706	14	6	1	1	0	2	2121
2015	3820	27637	15799	17624	1730	5166	22109	1059	433	437	782	107	0	0	0	0	1759
2016	1845	10258	61899	8780	5537	646	507	10150	262	151	9	146	8	0	0	1	57

Table 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20: Numbers at age data (thousands) for landings. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	0	2670	3908	396363	30232	4358	2126	620	118	97	47	0	0	0	0	0	262
1966	0	13034	6899	5332	419437	11113	1082	631	222	90	23	2	0	0	0	0	337
1967	0	55548	40030	4627	3607	198991	2821	223	231	61	34	0	0	0	0	0	326
1968	0	22108	151474	17130	2160	3176	59110	1051	84	22	5	0	0	0	0	0	111
1969	0	143	759680	175763	7965	2282	2760	23452	392	32	7	0	0	0	0	0	431
1970	0	2428	52031	1211535	53570	1184	1220	398	6539	81	13	19	0	0	0	0	6652
1971	0	35945	27011	37832	448352	10551	582	201	167	1767	176	3	5	0	0	0	2119
1972	0	13354	233966	35440	22165	210167	4054	241	53	27	475	11	0	0	0	0	566
1973	0	7277	211018	209961	6085	5459	72528	1406	140	34	234	49	5	0	0	0	462
1974	0	25699	55734	236624	53054	1868	1679	22156	345	57	63	4	7	4	0	0	480
1975	0	28773	211495	41030	93617	17406	1073	718	6163	339	70	11	0	8	0	0	6591
1976	0	3045	246027	155162	11292	29594	5846	228	84	1863	64	3	5	0	0	0	2019
1977	0	8934	33058	278741	42737	4737	6516	1608	163	40	460	8	0	1	0	0	672
1978	0	13913	55636	26119	123655	11479	1496	2317	740	122	33	275	16	2	0	0	1187
1979	0	16077	120456	38247	7752	37353	3052	377	629	181	57	13	52	3	0	0	935
1980	0	11487	154765	67241	9978	1985	11057	820	143	166	96	34	9	7	1	0	456
1981	0	1959	174018	128102	16447	2219	494	3320	164	78	26	32	5	1	4	0	311
1982	0	7623	40161	282492	45732	3811	820	551	1072	60	28	8	2	2	0	0	1172
1983	0	7669	114118	57151	152477	19147	2201	338	255	385	93	21	4	4	0	0	763
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706
1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381

2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284
2008	0	299	6472	50965	4461	1986	1378	563	1402	2566	5	8	1	1	0	0	3983
2009	0	486	4605	9666	61972	1775	793	521	239	276	566	6	2	0	0	0	1088
2010	0	1089	5150	12597	10176	35718	828	416	146	83	85	147	9	0	0	3	473
2011	0	224	16505	15260	13321	11383	22889	677	282	95	16	5	60	0	0	0	458
2012	0	261	3286	52091	4884	3660	2408	7885	157	178	68	44	57	24	4	0	532
2013	0	983	2493	4338	66123	2240	1526	867	3868	37	6	8	2	2	2	0	3924
2014	0	232	12630	3832	7626	42509	1100	965	382	1703	14	6	1	1	0	2	2110
2015	0	716	10568	16070	1635	5132	21108	1058	433	437	779	107	0	0	0	0	1756
2016	1	158	36148	8540	5499	641	496	10104	261	150	9	146	8	0	0	1	576

Table 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20: Numbers-at-age data (thousands) for discards. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	5757	111654	4897	141863	3704	4	1	0	0	0	0	0	0	0	0	0	0
1966	13832	445648	12742	1197	24643	35	2	0	0	0	0	0	0	0	0	0	0
1967	46372	408281	62831	1032	219	1576	9	0	0	0	0	0	0	0	0	0	0
1968	67	741402	244976	3512	97	15	186	0	0	0	0	0	0	0	0	0	0
1969	4475	5234	1273332	39179	432	16	8	0	0	0	0	0	0	0	0	0	0
1970	68905	99125	78340	306391	2663	13	4	0	0	0	0	0	0	0	0	0	0
1971	14189	1275394	37883	9623	25648	66	2	0	0	0	0	0	0	0	0	0	0
1972	18446	444794	380988	6846	1236	1212	13	0	0	0	0	0	0	0	0	0	0
1973	38129	287558	363916	50108	354	33	123	0	0	0	0	0	0	0	0	0	0
1974	88456	982287	99148	59143	2869	6	4	0	0	0	0	0	0	0	0	0	0
1975	7479	1653311	377845	16385	13423	143	0	0	0	0	0	0	0	0	0	0	0
1976	6418	122012	698428	41183	200	137	0	0	0	0	0	0	0	0	0	0	0
1977	16364	107748	47070	79922	664	9	0	0	0	0	0	0	0	0	0	0	0
1978	1193	83683	63997	4214	19568	248	80	0	0	0	0	0	0	0	0	0	0
1979	4795	119245	82074	5734	142	365	0	0	0	0	0	0	0	0	0	0	0
1980	258	146751	197725	4726	96	0	0	0	0	0	0	0	0	0	0	0	0
1981	442	15023	225773	47838	157	1	0	0	0	0	0	0	0	0	0	0	0
1982	505	36063	35089	94315	2293	0	0	0	0	0	0	0	0	0	0	0	0
1983	24327	76672	94323	20914	12092	905	164	0	0	0	0	0	0	0	0	0	0
1984	3275	361946	48893	23714	1623	3317	0	0	0	0	0	0	0	0	0	0	0
1985	4924	146668	156400	3624	115	1	16	0	0	0	0	0	0	0	0	0	0
1986	13007	84333	75071	39219	23	1	0	0	0	0	0	0	0	0	0	0	0
1987	1996	159860	134988	9142	2795	2	0	0	0	0	0	0	0	0	0	0	0
1988	7399	27412	244105	10535	427	10	0	0	24	0	0	0	0	0	0	0	24
1989	10673	43756	23611	67102	1048	23	35	0	2	0	2	0	0	0	0	0	4
1990	16290	69073	30530	1772	4932	28	25	0	0	0	0	0	0	0	0	0	0
1991	11794	143967	40697	1163	17	107	0	0	0	0	0	0	0	0	0	0	0
1992	36231	82605	115933	4063	97	0	6	0	0	0	0	0	0	0	0	0	0
1993	12346	191714	163172	17474	170	1	0	3	0	0	0	0	0	0	0	0	0
1994	19197	75840	254112	20271	2069	30	0	0	0	0	0	0	0	0	0	0	0
1995	2118	231490	84163	67644	2539	199	0	0	0	0	0	0	0	0	0	0	0
1996	22563	35010	413599	28996	10344	36	0	0	0	0	0	0	0	0	0	0	0
1997	15260	114893	69948	106789	1700	425	0	0	0	0	0	0	0	0	0	0	0
1998	2936	77065	162251	15801	20732	88	11	0	0	0	0	0	0	0	0	0	0
1999	20814	57336	83205	46764	1905	2561	49	0	0	0	0	0	0	0	0	0	0
2000	8472	320463	55818	24661	5703	321	201	0	0	0	0	0	0	0	0	0	0
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0
2004	3758	24613	21221	3967	14548	19811	5	4	0	0	0	0	0	0	0	0	0
2005	8779	16730	18722	6181	1258	4826	4496	1	1	0	0	0	0	0	0	0	1
2006	3229	118636	19862	8636	2634	823	1596	2520	6	1	1	0	0	0	0	0	8
2007	2045	19393	142509	5585	826	97	38	103	71	0	0	0	0	0	0	0	71

2008	3768	14623	25111	24195	243	46	134	2	30	4	0	0	0	0	0	0	34
2009	10468	10521	10601	11050	16522	79	50	46	0	1	4	0	0	0	0	0	5
2010	2930	102881	11872	5201	1125	2415	25	0	14	0	0	1	0	0	0	0	15
2011	3002	5858	49830	1817	806	105	224	0	0	0	1	1	0	0	0	0	2
2012	1319	3128	1973	14017	503	11	7	15	0	0	0	0	0	0	0	0	0
2013	1285	11014	1898	494	2695	26	11	12	24	0	1	0	0	0	0	0	25
2014	3537	7272	7187	980	161	4185	2	14	7	1	0	0	0	0	0	0	8
2015	3820	26920	5225	1545	94	31	989	0	0	0	2	0	0	0	0	0	2
2016	1843	9910	24898	207	17	2	9	10	0	0	0	0	0	0	0	0	0

Table 8.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20: Numbers-at-age data (thousands) for BMS landings. Ages 0–7 and 8+ are used in the assessment.

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**8+**
2016	0	189	725	2	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20: Numbers-at-age data (thousands) for IBC. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	644461	254237	7686	183288	2365	592	118	6	0	0	0	0	0	0	0	0	0
1966	1659093	548835	6546	1007	15861	755	25	2	0	0	0	0	0	0	0	0	0
1967	298999	392510	5539	155	24	2264	12	0	0	0	0	0	0	0	0	0	0
1968	11066	462938	81153	2029	46	19	738	1	0	0	0	0	0	0	0	0	0
1969	70826	15178	1703617	98650	632	380	126	252	0	0	0	0	0	0	0	0	0
1970	872884	170914	88509	485275	3967	153	61	2	0	0	0	0	0	0	0	0	0
1971	323088	570391	9972	3390	6381	299	6	0	0	0	0	0	0	0	0	0	0
1972	236664	238566	57010	1023	146	439	0	0	0	0	0	0	0	0	0	0	0
1973	41332	117470	12402	11	11	196	0	0	0	0	0	0	0	0	0	0	0
1974	576654	275266	32267	46862	4600	82	112	224	0	0	0	0	0	0	0	0	0
1975	44317	594854	84620	4761	5203	141	5	0	5	0	0	0	0	0	0	0	5
1976	164982	66973	183064	29188	46	2946	17	0	0	0	0	0	0	0	0	0	0
1977	103142	147019	29352	67628	2355	238	240	0	0	0	0	0	0	0	0	0	0
1978	280592	125698	11330	809	1480	64	6	5	0	0	0	0	0	0	0	0	0
1979	839615	125834	17671	1507	84	379	16	0	0	0	0	0	0	0	0	0	0
1980	374315	281436	21820	8258	1291	54	86	7	0	1	0	0	0	0	0	0	1
1981	644910	99247	30358	4613	440	6	2	0	0	0	0	0	0	0	0	0	0
1982	275003	174147	14740	13540	1810	464	0	0	0	0	0	0	0	0	0	0	0
1983	488707	63818	14331	5134	2242	3	0	0	0	0	0	0	0	0	0	0	0
1984	92587	98257	10644	4702	368	535	0	0	0	0	0	0	0	0	0	0	0
1985	122079	11672	17826	1739	547	223	17	0	0	0	0	0	0	0	0	0	0
1986	32696	40023	1831	802	103	7	0	0	0	0	0	0	0	0	0	0	0
1987	8253	82226	3797	295	138	0	0	0	0	0	0	0	0	0	0	0	0
1988	9280	3309	12819	2462	620	202	0	0	0	0	0	0	0	0	0	0	0
1989	8914	2541	1751	2789	460	37	86	10	0	0	0	0	0	0	0	0	0
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0
1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198033	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0
2004	0	590	265	84	258	753	8	4	0	0	0	0	0	0	0	0	0
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	0	1
2007	1	27	218	6	1	0	0	0	0	0	0	0	0	0	0	0	0

2008	12	82	280	180	52	18	4	1	0	0	0	0	0	0	0	0	0
2009	15	36	97	48	19	6	2	0	0	0	0	0	0	0	0	0	0
2010	0	4169	355	36	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	19	14	11	7	12	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	1	3	5	82	3	2	1	5	0	0	0	0	0	0	0	5
2014	0	0	20	6	12	67	2	2	1	3	0	0	0	0	0	0	3
2015	0	6	9	1	3	12	1	0	0	0	0	0	0	0	0	0	0
2016	0	0	38	9	6	1	1	11	0	0	0	0	0	0	0	0	1

Table 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weight at age data (kg) for total catch. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.010	0.070	0.227	0.370	0.655	0.846	1.170	1.190	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.088	0.247	0.394	0.536	0.962	1.254	1.512	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.014	0.116	0.278	0.478	0.591	0.641	1.072	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.129	0.254	0.516	0.743	0.827	0.829	1.483	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.012	0.064	0.217	0.410	0.817	0.905	1.029	1.074	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.013	0.075	0.222	0.353	0.738	0.925	1.195	1.246	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000
1971	0.012	0.109	0.246	0.359	0.509	0.888	1.269	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.025	0.117	0.242	0.383	0.503	0.585	0.987	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.043	0.118	0.239	0.369	0.578	0.611	0.648	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.025	0.129	0.226	0.339	0.536	0.867	0.828	0.863	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.023	0.105	0.240	0.353	0.442	0.678	1.190	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.014	0.129	0.225	0.394	0.505	0.578	0.916	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.020	0.111	0.238	0.339	0.586	0.612	0.787	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000
1978	0.011	0.104	0.254	0.396	0.424	0.707	0.784	0.921	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.009	0.093	0.287	0.417	0.611	0.669	0.931	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.012	0.081	0.276	0.464	0.693	0.985	0.908	1.264	1.511	1.501	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.009	0.060	0.264	0.445	0.726	1.055	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.010	0.074	0.286	0.423	0.759	1.109	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.011	0.132	0.303	0.431	0.612	0.904	1.211	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.010	0.142	0.303	0.461	0.645	0.736	1.077	1.205	1.821	2.030	1.732	1.950	2.422	2.822	4.995	0.000
1985	0.010	0.148	0.296	0.466	0.649	0.835	0.934	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.023	0.123	0.261	0.406	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.010	0.125	0.264	0.405	0.594	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.042	0.163	0.232	0.411	0.581	0.731	1.203	1.363	1.281	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.036	0.200	0.282	0.367	0.590	0.770	0.935	1.259	1.586	1.507	1.034	1.534	2.431	2.559	2.307	0.980
1990	0.040	0.187	0.313	0.422	0.506	0.795	0.995	1.179	1.495	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.030	0.175	0.308	0.454	0.574	0.644	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.019	0.102	0.306	0.466	0.717	0.923	0.903	1.382	1.514	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.010	0.110	0.282	0.454	0.660	0.877	1.053	1.062	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.018	0.121	0.247	0.435	0.599	0.846	1.240	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.012	0.107	0.290	0.369	0.581	0.774	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.022	0.126	0.241	0.382	0.484	0.746	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.029	0.138	0.280	0.360	0.585	0.634	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.027	0.153	0.255	0.396	0.444	0.665	0.777	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.025	0.166	0.250	0.356	0.477	0.510	0.735	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.052	0.121	0.256	0.355	0.480	0.605	0.656	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.029	0.111	0.219	0.321	0.466	0.658	0.735	0.945	1.690	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.017	0.109	0.255	0.311	0.527	0.703	0.829	0.818	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.024	0.082	0.221	0.327	0.400	0.681	0.758	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.039	0.139	0.238	0.378	0.395	0.440	0.686	0.926	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.054	0.160	0.271	0.364	0.495	0.479	0.522	0.925	1.054	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.042	0.126	0.283	0.352	0.442	0.507	0.538	0.550	1.048	1.395	2.031	2.525	1.834	3.532	5.274	2.580
2007	0.042	0.159	0.227	0.407	0.478	0.538	0.657	0.700	0.745	0.902	2.272	0.971	1.712	2.348	4.244	0.000

2008	0.030	0.170	0.256	0.366	0.593	0.662	0.714	0.928	0.924	0.878	1.689	1.970	0.988	0.224	3.792	3.024
2009	0.048	0.175	0.305	0.323	0.388	0.677	0.799	0.839	1.308	1.318	1.025	1.045	1.150	3.091	2.115	0.000
2010	0.016	0.078	0.288	0.411	0.454	0.466	0.710	0.899	1.269	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.017	0.140	0.260	0.399	0.434	0.466	0.534	0.661	0.864	0.558	1.484	1.787	1.593	0.000	0.000	0.000
2012	0.035	0.160	0.439	0.408	0.576	0.706	0.711	0.654	1.278	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.034	0.172	0.425	0.599	0.487	0.727	0.854	0.796	0.758	1.085	1.842	2.191	2.607	1.810	2.512	0.000
2014	0.042	0.139	0.433	0.589	0.656	0.537	0.780	0.831	0.923	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.031	0.145	0.417	0.561	0.752	0.698	0.631	0.685	0.970	0.725	0.715	0.719	1.448	2.954	0.000	0.000
2016	0.048	0.154	0.362	0.642	0.776	0.886	0.989	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.836

Table 8.2.12. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weight at age data (kg) for landings. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.000	0.308	0.348	0.413	0.680	0.904	1.211	1.197	1.479	1.714	2.175	0.000	0.000	0.000	0.000	0.000
1966	0.000	0.300	0.382	0.445	0.554	1.001	1.275	1.515	1.827	1.723	2.955	2.035	0.000	0.000	0.000	0.000
1967	0.000	0.260	0.399	0.530	0.610	0.646	1.077	1.511	1.898	2.084	2.342	0.000	0.000	0.000	0.000	0.000
1968	0.000	0.256	0.360	0.595	0.769	0.832	0.835	1.484	2.071	2.622	2.065	0.000	0.000	0.000	0.000	0.000
1969	0.000	0.178	0.302	0.508	0.878	0.989	1.058	1.081	1.808	2.772	3.259	0.000	0.000	0.000	0.000	0.000
1970	0.000	0.249	0.309	0.402	0.787	0.997	1.235	1.250	1.427	2.438	3.489	3.864	0.000	0.000	0.000	0.000
1971	0.000	0.256	0.332	0.393	0.525	0.905	1.280	1.525	1.338	1.284	1.961	4.270	3.513	0.000	0.000	0.000
1972	0.000	0.243	0.325	0.415	0.518	0.587	0.989	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000
1973	0.000	0.228	0.310	0.400	0.596	0.621	0.649	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000
1974	0.000	0.268	0.314	0.381	0.567	0.882	0.866	0.867	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000
1975	0.000	0.254	0.336	0.400	0.476	0.683	1.193	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000
1976	0.000	0.243	0.331	0.452	0.509	0.601	0.917	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000
1977	0.000	0.272	0.344	0.381	0.595	0.625	0.800	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000
1978	0.000	0.257	0.333	0.427	0.456	0.717	0.812	0.922	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000
1979	0.000	0.262	0.348	0.447	0.620	0.675	0.932	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000
1980	0.000	0.274	0.347	0.501	0.706	0.992	0.907	1.261	1.511	1.499	1.676	3.104	1.050	2.134	2.921	0.000
1981	0.000	0.334	0.364	0.503	0.734	1.056	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000
1982	0.000	0.299	0.349	0.478	0.788	1.153	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000
1983	0.000	0.320	0.375	0.464	0.624	0.914	1.242	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000
1984	0.000	0.280	0.350	0.493	0.666	0.764	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000
1985	0.000	0.279	0.348	0.478	0.651	0.844	0.935	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139
1986	0.000	0.277	0.348	0.428	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894
1987	0.000	0.265	0.335	0.440	0.603	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638
1988	0.000	0.236	0.322	0.437	0.594	0.732	1.203	1.363	1.370	0.974	1.633	2.163	2.547	3.139	3.435	2.863
1989	0.000	0.319	0.356	0.413	0.602	0.769	0.934	1.256	1.579	1.507	1.025	1.534	2.431	2.559	2.307	0.980
1990	0.000	0.260	0.372	0.439	0.525	0.796	1.015	1.196	1.504	1.898	2.519	2.259	2.188	0.562	1.852	4.731
1991	0.000	0.269	0.363	0.462	0.576	0.645	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888
1992	0.000	0.287	0.367	0.486	0.723	0.924	0.904	1.382	1.515	1.813	2.014	2.064	2.441	1.781	0.000	0.000
1993	0.000	0.293	0.372	0.484	0.666	0.878	1.053	1.067	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000
1994	0.000	0.269	0.378	0.473	0.617	0.851	1.241	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000
1995	0.000	0.316	0.400	0.424	0.600	0.782	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000
1996	0.000	0.326	0.364	0.471	0.519	0.747	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000
1997	0.000	0.344	0.410	0.418	0.615	0.641	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782
1998	0.000	0.271	0.370	0.441	0.470	0.670	0.778	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509
1999	0.000	0.297	0.349	0.422	0.490	0.523	0.746	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220
2000	0.000	0.334	0.368	0.421	0.515	0.617	0.663	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843
2001	0.000	0.379	0.352	0.448	0.483	0.675	0.735	0.946	1.695	1.148	1.725	2.923	1.286	2.534	1.239	3.425
2002	0.000	0.427	0.446	0.397	0.569	0.713	0.829	0.901	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000
2003	0.000	0.283	0.377	0.464	0.441	0.684	0.759	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092
2004	0.000	0.366	0.383	0.474	0.454	0.468	0.688	0.932	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000
2005	0.000	0.399	0.399	0.428	0.548	0.516	0.536	0.926	1.056	1.373	1.847	2.750	2.545	2.309	3.431	0.000
2006	0.000	0.392	0.386	0.418	0.493	0.546	0.574	0.583	1.093	1.431	2.109	2.643	1.926	3.592	5.292	2.709
2007	0.000	0.379	0.385	0.466	0.497	0.542	0.662	0.705	0.748	0.902	2.272	0.971	1.712	2.348	4.244	0.000

2008	0.000	0.357	0.408	0.414	0.607	0.668	0.754	0.931	0.935	0.879	1.703	1.970	0.988	0.224	3.792	3.024
2009	0.000	0.443	0.434	0.410	0.416	0.691	0.830	0.882	1.309	1.321	1.029	1.045	1.150	3.091	2.115	0.000
2010	0.000	0.278	0.473	0.457	0.471	0.476	0.721	0.899	1.364	1.431	1.366	1.420	2.766	2.214	2.677	2.588
2011	0.016	0.266	0.358	0.411	0.442	0.468	0.535	0.661	0.864	0.559	1.456	1.698	1.593	0.000	0.000	0.000
2012	0.000	0.358	0.525	0.445	0.606	0.707	0.712	0.654	1.279	0.895	1.564	2.223	2.121	2.134	2.368	0.000
2013	0.000	0.437	0.564	0.625	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.603
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000
2016	0.356	0.383	0.445	0.649	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	2.835

Table 8.2.13. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weight at age data (kg) for discards. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.062	0.131	0.203	0.335	0.607	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.053	0.141	0.208	0.245	0.309	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.043	0.170	0.210	0.273	0.306	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.054	0.181	0.212	0.257	0.317	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.049	0.129	0.216	0.238	0.300	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.057	0.131	0.210	0.239	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.052	0.135	0.202	0.244	0.264	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.045	0.140	0.207	0.239	0.261	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.051	0.135	0.201	0.237	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.046	0.146	0.201	0.234	0.259	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.041	0.126	0.201	0.257	0.275	0.348	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.053	0.172	0.198	0.239	0.291	0.337	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.062	0.191	0.198	0.220	0.306	0.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.042	0.175	0.199	0.222	0.225	0.265	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.037	0.128	0.221	0.245	0.259	0.314	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.051	0.147	0.232	0.276	0.325	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.074	0.160	0.199	0.296	0.621	0.727	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.055	0.194	0.247	0.265	0.289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.066	0.184	0.237	0.343	0.458	0.711	0.792	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.047	0.160	0.245	0.315	0.309	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.040	0.154	0.221	0.271	0.356	0.423	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.057	0.140	0.185	0.246	0.337	0.329	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.026	0.160	0.201	0.227	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.072	0.167	0.172	0.239	0.256	0.352	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.054	0.188	0.229	0.266	0.336	0.708	0.844	0.000	2.572	0.000	3.048	0.000	0.000	0.000	0.000	0.000
1990	0.047	0.189	0.229	0.248	0.264	0.290	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.059	0.179	0.238	0.341	0.464	0.480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.136	0.246	0.282	0.345	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.028	0.139	0.237	0.287	0.355	0.369	0.000	0.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.042	0.130	0.212	0.273	0.310	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.044	0.132	0.250	0.276	0.356	0.384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.047	0.133	0.218	0.279	0.297	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.060	0.159	0.250	0.286	0.322	0.374	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.075	0.159	0.232	0.293	0.317	0.391	0.428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.047	0.182	0.217	0.273	0.308	0.304	0.227	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.049	0.129	0.245	0.278	0.316	0.355	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.049	0.115	0.206	0.300	0.301	0.300	0.000	0.411	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.044	0.125	0.223	0.267	0.334	0.382	0.000	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.042	0.124	0.223	0.261	0.327	0.536	0.630	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.039	0.135	0.218	0.263	0.299	0.330	0.639	0.650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.054	0.150	0.232	0.273	0.318	0.301	0.342	0.499	0.493	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.042	0.121	0.231	0.265	0.279	0.274	0.217	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.042	0.146	0.195	0.291	0.314	0.358	0.375	0.356	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000

2008	0.030	0.166	0.217	0.262	0.365	0.456	0.317	0.454	0.427	0.596	0.321	0.000	0.000	0.000	0.000	0.000
2009	0.048	0.162	0.250	0.248	0.282	0.394	0.315	0.357	0.366	0.409	0.452	0.000	0.000	0.000	0.000	0.000
2010	0.016	0.076	0.209	0.303	0.307	0.315	0.350	0.523	0.284	0.000	0.000	1.445	0.000	0.000	0.000	0.000
2011	0.017	0.135	0.227	0.297	0.310	0.352	0.351	0.000	0.000	0.000	2.027	2.215	0.000	0.000	0.000	0.000
2012	0.035	0.143	0.295	0.271	0.286	0.406	0.353	0.392	0.633	0.488	0.316	0.000	0.000	0.000	0.000	0.000
2013	0.034	0.148	0.243	0.362	0.345	0.498	1.355	0.533	0.842	0.000	2.113	0.000	0.000	0.000	0.000	0.000
2014	0.042	0.133	0.298	0.336	0.394	0.340	0.572	0.617	0.475	0.885	0.000	0.000	0.000	0.000	0.000	0.000
2015	0.031	0.141	0.261	0.347	0.377	0.411	0.407	0.634	0.634	0.000	1.082	0.000	0.000	0.000	0.000	0.000
2016	0.048	0.149	0.245	0.357	0.361	0.876	0.457	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8.2.14. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weight at age data (kg) for BMS landings. Ages 0–7 and 8+ are used in the assessment.

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2016	0.068	0.239	0.213	0.386	0.000	0.000	0.481	0.000	0.991	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8.2.15. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weight at age data (kg) for IBC. Ages 0–7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.023	0.067	0.136	0.255	0.288	0.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.035	0.068	0.141	0.246	0.327	0.396	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.022	0.058	0.150	0.260	0.359	0.579	0.277	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.020	0.039	0.173	0.275	0.267	0.413	0.585	0.000	0.585	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.012	0.046	0.181	0.304	0.473	0.360	0.725	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.013	0.042	0.184	0.307	0.490	0.352	0.442	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.011	0.040	0.174	0.286	0.372	0.473	0.411	0.456	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1979	0.009	0.039	0.177	0.285	0.384	0.461	0.735	1.234	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1980	0.012	0.039	0.176	0.268	0.623	0.722	1.102	1.591	0.000	1.796	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.009	0.040	0.176	0.371	0.467	0.858	1.200	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1982	0.010	0.040	0.206	0.379	0.636	0.751	1.225	1.233	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.008	0.047	0.173	0.428	0.584	1.006	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.009	0.045	0.211	0.414	0.626	0.751	1.225	1.234	1.315	1.319	1.400	1.400	0.000	0.000	0.000	0.000
1985	0.009	0.043	0.186	0.371	0.550	0.563	0.565	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1986	0.010	0.040	0.186	0.375	0.626	1.259	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1987	0.006	0.038	0.258	0.442	0.908	1.171	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.018	0.077	0.196	0.274	0.455	0.549	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000
1989	0.015	0.165	0.251	0.347	0.670	0.923	1.065	1.492	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000
1990	0.005	0.104	0.229	0.506	0.609	0.842	0.829	0.796	0.956	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.027	0.058	0.206	0.357	0.472	0.477	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.015	0.059	0.217	0.422	0.552	0.615	0.548	1.234	0.621	0.820	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.008	0.053	0.206	0.399	0.521	0.578	1.225	0.582	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.011	0.055	0.155	0.435	0.595	0.698	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.012	0.045	0.193	0.285	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.018	0.077	0.136	0.162	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.007	0.076	0.149	0.309	0.419	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.020	0.075	0.166	0.291	0.351	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.018	0.064	0.177	0.304	0.416	0.309	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.058	0.070	0.113	0.176	0.370	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.014	0.086	0.133	0.110	0.353	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.016	0.064	0.178	0.283	0.374	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.031	0.056	0.231	0.326	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.116	0.183	0.255	0.276	0.446	0.539	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.107	0.187	0.239	0.268	0.287	0.598	0.619	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.127	0.232	0.273	0.273	0.280	0.283	0.286	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.035	0.141	0.192	0.290	0.315	0.370	0.427	0.342	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000

2008	0.042	0.146	0.291	0.388	0.454	0.526	0.414	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.047	0.180	0.252	0.247	0.279	0.410	0.417	0.413	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.080	0.244	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000
2012	0.451	0.762	1.045	1.498	1.854	2.098	2.188	2.317	2.541	2.173	2.324	2.121	2.452	2.368	0.000	0.000
2013	0.000	0.437	0.564	0.626	0.492	0.729	0.850	0.800	0.757	1.085	1.795	2.191	2.607	1.810	2.512	0.000
2014	0.000	0.311	0.510	0.654	0.662	0.557	0.781	0.834	0.932	0.794	1.605	2.788	1.323	2.682	0.000	1.830
2015	0.000	0.321	0.494	0.582	0.773	0.700	0.642	0.685	0.970	0.725	0.714	0.719	1.448	2.954	0.000	0.000
2016	0.356	0.383	0.445	0.49	0.777	0.886	0.998	0.738	0.819	1.077	2.632	1.123	1.285	1.978	3.312	3.766

Table 8.2.16. Haddock in Subarea 4, Division 6.a and Subdivision 20: Estimates of natural mortality from the most recent key run of SMS (ICES-WGSAM 2014).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1965	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1966	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1967	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1968	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1969	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1970	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1971	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1972	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1973	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1974	1.466	1.508	0.843	0.529	0.466	0.321	0.268	0.243	0.219	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1975	1.511	1.528	0.820	0.511	0.441	0.314	0.264	0.238	0.217	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1976	1.551	1.547	0.798	0.494	0.417	0.306	0.261	0.233	0.215	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1977	1.583	1.565	0.775	0.477	0.393	0.297	0.257	0.230	0.212	0.206	0.200	0.233	0.233	0.233	0.233	0.233
1978	1.605	1.578	0.753	0.462	0.372	0.287	0.252	0.226	0.210	0.206	0.200	0.232	0.232	0.232	0.232	0.232
1979	1.618	1.583	0.731	0.447	0.351	0.277	0.246	0.222	0.208	0.205	0.200	0.231	0.231	0.231	0.231	0.231
1980	1.624	1.579	0.708	0.433	0.333	0.269	0.240	0.219	0.207	0.205	0.200	0.230	0.230	0.230	0.230	0.230
1981	1.622	1.566	0.685	0.420	0.318	0.261	0.235	0.217	0.205	0.205	0.200	0.228	0.228	0.228	0.228	0.228
1982	1.616	1.539	0.662	0.409	0.306	0.256	0.230	0.215	0.204	0.204	0.200	0.226	0.226	0.226	0.226	0.226
1983	1.609	1.500	0.637	0.398	0.297	0.253	0.226	0.214	0.203	0.204	0.200	0.224	0.224	0.224	0.224	0.224
1984	1.603	1.452	0.612	0.387	0.291	0.251	0.224	0.213	0.202	0.204	0.200	0.222	0.222	0.222	0.222	0.222
1985	1.597	1.404	0.589	0.376	0.287	0.249	0.222	0.212	0.202	0.203	0.200	0.219	0.219	0.219	0.219	0.219
1986	1.589	1.358	0.567	0.366	0.284	0.248	0.221	0.211	0.201	0.203	0.200	0.217	0.217	0.217	0.217	0.217
1987	1.577	1.318	0.545	0.357	0.282	0.247	0.220	0.210	0.201	0.202	0.200	0.215	0.215	0.215	0.215	0.215
1988	1.555	1.285	0.525	0.349	0.281	0.246	0.220	0.209	0.201	0.202	0.200	0.213	0.213	0.213	0.213	0.213
1989	1.525	1.257	0.507	0.341	0.281	0.246	0.220	0.209	0.201	0.201	0.200	0.211	0.211	0.211	0.211	0.211
1990	1.487	1.234	0.489	0.333	0.280	0.245	0.220	0.209	0.201	0.201	0.200	0.210	0.210	0.210	0.210	0.210
1991	1.444	1.215	0.472	0.325	0.280	0.244	0.220	0.209	0.201	0.201	0.200	0.208	0.208	0.208	0.208	0.208
1992	1.401	1.203	0.458	0.319	0.279	0.243	0.220	0.209	0.202	0.200	0.200	0.207	0.207	0.207	0.207	0.207
1993	1.364	1.196	0.446	0.313	0.278	0.241	0.220	0.209	0.202	0.200	0.200	0.207	0.207	0.207	0.207	0.207
1994	1.333	1.194	0.437	0.309	0.278	0.240	0.220	0.210	0.203	0.200	0.200	0.206	0.206	0.206	0.206	0.206
1995	1.311	1.197	0.430	0.306	0.277	0.240	0.220	0.210	0.203	0.200	0.200	0.205	0.205	0.205	0.205	0.205
1996	1.298	1.202	0.425	0.305	0.277	0.240	0.221	0.211	0.204	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1997	1.292	1.211	0.422	0.305	0.276	0.241	0.221	0.211	0.205	0.200	0.200	0.204	0.204	0.204	0.204	0.204
1998	1.292	1.222	0.421	0.305	0.275	0.241	0.222	0.211	0.205	0.200	0.200	0.203	0.203	0.203	0.203	0.203
1999	1.299	1.238	0.420	0.306	0.274	0.241	0.223	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2000	1.310	1.260	0.421	0.306	0.272	0.240	0.223	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2001	1.320	1.289	0.424	0.306	0.271	0.241	0.224	0.211	0.206	0.201	0.200	0.203	0.203	0.203	0.203	0.203
2002	1.322	1.320	0.430	0.306	0.271	0.241	0.225	0.212	0.205	0.201	0.200	0.204	0.204	0.204	0.204	0.204
2003	1.313	1.346	0.437	0.306	0.271	0.243	0.226	0.213	0.205	0.202	0.200	0.205	0.205	0.205	0.205	0.205
2004	1.291	1.362	0.446	0.305	0.271	0.246	0.228	0.214	0.205	0.202	0.200	0.206	0.206	0.206	0.206	0.206
2005	1.259	1.361	0.456	0.303	0.272	0.248	0.229	0.215	0.205	0.202	0.200	0.208	0.208	0.208	0.208	0.208
2006	1.222	1.346	0.466	0.303	0.274	0.252	0.231	0.216	0.205	0.203	0.201	0.209	0.209	0.209	0.209	0.209
2007	1.183	1.320	0.479	0.304	0.277	0.256	0.232	0.216	0.205	0.203	0.201	0.212	0.212	0.212	0.212	0.212

2008	1.147	1.288	0.492	0.308	0.283	0.263	0.233	0.216	0.204	0.203	0.201	0.214	0.214	0.214	0.214	0.214
2009	1.115	1.257	0.507	0.313	0.290	0.273	0.235	0.216	0.204	0.202	0.201	0.216	0.216	0.216	0.216	0.216
2010	1.089	1.231	0.523	0.321	0.300	0.286	0.238	0.216	0.203	0.202	0.201	0.219	0.219	0.219	0.219	0.219
2011	1.067	1.212	0.541	0.332	0.312	0.301	0.242	0.217	0.202	0.201	0.201	0.219	0.219	0.219	0.219	0.219
2012	1.046	1.199	0.561	0.344	0.326	0.319	0.247	0.218	0.201	0.201	0.201	0.219	0.219	0.219	0.219	0.219
2013	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219
2014	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219
2015	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219
2016	1.024	1.188	0.581	0.357	0.340	0.337	0.252	0.219	0.201	0.200	0.201	0.219	0.219	0.219	0.219	0.219

Table 8.2.17. Haddock in Subarea 4, Division 6.a and Subdivision 20: Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS–Q1					
1983	2017				
1	1	0.00	0.25		
1	5				
100	302.278	403.079	89.463	116.447	13.182
100	1072.285	221.275	127.77	20.41	20.9
100	230.968	833.257	107.598	32.317	3.575
100	573.023	266.912	303.546	17.888	6.49
100	912.559	328.062	45.201	58.262	4.345
100	101.691	677.641	97.149	12.684	13.965
100	219.06	97.372	273.008	16.604	2.114
100	217.448	139.114	32.997	50.367	3.163
100	680.231	134.076	25.032	4.26	8.476
100	1141.396	331.044	17.035	3.026	0.664
100	1242.121	519.521	152.384	8.848	1.076
100	227.919	491.051	97.656	23.308	1.566
100	1355.485	201.069	176.165	24.354	5.286
100	267.411	813.268	65.869	46.691	7.734
100	848.966	354.766	466.823	24.987	15.238
100	357.597	420.926	103.531	112.632	8.758
100	211.139	222.907	127.063	48.217	36.649
100	3734.2	107.125	48.605	24.504	15.594
100	893.46	2220.593	76.321	14.493	6.385
100	57.304	473.461	1309.38	9.177	6.886
100	89.981	39.261	241.523	532.045	5.355
100	71.745	79.256	36.962	176.352	324.91
100	70.189	51.885	38.458	14.057	54.576
100	1158.194	46.081	28.477	9.896	4.837
100	109.44	963.393	35.962	14.956	3.019
100	61.357	107.39	241.221	14.886	1.592
100	75.068	141.444	102.986	135.595	2.528
100	674.962	71.132	68.015	51.48	90.942
100	46.068	781.507	101.666	35.942	47.87
100	14.006	66.409	390.588	21.18	15.108
100	58.227	24.55	32.549	93.814	6.488
100	24.066	104.024	18.339	49.978	126.068
100	388.205	32.597	29.955	3.879	9.103
100	110.75	412.721	16.872	11.824	1.929
100	217.836	138.166	222.102	8.578	3.028

Table 8.2.17. (cont.) Haddock in Subarea 4, Division 6.a and Subdivision 20: Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS–Q3						
1991	2016					
1	1	0.50	0.75			
0	5					
100	718.479	233.550	22.921	2.842	0.507	1.561
100	2741.140	595.235	189.015	10.529	1.583	0.396
100	577.382	605.990	140.146	37.604	2.360	0.372
100	1781.191	195.331	262.643	32.423	8.383	0.381
100	520.855	1019.607	106.642	97.383	8.060	3.131
100	627.502	247.469	428.471	30.426	20.215	2.649
100	195.255	347.567	123.793	149.048	6.672	5.282
100	276.401	257.140	164.853	53.690	42.660	3.093
100	6904.537	176.457	94.108	47.947	13.268	9.904
100	1092.754	2504.185	44.300	19.502	10.287	4.264
100	34.751	360.427	1099.298	30.289	6.371	3.648
100	137.707	45.969	237.729	573.752	9.826	2.485
100	163.931	69.348	31.171	199.259	368.665	2.942
100	183.977	69.539	40.556	23.119	82.685	154.820
100	1412.973	67.605	45.540	16.254	9.845	37.095
100	191.608	547.284	27.543	11.709	3.612	3.352
100	111.475	149.743	385.791	10.354	5.350	1.126
100	126.428	86.627	89.934	174.968	5.206	2.253
100	909.334	77.703	79.994	38.131	73.972	1.643
100	30.294	557.390	59.017	34.214	25.186	53.330
100	30.640	77.035	344.508	27.159	12.209	9.196
100	68.068	31.515	40.248	132.237	7.344	4.397
100	86.249	58.345	25.170	18.291	82.779	2.515
100	747.522	48.207	58.510	5.216	9.093	51.625
100	104.274	463.428	22.807	15.993	1.662	2.307
100	351.819	94.564	220.165	8.057	3.669	0.400

Table 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20: TSA final assessment: Model settings. ω is a multiplier on the permitted variance of the estimated value: a higher setting for ω indicates greater down weighting of that value in the overall assessment.

Landings	Ages	0-8+
	Years	1972-2016
Discards	Ages	0-8+
	Years	1972, 1978-2016
Industrial bycatch	Ages	0-8+
	Years	1972, 1978-2016
BMS landings	Ages	0-8+
	Years	2016
Survey: NS IBTS Q1	Ages	1-5
	Years	1983-2016
Survey: NS IBTS Q3	Ages	0-5
	Years	1991-2016
Maturity		Knife-edge at age 3 (interim measure)
Natural mortality		Age- and time-varying from North Sea SMS key runs
Catch weights		Catch abundance-weighted average of North Sea and West of Scotland catch weights
Stock weights		Set equal to catch weights (interim measure)
Large year-classes ($\lambda = 5$)		1974, 1979, 1999
Age-dependent F variability		$H(a) = (2,2,1,1,1,1,1,1,1)$
F plateau		$a_m = 5$
Measurement-error multiplier for landings		$B_{landings}(a) = (*, 3.7, 1.3, 1, 1.1, 1.4, 1.6, 2.7, 2.8)$
Measurement-error multiplier for discards+bycatch+bms		$B_{discards}(a) = (2.0, 1.7, 1, 1.5, 1.8, 2.4, *, *, *)$
Downweighted landings outliers		1996, age 7 (ω = 3)
Downweighted discards+bycatch+bms outliers		1982, age 5; 2002, age 0; 2012, age 2 (ω = 3 for all)
Downweighted survey outliers		NS IBST Q1: 2011, age 5 (ω = 3)

Table 8.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. TSA final assessment: Parameter estimates.

	ESTIMATE	LOWER BOUND	UPPER BOUND	ESTIMATED	ON BOUND
F age 0	0.0344	0.005	0.1	TRUE	FALSE
F age 1	0.0816	0.05	0.15	TRUE	FALSE
F age 2	0.8593	0.6	1	TRUE	FALSE
F age 7	1.3088	1	1.4	TRUE	FALSE
sd F	0.17	0.01	0.2	TRUE	FALSE
sd U	0.0648	0.01	0.15	TRUE	FALSE
sd V	0.1597	0.01	0.2	TRUE	FALSE
sd Y	0.1485	0.01	0.25	TRUE	FALSE
cv landings	0.1491	0.1	0.3	TRUE	FALSE
cv discards+bycatch+bms	0.2855	0.2	0.4	TRUE	FALSE
log mean recruitment at start	7.2864	7	9	TRUE	FALSE
sd of random walk	0.0743	0	0.25	TRUE	FALSE
recruitment cv	0.5259	0.3	0.6	TRUE	FALSE
discards sd transitory	0.0074	0	0.35	TRUE	FALSE
discards sd persistent	0.335	0.25	0.5	TRUE	FALSE
NSQ1 selection age 1	0.2506	0.1	0.3	TRUE	FALSE
NSQ1 selection age 2	0.6563	0.4	0.8	TRUE	FALSE
NSQ1 selection age 3	0.7142	0.6	0.9	TRUE	FALSE
NSQ1 selection age 4	0.5843	0.4	0.8	TRUE	FALSE
NSQ1 selection age 5	0.4587	0.4	0.8	TRUE	FALSE
NSQ1 sigma	0.3525	0.1	0.4	TRUE	FALSE
NSQ1 eta	0.2055	0.1	0.8	TRUE	FALSE
NSQ1 omega	0.0832	0	0.3	TRUE	FALSE
NSQ1 beta	0	0	0.1	FALSE	TRUE
NSQ3 selection age 0	0.2272	0.1	0.4	TRUE	FALSE
NSQ3 selection age 1	0.3703	0.2	0.6	TRUE	FALSE
NSQ3 selection age 2	0.5674	0.2	0.8	TRUE	FALSE
NSQ3 selection age 3	0.4923	0.2	0.8	TRUE	FALSE
NSQ3 selection age 4	0.3893	0.2	0.8	TRUE	FALSE
NSQ3 selection age 5	0.3526	0.2	0.8	TRUE	FALSE
NSQ3 sigma	0.242	0.1	0.4	TRUE	FALSE
NSQ3 eta	0.0832	0	0.3	TRUE	FALSE
NSQ3 omega	0.0927	0	0.3	TRUE	FALSE
NSQ3 beta	0	0	0.1	FALSE	TRUE

Table 8.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20: Estimates of fishing mortality at age from the final TSA assessment. Estimates refer to the full year (January–December) except for age 0, for which the mortality rate given refers to the second half-year only (July–December). The 2017 estimates (*) are TSA forecasts.

	0	1	2	3	4	5	6	7	8	MEAN F(2–4)
1972	0.033	0.078	0.606	1.007	0.958	0.92	1.012	1.054	0.991	0.857
1973	0.029	0.081	0.606	0.875	0.848	0.895	0.997	1.038	1.106	0.776
1974	0.026	0.082	0.619	0.714	0.833	0.752	0.888	0.959	0.961	0.722
1975	0.03	0.082	0.7	0.883	0.964	0.926	1.093	1.081	1.069	0.849
1976	0.027	0.083	0.554	0.971	0.853	1.041	0.968	0.996	1	0.793
1977	0.026	0.092	0.607	0.743	1.06	0.965	0.968	0.938	0.965	0.803
1978	0.023	0.113	0.652	0.943	1.08	1.075	1.069	1.074	1.113	0.892
1979	0.026	0.095	0.698	1.054	0.986	1.015	1.033	1.041	1.047	0.913
1980	0.03	0.077	0.488	1.051	1.106	0.797	0.923	0.961	0.96	0.882
1981	0.025	0.068	0.32	0.782	0.896	0.745	0.469	0.729	0.695	0.666
1982	0.018	0.069	0.377	0.579	0.697	0.592	0.608	0.706	0.624	0.551
1983	0.017	0.078	0.444	0.837	0.849	0.897	0.752	0.744	0.76	0.710
1984	0.02	0.109	0.481	0.936	1.075	0.815	0.833	0.799	0.799	0.831
1985	0.019	0.109	0.438	0.909	1.01	0.867	0.826	0.769	0.775	0.786
1986	0.015	0.113	0.631	0.92	1.104	0.819	0.677	0.678	0.726	0.885
1987	0.021	0.09	0.722	0.998	0.943	0.877	0.89	0.819	0.792	0.888
1988	0.02	0.108	0.575	1.154	1.088	0.942	0.858	0.781	0.823	0.939
1989	0.018	0.11	0.622	0.938	1.102	0.872	0.848	0.782	0.787	0.887
1990	0.014	0.107	0.707	0.964	0.981	0.86	0.729	0.683	0.702	0.884
1991	0.016	0.152	0.682	1.013	0.922	0.784	0.779	0.735	0.698	0.872
1992	0.018	0.112	0.628	0.993	0.998	0.66	0.86	0.7	0.725	0.873
1993	0.02	0.148	0.782	0.997	1.012	0.973	0.835	0.821	0.841	0.930
1994	0.014	0.115	0.713	1.031	0.982	1.034	0.981	0.915	0.832	0.909
1995	0.018	0.093	0.584	0.922	0.95	0.827	0.925	0.718	0.713	0.819
1996	0.017	0.091	0.518	0.882	1.018	0.985	0.973	0.715	0.711	0.806
1997	0.013	0.108	0.483	0.643	0.758	0.909	0.797	0.619	0.606	0.628
1998	0.013	0.134	0.62	0.703	0.886	0.836	0.813	0.632	0.618	0.736
1999	0.011	0.118	0.674	0.934	0.876	1.109	0.901	0.7	0.67	0.828
2000	0.011	0.094	0.736	0.984	0.987	0.85	0.891	0.641	0.616	0.902
2001	0.01	0.077	0.417	0.708	0.733	0.693	0.624	0.458	0.445	0.619
2002	0.006	0.098	0.282	0.386	0.511	0.497	0.448	0.315	0.313	0.393
2003	0.005	0.045	0.221	0.238	0.287	0.357	0.3	0.204	0.2	0.249
2004	0.004	0.051	0.219	0.256	0.269	0.331	0.265	0.177	0.173	0.248
2005	0.003	0.056	0.279	0.36	0.288	0.346	0.323	0.187	0.183	0.309
2006	0.005	0.052	0.432	0.542	0.559	0.546	0.411	0.291	0.246	0.511
2007	0.005	0.055	0.237	0.53	0.527	0.515	0.401	0.244	0.24	0.431
2008	0.004	0.036	0.183	0.233	0.345	0.325	0.273	0.158	0.158	0.254
2009	0.002	0.031	0.129	0.198	0.27	0.257	0.193	0.123	0.116	0.199
2010	0.003	0.031	0.161	0.24	0.232	0.275	0.189	0.119	0.114	0.211
2011	0.003	0.035	0.126	0.392	0.392	0.383	0.28	0.156	0.137	0.303
2012	0.002	0.032	0.121	0.164	0.244	0.233	0.163	0.105	0.093	0.176

2013	0.002	0.037	0.159	0.162	0.239	0.225	0.155	0.095	0.096	0.187
2014	0.002	0.034	0.262	0.326	0.326	0.366	0.187	0.129	0.122	0.305
2015	0.004	0.038	0.364	0.47	0.361	0.495	0.322	0.18	0.159	0.398
2016	0.003	0.033	0.182	0.357	0.312	0.316	0.187	0.145	0.118	0.284
2017*	0.003	0.04	0.227	0.346	0.337	0.368	0.229	0.141	0.141	0.303

Table 8.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20: Estimates of stock numbers at age (thousands) from the final TSA assessment. Estimates refer to January 1st, except for age 0 for estimates refer to July 1st. *TSA estimated survivors.

	0	1	2	3	4	5	6	7	8+
1972	9333070	13682140	2118270	79320	45080	396620	7160	440	1170
1973	35180830	2088020	2816900	488350	17530	11270	118100	2060	460
1974	69073220	7872660	427820	668050	121990	4940	3470	34600	720
1975	4518940	15597580	1597970	108810	192330	33770	1680	1110	10680
1976	7151100	975180	3121250	353370	28420	49060	10180	460	3430
1977	15461110	1621570	223910	827990	84910	8440	13470	3190	1250
1978	31678300	3134600	301870	64570	259070	21390	2660	4510	1530
1979	64187860	6213280	577890	78080	16470	63670	5430	750	1760
1980	11660360	12480540	1160650	141370	18100	4720	18760	1670	790
1981	19597460	2241090	2388790	343290	33760	4700	1650	6200	820
1982	11798300	3812450	440430	796050	100930	10780	1780	640	2580
1983	38263370	2319350	761660	162590	296910	37730	4730	790	1400
1984	7488600	7500850	479270	262010	48530	94050	12240	1820	840
1985	12354370	1652740	1566600	160950	71470	12740	30510	4310	910
1986	23431090	2529480	364730	554170	45550	20110	4270	10790	1940
1987	462920	4499130	580780	111440	151540	11640	6800	1640	4760
1988	1429200	384480	1099840	163320	29570	43860	3850	2310	2340
1989	2610810	610150	108490	366360	36190	7720	13470	1340	1730
1990	11064560	839110	153770	35340	104070	9310	2610	4780	1190
1991	12227450	2520070	218610	42530	9770	30540	3220	1040	2510
1992	20442380	2835300	638130	69650	11520	2750	9700	1170	1350
1993	5175020	4949140	756770	216020	17920	3170	1060	3310	1020
1994	20115760	1298800	1277310	220310	58790	4930	960	370	1610
1995	5564070	5230110	350890	401320	58360	16650	1390	300	730
1996	7877680	1475910	1440080	127790	118270	17190	5780	460	430
1997	4659270	2117620	405760	560950	39270	32730	5120	1800	360
1998	3478210	1264220	565070	164600	217910	14050	10400	1890	970
1999	51745410	955810	324710	196790	60220	68720	4810	3700	1280
2000	10121230	13958180	246310	106170	54870	18970	17640	1580	2070
2001	956810	2702420	3601530	77770	28420	15140	6320	5750	1640
2002	1327970	371300	689980	1557060	27490	10290	5890	2720	3890
2003	1499660	421400	90070	339360	781020	12380	4910	3020	4000
2004	1470410	451700	104890	46780	196930	446270	6750	2900	4710
2005	14198200	454260	109860	53840	26620	114340	247520	4080	5210
2006	3009410	4019620	110260	52640	27670	15210	62800	139900	6260
2007	1972900	884410	993690	45110	22680	12080	6880	33000	87200
2008	1361510	622850	223690	485650	19660	10170	5630	3680	76520
2009	10391530	488930	165340	113990	281960	10520	5670	3420	55900
2010	933840	3400020	134980	87720	68520	161200	6210	3710	43270
2011	88550	362580	962380	68180	50140	40310	92200	4070	34250
2012	1242320	121540	104220	493820	32710	24810	20390	54910	27330
2013	632680	458870	35510	52700	296270	18450	14320	13570	60310

2014	5809050	284770	134800	16660	31370	165740	10530	9550	54810
2015	1625860	2081600	83960	58010	8150	16120	82360	6800	46560
2016	3013290	587140	611250	32780	25290	4030	7040	46630	37180
2017*	4235840	1079360	173290	285360	16130	13240	2110	4550	59580

Table 8.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20: Stock summary table. Both estimates (EST) and standard errors (SE) are given. *TSA model fits or projections. **Discards refers to discard + bycatch + BMS.

YEAR	CATCH	CATCH.EST	CATCH.SE	LANDINGS	LANDINGS.EST	LANDINGS.SE	DISCARDS**	DISCARDS.EST**	DISCARDS.SE**	MEANF.EST	MEANF.SE	SSB.EST	SSB.SE	TSB.EST	TSB.SE	RECRUIT.EST	RECRUIT.SE
1972	408043	385576	41446	234140	229714	25053	173903	155862	29014	0.857	0.064	294731	29692	2641488	263253	9333067	2177437
1973	344581	382486	52556	207383	217101	21210	137198	165386	41211	0.776	0.070	276668	18796	2709069	250494	35180835	4411478
1974	397158	249771	29419	167655	157956	14008	229503	91816	22687	0.722	0.071	329950	23208	3169040	316817	69073223	9925706
1975	494390	300583	41857	160380	160588	14072	334009	139996	35730	0.849	0.081	160999	10932	2286193	262653	4518937	1878297
1976	401969	343040	52838	184244	205758	22959	217725	137282	40536	0.793	0.080	196556	15985	1124752	130355	7151096	1764446
1977	240259	198488	21636	156534	161602	17882	83726	36886	9123	0.803	0.084	351894	29523	894402	72188	15461105	2146223
1978	146700	138561	13476	102940	102361	9942	43760	36199	7217	0.892	0.086	158997	13533	910132	58940	31678298	2430482
1979	149260	144072	16142	97884	86785	9186	51376	57287	10449	0.912	0.088	93694	10553	1415075	78182	64187861	5636739
1980	202640	189390	19381	111375	105946	10300	91265	83444	14265	0.882	0.081	103231	10389	1574419	94879	11660364	1279325
1981	226585	225006	21305	147920	151102	14956	78665	73904	12180	0.666	0.063	192964	12591	1134448	59279	19597462	2005667
1982	256302	209362	15499	195572	167366	13184	60730	41996	6864	0.551	0.046	432753	19951	958820	39978	11798299	1045043
1983	253185	226705	16783	188735	178540	12947	64451	48165	7674	0.710	0.053	294743	15227	1252577	51105	38263370	2658625
1984	247238	227365	22902	158181	149734	11081	89057	77631	17223	0.831	0.060	238229	14673	1523455	79861	7488605	1688894
1985	247430	226133	18467	183055	165522	13856	64375	60612	9898	0.786	0.056	168006	8389	999868	43452	12354367	1511384
1986	223854	206634	15102	185119	164385	12481	38735	42249	6833	0.885	0.060	289540	16306	1234775	63333	23431090	2184412
1987	195046	178310	14866	135000	124900	9474	60046	53410	9377	0.888	0.062	163286	8772	883633	45400	462922	1397058
1988	179911	167906	13957	126181	121862	10841	53729	46044	7357	0.939	0.067	126846	8534	504705	98121	1429202	2150455
1989	127679	117782	9895	92801	93078	8573	34878	24704	4376	0.887	0.067	178319	11202	424931	61238	2610815	1561696
1990	86743	77881	7501	61584	56804	5154	25159	21077	4075	0.884	0.067	85305	5816	732932	68303	11064560	1597369
1991	97205	92078	12850	55211	45326	4579	41993	46753	10444	0.872	0.067	52413	3967	927580	46824	12227448	939700
1992	134993	125650	11946	81572	71440	7186	53421	54209	8293	0.873	0.054	55976	2868	928850	41324	20442383	1484267
1993	180206	209629	21165	98697	109625	10506	81509	100005	16276	0.930	0.058	119000	7465	928567	46380	5175016	466755
1994	169472	230907	21875	95175	129226	13310	74297	101681	14815	0.909	0.061	139202	9750	973936	41960	20115763	1360953
1995	168893	175240	17262	89858	104330	10837	79035	70910	11602	0.819	0.059	197776	14176	925924	44304	5564074	448053
1996	204687	200301	18790	92632	98410	8909	112055	101892	14599	0.806	0.057	124839	7290	831172	36201	7877682	663295
1997	170051	164413	14852	95448	95089	8947	74603	69324	10393	0.628	0.050	252753	14929	793715	36718	4659272	462085
1998	161971	159600	13860	95513	92631	7759	66457	66969	9555	0.736	0.058	182511	9824	613940	27487	3478206	328428
1999	123421	128291	11214	75974	73628	6181	47446	54662	7686	0.828	0.064	141479	8912	1674956	99767	51745407	3784149
2000	126870	167853	30337	54476	55519	5147	72395	112334	27915	0.902	0.069	90949	6411	2369247	135421	10121234	695567
2001	173526	276347	38660	47549	99083	14620	125978	177264	31175	0.619	0.055	60830	4332	1177282	68619	956807	753661
2002	155145	191546	22883	65399	101256	12558	89745	90290	16544	0.393	0.039	518942	36497	757934	40935	1327967	393110
2003	74415	102434	11944	47266	79279	9947	27149	23155	4487	0.249	0.027	445025	27679	535478	29804	1499661	356094
2004	72511	79985	9832	51925	68568	8948	20586	11418	2025	0.248	0.027	306241	22032	451336	25266	1470407	223227
2005	64116	65708	7902	51542	56248	7243	12573	9460	1499	0.309	0.032	227102	19642	1096258	47893	14198200	754948
2006	66955	67422	8415	43333	46591	5755	23622	20832	4548	0.511	0.045	157195	16093	821265	35140	3009409	212278
2007	67430	76309	8212	34680	45937	5369	32751	30372	4715	0.431	0.040	128666	15996	577716	28739	1972905	357975
2008	47733	56495	5918	33037	41437	4485	14697	15058	2628	0.254	0.027	272277	19003	476272	23884	1361509	304903
2009	47943	44995	4563	35569	36720	3879	12374	8275	1294	0.199	0.021	225693	18171	860479	33978	10391533	521011
2010	45412	44295	4696	31937	35375	3689	13474	8920	1754	0.211	0.023	210432	17622	529449	26747	933840	734463
2011	49658	57362	5566	36572	40319	3741	13086	17042	2959	0.303	0.031	151515	11624	454000	21188	88555	548464
2012	43196	44881	4571	38164	39560	4022	5032	5321	1097	0.177	0.020	326543	18292	435223	21136	1242318	240332
2013	47066	41659	4394	43712	38471	4078	3354	3187	661	0.187	0.020	258617	13855	374147	17734	632681	226782
2014	46317	49021	4954	41165	44249	4550	5152	4771	905	0.304	0.031	181098	11488	523028	27367	5809046	536623
2015	41594	48463	4988	35306	39535	3797	6287	8928	2207	0.398	0.041	142921	10402	530165	32959	1625860	261098
2016	43053	49717	5601	35060	40258	4730	7994	9460	1965	0.284	0.035	122886	10814	579216	45885	3013286	681441
2017*		68842	17729		60152	15759		8690	2944	0.303	0.087	248592	21636	647033	114929	4235842	2583569

Table 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20: Short-term forecast input.

MFDP VERSION 1A						
Run: 04						
Time and date: 14:04 01/05/2017						
Fbar age range (Total) : 2–4						
Fbar age range Fleet 1 : 2–4						
Fbar age range Fleet 2 : 2–4						
2017						
Age	N	M	Mat	PF	PM	SWt
0	4235840	1.02	0	0	0	0.040
1	1079360	1.19	0	0	0	0.146
2	173290	0.58	0	0	0	0.404
3	285360	0.36	1	0	0	0.503
4	16130	0.34	1	0	0	0.834
5	13240	0.34	1	0	0	0.957
6	2110	0.25	1	0	0	1.100
7	4550	0.22	1	0	0	1.113
8	59580	0.2	1	0	0	1.019
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.000	0.356	0.003	0.040		
1	0.001	0.338	0.039	0.142		
2	0.143	0.483	0.084	0.268		
3	0.309	0.628	0.036	0.344		
4	0.328	0.823	0.009	0.471		
5	0.355	0.850	0.012	0.494		
6	0.224	1.110	0.005	0.841		
7	0.14	1.052	0.001	0.578		
8	0.141	0.921	0.000	0.674		
IBC						
Age	Sel	CWt				
0	0.000	0.356				
1	0.000	0.3383				
2	0.000	0.483				
3	0.000	0.6283				
4	0.000	0.7373				
5	0.000	0.7143				
6	0.000	0.807				
7	0.000	0.7523				
8	0.000	0.907				

Table 8.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20: Short-term forecast input.

2018						
Age	N	M	Mat	PF	PM	SWt
0	4235840.000	1.020	0	0.000	0	0.040
1	.	1.190	0	0.000	0	0.146
2	.	0.580	0	0.000	0	0.404
3	.	0.360	1	0.000	0	0.597
4	.	0.340	1	0.000	0	0.663
5	.	0.340	1	0.000	0	1.044
6	.	0.25	1	0	0	1.144
7	.	0.22	1	0	0	1.280
8	.	0.2	1	0	0	1.081
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0.000	0.356	0.003	0.040		
1	0.001	0.338	0.039	0.142		
2	0.143	0.483	0.084	0.268		
3	0.309	0.628	0.036	0.347		
4	0.328	0.737	0.009	0.446		
5	0.355	0.992	0.012	0.580		
6	0.224	0.959	0.005	0.580		
7	0.14	1.273	0.001	0.986		
8	0.141	0.978	0.000	0.691		
IBC						
Age	Sel	CWt				
0	0	0.356				
1	0	0.3383				
2	0	0.483				
3	0	0.6283				
4	0	0.7373				
5	0	0.7143				
6	0	0.807				
7	0	0.7523				
8	0	0.907				

Table 8.6.1 (cont). Haddock in Subarea 4, Division 6.a and Subdivision 20: Short-term forecast input.

2019				
Age	N	M	Mat	PF
0	4235840	1.020	0	0
1	.	1.190	0	0
2	.	0.580	0	0
3	.	0.360	1	0
4	.	0.340	1	0
5	.	0.34	1	0
6	.	0.25	1	0
7	.	0.22	1	0
8	.	0.2	1	0
Catch				
Age	Sel	CWt	DSel	DCWt
0	0.000	0.356	0.003	0.04
1	0.001	0.338	0.039	0.142
2	0.143	0.483	0.084	0.268
3	0.309	0.628	0.036	0.347
4	0.328	0.737	0.009	0.378
5	0.355	0.714	0.012	0.547
6	0.224	1.161	0.005	0.69
7	0.14	1.068	0.001	0.665
8	0.141	1.247	0.000	1.014
IBC				
Age	Sel	CWt		
0	0	0.356		
1	0	0.3383		
2	0	0.483		
3	0	0.6283		
4	0	0.7373		
5	0	0.7143		
6	0	0.807		
7	0	0.7523		
8	0	0.907		
Input units are thousands and kg - output in tonnes				

Table 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20: Short-term forecast output. A number of management options are highlighted.

Basis	Total catch (2018)	Wanted catch* (2018)	Unwanted catch* (2018)	IBC** (2018)	F_{total} (2018)	F_{wanted} (2018)	$F_{unwanted}$ (2018)	F_{IBC} (2018)	SSB (2019)	% SSB change ***	% TAC change ****
ICES advice basis											
MSY approach: F_{MSY}	51037	43555	7482	0.000	0.194	0.163	0.028	0.000	266941	16%	30%
Other options											
F = 0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	315692	37%	-100%
F_{pa}	70025	59630	10395	0.000	0.274	0.235	0.039	0.000	249102	8%	78%
F_{lim}	94171	79935	14236	0.000	0.384	0.330	0.054	0.000	226609	-1%	139%
SSB (2019) = B_{lim}	205519	167418	38101	0.000	1.264	1.084	0.179	0.000	94000	-43%	426%
SSB (2019) = B_{pa}	184980	153374	31606	0.000	0.975	0.837	0.138	0.000	132000	-36%	372%
SSB (2019) = MSY $B_{trigger}$	184980	153374	31606	0.000	0.975	0.837	0.138	0.000	132000	-36%	372%
F = F_{2017}	48332	41259	7074	0.000	0.183	0.157	0.026	0.000	269491	17%	23%

* "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rate estimates for 2014–2016. Unwanted catch includes discards and BMS landings.

** Industrial bycatch (IBC) is based on average proportion of the total catch for 2014–2016.

*** SSB 2019 relative to SSB 2018.

**** Total catch in 2018 relative to TAC in 2017 Subdivision 20 (2 069) Subarea 4 (33 643). Division 6a (3697) = 39 409 tons.

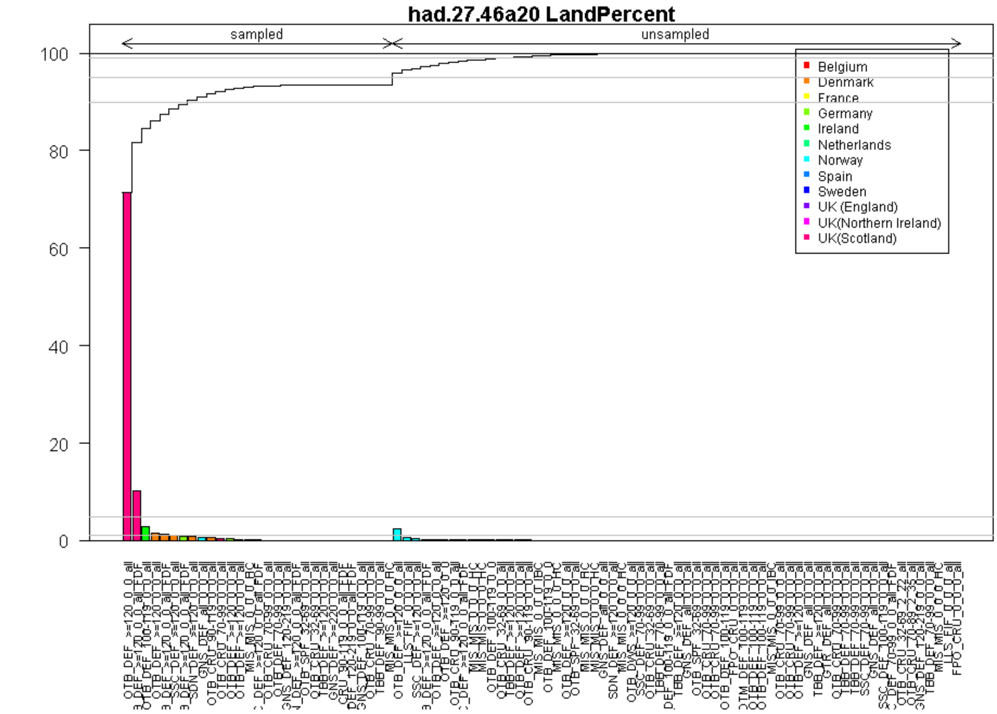


Figure 8.2.1. Haddock in Subarea 4, Division 6.a and Subdivision 20: Reported landings for each sampled and unsampled fleet in the full stock area, along with cumulative landings for fleets in descending order of yield.

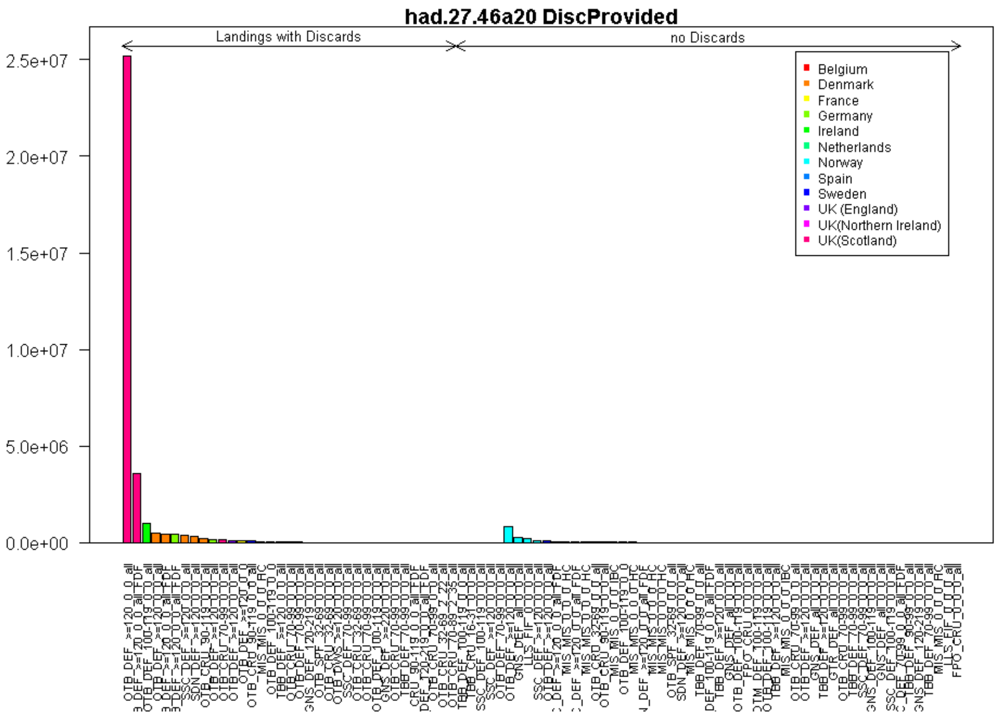


Figure 8.2.2. Haddock in Subarea 4, Division 6.a and Subdivision 20: Summary of landings for fleets with and without discard estimates.

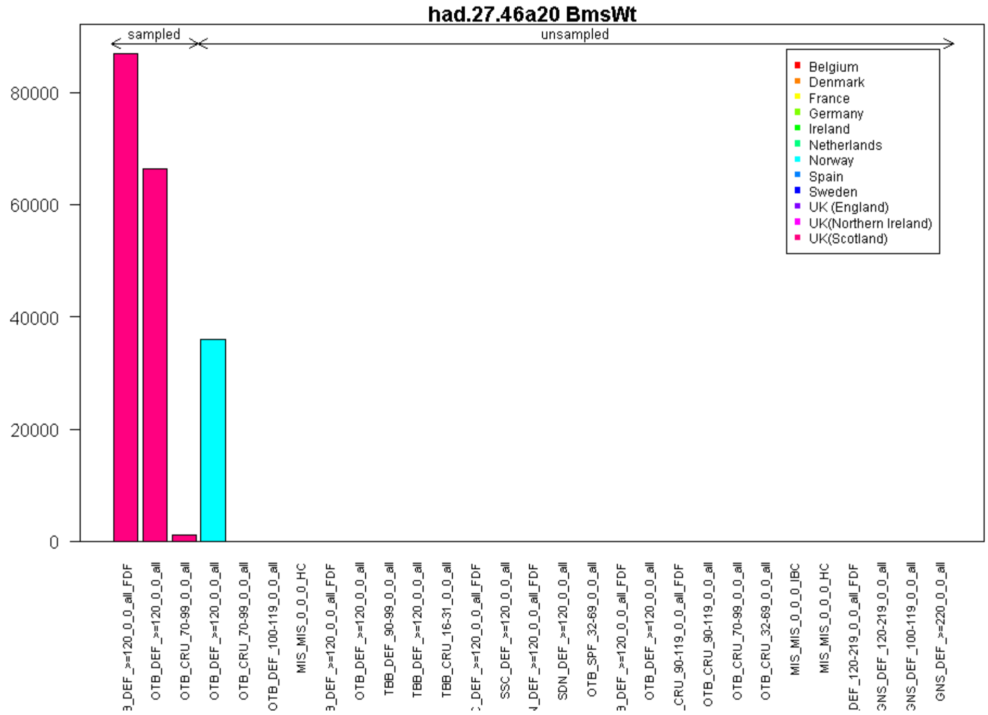


Figure 8.2.3. Haddock in Subarea 4, Division 6.a and Subdivision 20: Reported BMS landings for each sampled and unsampled fleet in the full stock area, in descending order of yield.

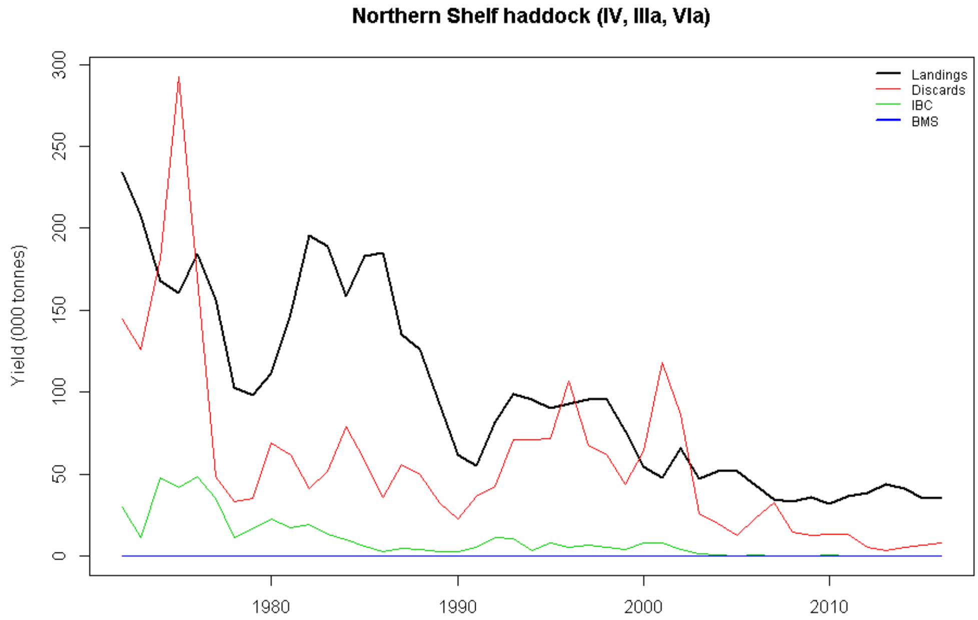


Figure 8.2.4. Haddock in Subarea 4, Division 6.a and Subdivision 20: Yield by catch component.

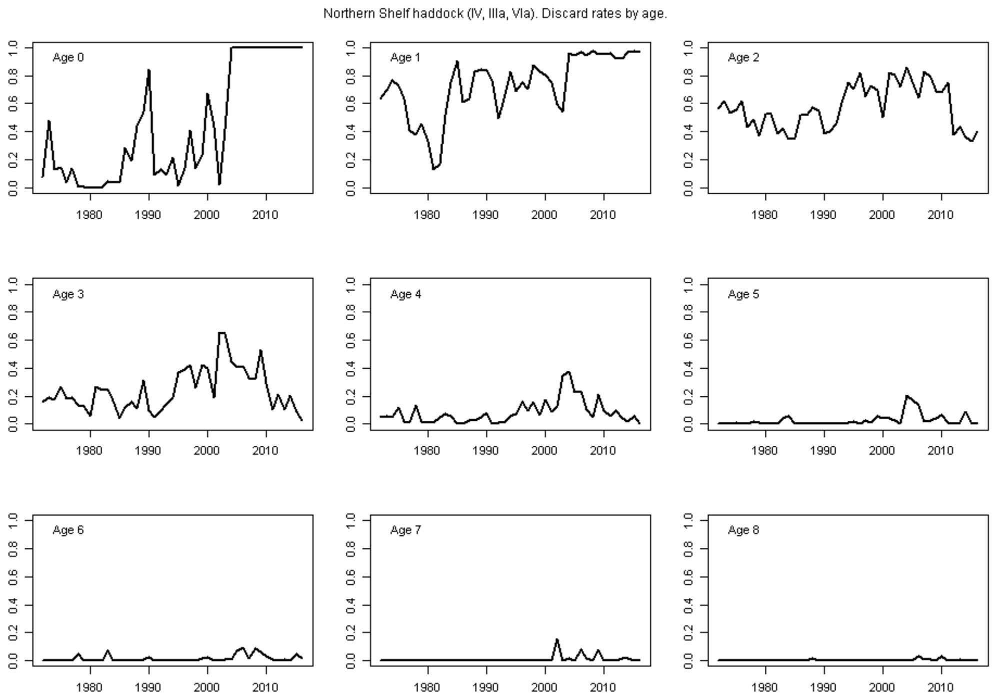


Figure 8.2.5. Haddock in Subarea 4, Division 6.a and Subdivision 20: Proportion of total catch discarded, by age and year.

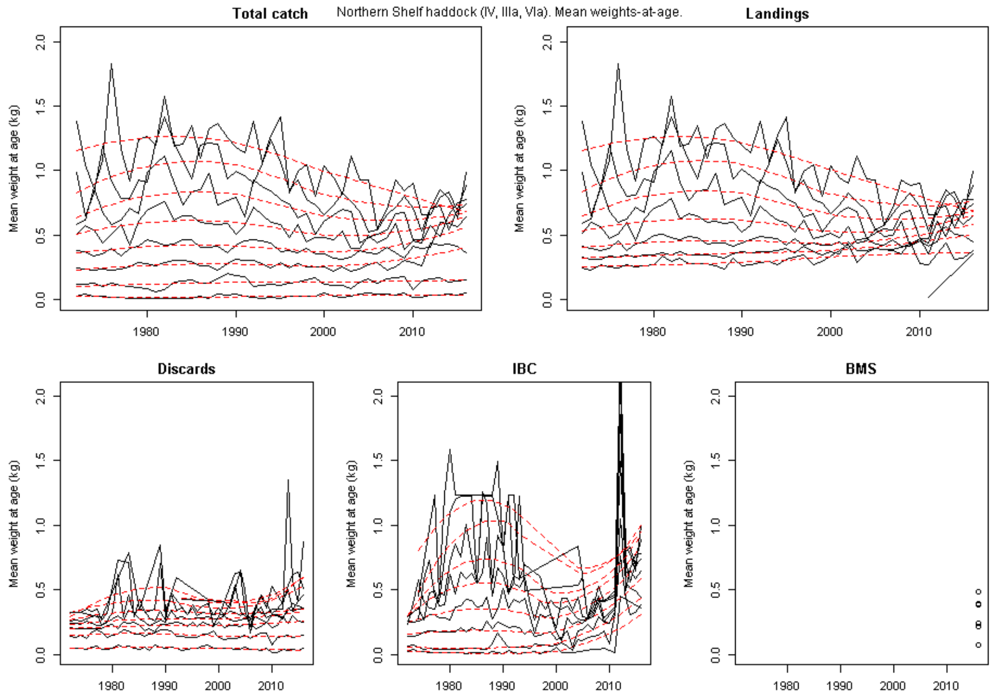


Figure 8.2.6. Haddock in Subarea 4, Division 6.a and Subdivision 20: Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

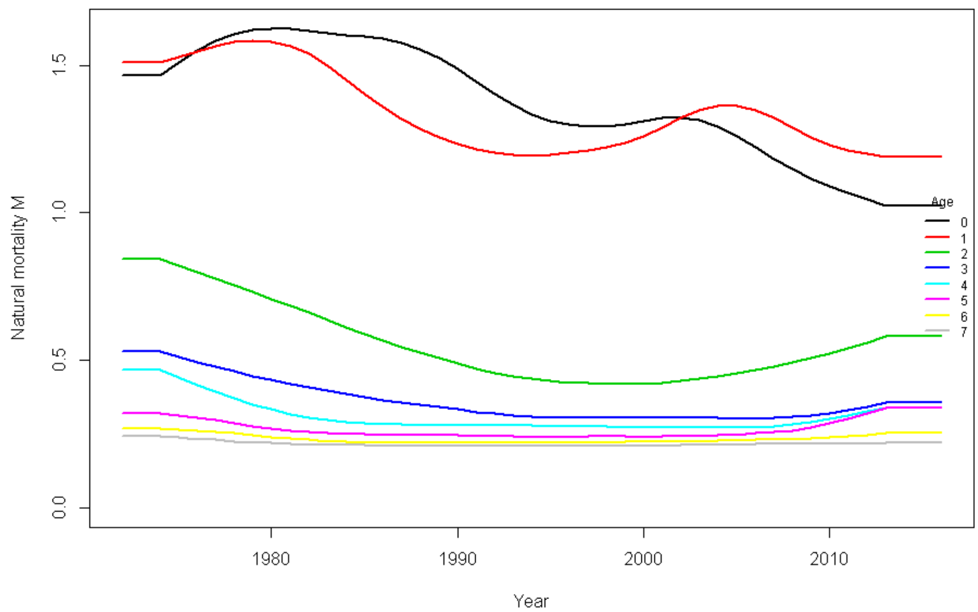


Figure 8.2.7. Haddock in Subarea 4, Division 6.a and Subdivision 20: Time series of estimated natural mortality at age, from ICES WGSAM (2014).

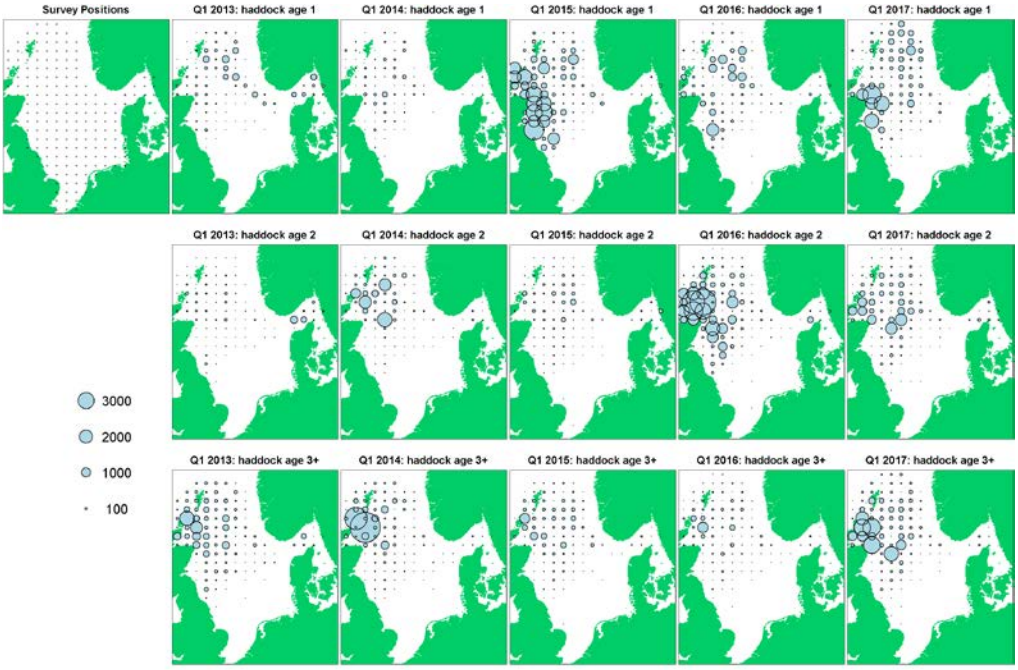


Figure 8.2.8. Haddock in Subarea 4, Division 6.a and Subdivision 20: Survey distributions by age for the international IBTS–Q1 survey (North Sea).

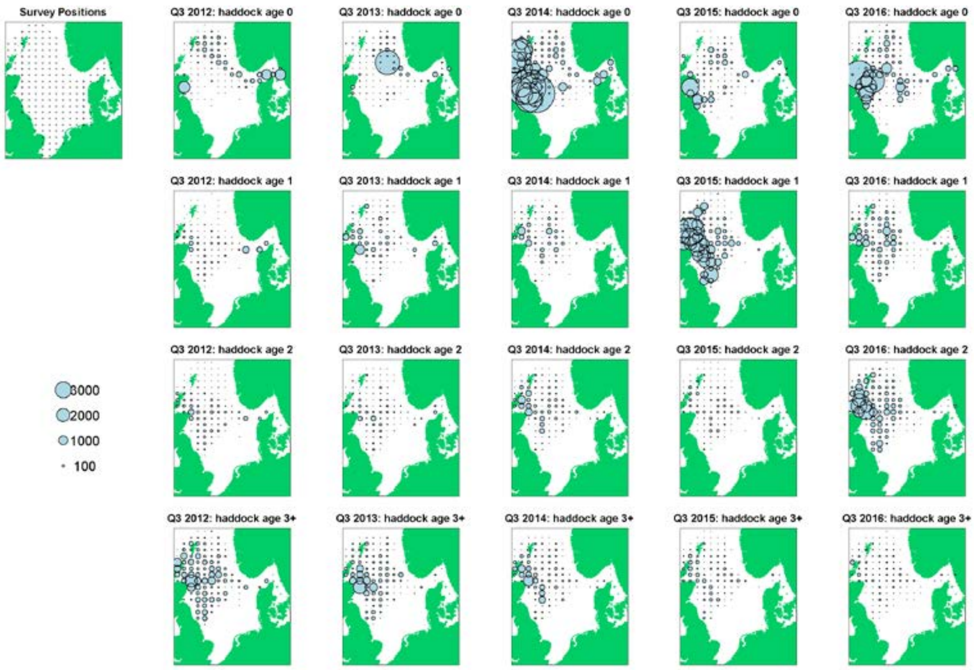


Figure 8.2.9. Haddock in Subarea 4, Division 6.a and Subdivision 20: Survey distributions by age for the international IBTS–Q3 survey (North Sea).

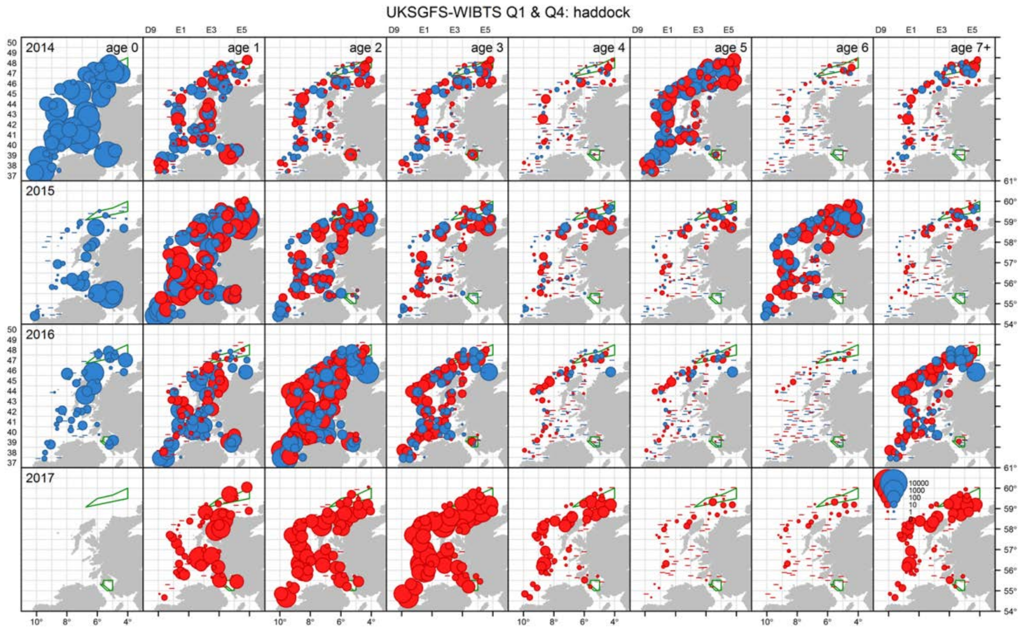


Figure 8.2.10. Haddock in Subarea 4, Division 6.a and Subdivision 20: Survey distributions by age and quarter for the Scottish West Coast Q1 survey (West of Scotland). Rows show years 2014–2017 (from top to bottom).

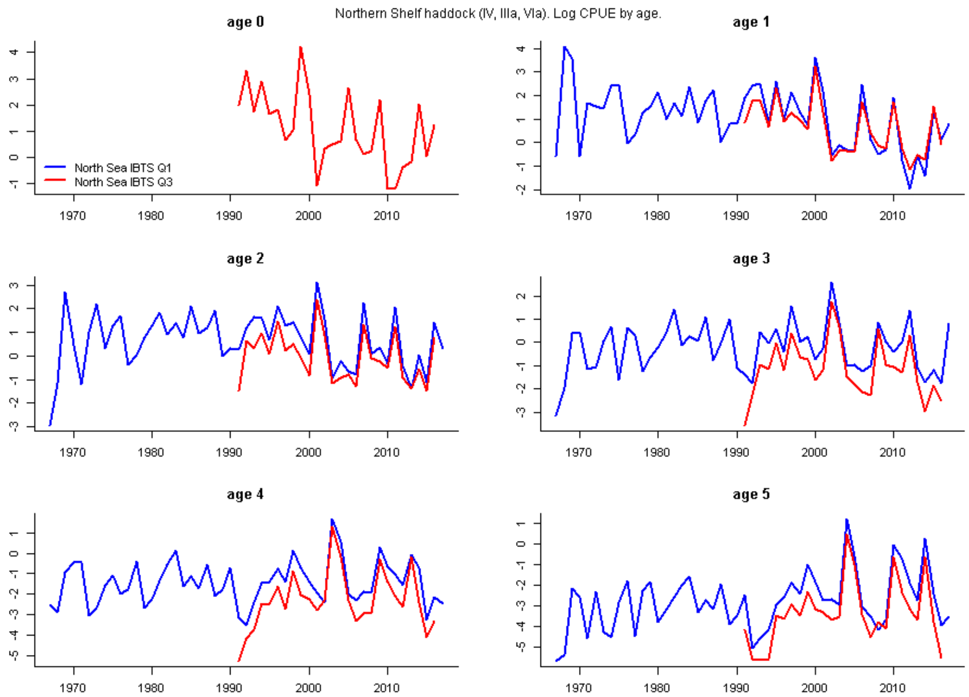


Figure 8.2.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Survey log-cpue (catch per unit effort) at age.

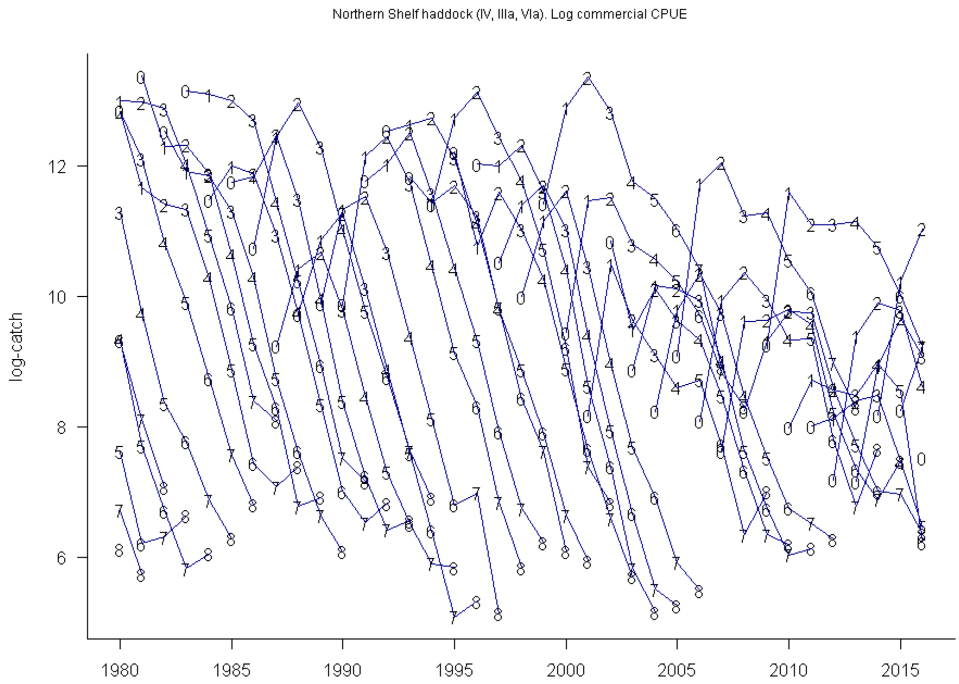


Figure 8.3.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log-catch curves by cohort for total catches.

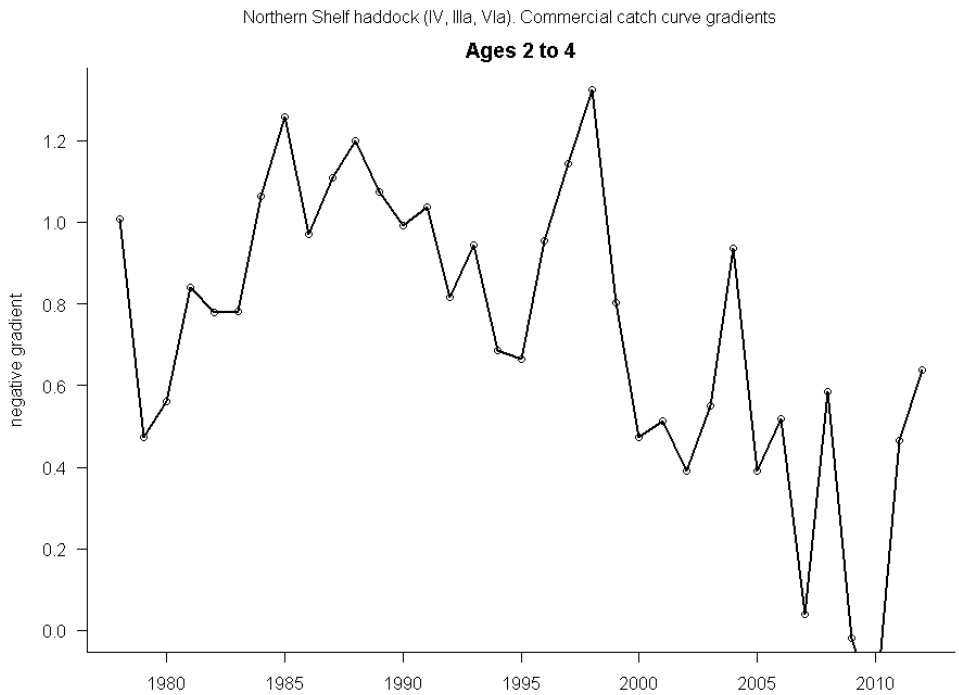


Figure 8.3.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Negative gradients of log catches per cohort, averaged over ages 2–4. The x-axis represents the spawning year of each cohort.

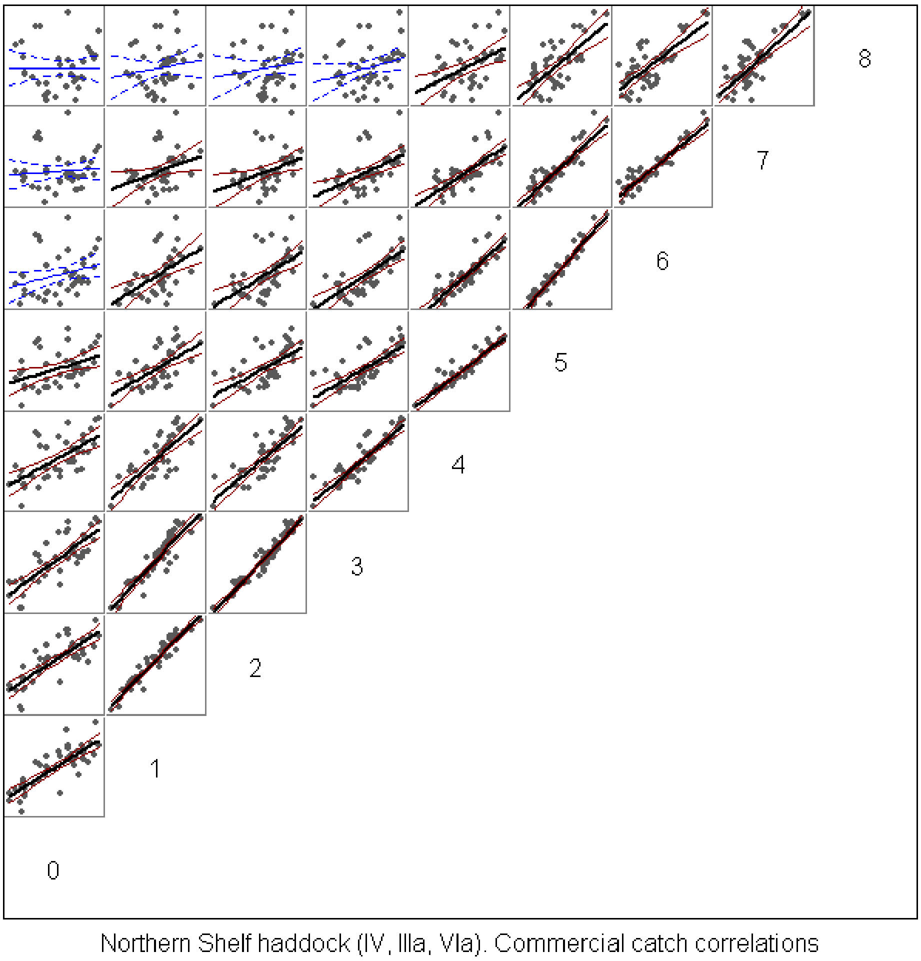


Figure 8.3.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

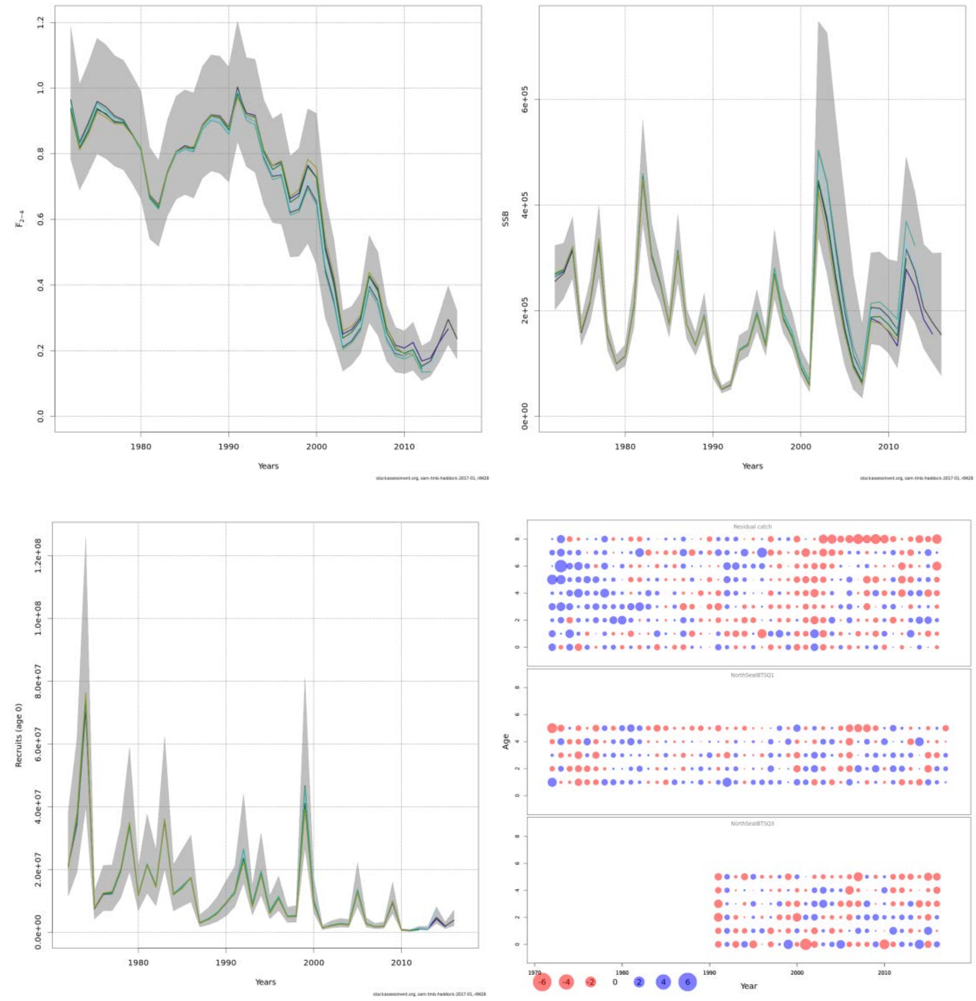


Figure 8.3.4. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SAM assessment. Time-series of estimated mean F (2–4) (top left), SSB F(2–4) (top right) and recruitment (bottom left) are shown with approximate pointwise 95% confidence intervals. Retrospective runs are included in these plots. Model residuals (bottom right) are depicted with a clear blue circle for a positive residual, and a solid red circle for a negative residual.

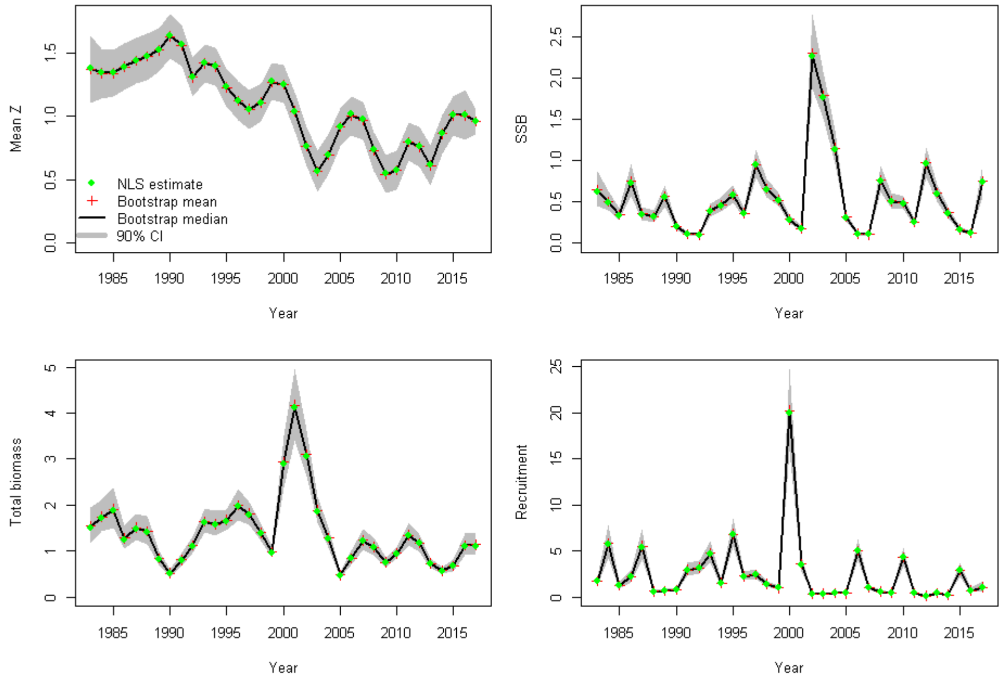


Figure 8.3.5. Haddock in Subarea 4, Division 6.a and Subdivision 20. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

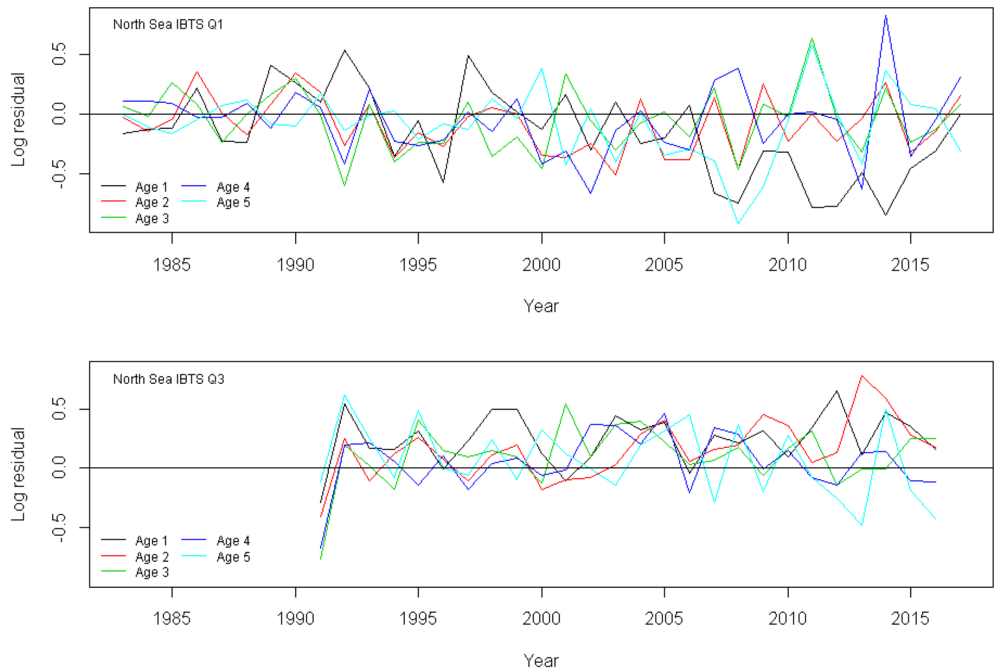


Figure 8.3.6. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3).

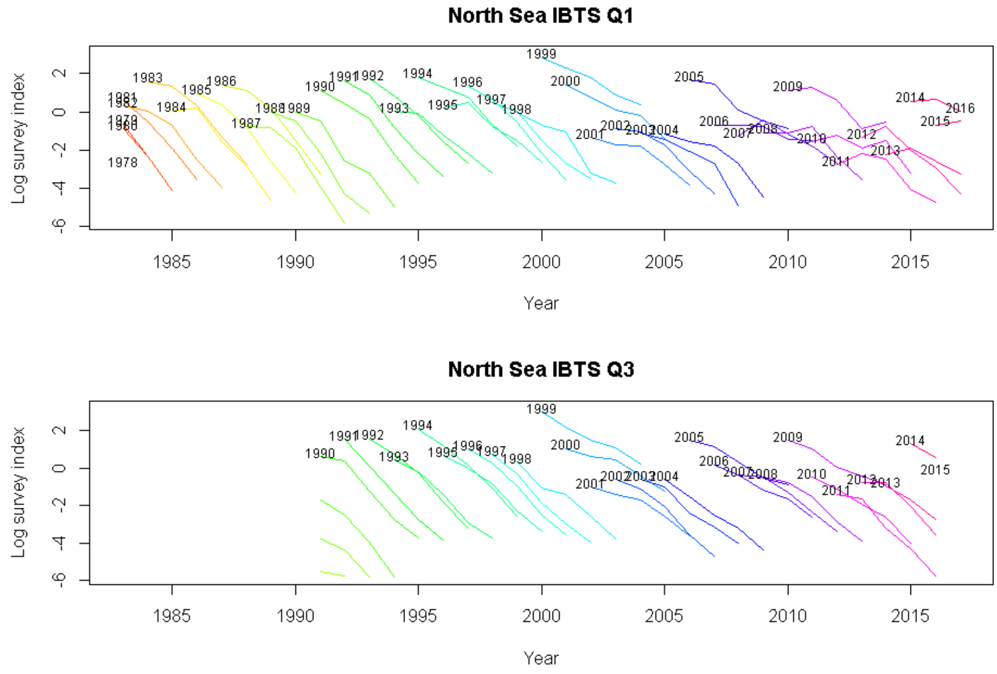


Figure 8.3.7. Haddock in Subarea 4, Division 6.a and Subdivision 20. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.

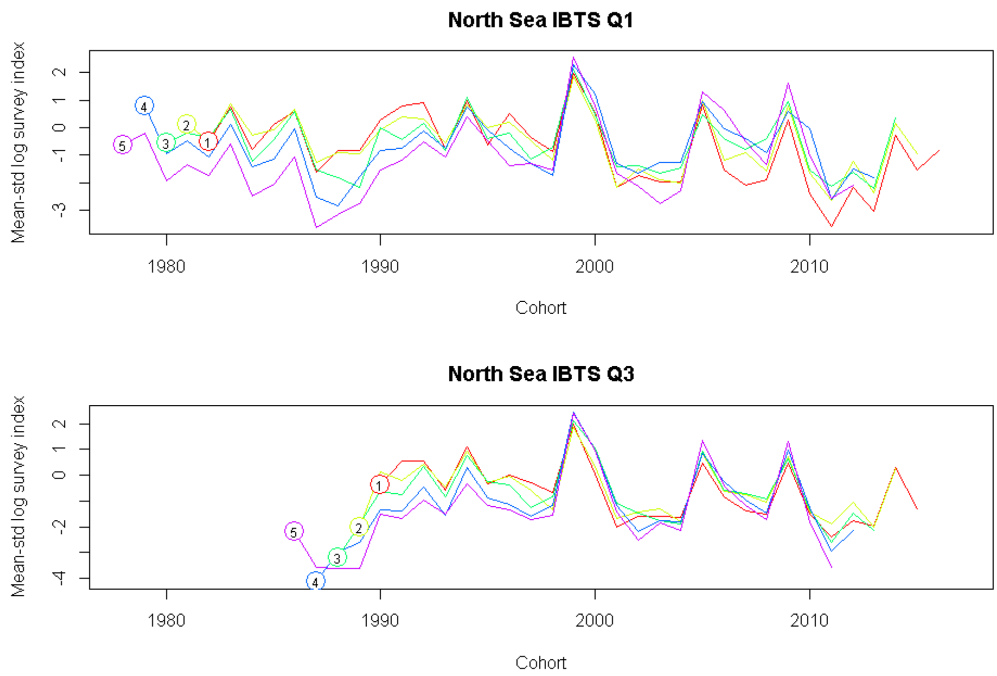
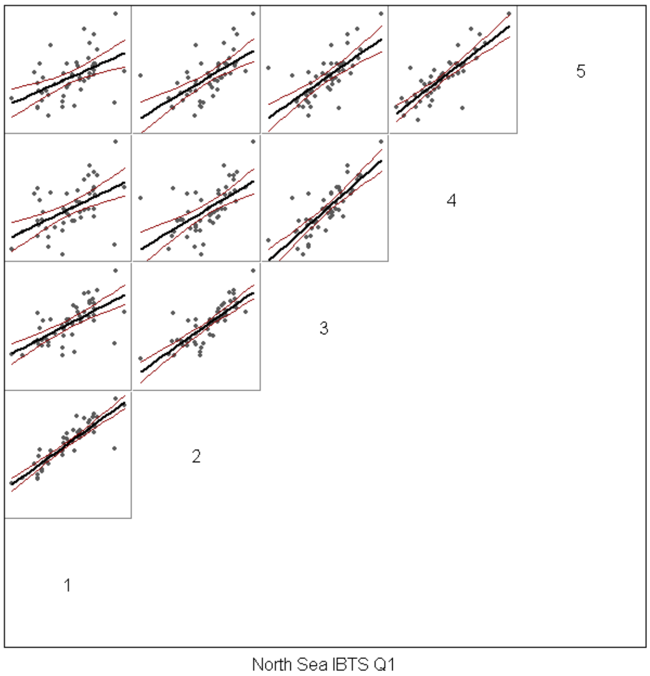


Figure 8.3.8. Haddock in Subarea 4, Division 6.a and Subdivision 20. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.



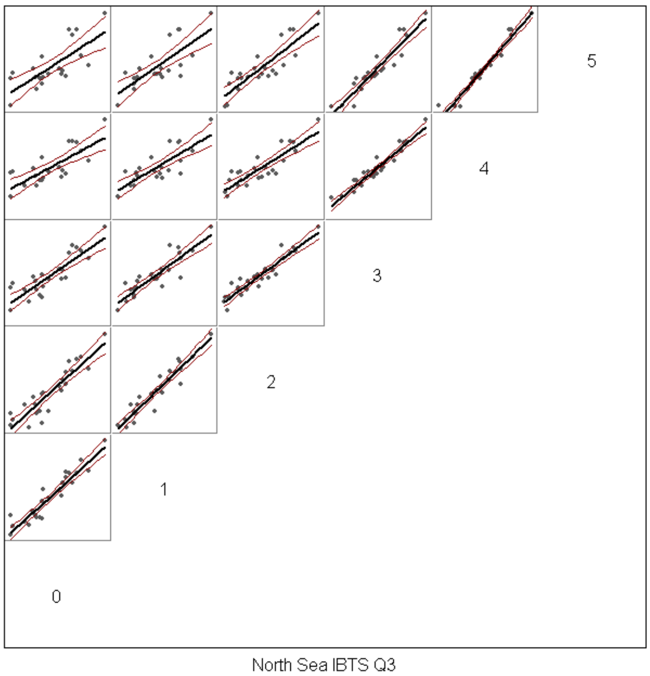


Figure 8.3.9. Haddock in Subarea 4, Division 6.a and Subdivision 20. Within survey correlations for the IBTS–Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

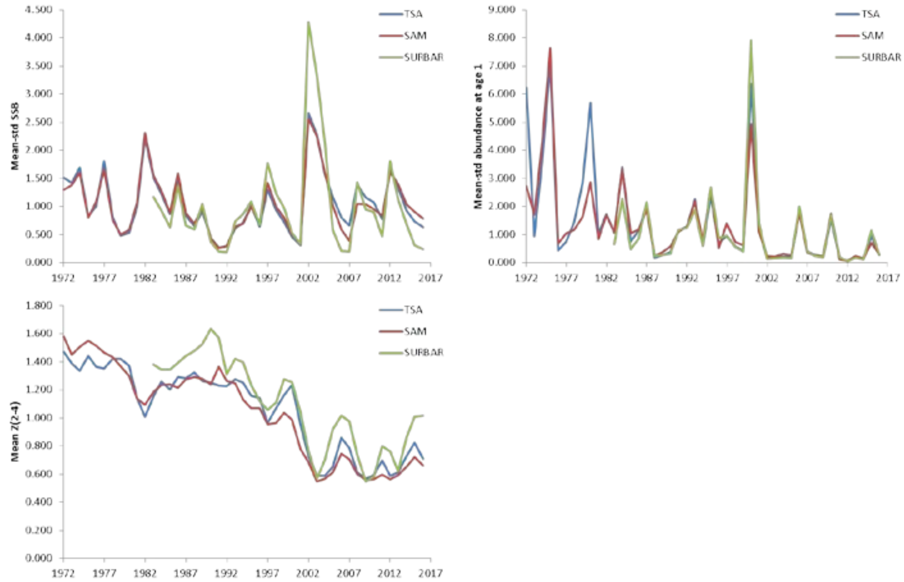


Figure 8.3.10. Haddock in Subarea 4, Division 6.a and Subdivision 20. Comparisons of stock summary estimates from TSA (blue), SAM (red) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models, and a composite Z estimate has been made for TSA, XSA and SAM by adding natural and fishing mortality estimates.

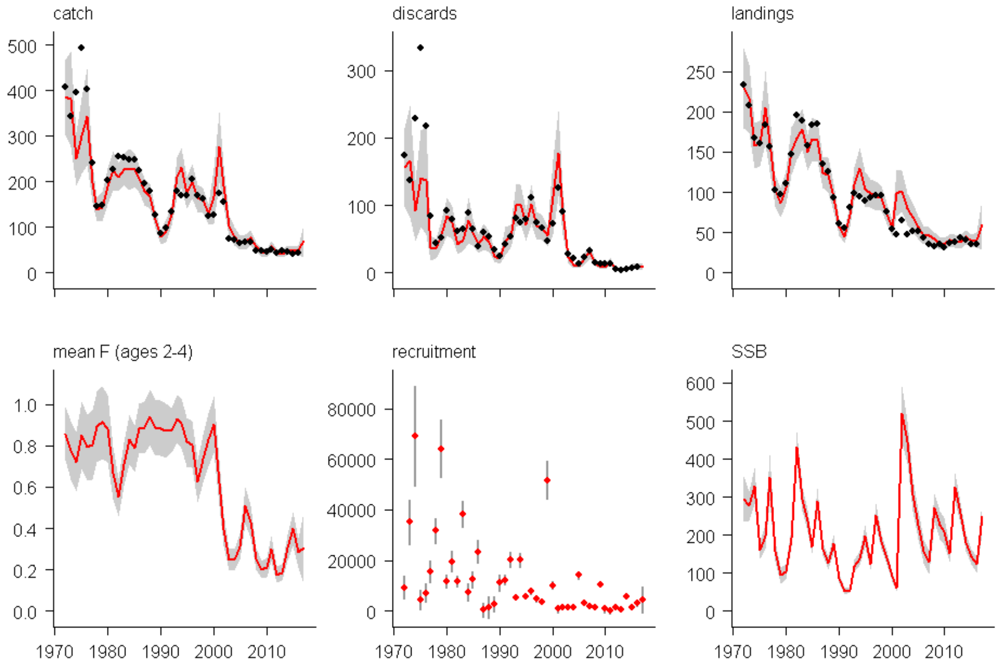


Figure 8.3.11. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock summary from final TSA assessment (including forecasts for 2017). Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for discards (discards + IBC + BMS), and landings).

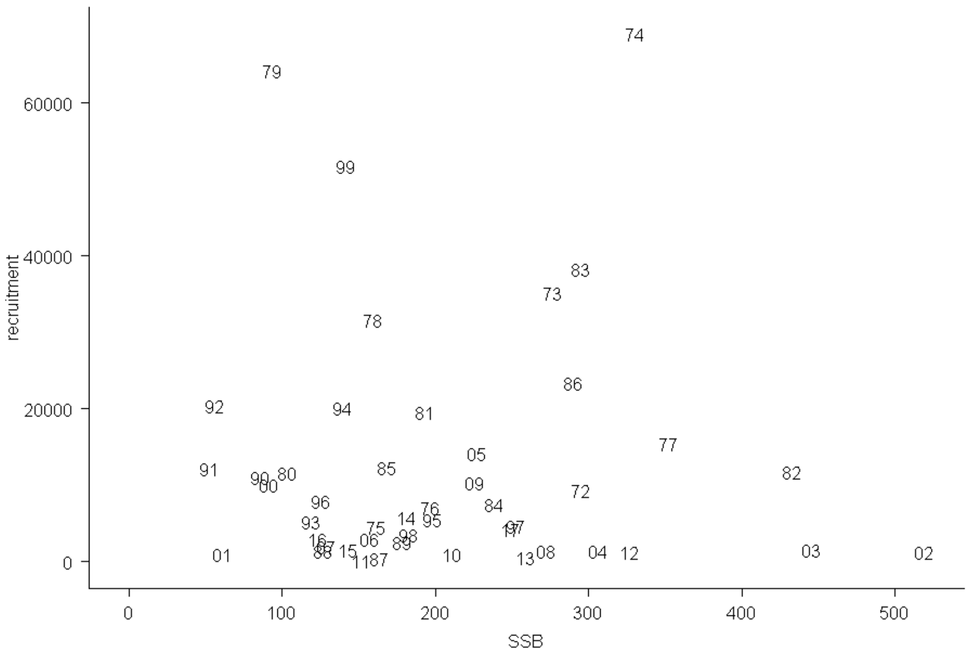


Figure 8.3.12. Haddock in Subarea 4, Division 6.a and Subdivision 20. Stock–recruitment estimates from the final TSA assessment. Points are labelled by year-class.

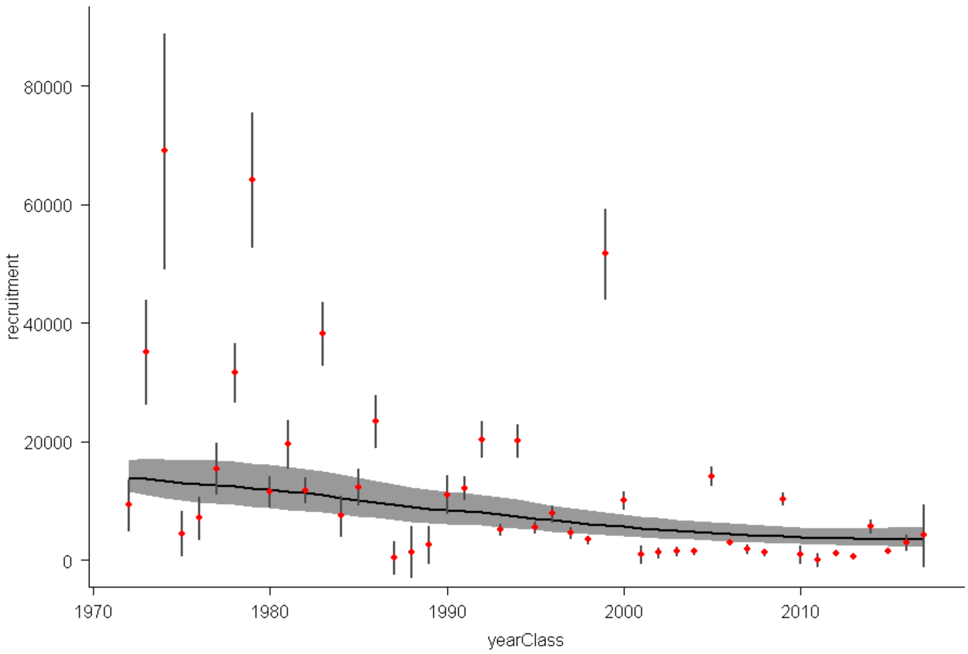


Figure 8.3.13. Haddock in Subarea 4, Division 6.a and Subdivision 20. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk recruitment model estimated by TSA.

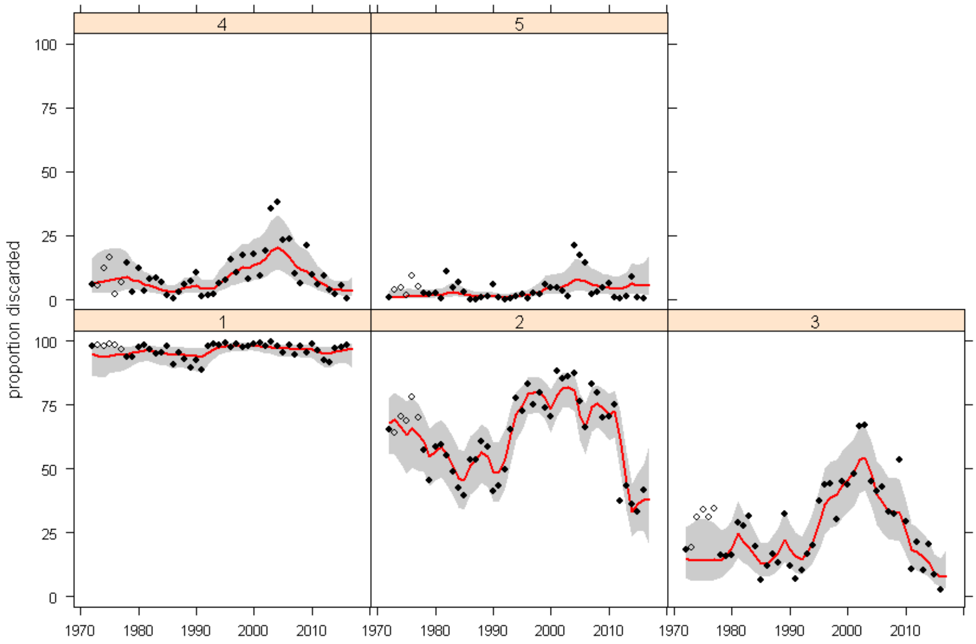


Figure 8.3.14. Haddock in Subarea 4, Division 6.a and Subdivision 20. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch + BMS. The open points for the years 1973–1977 indicate that these values are treated as missing in the TSA estimation. All haddock of age 0 are assumed to be either discarded or caught as industrial bycatch or BMS.

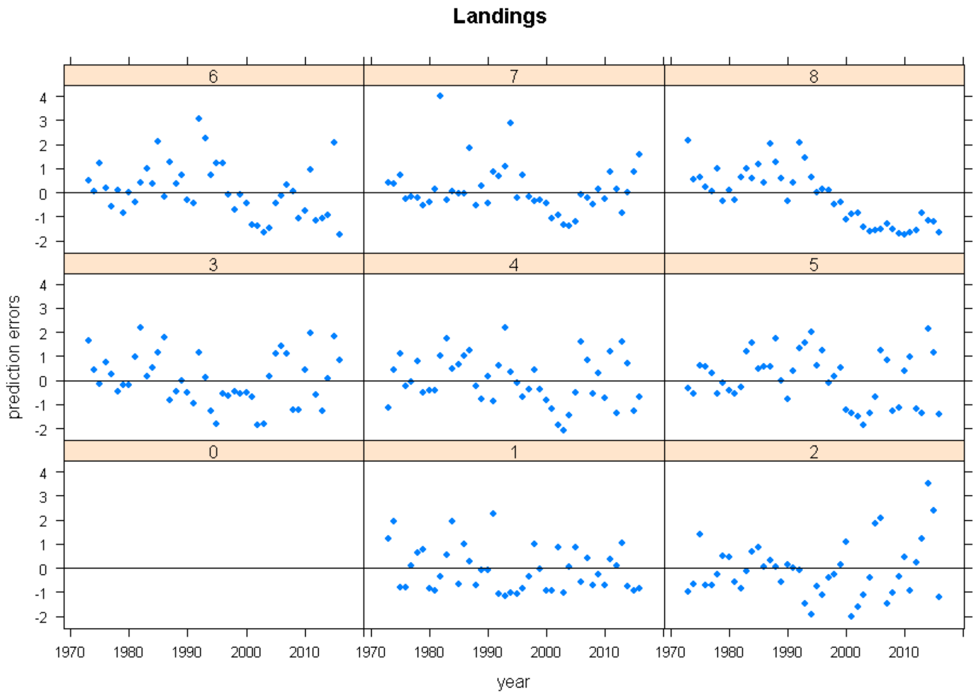


Figure 8.3.15. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA landings prediction errors by age.

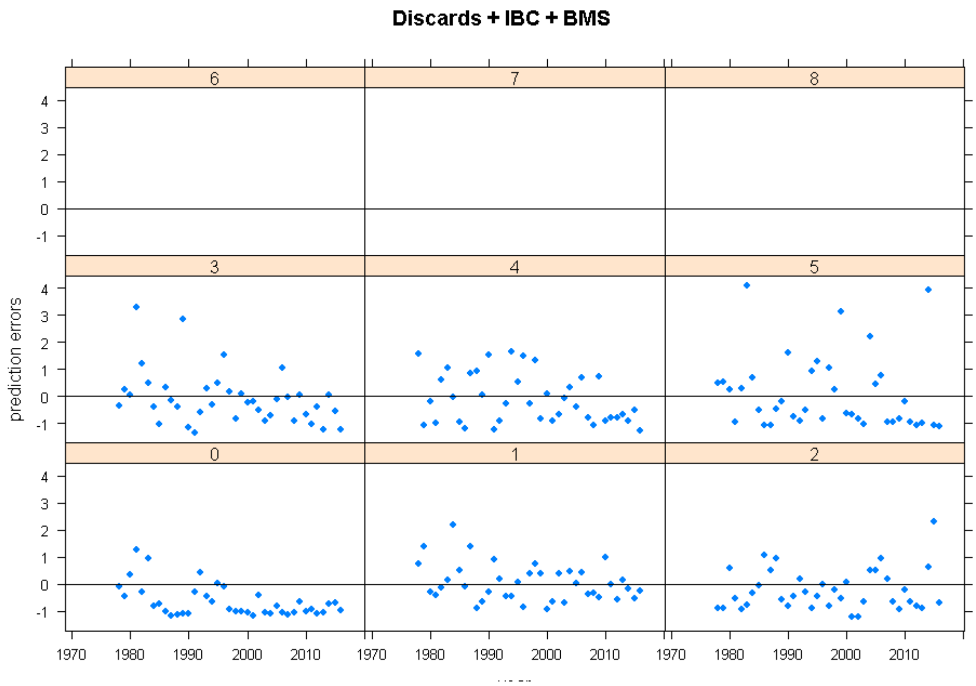


Figure 8.3.16. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA discards + IBC + BMS prediction errors by age.

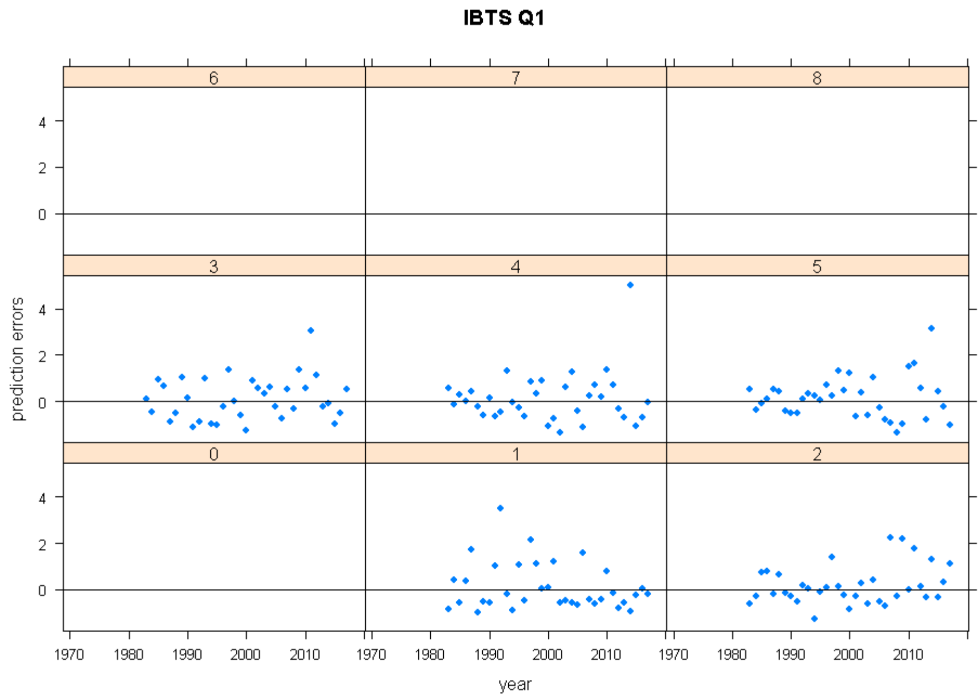


Figure 8.3.17. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS–Q1 survey index.

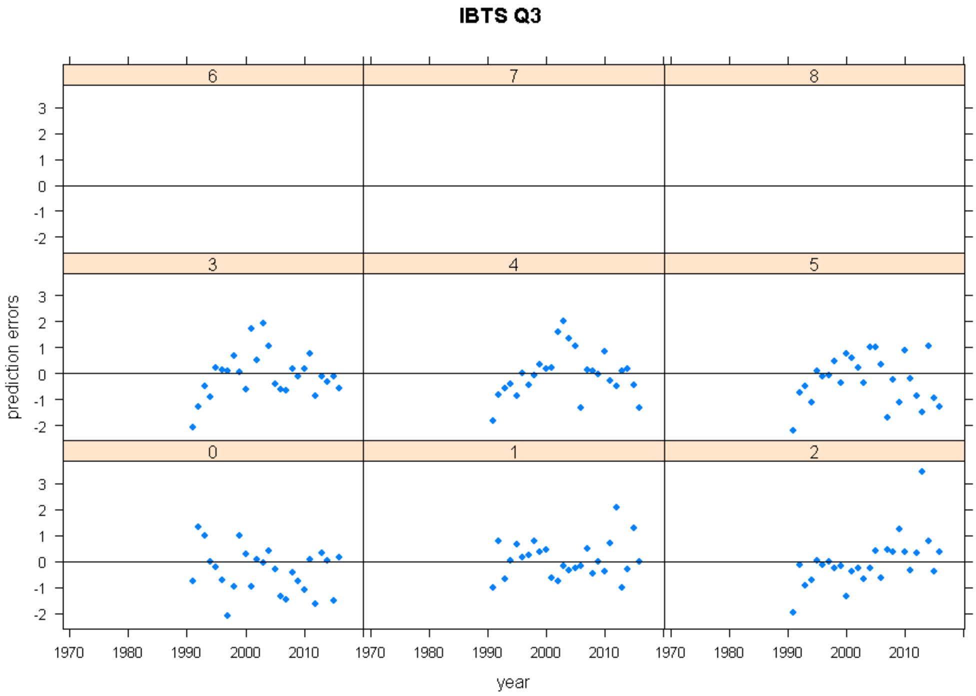


Figure 8.3.18. Haddock in Subarea 4, Division 6.a and Subdivision 20. Standardised TSA prediction errors by age for the IBTS–Q3 survey index.

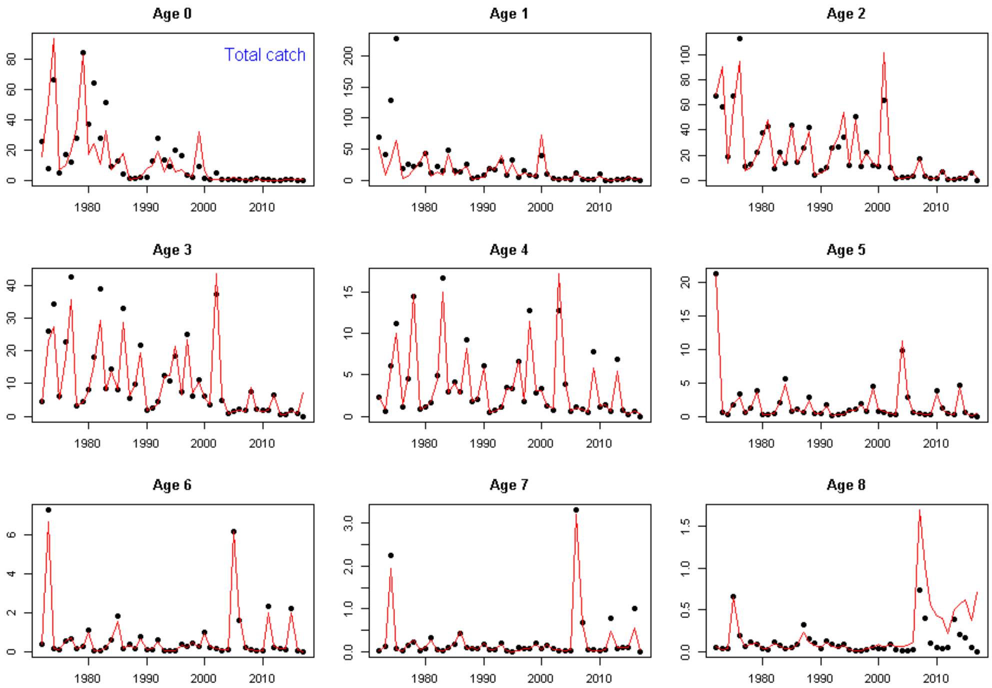


Figure 8.3.19. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for total catch, by age.

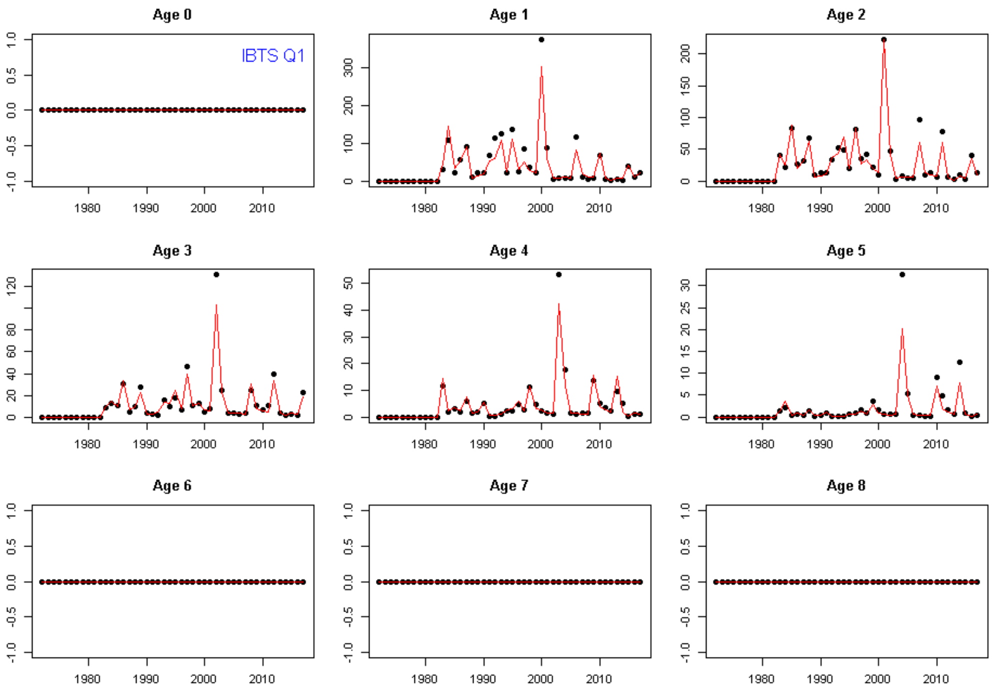


Figure 8.3.20. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.

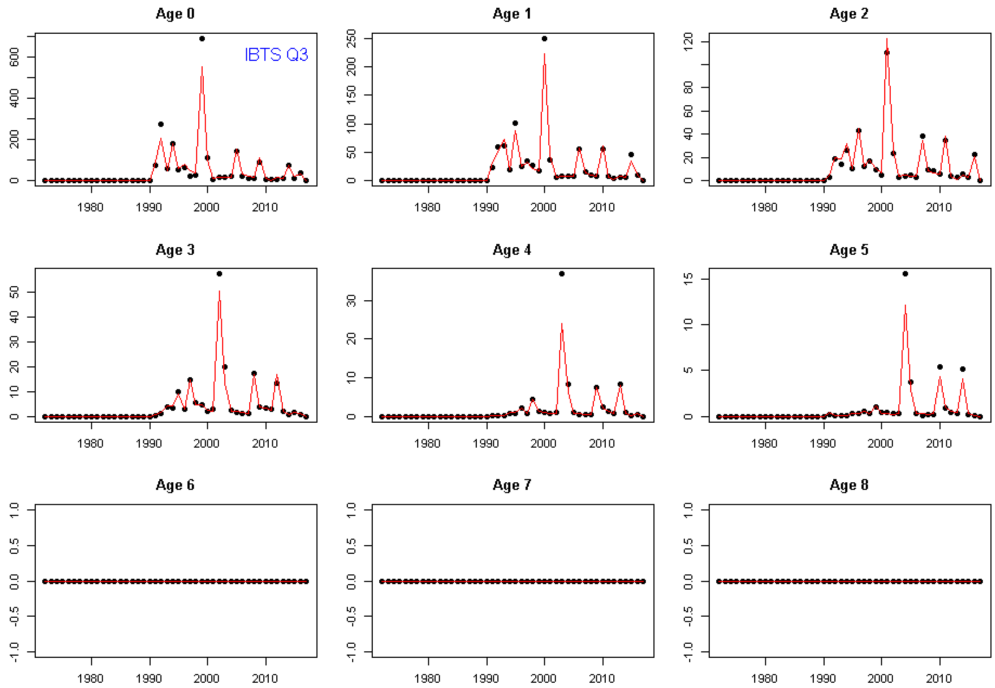


Figure 8.3.21. Haddock in Subarea 4, Division 6.a and Subdivision 20. Time-series of observed (points) and fitted (lines) values for the IBTS–Q3 survey index, by age.

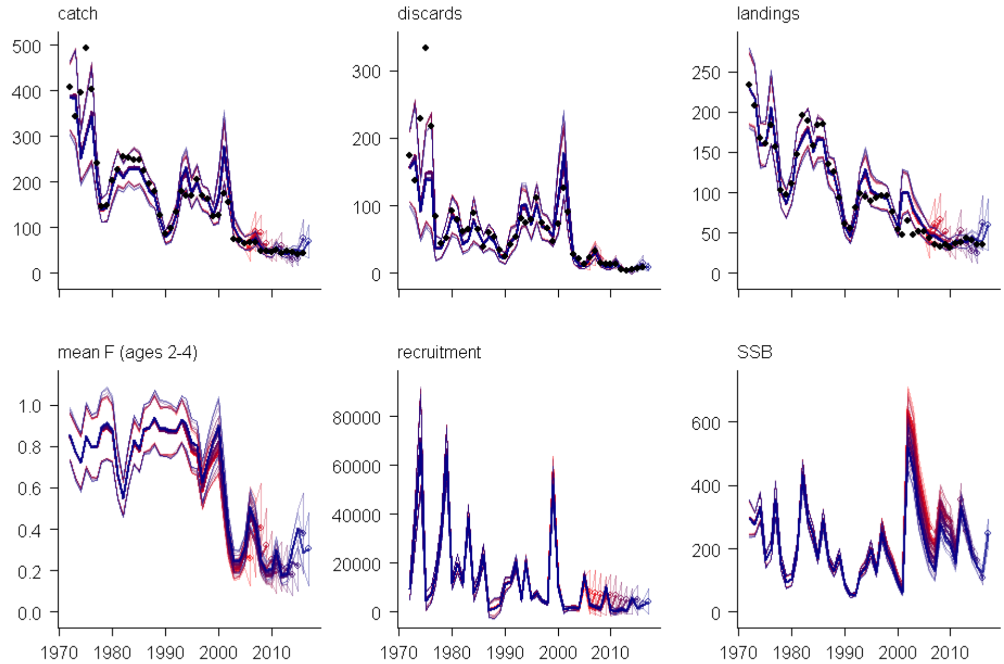


Figure 8.3.22. Haddock in Subarea 4, Division 6.a and Subdivision 20. Retrospective plots for the TSA assessment. The best estimates for each retrospective run end in an open circle, and each run is shown with the approximate pointwise 95% confidence interval. Estimates and CIs are colour-coded, with older runs becoming progressively more red.

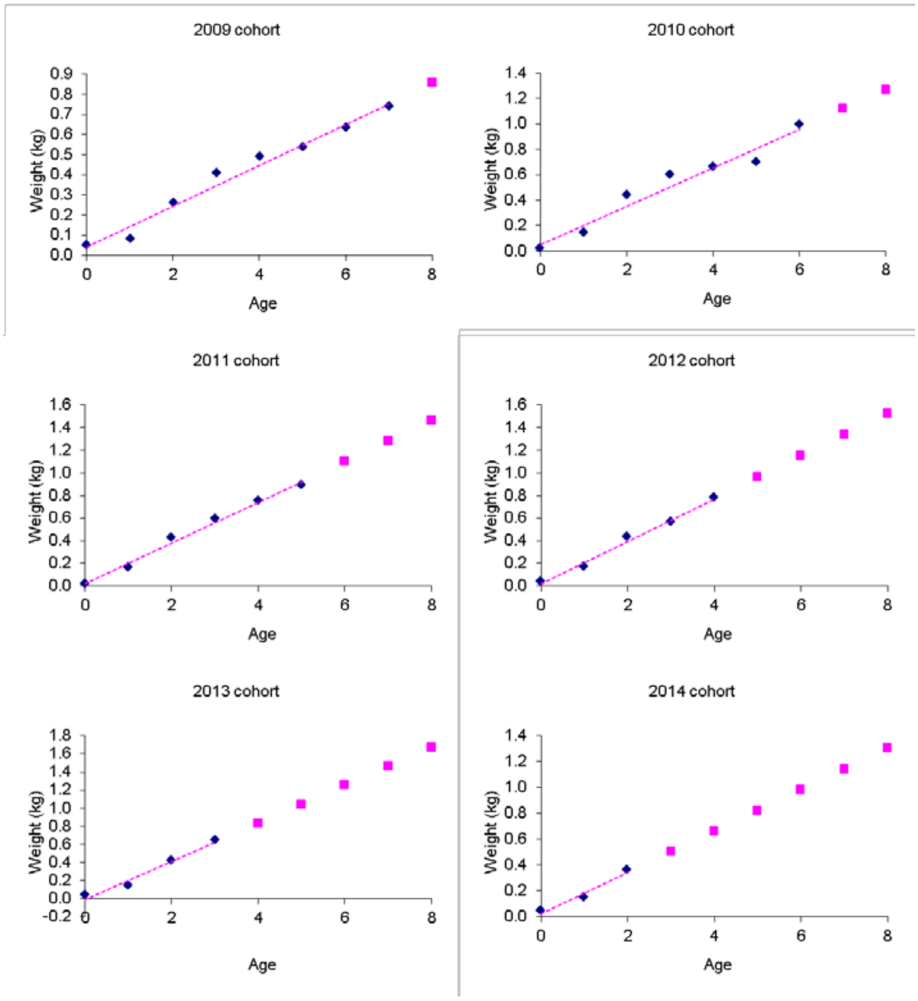


Figure 8.6.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski, 2011). Cohorts 2009–2014 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

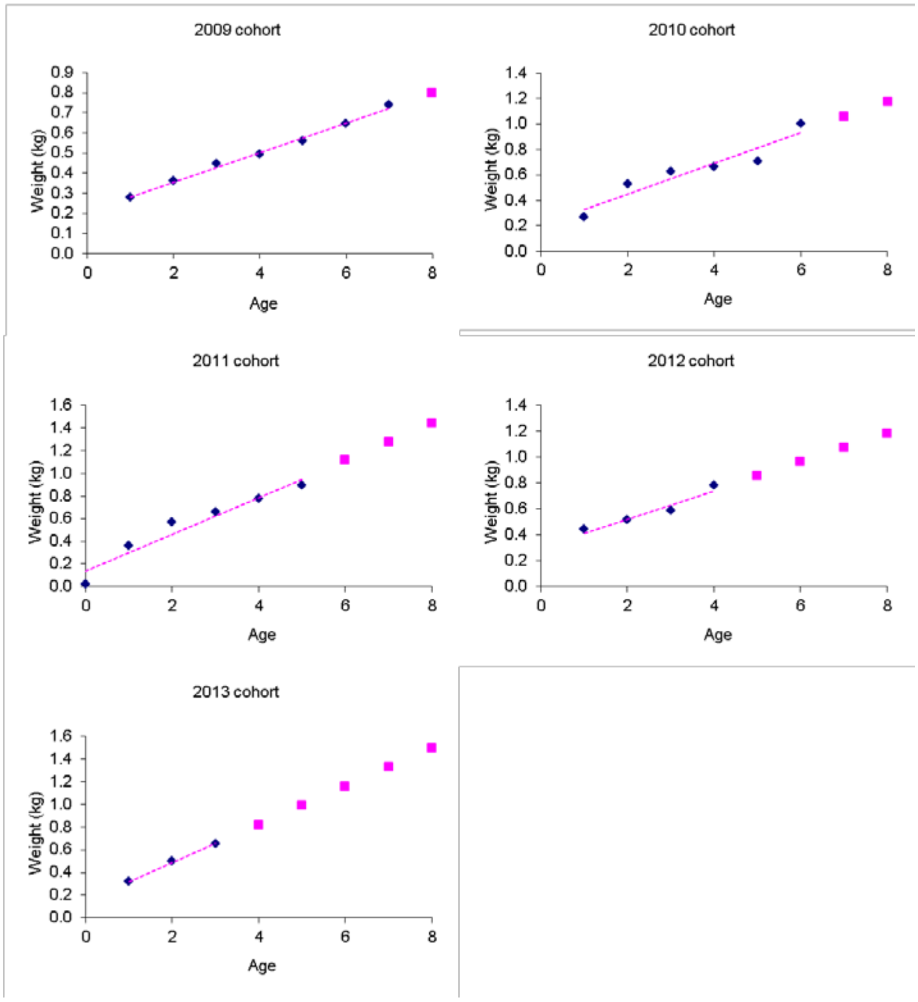


Figure 8.6.2. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for wanted catch (landings) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2009–2013 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

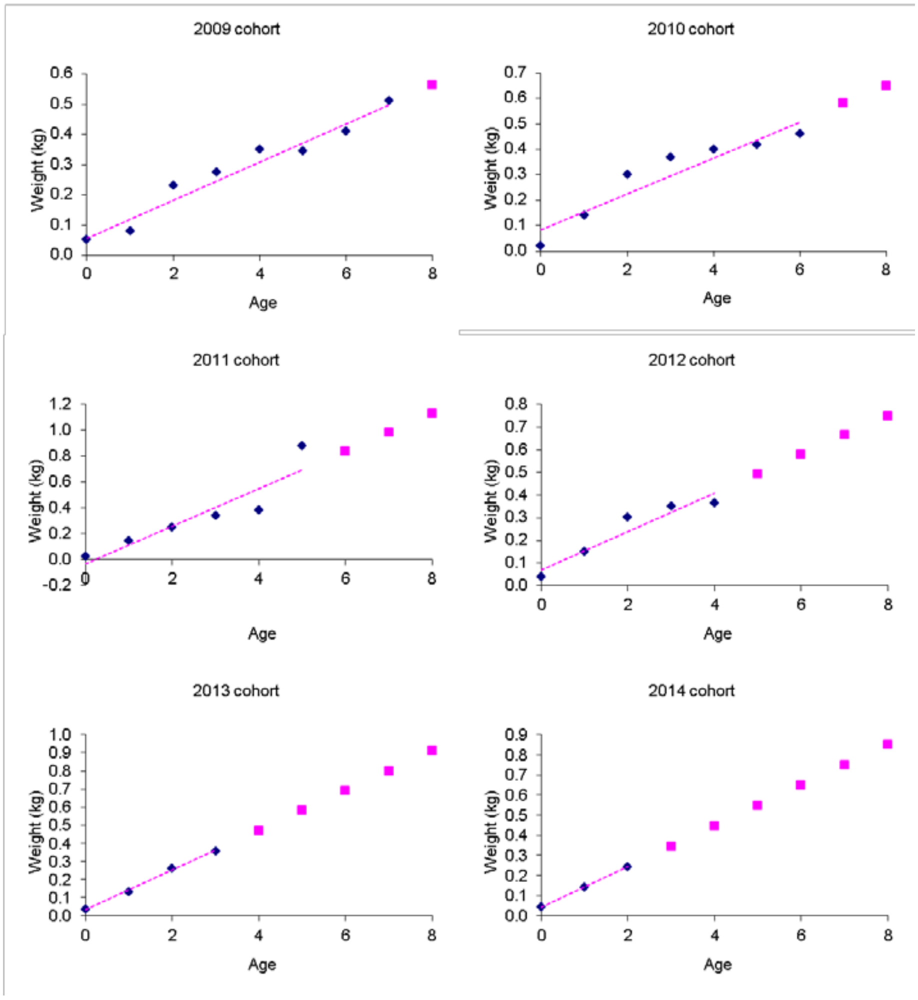


Figure 8.6.3. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of growth modelling for unwanted catch (discards + BMS) weights using cohort-based linear models (Jaworski, 2011). Cohorts 2009–2014 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

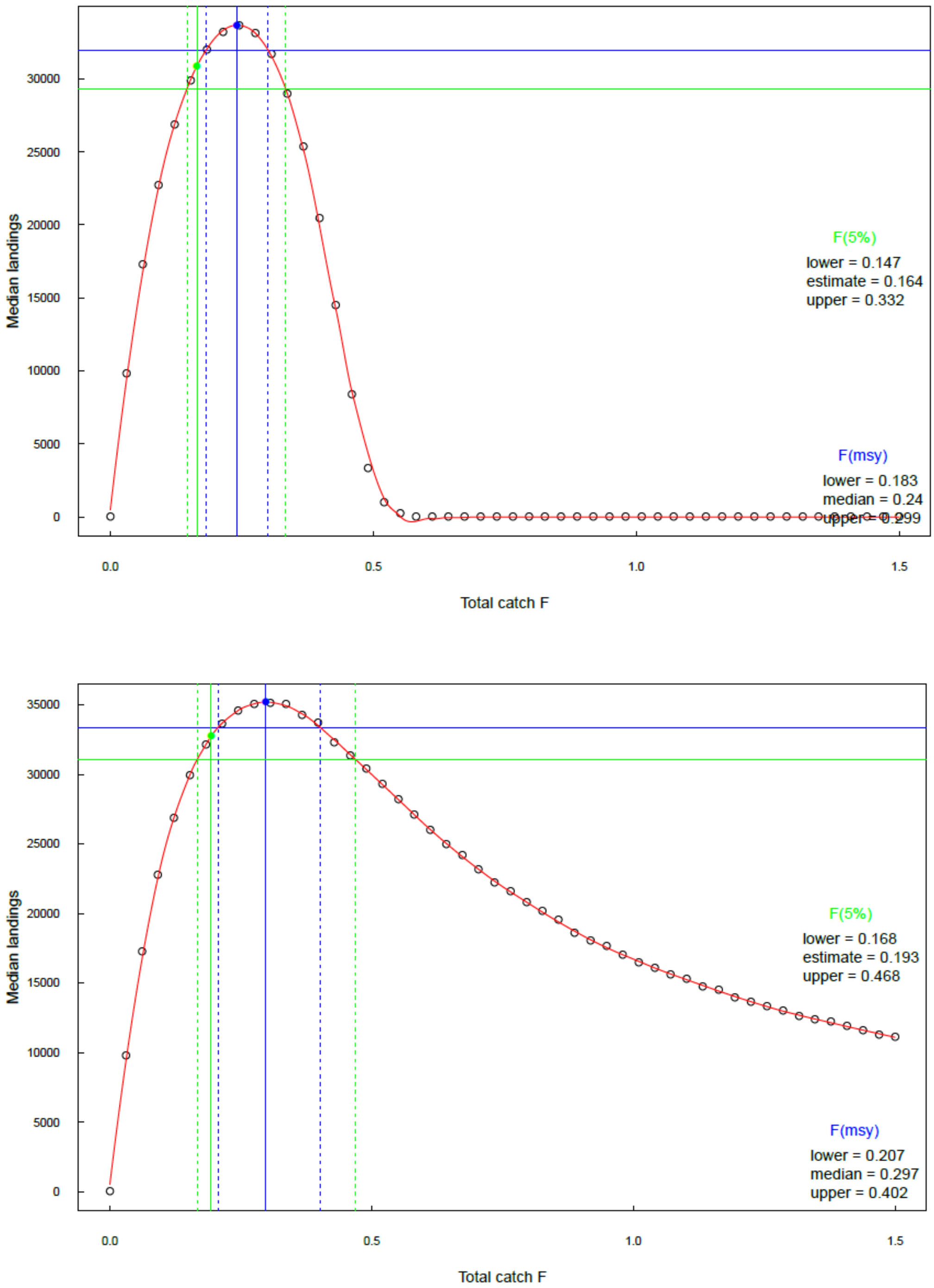


Figure 8.8.1. Haddock in Subarea 4, Division 6.a and Subdivision 20. Results of EqSIM estimation of F(MSY) with the advice error but no rule (top) and of Fp05 with both advice error and rule (bottom).

9 Lemon sole in Subarea 4, Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat and Eastern English Channel)

9.1 General

Until 2014, lemon sole (*Microstomus kitt*) was assessed in the Working Group on Assessment of New MoU Species (ICES 2013a). Lemon sole has been defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES 2012). Biennial advice for lemon sole was given in 2013 (ICES 2013b), based on survey trends. In 2014, lemon sole was included to the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). This is the fourth year in which the stock status for lemon sole has been evaluated by WGNSSK.

9.1.1 Biology and ecosystem aspects

Lemon sole is a commercially important flatfish that is found in the shelf waters of the North Atlantic from the White Sea and Iceland southwards to the Bay of Biscay. In Scottish waters, lemon sole start to spawn in the northwest of the North Sea in April and spawning spreads north and east as the season progresses (Rae, 1965). In the western English Channel, lemon sole spawn in April and May (Jennings *et al.*, 1993). In the English Channel, investigations of habitat association for plaice, sole and lemon sole indicated that distribution is restricted to a few sites and that lemon soles appear to prefer sandy and gravely strata, living deeper and at a higher salinity and lower temperature than plaice or sole (Hinz *et al*., 2006). Lemon sole feeds on small invertebrates, mainly polychaete worms, bivalves and crustaceans.

9.1.2 Stock ID and possible assessment areas

There is little information available on lemon sole stock identity for the greater North Sea.

9.1.3 Management regulations

No specific management objectives are known to ICES. An EU TAC is set for EU waters of ICES Division 2.a and Subarea 4 together with witch flounder (ICES 2013b).

9.2 Fisheries data

9.2.1 Historical landings

In the North Sea and in Skagerrak-Kattegat lemon sole is mainly a by-catch species in the fishery for plaice and in the mixed demersal fisheries. Landings in ICES Division 7.d, and Subarea 4 and Division 3.a are shown in Figures 9.2.1 to 9.2.4, and in Tables 9.2.1 to 9.2.4. The time-series of landings are not fully complete, and a number of countries have gaps in data provision.

9.2.2 Discards

Catch yields and age compositions for lemon sole were submitted for 2013–2016, enabling the estimation of discard rates (by weight) for those years. No age-sampled landings or discards were submitted for the years 2015–2016. Previously, only around 10% of metiers landing lemon sole were age-sampled for landings and discards, and all such sampling was carried out by England (although sampled data on lengths has continued to be submitted by England). However, the majority of landings have estimates of total discards by weight associated with them. The time-series of official landings for the full stock area, along with WG estimates of landings and discards by country for 2013–2016, are given in Tables 9.2.5 and 9.2.6 and Figure 9.2.5. Discard rates in 2016 are slightly less (25%) than those in 2015 (29%), 2014 (31%) and 2013 (28%).

9.3 Survey data/recruit series

Surveys providing information on distribution, abundance and length frequency for lemon sole in area 4, division 7.d and division 3.a are the International Bottom Trawl Survey (IBTS) in quarters 1 and 3, and the Beam Trawl Survey (BTS, only North Sea area 4) in quarter 3. The IBTS–Q1 was used for lemon sole to analyse stock trends. This survey uses a GOV demersal trawl which may not be the optimal gear to catch flatfish. However, the beam trawl surveys do not cover the whole distribution area of lemon sole (missing the northern area in particular) and catches of older lemon sole remain relatively high from the IBTS. It should be noted here that for the IBTS, the gear in use was fully standardized only since 1983. Additionally, several countries involved in the IBTS survey did not report lemon sole in the earlier years of the survey (see Section 9.4.2). Therefore, index data for the earlier years of the time-series should be interpreted with caution. Figure 9.3.1 displays the distribution of the abundance of lemon sole in the greater North Sea obtained from IBTS–Q1 data, for 2016 and 2017. The highest concentrations occur in the central to northern areas.

9.4 Analysis of stock trends/assessment

In 2013, lemon sole was assessed within the Working Group on the Assessment of MoU New Species (ICES, 2013a). Only landings data and survey trends were available for this species. Therefore, lemon sole was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2013). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = \bar{C}_{y-1,y}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{x-1} I_i/(z-x)}\right).$$

Here C_{y+1} is the advised catch for the next year, $\bar{C}_{y-1,y}$ is the average [or advised] catch of the last three years, and *I* is the stock index (see below). By default x=2 and z=5, and this setting was used by WGNSSK in 2017.

The index of mature biomass (Figure 9.4.1.) was calculated annually from the IBTS–Q1 data. For this index, the total weight per hour by centimetre length group was calculated using the length-weight relationship from Bedford *et al.* (1986):

$$W = 0.00756L^{3.142}.$$

The length-maturity ogive (Figure 9.4.2.) was then applied, and the resulting distribution was summed and divided by hours fished to generate a mature biomass index (in kg/hr). Lemon sole are reported to spawn in the west central North Sea during the period April to November with peak spawning during July–August (Rae, 1965). Therefore most spawning occurs between the Q1 and Q3 IBTS surveys. For this reason, the maturity ogive shown in Figure 9.4.2 was derived from the age at maturity data (2006–2012) from both of these surveys (see the Stock Annex for the maturity-length key). Information on lemon sole from the spawning period would improve the accuracy of these estimates.

The 2:3 ratio of the abundance index (Figure 9.4.3) was estimated to be -3%, resulting in an advised decrease in catch from 5 019 [5 655] tons (the average of actual catches over 2014–2016 [or advised catches for 2016–2017]) to 4 867 [5 484] t in 2018. If discard rates do not change from the average of the last 3 years (2014–2016; 28%), this implies landings of no more than 3 483 [3 924] tons in each of the years 2018 and 2019 (if biennial advice is still required).

As the suggested decrease in catch was less than 20%, there was no requirement to apply an uncertainty cap. To determine whether a PA buffer should be applied, WGNSSK considered two approaches to MSY proxy estimation length–based methods, and a surplus production model (SPiCT; Pedersen and Berg 2017). These are discussed in the following sections.

9.4.1 Length-based MSY proxy estimation

Length-based indicators were estimated for lemon sole, following the standard approach outlined by WKLIFE (ICES 2017a) and WKPROXY (ICES 2017b). Data were taken from the length samples submitted to InterCatch for 2016, principally by England (see Table 9.4.1).

The following text table summarises the output from the LBI analysis.

	Conservation				**Optimizing Yield**	**MSY**
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2016	1.30	1.33	0.57	1E-05	0.63	0.89

The majority of these results are not very favourable.

- Length at first catch (Lc) and Length of 25% of catches (L25%) are both above L(maturity) (15 cm) in 2016, which indicates a low number of immature individuals in the catches.
- The ratio of the mean length of upper 5th percentile of catches to Linf (65 cm) is around 0.57, which would suggest a lack of large (and hence old) fish in the population.
- The Lmean/Lopt ratio of around 0.63 suggests that the exploitation does not target the most productive length classes.
- Finally, Lmean/LF = M is also less than 1, which would tend to show that this stock is not being exploited at MSY.

At face value, the LBI results would suggest that individuals can reproduce before being recruited to the fishery and immatures are protected. However, the catch length distribution is truncated at larger sizes: under optimal and sustainable exploitation the mean length in the catch is expected to be higher than the observed value. Specific analysis on the catch selectivity of lemon sole in the main gears used in the fishery has not yet been carried out, but it is known that selectivity of larger fish is reduced when fishing for several related species (such as plaice and sole) using similar gear. If this is also the case for lemon sole, this could be one reason why the length-based indicators given above lead to a less positive conclusion that the production-model approach outlined below.

9.4.2 SPiCT analysis

A number of SPiCT model runs (Pedersen and Berg 2017) were undertaken, in an effort to determine whether this method would be appropriate for determining MSY proxy estimates for lemon sole.

Assessment 1 used catch (1970–2016), consisting of official landings and observed discards for 2013-2016, along with official landings raised to catch for 1970–2012 using the average yearly discard rate from 2013–2016 (Table 9.4.2). The index used was a biomass index derived from the IBTS–Q1 survey from ICES 1970–2016, for all submitting countries (Table 9.4.3 and Figure 9.4.5). Applying SPiCT to these data (using default priors) resulted in a very uncertain assessment, with wide confidence intervals and poor retrospective performance. Further runs using a starting date for the biomass index of 1966 up to 1969, and 1983 (which is the year commonly used for demersal whitefish assessments), did not lead to any improvement: nor did removing one or more of the priors.

Assessment 2 used the same catch and survey data as Assessment 1, but added a second biomass index based on IBTS–Q3 data (1991–2016), generated using the same approach as the IBTS–Q1 index (see Table 9.4.3 and Figure 9.4.5). This did not lead to any improvement in model fits.

Finally, Assessment 3 used the same catch data as Assessment 1, and one biomass index based on IBTS–Q1 data for 1966–2017 with survey data from Scotland and Netherlands only (see Table 9.4.2 and Figure 9.4.5). The driver for this was the observation that many countries did not report lemon sole data for IBTS purposes in the early part of the time series, and the hypothesis that this might be leading to the significantly lower mean level for the index prior to the mid–1980s (see Figure 9.4.1). Figure 9.4.4 illustrates this, showing that only Scotland and the Netherlands have submitted lemon sole IBTS data for the full time series. Using just these two countries gives a time-series that should be more consistent, as well as covering both northern (Scotland) and southern (the Netherlands) areas of the North Sea.

The revised IBTS–Q1 time series is shown in Figure 9.4.5, along with the full-country version and the corresponding series for IBTS–Q3 (for completeness). The fluctuations in both Q1 series occur concurrently; the Sco-Ned version is more noisy (as expected with fewer data points); and it doesn’t have such a strong step upwards in the mid-1990s, indicating that this may indeed have been caused by incomplete historical reporting.

The final SPiCT assessment then used catch data as before, and the biomass index from the Sco-Ned IBTS Q1 survey from 1968–2017 (exploratory runs showed that this performed better than runs with the index starting in 1966–67 or 1969–70). Default priors were implemented. The results are given in Figures 9.4.6 to 9.4.9.

This data configuration gives an acceptable SPiCT fit. Although the confidence intervals about the estimates of F(msy) and B(msy) are wide (Figure 9.4.6.), the uncertainties in the SPiCT estimates of F and SSB are much lower and it is clear that the likelihood of F > F(msy) or SSB < B(msy) is very low. The data cover a wide range of the production curve (Figure 9.4.7), residuals are reasonable apart from one abnormally low survey point for the Sco-Ned IBTS–Q1 survey in the early part of the time series (this seems to be a data issue; Figure 9.4.8), and the retrospective performance is extremely good (Figure 9.4.9).

On the basis of this final SPiCT analysis, WGNSSK concludes that there is sufficient evidence that F < F(msy) and B > B(msy) for lemon sole. This contradicts the tentative conclusion reached from the corresponding length-based indicators (see above), but WGNSSK recommends treating the LBIs with additional caution for this stock, given the high likelihood of a significantly dome-shaped selectivity curve for the relevant fishing gears. Therefore, WGNSSK concludes that the DLS 3.2 approach can be applied without applying a precautionary buffer.

9.5 Conclusions and further work

Application of the DLS 3.2 approach implies that catches in 2018 should be no more than 4 867 [5 484] tons. If discard rates do not change from the average of the last 3 years (2014–2016), this implies landings of no more than 3 483 [3 924] tons in each of the years 2018 and 2019.

Discard estimates were made available for the lemon sole stock for the first time in 2015, and are now been collated for the years 2013–2016. These have made the application of the DLS 3.2 advice method more justifiable than was the case when only landings data were provided. However, further backwards extension of the discard time-series would be beneficial.

The use of only the IBTS surveys is also a limitation, as the gear used may not be optimum for catching flatfish and there may thus be catchability problems. Further information on stock structure, biological data and catch at age information would be needed to be able to perform an analytic assessment. Age readings and maturity status evaluation techniques are still uncertain and under development. A benchmark assessment is planned for 2018, at which it is hoped that some or all of these issues will be addressed.

Table 9.2.1. Official lemon sole landings by area.

Year	3.a	4	7.d	Total
1950	307	3754	208	4269
1951	248	4710	314	5272
1952	243	4922	298	5463
1953	132	5440	386	5958
1954	128	3972	534	4634
1955	102	3836	141	4079
1956	96	3395	103	3594
1957	78	3419	102	3599
1958	94	3104	82	3280
1959	130	3647	82	3859
1960	153	4035	66	4254
1961	161	4900	108	5169
1962	93	4630	101	4824
1963	99	3791	66	3956
1964	134	4121	77	4332
1965	164	4949	105	5218
1966	159	5415	201	5775
1967	191	6188	331	6710
1968	185	6270	337	6792
1969	215	4470	315	5000
1970	169	3434	256	3859
1971	173	3967	357	4497
1972	168	3672	475	4315
1973	214	4568	451	5233
1974	183	4227	351	4761
1975	317	5029	33	5379
1976	361	4830	42	5233
1977	627	5661	36	6324
1978	705	6108	139	6952
1979	833	6428	260	7521
1980	722	6424	152	7298
1981	793	5933	290	7016
1982	735	7168	584	8487
1983	759	8257	491	9507
1984	595	6930	586	8111
1985	793	6435	347	7575
1986	639	5047	251	5937
1987	669	5516	310	6495
1988	642	5898	258	6798
1989	693	5967	364	7024
1990	872	6190	423	7485
1991	734	6618	428	7780
1992	952	6126	364	7442
1993	1152	5839	422	7413

1994	801	5262	695	6758
1995	712	4712	877	6301
1996	634	4737	1151	6522
1997	766	4727	563	6056
1998	865	6466	346	7677
1999	841	6316	140	7297
2000	802	5980	388	7170
2001	583	5389	483	6455
2002	518	3827	474	4819
2003	537	3688	491	4716
2004	602	3543	424	4569
2005	669	3444	350	4463
2006	417	3627	246	4290
2007	432	3892	164	4488
2008	276	3465	234	3975
2009	262	2691	441	3394
2010	351	2627	223	3201
2011	254	3365	403	4022
2012	483	3084	459	4026
2013	290	2980	491	3761
2014	315	3017	357	3689
2015	269	2873	253	3394
2016	299	3265	239	3803

Table 9.2.2. Official lemon sole landings in area 7.d by country.

Year	BEL	DNK	FRA	NED	UK	Other	Total
1950	10	0	174	0	24	0	208
1951	5	0	262	0	47	0	314
1952	10	0	188	0	100	0	298
1953	7	0	196	0	183	0	386
1954	9	0	361	0	164	0	534
1955	9	0	0	0	132	0	141
1956	4	0	0	0	99	0	103
1957	7	0	0	0	95	0	102
1958	1	0	0	0	81	0	82
1959	2	0	0	0	80	0	82
1960	4	0	0	0	62	0	66
1961	1	0	0	0	106	1	108
1962	2	0	0	0	99	0	101
1963	3	0	0	0	63	0	66
1964	5	0	0	0	72	0	77
1965	16	0	0	0	89	0	105
1966	7	0	0	0	194	0	201
1967	6	0	0	0	325	0	331
1968	8	0	0	0	329	0	337
1969	12	0	0	0	303	0	315
1970	16	0	0	0	240	0	256
1971	22	0	0	0	335	0	357
1972	18	0	0	0	457	0	475
1973	25	0	0	0	426	0	451
1974	16	0	0	1	334	0	351
1975	19	0	0	0	14	0	33
1976	24	0	0	0	18	0	42
1977	21	1	0	0	15	0	37
1978	45	2	63	0	31	0	141
1979	60	0	165	0	35	0	260
1980	33	0	109	0	10	0	152
1981	66	0	212	0	12	0	290
1982	96	0	406	1	81	0	584
1983	108	0	298	0	85	0	491
1984	110	0	367	0	109	0	586
1985	117	0	164	0	66	0	347
1986	77	0	133	0	41	0	251
1987	81	0	185	0	44	0	310
1988	74	0	155	0	29	0	258
1989	68	0	252	0	44	0	364
1990	68	0	272	0	83	0	423
1991	83	0	272	0	73	0	428
1992	66	0	176	0	122	0	364
1993	36	0	311	0	75	0	422

1994	97	0	505	0	93	0	695
1995	138	0	584	0	155	0	877
1996	213	0	720	0	218	0	1151
1997	143	0	305	0	115	0	563
1998	53	0	198	0	95	0	346
1999	50	0	0	0	90	0	140
2000	62	0	200	0	126	0	388
2001	104	0	191	0	188	0	483
2002	101	0	256	0	117	0	474
2003	128	0	251	0	112	0	491
2004	120	0	198	1	105	0	424
2005	90	0	187	2	71	0	350
2006	98	0	100	0	48	0	246
2007	70	0	72	1	21	0	164
2008	140	0	46	3	45	0	234
2009	149	0	176	9	108	0	442
2010	101	0	85	5	32	0	223
2011	153	0	178	15	57	0	403
2012	171	0	167	20	0	0	358
2013	176	0	179	26	110	0	491
2014	162	0	108	14	72	0	357
2015	123	0	84	5	41	0	253
2016	115	0	69	9	47	0	240

Table 9.2.3. Official lemon sole landings in ICES subarea 4 by country.

Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total
1950	112	435	139	31	156	0	2855	26	3754
1951	115	845	90	21	167	0	3430	42	4710
1952	98	391	227	26	168	0	3953	59	4922
1953	73	409	189	18	132	0	4590	29	5440
1954	2	272	177	24	112	0	3368	17	3972
1955	49	311	0	15	78	0	3374	9	3836
1956	48	222	0	19	58	0	3034	14	3395
1957	39	249	0	24	64	0	3032	11	3419
1958	30	171	0	13	43	0	2835	12	3104
1959	85	242	0	40	43	0	3226	11	3647
1960	155	577	0	46	67	0	3178	12	4035
1961	286	488	0	79	102	0	3934	11	4900
1962	175	501	0	54	106	0	3794	0	4630
1963	365	222	0	36	71	0	3097	0	3791
1964	484	358	0	62	75	0	3142	0	4121
1965	562	385	0	91	93	0	3818	0	4949
1966	594	548	0	98	65	0	4110	0	5415
1967	601	791	0	136	61	0	4599	0	6188
1968	422	775	0	96	34	0	4943	0	6270
1969	292	639	0	80	36	0	3423	0	4470
1970	241	307	0	52	58	0	2776	0	3434
1971	348	514	0	54	122	0	2929	0	3967
1972	423	530	0	59	130	0	2530	0	3672
1973	566	478	0	73	217	16	3218	0	4568
1974	486	447	0	59	269	0	2966	0	4227
1975	748	521	0	83	299	0	3367	11	5029
1976	493	506	0	68	308	0	3443	12	4830
1977	618	321	0	71	262	0	4387	2	5661
1978	760	517	28	54	231	0	4518	0	6108
1979	674	876	136	41	390	0	4308	3	6428
1980	484	599	102	49	303	0	4885	2	6424
1981	555	605	237	39	412	0	4084	1	5933
1982	879	670	419	52	759	0	4386	3	7168
1983	1122	735	402	28	1009	0	4957	4	8257
1984	1144	567	344	22	0	0	4850	3	6930
1985	989	555	157	26	0	0	4703	5	6435
1986	511	577	103	16	0	0	3839	1	5047
1987	448	742	174	14	0	0	4137	1	5516
1988	539	639	184	14	301	0	4220	1	5898
1989	441	828	176	40	397	0	4083	2	5967
1990	491	1007	208	49	0	0	4431	4	6190
1991	544	1099	250	41	0	12	4666	6	6618
1992	577	1149	177	30	0	13	4175	5	6126
1993	525	966	240	37	0	9	4059	3	5839

1994	436	597	436	27	0	11	3754	1	5262
1995	588	585	412	70	0	9	3046	2	4712
1996	592	547	534	67	0	18	2976	3	4737
1997	504	499	224	76	0	29	3391	4	4727
1998	815	796	197	149	838	23	3643	5	6466
1999	662	1015	0	62	681	24	3866	6	6316
2000	711	1277	184	72	492	17	3222	5	5980
2001	694	1281	191	77	451	22	2666	7	5389
2002	604	971	190	116	402	17	1521	6	3827
2003	517	1008	239	136	369	16	1399	4	3688
2004	667	1113	120	81	355	12	1192	3	3543
2005	595	1057	102	85	402	13	1188	2	3444
2006	552	968	57	183	412	13	1440	2	3627
2007	542	1136	65	143	367	23	1610	6	3892
2008	527	925	47	120	434	26	1383	4	3466
2009	389	898	88	64	294	31	927	2	2693
2010	375	821	32	102	323	35	935	2	2625
2011	387	999	56	96	641	27	1157	2	3365
2012	406	999	34	61	587	30	0	2	2119
2013	527	649	27	67	479	16	1214	2	2981
2014	648	626	27	63	425	23	1202	3	3017
2015	425	794	16	82	423	12	1116	3	2871
2016	448	1054	15	82	443	23	1196	5	3266

Table 9.2.4. Official landings in area 3.a by country.

Year	BEL	DNK	GER	NED	SWE	Other	Total
1950	0	100	1	0	206	0	307
1951	0	74	1	0	173	0	248
1952	0	64	0	0	179	0	243
1953	0	35	0	0	97	0	132
1954	0	33	0	0	95	0	128
1955	0	29	0	0	73	0	102
1956	0	33	0	0	63	0	96
1957	0	27	0	0	51	0	78
1958	0	38	0	0	56	0	94
1959	0	71	0	0	59	0	130
1960	0	95	1	0	57	0	153
1961	0	90	0	0	71	0	161
1962	0	92	1	0	0	0	93
1963	0	99	0	0	0	0	99
1964	0	133	1	0	0	0	134
1965	0	163	1	0	0	0	164
1966	0	159	0	0	0	0	159
1967	0	189	1	0	0	1	191
1968	0	184	0	0	0	1	185
1969	0	215	0	0	0	0	215
1970	0	169	0	0	0	0	169
1971	0	173	0	0	0	0	173
1972	0	168	0	0	0	0	168
1973	0	214	0	0	0	0	214
1974	0	183	0	0	0	0	183
1975	0	263	1	1	52	0	317
1976	10	294	1	19	37	0	361
1977	9	528	2	37	51	0	627
1978	4	628	2	12	59	0	705
1979	7	704	1	10	111	0	833
1980	12	622	0	0	87	1	722
1981	1	710	0	3	75	4	793
1982	2	647	0	9	77	0	735
1983	3	636	0	10	110	0	759
1984	6	525	0	0	64	0	595
1985	0	729	0	0	64	0	793
1986	7	576	0	0	56	0	639
1987	24	577	0	0	68	0	669
1988	11	569	0	6	56	0	642
1989	8	610	0	0	75	0	693
1990	16	782	0	0	74	0	872
1991	11	640	0	0	83	0	734
1992	22	793	0	0	120	17	952
1993	14	980	4	0	141	17	1156

1994	10	648	2	0	127	16	803
1995	27	576	2	0	91	18	714
1996	0	513	1	0	97	24	635
1997	0	628	2	0	115	23	768
1998	0	743	3	0	100	22	868
1999	0	731	3	0	88	22	844
2000	0	722	1	0	65	15	803
2001	0	511	1	0	53	19	584
2002	0	457	4	0	41	20	522
2003	0	451	6	30	35	21	543
2004	0	472	5	82	29	19	607
2005	0	468	5	147	38	16	674
2006	0	321	8	40	32	16	417
2007	0	374	5	16	18	19	432
2008	0	239	7	3	15	12	276
2009	0	233	4	1	15	9	262
2010	0	286	3	35	19	7	350
2011	0	223	0	0	12	16	254
2012	0	446	3	0	15	18	482
2013	0	259	3	5	10	12	289
2014	0	276	7	12	14	6	315
2015	0	250	4	0	9	6	269
2016	0	265	5	16	7	6	299

Table 9.2.5. ICES estimates of landings and discards by country, for areas 3.a, 4 and 7.d and years 2013–2016.

Area 7.d

Year	ICES estimates of landings							ICES estimates of discards						
	BEL	DNK	FRA	NED	UK	Other	Total	BEL	DNK	FRA	NED	UK	Other	Total
2013	174	0	178	0	110	0	463	51	0	43	0	19	0	113
2014	163	0	0	0	72	0	234	72	0	0	0	26	0	99
2015	123	0	85	10	42	0	260	46	0	46	4	17	0	113
2016	158	0	69	8	47	0	281	40	0	19	2	4	0	64

Area 4

Year	ICES estimates of landings									ICES estimates of discards								
	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total
2013	523	662	26	66	0	17	1213	2	2509	32	25	6	179	494	4	361	0	1102
2014	649	637	27	63	361	23	1202	3	2964	297	44	10	15	556	10	493	1	1426
2015	444	815	17	82	426	12	1120	3	2919	54	29	5	547	159	5	447	1	1248
2016	405	1055	15	82	420	23	1195	5	3200	20	22	2	76	500	5	471	1	1097

Area 3.a

Year	ICES estimates of landings							ICES estimates						
	BEL	DNK	GER	NED	SWE	Other	Total	BEL	DNK	GER	NED	SWE	Other	Total
2013	0	267	4	0	10	12	293	0	43	1	0	21	3	67
2014	0	283	7	0	14	6	310	0	61	1	0	22	3	87
2015	0	257	5	25	9	6	302	0	53	2	11	16	3	84
2016	0	265	5	20	7	6	302	0	43	0	4	18	1	67

Table 9.4.1. Length distributions for 2016, from InterCatch submissions. Values indicate raised fish numbers at length.

MEANLENGTH	2016
80	22883
90	13825
100	0
110	5771
120	255150
130	336875
140	214288
150	613630
160	370667
170	669618
180	1161291
190	1627758
200	1645055
210	1598237
220	1058275
230	1100447
240	911984
250	678935
260	676551
270	689199
280	796853
290	1060384
300	1491220
310	1207990
320	1125072
330	919879
340	563357
350	452161
360	354490
370	252352
380	163855
390	112424
400	63314
410	38280
420	15700
430	7665
440	5163
450	2316
460	1509
470	376
480	0
490	0
500	232

Table 9.4.2. ICES estimates of landings and discards for areas 3.a, 4 and 7.d. Note that a) landings for 2013–2016 are ICES estimates, while landings for 1966–2012 are official statistics, and b) the discard estimates for 2013–2016 (highlighted) are based on observations, while those for 1966–2012 are estimated by applying the mean 2013–2016 discard rate to official landings.

YEAR	CATCH	LANDINGS	DISCARDS
1966	7971	5775	2196
1967	9261	6710	2551
1968	9375	6792	2583
1968	6901	5000	1901
1970	5326	3859	1467
1969	6207	4497	1710
1972	5956	4315	1641
1970	7223	5233	1990
1974	6571	4761	1810
1971	7424	5379	2045
1976	7223	5233	1990
1972	8729	6324	2405
1978	9595	6952	2643
1973	10381	7521	2860
1980	10073	7298	2775
1974	9684	7016	2668
1982	11714	8487	3227
1975	13122	9507	3615
1984	11195	8111	3084
1976	10455	7575	2880
1986	8194	5937	2257
1977	8965	6495	2470
1988	9383	6798	2585
1978	9695	7024	2671
1990	10331	7485	2846
1979	10738	7780	2958
1992	10272	7442	2830
1980	10232	7413	2819
1994	9328	6758	2570
1981	8697	6301	2396
1996	9002	6522	2480
1982	8359	6056	2303
1998	10596	7677	2919
1983	10072	7297	2775
2000	9896	7170	2726
1984	8909	6455	2454
2002	6651	4819	1832
1985	6509	4716	1793
2004	6306	4569	1737
1986	6160	4463	1697
2006	5921	4290	1631

1987	6194	4488	1706
2008	5486	3975	1511
1988	4685	3394	1291
2010	4418	3201	1217
1989	5551	4022	1529
2012	5557	4026	1531
1990	4546	3265	1281
2014	5120	3508	1612
1991	4926	3481	1445
2016	4802	3784	1018

Table 9.4.3. Mature biomass index (kg/hour) calculated from IBTS–Q1 data, IBTS–Q3 data, and a subset of IBTS–Q1 data covering submissions by only Scotland and the Netherlands.

	IBTS–Q1	IBTS–Q3	IBTS–Q1 SCO NED
1966	0.327		0.052
1967	0.259		0.108
1968	0.453		1.068
1969	0.664		1.487
1970	0.44		0.935
1971	0.072		0.083
1972	0.181		0.341
1973	0.975		1.367
1974	0.573		1.552
1975	0.402		1.653
1976	0.279		0.971
1977	0.596		0.759
1978	0.565		1.25
1979	0.488		1.166
1980	0.321		0.629
1981	0.963		1.668
1982	0.853		1.666
1983	1.61		1.418
1984	1.629		1.667
1985	1.273		0.581
1986	1.467		1.128
1987	1.313		0.825
1988	1.357		1.15
1989	1.583		1.88
1990	1.548		2.133
1991	1.171	3.373	1.263
1992	1.542	3.987	2.162
1993	1.927	2.369	1.856
1994	1.185	3.048	1.37
1995	1.157	3.557	1.32
1996	1.381	3.317	1.293
1997	1.179	3.438	1.005
1998	1.733	4.246	2.33
1999	1.787	4.382	2.798
2000	1.659	4.557	2.618
2001	1.305	3.602	1.441
2002	1.785	3.748	1.817
2003	1.671	3.969	1.996
2004	1.683	3.125	1.363
2005	1.22	2.958	1.283
2006	1.02	3.452	1.074
2007	1.331	3.9	1.943
2008	1.331	2.927	1.747

2009	0.862	3.293	0.79
2010	0.954	3.854	1.19
2011	1.265	4.106	2.057
2012	1.895	4.474	2.383
2013	1.249	2.575	1.988
2014	0.968	2.766	0.934
2015	1.019	2.668	1.179
2016	1.097	2.985	1.068
2017	0.995		0.725

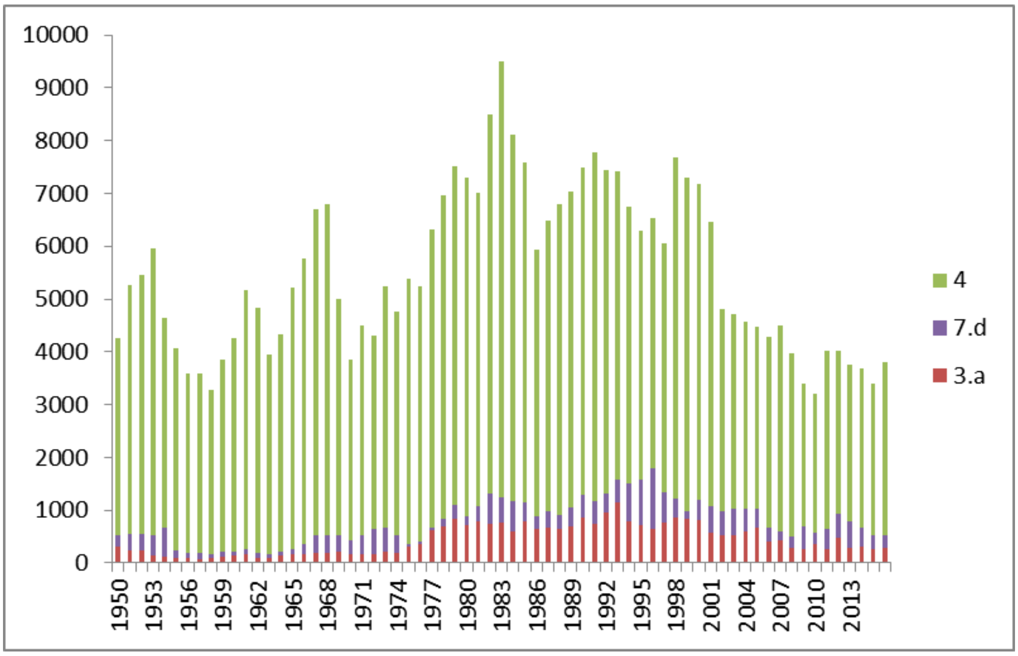


Figure 9.2.1. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tonnes) of lemon sole by area in the greater North Sea.

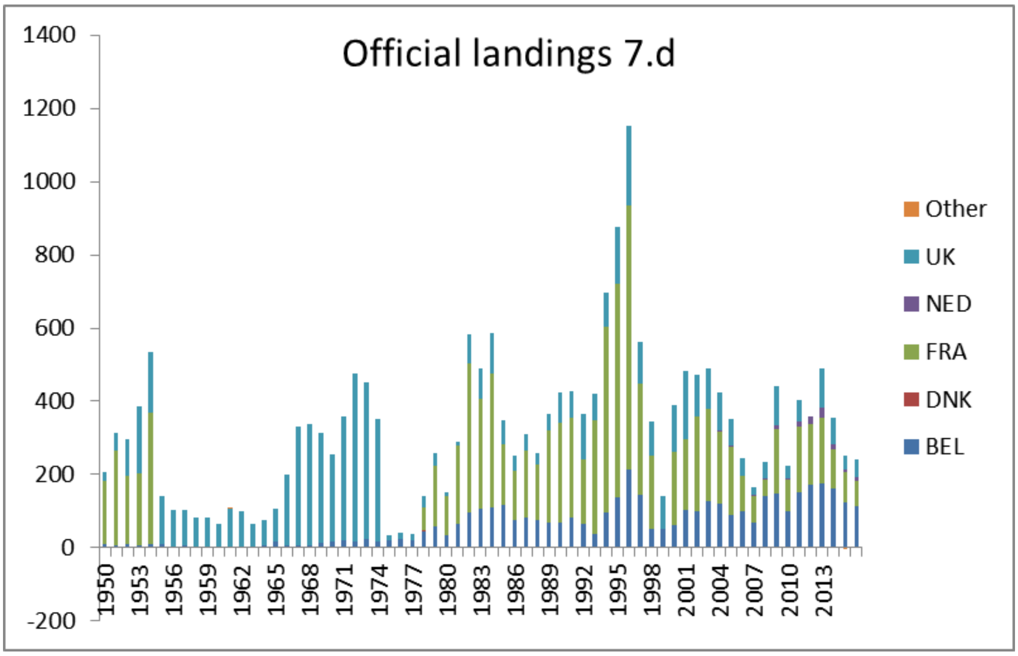


Figure 9.2.2. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tons) of lemon sole in area 7.d by country. For 2012, official landings data for UK are missing.

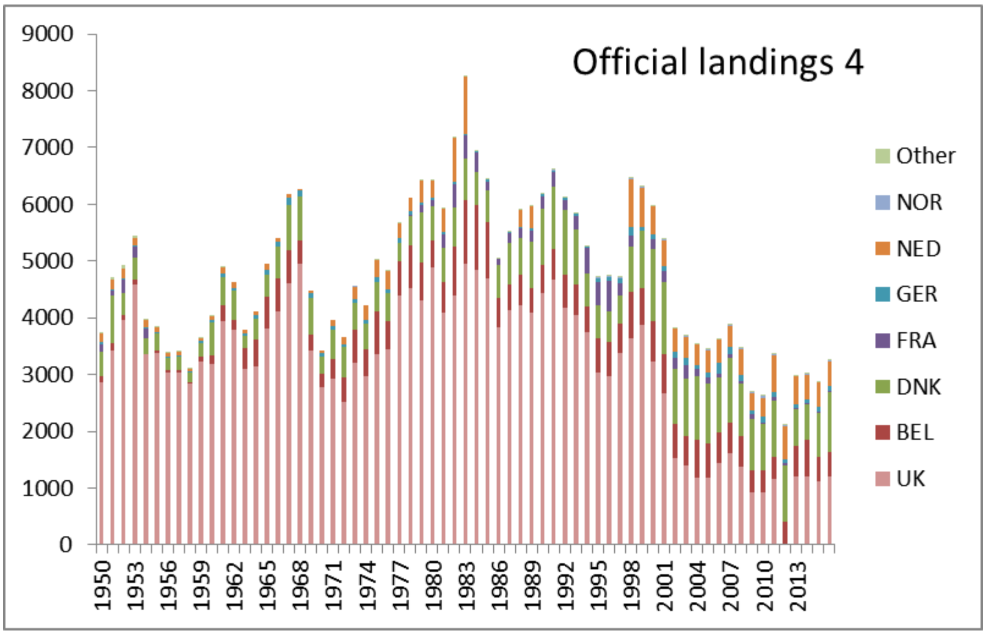


Figure 9.2.3. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tons) of lemon sole in area 4 by country. For 2012 official landings data for UK are missing.

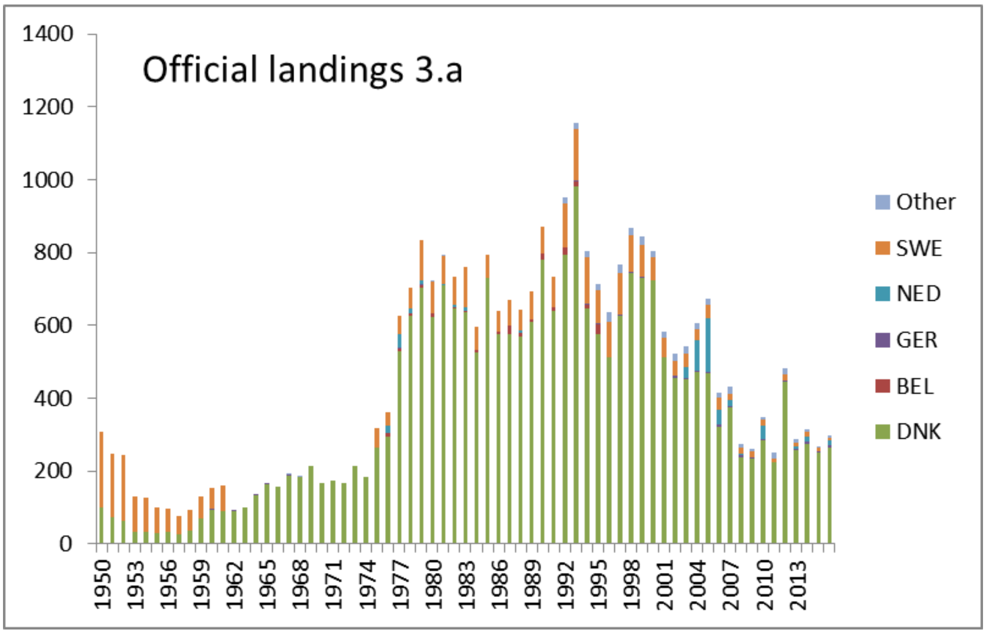


Figure 9.2.4. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Official landings (tons) of lemon sole in area 3.a by country.

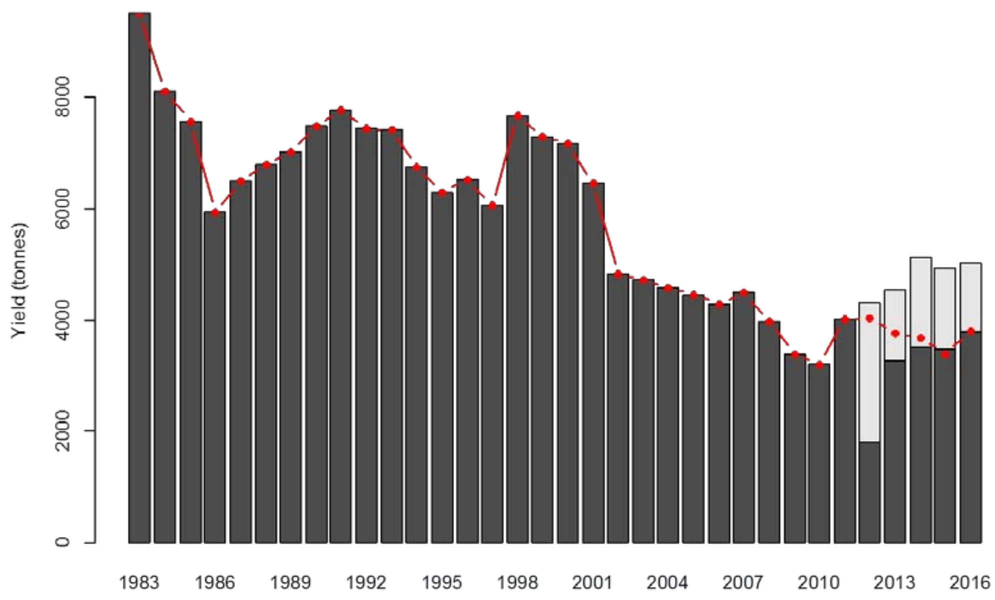


Figure 9.2.5. Lemon sole in Subarea 4, and Divisions 3.a and 7.d. Time-series of official landings (red dots) along with WG estimates of landings (dark bars) and discards (light bars). Note that discard estimates for 2012 were not provided by all relevant countries, and are therefore thought to be unrepresentative.

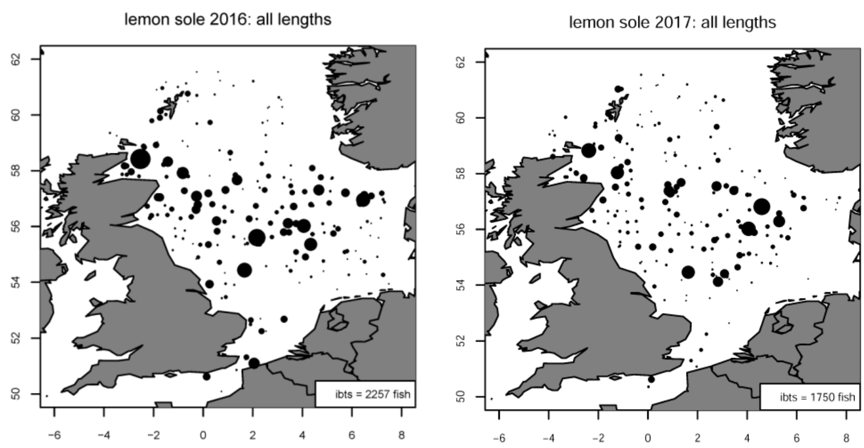


Figure 9.3.1. Distribution of lemon sole in the greater North Sea derived from IBTS–Q1 data (2016 and 2017). The sizes of the circles are proportional to abundance (all lengths).

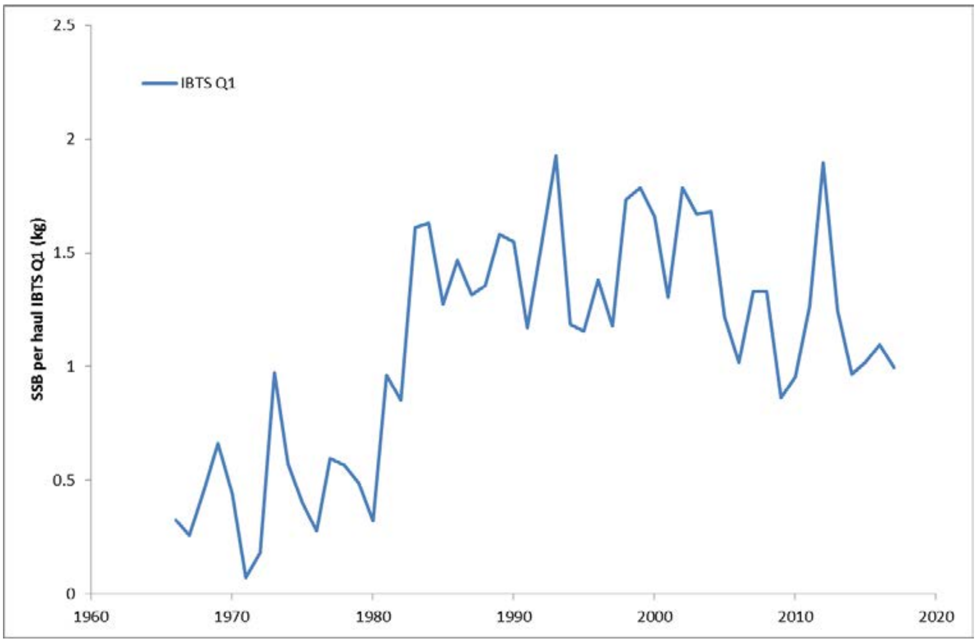


Figure 9.4.1. Index of mature biomass (kg/hr) for Subarea 4 derived from IBTS–Q1 data.

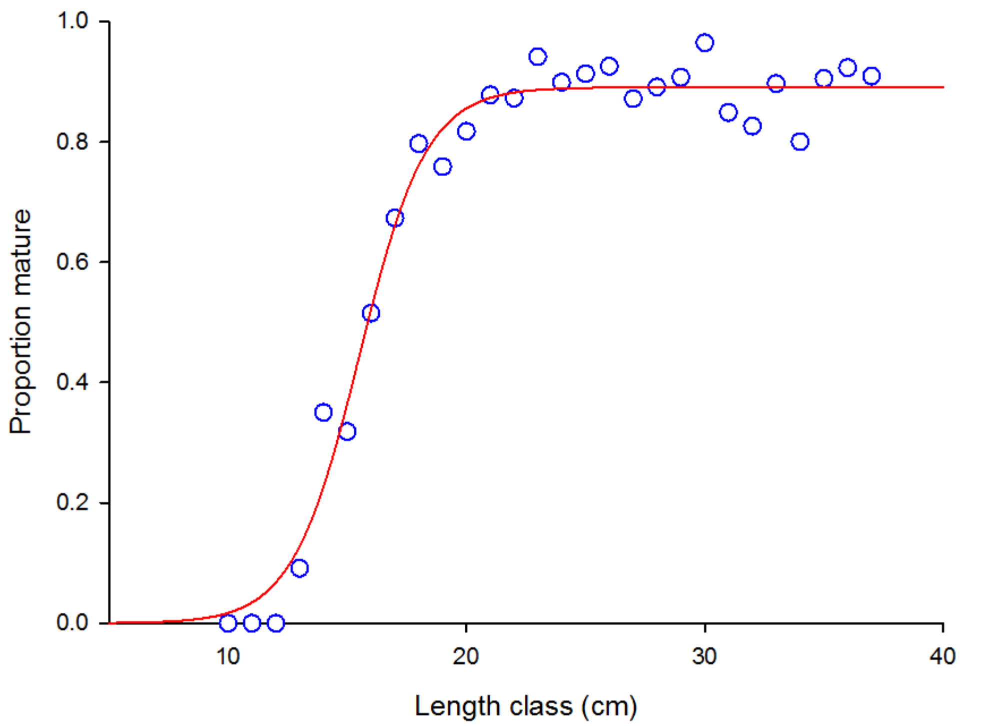


Figure 9.4.2. Length based maturity ogive for lemon sole derived from IBTS–Q1 and Q3 data (2006–2012).

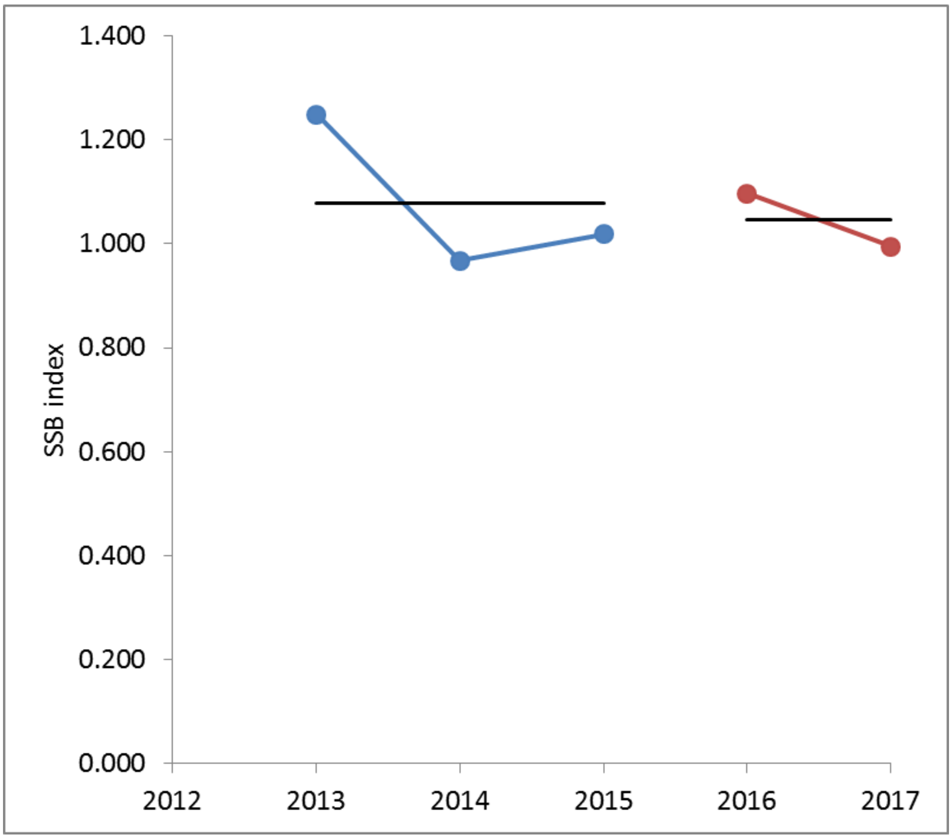


Figure 9.4.3. Application of DLS 3.2 rule for lemon sole, using the last five years of the biomass index given in Figure 9.4.1.

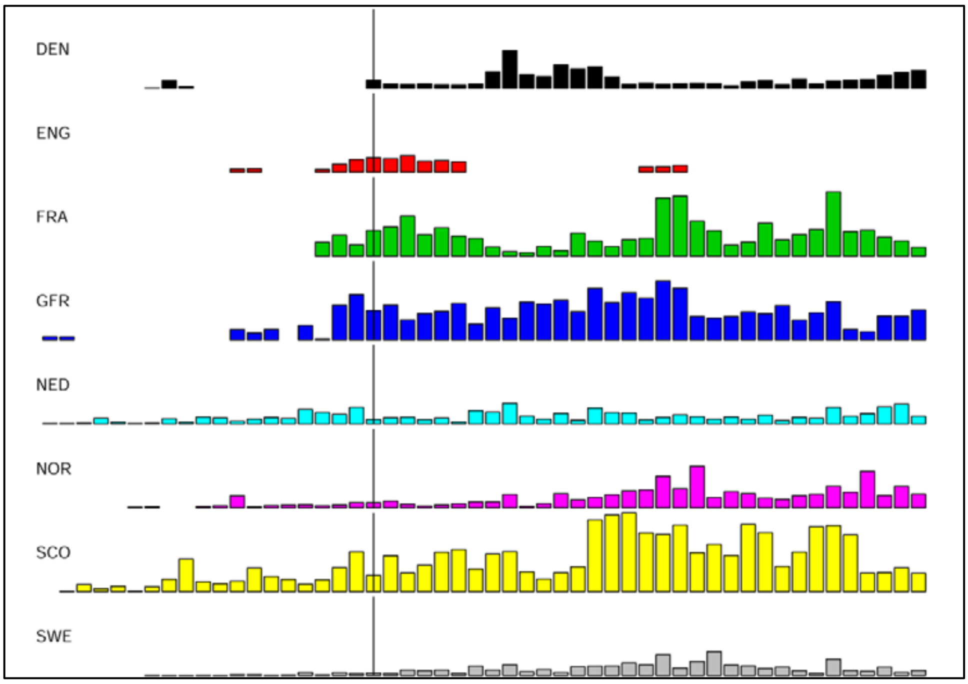


Figure 9.4.4. Time series summary of lemon sole reported from national parts of the IBTS–Q1 survey. The bars indicates the number of fish reported in each year for each country, from 1966 to 2017. The vertical line shows 1985.

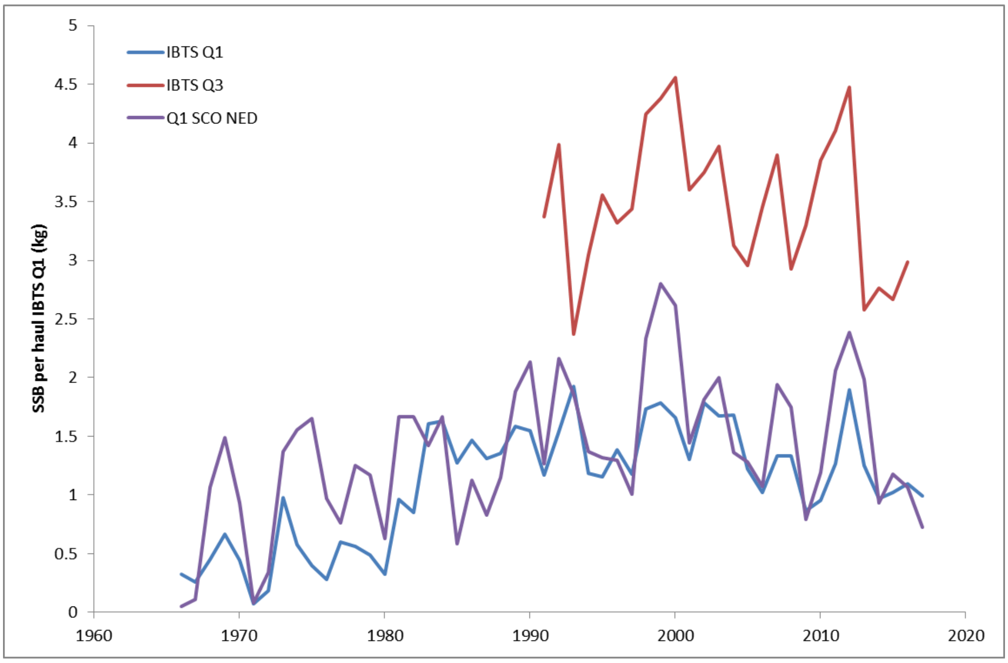


Figure 9.4.5. Index of mature biomass (kg/hr) for Subarea 4 derived from IBTS–Q1 data, for all countries and for just Scotland and the Netherlands, and for IBTS–Q3.

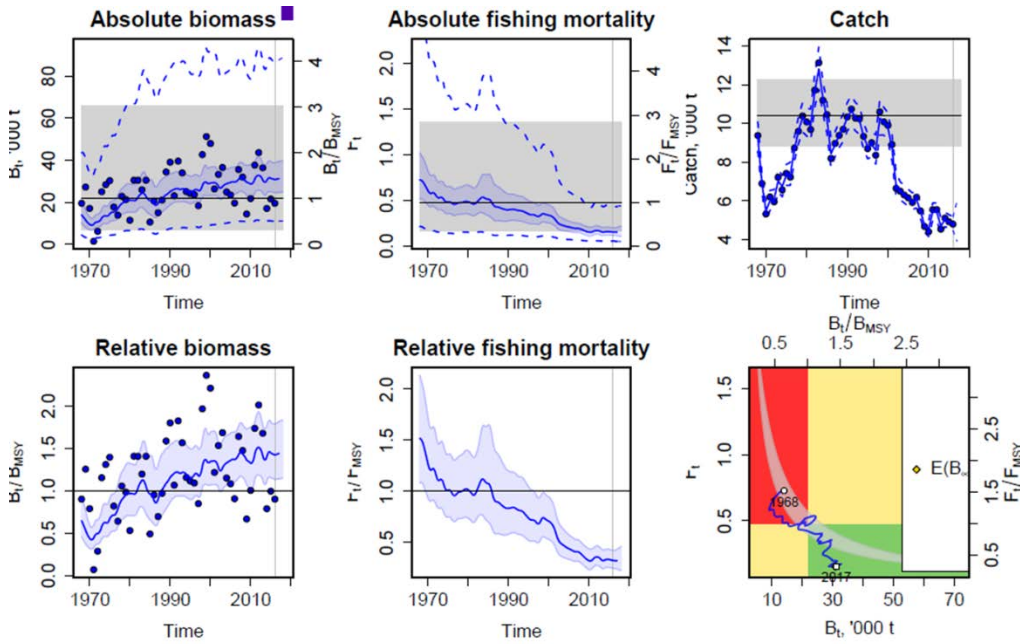


Figure 9.4.6. SPiCT output for North Sea lemon sole. Model results. Vertical grey lines show the last historical year, beyond which model forecasts are given. Top row: absolute biomass and *F* estimates, and fitted catch. Bottom row: relative biomass and *F*, and a Kobe plot comparing biomass and *F*. Dashed lines are 95% CI bounds for absolute estimated values, shaded blue regions are 95% CIs for relative estimates, grey regions are 95% CIs for estimated absolute reference points (horizontal lines), and solid circles are observations. The grey area in the Kobe plot (bottom right) summarises the uncertainty in the relative biomass and *F* estimates.

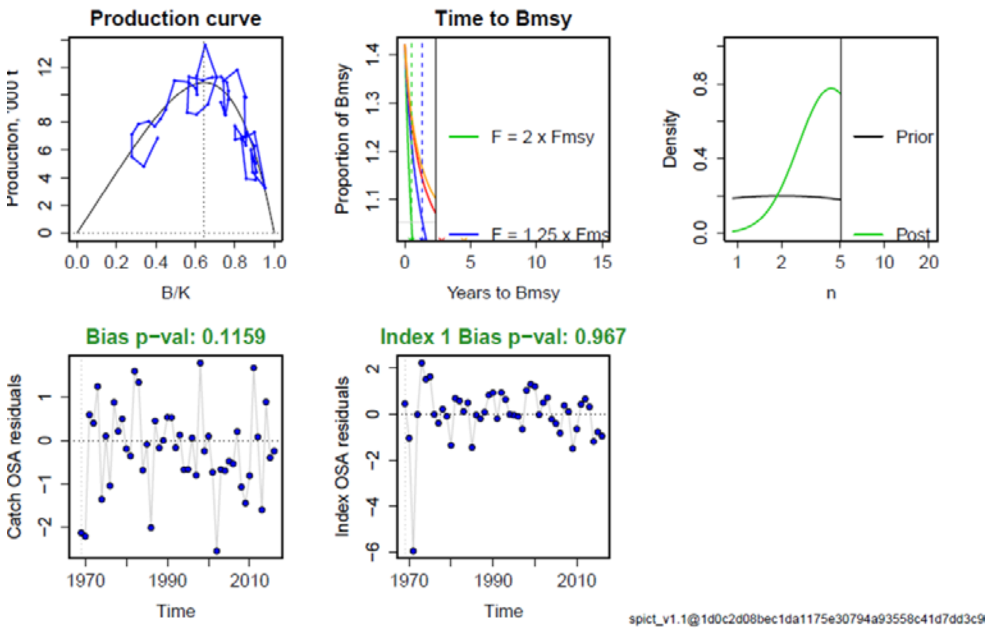


Figure 9.4.7. SPiCT output for North Sea lemon sole. Model results. Top row: Production curve, estimated time to BMSY, and prior and posterior parameter distributions. Bottom row: Catch and survey (index) residuals.

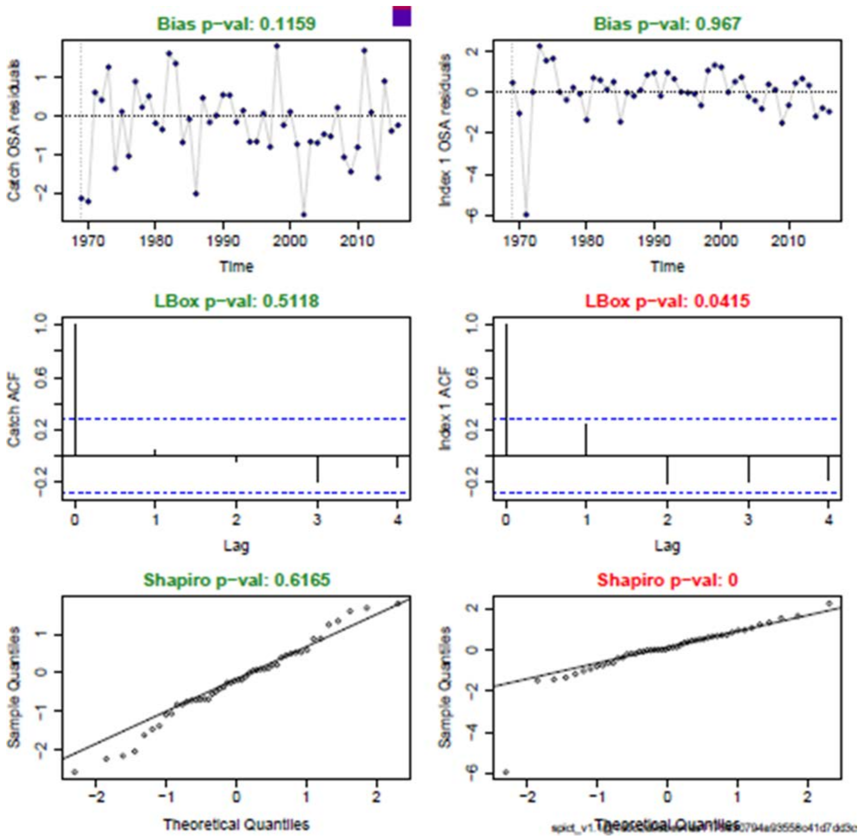


Figure 9.4.8. SPiCT output for North Sea lemon sole. Model diagnostics: residuals (top), autocorrelation functions (middle), and QQ distribution plots (bottom).

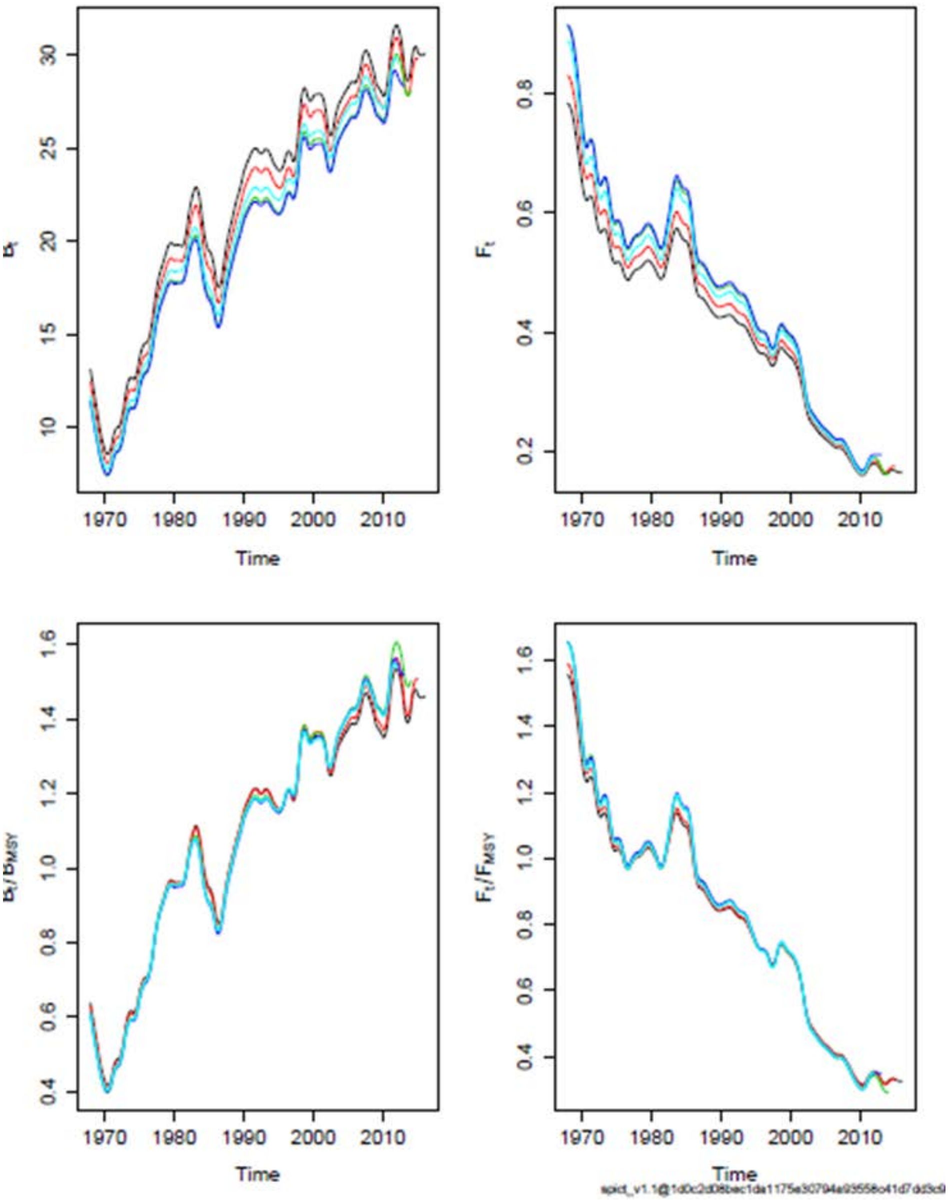


Figure 9.4.9. SPiCT output for North Sea lemon sole. Retrospective analysis.

10 Norway lobster (*Nephrops* spp.) in Division 3.a (Skagerrak, Kattegat)

10.1 General comments relating to all *Nephrops* stocks (3.a and 4)

10.1.1 Introduction

Nephrops stocks have previously been identified by WGNEPH on the basis of their population distribution and characteristics, and established as separate Functional Units. The Functional Units (FU) are defined by the groupings of ICES statistical rectangles given in Table 10.1.1 and illustrated in Figure 10.1.1. The statistical rectangles making up each FU encompass the distribution of mud sediment on which *Nephrops* live. There are two FUs in Division 3.a and nine FUs in Subarea 4. At the 2010 WG, it was noted that a significant and increasing proportion of *Nephrops* landings were being taken outside the previously defined FUs in Subarea 4. This has led to the introduction of a new FU (FU 34) covering the Devil's Hole. Additional catches of *Nephrops* are also taken from smaller, isolated pockets of mud distributed throughout the ICES divisions (e.g. off the east coast of Scotland at Arbroath). Management of *Nephrops* currently operates at the ICES Subarea/Division level.

Functional Units were previously aggregated by WGNEPH into a series of nominal Management Areas (MA) intended to provide a pragmatic solution for more localized management. In 2008 the Working Group agreed that this process had served no useful purpose and should be discontinued.

MSY estimation for *Nephrops* stocks is complicated by the absence of an age-based analytical assessment. The process for determining suitable F_{MSY} proxies for *Nephrops* stocks can be found in Section 10.2.3.2 under "MSY considerations".

10.1.2 A new approach for data poor *Nephrops* stocks

The WKLIFE considered the following *Nephrops* stocks: FU 5 (Botney Gut–Silver Pit), 10 (Noup), 32 (Norwegian Deep), and 33 (Off Horns Reef). All four stocks were considered to belong to category 6 (data-limited stocks under the original categorization of WKLIFE ICES 2012a) including stocks for which only landings data are available. The working group agreed with this classification. WKLIFE considered the available data for these stocks. An L_{50} value (Length at 50% maturity) exists for *Nephrops* in FU 5, otherwise there is no information on growth parameters or maturity. The newly established functional unit 34 (Devil's Hole) is also a category 6 data poor stock.

According to WKLIFE, SPR and F_{SPR} reference points have been identified as proxies for SSB_{MSY} and F_{MSY} respectively. These reference points could be used to inform risk assessment approaches applied to category 6 and 7 stocks (original WKLIFE categorization, ICES 2012a) and can be calculated on the basis of life history information and knowledge of selection patterns. Life-history traits (LHTs) should be compiled by stock experts in the relevant assessment working groups. LHTs are available from a number of sources including Fish-Base, literature not (yet) accounted in FishBase, grey literature, and recent estimates based on DCF data collection.

In 2014 the working group introduced a different approach to previous years in order to provide an estimated guidance of the biomass in FUs 5, 10, 32, 33, and 34 and consider different harvest rates. Using FU area (calculated from information on the extension of suitable habitat and/or extent of *Nephrops* fisheries), mean discard percentage from all years of data, and mean weight in catches, tables of harvest rates were calculated for each of the five data poor functional units, using a range of landings (100 t to maximum landings observed for each stock) and densities (0.05–0.8 animals m^{-2}). The density range comes from the North Sea/Skagerrak stocks for which UWTV surveys exist. For each data poor FU, the mean and maximum of the landings time series is marked in the table. Harvest rates larger than 10 % are marked red. For each stock the most likely densities are considered based on information from neighbouring FUs.

This approach enables the working group to consider the sustainability of historic landings as well as to present guidance to landings within safe biological limits. It should be noted that WKLIFE (via the RGLIFE meeting in 2012) re-categorized stocks, and FUs 5, 10, 32, 33 and 34 are now considered Category 4 stocks (stocks for which reliable catch data are available, ICES 2012b).

The presentation of specific data and assessments relating to the Divisions 3.a and 4 FUs can be found in the WGNSSK report sections 3 and 4, respectively.

10.2 *Nephrops* in Subarea 3a

10.2.1 General

At present there are two functional units in Division 3.a: Skagerrak (3.a.20) and Kattegat (3.a.21). This separation was based on observed differences between Skagerrak and Kattegat regarding *Nephrops* size composition in catches in the 1980s and 1990s. However, the distribution of *Nephrops* is almost continuous from southern Kattegat into Skagerrak, and the exchange of pelagic larvae between the southern and northern areas is very likely. With the longer data series now available, it seems the differences in size composition between the two areas are more likely to be random or caused by factors from fishing operations. The assessment is therefore conducted on *Nephrops* in 3.a as one stock.

Ecosystem aspects

Nephrops live in burrows in suitable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder in the burrows (Loo *et al*., 1993). This ability may contribute to maintaining a high production of this species in IIIa, due to increased organic production. *Nephrops* have recently been found to have a high prevalence of plastics which may have implications for the health of the stock (Murry and Cowie, 2011).

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of IIIa in late summer, where unusually high catch rates of *Nephrops* were observed. The increasing amount of dead specimens in the catches led to the conclusion of severe oxygen deficiency in especially the Kattegat (3.a.21) in late 1988 (Bagge *et al*., 1990).

No information is available on the extent to which larval mixing occurs between *Nephrops* stocks, but the similarity in stock indicator trends between 3.a.20 and 3.a.21 for both Denmark and Sweden indicates that recruitment has been similar in both areas. These observations suggest they may be related to environmental influences.

ICES Advice

The most recent advice for *Nephrops* in IIIa was given in 2016. ICES concluded that:

´The stock size is considered to be stable. The estimated harvest rate for this stock is currently below FMSY.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area 3.a was increased from 5 318 tons in 2015 to 11 001 tons in 2016 and to 1 212715 tons in 2017. The large increase in quota 2015 to 2016was due to the fact that the EU shifted from providing landings advice to providing catch advice. The minimum conservation reference size (previously referred to as minimum landings size) for *Nephrops* in area 3.a was reduced in 2016 from 40 to 32 mm carapace length. The historically large MLS led to a high discard ratios (discards/ discards + landings) around 50%, and the discard proportion 2016 was decreased to 12% of the catch (in numbers) in IIIa consisted of undersized individuals (Figure 10.2.1.1). The reduction in MLS has reduced the proportion of the catch discarded considerably. Furthermore, it is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. A discard ban was implemented in EU waters from the 1st January 2015. The discard ban became applicable to *Nephrops* from the 1st January 2016, however an exemption for high survivability was introduced for one year. New technical measures have also been agreed upon and have been implemented since the 1st February 2013.

Swedish gear regulations since 2004 imply that it is mandatory to use a 35 mm species selective grid together with an 8 m full square-mesh codend of 70 mm and extension piece when trawling for *Nephrops* in Swedish national waters. Additionally, the Danish gear regulations since 2011 imply a mandatory use of either the grid or the use of the SELTRA trawl which compromise a 90 mm cod end with either a square-mesh panel (180 mm in the Kattegat and 140 mm in the Skagerrak) or 270 mm diamond mesh panel. In Article 11 in the cod recovery plan, member states may apply for unlimited number of days when using the species selective grid trawl.

10.2.2 Data available from Skagerrak (FU3) and Kattegat (FU4)

Landings

Division IIIa includes FU 3 and 4, which are assessed together. Total *Nephrops* landings by FU and country are shown in Table 10.2.1.1 and Table 10.2.1.2.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 70 % and 28 % by weight of the landings in 2016, respectively. Landings by the Swedish creel fishery represented 13–18 % of the total Swedish *Nephrops* landings from the Skagerrak in the period 1991 to 2002. Since 2002 creel catches have been steadily increasing and have in 2009 to 2016 accounted for more than 30% of Swedish Skagerrak landings (Table 10.2.2.1). In the early 1980s, total *Nephrops* landings from the Skagerrak increased from around 1000 t to just over 2 670 tons. Since then they have been fluctuating around a mean of 2500 t (Figure 10.2.2.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2016, Denmark accounted for about 72 % of total landings in FU4, while Sweden took 28 % (Table 10.2.2.5). Minor landings have been taken by Germany (< 1%).

After a decline in the observed landings in 1994, total *Nephrops* landings from the Kattegat increased again until 1998 and have fluctuated around 1 500 tons. However, since 2006 the landings have increased and were in 2010 the highest on record over the 50 year period (Figure 10.2.2.4). Since 2010, landings show a decreasing trend.

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991-2016. In the beginning of the time series, the Swedish data can be considered as being the most complete, since sampling took place regularly throughout the time period and usually covered the whole year. Trends in mean size in catch and landings for Skagerrak are shown in Figure 10.2.2.2 and Table 10.2.2.4. Mean sizes for landings are fluctuating without trend. Mean size for undersized show an increasing trend since 2005.

For Kattegat, size distributions of both the landings and discards are available from Sweden for 1990–2016, and from Denmark for 1992–2016. The at-sea-sampling intensity has generally increased since 1999. The Danish sampling intensity was low in 2007 and 2008, but was normalized in 2009 to 2016. Information on mean size is shown in Figure 10.2.2.5 and Table 10.2.2.8. Notice, that except for small mean sizes from 1993 to 1996 all categories have since been fluctuating without trend.

In earlier years, the Swedish discard samples were obtained by agreement with selected fishermen, and this might have tempted fishermen to bias the samples. However, the reliability of the catch samplings was cross-checked by special discard sampling projects in both the Skagerrak and the Kattegat. In recent years, the Swedish *Nephrops* sampling has been carried out by onboard observers in both Skagerrak and Kattegat. In 1991, a biological sampling programme of the Danish *Nephrops* fishery was started on board fishing vessels in order to also cover the discards in this fishery. Due to its high cost and the lack of manpower, Danish sampling intensity in the early years was in general not satisfactory, and seasonal variations were not often adequately covered. The Norwegian *Nephrops* fishery is small and has not been sampled.

Natural mortality, maturity at age and other biological parameters

In previous analytical assessments (when Length Cohort Analyses were performed, see e.g. WGNEPH 2003), natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females. Discard survival was assumed to be 0.25 for both males and females (after Gueguen & Charuau, 1975, Redant & Polet, 1994, and Wileman *et al.* 1999).

Growth parameters are as follows:

Males:	$L\infty$ = 73 mm CL, k = 0.138.
Immature females:	$L\infty$ = 73 mm CL, k = 0.138.
Mature females:	$L\infty$ = 65 mm CL, k = 0.10, Size at 50% maturity = 29 mm CL.

Growth parameters for males were taken from Ulmestrand and Eggert (2001) and female growth parameters have been assumed to be similar to those of Scottish *Nephrops* stocks.

Data on size at maturity for males and females were presented at the ICES Workshop on *Nephrops* Stocks in January 2006 (ICES WKNEPH, 2006).

Catch and effort data–FU3

Effort data for the Swedish fleet are available from logbooks for 1978–2016 (Figure 10.2.2.1 and Table 10.2.2.2). During the period 1998 to 2005, twin trawlers shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in lpue during this period (Table 10.2.2.2). Since 2005, lpue for twin trawls has increased. The lpue for single trawls has shown and increasing trend throughout the entire time series. The long term trend in lpues is similar in the Swedish and Danish fisheries (Figure 10.2.2.1).

Total Swedish trawl effort shows a decreasing trend since 1992 and has been fluctuating without trend since 2003. From 2007 onwards, total Swedish trawl effort has been estimated from lpues from the single trawl with a grid (targeting only *Nephrops*).

Danish effort figures for the Skagerrak (Table 10.2.2.3 and Figure 10.2.2.1) were estimated from logbook data. For the whole period, it is assumed that effort is exerted mainly by vessels using twin trawls. The overall trend in effort for the Danish fleet is similar to that in the Swedish fishery. After having been at a relatively low level in 1994–1998, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2016. Also the trend in lpue is similar to that in the Swedish single trawl fishery, however with a much more marked increase in the Danish lpue for 2007 and 2008. This high lpue level is likely to be a consequence of the national (Danish) management system introduced in 2007.

It has not been possible to explicitly incorporate 'technological creeping' in a further evaluation of the Danish effort data. However, since 2000 the Danish logbook data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/lpue, e.g. vessel size (Figure 10.2.2.3).

Catch and effort data–FU4

Swedish total effort has been relatively stable over the period 1978–90. Effort increased from 1990 to 1993, followed by a decrease to 1996. During the last 20 years effort has remained relatively stable, except for 2007 and 2008 where effort increased (Figures 10.2.2.4 and Table 10.2.2.6). Figures for total Danish effort are based on logbook records since 1987. Danish effort increased from 1995 to 2001, decreased from 2002 to 2007 and has been fluctuating without trend since (Figure 10.2.2.4 and Table 10.2.2.7).

Since 2000 the Danish logbook data have been standardised to account for changes in fishing power due to changes in the physical characters of the *Nephrops* fleet. The data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/lpue, e.g. vessel size (Figure 10.2.2.6).

10.2.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

"No major issues. It was noted that it would be useful to show confidence intervals around the UWTV estimates. The lpue considerations were moved to additional considerations."

10.2.3.1 TV survey in 3.a

In 2008 and 2009, an exploratory UWTV survey was carried out by Denmark. In 2010, the TV survey was expanded covering the main *Nephrops* grounds in the western part of Skagerrak (subarea 1) and Northern part of Kattegat (subarea 2). Since 2011, the TV survey has been carried out in collaboration between Denmark and Sweden and covers the main *Nephrops* fishing grounds in 3.a (subarea 1–6). In 2014, subarea 1 was extended to the west (subarea 7; Figure 10.2.3.2). However, important parts of the assumed distributional range of *Nephrops* were still not covered in 2016. The survey is still developing and improved spatial coverage was raised during the 2016 benchmark and used from 2017 and onwards. Figure 10.2.3.4 presents the distribution of stations with valid density estimates from 2008 to 2016. A similar survey design has been applied for both national surveys: a fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in 3.a. VMS data from the Swedish and Danish fishery from 2010 were used (Figure 10.2.3.3) and are described in more detail in ICES (2011). The area estimates for each subarea are defined in Table 10.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS (ICES 2013).

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in 3.a divided into subareas Figure 10.2.3.2 is shown in Table 10.2.3.1 and Figure 10.2.3.4.

In WK*NEPH (*2009) a number of bias sources were highlighted relating to the "counted" density from the TV surveys. These bias sources are not easily estimated and are largely based on expert opinion. For the *Nephrops* stock in 3a it is assumed that the largest source of perceived bias is the "edge effect", due to the relative large sizes of the burrow systems. The cumulative biases result in a correction factor to take the raw counts to absolute densities. The correction factor for 3a was set to be 1.1, meaning that the raw TV survey is likely to overestimate *Nephrops* abundance by 10 %. TV survey results are presented as absolute values (i.e. the bias already taken into account).

FU	Area	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
3 and 4	Skagerrak and Kattegat (IIIa)	1.3	0.75	1.05	1	1.1

10.2.3.2 2015 Assessment

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2016. Additional used information was trends in total combined (Denmark and Sweden) lpue, and discards (numbers) as a proxy for recruitment during the period 1990–2015.

Combined relative effort declined slightly over the period 1990 to 2016 (Figure 10.2.4.1) while combined relative lpue shows an increasing trend and is at a high level in the recent 7 years (Figure 10.2.4.2). This high level may be attributed to the change in the Danish management system (Individual Transferable Quotas) in 2007. Technical creep, changes in targeting behaviour, stock size and catchability may also be responsible for some of this increase. High lpues attributable to sudden changes in catchability (caused by e.g. poor oxygen conditions) are known to occur but are generally of short duration.

Since the abundance of small *Nephrops* (typically discards of specimens below minimum landing size) may also be regarded as an index of recruitment, they can be used to further explain the current developments in the stock. The large amounts of discards in the periods 1993–1995 and 1999–2000 reflect strong recruitment during these years (Figure 10.2.4.3). The high levels of discards in 1993–1995 are believed to have significantly contributed to the high lpue in 1998–1999. The high amount of discards observed in 2007, 2008 and 2009 would then indicate high recruitment in these years, as could the low amount of discards in 2014 and 2015 indicate a low recruitment. The discards in 2016 is the lowest since 1991 due to the lowered MCRS. Low discard rate may also be due to a very low recruitment and/or an increase in gear size selectivity.

MSY considerations (TV–survey)

There are no precautionary reference points defined for *Nephrops*. Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yields (and low probability of stock overfishing) have been explored and proposed for Division IIIa. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} are determined. WGNSSK (2010) developed a framework for proposing F_{MSY} proxies for the various *Nephrops* stocks based upon their biological and historical characteristics, and is described in section 1 of that report. Three candidates for F_{MSY} are $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}. There may be strong differences in relative exploitation rates between the sexes in many stocks. To account for this, values for each of the candidates have been determined for males, females and the two sexes combined. An appropriate F_{MSY} candidate has been selected according to the perception of stock resilience, factors affecting recruitment, population density, knowledge of biological parameters and the nature of the fishery (relative exploitation of the sexes and historical harvest rate vs stock status).

A decision-making framework based on the table below was used in the selection of preliminary stock-specific F_{MSY} proxies (ICES 2010a). These proxies may be modified following further data exploration and analysis. The combined sex F_{MSY} proxy should be considered appropriate if the resulting percentage of virgin spawner-per-recruit for males or females does not fall below 20%. When this does happen a more conservative sex-specific F_{MSY} proxy should be picked instead of the combined proxy.

		Burrow density (average burrows m−2)		
		Low	Medium	High
		<0.3	0.3-0.8	>0.8
Observed harvest rate or landings compared to stock status	> Fmax	F35%SPR	Fmax	Fmax
	Fmax - F0.1	F0.1	F35%SPR	Fmax
	< F0.1	F0.1	F0.1	F35%SPR
	Unknown	F0.1	F35%SPR	F35%SPR
Stock size estimates	Variable	F0.1	F0.1	F35%
	Stable	F0.1	F35%SPR	Fmax
Knowledge of biological parameters	Poor	F0.1	F0.1	F35%SPR
	Good	F35%SPR	F35%SPR	Fmax
Fishery history	Stable spatially and temporally	F35%SPR	F35%SPR	Fmax
	Sporadic	F0.1	F0.1	F35%SPR
	Developing	F0.1	F35%SPR	F35%SPR

The absolute burrow density in Division IIIa is medium (0.3–0.8/m^2), the observed harvest rate is below $F_{0.1}$ and historically the fishery is stable both spatially and temporally. This means that $F_{0.1}$ may be selected as a proxy for F_{MSY}. As the MLS has been decreased in 2016 it is recommended to use Fmax as a proxy for F_{MSY} as in last years. For 2017 this corresponds to a TAC of 12 431 t if a landing obligation is applied. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with F_{MSY} as total catches would be subjected to 100% mortality (current discard survival is estimated to be 25 %).

Harvest rate as proxy for F_{MSY} for IIIa from length cohort analysis 2011 (2008–2010):

	Male	Female	Combined
Fmax	6.8 %	10.0 %	7.9 %
F0.1	4.9 %	7.6 %	5.6 %
F35%SpR	8.1 %	12.9 %	10.5 %

The harvest rates ((landings + dead discards)/total stock biomass) equivalent to F_{msy} proxies are based on yield-per-recruit analyses from length cohort analyses. These analyses utilise average length frequency data taken over the 3 year period (2008–2010). All F_{MSY} proxy harvest rate values are considered preliminary and may be modified following further data exploration and analysis.

Norway lobster in Division IIIa. The catch options:

Landings obligation

Basis	Total catch*	Wanted catch	Unwanted catch	Harvest rate*
	L+D	L	D	for L + DD
F2016	4730	4466	264	3.1%
Fcurrent (2014-2016)	4119	3889	230	2.7%
MSY Approach	12053	11380	673	7.9%

Weights in tonnes

*** as calculated for dead removals**

Discarding allowed

Basis	Total catch*	Dead removals	Landings	Dead discards*	Surviving discards*	Harvest rate**
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	12431	12258	11738	520	173	7.9%

Weights in tonnes.

***Total discard ratio is assumed to be 12.2% of the catches (by number, average of last three years, 2014–2016), MCRS is changed to 32 mm carapace length, discard survival (SD) is assumed to be 25% (WKNEPH; ICES 2009).**

**** as calculated for dead removals**

A summary of the results from the TV survey 2016 is presented in Table 10.2.3.1. The estimated abundance index was 0.291 resulting in a total abundance of 2863 million individuals. Total removals (landings + dead discards) were estimated to 88 million individuals resulting in a harvest rate of 3.1%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased by 50 % since 2002 and is currently at a low level while lpue shows an increasing trend and is at a long term high level in recent years (Figures 10.2.4.1 and 10.2.4.2). Mean sizes are fluctuating without trend. There are no signs of overexploitation in 3.a.

The conclusion from this indicator based assessment is that the stock is exploited sustainably.

10.2.4 Biological reference points

No biological reference points are used for this stock.

10.2.5 Quality of the assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling in this fishery has been conducted on a quarterly basis for Danish and Swedish *Nephrops* trawlers since 1990, and is considered to represent the fishery adequately.

The UWTV survey 2016 was conducted in all 7 defined subareas in IIIa. A correction factor of 1.1 was used. A total weighted mean density was estimated based on density estimates from each subarea and weighted by the size of each subarea. The estimated F_{msy} proxies for this stock provide a relatively low harvest rate which may be a result of the high discards ratios (31% in weight) which occur due to the high minimum landing size (40 mm). These removals do not increase the yield from the stock.

The Danish lpue data used as indicators for stock development have been standardised regarding engine size. However, lpue is also influenced by changes in catchability due to sudden changes in the environmental conditions or/and changes in selectivity, gear efficiency or a change in targeting behaviour due to the cod management plan in IIIa. Also the changes in management systems (indicated by the broken red line in Figure 10.2.4.2), which occurred in 2007 in Denmark, caused a general increase in lpue. In 3.a, fluctuations in catches of small *Nephrops* has been used as indicators of recruitment (Figure 10.2.4.3). This indicator will start a new series in 2016 depending on the lowered MCRS.

10.2.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the sixth year (2011–2016; new subarea 7 only in 2014–2016) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 10.3.6.1).

The average 2014–2016 harvest rate was estimated to be relatively low (2,9 % from UWTV surveys) implying the stock appears to be exploited sustainably.

The analysis of commercial lpue and effort data indicate that lpue shows an increasing trend while effort shows a decreasing trend and the WG concludes that current levels of exploitation appear to be sustainable.

10.2.7 Division IIIa: *Nephrops* management considerations

The observed trends in effort, lpue and discards are similar for FU 3 and FU 4. Our present knowledge on the biological characteristics of the *Nephrops* stocks in these two areas does not indicate obvious differences, and therefore the two FUs are treated as one single 'stock' in the assessment.

The UWTV- survey in IIIa suggests that the harvest rate of the stock is relatively low and the stock is exploited at a sustainable level.

The combined logbook recorded effort has decreased since 2002 and is currently the lowest level in the time series while lpue has increased and is at a relatively high level in the last ten years (Figures 10.2.4.1 and 10.2.4.2). The increase in lpue in 2016 is due to the lowered MCRS in 2016 from 40 to 32 mm carapace length. Mean sizes are fluctuating without trend (Figures 10.2.2.2 and 10.2.2.5). Note that the decrease in mean size for 2016 depends on the lowered MCRS. There are no signs of overexploitation in IIIa.

Given the apparent stability of the stock, the WG concludes that current levels of exploitation appear to be sustainable.

The WG encourages the work on size selectivity in *Nephrops* trawls to reduce the large amount of discarded undersized *Nephrops* in IIIa.

Mixed fishery aspects

Cod and sole are significant by-catch species in these fisheries in IIIa, and even if data on catches, including discards, of the bycatch gradually become available, they have not yet been used in the management. The WG has for many years recommended the use of species selective grids in the fisheries targeting *Nephrops* as legislated for Swedish national waters. New technical measures (Swedish grid and SELTRA trawl) have recently been agreed upon for the *Nephrops* directed fishery and have been implemented since the 1st February 2013. The European Union and Norway have also agreed that a discard ban will be implemented in EU waters from the 1st January 2015. The discard ban was applicable to *Nephrops* from the 1st January 2016 but preliminary results indicating high discard survival has resulted in an exception of landing obligation for *Nephrops* in IIIa during 2016 and 2017.

Table 10.1.1. Definition of *Nephrops* Functional Units in IIIa and IV in terms of ICES statistical rectangles.

FU no.	Name	ICES area	Statistical rectangles
3	Skagerrak	IIIaN	47G0; 46F9–G1; 45F8–G1; 44F7–G0; 43F8–F9
4	Kattegat	IIIaS	44G1; 42-43 G0–G2; 41G1–G2
5	Botney Gut - Silver Pit	IVb,c	36–37 F1–F4; 35F2–F3
6	Farn Deeps	IVb	38–40 E8–E9; 37E9
7	Fladen Ground	IVa	44–49 E9–F1; 45–46E8
8	Firth of Forth	IVb	40–41E7; 41E6
9	Moray Firth	IVa	44–45 E6-E7; 44E8
10	Noup	IVa	47E6
32	Norwegian Deep	lVa	44–52 F2–F6; 43F5–F7
33	Off Horn Reef	lVb	39–41F5; 39–41F6
34	Devil's Hole	IVb	41–43 F0–F1

Table 10.2.1.1. Division IIIa: Total *Nephrops* landings (tons) by Functional Unit, 1981–2016.

Year	FU 3	FU 4	Total
1981	992	1728	2720
1982	1470	1828	3298
1983	2205	1472	3677
1984	2675	2036	4711
1985	2191	1798	3989
1986	2018	1807	3825
1987	2441	1605	4046
1988	2363	1364	3727
1989	2564	1313	3877
1990	2866	1475	4341
1991	2924	1304	4228
1992	1893	1012	2905
1993	2288	924	3212
1994	1981	893	2874
1995	2429	998	3427
1996	2695	1285	3980
1997	2612	1594	4206
1998	3248	1808	5056
1999	3194	1755	4949
2000	2894	1816	4710
2001	2282	1774	4056
2002	2977	1471	4448
2003	2126	1641	3767
2004	2312	1653	3965
2005	2546	1488	4034
2006	2392	1280	3672
2007	2771	1741	4512
2008	2851	2025	4876
2009	3004	1842	4846
2010	2938	2185	5123
2011	2511	1475	3986
2012	2536	1893	4429
2013	2147	1613	3760
2014	2856	1294	4150
2015	2123	1228	3350
2016	3238	1652	4890

Table 10.2.1.2. Division IIIa: Total *Nephrops* landings (tons) by country, 1991–2016.

Year	Denmark	Norway	Sweden	Germany	Total landings	Total Disc.	Total Catch
1991	2824	185	1219		4228	5183	9411
1992	2052	104	749		2905	2523	5428
1993	2250	103	859		3212	8493	11705
1994	2049	62	763		2874	6450	9324
1995	2419	90	918		3427	4464	7891
1996	2844	102	1034		3980	2148	6128
1997	2959	117	1130		4206	3469	7675
1998	3541	184	1319	12	5056	1944	7000
1999	3486	214	1243	6	4949	4108	9057
2000	3325	181	1197	7	4710	5664	10374
2001	2880	138	1037	1	4056	3767	7823
2002	3293	116	1032	7	4448	4311	8760
2003	2757	99	898	13	3767	2208	5975
2004	2955	95	903	12	3965	2532	6497
2005	2901	83	1048	2	4034	3014	7048
2006	2432	91	1143	6	3672	2926	6598
2007	2887	145	1467	13	4512	6524	11036
2008	3174	158	1509	19	4860	4746	9606
2009	3372	128	1331	15	4846	6129	10975
2010	3721	124	1249	29	5123	3548	8671
2011	2937	87	945	17	3986	2847	6833
2012	2970	104	1355	0	4429	4771	9200
2013	2550	73	1134	3	3760	4010	7770
2014	2785	88	1269	7	4150	1854	6004
2015	2121	91	1138	0	3350	1038	4389
2016	3440	87	1363	0	4889	256	5145

Table 10.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tons) by country, 1991–2016.

Year	Denmark	Norway			Sweden			Germany	Total
		Trawl	Creel	Sub-total	Trawl	Creel	Sub-total		
1991	1639	185	0	185	949	151	1100	0	2924
1992	1151	104	0	104	524	114	638	0	1893
1993	1485	101	2	103	577	123	700	0	2288
1994	1298	62	0	62	531	90	621	0	1981
1995	1569	90	0	90	659	111	770	0	2429
1996	1772	102	0	102	708	113	821	0	2695
1997	1687	117	0	117	690	118	808	0	2612
1998	2055	184	0	184	864	145	1009	0	3248
1999	2070	214	0	214	793	117	910	0	3194
2000	1877	181	0	181	689	147	836	0	2894
2001	1416	125	13	138	594	134	728	0	2282
2002	2053	99	17	116	658	150	808	0	2977
2003	1421	90	9	99	471	135	606	0	2126
2004	1595	85	10	95	449	173	622	0	2312
2005	1727	71	12	83	538	198	736	0	2546
2006	1516	80	11	91	583	201	784	0	2391
2007	1664	127	18	145	709	253	962	0	2771
2008	1745	124	34	158	675	273	948	0	2851
2009	2012	101	27	128	605	260	864	0	3004
2010	1981	105	20	125	563	266	829	4	2938
2011	1801	74	12	87	432	188	621	2	2510
2012	1516	80	24	104	592	324	916	0	2536
2013	1309	57	16	73	484	279	763	0	2146
2014	1868	68	20	88	594	305	899	0	2856
2015	1226	66	25	91	479	327	806	0	2123
2016	2260	66	21	87	604	289	892	0	3239

Table 10.2.2.2. *Nephrops* Skagerrak (FU 3): Catches and landings (tons), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2016. (*Include only *Nephrops* trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	cpue	lpue
1991	676	401	71.4	9.5	5.6
1992	360	231	73.7	4.9	3.1
1993	614	279	72.6	8.4	3.8
1994	441	246	60.1	7.3	4.1
1995	501	336	60.8	7.8	5.2
1996	754	488	51.1	14.8	9.6
1997	643	437	44.4	14.4	9.8
1998	794	557	49.7	16.0	11.2
1999	605	386	34.5	17.5	9.3
2000	486	329	32.7	14.9	10.9
2001	446	236	26.2	17.0	10.4
2002	503	301	29.4	17.1	8.8
2003	310	254	21.5	13.9	11.4
2004*	474	257	20.1	23.6	13.4
2005*	760	339	29.7	25.6	12.7
2006*	839	401	37.5	22.4	12.2
2007*	894	314	24.1	37.0	13.0
2008*	605	264	20.0	30.3	13.2
2009*	482	285	19.6	24.5	14.5
2010*	476	286	20.7	23.0	13.8
2011*	334	198	16.8	19.9	11.8
2012*	542	238	16.0	33.8	14.9
2013*	251	137	11.3	22.2	12.1
2014*	240	157	11.0	21.7	14.2
2015*	187	133	9.5	19.6	14.0
2016*	216	188	14.9	14.4	12.6
Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1

2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3
2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6
2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8
2014*	484	316	16.0	30.3	19.8
2015*	328	234	11.3	28.9	20.6
2016*	471	410	20.1	23.4	20.4

Table 10.2.2.3. ***Nephrops*** **Skagerrak (FU 3): Logbook recorded effort (kW days, Days at sea, and fishing days) and lpue (kg/day) for bottom trawlers catching** ***Nephrops*** **with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2016.**

Year	kW days	Days at sea	Fishing days	lpue
1991	5501223	21043	18762	87
1992	4043742	16125	13970	82
1993	3728965	13698	11958	124
1994	3276355	12324	10778	120
1995	3024232	12070	10448	150
1996	3020019	11871	10385	171
1997	3053570	11950	10509	161
1998	3353072	12131	10899	189
1999	3967797	13767	12376	167
2000	4371006	14849	13307	141
2001	3970228	13337	11579	122
2002	4693962	16575	14197	145
2003	3476385	11589	10333	138
2004	3871974	13149	11694	136
2005	3757466	12560	11166	155
2006	3296744	10825	9725	156
2007	2424063	8026	7294	228
2008	2332056	8016	7300	239
2009	2549895	8814	8058	250
2010	2668904	9027	8338	238
2011	2666680	9767	8912	202
2012	2183682	8330	7507	202
2013	1738286	6770	6332	207
2014	2094860	8060	7653	244
2015	1592065	6337	5923	207
2016	2032034	8060	7673	295

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2016.

	Catches					
	Undersized		Full sized		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.2	30.9	41.2	42.7	30.9	29.8
1992	33.3	32.3	43.3	44.7	33.3	32.2
1993	33.0	31.5	42.0	43.6	33.0	31.5
1994	31.7	29.6	41.7	43.6	31.7	29.6
1995	30.0	28.5	41.6	41.3	32.9	29.8
1996	33.2	31.9	42.9	44.0	37.6	37.0
1997	35.8	34.5	44.6	44.1	39.8	39.1
1998	34.8	34.4	46.1	43.9	40.7	37.3
1999	34.6	33.9	44.9	43.8	39.3	36.1
2000	30.6	30.5	45.6	45.0	32.5	34.1
2001	33.6	33.6	45.5	43.6	37.3	36.4
2002	33.9	33.7	44.0	42.5	37.2	37.3
2003	33.5	32.6	43.2	43.4	38.0	36.7
2004	34.3	33.4	44.6	45.2	38.7	36.6
2005	33.5	32.4	43.7	43.0	36.4	35.3
2006	33.2	32.9	44.7	42.7	37.1	36.1
2007	32.6	31.9	44.4	42.4	34.9	33.5
2008	33.6	32.3	44.0	42.7	36.5	34.5
2009	35.0	33.8	45.3	42.8	39.8	35.9
2010	34.2	33.8	46.2	44.8	38.9	36.6
2011	33.8	33.1	44.5	43.3	38.4	36.5
2012	34.8	34.1	44.2	42.5	38.2	36.2
2013	35.1	34.8	45.0	42.9	38.6	36.9
2014	35.7	35.3	45.5	43.7	41.7	39.1
2015	35.5	36.2	47.2	44.1	43.6	41.1
2016	32.0	31.8	43.5	41.0	42.2	39.9

Table 10.2.2.5. ***Nephrops*** **Kattegat (FU 4): Landings (tons) by country, 1991–2016.**

		Sweden				
Year	**Denmark**	Trawl	Creel	**Sub-total**	**Germany**	**Total**
1991	1185	119	0	119	0	1304
1992	901	111	0	111	0	1012
1993	765	159	0	159	0	924
1994	751	142	0	142	0	893
1995	850	148	0	148	0	998
1996	1072	213	0	213	0	1285
1997	1272	319	3	322	0	1594
1998	1486	306	4	310	12	1808
1999	1416	329	4	333	6	1755
2000	1448	357	4	361	7	1816
2001	1464	304	6	309	1	1774
2002	1240	219	5	224	7	1471
2003	1336	287	5	292	13	1641
2004	1360	270	11	281	12	1653
2005	1175	303	8	311	2	1488
2006	916	347	11	358	6	1280
2007	1223	491	15	505	13	1741
2008	1429	561	16	577	19	2025
2009	1360	450	16	467	15	1842
2010	1740	403	17	420	25	2185
2011	1136	308	16	324	15	1475
2012	1454	406	33	439	0	1893
2013	1241	341	27	368	3	1612
2014	917	335	34	369	7	1294
2015	895	301	31	333	0	1228
2016	1180	436	34	470	0	1650

Table 10.2.2.6. Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), cpue and lpue (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2016 (*Include only *Nephrops* trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	66	39	10.3	6.4	3.7
1992	44	28	11.6	3.8	2.4
1993	128	58	14.9	8.6	3.9
1994	95	53	16.2	5.7	3.2
1995	79	53	9.6	7.8	5.5
1996	207	134	13.7	15.1	9.8
1997	269	183	18.0	15.0	10.2
1998	181	127	13.1	13.8	9.7
1999	146	93	8.1	17.9	11.4
2000	114	77	8.5	13.4	9.1
2001	117	62	7.6	15.4	8.2
2002	42	25	3.7	11.2	6.7
2003	49	40	4.6	10.7	8.7
2004	70	44	4.3	16.2	10.1
2005	147	100	12.3	11.9	8.1
2006	234	154	15.1	15.5	10.2
2007*	107	51	4.1	25.7	12.3
2008*	121	57	4.4	27.6	13.0
2009*	157	81	5.1	30.9	16.1
2010*	181	102	7.6	23.8	13.4
2011*	75	45	3.8	20.0	12.0
2012*	80	45	3.4	23.5	13.3
2013*	44	26	2.3	19.5	11.6
2014*	35	25	2.2	15.8	11.6
2015	43	29	2.6	16.6	11.0
2016*	50	47	5.4	9.4	8.7
Twin trawl					
Year	Catches	Landings	Effort	cpue	lpue
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	8.9	7.3

2004	253	158	16.5	15.4	9.6
2005	198	135	15.3	12.9	8.8
2006	183	121	12.7	14.4	9.5
2007*	112	54	3.6	30.9	14.8
2008*	164	78	4.8	34.1	16.1
2009*	309	161	11.0	28.2	14.6
2010*	297	167	9.2	32.2	18.1
2011*	266	159	9.7	27.3	16.3
2012*	406	231	12.4	32.8	18.6
2013*	354	210	15.0	23.7	14.0
2014*	282	206	14.4	19.6	14.4
2015	262	173	11.3	23.2	15.4
2016*	404	378	19.4	20.9	19.5

Table 10.2.2.7. ***Nephrops*** **Kattegat (FU 4): Logbook recorded effort (kW days, Days at sea, and fishing days) and lpue (kg/day) for bottom trawlers catching** ***Nephrops*** **with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2016.**

Year	kW days	Days at sea	Fishing days	lpue
1991	4223351	23040	16770	71
1992	3689413	20184	14240	63
1993	2827025	15392	10598	72
1994	2480847	13989	10985	68
1995	2330909	13023	10028	85
1996	2707363	14856	11688	92
1997	2807943	14389	11558	110
1998	2957280	15264	12380	120
1999	3417242	16734	13536	105
2000	3642120	18307	14661	99
2001	3826693	18764	15294	96
2002	3258819	16568	13325	93
2003	3173969	15345	12507	107
2004	2929407	14229	11289	120
2005	2452852	11814	9337	126
2006	2147461	10431	8467	108
2007	2022910	9883	7897	155
2008	2148132	10538	8469	169
2009	2219200	11120	8726	156
2010	2438736	12055	9707	179
2011	2009409	10286	8099	140
2012	2292229	11800	9661	150
2013	2221959	11669	9226	135
2014	1908170	10393	7865	117
2015	1847763	10094	7704	116
2016	1899286	10249	7815	151

Table 10.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991–2016. Since 2005 based on combined Danish and Swedish data.

	Catches					
	Discards		Landings		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.7	31.1	42.4	42.5	32.5	32.9
1992	33.0	30.3	44.4	43.2	36.7	34.9
1993	30.5	29.3	42.3	43.1	31.3	30.1
1994	29.7	28.3	40.8	40.2	31.2	28.9
1995	30.8	30.5	42.4	42.0	33.7	33.2
1996	32.7	31.3	42.0	44.0	36.7	37.3
1997	33.6	33.2	45.0	44.5	37.1	35.0
1998	34.2	33.2	45.6	44.1	41.3	36.8
1999	32.9	33.8	45.3	40.9	37.8	34.9
2000	35.1	35.2	45.7	42.1	40.4	36.9
2001	32.2	33.0	44.1	41.9	35.9	36.5
2002	34.4	33.3	44.4	43.8	37.2	36.2
2003	33.0	33.2	43.5	42.2	37.1	36.0
2004	34.7	34.2	45.1	43.2	39.9	37.5
2005	33.5	33.9	45.8	43.1	38.7	38.7
2006	33.2	33.6	45.1	42.8	37.9	37.4
2007	33.9	33.2	44.8	43.5	37.2	35.5
2008	32.6	32.4	44.0	43.9	37.5	35.9
2009	33.8	33.1	44.7	44.1	36.8	35.2
2010	34.6	33.8	45.9	44.5	39.8	36.9
2011	33.7	32.9	44.7	43.3	38.1	35.5
2012	33.8	33.2	44.3	42.9	37.1	35.7
2013	34.4	34.6	44.8	42.9	38.0	36.5
2014	35.0	34.8	45.6	42.9	40.4	37.4
2015	34.5	34.8	45.6	42.7	40.9	38.3
2016	30.1	29.8	45.1	40.6	43.4	38.5

Table 10.2.3.1. Summary output of the TV-survey in IIIa from 2016.

Subarea	Area (km2)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)
1	2044	35	0.269	0.086	550
2	1982	31	0.339	0.178	671
3	2462	43	0.246	0.084	607
4	676	12	0.337	0.166	228
5	670	14	0.448	0.371	300
6	973	23	0.362	0.138	352
7	1019	18	0.151	0.126	154
Total	9826	176	0.291	0.010	2863
				Harvest rate	0.0307
Removals 2016 (landings + dead discards**)				88*	

*** In millions**

****The survival rate of discard is estimate to be 25% (Wileman *et al*. 1999)**

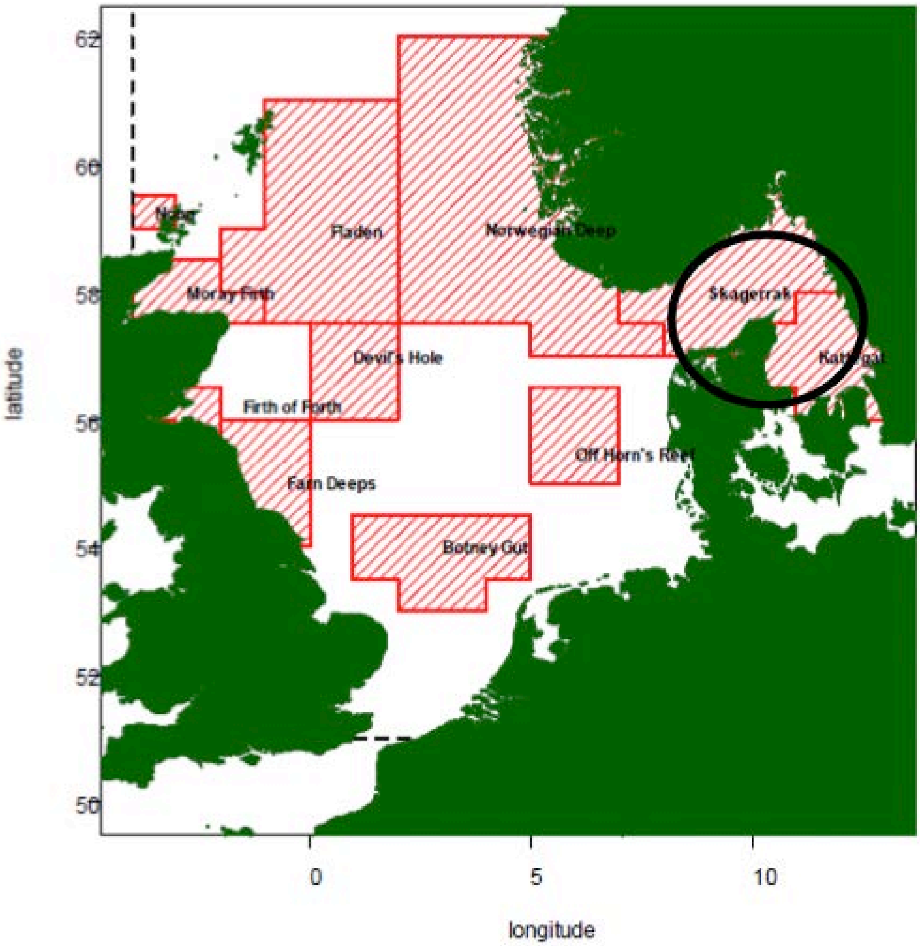


Figure 10.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

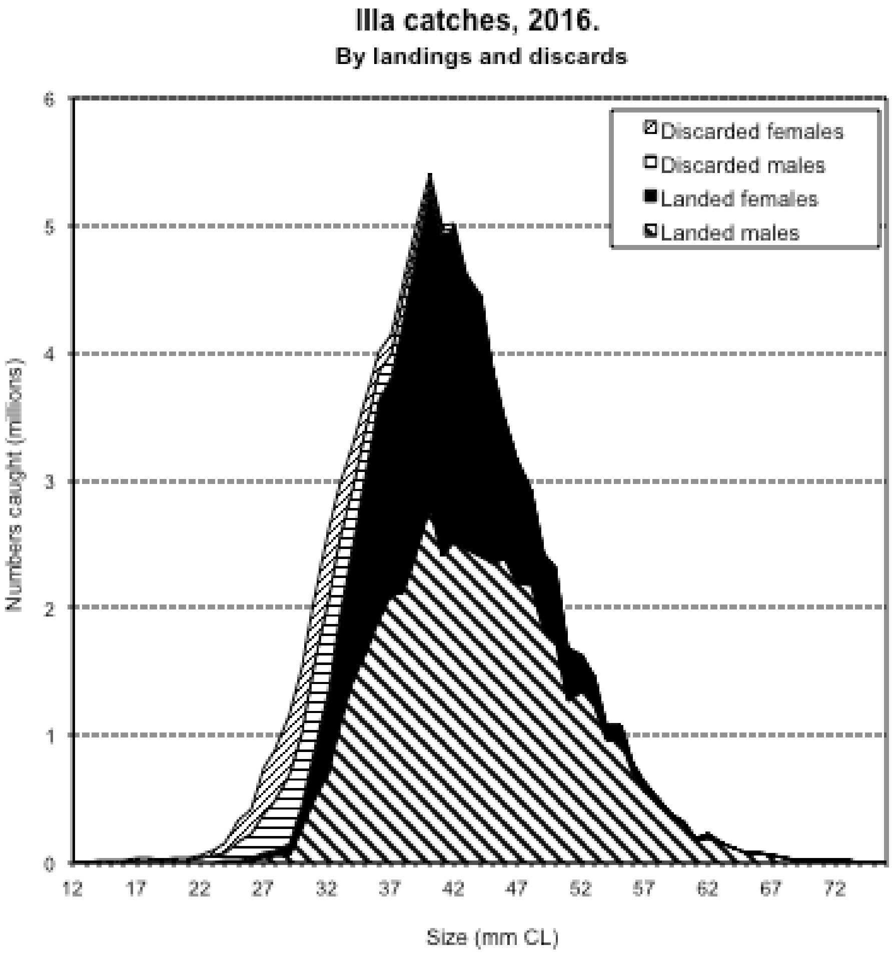


Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2016.

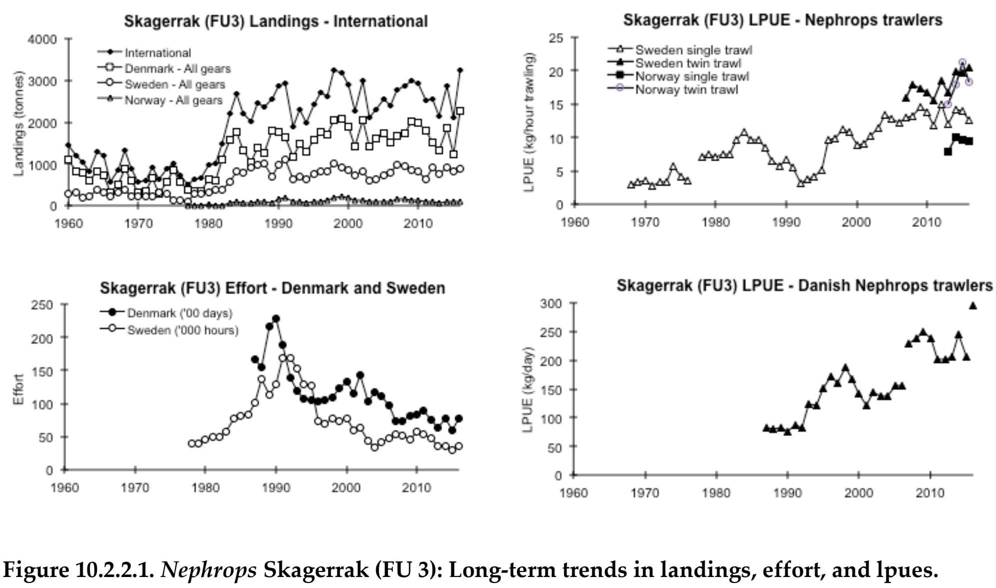


Figure 10.2.2.1. *Nephrops* Skagerrak (FU 3): Long-term trends in landings, effort, and lpues.

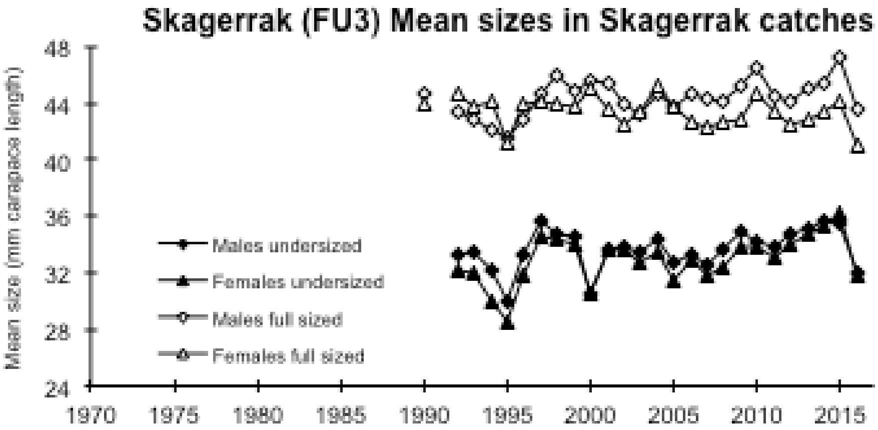


Figure 10.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

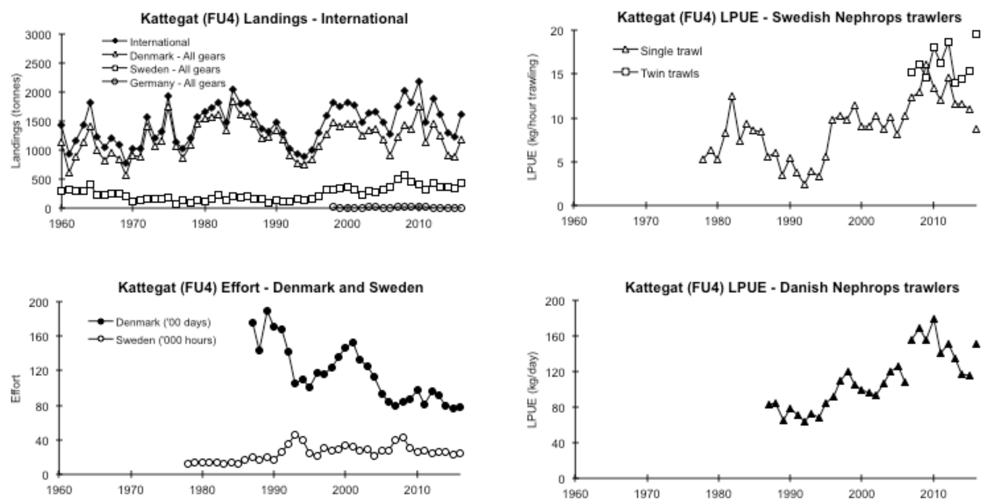


Figure 10.2.2.4. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort and lpues.**

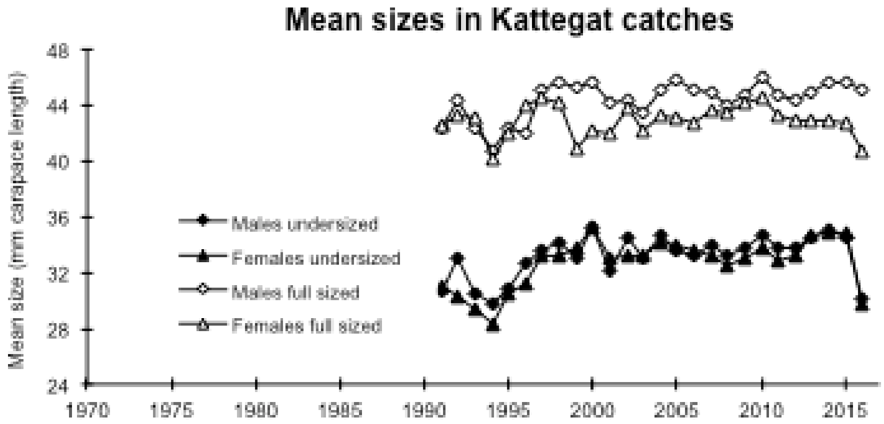


Figure 10.2.2.5. ***Nephrops*** **in FU 4: Mean sizes in the catches.**

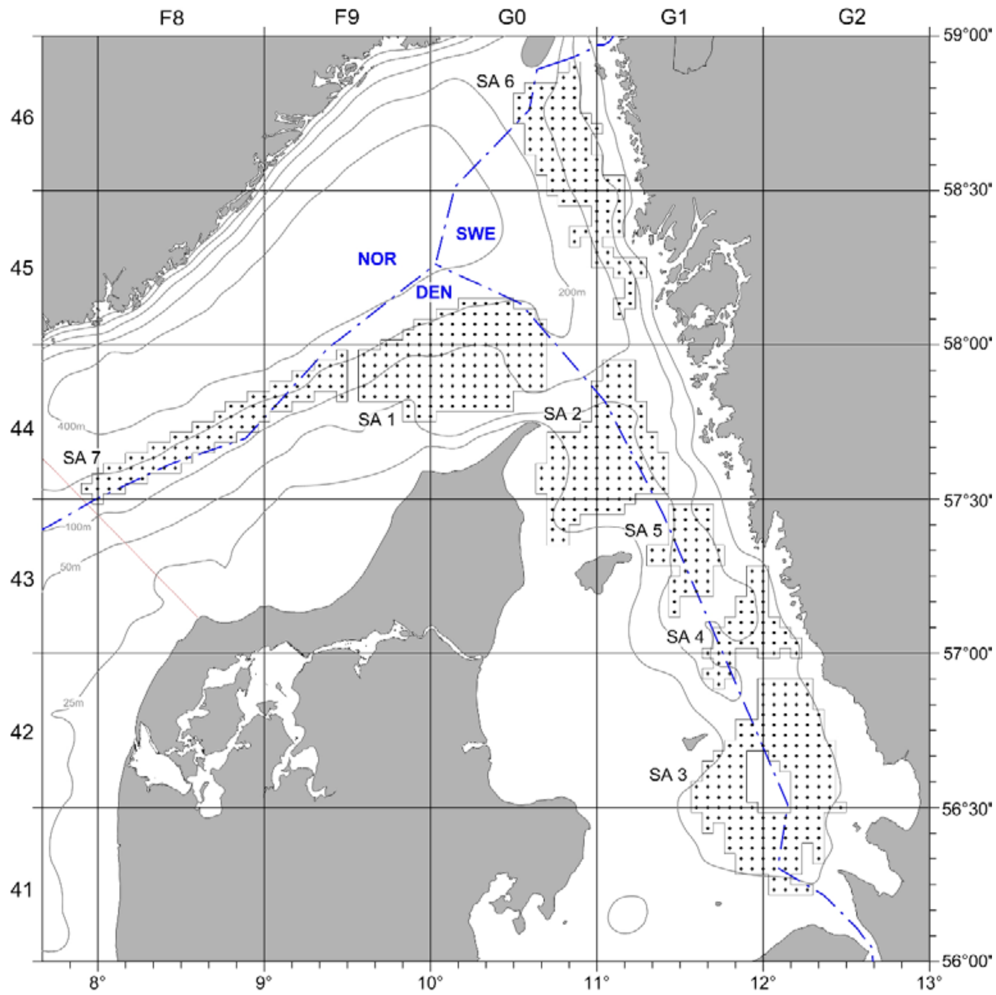


Figure 10.2.3.2. The defined sub areas of the ***Nephrops*** **stock in IIIa.**

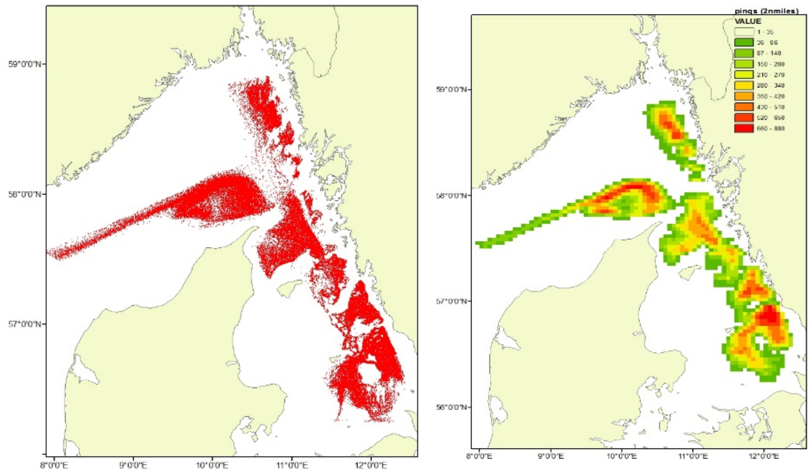


Figure 10.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

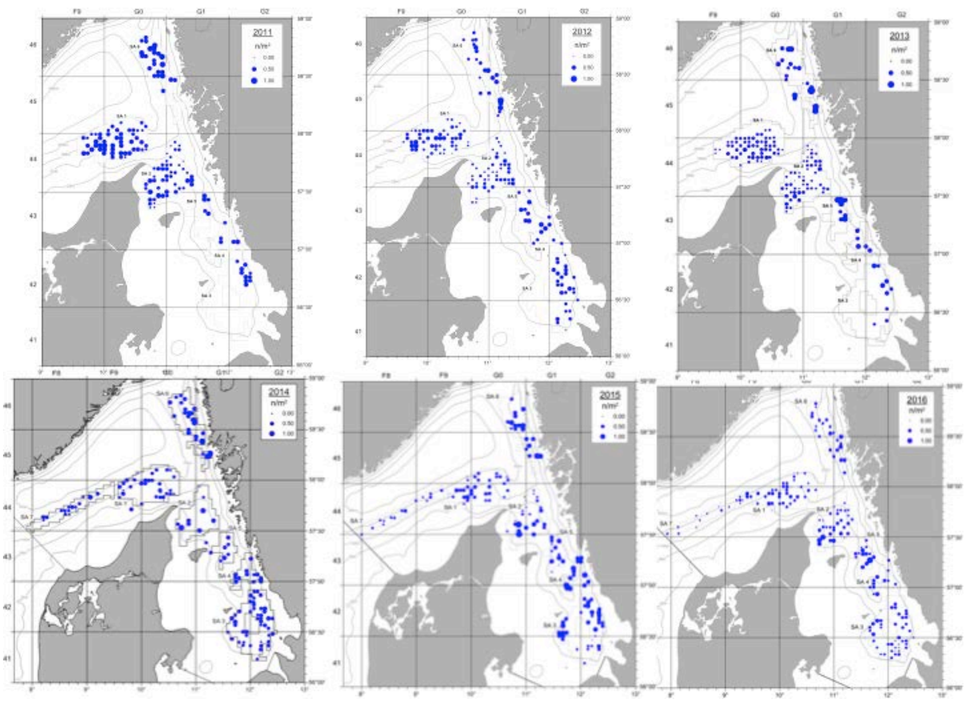


Figure 10.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations) and in 2016 (176 stations).

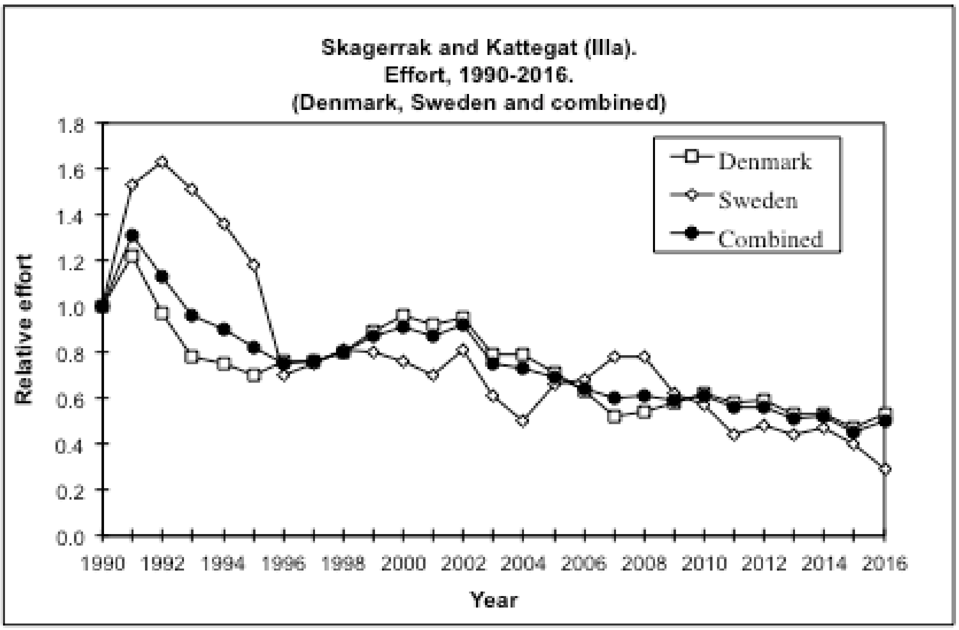


Figure 10.2.4.1 ***Nephrops*** **in Area IIIa: Combined Effort for FU 3&4.**

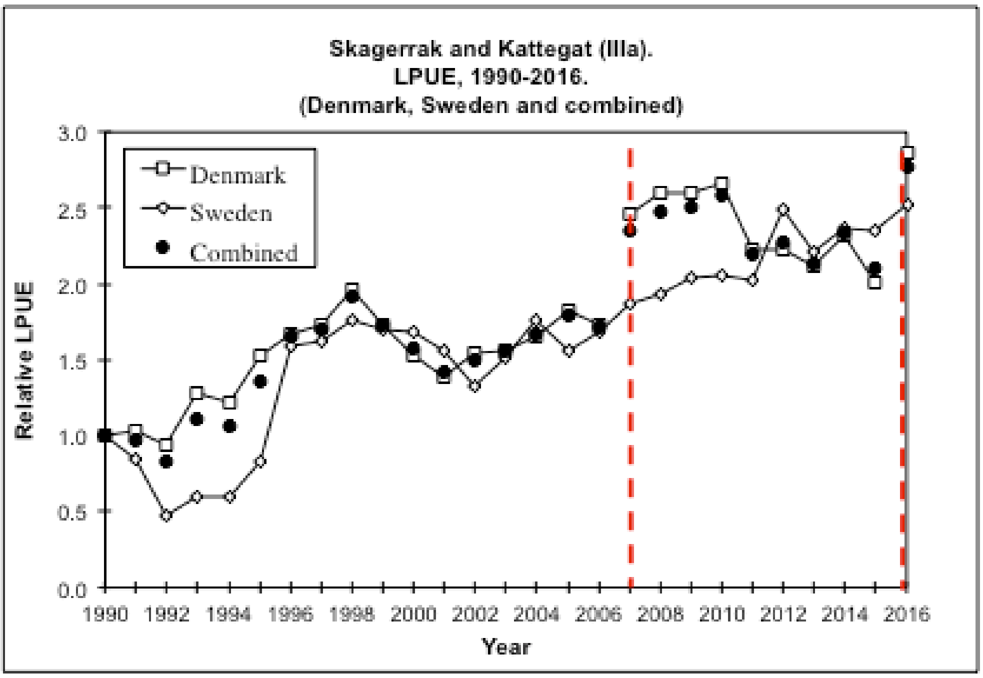


Figure 10.2.4.2 ***Nephrops*** **in Area IIIa: Combined lpue for FU 3&4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.**

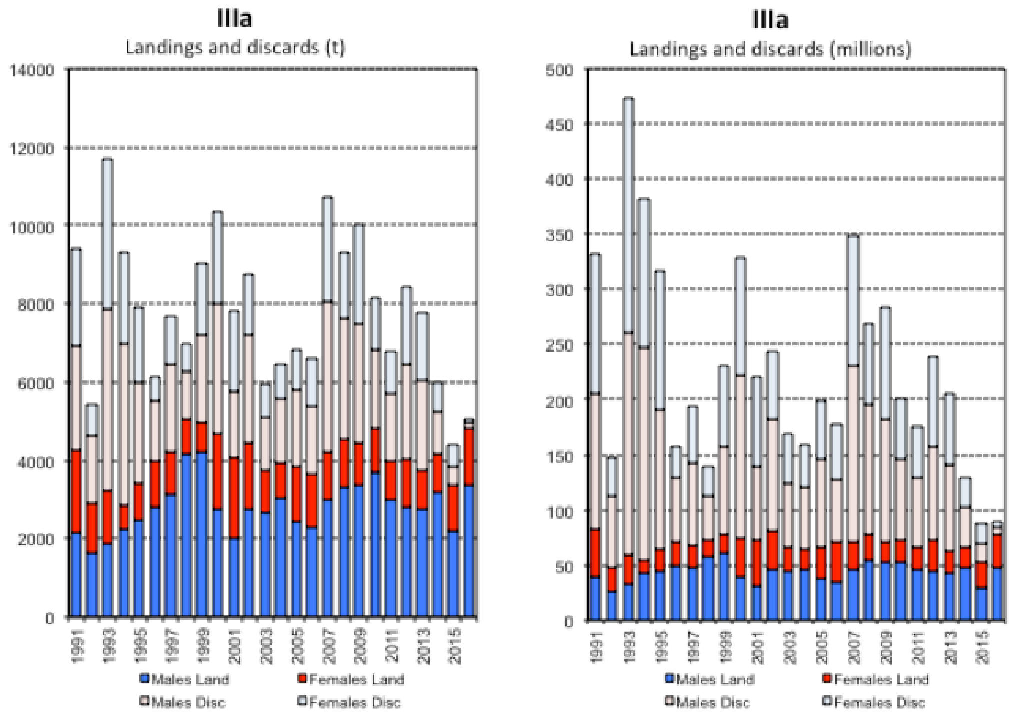


Figure 10.2.4.3. ***Nephrops*** **in IIIa FUs 3&4: Catch by sex and size category in numbers and biomass.**

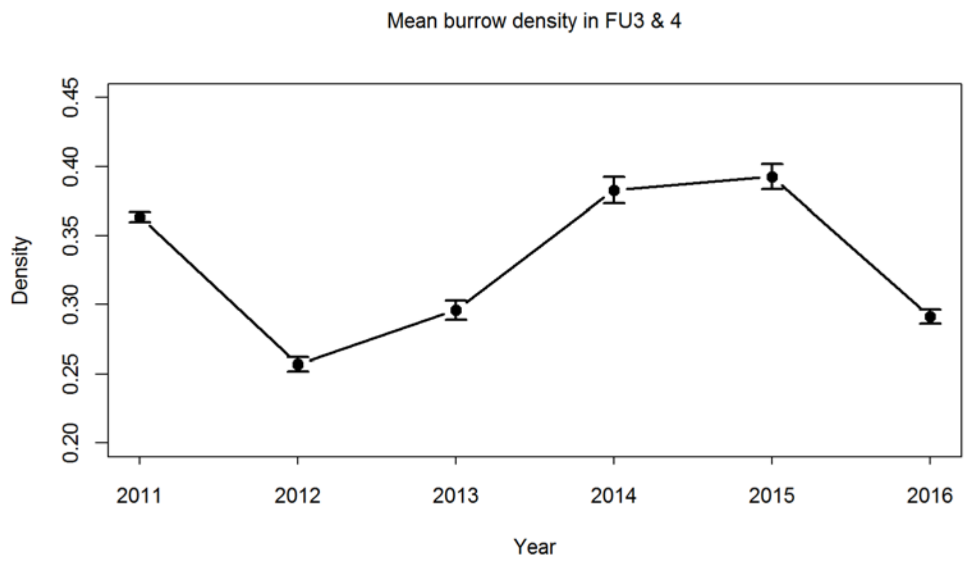


Figure 10.2.4.4. Mean burrow density in IIIa by year: Error bars indicate the 95 % confidence intervals.

11 Norway lobster (*Nephrops* spp.) in Subarea 4 (North Sea)

11.1 General comments relating to all *Nephrops* stocks

See section 10.1

11.2 *Nephrops* in Subarea 4

Subarea 4 contains nine FUs 5, 6, 7, 8, 9, 10, 32, 33 and 34. Management is applied at the scale of ICES Subarea through the use of a TAC and an effort regime. FU34 (The Devil's Hole) is a relatively new functional unit having been designated in 2010 (SGNepS 2010).

Management at ICES Subarea Level

The 2015 EC TAC for *Nephrops* in ICES Subarea 2.a and 4 was 17 483 tons in EC waters (plus 1 000 tons in Norwegian waters). For 2016, this was decreased to 13 700 tons in EC waters and 1 000 tons in Norwegian waters.

A major change in the management of *Nephrops* fisheries in ICES Subarea 4 for 2016 was the introduction of the landing obligation for *Nephrops* fisheries in the 80–99mm trawl fisheries. A *de minimis* exemption for catches below the Minimum Conservation Reference Size (MCRS) of up to 6% was permitted for the fishery in Subarea 4. The application of this exemption was not clear (i.e. whether the 6% applied at a trip level or to the total annual catch). There was no evidence presented to the Working Group that the introduction of the landing obligation had caused any change to discarding practices for the 2016 fishery. Catch options are presented for scenarios where a) the landing obligation is applied without exemptions, b) discarding continues according to historic patterns and c) the landing obligation is applied with the exemption. In 2016 it was calculated that where discard length frequencies and rates were available, the proportion of catch (in biomass) of animals below the MCRS was always below 6% and therefore no change in fishing behaviour would be expected under the landing obligation however those animals previously discarded above MCRS would now be expected to be landed but not for consumption. Catch options therefore are presented in four categories, "wanted landings", "unwanted landings" (catch historically discarded but above MCRS), "*de minimis* discards" and surviving discards (as not all discards die).

The minimum landings size (MLS) for *Nephrops* in Subarea 4 (EC) is 25 mm carapace length. Denmark, Sweden and Norway applied a national MLS of 40 mm up to 2015 but this was changed to 32 mm from 01/01/2016.

Days-at-sea regulations and recently introduced effort allocation schemes (kW*day) have reduced opportunities for directed whitefish fishing. STECF 2010 stated that the overall effort (kW*days) by demersal trawls, seines and beam trawls shows a substantial reduction since 2002. However, there have also been substantial changes in the usage of the different mesh size categories by the demersal trawls. In particular there has been a sharp reduction in usage of gears with a mesh size of between 100 mm and 119 mm (targeting whitefish), but only a gradual decline in the effort of *Nephrops* vessels (TR2).

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops,* the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70–99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double. The UK introduced emergency technical measures for UK vessels targeting *Nephrops* in the Farn Deeps during 2016 (see section 11.4).

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90 mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller than 100 mm in the North Sea south of 57°30′N.

Official catch statistics for Subarea 4 are presented in Table 11.3.1. The preliminary officially reported landings in 2016 are around 13 400 tons, representing a decline of around 45% from the peak observed in 2009 (24 500 tons). The decline has been most prevalent in landings from the UK. Landings from other countries increased substantially in 2016 with Belgium and Germany showing a ~50% increase over recent landings.

Table 11.2.2 shows landings by FU as reported to the WG. It also shows that a small but significant proportion of the landings from Subarea 4 come from outside the defined *Nephrops* FUs. This value increased to nearly 10 % of the total in 2009 and as a response, a new Functional Unit at the Devil's Hole (FU 34) was designated in 2011. Landings from outside the Functional Units increased between 2015–2016 to nearly 1000 tons.

11.3 Botney Cut (FU 5)

11.3.1 The fishery in 2015 and 2016.

Landings from FU5 had been gradually increasing from a low point in 2009 to 2015, however landings for 2016 saw a 67% increase over the 2015 value and are the highest value on record at 2 535 tons. This is three and a half times greater the 2009 landings. Germany and the UK saw the largest increase in landings (around double their 2015 level) with Belgium and the Netherlands increasing by 60% and 18% respectively. Danish activity has been at a low level but erratic since 2006 with minimal activity reported in 2015 and 2016.

Nephrops in FU5 are caught by trawling, there is no creeling in the area.

11.3.2 Data Available

Landings

Landings by country for FU 5, including Belgium, Denmark, Netherlands, Germany and UK are available since 1991 (Table 11.3.1 & Figure 11.3.2). Landings increased from ~800 tons in the early 1990s to ~1 200 tons in the early 2000s, peaking at ~1 400 tons in 2001. There then followed a period of general decline to a low in 2009 but landings have subsequently increased and in 2015 were 1516, before jumping to 2 535 tons in 2016. Between 1991 and 1995, the Belgian fleet took more than 75% of the international *Nephrops* landings from this FU, but since then, the Belgian landings have declined drastically, and since 2006 there has been no directed Belgian *Nephrops* fishery by Belgian operated vessels. Some Belgian owned vessels operating as Dutch vessels have a directed fishery and increased the landings between 2010 and 2016 by a factor of 5. Danish landings have been sporadic since 2006 with almost no landings in 2015 and

2016. In the most recent years UK and Netherlands have accounted for most of the landings from this FU, the large increase in landings 2014–2015 being driven entirely by these two fleets. The sharp jump in landings was dominated by increases from the UK and Germany, with lesser increases from the Netherlands and Belgium.

Annual discard data for 2015 and 2016 were available from the Dutch self-sampling program. Discard data were available for the Belgian *Nephrops* fleet for the period 2002–2005 but in the absence of a directed fishery since 2006, there have been no data collection from the Belgian *Nephrops* landings. There are distinct differences in the discarding rates reported by the three sampled metiers between years (Table 11.3.2). Whereas the discard rate for otter trawls targeting crustaceans (OTB_CRU_70-99_0_0_all) decreased from 85.9% (by number) in 2015 to 44.9% in 2016, the discards in otter trawls targeting fish (OTB_DEF_70-99_0_0_all) increased from ~68% in 2015 to ~96% in 2016.

Length compositions in the Dutch landings are available from 2004 to 2016 with the exception of 2013 (Figure 11.3.1). Length composition for the 2015 and 2016 discard data from the Dutch self-sampling program were also available. Data for 2013 were not considered of sufficient quality for inclusion due to a large SOP error (SOP=sum of products, the sum of number landed at length * weight at length should be close to the total landing biomass). Both mean sizes of males and females showed a slight increasing trend over time up to around 2012 but have been stable since (Table 11.3.3), although the intensity of sampling is fairly low in FU 5 and as a result samples may not be fully representative of actual removals. Between 2005 and 2009 the average numbers measured were >10 000 individuals a year, while between 2010 and 2012 the sampling measurements dropped to around 2500–3000 individuals. Sampling intensity in 2011 and 2012 was particularly low in the third quarter which is the main period of the fishery.

11.3.3 Natural mortality, maturity at age and other biological parameters

No analytical assessment has been performed this year.

In previous analytical assessments (see e.g. WGNEPH, 2003), natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females. Discard survival was assumed to be 0.25 for both males and females (after Gueguen & Charuau, 1975, and Redant & Polet, 1994).

Growth parameters are as follows:

Males: $L\infty$ = 62mm CL, k = 0.165.

Immature females: $L\infty$ = 62 mm CL, k = 0.165.

Mature females: $L\infty$ = 60 mm CL, k = 0.080, Size at 50% maturity = 27 mm CL.

Growth parameters have been assumed to be similar to those of Scottish *Nephrops* stocks with similar overall size distributions of the landings (see e.g. WGNEPH, 2003). Female size at 50% maturity was taken from Redant (1994).

11.3.4 Commercial catch-effort data and research vessel surveys

Effort and lpue data have been presented for this FU for several years as indicator indices however in 2015 it was discovered that there were serious concerns regarding the way in which effort had been reported for the Dutch, Belgian and English fleets.

- Historic Belgian effort data claimed to be from vessels targeting *Nephrops* however it transpired that the effort data were for the whole towed gear fleets operating in this area. It was not possible to reconstruct a new effort series in time for the 2015 assessment meeting but this should be completed in time for the 2016 assessment.

- Dutch data had always stated that effort was being reported for all vessels catching *Nephrops* but closer investigation showed that the majority of the landings were made from TR2 gears whilst the effort figures were dominated by TBB gears where *Nephrops* are picked up as bycatch. Revised lpue indices will be developed in time for the next assessment in 2016.
- English effort data purported to represent hours fished, however there were discovered to be a large number of inconsistent entries in the effort fields on the database. It was decided that reporting effort in hours fished was not a viable option and therefore days fishing for targeted *Nephrops* activity have been reported instead. A landing targeting *Nephrops* is defined as using 70–99 mm otter trawl with at least 25% by weight of *Nephrops* per record. Changes to the way in which fishing activities were recorded in 2006 significantly sharply changing the level of landings and targeted reported.
- In addition to the erroneous data in the Dutch, Belgian and English data, Danish activity in the area has become sporadic with only one or two vessels prosecuting the fishery, therefore lpue data for this sector is not used as an index of abundance.

Changes to the way in which gear is specified in the English fishery since 2014 necessitates a re-calculation of the landings and effort for the directed fishery. The basic premise of the calculation remains the same, otter trawl gears in the 70–99 mm category in which >25% of the total landing comprises *Nephrops*, but the number of days fishing included in this categorisation has increased since the previous data extraction however there are minimal changes to the resulting lpue. The only lpue series considered to be an appropriate abundance proxy is the English lpue series since 2006 (Table 11.3.4 and Figure 11.3.2.).

Effort by English vessels targeting *Nephrops* (targeting being classed as trips where *Nephrops* comprise >=25% of landings by biomass) in FU5, had been generally falling since 2006 and was relatively stable between 2013–2015 but experienced a sharp upturn in 2016. This was likely to have been caused by displacement of larger vessels from the FU6 following the emergency technical measures imposed by the UK. Lpue has fluctuated without trend over the period 2006–2015.

TV Survey in FU5 (Botney Cut / Silver Pit):

There were no new surveys in this FU since the last assessment in 2013. Details of the 2010 and 2012 surveys are given in the WGNSSK report from 2013.

Intercatch

FU5 data are available from Intercatch for all nationalities from 2011 onwards. Quarterly landings by metier were available for all countries fishing the functional unit. Length composition data were not available for 2013 as the sample rate was considered insufficient to raise the distributions. Discards were not raised for non-sampled strata as the only available discards were from the Netherlands where discarding practices are essentially dictated by Producer Organisation rules and therefore not applicable to other metiers.

Status of stock

The status of this stock is uncertain although there are no consistent signals that this stock is suffering from over-exploitation. The lack of reliable of length information on this stock in recent years means that there is no information regarding incoming recruitment. The advent of discard data from the Dutch fleet from 2015 indicates that harvest rates are likely to have been significantly higher than previously assumed although it is not known how long these high discard rates have been in practice.

In previous assessments there had been concern regarding conflicting signals in lpue series, however this was most likely due to the inclusion of non-targeted behaviours and there is now only one lpue series presented which shows no trends.

Following the procedure outlined in section 10.1.2, an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in this functional unit. Mean weight in landings component came from the average of 2015 and 2016. The discard proportion takes the reported discard numbers at length (i.e. Netherlands only) divided by the reported discards plus raised landings-averaged for 2015 and 2016. Discard survival was set to zero in line with the protocol for data limited *Nephrops* stocks. The 2012 survey shows that density is relatively high on this ground at 0.7 burrows per metre squared.

Under the assumption that the landing obligation applies (i.e. no discarding) and that the abundance is around 0.7 burrows per metre squared, the 2017 catch advice should result in a Harvest Rate of around 3.6%. Even a 20% increase in the 2017 catch advice should result in a Harvest Rate of less than 7.5% (the lowest MSY harvest rate for the analytically assessed stocks in area 4). The current fishery rates may be in excess of the proxy MSY rate.

Basis	Total Catch	Wanted Catch	Unwanted Catch	Dead discards	Surviving discards	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.2*2016	740	507	233	-	-	25.6%	12.8%	6.4%	4.3%	3.2%	2.6%	2.1%	1.8%	1.6%
0.8* 2017 land advice	1045	716	329	-	-	36.1%	18.1%	9.0%	6.0%	4.5%	3.6%	3.0%	2.6%	2.3%
0.3*2016	1110	761	350	-	-	38.4%	19.2%	9.6%	6.4%	4.8%	3.8%	3.2%	2.7%	2.4%
2017 landings advice	1307	895	412	-	-	45.1%	22.6%	11.3%	7.5%	5.6%	4.5%	3.8%	3.22%	2.8%
0.8*10 yr av	1489	1020	469	-	-	51.4%	25.7%	12.9%	8.6%	6.4%	5.1%	4.3%	3.7%	3.2%
Fmsy	1526	1045	481	-	-	52.7%	26.4%	13.2%	8.8%	6.6%	5.3%	4.4%	3.8%	3.3%
2017 Landings adv* 1.2	1568	1074	494	-	-	54.2%	27.1%	13.5%	9.0%	6.8%	5.4%	4.5%	3.9%	3.4%
0.5*2016	1851	1268	583	-	-	63.9%	32.0%	16.0%	10.7%	8.0%	6.4%	5.3%	4.6%	4.0%
10 year av land	1862	1275	587	-	-	64.3%	32.2%	16.1%	10.7%	8.0%	6.4%	5.4%	4.6%	4.0%

0.8*2016	2961	2028	933	-	-	102.3%	51.1%	25.6%	17.0%	12.8%	10.2%	8.5%	7.3%	6.4%
2016	3701	2535	1166	-	-	127.9%	63.9%	32.0%	21.3%	16.0%	12.8%	10.7%	9.1%	8.0%
													Latest TV survey *	

Under the scenario in which the landing obligation applies but discarding is permitted on a *de minimis* basis (i.e. catch below MCRS is permitted to be discarded up to 6% of total catch weight), the picture is similar in terms of the 2017 advice being below the 7.5% harvest rate.

Basis	Total Catch	Wanted Catch	Unwanted Catch >MCRS	*De minimis* discards <MCRS	Surviving discards	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.2*2016	742	507	235	8	0	25.6%	12.8%	6.4%	4.3%	3.2%	2.6%	2.1%	1.8%	1.6%
0.8* 2017 land advice	1047	716	331	11	0	36.1%	18.1%	9.0%	6.0%	4.5%	3.6%	3.0%	2.6%	2.3%
0.3*2016	1112	761	352	12	0	38.4%	19.2%	9.6%	6.4%	4.8%	3.8%	3.2%	2.7%	2.4%
2017 landings advice	1159	895	414	14	0	45.1%	22.6%	11.3%	7.5%	5.6%	4.5%	3.8%	3.2%	2.8%
0.8*10 yr av	1492	1020	472	16	0	51.4%	25.7%	12.9%	8.6%	6.4%	5.1%	4.3%	3.7%	3.2%
Fmsy	1528	1045	483	17	0	52.7%	26.4%	13.2%	8.8%	6.6%	5.3%	4.4%	3.8%	3.3%
2017 Landings adv * 1.2	1571	1074	497	17	0	54.2%	27.1%	13.5%	9.0%	6.8%	5.4%	4.5%	3.9%	3.4%
0.5*2016	1854	1268	586	20	0	63.9%	32.0%	16.0%	10.7%	8.0%	6.4%	5.3%	4.6%	4.0%
10 year av land	1865	1275	590	20	0	64.3%	32.2%	16.1%	10.7%	8.0%	6.4%	5.4%	4.6%	4.0%
0.8*2016	2966	2028	938	32	0	102.3%	51.1%	25.6%	17.0%	12.8%	10.2%	8.5%	7.3%	6.4%
2016	3708	2535	1173	40	0	127.9%	63.9%	32.0%	21.3%	16.0%	12.8%	10.7%	9.1%	8.0%
													Latest TV survey *	

11.3.5 Management considerations for FU 5.

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock. Given the paucity of metrics available for monitoring stock development, the exploitation of this stock should monitored closely.

11.4 Farn Deeps (FU 6)

11.4.1 Fishery in 2015 & 2016

Since the beginning of the time-series, the UK fleet has accounted for virtually all landings from the Farn Deeps (Table 11.4.1). The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2016 data comprise the end of the 2015–2016 fishery and the start of the 2016–2017 fishery.

Landings in 2015 were 1 371 tons, the lowest since 2008 and the second lowest on record (Figure 11.4.1). The majority of this reduction occurred in the second half of 2015, the winter fishery of 2015–2016 being particularly poor. Landings in 2016 increased to 1 854 tons, however this is below the 10 year average (2006–2015) of ~2 500 tons.

The introduction of the buyers and sellers legislation in 2006 means direct comparison with previous years should be viewed with caution because the suspected resulting improvement in reporting levels will have created a discontinuity in the data.

Directed effort (i.e. days fishing by vessels fishing with *Nephrops* gears) from English vessels during 2015 declined from the 2014 level, particularly for the <10 m sector but then rose in 2016 to the highest level on record. Directed English effort also rose for the 10–15 and >15 m sectors but not by the same level.

Historically the fishery has been prosecuted by a combination of local English boats (smaller vessels undertaking day–trips) and larger vessels from Scotland with occasional influxes of effort by Northern Irish vessels. The total number of vessels in the fishery (which land into England) declined between 2007–2011 before rising again. Total vessel numbers fell in 2015 and 2016 although the number of <10m vessels increased slightly between 2015 and 2016 (Figure 11.4.2). The majority of the dynamic in fleet size over the 2007–2016 period is due to larger (>15 m) Scottish boats, likely to be a response of vessels moving away from reduced catch rates in FU7.

The UK introduced emergency measures for UK vessels fishing in the Farn Deeps from April 2016 onwards in an attempt to reduce the fishing pressure on the Farn Deeps stock unit. These measures were as follows:

- Vessel owners will be required to use a minimum mesh size of 90mm using single twine of 5mm.
- The use of a lifting bag will continue to be permitted
- Only single-rig vessels of 350 kW (476 hp) or less will be permitted to fish within 12nm of the coast.
- Multi-rig vessels (vessels with three or more rigs) will be prohibited from operating within the Farn Deeps. Twin rig vessels will be permitted to operate outside 12 nm.
- No vessel will be permitted to use gear with more than one cod end per rig.

ICES Advice in 2016

The last assessment of *Nephrops* in FU6 was in 2015

ICES advises that when the MSY approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in 2017 should not exceed 1 143 tons. This would imply wanted catch of no more than 1020 tonnes.

In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to this FU could rapidly lead to over-exploitation.

Management of the fishery is at the ICES Subarea level as described in Section 10.1.

11.4.2 Assessment

Review of the 2016 assessment

The assessment has been performed correctly with no deviations from the standard procedure for this stock. The update assessment gives a valid basis for advice.

Data available

Catch, effort and research vessel data

Three types of sampling occur on this stock, landings sampling, catch sampling and discard sampling providing information on size distribution and sex ratio. The sampling intensity is considered to be generally good although concerns regarding the sampling levels of tail (as opposed to whole) landings has resulted in the catch and landings distributions being estimated from the monthly catch samples, supplemented by the discard sampling. The use of landings sampling where the tailed portion of the catch is under-represented would upwardly bias the estimate of landing lengths.

Discards

The procedure used to estimate discards changed in 2002. The methods are described in detail in the Stock Annex. Discarding practice varies considerably between vessels in any given period but there is no significant trend in the computed discard ogives (Figure 11.4.3) hence the use of a fixed discard ogive on the catch length distributions since 2002. The Benchmark meeting in 2013 concluded that the historical assumption of 0% discard survival was no longer applicable as a significant proportion of catch sorting now takes place at sea. For day-boats, the first haul of the day will generally be sorted on the fishing grounds whilst the second haul will be sorted whilst steaming back to port (and therefore passing over habitat unsuitable for *Nephrops*. Discarding practice for multi-day boats will generally result in discards returning to suitable sediment. The conclusion was therefore that although the full 25% survival assumed in other FUs was not likely to be applicable a 15% survival rate was a reasonable estimate for this FU.

Length Frequency

There is a clear change in length frequencies around 2007 with much lower contributions from the smaller (discarded) size classes (Figure 11.4.7). This may reflect an improvement in selectivity by the fleet or alternatively a decrease in recruitment levels. There is a decrease in the overall level of TV survey around the same time indicating that this change in length distribution may at least partly reflect a reduction in the level of recruitment.

A bi-modal length frequency distribution for landed females had been present since 2009 and become steadily more pronounced until 2014 but has receded in 2015 and 2016. This could be the result of a large year class, but a similar phenomenon is not observed in the male part of the population, in fact the mean size in the males decreased in 2012 and 2013. In addition to the lack of mode in the males, the mean annual increment of the female second mode is only around 2 mm whereas inter annual growth would be expected to be more and therefore year class strength is unlikely to be the cause of this feature. The predominance of large females in the catches means they were foraging for food on the surface at a time when they would have been expected to be brooding eggs within their burrows. Given that there are very few males of similar size appearing in the catches it is possible that there is a physical size differential constraint in mating patterns of *Nephrops*. This may either be an inability of the males to successfully transfer spermatophores, or alternatively large females may be able to resist the (usually quite aggressive) approaches of the smaller males when they try to mate with large females. The reduction in the bi-modal nature of the female length distribution in 2015 and 2016 implies a lower relative availability of females at larger sizes and may indicate a better spawning success. The alternative hypothesis is that this part of the population was removed by the fishery and would therefore suggest continued low recruitment.

There is therefore considerable concern that this stock is likely to have experienced reduced recruitment and may continue to do so for at least the next year or two (assuming that recruits enter the fishery between age 2 and 3). Whether the change in proportion of large mature females in the landings is a result of improved mating conditions remains to be seen and will not be evident for a further 12 months in the form of improved recruitment.

Effort and lpue

The way in which data regarding both landings and effort were collected within the UK changed in 2006 (Buyers and Sellers legislation) which had a noticeable change in the level of reported metrics. Comparison between these two time periods is therefore inadvisable.

Directed effort fell for the under 10m sector has remained constant from 2006 onwards, whilst for the larger vessels this dropped from 2006. 2006 saw a large influx of larger vessels from other areas of the UK including Scotland and Northern Ireland. There was an increase in the number of Scottish boats, particularly the large >15 m sector in 2013 and 2014. (Figure 11.4.2) although the number of participating vessels has decreased again slightly in 2015–2016.

The use of lpue as an index of stock abundance for *Nephrops* is confounded by changes in availability of *Nephrops* to fishing gears depending upon environmental factors such as tide and light levels, plus changes to emergence behaviour induced by mating and predator avoidance. There is a general level of agreement between lpue for the different gears and a decline in stock abundance from around 2006 to 2008.

Effort and lpue show distinct differences between vessel size classes, twin-rig being more efficient for a size class of vessel than single-rigs (figure 11.4.5). There remain some consistency issues between periods pre and post 2006, but despite this there appears to be a difference in the trajectory of lpue between the vessel size classes. Small (<10m) single-rig vessels have seen a sharp drop from ~300kg per day in 2006 to around 150kg per day in 2014 and this level had remained fairly constant between 2009 and 2014, vessels larger than this on the other hand appeared to be experiencing increasing lpue, particularly for the >15m vessel sector. This may represent a spatial difference in stock development as the smaller vessels are restricted to more inshore areas, however there may be some fleet changes (larger vessels) or reporting changes (issues with data from e-logs) which are driving some of these differences. For 2015 however, all fleet sectors experienced their lowest recorded catch rates however catch rates returned to around the recent (2006–2015) average in 2016.

Traditionally, males tend to predominate the landings, averaging about 70% (range 64%–79%) by biomass in the period 1992–2005. Towards the end of the fishing season (February-March) there is usually an increase in female availability as mature females emerge from their burrows having released their eggs. There has been a marked change in the seasonal pattern of sex-ratio for Farn Deeps *Nephrops* since the winter of 2005. Prior to this the ratios were generally smooth with small (~10%) seasonal fluctuations, but since then the fishery has observed very large swings, with whole years being dominated by landings of females (2006, 2010, 2014–2014, Figure 11.4.4). The sex ratio for 2015 returned to a generally male dominated fishery and can be explained by the lack of large females in the catches (Figure 11.4.7).

Effort in the 2014–2015 winter fishery was markedly lower than the same period 12 months previously but no lower than that observed in the early 2000s when abundance was estimated to be much higher. The relative strength of effort within a season (i.e. the fourth quarter compared to the first quarter) fluctuates without trend. Effort in the summer of 2016 was unusually high, with a clear spike in the catch rate of females (Figure 11.4.6)

Female lpue in the fourth quarters of 2000, 2006, 2009, 2001 and 2013 have been higher than one might expect given that they are supposed to have reduced availability due to egg-brooding.

UWTV

Underwater TV surveys of the Farn Deeps grounds have been conducted at least once in each year from 1996 onwards.

A time series of indices is given in Figure 11.4.8 and Table 11.4.5. The procedure used to work up the TV survey has been changed in 2011. The original survey design was a random-stratified design where the ground was split into regular boxes with stations randomly placed within. At a later stage additional stations were inserted into areas of high density to better define them, however this was not accounted for in the process of estimating overall abundance and therefore the higher density of stations in high-density *Nephrops* areas will have biased the estimate upwards. In addition, the distance covered by the TV sledge was determined by assuming a straight-line between the start and finish positions of the vessel. Since 2007, GPS logging of the position of the vessel and the sledge (via a Hi-Pap beacon) at short intervals (~5 seconds) has enabled a considerably more robust estimate of viewed distance to be made. The abundance estimate is now made using a geostatistical procedure in which the spatial position of the burrow density estimates are first fitted by a semi-variogram model and then a 3D surface of burrow density is created using Kriging on a 500 m*500 m grid. Uncertainty estimation of the overall abundance estimate is performed by bootstrapping the counts, re-fitting the semi-variogram and re-estimating the surface. Uncertainty estimates are typically 2%, much lower than the previous estimates which ignored spatial structure to a large degree. Figure 11.4.9 shows the final maps for 2013–2016. The TV survey in 2009 was hampered by a period of poor weather and low visibility which coincided with the surveying of the areas traditionally associated with the highest densities (fishing vessels were working this area at the time of survey and consequently disturbing the sediment). The spatial pattern of burrow density is similar through time with the highest density ground running along the eastern edge of the mud-patch.

Intercatch

All data for 2016 were entered onto Intercatch. Landings data by fleet were provided by Scotland, England, Denmark, Belgium and the Netherlands, whilst England provided length distributions for landings and discards by fleet where available.

Discard ratios for all unsampled fleets were raised on the combined annual data from England. Quarterly length distributions were imported for England which represented 84% of the landings. Consequently, length frequencies for the remaining metiers were generated from the pooled data (i.e. irrespective of metier or quarter) for both landing and discard components.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex which was updated at the 2013 benchmark.

Exploratory analyses of RV data

A comprehensive review of the use of underwater TV surveys for *Nephrops* stock assessment was undertaken by WKNeph (ICES 2009). This covered the range of potential biases resulting from factors including edge effects, species mis-identification, and burrow occupancy. Cumulative bias-correction factors were estimated for each FU and for FU6 the bias correction factor is 1.2 meaning that the raw counts from the TV survey are likely to overestimate densities of *Nephrops* by 20%. The correction factor is therefore applied to the raw counts to arrive at the absolute abundance index. Estimates of absolute burrow density total abundance estimates (with confidence estimates) are given in Table 11.4.4

For the purposes of advising on management for the next year, the TV survey from the assessment year is assumed to be representative of the fishing opportunities for the forecast year. Whilst the main ICES assessment is undertaken in May, the TV survey for FU6 is not undertaken until June. This means that the initial assessment and advice for 2018 relies upon the TV survey from 2016, however both the assessment and advice are usually updated for the round of revised advice in the autumn. The validity of using the TV survey to determine advice for the following year was explored by looking at how the TV survey predicts metrics such as catch rate and landings in the following year. Significant relationships were found between TV survey in the previous year and lpue, Effort and Landings (Figure 11.4.12), whereas there were no significant relationships for when using the TV survey in the same year as the fishery metrics. This suggests that for FU6, using the TV survey from the previous year is a valid predictor of fishery activity in the following year.

Final Assessment

The estimated abundance in 2016 was 697 million individuals (95% confidence interval of ±19 million), significantly below the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2015 was 13.3% (Table 11.4.5), well above the MSY proxy level of 8.1%.

The stock therefore remains in a vulnerable state. The dominance of large females in the landings again for the 2012–2014 fishery suggests that they had not successfully mated and therefore there remains the potential for poor recruitment for 2017 and 2018 (recruits to the fishery are estimated to be ~ 2–3 years old)

11.4.3 Historical stock trends.

The time series of TV surveys is 16 consecutive years although the new geostatistical method has only been applied retrospectively to 2007. Whilst there is expected to have been a small over-estimation of abundance using the previous technique it is likely that the reduction in stock abundance observed between the two periods of estimation procedure is real.

Estimates of historical harvest ratio (the proportion of the stock which is removed) range from 6.1% to 25.5% (Table 11.4.5). The harvest ratio jumped from around 12% in 2004–2005 to 25.5% in 2006 when the new reporting legislation came in. The harvest rate has only been below the MSY level once in 13 years.

11.4.4 MSY considerations

Considerations for setting Harvest Ratios associated with proxies for F_{msy} for *Nephrops* are described in ICES, WGNSSK, 2010, section 10.1.

- Average density in the stock is at a medium level, above the level of the FU 7 but below that of FU 8.
- Density has varied through time but does not appear to undergo large scale interannual fluctuations. Spatially there is a good degree of consistency in the pattern of high and low density between the years.
- Estimated growth rates are at a moderate level although the data supporting them are quite old. Natural mortality estimates are standard.
- The fishery in the Farn Deeps is a winter fishery (October–March) with typically male dominated catches. The intra-annual pattern of sex ratios in the catches has changed in 2006 and 2009 possibly due to sperm limitation leading to more mature but unfertilised females being available to the fishery. This may lead to reduced recruitment to the fishery.
- Although the time series of observed harvest rates is relatively short, there has been a fair degree of fluctuation (7–25%). The observed harvest rate is, of course, confounded by the change in reporting levels considered to have occurred around 2006. The average harvest rate since 2006 is 15.9% which is above the most recent estimate of Fmax for males.

The following table shows the mean F, implied harvest rate and resulting spawner per recruit values (expressed as a percentage of virgin) for the range of F_{msy} proxies suggested for *Nephrops* stocks. These values were last recalculated in 2013 using a length cohort analysis model (SCA, see ICES, WKNEP 2009) on the combined length frequencies for 2010–2012. The model fit to the data (Figure 11.4.11) is reasonable but the increasing bi-modality of the length frequency observed in the females over the past 4 years does violate model assumptions and the model under-predicts the landings of larger females.

		Fbar 20–40 mm		**Harvest Rate**	**% Virgin Spawner per Recruit**	
		Female	Male		Female	Male
F0.1	Comb	0.09	0.09	8.7%	47.52%	32.11%
F0.1	Female	0.16	0.16	14.0%	32.63%	18.26%
F0.1	Male	0.07	0.07	7.1%	53.02%	38.50%
F35%	Comb	0.12	0.12	11.1%	39.98%	24.50%
F35%	Female	0.17	0.17	15.2%	34.82%	16.64%
F35%	Male	0.16	0.16	8.1%	57.17%	34.88%
Fmax	Comb	0.17	0.17	15.3%	34.58%	16.48%
Fmax	Female	0.29	0.29	21.6%	22.22%	9.47%
Fmax	Male	0.12	0.12	11.6%	44.70%	23.73%

The default Harvest Rate suggested for *Nephrops* is the combined sex F35%SpR. The effects of sperm limitation appear to have been a factor in the recent development of this stock. There are signs that this stock may be in a period of lower productivity and so a harvest rate which gives greater protection to the spawning potential of males would be advisable. The group therefore recommends moving the F_{msy} proxy to the harvest rate equivalent to F35% on males for this stock (8.1%).

WGNSSK suggests the absolute abundance index from the TV survey as observed in 2007 (i.e. the first year when the stock was considered to be depleted in the recent series) should become a proxy for $B_{trigger}$ ($B_{trigger}$ = 858 million).

Short term forecasts

Catch and landing predictions for 2018 are given in the text table below. This assumes that the absolute abundance estimate made in June 2016 is relevant to the stock status for 2018. The ICES MSY approach dictates that where the stock status is below the trigger point, the maximum advised fishing rate should be the MSY rate adjusted by the ratio of the current stock status to the Btrigger level. For 2017 this gives

HR_{2017} = HR_{MSY} (8.12%) * Abundnace 2016 (697) / Btrigger (858) = 6.6%

The advice given for 2018 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea) allowed. A catch options table is provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Animals which would previously have been discarded are assumed to still be unwanted and landed as “unwanted catch”.

Under scenario 2 where discarding practice continues, the catch will either be landed, discarded dead or discarded alive.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2017 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (15% survival rate is still assumed).

Variable	Value	Source	Notes
Abundance in TV assessment	697	ICES (2016a)	UWTV 2016
Mean weight in landings	29.09	ICES (2016a)	Average 2014–2016
Mean weight in discards	10.88	ICES (2016a)	Average 2014–2016
Mean weight in unwanted catch >MCRS	13.64	ICES (2016a)	Average 2014–2016
Mean weight in unwanted catch <MCRS	6.91	ICES (2016a)	Average 2014–2016
Discard rate (total)	24.18%	ICES (2016a)	Average 2014–2016 (proportion by number)
Discard rate (>MCRS)	14.26%	ICES (2016a)	Average 2014–2016 (proportion by number)
Discard rate (<MCRS)	9.92%	ICES (2016a)	Average 2014–2016 (proportion by number)
Discard survival rate	15%	ICES (2016a)	Only applies in scenarios where discarding is allowed.
Dead discard rate (total)	21.33%	ICES (2016a)	Average 2014–2016 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	8.56%	ICES (2016a)	Average (proportion by number) 2014–2016, only applies in scenarios where when discarding allowed for de minimus exemptions.

***Nephrops* in FU6. Catch options assuming the landing obligation applies.**

	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
FMSY ApproachComb	1135	1014	121	6.60%
FmsyLower	1204	1076	128	7.00%
F0.1Male	1223	1093	130	7.11%
FmsyUpper	1376	1230	147	8.00%
F35%Male = FMSY	1397	1248	149	8.12%
F0.1Comb	1493	1334	159	8.68%
F35%Comb	1917	1712	204	11.14%
FmaxMale	1996	1783	213	11.60%
Fcurrent (2014-2016)	2178	1946	232	12.66%
F0.1Female	2412	2155	257	14.02%
F35%Female	2613	2335	279	15.19%
FmaxComb	2632	2352	281	15.30%
FmaxFemale	3716	3320	396	21.60%
F0.1Male	1204	1076	128	7.00%
	1222	1091	130	7.10%
	1239	1107	132	7.20%
	1256	1122	134	7.30%
	1273	1137	136	7.40%
	1290	1153	138	7.50%
	1308	1168	139	7.60%
	1325	1184	141	7.70%
	1342	1199	143	7.80%
	1359	1214	145	7.90%
	1376	1230	147	8.00%
FmsyUpper	1394	1245	149	8.10%

***Nephrops* in FU6. Catch options assuming that discarding continues at historic patterns.**

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
FMSY ApproachComb	1178	1159	1052	107	19	6.60%
FmsyLower	1250	1230	1116	113	20	7.00%
F0.1Male	1269	1249	1134	115	20	7.11%
FmsyUpper	1428	1405	1276	129	23	8.00%
F35%Male = FMSY	1450	1426	1295	131	23	8.12%
F0.1Comb	1550	1525	1384	140	25	8.68%
F35%Comb	1989	1957	1777	180	32	11.14%
FmaxMale	2071	2038	1850	188	33	11.60%
Fcurrent (2014-2016)	2260	2224	2019	205	36	12.66%
F0.1Female	2503	2463	2236	227	40	14.02%
F35%Female	2712	2668	2423	246	43	15.19%
FmaxComb	2731	2688	2440	247	44	15.30%
FmaxFemale	3856	3794	3445	349	62	21.60%
FmsyLower	1250	1230	1116	113	20	7.00%
	1267	1247	1132	115	20	7.10%
	1285	1265	1148	116	21	7.20%
	1303	1282	1164	118	21	7.30%
	1321	1300	1180	120	21	7.40%
	1339	1317	1196	121	21	7.50%
	1357	1335	1212	123	22	7.60%
	1375	1353	1228	125	22	7.70%
	1392	1370	1244	126	22	7.80%
	1410	1388	1260	128	23	7.90%
	1428	1405	1276	129	23	8.00%
FmsyUpper	1446	1423	1292	131	23	8.10%

***Nephrops* in FU6. Catch options assuming the landing obligation applies with the *de minimis* rules for animals below MCRS.**

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
FMSY ApproachComb	1152	1147	1029	91	27	5	6.60%
FmsyLower	1223	1217	1092	96	29	5	7.00%
F0.1Male	1242	1237	1109	98	29	5	7.11%
FmsyUpper	1397	1391	1248	110	33	6	8.00%
F35%Male = FMSY	1418	1412	1267	112	33	6	8.12%
F0.1Comb	1516	1510	1354	119	36	6	8.68%
F35%Comb	1946	1937	1738	153	46	8	11.14%
FmaxMale	2026	2017	1810	160	48	8	11.60%
Fcurrent (2014–2016)	2211	2202	1975	174	52	9	12.66%
F0.1Female	2449	2438	2188	193	58	10	14.02%
F35%Female	2653	2642	2370	209	63	11	15.19%
FmaxComb	2672	2661	2387	210	63	11	15.30%
FmaxFemale	3772	3757	3370	297	89	16	21.60%
FmsyLower	1223	1217	1092	96	29	5	7.00%
	1240	1235	1108	98	29	5	7.10%
	1257	1252	1123	99	30	5	7.20%
	1275	1270	1139	100	30	5	7.30%
	1292	1287	1155	102	31	5	7.40%
	1310	1304	1170	103	31	5	7.50%
	1327	1322	1186	105	31	6	7.60%
	1345	1339	1201	106	32	6	7.70%
	1362	1357	1217	107	32	6	7.80%
	1380	1374	1233	109	33	6	7.90%
	1397	1391	1248	110	33	6	8.00%
FmsyUpper	1415	1409	1264	111	33	6	8.10%

11.4.5 BRPs

Suggestions for proxies of biological reference points are shown in the catch option table and discussed in 11.4.3.

11.4.6 Quality of assessment

Changes to the legislation regarding the reporting of catches in 2006 means that the levels of reported landings from this point forward are considered to better reflect the true landings and hence effort input into this fishery. This does mean that comparison of LPUE with previous years is inadvisable and the independence of the final assessment from these data is likely to continue for some time.

The length and sex compositions arising from the land-based catch sampling programme are considered to be representative of the fishery. Estimates of discarded and retained length frequencies arising from the discard sampling programme are also considered robust since 2002.

The TV survey in this area has a high density of survey stations compared to other TV surveys and the abundance estimates are generally considered robust. There is greater uncertainty in the index for 2009 due to the absence of stations in the higher density areas which may result in an over-estimate of the magnitude of the decline for this year.

The spatial distribution of the 2016 survey results continues the pattern observed in other years with the spine of high density on the western edge of the ground remaining a regular feature. The main features of the survey series are peaks in abundance 2001 and 2005, with reasonably constant series since 2007.

The only harvest rate observed to be below the MSY level was in 2008, the mean harvest rate of 16.4% is almost double the MSY level.

Without suitable controls on the movement of effort between Functional Units there is nothing to prevent the effort in 2018 continuing to inflict fishing mortality above the F35% SprR level and indeed above the level of F_{max}. Prior to the introduction of “Buyers and Sellers” legislation in 2006 reporting rates are considered to have been low and hence the estimated Harvest Ratios prior to 2006 are also likely to have been underestimated.

11.4.7 Status of stock

The 2016 TV survey indicates the stock continues to be in a depleted state, below the level of MSY $B_{trigger}$ with harvest rates well in excess of the MSY advised rate. There is an indications that there is a slightly stronger recruitment in 2016 coming into the stock.

11.4.8 Management considerations

The WG, ACFM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level and management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Decreases in abundance in other FUs (i.e. Firth of Forth and the Fladen grounds) may raise the risk of higher effort being deployed in this FU. The high cost of fuel combined with the relative coastal proximity of this ground makes fishing this Functional Unit a relatively attractive proposition and additional fishing effort would be inadvisable given the current low level of the stock.

It is not yet possible to fully assess whether the UK emergency measures had an impact upon the fishing rates as they were introduced mid–year during 2016, although effort in some sectors appears to have increased as did landings.

11.5 Fladen Ground (FU 7)

11.5.1 Ecosystem aspects

The Fladen Ground (Functional Unit 7) is located towards the centre of the Northern North Sea off the east coast of Scotland (Figure 10.1.1). This region is characterised by an extensive area of mud and muddy sand, and hydrographic conditions include a large scale seasonal gyre which develops in the late spring over a dome of colder water.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the Fladen Ground FU these substrates are distributed more or less continuously over a very large area (approx. 30 000 km^2). Figure 11.5.5 shows the distribution of sediment in the area. Sandy mud and muddy sand are the dominant sediment types, with patches of mud in the south west area of the FU. Numerous fish species occur in in the same area as *Nephrops* with demersal fish more prevalent in the northern area. In the softest areas of mud, *Pandalus borealis* is also found.

11.5.2 The Fishery in 2016

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (2399 tonnes in 2016), with England taking 2 tonnes and Denmark 2 tons (Table 11.5.1). Around 80 vessels participated in the Fladen fishery at various times throughout the year. The majority are Scottish vessels fishing out of and landing to Fraserburgh and Peterhead. Catch consisted of *Nephrops*, haddock, whiting, cod, monkfish and megrim. A number of vessels have installed freezer capabilities to enable longer trips, but the average trip is around seven days. The fishery is seasonal and the fleet nomadic, moving between Fladen, Moray Firth, Firth of Forth, Devil's Hole, Farn Deeps and west coast of Scotland according with the time of the year and catch rates. Fishing in 2016 was generally better than in 2015 when Fladen landings reached its lowest figure since the late eighties. A reduced number of trips have been registered in Fladen with large areas of FU 7 not visited, mostly to the north of the ground. In the second quarter of 2016, low catch rates lead to a significant exodus from the Fladen grounds to the Firth of Forth, Farn Deeps and the west coast of Scotland. Information on the fishery suggests that due to poor fishing in the Minches, some vessels moved further through the west to the South of England, fishing off the Scilly Islands (FU 20–21) between April and July. Some vessels also spent time during summer in the Silver Pits (FU 5) and Devil's Hole (FU 34). The fishery in Fladen improved slightly in the second half of 2016 when most landings took place, but remained low compared with the figures obtained in the 2000's.

Most vessels fishing in FU 7 traditionally have used twin rigs with 80/90 mm mesh. Recently, to reduce catches of whitefish (e.g. cod), mandatory measures implied that any vessel using gear with a mesh size of less than 100 mm (TR2) in Area 4.a in the North Sea must fish exclusively with any of the Highly Selective Gears (HSGs). Examples of these are the Gamrie Bay Trawl or Faithlie Cod Avoidance Panel. This made a significant portion of the fleet to switch to 100 mm mesh, as they can target both *Nephrops* and fish. This confirms the information on the TR1 vs TR2 split which shows that in recent years, vessels fishing in Fladen have become more dual purpose in the sense that the large majority are now using TR1 gears and no longer solely dependent on *Nephrops*. This implies that these vessels have to buy both quota and days. Further general information on the fishery can be found in the Stock Annex.

11.5.3 ICES advice in 2016

The ICES conclusions in 2016 in relation to state of the stock were as follows:

"The stock size has declined from the highest observed value in 2008 until the lowest abundance estimate in the time-series in 2015. In 2016 the stock size increased again and is now above MSY Btrigger. The harvest rate has declined in recent years and remains well below FMSY."

The ICES advice in 2016 (for 2017) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in 2017 should not exceed 12 699 tons. This would imply wanted catch of no more than 12 656 tons.

In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the FU level. In recent years, the catch in this FU has been lower than advised, and if the difference is transferred to other FUs, this could result in non-precautionary exploitation of those FUs."

11.5.4 Management

Total Allowable Catch (TAC) management is at the ICES Subarea level. Most *Nephrops* vessels operate TR2 gear (>=70 and <100 mm) and are subject to the effort regulations of the cod recovery plan. In recent year there has been a shift to using TR1 gears in Fladen allowing vessels to target *Nephrops* and fish simultaneously. In Scotland the Conservation Credits scheme is in operation and various technical measures apply to *Nephrops* vessels.

11.5.5 Assessment

Approach in 2017

The assessment of *Nephrops* in 2017 is based on examining trends in the UWTV survey data (1992–2016) and utilising an extensive series of commercial fishery data and follows the process defined by the benchmark WG 2009. The assessment approach is further described in the stock annex.

The provision of advice in 2017 followed the process of 2016, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

11.5.6 Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with small contributions from Denmark and England, and are presented in Table 11.5.1 and Figure 11.5.1. Total international landings (as reported to the WG) in 2016 were 2399 tonnes (34% higher than the 2015 total), consisting mostly of Scottish landings with only 4 tonnes landed by other countries. *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 7 in 2016.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas, particularly Fladen. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to 2016 and only annual summaries are available.

Trends in Scottish effort of *Nephrops* trawlers and lpue are shown in Figure 11.5.1 and Table 11.5.2. From 2015, effort data for this stock is expressed both in days fishing and kW days (there are no major differences in effort trends between those different units). Effort has been relatively stable from 2002 to 2010 but fell markedly in the last five years because of poor fishing and part the fleet relocating to other areas. The spatial contraction of the fishery is further confirmed by the VMS distribution of otter trawlers fishing in Fladen (2010–2015) shown in Figure 11.5.8. In recent years a decreasing numbers of trips have been taking place in FU 7 and in 2015, the south of the ground was the area where most fishing took place (no VMS data for 2016 was available at the time of the WG meeting). Lpue has gradually increased since 2000 to a peak of over 620 kg/day in 2009. It has fallen since then in recent years and the 2016 value was ~200 kg/day. Danish lpue data (1991–2016) are presented in Table 11.5.3. Effort has generally decreased over the time whilst lpue has gradually increased to its highest value in 2009 followed by a dramatic decrease as *Nephrops* became mostly a bycatch species for the Danish fleet in recent years.

Males consistently make the largest contribution to the landings (Figure 11.5.2). This is likely to be due to the varying seasonal pattern in the fishery and associated relative catchability (due to different burrow emergence behaviour) of male and female *Nephrops*. This is confirmed by the quarterly landings as shown in Figure 11.5.2. From 2012 landings were much lower in the second quarter of the year, a period when females would be expected to be more available for capture. In recent years landings were larger in the third and fourth quarters. Figure 11.5.7 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is apparent with males dominating catches, in particular during winter time (quarters 1 and 4). In quarters 2 and 3, females become more active and are more available to the fishery, although in FU 7 (unlike FU 8 and 9) the sex ratio is less seasonal and closer to 50:50 all year round. In the last four years the male proportion in quarter 2 is much higher than previously. This may be related with sampling noise associated with the recent decrease in landings (and sampling opportunities) in that quarter. Sex ratio data does not seem to show an overall increase of female proportion in catches in the time series, except for the last three winters (2014–2016) where male percentage in catches decreased to less than 50%. Increased female catchability has been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). It is unclear if this is the case in FU 7 but sex ratio monitoring in catches will continue to inform on potential shifts in the balance of the population.

Discarding of undersized and unwanted *Nephrops* has occurred in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 2000. The discarding rate average from 2000 is approximately 7% by number in this FU. From 2008 discard rates have dropped below the long term average and in the last six years the discard rates have been close to zero. In 2015–2016 no discards have been recorded in the observer trips conducted. This reduction in discard rate appears to be due to a change in the discard pattern with lower numbers of small individuals being caught and could also signal reduced recruitment and a tendency towards the use of larger mesh gears (see below on length compositions).

It is likely that some *Nephrops* survive the discarding process. An estimate of 25% survival has been assumed in order to calculate dead removals (landings + dead discards) from the population.

Intercatch

Scottish 2016 data (official landings and sampled data for landings and discards) were successfully uploaded into Intercatch. National data co-ordinators for other countries (England and Denmark) also uploaded landings data to Intercatch ahead of the 2017 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2016.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch data analysis are not presently possible for this species, examination of length compositions can provide a preliminary indication of exploitation effects.

Figure 11.5.3 shows a series of annual length frequency distributions for the period 2000 to 2016. Catch (removals) length compositions are shown for each sex with the mean catch and landings lengths shown in relation to MLS (25 mm) and 35 mm. In both sexes the mean sizes have been generally stable over time except for the last five years where a noticeable shift in the length distribution and an increase in the mean size has been observed for males and to a lesser extent, females.

Figure 11.5.1 and Table 11.5.4 show the series of mean sizes of larger *Nephrops* (>35 mm) in the landings. This parameter might be expected to reduce in size if overexploitation were taking place but there is no evidence of this. The mean size of smaller animals (<35 mm) in the catch is also fairly stable through time until 2010 when an increase is noticeable which may be associated with lower recruitments. In the last five years the landings mean size increased but discarding stopped, this may signal a period of reduced recruitment but could also reflect the increasing use of more selective gears. The discard rate in 2016 was estimated to be zero (as in 2011–2013 and 2015). Quantitative information on trends in gear changes is not currently available but a shift from TR2 to TR1 gears was observed from 2010. A further difficulty in the interpretation of these size observations is that the ground extends over a wide area and the distributional pattern of fleet activity is known to vary over time. This may lead to exploitation of sub-areas within the ground, where size compositions may be slightly different.

Mean weights in the landings through time (1990–2016) are shown in Figure 11.5.4 and Table 11.5.5. The variability in mean size is greater in Fladen (and Devil's Hole) than in other areas. In 2016, the mean weight in landings increased to 39.4g.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

Underwater TV (UWTV) surveys using a stratified random design are available for FU 7 since 1992 (missing survey in 1996). UWTV surveys of *Nephrops* burrow density and distribution reduces the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 11.5.6. On average, approximately 65 stations have been considered valid each year (78 stations in 2016). Data are raised to a stock area of 28 153 km^2 based on the stratification (by sediment type). General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in more detail in the Stock Annex.

Previous review groups have noted that the UWTV survey did not cover the stock distribution. The survey stations are randomly distributed within strata and therefore the actual location of the survey stations varies from year to year and in some years, particular regions of the main part of the ground may not be surveyed. There is an additional small patch of mud to the north of the ground which it is not possible to survey (due to time constraints and distance to survey ground) and therefore the estimated absolute abundance is likely to be slightly underestimated by the UWTV survey.

11.5.7 Data analyses

Exploratory analyses of survey data

Table 11.5.7 shows the basic analysis (corrected to absolute values) for the three most recent UWTV surveys conducted in FU 7. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground has a range of mud types from soft silty clays to coarser sandy muds (<40% silt and clay) and the latter predominates. Most of the variance in the survey is associated with the coarse sediment which surrounds the main centres of abundance.

Figure 11.5.5 shows the distribution of stations in recent UWTV surveys (2010–2016), with the size of the symbol reflecting the *Nephrops* burrow density. The abundance in 2016 increased sharply (73% from 2015) indicating a potential good recruitment in the ground. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground. Table 11.5.6 and Figure 11.5.6 show the time series estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. Following the recent low UWTV estimated densities and the apparent *Nephrops* fleet preference for the fishing grounds located to the south of Fladen (Figure 11.5.8), the WG looked closely at the spatial distribution of the UWTV survey in the last eight years. It was suggested (as a hypothesis) that the north of the ground has been more affected by the recent decline (from 2009) in abundance than the areas in the south where most fishing took place in recent years. To test this, the TV surveys from 2009–16 were re-worked by sediment type, splitting the ground in two areas, north and south of the 58.75 N latitude line. Results seem to support that the areas mostly affected by the reduction in the mean *Nephrops* burrow density from 2009 were in fact located in the south, especially those made of finer sediments located in the central south region (Figure 11.5.9). In the north of Fladen, where coarser sediments (<40% silt and clay) dominate, a decrease in density was also observed but to a lesser extent when compared with those in the south. This analysis also shows that despite the recent decrease in density in the south, the mean densities remain in average higher than in the north. The density increase in 2016 occurred across the different strata but is more evident in the medium fine (MF) sediment in the south and in the medium coarse (MC) sediment in the north (Figure 11.5.9).

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES 2009). A number of potential biases were highlighted including those due to edge effects, species burrow mis–identification and burrow occupancy. The cumulative bias correction factor estimated for FU 7 was 1.35 meaning that the raw UWTV survey is likely to overestimate *Nephrops* abundance by 35 %. In order to convert the raw UWTV survey abundance to an absolute abundance the raw data are divided by 1.35.

Final assessment

The UWTV survey is again presented as the best available information on the Fladen *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey and it therefore only provides information on abundance over the area of the survey.

The 2016 UWTV survey data shows that the abundance has increased markedly from the 2015 estimate. The stock is approximately at the average abundance over the time series and is now above the biomass trigger. The harvest ratio in 2016 (1.4%, calculated as dead removals/TV abundance) is well below FMSY. The effort by *Nephrops* trawlers and respective lpue declined from 2010 and this appears to be consistent with the abundance trends from the UWTV survey. The lpue in recent years is approximately at the same level as in the period prior to 2006 but this may be due the under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The relatively high lpues calculated for the period 2009–11, after the stock have declined could also be explained by the fishing fleet targeting areas where the density of *Nephrops* is higher. The mean size of individuals > 35 mm in the catch shows a clear increase. The discard rate remain at a very low level (0% in 2015–2016) and the mean size of individuals below 35 mm shows an increasing trend from 2010, which points to a period of lower recruitment between 2010 and 2015. The abundance increase in 2016 suggests a recruitment event. Larger square mesh panels and new, more selective gears combined with a shift towards TR1 gears implemented from 2010 as part of the Scottish Conservation Credits scheme in Division 4a may have improved the exploitation pattern and reduced catches of smaller individuals.

Historical Stock trends

The UWTV survey estimates of abundance for *Nephrops* in the Fladen suggest that the population has fluctuated over the 20 year period of the surveys. From 1997 to 2008 the abundance has generally increased and reached a peak of 7 360 million individuals in 2008. The abundance has fallen subsequently and was below the $B_{trigger}$ in 2012 and 2015. In 2016 the abundance has increased sharply from the lowest point of the time series (2015) to 4 449 million (Table 11.5.8).

Table 11.5.8 also shows the estimated harvest ratios from 1992–2016. These range from 1.4–10% over this period and are all below $F_{0.1}$. It is unlikely that prior to 2006, the estimated harvest ratios are representative of actual harvest ratios due to under-reporting of landings. In 2016, due to a 73% increase in the abundance and the landings remaining at a low level, the harvest ratio was estimated to be 1.4%, which is the lowest value recorded.

In addition to the discard rate, Table 11.5.8 shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards). Discards have been estimated to be zero in the last 6 years with the exception of 2014 (2.5%).

11.5.8 Recruitment estimates

Recruitment estimates from surveys are not available for this FU. However, the increase in mean size of small animals <35 mm (i.e. a lower proportion of small animals in this component of the catch) observed in recent years may be indicative of lower recruitments in the period 2010–2015. The recent increase in abundance suggests a good recruitment in 2016.

11.5.9 MSY considerations

FMSY proxies for *Nephrops* are obtained from the per-recruit analysis as documented in the WGNSSK 2015 report. The most recent analysis used 2012–14 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. Length frequency data in Fladen have clearly shifted towards larger animals since 2010 (see section 11.5.5 and Figure 11.5.3) suggesting a different selection pattern in the fishery. In addition, the discard rate has declined (average of 7% by number in 2008–10 and around 0% in recent years), due to a shift to larger meshes (TR1) and the increase in the use of the use of Highly Selective Gears for reducing fish bycatch. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit FMSY proxies is given in the table below and the basis for choosing an appropriate FMSY proxy remains the same and is described in WGNSSK 2010 report.

WGNSSK 2015		Fbar(20–40 mm) M	Fbar(20–40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.07	0.07	6.4	47.4	58.3	51.9
	F	0.14	0.15	10.6	33.3	40.8	36.4
	T	0.08	0.09	7.5	43.0	53.1	47.2
Fmax	M	0.21	0.22	13.8	26.6	31.6	28.7
	F	0.44	0.46	21.2	17.5	18.7	18.0
	T	0.27	0.29	16.4	22.8	26.1	24.2
F35%SpR	M	0.13	0.13	10.0	34.8	42.9	38.1
	F	0.18	0.19	12.6	29.0	34.9	31.4
	T	0.15	0.16	11.2	31.9	39.0	34.8

*** M = males, F = females, T = combined**

For this FU, the absolute density observed on the UWTV survey remains low (average of just below 0.2 m^{-2}) suggesting the stock may have low productivity. In addition, the expansion of the fishery in this area is a relatively recent phenomenon and as a result the population has not been well-studied and biological parameters are considered particularly uncertain. Furthermore, historical harvest ratios in this FU have been below that equivalent to fishing at $F_{0.1}$. For these reasons, it is suggested that a conservative proxy is chosen for FMSY such as $F_{0.1(T)}$.

The FMSY proxy harvest ratio is 7.5%.

The $B_{trigger}$ point for this FU (lowest observed absolute UWTV abundance, 1992–2010) is calculated as 2 767 million individuals.

11.5.10 Short-term forecasts

A catch prediction for 2018 was made for the Fladen Ground (FU 7) using the approach agreed at the Benchmark Workshop in 2009 and outlined in the introductory section of the 2010 WGNSSK report. The table below shows catch predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed in Section 10.1 of this report and the harvest ratio in 2016 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections).

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2017 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding allowed (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea). Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU 7 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2018 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2018 at the FMSY proxy harvest ratio under a *de minimis* exemption is 6 844 tons. It should be noted that the FMSY proxy harvest ratio for Fladen is based on a combined Length Cohort Analysis (data 2012–2014) using dead removals (landings + dead discards). This value is expected to be updated in the future (using updated length information) to account for the landings obligation where no discard survival is assumed. A discussion of FMSY reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	4449 million	ICES (2017a)	UWTV 2016
Mean weight in landings	39.75g	ICES (2017a)	Average 2014–2016
Mean weight in discards	-	ICES (2017a)	No discards in 2015–2016
Mean weight in unwanted catch >MCRS	-	ICES (2017a)	No discards in 2015–2016
Mean weight in unwanted catch <MCRS	-	ICES (2017a)	No discards in 2015–2016
Discard rate (total)	0%	ICES (2017a)	No discards in 2015–2016
Discard rate (>MCRS)	0%	ICES (2017a)	No discards in 2015–2016
Discard rate (<MCRS)	0%	ICES (2017a)	No discards in 2015–2016
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios when discarding is allowed.
Dead discard rate (total)	0%	ICES (2017a)	No discards in 2015–2016
Dead discard rate (<MCRS)	0%	ICES (2017a)	No discards in 2015–2016

Catch options assuming zero discards

	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
MSY approach	13264	13264	0	7.5%
F2016	2476	2476	0	1.4%
F2014–2016	4067	4067	0	2.3%
F35%SpR	19807	19807	0	11.2%
Fmax	29003	29003	0	16.4%
MSY approach	13264	13264	0	7.5%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

Basis	Total catch L+DD+SD	Dead removals L+DD	Landings L	Dead discards DD	Surviving discards SD	Harvest rate* for L+DD
MSY approach	13264	13264	13264	0	0	7.5%

*** Calculated for dead removals.**

Discarding allowed for *de minimis* excemptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	13264	13264	13264	0	0	0	7.5%
F2016	2476	2476	2476	0	0	0	1.4%
F2014–2016	4067	4067	4067	0	0	0	2.3%
F35%SpR	19807	19807	19807	0	0	0	11.2%
Fmax	29003	29003	29003	0	0	0	16.4%
MSY approach	13264	13264	13264	0	0	0	7.5%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

Biological Reference points

Biological reference points have not been defined for this stock.

11.5.11 Quality of assessment

The TV surveys results show that the abundance has fallen in recent years, but not to the extent that would cause such a loss of fishing opportunity as observed. It is necessary to consider the biology of *Nephrops* (and indeed other crustaceans using cryptic, or burrow orientated behaviours) that are only available to trawling when they emerge from burrows. One explanation for the recent lower emergences is that bottom temperatures appear to have been unusually low and for longer. Other environmental variables such as light levels, strength of tides are also known to exert an effect in the emergency behaviour of *Nephrops*. Exploratory analysis of the UWTV survey by sediment type (split by north and south of the ground) have shown that, despite the recent decrease in density, the mean densities remain in average higher in the south than in the north of FU 7 (see section 11.5.6). Taking into account the fact that the south of Fladen is located closer to the ports of Fraserburgh and Peterhead, where most of the fleet is based, this may explain why, in a period of lower densities, the south of FU 7 remains the area where most fishing activity takes place. Another factor that may play a role is that fishing in Fladen has become mixed in recent years and vessels may look for areas where economic returns are more favourable targeting both *Nephrops* and whitefish using larger mesh sizes, while reducing fuel costs.

The recent low landings in Fladen may be the result of a complex interplay of factors combined with reduced average densities in the population as confirmed by the recent TV survey results.

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately. Discard data covered 60% of the landings in 2016 (no discards were recorded).

The quality of landings (and catch) data is likely to have improved in recent years following the implementation of 'the registration of buyers and sellers' legislation in the UK in 2006, but because of concerns over the accuracy of earlier years, the final assessment adopted is independent of official statistics.

Underwater TV surveys have been conducted for this stock since 1992, with a continuous annual series available since 1997. The number of valid stations in the survey has remained relatively stable throughout the time period. Confidence intervals are relatively small.

The UWTV survey is conducted over the main part of the ground, representing an area of around 28 200 km^2 of suitable mud substrate (the largest ground in Europe). The Fladen Functional Unit contains several patches of mud to the north of the ground which are fished, bringing the overall area of substrate to 30 633 km^2. This area is not surveyed but would add to the abundance estimate. The absolute abundance estimate for this ground is therefore likely to be underestimated by the current methodology.

The Fishers' North Sea stock survey suggests that moderate or high amounts of recruits were apparent in Area 1 (which Fladen FU lies largely within) in 2011 compared to 2009. The time series of perceived abundance in Area 1 increases up to 2011. Opinion on discards appears to be split fairly evenly between lower, higher and no change. There are no Fishers' North Sea survey data available for 2013–2016.

11.5.12 Status of the stock

The stock has declined in the period 2008–2015 to the lowest point in the time series, then increased 73% in 2016. The abundance is now above the MSY $B_{trigger}$ level. Landings taken from this FU in 2016 (2 399 tons) were much lower than the 2015 advice (for 2016) of 6 856 tons. The harvest rate decreased in 2016 to 1.4% and remains well below F_{MSY}. Length frequencies in the caches have evolved towards larger animals over the last five years suggesting a selectivity change and/or lower recruitment in the period 2010–2015. The large abundance increase in 2016 suggests a recruitment event.

11.5.13 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES division level. Management implemented at the Functional Unit level could provide controls to ensure that catch opportunities and effort were in line with the scale of the resource and that other FUs do not suffer from displacement from unused catch options from this FU.

Nephrops fisheries have a bycatch of cod. In 2005, high abundance of 0 group cod was recorded in Scottish surveys near to this ground. This year class of cod has subsequently contributed to slightly improved cod stock biomass and efforts are being made to avoid the capture of cod so that the stock can build further. The Scottish industry operates under the Conservation Credits Scheme and is implementing improved selectivity measures in gears which target *Nephrops* and real time closures with a view to reducing unwanted by-catch of cod and other species.

The increase in abundance registered in 2016 points to a high recruitment event. If this is the case, it is uncertain whether these small individuals will become available to the fishery in the following year given the increase in selectivity recently observed for this FU. The selectivity of the survey is >17 mm carapace length (CL), the current MCRS is 25 mm CL. This stock is considered to be lightly exploited, and the difference between advice and catches may be transferred to other FUs in the North Sea which could result in non-precautionary exploitation of those FUs.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. Animals below the minimum conservation reference size may be discarded, up to a maximum of 6 % of the total annual catches of this species by vessels using bottom trawls (OTB, TBN, OTT, TB) of mesh size 80-99 mm in ICES Subarea IV and Union waters of ICES Division IIa. In 2016, no *Nephrops* were recorded as below the minimum size (BMS) in FU 7. This is consistent with the discard rates estimated for the FU in recent years which have been close to zero. It remains however, uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.6 Firth of Forth (FU 8)

11.6.1 Ecosystem aspects

The Firth of Forth Functional Unit 8 is located in the south-west of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 10.1.1.). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to seaward, narrowing towards the coast with river basins draining into the area. Sandy mud and muddy sand deposits are widespread throughout the area covering an area of 915 km^2, the coarsest muds being found offshore beyond the Isle of May.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 11.6.4 shows the distribution of sediment in the area. There is some evidence of *Nephrops* larval drift from grounds to the south of the area but most larvae appear to be produced locally and the population is characterised by high density and generally small size. Although this area was historically important for fish catches, this area has now declined and *Nephrops* is the main commercial species. The recruits of numerous demersal fish species occasionally aggregate in the area and small pelagics (sprat and juvenile herring) are seasonally abundant. Important seabird colonies occur in the area and the 'Wee Bankie' gravel area, important for sandeels is located further offshore to the north and east of the Firth.

11.6.2 The fishery in 2016

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 11.6.1). In recent years around 40 vessels worked regularly in the Firth of Forth. Most vessels are under 12m in length with about 10 in 12–15m category and a few above 15m. Engine power ranges from just under 100kw to around the 300 kw. The trip length for most of the fleet is one day. In the winter, most vessels fish from around dawn till 16:00–19:00. In spring/summer, vessels switch to nights, working from around 19:00 to 07:00–10:00. The few larger vessels (over 15m) fishing in FU 8, undertake trips of around 2–3 days. The overall number of boats operating varies seasonally as vessels move around the UK in response to varying catch rates. In 2016 some large Fraserburgh boats, which usually operate in FU 7, moved into the area, fishing mostly to the east grounds of the Firth. Visitor boats come generally from the Northeast of Scotland (FU 7 and FU 9) in periods of poor fishing in those grounds but tend to land to harbours in the northeast of Scotland. A few English vessels visited FU 8, mostly during summer, with landings from the rest of UK decreasing from 68 tonnes in 2015 to 32 tonnes in 2016. Catches were generally reported as good with considerable market demand and a slight increase in prices for all sizes of *Nephrops* caught. Fuel prices have been reported as lower than in previous years. The predominant trawl gear mesh sizes are 80 mm and 95 mm (TR2 gears with several vessels working with twin rigs). A few vessels have been involved with FDF (Fully documented Fisheries) getting some benefits in days at sea because of this. The fishery continues to be characterised by catches of small *Nephrops* which often leads to higher discard rates than in other east coast Functional Units. There was an increase in the amount of landings by creel vessels in this area to 116 tons in 2016 (43 tons in 2015) although typically the main target species of these vessels are crabs and lobsters.

Further general information on the fishery can be found in the Stock Annex.

11.6.3 Advice in 2016

The ICES conclusions in 2016 in relation to State of the Stock were as follows:

"The stock size is above MSY Btrigger. The harvest rate is varying above FMSY. "

The ICES advice in 2016 (for 2017) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in 2017 should not exceed 2548 tonnes. This would imply wanted catch of no more than 2190 tonnes.

In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to this FU could rapidly lead to over-exploitation."

11.6.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.6.5 Assessment

Approach in 2017

The assessment in 2017 is based on a combination of examining trends in fishery indicators and underwater TV using an extensive data series for the Firth of Forth Ground FU 8. The assessment of *Nephrops* through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice in 2017 followed the process of 2016, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involving collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.6.1 and Figure 11.6.1. Most of the landings are made by trawlers with creels accounting for 6% of the total. Reported landings rose from 1 100 to over 2 650 tons between 2003 and 2009 and have fluctuated since then around 2 000 tons. The value for 2009 of over 2 663 tons was the highest in the available time series whilst the 2016 landings (1 937 tons) are below the ten year average (2 150 tons). *Nephrops* is one of the species in the North Sea under the landing obligation. A small amount of landings below the minimum conservation reference size (1.5 tons) were reported for FU 8 as BMS category in 2016.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of effort data by the Marine Scotland data unit in Edinburgh covering the 4 main trawl gears landing *Nephrops* into Scotland produced higher figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and lpue are shown in Figure 11.6.1 and Table 11.6.2. Effort data is expressed both in days fishing and kW days (there are no major differences in effort trends between these different units). Effort has shown a gradual decline over the time period. Some of this is recently attributable to the EU effort management regime although, as part of the Scottish conservation credits scheme, *Nephrops* vessels have been eligible for effort 'buy-backs'. Lpue rose in the early 2000s and since 2006 has stabilised at a relatively high level.

Males consistently make the largest contribution to the landings by weight (Figure 11.6.2), although the sex ratio does vary and in 2011 more females in the catches moved the ratio closer to 1:1. This situation continued in 2012–2013. The proportion of females in the landings has increased in other years too (for example 2008). This may be due to the change in seasonal effort distribution with greatest effort in the 3rd quarter in 2008 when females are likely to be more available to the fishery (compared with a more evenly distributed seasonal effort pattern in 2007, Figure 11.6.2). Figure 11.6.6 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is evident with males dominating catches during winter time. In quarters 2 and 3 females become more active and are more available to the fishery. These data suggest a gradual increase of female proportion in catches in recent years. Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This does not appear to be the case here.

Discarding of undersized and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Historically, discard rates have been higher in this stock than the more northerly North Sea FUs for which Scottish discard estimates are also available. This could arise from the fact that the use of larger meshed nets is not so prevalent in this fishery (80–95 mm is more common) and in addition, the population appears to consist of smaller individuals due to slower growth. Discarding rates in this FU have varied between 16% and 55 % of the catch by number (2007–2016 average 26 %). In the last five years, discard rates appear to have dropped to below this value (24 % on average by number) and 2016 is the year with the lowest discard rate recorded (16%). This appears to be due to increased retention of *Nephrops* rather than an absence of small *Nephrops* from the catches.

It is likely that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed in order to calculate dead removals (landings + dead discards) from the population.

InterCatch

Scottish 2016 data (official landings and sampled data for landings and discards) were successfully uploaded into InterCatch. National data co-ordinators for other countries (England) also uploaded landings data to InterCatch ahead of the 2017 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No sampling length data was provided for the BMS category. Length distributions from discard data were allocated to raise BMS data.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed annual catch data analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 11.6.3 shows a series of annual length frequency distributions for the period 2000 to 2016. Size information on catches (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35 mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35 mm shows no evidence of reductions in relative numbers of larger animals.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35 mm) in the landings shown in Figure 11.6.1 and Table 11.6.3. This parameter might be expected to reduce in size if overexploitation were taking place but over the last 20 years has in fact been quite stable. The mean size in the catch in the < 35 mm category (Figure 11.6.1) also shows no particular trend although it has risen slightly in the period 2009–2014 followed by a small decrease in 2015. The recent increase in the lower tail of discarded length frequencies (Figure 11.6.3), the decrease in the mean size of animals below 35 mm (Figure 11.6.1) and a slight increase in the discard rate suggest possible a better recruitment in 2015.

Mean weight in the landings is shown in Figure 11.5.4 and Table 11.5.5 and this shows no systematic changes over the time series.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

TV surveys using a stratified random design are available for FU 8 since 1993 (missing surveys in 1995 and 1997). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 11.6.4. On average, about 44 stations have been considered valid each year. In 2016, there were 50 valid stations. Abundance data are raised to a stock area of 915 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

A further non-surveyed area of sediment (Lunan Bay) exists just north of the Firth of Forth FU. There is a small *Nephrops* fishery in this area (off Arbroath), but the area is only surveyed on an irregular basis and therefore is not included in any estimates of abundance. The WG wishes to emphasise that this area is out-with the Firth of Forth functional unit, is considered as part of the 'other' North Sea *Nephrops* area and hence not further considered in this section.

Data analyses

Exploratory analyses of survey data

Table 11.6.5 shows the basic analysis for the three most recent TV surveys conducted in FU 8. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand. Depending on the year, high variance in the survey is associated with different strata and there is no clear distributional or sedimentary pattern in this area. Densities observed in this FU are typically higher than those of the more northerly FUs in the North Sea.

Figure 11.6.4 shows the distribution of stations in TV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is currently higher towards the eastern and central parts of the ground and around the Isle of May. Table 11.6.4 and Figure 11.6.5 show the time series of estimated abundance for the TV surveys, with 95% confidence intervals on annual estimates. The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES 2009). A number of potential issues were highlighted including those arising from edge effects, species burrow mis-identification and burrow occupancy. To take account of these effects, a cumulative correction factor of 1.18 was estimated for FU 8 and this is applied to raw counts in order to derive the absolute abundance.

Final assessment

The underwater TV survey is again presented as the best available information on the Firth of Forth *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey, and it therefore only provides information on abundance over the area of the survey.

The UWTV abundance was relatively high in the period 2003 to 2008 but has shown a decreasing trend in 2008–2012. The stock has increased in the last 4 years to 797 million individuals. The stock is currently above the average abundance over the time series and remains above the biomass trigger. The calculated harvest ratio in 2016 (dead removals/TV abundance) decreased markedly and is now below FMSY. This is the result of a 20% increase in stock abundance combined with just a small increase in landings in 2016. The mean size of individuals > 35 mm in the catch show no strong trend in recent years but the mean size of individuals below 35 mm has shown a slight increase from 2009. Larger square mesh panels and new, more selective TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme may have improved the exploitation pattern. The effect of these changes are not however, as evident as those observed in FU 7 and length frequencies in recent years remain relatively stable in the Firth of Forth.

11.6.6 Historical stock trends

The TV survey estimate of abundance for *Nephrops* in the Firth of Forth suggests that the population decreased between 1993 and 1998 and then began a steady increase up to 2003. Abundance is estimated to have fluctuated without trend in the years since then. The abundance estimates from 1993–2016 are shown in Table 11.6.6. The stock is currently estimated to consist of 797 million individuals.

Table 11.6.6 also shows the estimated harvest ratios over this period. From 2003 (the period over which the survey estimates have been revised) these range from 12–29 % with the upper range being the value for 2014 (estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation). The estimated harvest rate in 2016 is 12.3% which is below the estimated value at F_{MSY} (16.3 %).

In addition to the discard rate, Table 11.6.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

11.6.7 Recruitment estimates

Survey recruitment estimates are not available for this stock.

11.6.8 MSY considerations

A number of potential FMSY proxies were obtained from the per-recruit analysis for *Nephrops* as documented in the WGNSSK 2010 report. The most recent analysis (in 2011) used 2008–10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit FMSY proxies is given in the table below and the process for choosing an appropriate FMSY proxy is described in WGNSSK 2010 report.

		Fbar(20–40 mm)			**SPR (%)**		
WGNSSK 2011		M	F	**HR (%)**	M	F	T
F0.1	M	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29.0
	T	0.17	0.07	9.4	34.6	56.6	43.9
Fmax	M	0.25	0.11	12.7	25.3	46.8	34.4
	F	0.64	0.28	26.7	9.1	22.9	14.9

	T	0.34	0.14	16.3	18.8	38.5	27.1
F35%SpR	M	0.17	0.07	9.4	34.6	56.6	43.9
	F	0.39	0.17	18.3	16.0	34.5	23.9
	T	0.25	0.11	12.7	25.3	46.8	34.4

For this FU, the absolute density observed in the UWTV survey is relatively high (average of ~ 0.7 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) have mostly been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2 000 tons, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that the sexes combined $F_{max(T)}$ is chosen as the FMSY proxy.

The FMSY proxy harvest ratio is 16.3 %.

The $B_{trigger}$ point for this FU (lowest observed absolute UWTV abundance) is calculated as 292 million individuals.

11.6.9 Short-term forecasts

A catch prediction for 2018 was made for the Firth of Forth (FU 8) using the approach agreed at the Benchmark Workshop and outlined in Section 10.1. The table below shows catch predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed in Section 10.1 of this report and the harvest ratio in 2016 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections). The calculation of HR is based on dead removals and in FU 8 that includes landings, dead discards and the BMS component.

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2017 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding allowed (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea). Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU 8 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2018 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2018 at the FMSY proxy harvest ratio under a *de minimis* exemption is 2122 tonnes. It should be noted that the FMSY proxy harvest ratio in the Firth of Forth is still based on a combined Length Cohort Analysis (data 2008–2010) using dead removals (landings + dead discards). A discussion of FMSY reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	797 million	ICES (2017a)	UWTV 2016
Mean weight in landings	23.25g	ICES (2017a)	Average 2014–2016
Mean weight in discards	10.75g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch >MCRS	13.98g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch <MCRS	7.22g	ICES (2017a)	Average 2014–2016
Discard rate (total)	21.2%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (>MCRS)	11.1%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (<MCRS)	10.1%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios when discarding is allowed
Dead discard rate (total)	16.8%	ICES (2017a)	Average 2014–2016 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	7.8%	ICES (2017a)	Average (proportion by number) 2014–2016, only applies in scenarios where when discarding allowed for de minimus exemptions.

Catch options assuming zero discards

Basis	Total catches	Wanted catches*	Unwanted catches*	Harvest rate**
MSY approach	2676	2380	296	16.3%
F0.1	1544	1373	171	9.4%
F2016	2019	1796	223	12.3%
F35SpR	2085	1854	231	12.7%
F2014-2016	3185	2833	352	19.4%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2013–2015).**

**** Calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

Basis	Total catches	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	2826	2748	2513	235	78	16.3%

*** Calculated for dead removals.**

Discarding allowed for *de minimis* exemptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	2745	2721	2441	207	73	24	16.3%
F0.1	1583	1569	1408	119	42	14	9.4%
F2016	2071	2053	1842	156	55	18	12.3%
F35SpR	2139	2120	1902	161	57	19	12.7%
F2014-2016	3267	3238	2905	246	87	29	19.4%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

Biological Reference points

Biological reference points have not been defined for this stock.

11.6.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. Discard data covered 89% of the landings in 2016 (95% of the discards were imported and 5% were raised discards).

There are concerns over the accuracy of historical landings (pre 2006) due to misreporting and because of this the final assessment adopted is independent of officially reported data.

UWTV surveys have been conducted for this stock since 1993, with a continual annual series available since 1998.

The Fishers' North Sea Stock survey does not include specific information for the Firth of Forth. Area 3 shows a perception of decreased abundance over the period 2007–2012, but this covers the Firth of Forth and parts of the Devil's Hole in addition to the Moray Firth. There are no Fishers' North Sea survey data available for 2013–2016.

11.6.11 Status of the stock

The stock has declined in size since 2008 when it was at the highest point in the series but is well above the average abundance and well above the MSY $B_{trigger}$ level. The value calculated for 2016 (797 million) is the third largest abundance recorded in the time series. Landings taken from this FU in 2016 (1 937 tons) were just below the the 2015 advice (for 2016) of 2 040 tons. The harvest rate decreased in 2016 to 12.3% and is now below F_{MSY}. Length frequencies in the catches have been stable.

11.6.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Nephrops discard rates in this Functional Unit are relatively high in comparison to other Functional Units and there is a need to reduce these and to improve the exploitation pattern. An additional reason for suggesting improved selectivity in this area relates to bycatch. It is important that efforts are made to ensure that other fish are not taken as unwanted bycatch in this fishery which mainly uses 80 mm mesh. Larger square mesh panels and new, more selective TR2 gears implemented as part of the Scottish Conservation Credits scheme should help to improve the exploitation pattern for some species such as haddock and whiting and small cod.

Although the persistently high estimated harvest rates do not appear to have adversely affected the stock, they are estimated to be equivalent to fishing at a rate greater than FMSY and therefore it would be unwise to allow effort to increase in this FU.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. *Nephrops* caught with pots may be discarded without restrictions due to higher survival rates. Animals below the minimum conservation reference size may be discarded, up to a maximum of 6 % of the total annual catches of this species by vessels using bottom trawls (OTB, TBN, OTT, TB) of mesh size 80–99 mm in ICES Subarea IV and Union waters of ICES Division IIa. In 2016, only a very small percentage of *Nephrops* were recorded as below the minimum size (BMS) in FU 8 (less than 0.1%) despite this being a Functional unit that historically have shown relatively high discard rates. It remains uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.7 Moray Firth (FU 9)

11.7.1 Ecosystem aspects

The Moray Firth Functional Unit is located in the east of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 10.1.1). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to seaward, narrowing towards the coast with river basins draining into the area. Muddy sand deposits are the most widespread sediment, particularly towards the outer areas of the Firth, with smaller areas of sandy mud. Overall the ground covers an area of 2195km^2. In the inner parts of the Firth the sediment is patchier and there are several areas of sand and of gravel.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 11.7.4 shows the distribution of sediment in the area. It is thought that most larvae are produced locally although some drift from the Fladen may occur. The population is characterised by medium densities of *Nephrops*. Although the Moray Firth was historically important for whitefish fisheries, catches declined and *Nephrops* is the main commercial species with squid catches important in some years. The recruits of numerous demersal fish species occasionally aggregate in the area and small pelagics (sprat and juvenile herring) are seasonally abundant. The area is important for marine mammals (seals and cetaceans).

11.7.2 The fishery in 2016

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 11.7.1). Vessels targeting this fishery typically conduct day trips from the nearby ports along the Moray Firth coast. Around 15–20 local vessels (all single riggers) regularly fish in Moray Firth area, mostly out of Burghead. The majority of the Moray Firth fleet is under 10m and are not affected by Cod Recovery Measures. Most vessels over 10m are using 250mm square mesh panels and reporting better catches than when they used HSGs. The fleet have been consistent in their grounds throughout the years, with smaller vessels fishing locally from Burghead and larger and more powerful vessels venturing further out. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. These larger twin riggers (typically over 15m) fished in the outer areas of the Firth during the winter months and unlike the smaller local vessels, they can continue to operate in periods of poor weather. In 2012, a new voluntary code of conduct for *Nephrops* trawlers (Moray Firth Prawn Agreement) has been agreed amongst fishermen for the Inner Moray Firth so as to protect the viability of smaller vessels based in the area. The agreement proposes that an area in the most westerly part of the Moray Firth be reserved for vessels under 300HP with a further small area reserved for vessels under 400 HP. Prices of *Nephrops* have been reported as similar to previous years and fuel costs generally low in 2016. Anecdotal evidence suggests some by-catch of monkfish and haddock occurred but vessels under 10m, which make most of the fleet, are generally limited by quota restrictions. *Nephrops* creeling in the Moray Firth is not common (no landings in 2015) as grounds are in open water and gear conflicts with trawl vessels are likely to happen. A squid fishery usually takes place in the Moray Firth in the late summer, starting in the Southern Trench when squid moves inshore. The majority of the local fleet participated in the squid fishery between September and October, returning to *Nephrops* fishing in November. Further general information on the fishery can be found in the Stock Annex.

11.7.3 Advice in 2016

The ICES conclusions in 2016 in relation to State of the Stock were as follows:

"The stock has remained above MSY Btrigger. The harvest rate has fluctuated and is now below FMSY."

The ICES advice in 2016 (for 2017) (Single-stock exploitation boundaries) was as follows:

MSY approach

"ICES advises that when the MSY approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in 2017 should not exceed 1 070 tons. This would imply wanted catch of no more than 1018 tonnes.

In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level. Any substantial transfer of the current surplus fishing opportunities from other FUs to this FU could rapidly lead to over-exploitation."

11.7.4 Management

Management is at the ICES Subarea level as described in Section 10.1.

11.7.5 Assessment

Approach in 2017

The assessment in 2017 is based on a combination of examining trends in fishery indicators and UWTV using an extensive data series for the Moray Firth FU 9. The assessment of *Nephrops* through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice in 2017 followed the process of 2016, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for FMSY for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 11.7.1. Total landings (as reported to the WG) in 2016 for Scotland were 1 146 tons (a 40% increase in relation to 2015) and England landed only less than 1 ton. Landings in recent years (post 2006) are more reliable due to the introduction of 'buyers and sellers' legislation. The long term landings trends are shown in Figure 11.7.1. *Nephrops* is one of the species in the North Sea under the landing obligation. No landings below the minimum conservation reference size (BMS) were reported for FU 9 in 2016.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and lpue are shown in Figure 11.7.1 and Table 11.7.2. From 2015, effort data for this stock is expressed both in days fishing and kW days (there are no major differences in effort trends between those different units). Effort has shown a gradual decline over the time period. Some of this is attributable to the EU effort management regime although *Nephrops* vessels have generally been allocated exemptions. lpue rose in the early 2000s and since 2006 it has fluctuated with a slightly downwards trend.

Males generally make the largest contribution to the landings by weight (Figure 11.7.2), although in 2011 and 2015 the proportion of females is higher than in the recent past. In 2016 males dominate again. The high contribution of females appears to be due to a much higher proportion of the fishery taking place in the second and third quarter when females are more available. This observation has been made a number of times before in the Moray Firth (particularly for example in 1994 when female catches exceeded those of males). Figure 11.7.6 shows the quarterly sex ratio by number from 2000. The seasonality of *Nephrops* emergency behaviour is evident with males dominating catches during winter time. In quarters 2 and 3, females become more active and are more available to the fishery. These data suggest a fairly stable sex ratio in quarterly catches throughout the time series. Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This is not the case here.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates in this FU appear to be highly variable with rates over the time series of 3 to 54 % of the catch by number. In 2013 the observed rate by number was at its lowest level, approximately 3% by number but it increased to 18% in 2016 (a similar level to that observed in 2010) suggesting a good recruitment to the fishery. Discards rates were generally higher in the past and in recent years appear to be generally lower but with occasional high annual levels which may be associated with sporadic high recruitments (e.g. 2002, 2004, 2010 and 2015).

It is likely that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed in order to calculate dead removals (landings + dead discards) from the population.

InterCatch

Scottish 2016 data (official landings and sampled data for landings and discards) were successfully uploaded into InterCatch. National data co-ordinators for other countries (England) also uploaded landings data to InterCatch ahead of the 2017 WG. Output data for landings and discards were produced and extracted following the same raising procedure used in previous years to obtain length compositions in formats suitable for running the assessment. No BMS data were reported for this FU in 2016.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 11.7.3 shows a series of annual length frequency distributions for the period 2000 to 2016. Catch (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35 mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35 mm shows no evidence of reductions in relative numbers of larger animals. Occasional large year classes can be observed in these length frequency data (2002 and 2004). This is consistent with the occasional high discard rates observed for this FU.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35 mm) in the landings shown in Figure 11.7.1 and Table 11.7.3. This parameter might be expected to reduce in size if overexploitation were taking place, but it appears to be stable throughout the time series. In 2013–2015, length frequencies seem to suggest a slight increase in the retention of larger males, which given the larger male contribution to the catches, caused an increase in the mean weight in the landings (Figure 11.5.4 and Table 11.5.5).

The mean size in the catch in the < 35 mm category (Figure 11.7.1) shows no particular trend over the time series although it has risen slightly in the period 2011–2013, followed by a small decrease in males in 2014 and both sexes from 2015. This is consistent with the recent increase in the discard rate and relates to the trend found in the length frequency distributions suggesting a good recruitment in 2016.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

Underwater TV (UWTV) surveys of *Nephrops* burrow number and distribution reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 11.7.4. On average, 42 stations have been considered valid each year, 53 stations were sampled in 2016. Abundance data are raised to a stock area of 2 195 km^2. General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 11.7.5 shows the basic analysis for the three most recent UWTV surveys conducted in FU 9. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand and typically, the variance in the survey seems to be evenly split among the different strata in recent years. The densities typically observed in this FU are lower than those observed in FU 8.

Figure 11.7.4 shows the distribution of stations in UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In 2016, the abundance appears to be highest at the western inshore end of the FU, with lower densities in the central north and eastern areas. Table 11.7.4 and Figure 11.7.5 show the time series of estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES 2009). A number of potential biases were highlighted including those due to edge effects, species burrow mis-identification and burrow occupancy. The cumulative bias correction factor estimated for FU 9 was 1.21 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 21 %. In order to convert the raw UWTV survey abundance to an absolute abundance the raw data are divided by 1.21.

Final assessment

The UWTV survey is again presented as the best available information on the Moray Firth *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey and it therefore only provides information on abundance over the area of the survey.

The abundance in the Moray Firth has gradually declined since 2007 having increased in 2013 followed by a further decrease in 2014 and increased again slightly in the last 2 years. The abundance in 2016 was 388 million, an increase of 12% compared with the previous year. The stock is currently below the average abundance over the time series but remains above the biomass trigger. The calculated harvest ratio in 2016 (dead removals/TV abundance) is just above FMSY as a result of increasing landings and just a slight increase in stock abundance in 2016. The mean size of individuals > 35 mm in the catch shows no strong trend in recent years but the mean size of individuals below 35 mm has shown an increase in 2011–2014 followed by a further decrease, particularly in 2016, suggesting a good recruitment. Larger square mesh panels and new, more selective TR2 gears implemented from 2010 as part of the Scottish Conservation Credits scheme may have improved the exploitation pattern as shown by a small increase in the proportion of large males in caches in 2013–2015. The effect of these changes are not however, as evident as those observed in FU 7 and length frequencies in recent years remain relatively stable in the Moray Firth.

11.7.6 Historical stock trends

The UWTV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased in 1997–2005 and has gradually fallen until 2012. In recent years abundance has remained at a relatively low level showing a slight increase in the last 2 years. The abundance estimates from 1993–2016 are shown in Table 11.7.6 and Table 11.7.6 shows the estimated harvest ratios. These range from 6–33 % over this period. Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The harvest ratio has increased in 2016 to 12.7% and is now above the FMSY proxy value of 11.8 %.

In addition to the discard rate, Table 11.7.6 also shows the dead discard rate which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

11.7.7 Recruitment estimates

Survey recruitment estimates are not available for this stock, although the length frequency distributions and highly variable discard rates suggest that this FU may be characterised by occasional large year classes.

11.7.8 MSY considerations

A number of potential FMSY proxies were obtained from the per-recruit analysis for *Nephrops* as documented in the WGNSSK 2010 report. The analysis was updated in 2011 using 2008–10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery and since previous estimates were derived several years before. An update was not performed this year. The complete range of the per-recruit FMSY proxies is given in the table below and the process for choosing an appropriate FMSY proxy is described in WGNSSK 2010 report.

		Fbar(20–40 mm)			**SPR (%)**		
		M	F	**HR (%)**	M	F	T
F0.1	M	0.13	0.07	7.16	42.35	61.48	49.89
	F	0.24	0.12	11.61	27.45	47.01	35.16
	T	0.14	0.07	7.84	39.46	58.93	47.13
Fmax	M	0.26	0.13	12.31	25.80	45.16	33.42
	F	0.68	0.36	23.82	11.42	25.16	16.83
	T	0.34	0.18	14.92	20.79	39.10	28.01
F35%SpR	M	0.17	0.09	9.11	34.69	54.48	42.48
	F	0.41	0.22	17.12	17.62	34.83	24.40
	T	0.24	0.13	11.79	27.02	46.53	34.71

The changes in the selection and discard patterns, and relative availability of females as estimated by the LCA result in slight decreases in the estimated MSY harvest ratio proxies compared to those calculated previously. (See stock annex for previously calculated values used at WGNSSK 2010).

Moderate absolute densities are generally observed on the UWTV survey of this FU (average of ~ 0.2 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) appear to have been above $F_{35\%SPR}$ and in addition there is a long time series of relatively stable landings (average reported landings ~ 1 300 tons, above those predicted by currently fishing at $F_{35\%SPR}$). For these reasons, it is suggested that $F_{35\%SPR(T)}$ is used as the FMSY proxy.

The FMSY proxy harvest ratio is 11.8 %.

The $B_{trigger}$ point for this FU (lowest observed UWTV abundance) is calculated as 262 million individuals.

11.7.9 Short-term forecasts

A catch prediction for 2018 was made for the Moray Firth (FU 9) using the approach agreed at the Benchmark Workshop. The table below shows catch predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed in Section 10.1 of this report and the harvest ratio in 2016 using the input parameters agreed at WKNEPH (ICES 2009). The catch prediction is calculated following the procedure outlined in the stock annex (section: short term projections).

Recently, to account for the landings obligation coming into force for *Nephrops* in 2016, the projected amount of discards (now referred to as unwanted catches) have been added to the catch options table. The advice given in 2017 considers three different scenarios: 1. Landings obligation applying for *Nephrops* with no discarding allowed; 2. *Nephrops* discarding is allowed to continue as before 2016; 3. Landings obligation with *de minimis* exemption applying for *Nephrops* with 6% discarding allowed (by weight) under the minimum conservation reference size (MCRS, 25 mm in the North Sea). Three catch options tables are provided to account for each of these scenarios.

Under scenario 1, all catch is assumed to be landed, no discards will survive and therefore the harvest rate is assumed to include all catch and not only landings plus dead discards. Unwanted catches (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings (referred to as wanted catches) under a landings obligation (Total Catches = Wanted Catches + Unwanted Catches). The total catches calculated in this way are lower than those calculated previously based on Landings + Surviving discards + Dead discards.

Under scenario 2, the catch options table includes surviving discards, in the same format as of the previous advice. This is to account for the possibility that *Nephrops* qualifies for a high survival exemption in which case a landings obligation would not be applicable. Discards survival for *Nephrops* in FU8 is assumed to be 25%.

A *de minimis* exemption of 6% discards by weight below MCRS (Scenario 3) has been applied in the North Sea since the 1st January 2016 and therefore, a catch options table accounting for a continuation of this rule in 2018 has been considered for the first time in the 2016 WG. The main difference from scenario 2 is that, under a *de minimis* exemption, if discard patterns remain unchanged, some unwanted animals above MCRS (these are typically soft animals with no commercial value) will have to be landed. As such, the catch options under this scenario include a new column for unwanted catch above MCRS (animals that would have been previously discarded) as this is not expected to be taken as landings. As all discarded animals are below MCRS under this assumption, the predicted weight of discards (dead + surviving) is lower than in scenario 2 (25% survival rate is still assumed).

The advice for Category 1 stocks (where assessment includes landings and discards data) is based on catches. The catch prediction for 2018 at the FMSY proxy harvest ratio under a *de minimis* exemption is 1 070 tons. It should be noted that the FMSY proxy harvest ratio in the Moray Firth is still based on a combined Length Cohort Analysis (data 2008–2010) using dead removals (landings + dead discards. A discussion of FMSY reference points for *Nephrops* is provided in Section 10.1.

The inputs to the landings forecast were as follows:

Variable	Value	Source	Notes
Abundance in TV assessment	388 million	ICES (2017a)	UWTV 2016
Mean weight in landings	28.29 g	ICES (2017a)	Average 2014–2016
Mean weight in discards	11.10 g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch >MCRS	13.68g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch <MCRS	6.78g	ICES (2017a)	Average 2014–2016
Discard rate (total)	15.9%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (>MCRS)	10.0%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (<MCRS)	5.9%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios when discarding is allowed
Dead discard rate (total)	12.4%	ICES (2017a)	Average 2014–2016 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (<MCRS)	4.5%	ICES (2017a)	Average (proportion by number) 2014–2016, only applies in scenarios where when discarding allowed for de minimus exemptions.

Catch options assuming zero discards

Basis	Total Catch	Wanted catch*	Unwanted catch**	Harvest rate**
MSY approach	1170	1089	81	11.8%
F0.1	773	720	53	7.8%
F2014-2016	1210	1126	84	12.2%
F2016	1259	1172	87	12.7%
Fmax	1477	1375	102	14.9%

*** Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation based on discard rates estimates for average (2014–2016).**

**** calculated for dead removals and applied to total catch.**

Catch options assuming discarding is allowed

Basis	Total Catches	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
MSY approach	1219	1198	1135	63	21	11.8%

*** calculated for dead removals**

Discarding allowed for *de minimis* exceptions only

Basis	Total catch	Dead removals	Landings	Unwanted >MCRS*	Dead discards <MCRS	Surviving discards	Harvest rate**
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
MSY approach	1188	1183	1105	64	14	5	11.8%
F0.1	785	782	731	42	9	3	7.8%
F2014–2016	1228	1223	1143	66	14	5	12.2%
F2016	1278	1273	1190	68	15	5	12.7%
Fmax	1500	1494	1396	80	18	6	14.9%

***Unwanted landings are those animals >MCRS but historically discarded**

**** Calculated for dead removals**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

Biological Reference points

Biological reference points have not been defined for this stock.

11.7.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. Discard data covered 43% of the landings in 2016 (33% of the discards were imported and 67% were raised discards). The reduction in the proportion of landings covered by discard data relates to missing sampling events in quarter 2 of the main metier (*Nephrops* trawlers, TR2 gears) and the absence of sampling data for TR1 gears.

There are concerns over the accuracy of landings (pre 2006) and effort data and because of this the final assessment adopted is independent of official statistics.

UWTV surveys have been conducted for this stock since 1993, with a continual annual series available since 1996. The number of valid stations in the survey has remained relatively stable throughout the time period.

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. Area 3 covers the Moray Firth, Firth of Forth and areas of the Devil's Hole and there appears to be some inconsistencies between the report in 2011 and 2012. In 2011 the report documented a perceived increase in the *Nephrops* abundance in this area since 2008; however the 2012 report appears to show a perceived decrease since 2008. There are no Fishers' North Sea survey data available for 2013–2016.

11.7.11 Status of the stock

The evidence from the UWTV survey suggests that following a continuous decrease from 2007 to 2012 the abundance has fluctuated around 400 million in recent years. The abundance has increased 12% in 2016 (to 388 million) remaining approximately at the same level as the late 2000's. The stock size is above the MSY $B_{trigger}$ level. Landings taken from this FU in 2016 (1 146 tons) were higher than the 2015 advice (for 2016) of 943 tons. The harvest rate increased in 2016 to 12.7% and is now above F_{MSY} (11.8%). Length frequencies in the catches have been relatively stable.

11.7.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

There is a by-catch of other species in the Moray Firth area. It is important that efforts are made to ensure that unwanted bycatch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The estimated harvest rates have generally been greater than FMSY and because the abundance (as estimated by the UWTV survey) appears to have declined in recent years, it would be unwise to allow effort to increase in this FU.

This stock is under the landings obligation although there is a *de minimis* exemption in place for *Nephrops* in the North Sea. Animals below the minimum conservation reference size may be discarded, up to a maximum of 6 % of the total annual catches of this species by vessels using bottom trawls (OTB, TBN, OTT, TB) of mesh size 80-99 mm in ICES Subarea IV and Union waters of ICES Division IIa. In 2016, no *Nephrops* were recorded as below the minimum size (BMS) in FU 9 despite this being a Functional unit that historically have shown occasional high discard rates. It remains uncertain how the *de minimis* exemption for *Nephrops* in the North Sea is going to be enforced.

11.8 Noup (FU 10)

11.8.1 Ecosystem aspects

The Noup is a small area of muddy sand located to the west of Orkney. The area is exposed to the open Atlantic to the west and strong tidal currents occur in the area. The surrounding coarser grounds are important edible crab fishing areas and fish populations (mixed demersal species) are important in the locality.

11.8.2 The fishery in 2015 and 2016

The Noup currently supports a relatively small fishery. Few vessels target *Nephrops* regularly in this area. In Orkney there is currently only one under 10 m part-time (summer) vessel fishing for *Nephrops* as most of the local fleet targets crabs and lobsters. *Nephrops* boats from Orkney spend most of the year fishing in the Moray Firth (FU 9). In recent years, vessels from Scrabster landing *Nephrops* use 120 mm mesh twin rigs (targeting whitefish). Landings from Noup have decreased steadily since 2002 and in 2016 only 23 tonnes of *Nephrops* were landed (Table.11.8.1). Further general information on the fishery can be found in the Stock Annex.

11.8.3 Advice in 2016

The advice provided in 2016 was biennial and valid for 2017 and 2018.

"ICES advises that when the precautionary approach is applied, and under the assumptions that discarding would occur only below the minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2013–2015), catches in each of the years 2017 and 2018 should not exceed 40 tons. This would imply wanted catch of no more than 38 tons.

In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level."

Data available

Commercial catch and effort data

Landings from this fishery are reported only from Scotland and are presented in Table 11.8.1 and Figure 11.8.1. Total landings (as reported to the WG) in 2016 were only 23 tonnes, an increase of 8 tonnes from 2015. *Nephrops* are almost exclusively landed by 'non-*Nephrops'* vessels. This supports the anecdotal information received from the fishing industry that this area is rarely fished by *Nephrops* vessels due to the high catch rates of whitefish in the area.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and lpue are shown in Figures 11.8.1 and Table 11.8.2. Effort has declined over the time period and this is more marked than on other *Nephrops* grounds owing to the presence of demersal fish in the area. Lpue remained approximately at the same level of 2015.

Length compositions

Levels of market sampling are low and discard sampling is not available. Mean sizes in the landings in previous years are shown in Figure 11.8.1 and Table 11.8.3. There were no sampling data available for 2015 and only two trips were carried out in 2016. The low levels of sampling for this fishery mean it is not realistic to draw conclusions from changes in size composition or sex ratio.

InterCatch

Scottish data for 2016 were successfully uploaded into InterCatch prior to the 2017 WG meeting according with the deadline proposed. Data for this stock in previous years has been limited to official landings (classified as "Landing only" in InterCatch with no sampling data). The 2016 data provided by Scotland was raised based on length frequencies collected in quarter 1. Careful must be taken however when interpreting this information due to the low levels of sampling.

Natural mortality, maturity at age and other biological parameters

No data available.

Research vessel data

An underwater TV (UWTV) survey of this FU has been conducted sporadically (1994, 1999, 2006 and 2007). In 2014 Noup was re-visited by the summer Scotia UWTV survey after seven years past the previous survey. Figure 11.8.3 shows the distribution of stations in the UWTV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. In 2014, 12 stations were successfully surveyed. The most recent survey gives an estimate of population size (51 million) similar to that found in 2006 and 2007 which is slightly lower than the 1999 value. All of these are lower than the very high value observed in 1994. The results of the UWTV surveys are shown in Figure 11.8.4 and Table 11.8.4.

11.8.4 Historical stock trends

The TV survey estimate of abundance for *Nephrops* in the Noup suggests that the population declined from the first survey in 1994 to 1999 and remained at a lower level on the following surveyed years. Landings fluctuated between 200 and 400 tons between 1995 and 2002, and declined markedly from then. Recent landings for this FU have been low, 15 tons in 2014–2015 and 23 tons in 2016.

11.8.5 Recruitment estimates

There are no recruitment estimates for this FU.

11.8.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

11.8.7 Status of the stock

The current state of the stock is unknown.

11.8.8 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

The Noup area supports a mixed fishery in which *Nephrops* are taken mainly by demersal trawlers targeting fish. It is important that efforts are made to ensure that unwanted bycatch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (ICES 2013). Following the procedure outlined (section 10.1), the spatial extent of the *Nephrops* grounds were estimated (based on BGS sediment maps) to provide a likely envelope for the total abundance of *Nephrops* in FU 10 (see table below). UWTV survey information on the mean density of *Nephrops* (0.13 *Nephrops*/m^2), from the 2014 survey, was used together with discard percentages, and mean weights taken from FU 9 (Moray Firth). The same advice as provided in 2014 of 33 tonnes (catch) results in a harvest ratio of 2.4% which is below the range of harvest ratios observed for other North Sea functional units (7.5–16%) and therefore considered precautionary. Additional options including an increase in 20% in catches and the medium term (10 year) average were included in the table. All the options (with the exception of the time series maximum landing value) result in a harvest ratio lower than 7.5%, reflecting the low exploitation level in recent years in FU 10. The advice (given in 2016) for 2017 and 2018 (based on the Precautionary approach) was that catches should be no more than 40 tons (2014 advice + 20%) implying wanted catch of no more than 38 tonnes. In line with the advice for other stocks, total catches, wanted catches and unwanted catches expected under the landing obligation policy were added to the table. A second catch options table allowing for discarding under *the de minimis exemption* (6% < MCRS by weight for North Sea *Nephrops*) is also included below. This assumes the discard patterns do not change from average values previously observed, and the total catch is split in wanted catch, unwanted catch > MCRS, unwanted catch < MCRS and surviving discards. For data limited stocks the discard survival is assumed to be zero.

Catch options assuming zero discards

Basis	Total catch	Wanted catch	Unwanted catch	Range of potential densities (*Nephrops* m^{-2})								
				0.05	0.1	0.13	0.15	0.2	0.3	0.4	0.6	0.8
				Harvest rate in %								
Recent average landings (2013–2015)	16	15	1	3.0	1.5	1.1	1.0	0.7	0.5	0.4	0.2	0.2
2014 Advice −20%	26	25	1	5.0	2.5	1.9	1.7	1.2	0.8	0.6	0.4	0.3
2014 Advice	33	31	2	6.2	3.1	2.4	2.1	1.5	1.0	0.8	0.5	0.4
2014 Advice + 20%	40	38	2	7.5	3.8	2.9	2.5	1.9	1.3	0.9	0.6	0.5
Average landings (2006–2015)	75	71	4	14.1	7.1	5.4	4.7	3.5	2.4	1.8	1.2	0.9
Maximum landings	519	494	25	98.1	49.1	37.7	32.7	24.5	16.4	12.3	8.2	6.1

Catch options assuming discarding allowed for *de minimis* exemptions

Basis	Total catch	Wanted catch	Unwanted catch > MCS	*de minimis* discards < MCS	Surviving discards	Range of potential densities (*Nephrops* m^{-2})								
						0.05	0.1	0.13	0.15	0.2	0.3	0.4	0.6	0.8
						Harvest rate in %								
Recent average landings(2013–2015)	16	15	1	0	0	3.0	1.5	1.1	1.0	0.7	0.5	0.4	0.2	0.2
2014 Advice −20%	26	25	1	0	0	5.0	2.5	1.9	1.7	1.2	0.8	0.6	0.4	0.3
2014 Advice	32	31	1	0	0	6.2	3.1	2.4	2.1	1.5	1.0	0.8	0.5	0.4
2014 Advice + 20%	40	38	2	0	0	7.5	3.8	2.9	2.5	1.9	1.3	0.9	0.6	0.5
Average landings (2006–2015)	75	71	3	1	0	14.1	7.1	5.4	4.7	3.5	2.4	1.8	1.2	0.9
Maximum landings	519	494	20	5	0	98.1	49.1	37.7	32.7	24.5	16.4	12.3	8.2	6.1

Basis for the catch options.

Variable	Value	Source	Notes
Density in TV assessment	0.13 *Nephrops* m2	ICES (2016a)	UWTV 2014
Mean weight in landings	27.66g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in discards	11.45g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in unwanted catch >MCRS	14.37g	ICES (2016a)	Average 2013–2015 (from FU 9)
Mean weight in unwanted catch <MCRS	6.63g	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard rate (total)	11.0%	ICES (2016a)	Average 2013–2015 (from FU 9, proportion by number)
Discard rate (>MCRS)	6.9%	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard rate (<MCRS)	4.1%	ICES (2016a)	Average 2013–2015 (from FU 9)
Discard survival rate	0%	ICES (2016a)	Discard survival is assumed to be zero.
Surface area estimate	409 km2	ICES (2007)	Benchmark estimate WKNEPH (2007)

11.9 Norwegian Deep (FU 32)

11.9.1 Ecosystem aspects.

See stock annex (section A.3).

11.9.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2). Maps showing the annual spatial distribution of the Danish fishery in FU 32 were provided for the first time in 2015. Maps showing the annual spatial distribution of the Norwegian trawl fishery (vessels ≥ 15 m) in FU 32 (since 2011) were provided for the first time in 2016.

New maps of the annual spatial distribution of the Danish trawl fishery was made at the 2016 benchmark (REF). Danish *Nephrops* fishing grounds were identified using Danish VMS and logbook data. Data from the mixed fishery (≥ 120 mm mesh size) were used, where daily *Nephrops* landings from logbooks were distributed evenly on the corresponding VMS signals. Spatial analysis was preformed using a geographic grid of the size of 1 x 2 minutes. The data were filtered for daily *Nephrops* ratios > 0.05 in the landings. For each year, fishing ground, defined as the smallest number of grid cells containing 95% of the landings, was estimated (Figure 11.9.1). These maps confirm the declining temporal pattern in Figure 11.9.2, but show a further decrease in the distribution of the Danish fishery from 2012 to 2013 which is not evident from the former figure.

The benchmark decided to use the present distribution of the Danish fishery to estimate a new area for the harvest rate table for FU 32. Both the union and the intersection of the areas for each year was calculated representing the maximum and minimum estimate of the fishing grounds. By shifting the starting year to use in the calculations, the spatial contraction of the utilized fishing ground was visualized; the fishery presently uses only approximately one third of the area used in the mid–2000s.

11.9.3 Advice in 2016

Advice for *Nephrops* was updated in 2016. This advice applies for 2017 and 2018.

- The perceptions of this stock (FU 32) are based on Danish landings and effort data as well as mean sizes (CL) in landings and discards.
- The new Danish lpue index shows a stepwise declining trend from the mid-1990s until present. However, it is not possible to determine whether this decrease in lpue is due to changes in management or whether the decrease to some extent also reflects stock changes.
- The recent Danish landings from the stock are very small, but are fished in a restricted area. The low lpue in 2013–2015 might therefore imply stock size changes in the southern part of FU 32.
- Trends in mean size in Danish landings and discards and overall size distribution in catches have for many years indicated that the *Nephrops* stock in FU 32 is not over-exploited. However, trends in mean size of landings in 2013–2015 are difficult to interpret.
- The low catches of small *Nephrops* during the last two years indicate low recruitment to the stock.
- The WG concludes that the available data give a non-conclusive perception of stock status. The average annual landings over the last ten years are 464 tons (2006–2015), while the short-term average landings are 259 tons (2011–2015). The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 1%), even in years when landings were highest.

11.9.4 Management

An overview of the management of *Nephrops* in FU 32 is given in the stock annex (section A.2). The EU fisheries are managed by a separate TAC for this FU, decided by the annual Norway–EU negotiations. For 2008 the agreed TAC for EU vessels was 1 300 tons, and for 2009–2012, 1 200 tons. In 2013, the TAC was reduced to 1 000 tons, following the ICES advice, and it has remained at this level since. The EU quota of *Nephrops* in Norwegian waters (area 04-N) is mainly allocated to Denmark (app. 95%) with a small fraction of app. 5% to UK. There is no quota restriction currently for the Norwegian fishery. It is not prohibited to discard *Nephrops* in Norwegian waters outside of Skagerrak.

11.9.5 Assessment

Data available

Landings data for all fleets in 2016 have been uploaded using InterCatch.

Catch

Dutch landings from FU 32 were incorporated in the report for the first time in 2010. Only in 2006 and 2016 have the Netherlands landed more than a ton of *Nephrops* from this FU. International landings from the Norwegian Deep increased from less than 20 tons in the mid–1980s to 1 190 tons in 2001 (Table 11.9.1, Figure 11.9.3). Since then, landings have declined due to a reduction of Danish landings, and total landings in

2016 amounted to only 178 tons, the lowest Figure since 1992. The decreased Danish landings can be explained by increasing fuel costs, fewer vessels, and *Nephrops* catches now occurring mainly as bycatch in mixed fisheries. Danish vessels used to take 80–90% of the total landings, but since 2008, this percentage has decreased. In 2016, Denmark landed only 45% of the total landings. Norwegian landings decreased from 2008 (142 tons) to 2014 (62 tons), but increased in 2015 and 2016, to 97 tons. In 2016, 93% of Norwegian landings were from traps; only 7 tons were landed from the shrimp and mixed fishery (stock annex, section A.2).

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Table 11.9.1). Danish discards are low due to the legislated 120 mm mesh size. The Danish discard ratio (discard as percentage of catch) was high in 2004–2005 (21–24%), but decreased to 10–17% in the years 2006–2012. In 2013, estimated Danish discards were 68 tons, and the Danish discard ratio increased to 35%, while in 2014–2016 estimated Danish discards were only 5, 6 and 1 t, respectively, resulting in very low Danish discard ratios of 3%, 5% and 1%. The low discards the last three years may indicate low recruitment to the stock. It should be noted that the 2014–2016-discards in FUs 3-4 also were very low. There are no Norwegian discard data, and Norwegian discards are assumed to be zero. As the Norwegian fishery is now basically a trap fishery, with high survival of discarded *Nephrops* (stock annex, section A.3), this is a valid assumption at least for the last couple of years (Table 11.9.1).

Length composition

The average size of *Nephrops* in Danish landings (≥ 40 mm) showed a general increasing trend for both males and females in the period 2005–2012 (Figure 11.9.3). This increase coincides with a sharp decrease in landings and may imply a lower exploitation pressure. However, the mean size of both males and females in the Danish landings decreased sharply from 2012 to 2013. In 2014, the mean size of landed males jumped back to the high 2012–level, and remained at this level in 2015 and 2016. The average size of landed females, on the other hand, has remained at the low 2013–level both in 2014, 2015 and 2016. The mean size of discards (< 40 mm) has fluctuated without trend since 2002. In the 2014-report it was suggested that a possible explanation for the decreased mean size of large *Nephrops* could be that the declining Danish fishery in 2013 contracted into an area with small *Nephrops*, possibly in the southern part of FU 32. This contraction of the fishery is confirmed by Figure 11.9.1. It is, however, unclear why it is only the large females that have shown a decreased size in recent years.

The length frequency distributions of the Danish catches from the years 2007, 2010, 2012, 2014 and 2016 had a greater proportion of large *Nephrops* compared with former years (Figure 11.9.4). The 2013 and 2015 length frequency distributions, on the other hand, had a relatively smaller proportion of large specimens. In general, there are few individuals below the MLS of 40 mm due to the legislated 120 mm mesh size. Size distributions of catches from Norwegian coast guard inspections of Danish and Norwegian trawlers have not been updated since 2012 due to lack of CL data.

Natural mortality, maturity at age and other biological parameters

No data are available at present. Data from the Norwegian shrimp survey covering FU 32 were considered by the 2013 benchmark (ICES 2013) for estimation of maturity at length. However, annual catches in the survey are too small for estimation of annual maturity values. Possibilities for obtaining maturity data and length-weight relationships from the Danish at-sea-sampling programme are investigated.

Catch, effort and research vessel data

Effort and lpue Figures for the period 1989–2016 are available from Danish logbooks (Table 11.9.2, Figure 11.9.3). In 2013, the Danish effort index was changed to kW days (formerly fishing days) (stock annex, section B.4), as kW days account for temporal differences in vessel size. Days at sea and fishing days are presented in addition to kW days (Table 11.9.2). In 2016, all efforts numbers back to 1987 changed slightly due to some minor adjustments to the métier codes for the whole time series. The lpue values thus also changed slightly, but the trend remained the same. The Danish lpue index based on kW days shows a decreasing trend (Figure 11.9.3). However, due to changes in the management regime, changes in the lpue index do not necessarily imply stock size changes (see below).

In the beginning of the 1990s, vessel size increased in the Danish fleet fishing in FU 32. This increase, and more directed fisheries for *Nephrops* in areas with previously low exploitation levels are probably partly responsible for the observed increase in the Danish lpue in those years (Table 11.9.2, Figure 11.9.3). The Norwegian mesh size legislation was changed in 2004 (stock annex, section A.2) with the introduction of a larger mesh size of 120 mm. This change in legislation occurred some years too late to explain the decrease in lpue (catch rate) from 1999 to 2001 with a subsequent stabilizing at a lower level relative to the late 1990s. The lower lpue may, on the other hand, reflect a stock decrease as Danish landings in 1999 increased to > 1 000 tons and remained at this level until 2006. In 2007, individual vessel quotas were introduced in the Danish fishery. This resulted in vessels buying up a lot of fish quotas and shifting their effort to fin fish rather than *Nephrops*. To get good catches of *Nephrops* vessels need to target this species by fishing at dusk/dawn when the animals are out of their burrows, as opposed to fin fish fisheries where good catches can be obtained around the clock. This change in management coincided with a decreasing lpue (2008–2009) and the onset of steadily falling Danish landings. From 2012 to 2013, the Danish lpue decreased by approximately 40% and has remained at this low level since.

Spatial analyses of Danish logbooks and VMS data from the 2016 benchmark (Figure 11.9.5) show that the LPUE have decreased over the whole Norwegian Deep from 2005 to 2015, with the largest declines in the north. Only the southernmost part of the FU has had reasonably good catch rates since 2013, explaining the present distribution of the Danish fishery (Figure 11.9.1). Environmental changes resulting in lower *Nephrops* densities in the whole FU cannot be ruled out. The likely low recruitment to the stock in 2014–2016 may imply continue low catch rates.

The Danish effort increased from 2004 to 2006, but showed a strong decline in 2007 and has since continued decreasing to 462 kW days in 2016, the lowest observed effort since 1990. It has not been possible to incorporate 'technological creep' in the evaluation of the effort data. However, the use of twin trawls has been widespread for many years.

The 2013 benchmark (ICES 2013) analysed the Norwegian lpue Figures from bottom and shrimp trawls. The trawl data prior to 2011 are considered unsuitable for lpue analyses (Stock Annex, section B.4). The 2016 benchmark (ICES 2017) analysed data from the Norwegian electronic logbooks, compulsory since 2011 for all vessels ≥ 15 m length. The data situation did not improve with the introduction of the electronic logbooks, basically because there are so few large Norwegian vessels landing *Nephrops* from this area. The Norwegian fishery is now basically a trap fishery (< 10% trawl landings), which is carried out by small vessels, not obliged to fill out logbooks. The 2016 benchmark concluded that an lpue index based on the electronic logbooks is not representative of the present Norwegian *Nephrops* fishery in FU 32.

The electronic logbook data show that the Norwegian large vessel trawl fishery for *Nephrops* in FU 32 declined from 2012 to 2013 (Figure 11.9.6). In 2013–2014, the fishery was confined to the southernmost part of the FU as well as an area just west of Stavanger, while in 2015 and 2016 some trawling again took place along the western rim of the Norwegian Trench. The trap fishery takes place in coastal areas, but there is no information on either exact location or effort.

The annual Norwegian bottom trawl shrimp survey covers all of Skagerrak and the Norwegian Deep. Catches of *Nephrops* in the Campelen trawl are small and variable within and between years. The survey shows that *Nephrops* is distributed in areas deeper than 100 m in FU 32 (Figure 11.9.7). (Areas shallower than 100 m are not covered by the survey). The 2016 benchmark (ICES 2017) analysed the *Nephrops* data from the shrimp survey with the aim of establishing a fisheries independent stock size index (see below).

Data analysis

Review of last year's assessment

"Technical comments

The technical comments formulated last year have been addressed in the 2016 report, and will be further investigated for the coming benchmark.

It is suggested to remove the old time series (red lines) from all figures, now that there has been three years since the change in Danish lpue series.

Conclusions

The advice is the average catch of the last ten years. It seems OK but given the major changes in landings and discards in the recent years, a shorter average might be considered.

New data are expected to be investigated further during the incoming benchmark."

Exploratory analysis of catch data

There was no age based analysis carried out

Exploratory analysis of survey data

As part of the benchmark in 2016 (ICES 2017) a biomass index was established using GLMs within a mixed generalized gamma-binomial model and Bayesian inference (Stock Annex, section B.3). The biomass index showed high values in 2006 and 2007, but declined to a lower level in 2008. Thereafter it has fluctuated without trend (Figure 11.9.8). The Danish lpue has similarly decreased since 2008–2009 (Figure 11.9.3). It should be noted that the survey index covers the whole Norwegian Deep for depths > 100 m, while the Danish lpue covers the western and southern part of the Norwegian Deep. The new survey index is based on few observations (Figure 11.9.7). However, in lack of better data, the benchmark considered that the index should be presented and updated as part of the annual assessment procedure of the FU 32 stock.

Final assessment

No age based numerical assessment is presented for this stock. The state of the stock was judged on the basis of basic fishery data.

11.9.6 Historic stock trends

The increase in mean size in landings from 2006 to 2012 in females and from 2005 to 2012 in males could indicate a lower exploitation pressure as this increase coincided with decreasing landings. Mean sizes in landings in 2013–2016 are difficult to interpret. The introduction of a new effort index (kW days) in 2013 resulted in a stepwise declining trend in the new lpue index, from the mid–1990s until present. The survey biomass index declined from 2007 to 2008 and has thereafter fluctuated without trend.

11.9.7 Recruitment estimates

There are no recruitment estimates for this stock. Fluctuations in catches of small *Nephrops* are used as a proxy for recruitment. Discards of small *Nephrops* have been very low in 2014–2016 indicating low recruitment these years.

11.9.8 Forecasts

There were no forecasts for this stock.

11.9.9 Biological reference points

No reference points are defined for this stock.

11.9.10 Quality of assessment

The data available for this stock remain limited.

11.9.11 Status of stock

The perceptions of this stock (FU 32) are based on Danish landings and effort data, mean sizes (CL) in landings and discards, and from 2017, a biomass index from a Norwegian bottom trawl survey. The effect of technological creep on the effective effort of the fishery is not known. The Danish lpue index shows a stepwise declining trend from the mid–1990s until present. However, it is difficult to determine whether this decrease in lpue is due to changes in management and fishery patterns, or whether the decrease to some extent also reflects stock changes. The recent Danish landings from the stock are very small, but are fished in a restricted area. The low lpue in 2013–2016 might imply stock size changes in the southern part of FU 32, but could also be caused by vessels now targeting finfish rather than *Nephrops*. The survey index is presently at a low level compared with the years 2006-2007, indicating a lower stock size. Trends in mean size in Danish landings and discards and overall size distribution in catches have for many years indicated that the *Nephrops* stock in FU 32 is not over-exploited. However, trends in mean size of landings in 2013–2016 are difficult to interpret. The low catches of small *Nephrops* during the last three years indicate low recruitment to the stock.

The WG concludes that the available data give a non-conclusive perception of stock status. The average annual landings over the last ten years are 379 tons (2007–2016), while the short-term average landings are 215 tons (2012–2016).

11.9.12 Management considerations

For 2006–2008 the agreed TAC for EU vessels was 1 300 tons. This decreased to 1 200 tons in 2009–2012 and 1 000 tons in 2013–2017. The WG notes that there is no TAC for the Norwegian vessels fishing in FU 32.

The Danish at-sea-sampling programme provided a satisfactory number of observer trips in 2016. However, quarters 1 and 2 were not sampled. Possibilities for obtaining biological data from the at-sea-sampling programme are explored. Norwegian sampling of catches by the Norwegian coast guard should be improved. Sample weights are not recorded, not allowing calculation of catches by length. Discard and landings components are not sampled separately and discards can therefore not be estimated.

ICES provide catch advice for FU 32. Advice is given for two scenarios: with and without a discard ban. Following the procedure outlined in the stock annex (section H) a table of harvest rates (see table below) was calculated. The biomass estimates imply low harvest rates in FU 32, even in former years with high landings (1 000–1 200 tons).

									mean (2014-2016)			mean (2014-2016)	
	FU32 : Norwegian Deep						3 613	Area (km2	92	land wt		6 %	percentage discards
									29	disc wt			
Landing obligation					Density								
Basis	**Total catch**	**Wanted catch**	**Unwanted catch**		**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	193	189	4		1.2%	0.6%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%
Average	387	379	8		2.4%	1.2%	0.6%	0.4%	0.3%	0.2%	0.2%	0.2%	0.2%
Maximum	1214	1190	24		7.6%	3.8%	1.9%	1.3%	1.0%	0.8%	0.6%	0.5%	0.5%
						minimum Fladen (FU7) density	**mean Skagerrak (FU3) density**						
Discarding allowed													
Basis	**Dead removals**	**Landings**	**Dead discards**	**Live discards**	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	192	189	3	1	1.2%	0.6%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Average	385	379	6	2	2.4%	1.2%	0.6%	0.4%	0.3%	0.2%	0.2%	0.2%	0.1%
Maximum	1208	1190	18	6	7.5%	3.8%	1.9%	1.3%	0.9%	0.8%	0.6%	0.5%	0.5%
						Fladen (FU7) density	**Skagerrak (FU3) density**						

11.10 Off Horns Reef (FU 33)

11.10.1 Data available

Catch

The landings from FU 33 were marginal for many years. However, from 1997 to 2004, Danish landings increased considerably, from 274 to 1097 tons. Denmark dominated the fishery during this period. Between 2004 and 2015, Danish landings gradually decreased, and in 2015 were 371 tons. In 2016, the Danish landings increased considerably from previous years, and were 642 tons. The other countries reporting landings from the area are Belgium, Netherlands, Germany and the UK. Dutch landings show an increasing trend from the start of the time series until 2007 when landings were almost 500 tons. Since 2007, Dutch landings show a decreasing trend and in 2015 were the lowest landings recorded over the last decade (187 tons). However, in 2016 Dutch landings increased considerably from the previous year and were 320 tons. Belgium and German landings having increased throughout the time period and were around 430 and 201 tons respectively in 2016. UK landings were highest in 2009 (170 tons) and have since decreased dramatically. In 2016, total landings were the highest on record (1 636 tons). (Table 11.10.1 and Figure 11.10.1).

Discards from FU 33 are poorly documented and scarce. Discard information from Denmark were recorded in InterCatch for 2015 and 2016. These data consist of 1 trip per year and are considered to scarce to be used for providing catch advice. In 2015, Dutch discards were recorded in InterCatch, however, length information was missing.

In 2016, Dutch discards included length information. Due to a National minimum landing size, a large majority of the Dutch discards were above the MCS of 25 mm set for the North Sea.

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 to 2016 are shown in Figure 11.10.2. Notice, that except for 2005 and 2011 they are rather similar. No discards were observed in the Danish at-sea observer data in 2016, hence the large increase in mean length. Figure 11.10.1 shows the development of the mean size of *Nephrops* in catches. The drop in the mean CL in the catches in 2005 and 2011 reflects an increase in numbers at around 30 mm CL and could indicate a large recruitment in these years, see also Figure 11.10.1.

In the period 2001–2005, and in 2009–2016 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples do not cover all quarters.

Natural mortality, maturity at age and other biological parameters

No data available

Catch and effort data

Table 11.10.2 and Figure 11.10.1 show the development in Danish effort and LPUE. Notice that the 10-fold increase in fishing effort from 1996 to 2004 seems to correspond to the increase in landings during the same period and the lpue was relatively stable. After 2004 the Danish effort decreased markedly, and since 2009 has remained stable at around 300 000 kW days. Dutch effort data are available from 2005–2016 and shows an increasing trend over the time period. However, Dutch effort decreased from around 1 300 000 kW days in 2013 to 1 000 000 kW days in 2014 and 2015. In 2016, Dutch effort was the highest in the time series at around 1 350 000 kW days. The Danish lpue shows an increasing trend during the whole period, and since 2011 has remained above 1.0 kg/ kW day). In 2016, the Danish lpue was the highest in the time series at around 1.7 kg/ kW day. This increase in lpue could reflect an increase in gear efficiency (technological creep) or in fishers' ability to exploit the stock. Lpue from the Netherlands increased from 0.3 kg/kW day in 2005 to around 0.7 kg/kW day in 2007, and has since fluctuated between 0.2 and 0.5 kg/kW day.

Data analysis

Exploratory analyses of catch data

No catch at age analysis has been carried out for this stock.

Exploratory analyses of survey

No survey data were available

11.10.2 Historic stock trends

The available data do not provide any clear signals on stock development:

Danish effort began decreasing after 2004. Since then, the lpue has steadily increased, except for 2010 and 2014 when lpue declined slightly. In 2013, new data from the Netherlands became available for the last nine years, and shows a more stable effort. lpue has increased for Denmark and the Netherlands in 2016.

In 2016, the size distribution in the catches is similar to those in 2001–04, 2009–2010 and 2012–2013. The smaller individuals in the 2005 and 2011 catches could reflect a high recruitment in these years. The decrease in mean size could indicate either high recruitment or a decline in the stock, reflected by fewer large individuals. However, there are no recruitment estimates for this FU.

Forecasts: Forecasts were not performed.

Biological reference points: There are no reference points defined for this stock.

Perceptions of the stock are based on Danish and Dutch lpue data and trends in size composition in Danish catches. As stated above, comparing the size distribution in the 2005 and 2011 catches with those in other years could indicate high recruitment in 2005 and 2011.

11.10.3 Management considerations for FU 33

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock. Considering the recent trend in lpue and the technological creep of the gear, the exploitation of this stock should be monitored closely.

11.10.4 Status of the stock

The state of this stock is unknown. Based on the assumed low density (based on lowest observed density at FU 7 (Fladen Ground), harvest rates are considered low for this stock.

The size of the Off Horns Reef *Nephrops* grounds are 5 700 km^2 and are believed to have a density similar to the Fladen Grounds (FU 7) of 0.1 *Nephrops* m^{-2}. The mean individual weight in landings and discards in 2015 are 40.57 and 17.19 g respectively and the survival rate of discards is 25 %. Discards are known to take place for the entire fishery, however only length measured discard data exist for the Danish fishery. These data are believed to be representative for the entire fishery and have been used to calculate the values in the catch options table.

11.11 Devil’s Hole (FU 34)

The Devil’s Hole was designated as a functional unit in 2010, after recommendation from SGNEPS because of increasing landings in the area. The latest advice for this functional unit was provided in 2016 using the ICES data limited approach for *Nephrops*.

11.11.1 Ecosystem aspects

The area consists of a number of narrow trenches (up to 2 km wide) running in a north-south direction, with an average length of 20–30 km. These trenches fall across six ICES statistical rectangles: 41–43F0 and 41–43F1, which are used to define this functional unit. The British Geological Survey (BGS) sediment map (showing sediments suitable for *Nephrops*) of the area is shown in Figure 11.11.1 and suggests that there is one large, and several smaller areas of muddy sand (10–50 % silt and clay).

11.11.2 The Fishery in 2015 and 2016

The fishery in this area is prosecuted largely by Scottish vessels operating out of ports in the northeast of Scotland, but occasionally making landings into northeast England. The fleet consists of large *Nephrops* trawlers which have the capability of operating in such offshore areas. Around five vessels operate out of Peterhead with another 12 from Fraserburgh regularly visiting the areas. These vessels also fish the Fladen on a regular basis and visit the other more inshore functional units in times of poor weather or poor *Nephrops* catch rates in the offshore areas.

Advice in 2014

Advice provided in 2016 was biennial for 2017 and 2018.

"ICES advises that when the precautionary approach is applied, and under the assumptions that discarding would occur only below minimum conservation size (MCS) and that fishery selection patterns do not change from the average (2008–2011), catches in each of the years 2017 and 2018 should not exceed 492 tonnes. This would imply wanted catch of no more than 459 tons.

In order to ensure the stock in this functional unit (FU) is exploited sustainably, management should be implemented at the functional unit level."

11.11.3 Management

Total Allowable Catch (TAC) management is at the ICES Subarea level.

11.11.4 Assessment

Data are presented which in future may form the basis for an assessment. A benchmark was carried out for this functional unit in 2013 (WKNEPH 2013) which advised to continue with the data limited approach at present with the aim of moving to a full underwater TV (UWTV) assessment in the near future.

11.11.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 1986–2016 are presented in Table 11.11.1 and Figure 11.11.2. Landings gradually increased from 378 tons in 2005 to approximately 1 305 tons in 2009 followed by a decline in the following years to 121 tons in 2013. In 2016 landings increased to 780 tons. This is explained by an increase in landings from TR1 (which target mostly whitefish) vessels.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort.

Trends in Scottish effort and lpue are shown in Figure 11.11.3 and Table 11.11.2. Combined effort for trawlers has declined over the time period showing generally a downwards trend and reaching its lowest point in 2013. The decrease may partly be explained as a result of reductions in available effort imposed by the effort management regime and partly because this ground is more remote than a number of other *Nephrops* grounds and costs of steaming to and from the ground are likely to be high. From 2014 effort increased again to a similar level to that recorded in the late 2010's.

Lpue showed an increasing trend until 2009 followed by a slight drop in 2011 and has fluctuated around 400 kg/day in the last four of years.

Length compositions

Levels of both market and discard sampling are low and data are only available from the Scottish fleet. Most observer sampling in FU 34 took place in the period 2008–2011. In 2015 and 2016, occasional sampling events in observer trips targeting FU 7 reveal low levels of discarding in the fishery. No market samples were taken in 2012–2013 and in the last three years only a few fishing trips were sampled. Mean sizes in the catch and landings for 2006 to 2011 are shown in Table 11.11.3. Sampling has not been conducted in all quarters, so there is potential bias in these results.

InterCatch

Scottish data for 2016 were successfully uploaded into InterCatch prior the 2017 WG meeting according with the deadline proposed. Both landings and discard sampling have been very limited in recent years and Intercatch was used only to record official landings data (no raising) from counties who submitted data into FU 34 (Scotland and England).

Natural mortality, maturity at age and other biological parameters

No specific data are available for this functional unit, but there may be potential to adapt parameters from other functional units which have apparently similar biological characteristics.

Research vessel data

Marine Scotland Science (MSS) have carried out UWTV surveys of the Devil's Hole area opportunistically over the past 10 years. Since 2009, VMS data have been used to define the location of the survey stations. It is not known how station locations were selected on the earlier surveys in this area. It was not possible to survey FU 34 in 2013 but the survey has continued in 2014 and 2015. The TV surveys in the period 2009–2014 were re-worked to exclude any station lying outside the VMS strata that was adopted in the 2013 benchmark (ICES 2013). Overall, 6 stations were excluded in the 5 year period and this had little impact on the new abundance values which are very similar to previous estimates. It was not possible to survey FU 34 in 2016 but it is expected that this FU will be visited in the 2017 UWTV survey. The most recent survey (2015) give estimates of density (0.16 burrows/m^2) similar to those found in 2011. A density distribution map of these surveys is shown in Figure 11.11.4 with the size of the symbol reflecting the *Nephrops* burrow density. Table 11.11.4 and Figure 11.11.5 show the time series of mean burrow densities and 95 % confidence intervals.

11.11.6 Historical stock trends

Scottish landings from this area have risen substantially from 2005 to 2009 followed by a general decreasing trend until 2013 and increased again in the last 3 years. Estimates of mean density in the stock have declined from 2009 to 2014 but increased slightly in 2015, remaining higher than in 2003, although this may be due to the change is survey sampling design, with a greater proportion of stations in the western trenches since 2009, producing the high densities.

11.11.7 Recruitment estimates

There are no recruitment estimates for this FU.

11.11.8 MSY considerations

There is currently insufficient catch-at-length data to conduct a combined length cohort analysis, and therefore FMSY proxy harvest rates have not been calculated for this functional unit.

11.11.9 Short-term forecasts

No short-term forecasts are presented for this FU.

11.11.10 Status of the stock

The current state of the stock is unknown.

11.11.11 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

There is a by-catch of other species in the Devil's Hole area. It is important that efforts are made to ensure that unwanted by-catch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted by-catches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (ICES 2013). Following the procedure outlined (section 10.1), an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in the FU 34 (see text table below). UWTV survey information on the mean density of *Nephrops* (0.16 *Nephrops*/m^2) from the UWTV survey (2015), was used together with the mean weight (average 2007–2010) and discard percentage (average 2008–2011). The same advice as provided in 2014 of 410 tonnes (catch) results in a harvest ratio of 4.9% which is below the range of harvest ratios observed for other North Sea functional units (7.5–16%). The 10 year average (2006–2015) results in a higher harvest ratio (8.0%). Additional options were added to the table including an increase in 20% in catches (uncertainty cap) and a 20% reduction (precautionary buffer) on the 10 year average. These two options yield a harvest ratio of 5.9% and 6.4% respectively, both below the 7.5% threshold. The proposed advice (given in 2016) for 2017 and 2018 (based on the Precautionary approach) was that catches should be no more than 492 tons (2014 advice + 20%) implying wanted catch of no more than 459 tonnes. In line with the advice for other stocks, total catches, wanted catches and unwanted catches expected under the landing obligation policy were added to the table. A second catch options table allowing for discarding under *the de minimis* exemption (6% < MCRS by weight for North Sea *Nephrops*) is also included below. This assumes the discard patterns do not change from average values previously observed, and the total catch is split in wanted catch, unwanted catch > MCRS, unwanted catch < MCRS and surviving discards. For data limited stocks the discard survival is assumed to be zero.

Catch options assuming zero discards

Basis	Total Catch	Wanted Catch	Unwanted Catch	Density (Nephrops per m2)							
				0.05	0.1	0.16	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	314	293	21	12.08%	6.04%	3.78%	3.02%	2.01%	1.51%	1.01%	0.76%
2014 Advice - 20%	328	306	22	12.62%	6.31%	3.94%	3.16%	2.10%	1.58%	1.05%	0.79%
2014 Advice	410	383	27	15.80%	7.90%	4.94%	3.95%	2.63%	1.97%	1.32%	0.99%
2014 Advice + 20%	492	459	33	18.93%	9.47%	5.92%	4.73%	3.16%	2.37%	1.58%	1.18%
Average (2006-2015) - 20%	529	494	35	20.39%	10.20%	6.37%	5.10%	3.40%	2.55%	1.70%	1.27%
	612	571	41	23.55%	11.77%	7.36%	5.89%	3.92%	2.94%	1.96%	1.47%
Average (2006-2015)	662	618	44	25.49%	12.74%	7.97%	6.37%	4.25%	3.19%	2.12%	1.59%
Maximum	1398	1305	93	53.82%	26.91%	16.82%	13.46%	8.97%	6.73%	4.49%	3.36%

Catch options assuming discarding allowed for *de minimis* exemptions

Basis	Total Catch	Wanted Catch	Unwanted Catch >MCRS	de minimis discards <MCRS	Surviving discards	Density (Nephrops per m2)							
						0.05	0.1	0.16	0.2	0.3	0.4	0.6	0.8
Recent average (2013-2015)	314	293	20	1	0	12.08%	6.04%	3.78%	3.02%	2.01%	1.51%	1.01%	0.76%
2014 Advice - 20%	328	306	21	1	0	12.62%	6.31%	3.94%	3.16%	2.10%	1.58%	1.05%	0.79%
2014 Advice	410	383	26	1	0	15.80%	7.90%	4.94%	3.95%	2.63%	1.97%	1.32%	0.99%
2014 Advice + 20%	492	459	31	2	0	18.93%	9.47%	5.92%	4.73%	3.16%	2.37%	1.58%	1.18%
Average (2006-2015) - 20%	529	494	33	2	0	20.39%	10.20%	6.37%	5.10%	3.40%	2.55%	1.70%	1.27%
	612	571	39	2	0	23.55%	11.77%	7.36%	5.89%	3.92%	2.94%	1.96%	1.47%
Average (2006-2015)	662	618	42	2	0	25.49%	12.74%	7.97%	6.37%	4.25%	3.19%	2.12%	1.59%
Maximum	1398	1305	88	5	0	53.82%	26.91%	16.82%	13.46%	8.97%	6.73%	4.49%	3.36%

Basis for the catch options.

Variable	Value	Source	Notes
Density in TV assessment	0.16 *Nephrops* m2	ICES (2016a)	UWTV 2015
Mean weight in landings	31.76 g	ICES (2016a)	Average 2007–2010 (benchmark estimate WKNEPH, 2013)
Mean weight in discards	15.3 g	ICES (2016a)	Average 2013–2015 (from FU 7)
Mean weight in unwanted catch >MCRS	16.13g	ICES (2016a)	Average 2013–2015 (from FU 7)
Mean weight in unwanted catch <MCRS	7.58g	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard rate (total)	12.9%	ICES (2013)	Average 2008–2011 (benchmark estimate WKNEPH, 2013; proportion by number)
Discard rate (>MCRS)	11.6%	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard rate (<MCRS)	1.3%	ICES (2016a)	Average 2013–2015 (from FU 7)
Discard survival rate	0%	ICES (2016a)	Discard survival is assumed to be zero.
Surface area estimate	1753 km2	ICES (2013)	Benchmark estimate WKNEPH (2013)

Table 11.2.1. Nominal landings (tons) of *Nephrops* in Subarea 4, 1984–2013, as officially reported to ICES.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Belgium	638	679	344	437	500	574	610	427	384	418	304	410	185	311	238
Denmark	7	50	323	479	409	508	743	880	581	691	1128	1182	1315	1309	1440
Faeroe Islands	-	-	-	0	0	0	0	0	0	1	3	12	0	1	1
France	-	-	-	7	0	0	0	0	0	0	0	0	0	0	0
Germany	.	.	.	0	0	0	0	2	2	16	24	16	69	64	58
Germany (Fed. Rep.)	5	4	5	1	2	1	2	0	0	0	0	0	0	627	
Netherlands	-	-	-	0	0	0	9	3	134	131	159	254	423	64	6945
Norway	1	1	1	2	17	17	46	117	125	107	171	74	83	1	93
Sweden	-	1	-	0	0	0	0	4	0	1	1	1	0		3
UK (Eng + Wales + NI)	.	.	.	0	0	2938	2332	1955	1451	2983	3613	2530	2462	2206	2094
UK (Eng + Wales)	1477	2052	2002	2173	2397	0	0	0	0	0	0	0	-	-	8980
UK (Scotland)	4158	5369	6190	5304	6527	7065	6871	7501	6898	8250	8850	10018	8981	10466	13602
UK	-	-	-	-	-	-	-	-	-	-	-	-	-		
Total	6286	8156	8865	8403	9852	11103	10613	10889	9575	12598	14253	14497	13518	15049	13602

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	350	252	283	284	229	213	180	214	205	200	265	115	295	374
Denmark	1963	1747	1935	2154	2128	2244	2339	2024	1408	1078	875	603	828	728
Faeroe Islands	1	0	-	-	-	-	-	-	-	-	-	-		
France	0	0	-	-	-	-	-	-	-	-	-	+		+
Germany	104	79	140	125	50	50	109	288	602	266	410	373	552	385
Netherlands	662	572	851	966	940	918	1019	982	1147	737	882	701	1012	1024
Norway	144	147	115	130	100	93	132	96	99	143	139	123	70	75
Sweden	4	37	26	14	1	1	3	1	5	26	2	1	1	1
UK (Eng + Wales + NI)	2431	2210	2691	1964	2295	2241	3236	4937	3295	1679	3437	-		
UK (Scotland)	10715	9834	9681	11045	10094	12912	10565	16165	17930	17960	18587	-		
UK	-	-	-	-	-	-		-	-	-	-	18941	14190	10976
Total	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20857	16948	13541

	2013	2014	2015	2016
Belgium	303	494	349	880
Denmark	387	624	515	755
Faeroe Islands	0	0	0	0
France	0	0	0	0
Germany	425	418	435	862
Ireland	0	1	0	0
Netherlands	910	1154	1113	1464
Norway	63	63	81	98
Sweden	0		0	1
UK (Eng + Wales + NI)	-			
UK (Scotland)	-			
UK	8625	11211	6825	9337
Total	10713	13965	9318	13397

*** Landings data for 2016 are preliminary.**

Table 11.2.2. Summary of *Nephrops* landings from the ICES area, by Functional Unit, 1991–2008.

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981		1073	373	1006	1416	36				76	3980
1982		2524	422	1195	1120	19				157	5437
1983		2078	693	1724	940	15				101	5551
1984		1479	646	2134	1170	111				88	5628
1985		2027	1148	1969	2081	22				139	7386
1986		2015	1543	2263	2143	68				204	8236
1987		2191	1696	1674	1991	44				195	7791
1988		2495	1573	2528	1959	76				364	8995
1989		3098	2299	1886	2576	84				233	10176
1990		2498	2537	1930	2038	217				222	9442
1991	862	2063	4223	1404	1519	196				560	10827
1992	612	1473	3363	1757	1591	188				401	9385
1993	721	3030	3493	2369	1808	376	339	160		434	12730
1994	503	3683	4569	1850	1538	495	755	137		703	14233
1995	869	2569	6440	1763	1297	280	489	164		844	14715
1996	679	2483	5217	1688	1451	344	952	77		808	13699
1997	1149	2189	6171	2194	1446	316	760	276		662	15163
1998	1111	2177	5136	2145	1032	254	836	350		694	13735
1999	1244	2391	6521	2205	1008	279	1119	724		988	16479
2000	1121	2178	5569	1785	1541	275	1084	597		900	15050
2001	1443	2574	5541	1528	1403	177	1190	791		1268	15915
2002	1231	1954	7247	1340	1118	401	1170	861		1383	16705
2003	1144	2245	6294	1126	1079	337	1089	929		1390	15633
2004	1070	2153	8729	1658	1335	228	922	1268		1224	18587
2005	1099	3094	10685	1990	1605	165	1089	1050		1120	21897
2006	974	4903	10791	2458	1803	133	11033	1288		1249	24627
2007	1294	2966	11910	2652	1842	155	755	1467		1637	24678
2008	963	1218	12240	2450	1514	173	675	1444		1673	22350
2009	728	2703	13327	2662	1067	89	477	1163		2367	24583
2010	959	1443	12825	1871	1032	38	407	806	757	709****	20847
2011	1053	2070	7558	1888	1391	69	395	1191	433	1166*****	17214
2012	1240	2460	4369	2091	860	13	310	1084	597	608****	13632
2013	1050	2982	2951	1503	623	16	191	946	120	409	10791
2014	1416	2503	4147	2370	1252	15	205	1146	320	393	13766
2015	1516	1371	1784	1897	816	15	192	1003	440	610	9656
2016	2535	1854	2399	1937	1146	23	178	1636	780	966	13454

*** Provisional**

**** Includes 3.a.**

*****Devil's Hole landings only separated from 2011.**

****** *695t in IV and 14t in 3.a**

*******4 only**

Table 11.3.1. ***Nephrops*** **in FU 5: Nominal Landings (tons) of** ***Nephrops*****, 1991–2010, as reported to the WG.**

	Belgium	Denmark	Netherlands	Germany	UK	Total**	Catch***
1991	682	176	na		4	862	
1992	571	22	na		19	612	
1993	694	20	na		7	721	
1994	494	0	na		9	503	
1995	641	77	148		3	869	
1996	266	41	317		55	679	
1997	486	67	540		56	1149	
1998	372	88	584	39	28	1111	
1999	436	53	538	59	158	1244	
2000	366	83	402	52	218	1121	
2001	353	145	553	114	278	1443	
2002	281	94	617	88	151	1231	
2003	265	36	661	24	158	1144	
2004	171	39	646	16	198	1070	
2005	109	87	654	51	198	1099	
2006	77	24	444	99	330	974	
2007	75	3	464	201	551	1294	
2008	49	29	268	108	509	963	
2009	52	3	288	98	287	728	
2010	48	5	354	140	411	959	
2011	60	18	480	145	350	1053	
2012	129	0	497	121	493	1240	
2013	142	1	447	168	292	1050	
2014	131	41	645	139	460	1416	
2015	146	0	681	184	505	1516	3562
2016	233	0	801	442	1059	2535	3243

*** provisional na = not available**

**** Totals for 1991–94 exclusive of landings by the Netherlands**

***** Landings plus Netherlands discard estimates.**

Table 11.3.2. *Nephrops* in FU 5: Landings and discards of *Nephrops*, 2015–2016, estimated from the Dutch self-sampling program for three métiers.

	Métier	Biomass (t)		% Discards (numbers)	% Discards (biomass)
		Discards	Landings		
2015	OTB_CRU_70-99_0_0_all	1268	429	85.9%	74.7%
	OTB_DEF_70-99_0_0_all	83	90	67.8%	48.0%
	TBB_DEF_70-99_0_0_all	1	31	8.4%	2.7%
2016	OTB_CRU_70-99_0_0_all	209	546	44.9%	27.7%
	OTB_DEF_70-99_0_0_all	462	37	96.3%	92.6%
	TBB_DEF_70-99_0_0_all	37	70	50.7%	34.3%

Table 11.3.3. ***Nephrops*** **in FU5: Mean length (mm) by sex in landings from Dutch sampling.**

Year	**Mean length (mm)**		
	Females	**Males**	**Unsexed**
2004	37.19	38.70	
2005	36.36	36.95	
2006	36.84	37.33	
2007	37.54	38.38	
2008	38.21	39.27	
2009	37.68	39.39	
2010	40.65	40.60	
2011	41.37	40.62	
2012	39.19	40.31	
2013	na	na	
2014	39.72	39.67	
2015	na	na	32.79
2016	na	na	34.35

*** provisional na = not available**

Table 11.3.4. ***Nephrops*** **in FU5: Landings, effort and lpue for directed fisheries.**

	Landings	Effort	Lpue
	tons	Boat Days Fished	T/Day
2000	53.2	36	1.48
2001	104.2	73	1.43
2002	7.4	10	0.74
2003	215	24	0.89
2004	32.5	21	1.55
2005	66.8	35	1.91
2006	176.8	214	0.83
2007	208.7	177	1.18
2008	267.8	292	0.92
2009	193.9	188	1.03
2010	176.2	152	1.16
2011	181.6	147	1.24
2012	204.7	185	1.11
2013	111.6	142	0.79
2014	147.1	138	1.07
2015	136.2	147	0.93
2016	209.2	212	0.98

Logbook records from English vessels operating in FU 5, with mesh size >=70 mm with ***Nephrops*** **in catches.**

Table 11.4. ***Nephrops*** **in FU 6: Nominal Landings (tons) of** ***Nephrops*****, 1981–2015, as reported to the WG.**

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
1981	1006	67	1073	0	1073
1982	2443	81	2524	0	2524
1983	2073	5	2078	0	2078
1984	1471	8	1479	0	1479
1985	2009	18	2027	0	2027
1986	1987	28	2015	0	2015
1987	2158	33	2191	0	2191
1988	2390	105	2495	0	2495
1989	2930	168	3098	0	3098
1990	2306	192	2498	0	2498
1991	1884	179	2063	0	2063
1992	1403	60	1463	10	1473
1993	2941	89	3030	0	3030
1994	3530	153	3683	0	3683
1995	2478	90	2568	1	2569
1996	2386	96	2482	1	2483
1997	2109	80	2189	0	2189
1998	2029	147	2176	1	2177
1999	2197	194	2391	0	2391
2000	1947	231	2178	0	2178
2001	2319	255	2574	0	2574
2002	1739	215	1954	0	1954
2003	2031	214	2245	0	2245
2004	1952	201	2153	0	2153
2005	2936	158	3094	0	3094
2006	4430	434	4864	39	4903
2007	2525	437	2962	4	2966
2008	976	244	1220	0	1220
2009	2299	414	2713	0	2713
2010	1258	185	1443	0	1443
2011	1806	250	2056	14	2070
2012	2177	256	2433	27	2460
2013	2666	305	2971	11	2982
2014	2104	345	2449	54	2503
2015	1186	174	1360	11	1371
2016*	1726	125	1851	3	1854

*** provisional na = not available**

**** Other countries includes Ne, Be and Dk**

Table 11.4.2. ***Nephrops*** **in FU 6: Landings and effort by English vessels targeting** ***Nephrops***

Year	<10m			10–15m			>15 m		
	Landings	Days	lpue (kg/d)	Landings	Days	lpue (kg/d)	Landings	Days	lpue (kg/d)
2000	124	591	210	368	1611	228	552	1465	377
2001	139	665	209	306	1264	242	460	1363	338
2002	125	654	191	354	1376	257	456	1320	346
2003	319	958	333	483	1614	299	517	1461	354
2004	384	1088	353	456	1604	284	371	863	430
2005	581	1472	395	511	1669	306	647	1276	507
2006	778	2296	339	489	1372	356	1324	2062	642
2007	523	2067	253	259	1034	251	568	1571	362
2008	299	2181	137	152	798	190	163	611	266
2009	449	2279	197	314	1103	285	574	1195	480
2010	340	1773	192	176	650	271	322	969	332
2011	401	2320	173	235	827	285	414	1006	412
2012	388	2174	178	333	1263	264	406	1014	400
2013	465	2374	196	402	1246	323	484	899	539
2014	399	2160	185	280	870	322	420	917	458
2015	195	1565	125	126	647	195	242	901	269
2016	486	2707	180	201	897	224	383	1287	298

Table 11.4.3. *Nephrops* in FU 6: Mean sizes in catches and landings by sex.

	Catches		Landings	
Year	**Males**	**Females**	**Males**	**Females**
1985	30.1	28.5	35.4	33.8
1986	31.7	30.2	35.3	33.7
1987	28.6	27	35.3	33.3
1988	28.7	27.3	35	33.9
1989	29	28.2	32.4	31.9
1990	27.1	27.4	31.8	31.3
1991	28.9	27.1	33.5	33.1
1992	30.8	29	33	31.9
1993	32.1	28.7	33.4	30.1
1994	30.5	27.7	33.8	30.5
1995	28.4	27.4	33.8	31.6
1996	29.8	28.2	34.5	32.1
1997	29.9	29.6	33.5	32.1
1998	30	28.9	34.9	33.7
1999	29.6	27.5	35.1	33.6
2000	27.2	26.8	31.1	31.3
2001	26.2	26.3	30.6	31.3
2002	28.0	26.9	30.9	30.0
2003	29.0	27.1	31.7	30.6
2004	29.2	27.0	32.3	30.6
2005	29.7	29.4	32.1	32.2
2006	29.0	30.3	31.4	32.4
2007	31.3	30.7	33.3	32.6
2008	31.5	31.1	33.5	33.3
2009	30.0	31.0	32.1	33.3
2010	31.2	31.4	32.8	33.2
2011	32.0	31.6	33.7	33.6
2012	30.8	32.0	33.2	34.5
2013	29.6	32.4	32.0	35.3
2014	31.8	35.4	32.9	36.6
2015		31.5	31.7	33.9
2016		31.2	31.3	33.3
	na = not available			

Table 11.4.4. ***Nephrops*** **in FU 6: Results of the UWTV survey.**

Year	Stations	Season	Mean density	Absolute Abundance	95% confidence interval	Method
			burrows/m²	millions	millions	
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	73	Autumn	0.33	1085	90	Box
2004	76	Autumn	0.43	1377	101	Box
2005	105	Autumn	0.49	1657	148	Box
2006	105	Autumn*	0.37	1244	114	Box
2007	105	Autumn*	0.28	858	23	Geostatistics
2008	95	Autumn*	0.31	987	39	Geostatistics
2009	76	Autumn*	0.22	682	38	Geostatistics
2010	95	Autumn*	0.25	785	21	Geostatistics
2011	97	Autumn*	0.28	878	17	Geostatistics
2012	97	Autumn*	0.24	758	13	Geostatistics
2013	110	Summer	0.23	706	18	Geostatistics
2014	110	Summer	0.24	755	18	Geostatistics
2015	110	Summer	0.18	565	13	Geostatistics
2016	110	Summer	0.22	697	19	Geostatistics

Table 11.4.5. Nephrops in FU 6: Historical harvest rate determination.

Year	TV abundance index	Landings (t)	Discard rate	Mean Weight Landings(g)	Mean Weight Discards (g)	N removed	Observed Harvest Rate
2001	1685	2574	66.60%	20.67	9.62	373	22.1%
2002	1048	1953	46.10%	20.00	9.50	181	17.3%
2003	1085	2245	42.10%	21.89	9.56	177	16.3%
2004	1377	2152	41.70%	23.14	9.22	160	11.6%
2005	1657	3094	34.50%	23.58	10.32	200	12.1%
2006	1244	4858	31.30%	22.53	10.58	314	25.2%
2007	858	2966	25.00%	24.95	10.89	159	18.5%
2008	987	1213	24.90%	26.63	10.97	61	6.1%
2009	682	2711	29.30%	24.45	10.54	157	23.0%
2010	785	1443	23.00%	25.18	11.74	74	9.5%
2011	878	2072	22.60%	27.05	11.02	99	11.3%
2012	758	2457	27.42%	27.30	10.16	124	16.4%
2013	706	2982	29.80%	27.60	9.80	154	21.8%
2014	755	2503	14.90%	29.90	13.50	98	13.0%
2015	565	1371	28.97%	29.39	9.99	66	11.6%
2016	697	1854	28.65%	27.97	10.23	93	13.3%

Table 11.5.1. ***Nephrops*****, Fladen (FU 7), Nominal Landings (tons) of** ***Nephrops*****, 1981–2016, as reported to the WG**

	UK Scotland					**Other**	**Total**
	Nephrops	Other	Creel	Sub-total	Denmark	countries	
Year	trawl	trawl				**	
1981	304	68	0	372	0	0	372
1982	381	40	0	421	0	0	421
1983	588	105	0	693	0	0	693
1984	552	94	0	646	0	0	646
1985	1020	120	0	1140	7	0	1147
1986	1401	92	0	1493	50	0	1543
1987	1023	349	0	1372	323	0	1695
1988	1309	185	0	1494	81	0	1575
1989	1724	410	0	2134	165	0	2299
1990	1703	598	0	2301	236	3	2540
1991	3021	772	0	3793	424	6	4223
1992	1809	1164	0	2973	359	31	3363
1993	2031	1234	0	3265	224	3	3492
1994	1816	2356	0	4172	390	6	4568
1995	3568	2389	19	5976	439	4	6419
1996	2338	2578	7	4923	286	1	5210
1997	2712	3221	0	5933	235	2	6170
1998	2290	2673	0	4963	173	0	5136
1999	2860	3546	0	6406	96	16	6518
2000	2916	2546	0	5462	103	5	5570
2001	3540	1936	0	5476	64	2	5542
2002	4511	2546	0	7057	173	15	7245
2003	4175	2033	0	6208	82	4	6294
2004	7274	1319	1	8594	136	0	8730
2005	8849	1508	5	10362	321	1	10684
2006	9470	1026	1	10497	283	11	10791
2007	11055	734	0	11789	119	3	11911
2008	11432	666	0	12098	133	8	12239
2009	12688	499	0	13187	130	10	13327
2010	12544	288	0	12832	124	12	12968
2011	7367	128	0	7495	64	<0.5	7559
2012	4257	81	0	4338	75	2	4415
2013	2275	663	0	2938	5	8	2951
2014	3928	206	0	4134	10	3	4147
2015	1465	307	0	1772	8	4	1784
2016*	2021	374	0	2395	2	2	2399

* provisional na = not available

**Other countries includes Belgium, Norway, Sweden and UK England

Table 11.5.2. *Nephrops*, Fladen (FU 7): Landings, effort (days fishing) and lpue (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2016.

Year	Landings (tons)	Effort (days)	Lpue (kg/day)
2000	5462	35367	154.4
2001	5476	28558	191.8
2002	7057	28586	246.9
2003	6208	21960	282.7
2004	8593	21562	398.5
2005	10357	23555	439.7
2006	10496	22836	459.6
2007	11789	21603	545.7
2008	12098	22856	529.3
2009	13187	21153	623.4
2010	12832	20968	612.0
2011	7495	15273	490.7
2012	4338	11994	361.7
2013	2938	11933	246.2
2014	4134	12629	327.3
2015	1772	10562	167.8
2016*	2395	12297	194.8

*** Provisional**

Table 11.5.3. ***Nephrops*****, Fladen (FU 7): Logbook recorded effort (kW days) and lpue (kg/kW day) for bottom trawlers catching** ***Nephrops*** **with cod end mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2016.**

	Logbook data	
Year	Effort	Lpue
1991	2487464	0.170
1992	1952431	0.184
1993	653665	0.343
1994	1029253	0.379
1995	696951	0.630
1996	524375	0.545
1997	278210	0.845
1998	207196	0.835
1999	144720	0.663
2000	236941	0.435
2001	142562	0.449
2002	217053	0.797
2003	105864	0.775
2004	196984	0.690
2005	430272	0.746
2006	363866	0.778
2007	160590	0.741
2008	106969	1.243
2009	92461	1.406
2010	125830	0.985
2011	65646	0.975
2012	129719	0.578
2013	130458	0.038
2014	171105	0.058
2015	71790	0.111
2016	118291	0.013

Table 11.5.4. *Nephrops*, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1993–2016.

	Catches		**Landings**			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
Year	Males	Females	Males	Females	Males	Females
1993	na	na	30.4	29.6	38.7	38.2
1994	na	na	30.0	28.9	39.2	37.8
1995	na	na	30.6	29.8	39.9	38.1
1996	na	na	30.4	29.1	40.6	38.8
1997	na	na	30.2	29.1	40.9	38.8
1998	na	na	30.8	29.4	40.7	38.3
1999	na	na	30.9	29.6	40.5	38.5
2000	30.7	30.1	31.2	30.5	41.3	38.7
2001	30.1	29.4	30.7	29.7	39.6	38.0
2002	30.6	30.0	31.3	30.7	39.5	38.3
2003	30.9	29.8	31.2	30.1	40.0	38.1
2004	30.8	29.9	31.1	30.2	40.1	38.7
2005	30.9	30.0	31.2	30.1	40.1	38.2
2006	30.3	29.7	30.8	30.0	40.7	38.2
2007	29.8	29.2	30.4	29.5	40.8	38.8
2008	29.7	28.6	29.8	28.7	41.8	39.1
2009	30.7	29.5	31.2	29.9	39.7	38.7
2010	30.4	29.0	30.5	29.0	39.8	38.4
2011	31.7	29.6	31.7	29.6	41.2	38.6
2012	31.9	30.6	31.9	30.6	41.8	38.5
2013	31.4	30.2	31.4	30.2	42.2	39.0
2014	30.4	30.1	30.8	30.2	411.5	39.2
2015	32.3	31.2	32.3	31.2	41.5	40.0
2016	32.0	31.0	32.0	31.0	41.2	40.6

na = not available

Table 11.5.5. ***Nephrops*****, FUs 7–9 and 34 (Fladen, Firth of Forth, Moray Firth and Devil's Hole: Mean weight (g) in the landings.**

Year	Fladen	Firth of Forth	Moray Firth	Devil's Hole	Noup
1990	31.59	20.29	20.05	na	na
1991	26.50	20.03	18.53	na	na
1992	29.61	20.96	23.49	na	na
1993	25.38	24.30	23.42	na	na
1994	23.72	19.51	22.25	na	na
1995	27.51	19.55	20.59	na	na
1996	29.82	20.81	21.40	na	na
1997	32.08	18.87	20.43	na	23.94
1998	31.37	18.23	20.47	na	20.58
1999	30.55	20.05	21.79	na	21.23
2000	36.35	21.83	25.44	na	30.81
2001	25.10	21.22	24.18	na	25.30
2002	27.93	19.62	27.68	na	27.95
2003	30.15	22.31	23.32	na	20.05
2004	30.98	22.45	27.57	na	28.98
2005	29.05	22.33	23.84	na	24.13
2006	29.25	21.43	22.34	22.93	25.97
2007	26.63	20.97	23.04	26.27	25.58
2008	28.18	17.23	25.29	30.08	33.18
2009	28.20	19.41	23.46	39.62	49.38
2010	26.38	19.76	26.94	31.08	51.93
2011	36.17	19.75	21.63	42.05	45.73
2012	36.91	21.66	23.16	na	34.48
2013	34.90	19.30	24.95	na	43.56
2014	43.11	24.30	28.94	50.09	68.31
2015	36.70	21.84	29.10	48.75	na
2016	39.43	23.62	26.83	33.51	35.61
Mean (14–16)	39.75	23.25	28.29	31.76*	-
* Mean weight for Devil's Hole based on 2007–2010 range (WKNEPH, 2013)					
na = not available					

Table 11.5.6. *Nephrops*, Fladen (FU 7): Results of the 1992–2016 TV surveys

Year	Stations	Abundance millions	Mean density burrows/m2	95% confidence interval millions
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996	No survey			
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	336
2014	70	2990	0.11	412
2015	71	2569	0.09	320
2016	78	4449	0.16	662

Table 11.5.7. ***Nephrops*****, Fladen Ground (FU 7): Summary of TV results for most recent 3 years (2014–2016) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum (ranges of % silt clay)	Area (km2)	Number of Stations	Mean burrow density (no./m2)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2014 TV survey							
>80	3248	9	0.197	0.007	639	7993	0.188
55<80	4967	15	0.143	0.004	709	6387	0.15
40<55	4304	12	0.112	0.004	481	6643	0.156
<40	15634	34	0.074	0.003	1162	21432	0.505
Total	28153	70			2990	42455	1
2015 TV survey							
>80	3248	10	0.201	0.002	652	2450	0.096
55<80	4967	15	0.124	0.002	613	4043	0.158
40<55	4304	12	0.096	0.004	414	6174	0.241
<40	15634	34	0.057	0.002	889	12974	0.506
Total	28153	71			2569	25642	1
2016 TV survey							
>80	3248	11	0.238	0.007	772	7067	0.065
55<80	4967	15	0.254	0.022	1261	36692	0.335
40<55	4304	14	0.197	0.009	849	11754	0.107
<40	15634	38	0.100	0.008	1566	54022	0.493
Total	28153	78			4449	109535	1

Table 11.5.8. ***Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2016.**

year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard rate
1992	3661	376	3.1	114	NA	NA	3363	NA	0	NA	29.61	NA	NA
1993	4450	569	3.1	138	NA	NA	3492	NA	0	NA	25.38	NA	NA
1994	6170	814	3.1	193	NA	NA	4568	NA	0	NA	23.72	NA	NA
1995	4987	896	4.7	233	NA	NA	6419	NA	0	NA	27.51	NA	NA
1996	NA	NA	NA	175	NA	NA	5210	NA	0	NA	29.82	NA	NA
1997	2767	510	7	192	NA	NA	6170	NA	0	NA	32.08	NA	NA
1998	3838	717	4.3	164	NA	NA	5136	NA	0	NA	31.37	NA	NA
1999	4146	649	5.1	213	NA	NA	6518	NA	0	NA	30.55	NA	NA
2000	3628	491	4.7	153	21	169	5570	340	255	12	36.35	16.24	9.3
2001	4981	970	5.1	221	43	253	5542	687	515	16.3	25.1	15.94	12.8
2002	6087	757	4.9	259	55	301	7245	820	615	17.4	27.93	14.97	13.7
2003	5547	1076	4.1	209	24	226	6294	349	262	10.1	30.15	14.83	7.8
2004	5725	1030	5.4	282	34	307	8730	506	379	10.6	30.98	15.06	8.2
2005	4325	662	9.3	368	46	403	10684	823	617	11.2	29.05	17.74	8.6
2006	4862	619	8.4	369	54	409	10791	798	599	12.7	29.25	14.87	9.8
2007	7017	730	7	447	55	488	11911	747	560	10.9	26.63	13.67	8.4
2008	7360	1019	6.1	434	18	448	12239	257	192	3.9	28.18	14.54	3.0
2009	5457	772	9.4	473	51	511	13327	707	530	9.7	28.20	13.85	7.5
2010	5224	711	9.9	492	34	517	12968	560	420	6.5	26.38	16.44	4.9
2011	3382	435	6.2	209	0	209	7559	0	0	0	36.17	NA	0
2012	2748	392	4.7	128	0	128	4415	0	0	0	36.91	NA	0
2013	2902	335	3.1	89	0	89	2951	0	0	0	34.90	NA	0
2014	2990	412	3.5	102	3	104	4147	37	28	2.5	43.11	13.9	1.9
2015	2569	320	2	51	0	51	1784	0	0	0	36.7	NA	0
2016	4449	662	1.4	63	0	63	2399	0	0	0	39.43	NA	0

Table 11.6.1 ***Nephrops*****. Firth of Forth (FU 8), Nominal Landings (tons) of** ***Nephrops*****, 1981–2016, as reported to the WG.**

Year	UK Scotland					UK	
	Nephrops trawl	Other trawl	Creel	BMS	Sub-total	(E, W & NI)	**Total ****
1981	947	60	0	0	1007	0	1007
1982	1138	57	0	0	1195	0	1195
1983	1681	43	0	0	1724	0	1724
1984	2078	56	0	0	2134	0	2134
1985	1907	61	0	0	1968	0	1968
1986	2204	59	0	0	2263	0	2263
1987	1583	90	2	0	1675	0	1675
1988	2455	74	0	0	2529	0	2529
1989	1834	53	0	0	1887	1	1888
1990	1900	30	0	0	1930	1	1931
1991	1362	43	0	0	1405	0	1405
1992	1715	41	0	0	1756	0	1756
1993	2349	17	0	0	2366	2	2368
1994	1827	17	0	0	1844	6	1850
1995	1707	53	0	0	1760	2	1762
1996	1621	66	0	0	1687	0	1687
1997	2136	55	0	0	2191	2	2193
1998	2105	37	0	0	2142	2	2144
1999	2193	10	1	0	2204	3	2207
2000	1775	9	0	0	1784	1	1785
2001	1484	34	0	0	1518	9	1527
2002	1302	31	1	0	1334	6	1340
2003	1116	8	0	0	1124	3	1127
2004	1650	4	0	0	1654	3	1657
2005	1974	0	4	0	1978	11	1989
2006	2438	3	12	0	2453	5	2458
2007	2627	10	7	0	2644	7	2651
2008	2435	2	8	0	2445	5	2450
2009	2620	8	26	0	2654	9	2663
2010	1923	5	13	0	1941	9	1950
2011	1789	6	89	0	1884	5	1889
2012	1944	17	126	0	2087	42	2129
2013	1409	24	58	0	1491	12	1503
2014	2344	4	14	0	2362	22	2384
2015	1784	2	43	0	1829	68	1897
2016*	1786	1	116	1.5	1905	32	1937

*** provisional na = not available**

**** There are no landings by other countries from this FU**

Table 11.6.2 *Nephrops*, Firth of Forth (FU 8): Landings, effort (days fishing) and lpue (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000–2016.

Year	Landings (tons)	Effort (days)	Lpue (kg/day)
2000	1784	10508	169.8
2001	1518	11513	131.9
2002	1333	10394	128.2
2003	1124	8279	135.8
2004	1654	9505	174.0
2005	1974	7704	256.2
2006	2441	6174	395.4
2007	2637	6409	411.5
2008	2437	6440	378.4
2009	2628	5852	449.1
2010	1928	5054	381.5
2011	1795	4614	389.0
2012	1961	5058	387.7
2013	1433	4029	355.7
2014	2348	6812	344.7
2015	1786	6024	296.5
2016*	1787	5224	342.1

*** provisional na = not available**

Table 11.6.3 *Nephrops*, Firth of Forth (FU 8): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1981–2016.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31.0	39.7	38.7
1982	na	na	30.4	30.1	40.0	39.1
1983	na	na	31.1	30.8	40.2	38.7
1984	na	na	30.3	29.7	39.4	38.4
1985	na	na	30.6	29.9	39.4	38.2
1986	na	na	29.7	29.2	39.1	38.5
1987	na	na	29.9	29.6	39.1	38.2
1988	na	na	28.5	28.5	39.1	39.0
1989	na	na	29.2	28.9	38.7	38.9
1990	28.9	27.8	29.8	28.6	38.3	38.8
1991	28.7	27.5	29.8	28.7	38.3	38.7
1992	29.5	27.9	30.2	28.7	38.1	38.7
1993	28.7	28.0	30.3	29.5	39.0	38.6
1994	25.7	25.1	29.1	28.5	38.8	37.8
1995	27.9	27.1	29.4	28.9	38.7	37.9
1996	28.0	27.4	29.8	28.8	38.6	38.6
1997	27.2	27.0	29.2	28.7	38.8	38.2
1998	27.7	26.4	29.0	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38.0	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011	28.6	27.5	30.0	28.3	38.8	38.2
2012	28.4	28.0	30.4	29.3	39.0	38.1
2013	28.3	27.4	29.6	28.8	38.8	37.9
2014	29.6	29.1	31.1	30.3	38.6	38.1
2015	27.9	28.3	29.5	29.3	39.6	38.5
2016	29.3	28.6	30.5	29.7	39.4	38.5
	na = not available					

Table 11.6.4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1993–2016 TV surveys.**

		Mean Density	Abundance	95% conf interval
Year	**Stations**	burrows/m²	millions	millions
1993	37	0.61	555	142
1994	30	0.49	448	78
1995	no survey			
1996	27	0.41	375	88
1997	no survey			
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125
2014	51	0.47	428	80
2015	51	0.73	664	127
2016	50	0.87	797	146

Table 11.6.5. ***Nephrops*****, Firth of Forth (FU 8): Summary of TV results for most recent 3 years (2014–2016) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum	**Area** (km²)	**Number of** Stations	**Mean burrow** density (no./m²)	**Observed variance**	**Abundance** (millions)	**Stratum** variance	**Proportion** of total variance
2014 TV survey							
M & SM	170	10	0.317	0.081	54	236	0.147
MS(west)	139	7	0.198	0.010	28	27	0.017
MS(mid)	211	12	0.725	0.134	153	496	0.309
MS(east)	395	22	0.491	0.119	194	847	0.527
Total	915	51			428	1606	1
2015 TV survey							
M & SM	170	9	0.613	0.447	105	1444	0.357
MS(west)	139	8	0.462	0.200	64	482	0.119
MS(mid)	211	12	0.955	0.243	201	898	0.222
MS(east)	395	22	0.746	0.173	295	1226	0.303
Total	915	51				4050	1
2015 TV survey							
2016 TV survey							
M & SM	170	9	0.832	0.431	142	1391	0.262
MS(west)	139	7	0.495	0.183	69	506	0.095
MS(mid)	211	12	1.234	0.393	260	1451	0.273
MS(east)	395	22	0.826	0.278	326	1972	0.371

Table 11.6.6. ***Nephrops*****, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003–2016.**

year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard rate
1993	555	142	24.1	97	49	134	2368	426	426	33.3	24.3	11.64	27.3
1994	448	78	51.3	95	180	230	1850	1188	1188	65.5	19.51	8.79	58.8
1995	NA	NA	NA	90	59	134	1762	465	465	39.5	19.55	10.54	32.9
1996	375	88	37.3	81	78	140	1687	697	697	49.2	20.81	11.85	42.1
1997	NA	NA	NA	116	56	158	2193	371	371	32.6	18.87	8.79	26.6
1998	292	81	55.7	118	60	163	2144	434	434	33.9	18.23	9.6	27.8
1999	463	78	39.6	110	97	183	2207	704	704	47	20.05	9.63	39.9
2000	443	70	33.7	82	90	150	1785	774	774	52.5	21.83	11.42	45.3
2001	419	79	25.3	72	45	106	1527	327	327	38.7	21.22	9.59	32.1
2002	508	119	21.1	68	52	107	1340	316	316	43.1	19.62	8.16	36.2
2003	767	138	12.4	51	59	95	1127	546	410	53.9	22.31	9.25	46.7
2004	630	140	16.4	74	40	103	1657	406	304	34.9	22.45	10.25	28.7
2005	710	143	19.4	89	65	138	1989	602	452	42.1	22.33	9.28	35.3
2006	827	126	26.7	115	142	221	2458	1510	1133	55.2	21.43	10.67	48.1
2007	692	132	22.9	126	43	159	2651	614	461	25.3	20.97	14.34	20.3
2008	881	297	21.1	142	58	186	2450	796	597	29.1	17.23	13.65	23.5
2009	732	142	26	137	71	190	2663	573	430	34.1	19.41	8.09	27.9
2010	682	147	19.2	99	43	131	1950	407	305	30.2	19.76	9.55	24.5
2011	533	87	22.1	100	24	118	1889	231	173	19.5	19.75	9.56	15.3
2012	522	64	24.6	100	38	129	2129	379	284	27.2	21.66	10.10	21.9
2013	668	126	15.6	81	31	104	1503	301	226	27.4	19.30	9.82	22.0
2014	428	80	29.1	102	30	124	2384	353	265	22.9	24.30	11.66	18.3
2015	664	127	16.8	90	29	112	1897	311	234	24.4	21.84	10.74	19.5
2016	797	146	12.3	85	17	98	1937	165	123	16.4	23.62	9.86	12.8

Table 11.7.1. *Nephrops*, Moray Firth (FU 9), Nominal Landings (tons) of *Nephrops*, 1981–2016, as reported to the WG.

	UK Scotland				UK*	
Year		Other			England	
	Nephrops trawl	trawl	Creel	Sub-total		**Total** **
1981	1299	117	0	1416	0	1416
1982	1033	86	0	1119	0	1119
1983	850	91	0	941	0	941
1984	960	209	0	1169	0	1169
1985	1908	173	0	2081	0	2081
1986	1932	211	0	2143	0	2143
1987	1724	268	0	1992	0	1992
1988	1637	322	0	1959	0	1959
1989	2102	474	0	2576	0	2576
1990	1698	339	0	2037	0	2037
1991	1285	235	0	1520	0	1520
1992	1285	306	0	1591	0	1591
1993	1505	304	0	1809	0	1809
1994	1179	358	0	1537	0	1537
1995	967	312	0	1279	0	1279
1996	1084	364	1	1449	2	1451
1997	1103	343	0	1446	1	1447
1998	739	289	4	1032	0	1032
1999	813	194	2	1009	0	1009
2000	1341	196	2	1539	0	1539
2001	1186	213	2	1401	0	1401
2002	883	247	2	1132	0	1132
2003	873	196	11	1080	0	1080
2004	1222	103	8	1333	0	1333
2005	1526	64	12	1602	3	1605
2006	1751	42	11	1804	1	1805
2007	1818	17	6	1841	2	1843
2008	1444	68	3	1515	0	1515
2009	1033	31	2	1066	1	1067
2010	1026	28	9	1063	0	1063
2011	1358	23	9	1390	1	1391
2012	834	24	8	866	0	866
2013	497	116	7	620	3	623
2014	1183	56	2	1241	12	1253
2015	774	40	0	814	2	816
2016*	1105	37	4	1146	<0.5	1146

*** provisional na = not available**

**** No landings by non UK countries from this FU**

Table 11.7.2. ***Nephrops*****, Moray Firth (FU 9): landings, effort (days fishing) and lpue (kg/day) for UK bottom trawlers landing in Scotland and fishing** ***Nephrops*** **with codend mesh sizes of 70 mm or above, 2000–2016**

Year	Landings (tons)	Effort (days)	Lpue (kg/day)
2000	1537	7943	193.5
2001	1399	7219	193.8
2002	1130	7495	150.8
2003	1069	5934	180.1
2004	1325	6200	213.7
2005	1590	4805	330.9
2006	1793	4588	390.8
2007	1835	4758	385.7
2008	1512	4328	349.4
2009	1064	3546	300.1
2010	1054	3589	293.7
2011	1381	3880	355.9
2012	858	3079	278.7
2013	613	2954	207.5
2014	1239	4099	302.3
2015	814	3755	216.8
2016*	1142	3577	319.3

*** provisional na = not available**

Table 11.7.3. ***Nephrops*****, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female** ***Nephrops*** **in Scottish catches and landings, 1991–2016.**

Year	**Catches**		**Landings**			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	30.5	28.2	39.1	37.7
1982	na	na	30.2	29.0	40.0	37.9
1983	na	na	29.9	29.1	40.6	38.3
1984	na	na	29.7	29.3	39.4	38.1
1985	na	na	28.9	28.7	38.7	37.8
1986	na	na	28.7	27.8	39.1	38.4
1987	na	na	29.0	28.3	39.4	38.6
1988	na	na	29.1	28.7	38.9	38.4
1989	na	na	29.8	28.8	40.1	39.4
1990	28.8	28.1	30.3	29.1	38.4	38.7
1991	28.3	27.4	30.1	28.6	38.2	38.2
1992	29.4	28.6	31.0	30.5	38.3	38.0
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31.0	39.4	37.5
1995	25.8	25.0	29.9	29.3	39.1	38.0
1996	29.3	28.4	30.6	29.7	38.5	38.0
1997	28.5	27.9	29.5	28.9	38.8	38.2
1998	28.7	28.2	30.1	29.3	38.8	38.2
1999	29.5	28.8	30.4	29.7	38.9	37.6
2000	29.8	29.1	31.5	30.6	39.2	38.3
2001	30.0	29.2	30.9	30.2	39.5	37.9
2002	27.2	27.0	31.2	30.9	41.0	38.7
2003	29.3	29.2	30.3	30.1	39.8	38.0
2004	29.3	28.4	31.3	30.8	39.0	39.2
2005	30.0	28.7	31.0	29.6	39.2	38.5
2006	29.7	28.9	30.6	29.6	39.3	38.6
2007	30.1	28.8	30.3	29.0	39.4	38.6
2008	29.3	27.7	30.2	28.2	39.8	40.2
2009	29.7	28.9	30.7	29.3	39.6	38.5
2010	29.7	29.1	31.1	30.5	40.0	38.9
2011	28.6	28.4	29.4	29.0	39.5	38.4
2012	29.5	29.1	30.5	29.9	39.2	38.5
2013	30.7	29.3	30.9	29.5	39.6	38.4
2014	30.2	29.8	31.6	30.8	40.3	39.0
2015	29.8	29.4	31.5	30.6	40.6	39.1
2016	29.3	28.6	30.7	29.8	40.1	38.5

na = not available

Table 11.7.4. ***Nephrops*****, Moray Firth (FU 9): Results of the 1993–2016 TV surveys**

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995	no survey			
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84
2016	53	0.18	388	87

Table 11.7.5. ***Nephrops*****, Moray Firth (FU 9): Summary of TV results for most recent 3 years (2014–2016) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum	**Area** (km²)	**Number of** Stations	**Mean burrow** density (no./m²)	**Observed variance**	**Abundance** (millions)	**Stratum** variance	**Proportion** of total variance
2014 TV survey							
M & SM	169	3	0.19	0.04	33	412	0.202
MS(west)	682	16	0.14	0.03	98	851	0.417
MS(mid)	698	17	0.15	0.02	103	436	0.213
MS(east)	646	16	0.15	0.01	97	344	0.168
Total	2195	52			331	2042	1
2015 TV survey							
M & SM	169	3	0.30	0.03	51	235	0.134
MS(west)	682	19	0.11	0.02	75	542	0.309
MS(mid)	698	17	0.22	0.02	151	456	0.259
MS(east)	646	13	0.11	0.02	71	525	0.299
Total	2195	52			347	1757	1
2016 TV survey							
M & SM	169	2	0.33	0.01	55	176	0.093
MS(west)	682	18	0.14	0.04	98	913	0.479
MS(mid)	698	16	0.16	0.01	112	285	0.15
MS(east)	646	17	0.19	0.02	124	529	0.278
Total	2195	53			388	1903	1

Table 11.7.6. ***Nephrops*****, Moray Firth (FU 9): Adjusted TV survey abundance, landings, discard rate (proportion by number), dead discard rate (proportion by number) and estimated harvest ratio 2003–2016.**

Year	Adjusted abundance (millions)	95% CI	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Dead Discards (tonnes)	Discard rate	Mean weight in landings	Mean weight in discards	Dead discard rate
1993	345	78	26.5	77	19	91	1809	214	161	19.8	23.42	11.26	15.6
1994	702	176	11.4	69	15	80	1537	153	115	17.8	22.25	10.21	14
1995	NA	NA	NA	62	72	116	1279	502	376	53.8	20.59	6.93	46.6
1996	465	90	21.1	68	41	98	1451	492	369	37.5	21.4	12.11	31
1997	262	55	33.3	71	22	87	1447	230	172	23.8	20.43	10.42	18.9
1998	323	95	18.1	50	11	58	1032	89	67	17.6	20.47	8.29	13.8
1999	400	87	12.8	46	6	51	1009	55	41	12	21.79	8.63	9.3
2000	386	98	20.1	61	23	78	1539	269	201	27.5	25.44	11.73	22.1
2001	345	112	19.3	58	11	66	1401	125	94	16.3	24.18	11.04	12.8
2002	521	121	11.7	41	27	61	1132	220	165	39.7	27.68	8.18	33.1
2003	730	314	7.1	46	7	52	1080	70	52	13.7	23.32	9.51	10.6
2004	626	186	10.5	48	23	66	1333	272	204	32.6	27.57	11.62	26.6
2005	869	198	8.8	67	12	76	1605	122	92	15.0	23.84	10.31	11.7
2006	445	124	20.1	81	12	90	1805	117	87	12.8	22.34	9.86	9.9
2007	531	156	16	80	7	85	1843	95	72	7.9	23.04	13.95	6.0
2008	481	151	13.7	60	8	66	1515	74	55	11.4	25.29	9.60	8.8
2009	415	140	11.6	45	4	48	1067	33	25	7.6	23.46	8.72	5.8
2010	406	115	11.5	39	10	47	1063	104	78	19.8	26.94	10.63	15.7
2011	372	161	18.9	63	10	70	1391	102	77	13.9	21.63	10.12	10.8
2012	299	90	13.7	37	6	41	866	54	41	13.2	23.16	9.72	10.3
2013	469	106	5.8	26	1	27	623	10	8	3.3	24.95	11.21	2.5
2014	331	90	14.7	43	7	49	1253	87	65	14.6	28.94	11.79	11.3
2015	347	84	9.1	28	5	32	816	56	42	15.1	29.1	11.35	11.8
2016	388	87	12.7	42	9	49	1146	95	71	18.0	26.83	10.16	14.2

Table 11.8.1. ***Nephrops*****, Noup (FU 10): Nominal landings (tons) of** ***Nephrops*****, 1981–2016, as reported to the WG.**

Year	*Nephrops* Trawl	Other trawl	Creel	Sub Total	Other UK	Total
1981	12	23	0	35	0	35
1982	12	7	0	19	0	19
1983	10	6	0	16	0	16
1984	76	35	0	111	0	111
1985	1	21	0	22	0	22
1986	45	22	0	67	0	67
1987	13	32	0	45	0	45
1988	23	53	0	76	0	76
1989	24	60	0	84	0	84
1990	101	117	0	218	0	218
1991	111	86	0	197	0	197
1992	58	130	0	188	0	188
1993	200	176	0	376	0	376
1994	307	187	0	494	0	494
1995	163	116	0	279	0	279
1996	181	164	0	345	0	345
1997	185	131	1	317	0	317
1998	184	72	0	256	0	256
1999	211	67	0	278	0	278
2000	196	78	0	274	0	274
2001	88	89	0	177	0	177
2002	246	157	0	403	0	403
2003	258	78	0	336	0	336
2004	174	54	0	228	0	228
2005	81	84	0	165	0	165
2006	44	89	0	133	0	133
2007	46	107	0	153	0	153
2008	74	98	0	172	0	172
2009	24	63	0	87	0	87
2010	4	35	0	39	0	39
2011	27	41	0	68	0	68
2012	2	11	0	13	0	13
2013	4	12	0	16	0	16
2014	3	11	1	15	0	15
2015	1	14	0	15	0	15
2016*	9	14	0	23	0	23

* provisional

Table 11.8.2. ***Nephrops*****, Noup (FU 10): Landings (tons), effort (days fishing) and lpue (kg/day) for UK bottom trawlers landing in Scotland and fishing** ***Nephrops*** **with codend mesh sizes of 70 mm or above, 2000–2016.**

Year	Landings (tonnes)	Effort (days)	Lpue (kg/day)
2000	274	1622	168.9
2001	177	1383	128.0
2002	403	2036	197.9
2003	336	1434	234.3
2004	228	899	253.6
2005	165	730	226.0
2006	133	612	217.3
2007	153	591	258.9
2008	172	746	230.6
2009	87	871	99.9
2010	39	813	48.0
2011	68	776	87.6
2012	13	574	22.6
2013	16	454	35.2
2014	14	673	20.8
2015	15	514	29.2
2016*	23	520	44.2
*** provisional**			

Table 11.8.3. ***Nephrops*****, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female** ***Nephrops*** **in landings, 1997–2016. No females in samples in 2010 and no sampling in 2015.**

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
1997	29.7	28.3	40.4	38.2
1998	30.4	29.8	38.8	38.6
1999	30.4	30.1	39.2	37.8
2000	31.8	30.1	38.2	39.1
2001	31.4	29.5	38.7	37.9
2002	30.8	29.9	39.7	38.5
2003	29.3	30.4	39.9	38.5
2004	31.4	30.0	40.2	38.8
2005	31.0	29.3	39.3	38.4
2006	30.8	30.2	40.4	38.7
2007	30.7	29.4	40.2	38.7
2008	31.9	30.6	40.3	39.3
2009	33.2	33.2	42.6	42.7
2010	33.3	na	42.6	na
2011	32.8	32.7	43.3	40.1
2012	32.4	31.8	40.7	40.1
2013	34.0	32.4	43.7	39.7
2014	33.3	33.0	46.6	43.2
2015	na	na	na	na
2016	33.2	32.1	38.5	43.9
	na = not available			

Table 11.8.4. ***Nephrops*****, Noup (FU 10): Results of the 1994, 1999, 2006, 2007 & 2014 TV surveys (absolute conversion factor =1.35, from Fladen).**

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1994	10	0.47	185	67
1995	no survey			
1996	no survey			
1997	no survey			
1998	no survey			
1999	10	0.22	89	31
2000	no survey			
2001	no survey			
2002	no survey			
2003	no survey			
2004	no survey			
2005	2	poor visibility, limited survey - see text		
2006	7	0.13	55	35
2007	9	0.11	44	19
2008	no survey			
2009	no survey			
2010	no survey			
2011	no survey			
2012	no survey			
2013	no survey			
2014	12	0.13	51	22
2015	no survey			
2016	no survey			

Table 11.9.1. ***Nephrops*** **Norwegian Deep (FU 32): Landings (tons) by country, 1993–2016, estimated Danish discards (2003–2016), and TAC (EU).**

		Danish discards		Norway							
Year	**Denmark**	dead	live	Trawl	Creel	Sub-total	**Sweden**	**UK**	**Netherlands**	**Total**	**TAC**
1993	220			102	1	103		16		339	
1994	584			161	0	161		10		755	
1995	418			68	1	69		2		489	
1996	868			73	1	74		10		952	
1997	689			56	8	64		7		760	
1998	743			88	1	89		4		836	
1999	972			119	15	134		13		1119	
2000	871			143	0	143	37	34		1085	
2001	1026			72	13	85	26	53		1190	
2002	1043			42	21	63	13	52		1171	
2003	996	145	48	68	11	79	1	14		1090	
2004	835	200	67	72	8	80	1	6		922	1000
2005	979	194	65	89	13	102	2	6		1089	1000
2006	939	126	42	62	19	81	1	7	5	1033	1300
2007	652	64	21	77	20	97	5	1		755	1300
2008	505			112	30	142	24	4		675	1300
2009	331	29	10	107	31	138	2	6		477	1200
2010	282	36	12	82	41	123	1	1		407	1200
2011	322			29	40	69	1	3		395	1200
2012	234	35	12	25	50	75	1	0		310	1200
2013	128	51	17	18	45	63	0	0		191	1000
2014	143	4	1	15	47	62	0	0		205	1000
2015	110	5	2	8	74	82	0	0		192	1000
2016*	80	1	0	7	90	97	0	0	1	178	1000

*** Provisional**

Table 11.9.2. ***Nephrops*** **Norwegian Deep (FU 32): Danish effort (kW days, days at sea, fishing days) and lpue (kg/kW day) for bottom trawlers catching** ***Nephrops*****, 1993–2016. Effort values were up-dated in 2016.**

Year	kW days ('1000)	Days at sea	Fishing days	Lpue
1993	891	1980	1536	247
1994	1439	3574	2793	406
1995	1009	2464	1936	414
1996	1734	4000	3229	501
1997	1962	4162	3410	351
1998	1471	3251	2644	505
1999	2262	4658	3763	430
2000	2662	5068	4152	327
2001	3511	6429	5464	292
2002	3105	5743	4791	336
2003	3494	6287	5404	285
2004	2443	4297	3653	342
2005	2787	5076	4348	351
2006	3023	5274	4514	311
2007	1782	3052	2557	366
2008	1589	2521	2123	318
2009	1351	2160	1793	245
2010	1151	1903	1612	245
2011	1152	1863	1543	280
2012	907	1474	1224	258
2013	862	1450	1200	149
2014	747	1224	1054	191
2015	576	927	784	191
2016	462	729	644	173

Table 11.10.1 ***Nephrops*** **in FU 33: (Off Horns Reef) Landings (tons) by country, 1993–2013.**

	Belgium	Denmark	Germany	Netherl.	UK	Total **
1993	0	159		na	1	160
1994	0	137		na	0	137
1995	3	158		3	1	164
1996	1	74		2	0	77
1997	0	274		2	0	276
1998	4	333	8	12	1	350
1999	22	683	14	12	6	724
2000	13	537	12	39	9	597
2001	52	667	11	61	+	791
2002	21	772	13	51	4	861
2003	15	842	4	67	1	929
2004	37	1097	24	109	1	1268
2005	16	803	31	191	9	1050
2006	97	710	151	314	15	1288
2007	118	610	201	496	42	1467
2008	130	362	160	386	58	1096
2009	121	231	150	491	170	1163
2010	56	180	206	295	69	806
2011	163	396	202	403	28	1191
2012	181	394	132	376	2	1084
2013	156	310	174	304	2	946
2014	229	387	161	360	9	1146
2015	299	371	142	187	4	1003
2016*	430	642	201	320	43	1636

*** provisional na = not available**

**** Totals for 1993–94 exclusive of landings by the Netherlands**

Table 11.10.2. *Nephrops* in FU 33: (Off Horns Reef): Danish logbook recorded effort (kW days, days at sea and fishing days) and lpue (kg/kW day) for bottom trawlers catching *Nephrops* with cod end mesh sizes of 70 mm or above, 1991–2015.

Year	kW days	Days at sea	Fishing days	Lpue*
1991	596893.4	1365	1110	0.12
1992	530942.1	1373	1148	0.14
1993	626892.7	1438	1229	0.25
1994	387211.1	996	849	0.35
1995	377259.4	1070	857	0.42
1996	213421.5	636	541	0.35
1997	490283.3	1445	1157	0.56
1998	753395.8	2256	1758	0.44
1999	1169139	3400	2811	0.58
2000	1040670	3201	2535	0.52
2001	1250865	3835	3137	0.53
2002	1611737	4545	3648	0.48
2003	1598038	4722	3795	0.53
2004	1900334	5625	4415	0.58
2005	1084501	3275	2637	0.74
2006	959737.6	2703	2146	0.74
2007	773976.6	1972	1548	0.79
2008	453867.9	939	736	0.80
2009	287076.4	668	560	0.81
2010	246616.9	525	425	0.73
2011	345697.8	759	610	1.15
2012	297221.6	699	593	1.33
2013	239220.6	561	494	1.29
2014	375007.1	884	865	1.03
2015	281207.3	668	620	1.32
2016	388455.5	992	887	1.65

***kg/ kW days**

Table 11.11.1. ***Nephrops*****, Devil's Hole (FU 34): Nominal landings (tons) of** ***Nephrops*** **1986–2016 as reported to the WG. Scottish data only from 1986 to 2009.**

	UK Scotland							
Year	*Nephrops* trawl	Other trawl	Creel	Sub-total	**UK (E, W & NI)**	**Denmark**	**Netherlands**	**Total**
1986	20	3	0	23				23
1987	2	3	0	5				5
1988	1	1	0	2				2
1989	15	13	0	28				28
1990	20	6	0	26				26
1991	64	21	0	85				85
1992	78	28	0	106				106
1993	23	21	0	44				44
1994	79	50	0	129				129
1995	37	95	0	132				132
1996	40	89	0	129				129
1997	30	70	0	100				100
1998	15	73	0	88				88
1999	80	122	0	202				202
2000	89	95	0	184				184
2001	159	112	0	271				271
2002	240	103	0	343				343
2003	518	157	0	675				675
2004	398	90	0	488				488
2005	253	125	0	378				378
2006	359	89	0	448				448
2007	649	68	0	717				717
2008	844	93	0	937				937
2009	1297	8	0	1305				1305
2010	816	22	0	838	25	1	1	865
2011	406	16	0	422	6	4		432
2012	546	4	0	550	37	10		597
2013	65	41	0	106	11	3		120
2014	293	14	0	307	13			320
2015	383	18	0	401	39	<0.5		440
2016*	738	6	0	744	36			780

*** Provisional**

Table 11.11.2. ***Nephrops*****, Devils Hole (FU 34): Landings, effort (days fishing) and lpue (kg/day) for UK bottom trawlers landing in Scotland and fishing** ***Nephrops*** **with cod end mesh sizes of 70 mm or above, 2000–2016.**

Year	Landings (tons)	Effort (days)	Lpue (kg/day)
2000	184	3391	54.3
2001	271	3142	86.3
2002	343	2022	169.6
2003	675	2614	258.2
2004	488	1551	314.6
2005	378	1545	244.7
2006	448	1440	311.1
2007	717	1824	393.1
2008	937	1673	560.1
2009	1305	1921	679.3
2010	838	1465	572.0
2011	422	1041	405.4
2012	550	1255	438.2
2013	106	438	242.0
2014	307	758	405.0
2015	401	1222	328.2
2016*	744	1640	453.7

*** Provisional**

Table 11.11.3. ***Nephrops*****, Devil's Hole (FU 34): Mean sizes (CL mm) above and below 35 mm of male and female** ***Nephrops*** **in Scottish catches and landings, 2006–2016. Samples not available in 2012 and 2013.**

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
2006	29.7	29.8	39.7	38.1
2007	30.4	28.7	40.5	39.2
2008	31	30.5	40.3	39.6
2009	31.7	31.1	41.3	40.6
2010	32.1	29.7	39.1	38.8
2011	31.7	30.7	43.7	40.4
2012	na	na	na	na
2013	na	na	na	na
2014	33.0	34.0	42.0	41.4
2015	33.0	31.4	41.2	39.9
2016	31.7	30.6	41.0	39.1
	na = not available			

Table 11.11.4. ***Nephrops*****, Devil's Hole (FU 34): Results of the 2003, 2005, 2009–12 and 2014–2015 surveys**

Year	Stations	**Mean** density burrows/m²	**95%** confidence interval burrows/m²
2003	20	0.09	0.02
2004	no survey		
2005	29	0.09	0.04
2006	no survey		
2007	no survey		
2008	no survey		
2009	12	0.28	0.13
2010	19	0.24	0.08
2011	14	0.16	0.09
2012	15	0.14	0.06
2013	no survey		
2014	13	0.13	0.04
2015	17	0.16	0.06
2016	no survey		

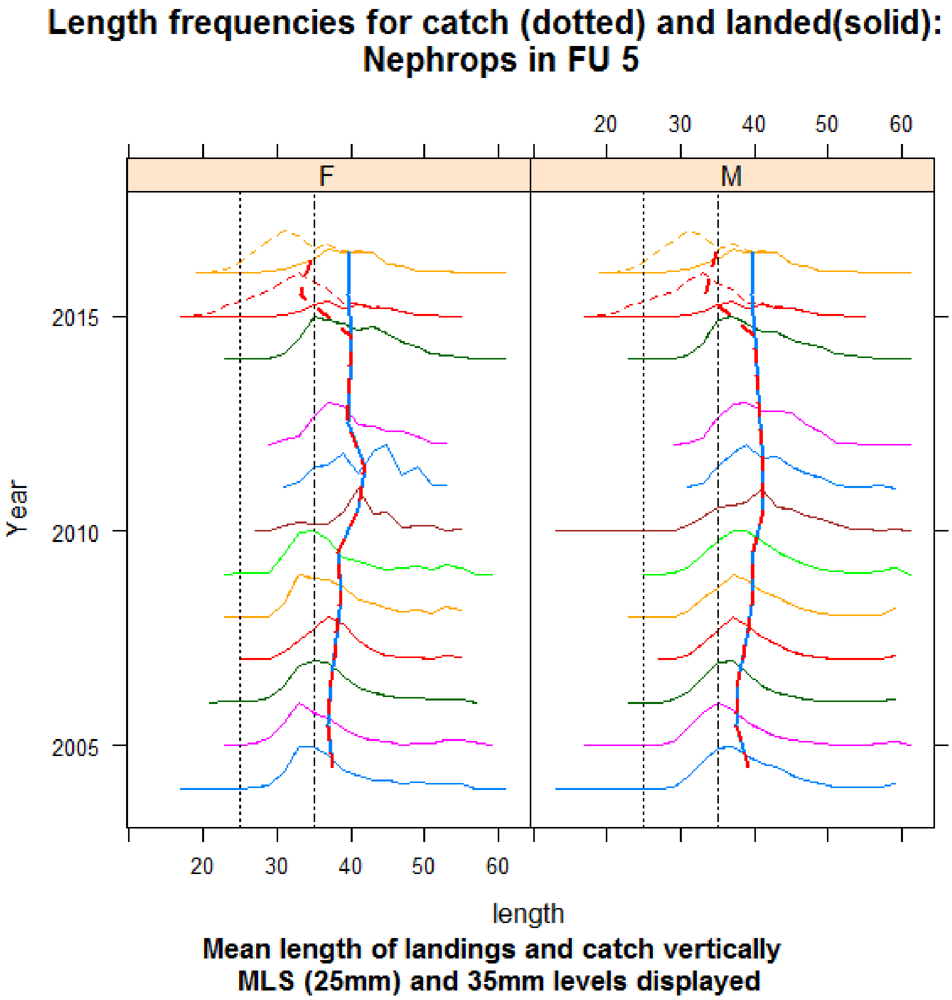


Figure 11.3.1. FU5 Botney Gut/Silver Pit: Size distribution for Dutch landings, from 2004 to 2016.

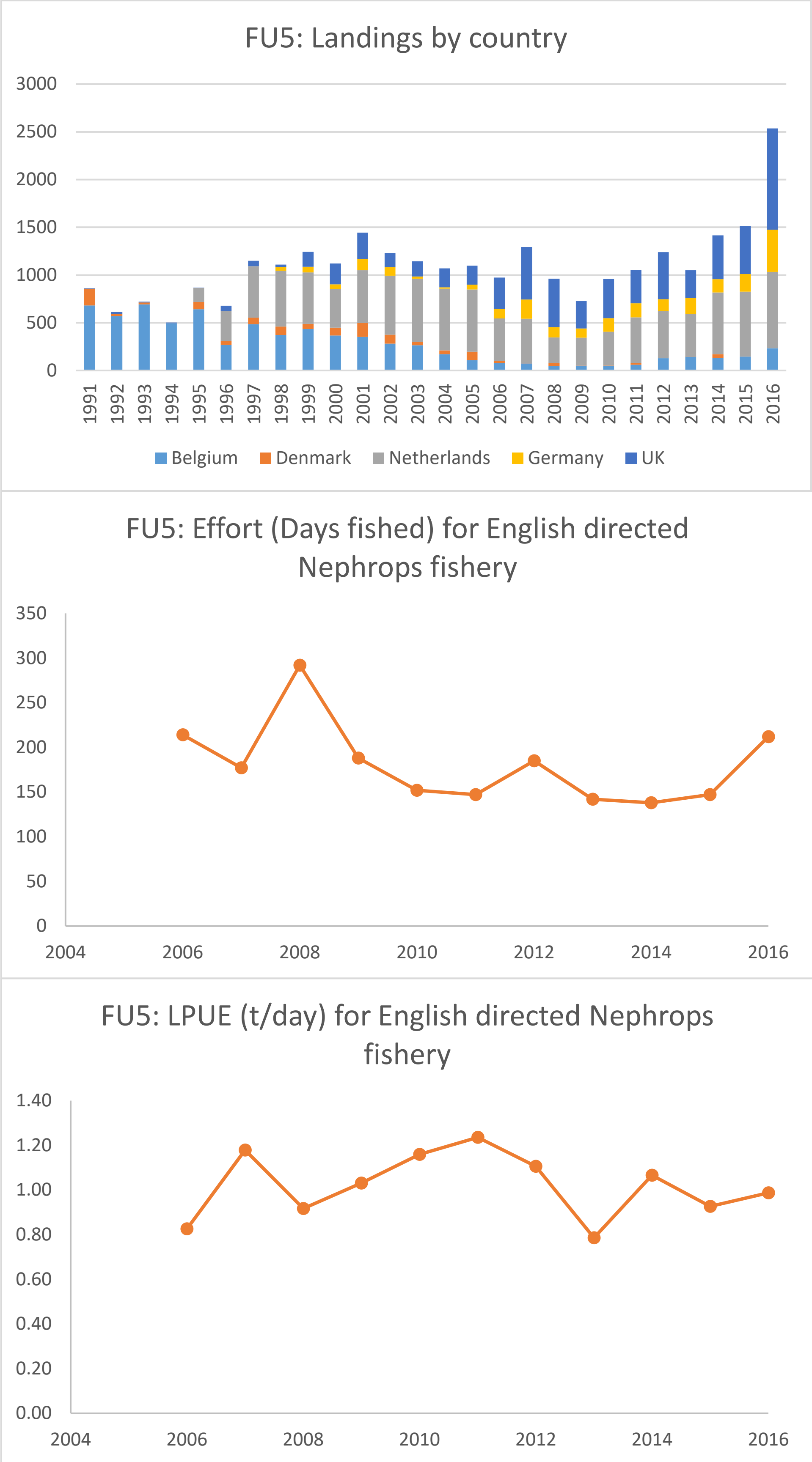


Figure 11.3.2. FU5 Botney Gut/Silver Pit: Long-term trends in landings, effort and lpue.

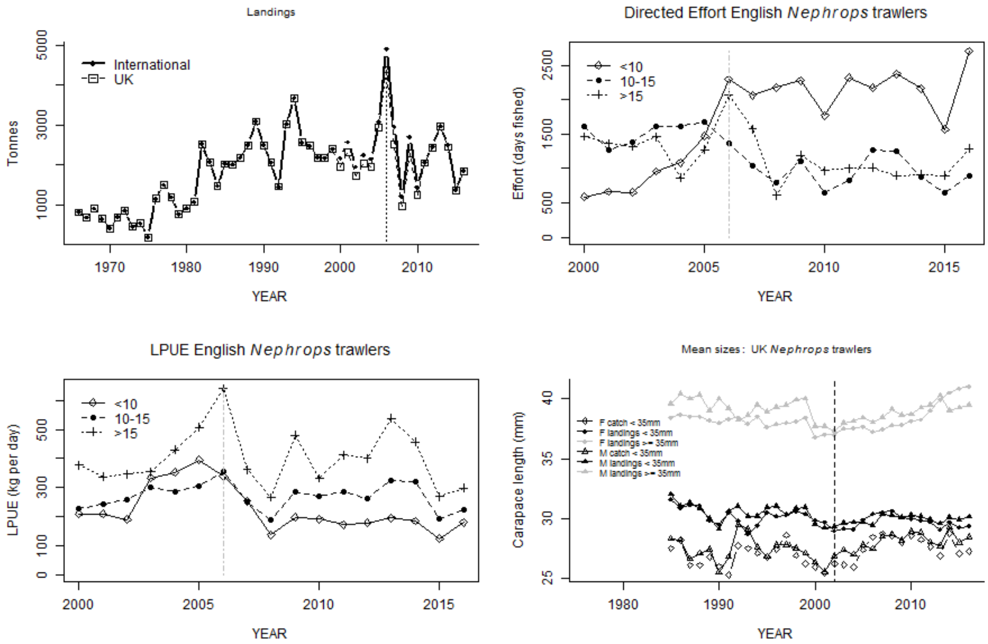


Figure 11.4.1. ***Nephrops*** **in FU6: Landings, directed effort, directed lpue and mean sizes of different catch components.**

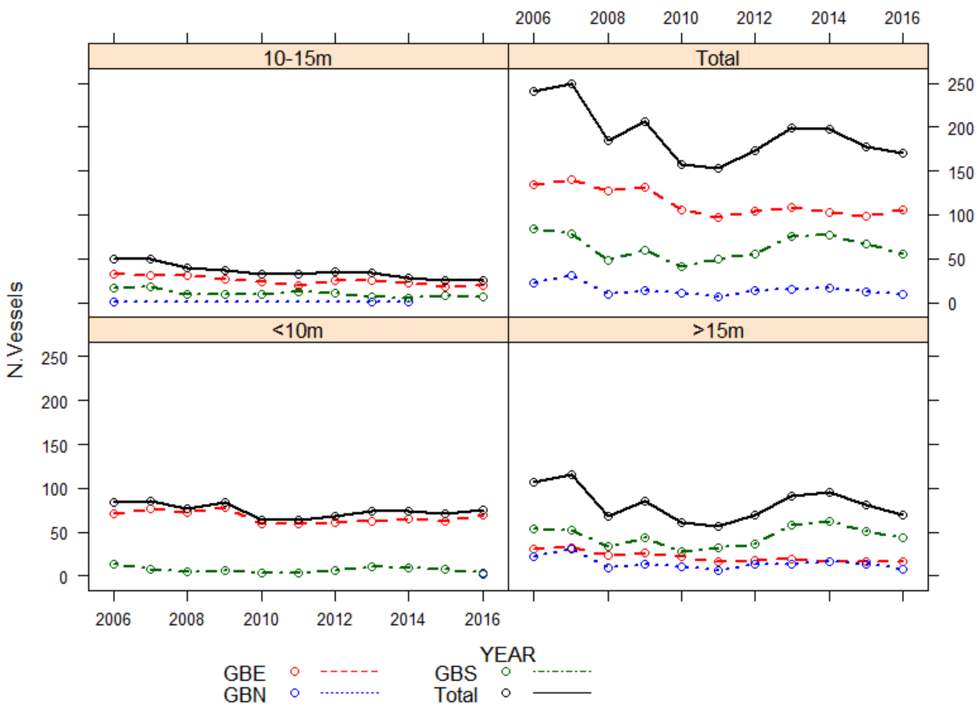


Figure 11.4.2. ***Nephrops*** **in FU6: Number of participating vessels (from UK) by vessel size category.**

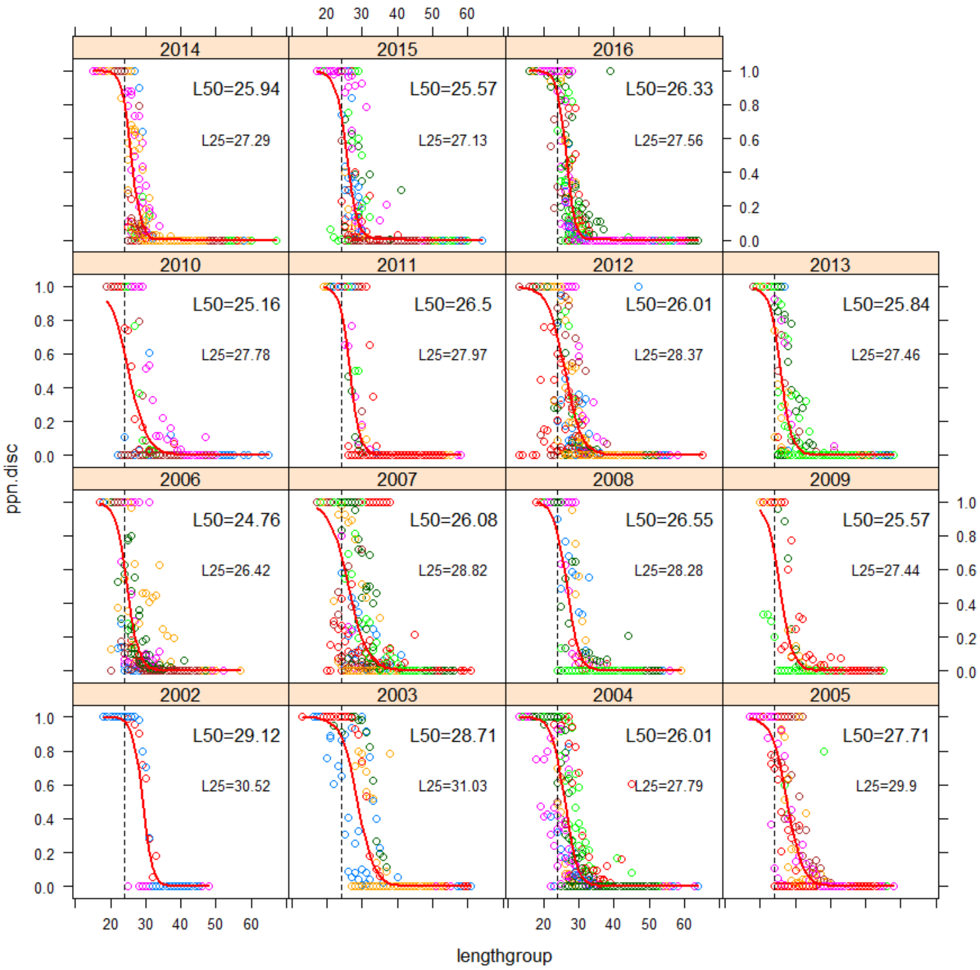


Figure 11.4.3. ***Nephrops*** **in FU6, annual discard ogives: The different point shapes represent different sampling trips within any year.**

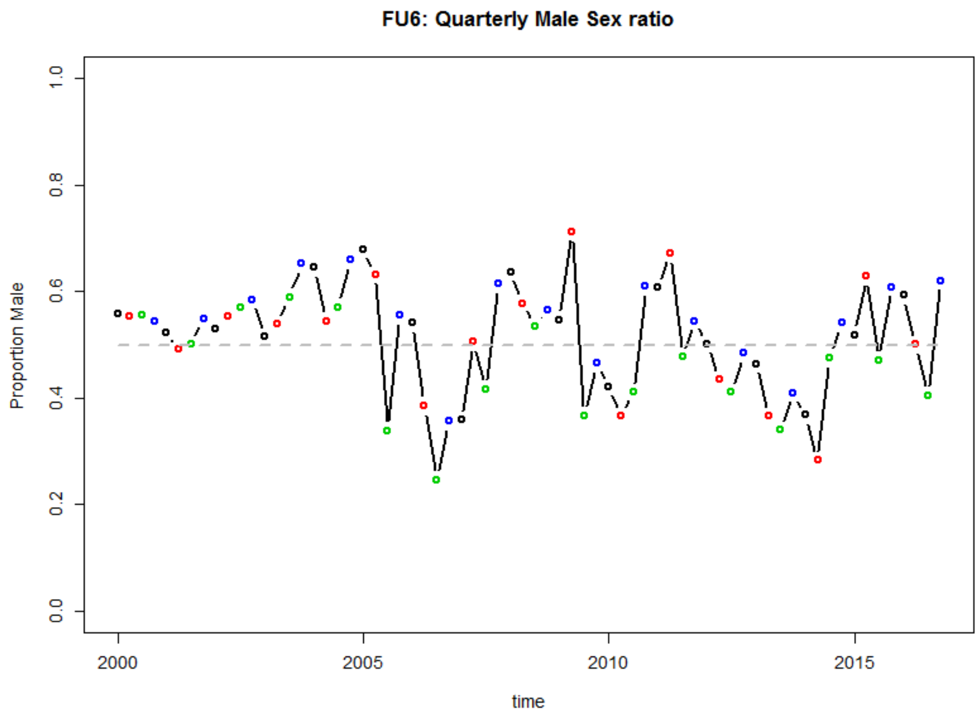


Figure 11.4.4. ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

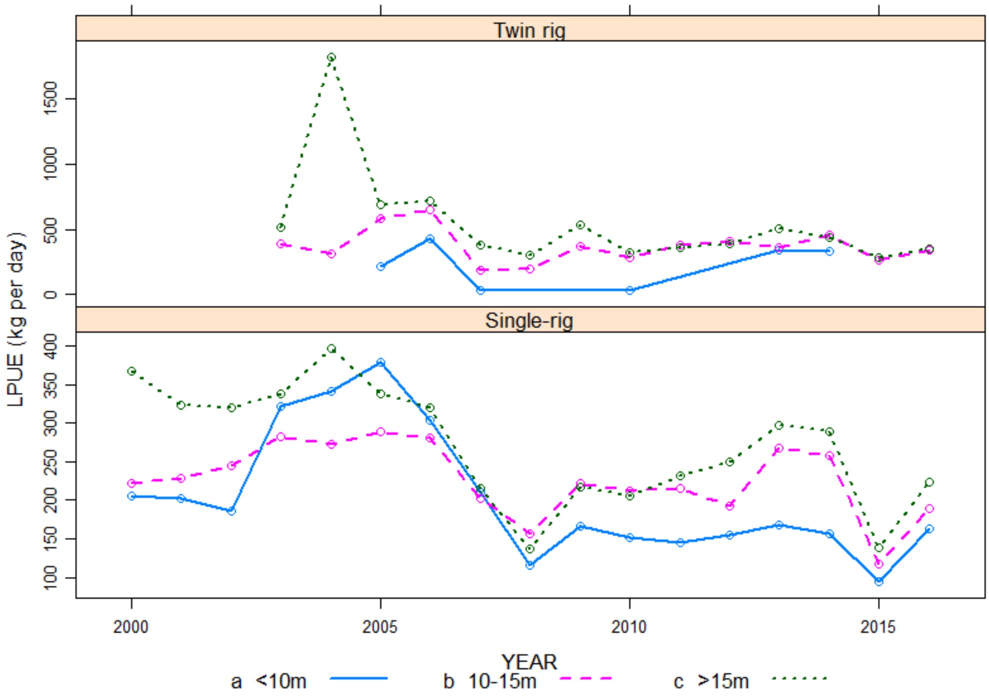


Figure 11.4.5. ***Nephrops*** **in FU6: Lpue for directed English trawlers by gear type and vessel size.**

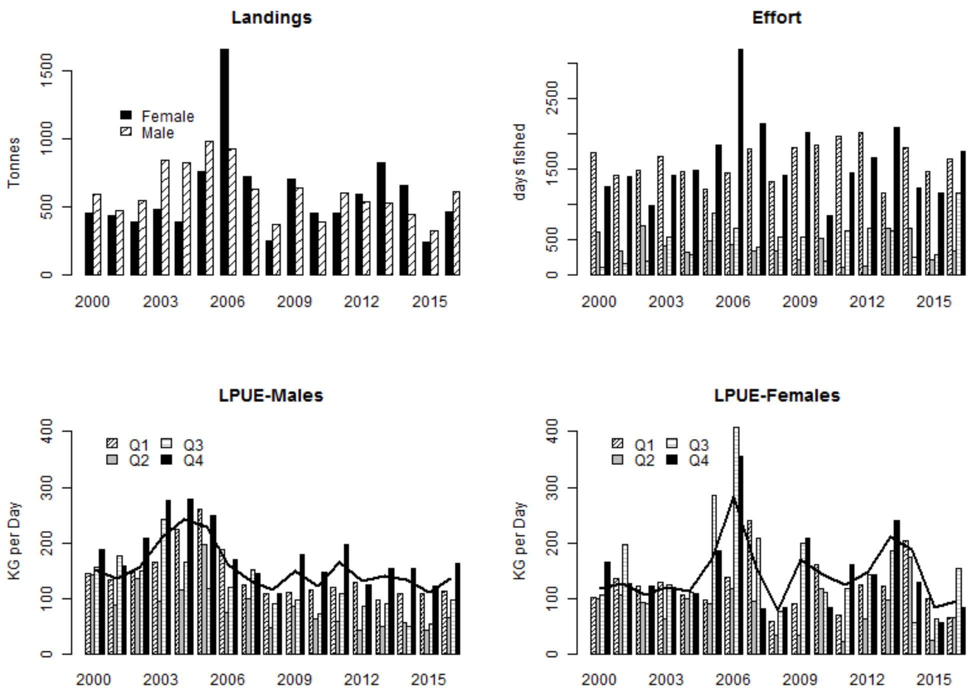


Figure 11.4.6. ***Nephrops*** **in FU6: Lpue by sex and quarter.**

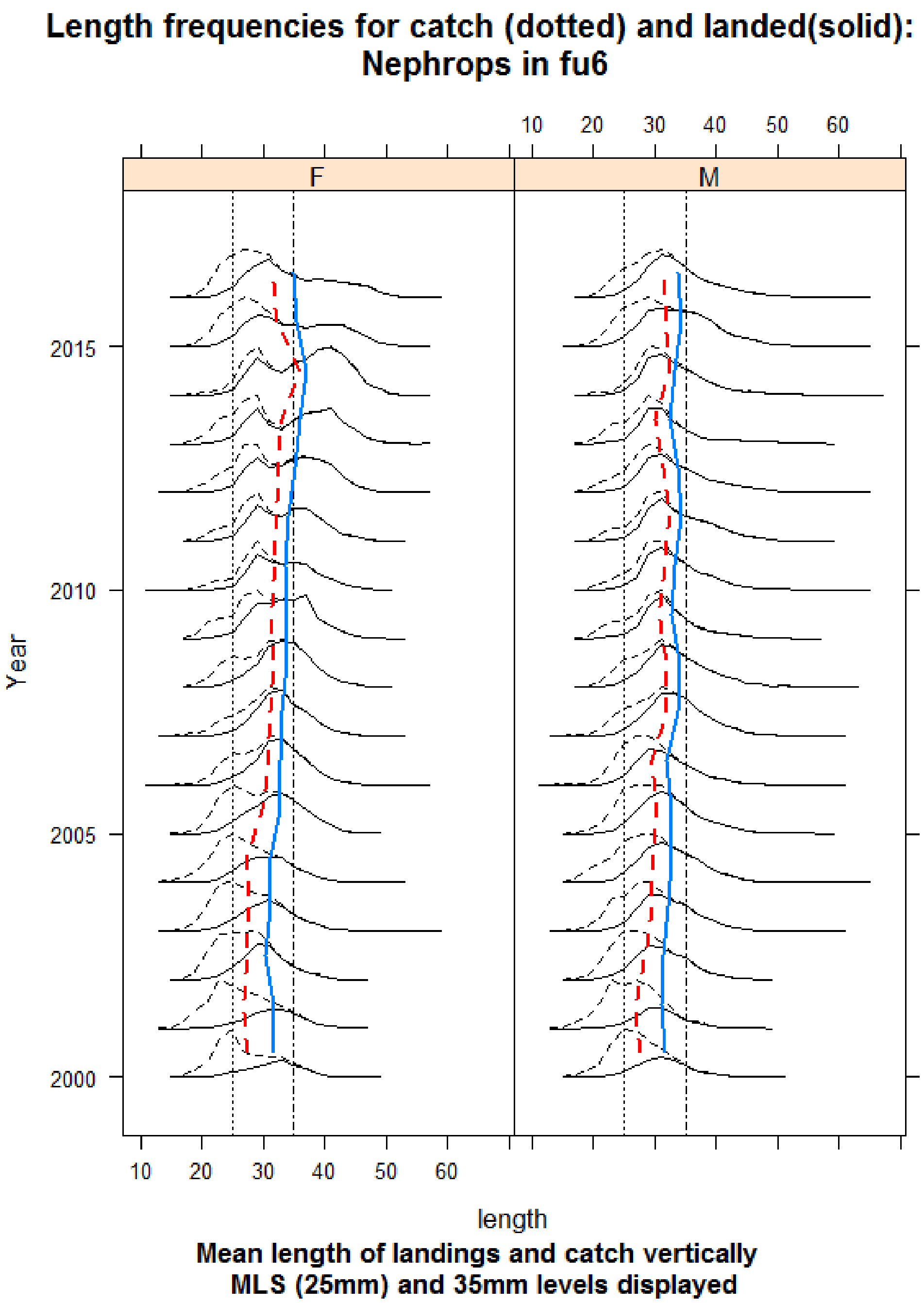


Figure 11.4.7. ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

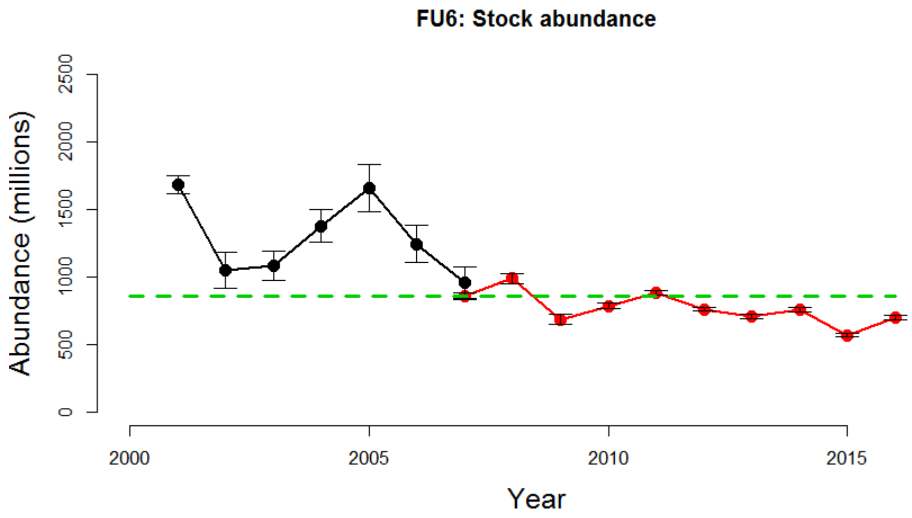


Figure 11.4.8. ***Nephrops*** **in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the geostatistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.**

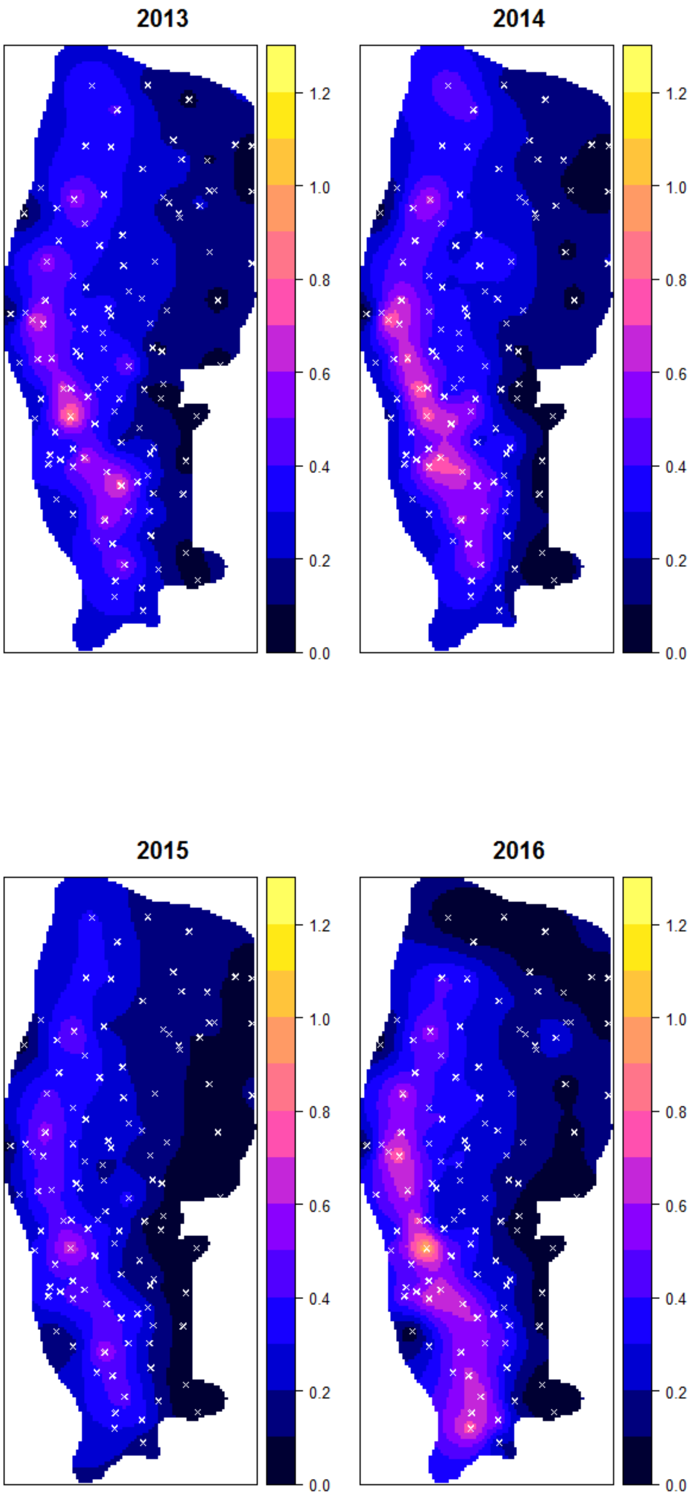


Figure 11.4.9. ***Nephrops*** **in FU6: Results of the UWTV survey.**

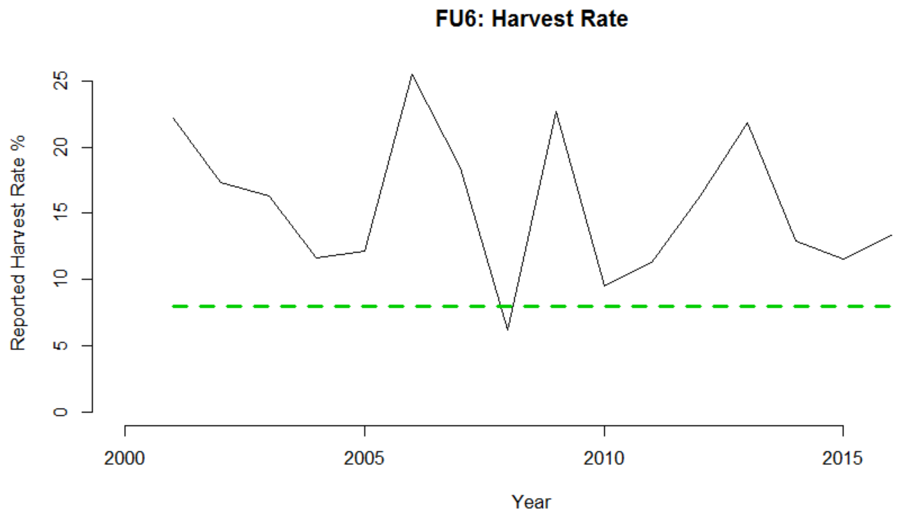


Figure 11.4.10. ***Nephrops*** **in FU6: Observed harvest ratio (removals divided by abundance estimate).**

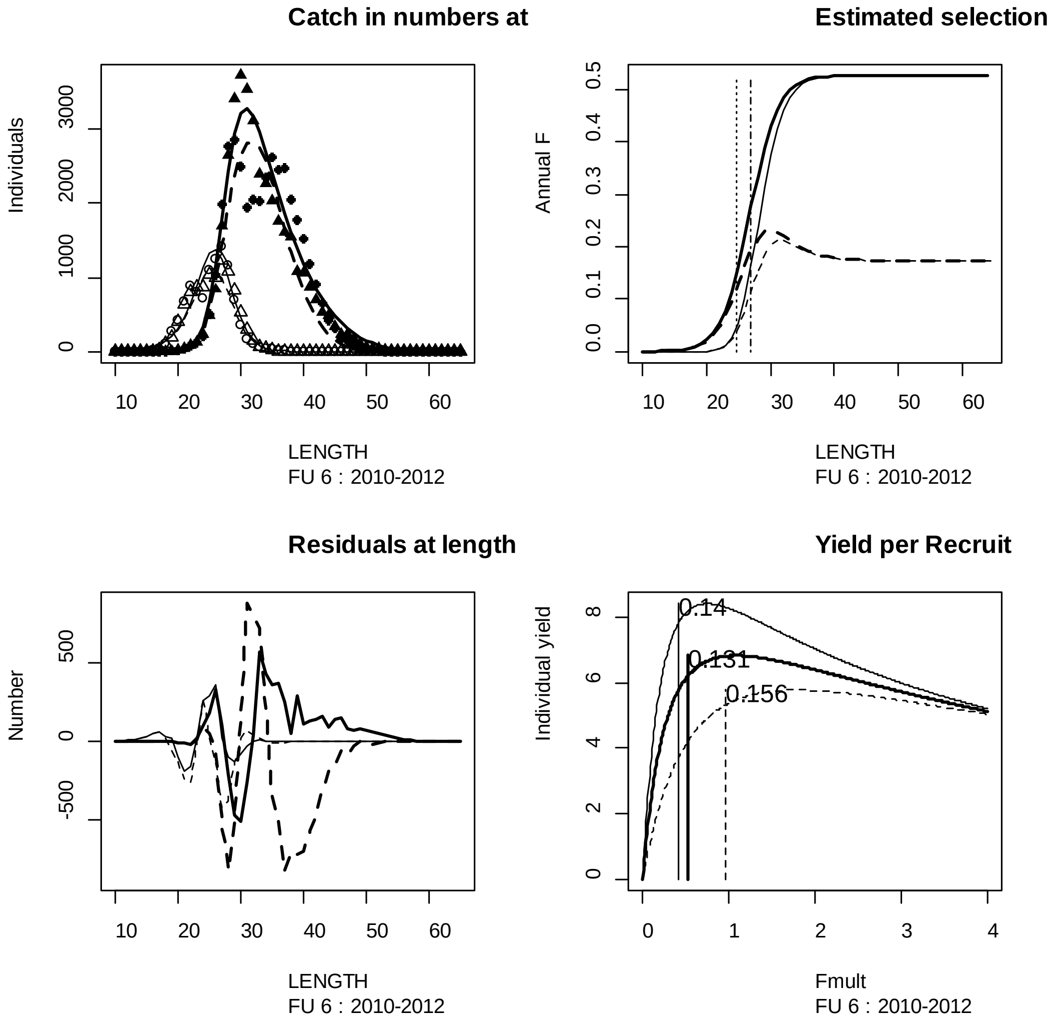


Figure 11.4.11. ***Nephrops*** **in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed-expected) at length. The bottom right gives the Yield Per recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent $F_{0.1}$ for the three curves.**

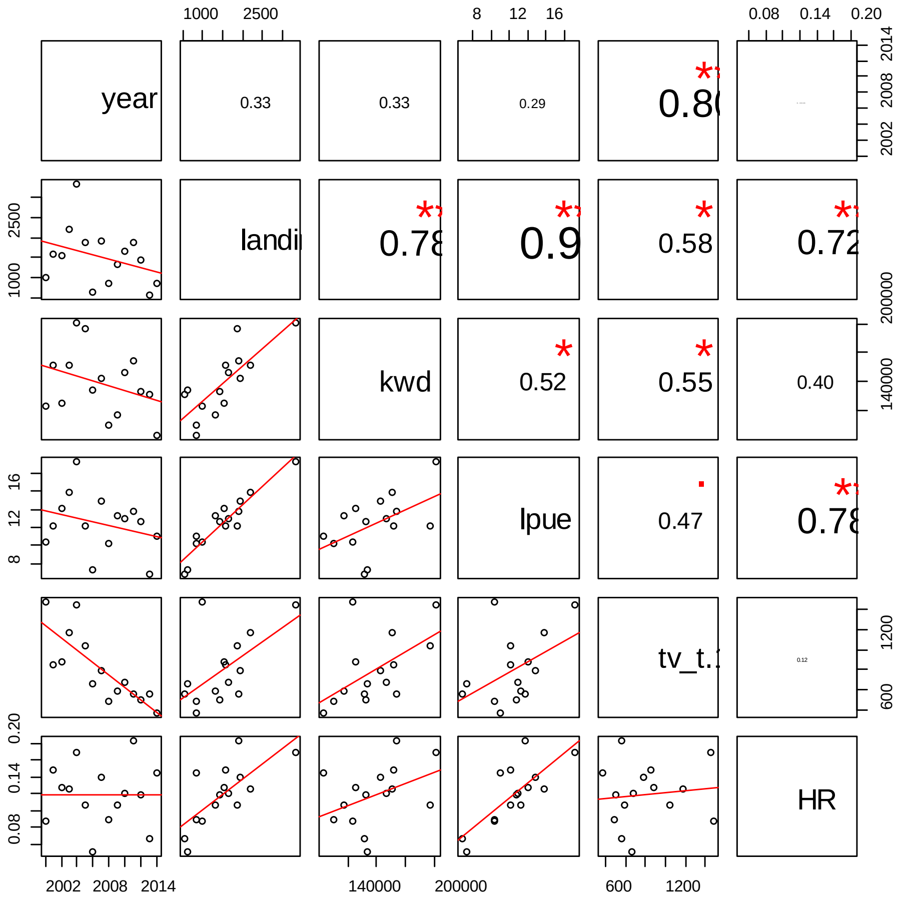


Figure 11.4.12. ***Nephrops*** **in FU6: 11.4.12 Scatterplot matrices of** ***Nephrops*** **metrics where the TV survey lagged by 1 year (i.e. TV survey in the year preceding the fishery statistics).**

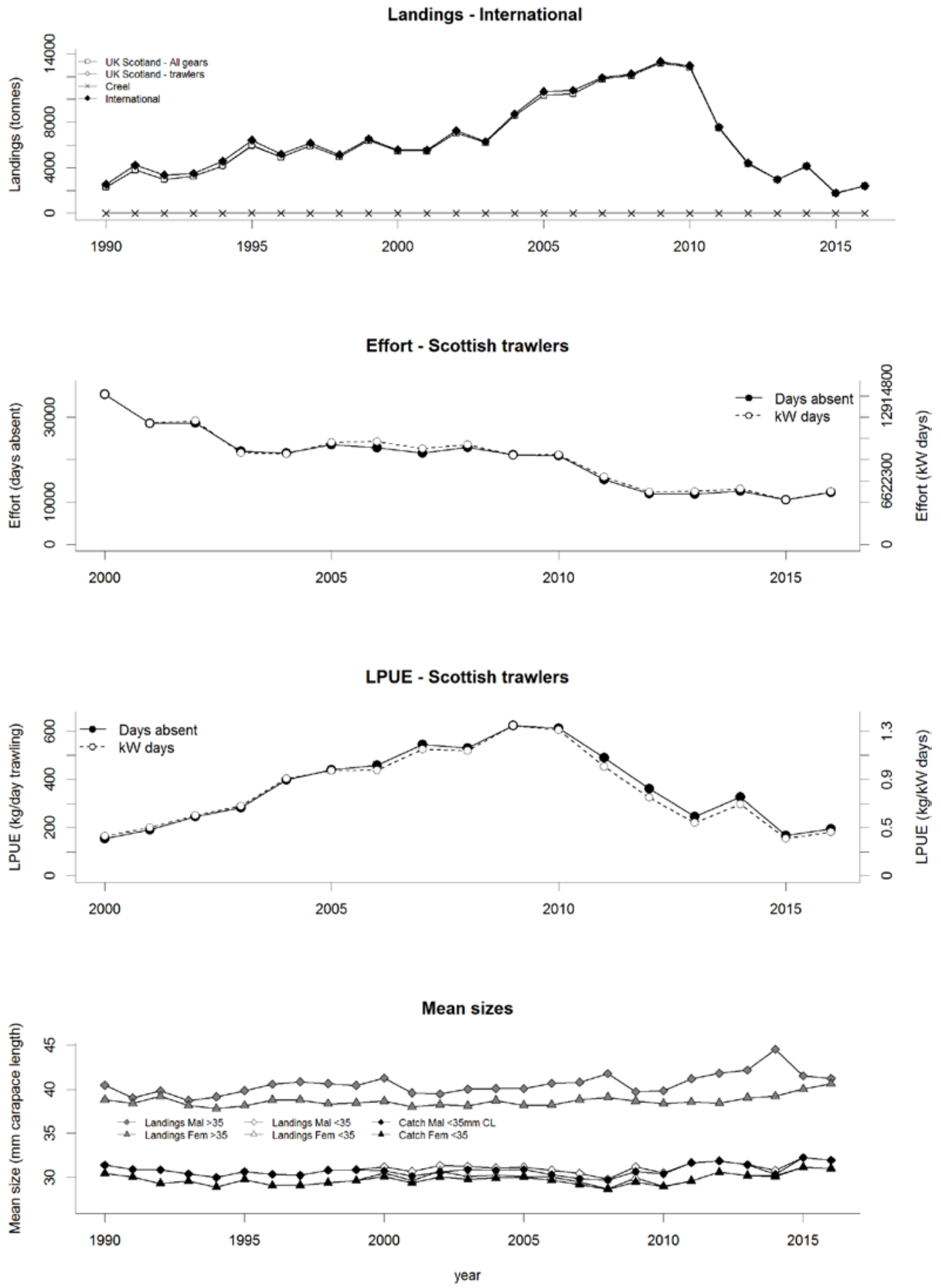


Figure 11.5.1. ***Nephrops*, Fladen (FU 7): Long term landings, effort, lpue and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000–2016.**

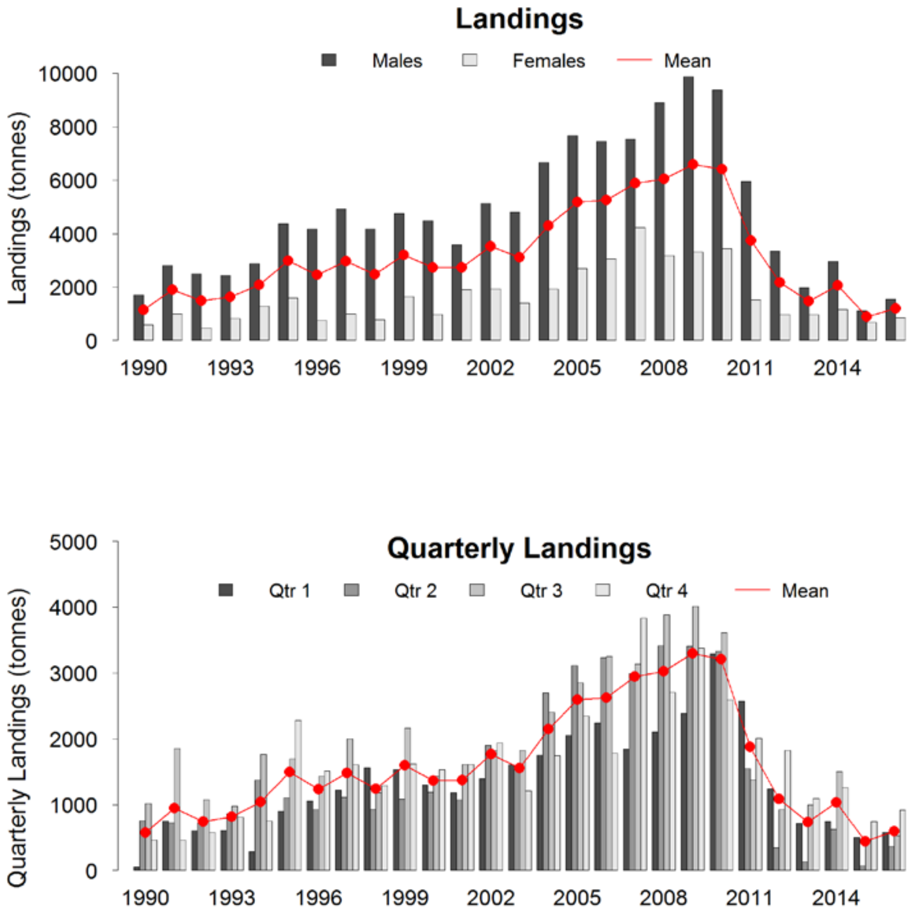


Figure 11.5.2. *Nephrops*, Fladen (FU 7): Landings by quarter and sex from Scottish *Nephrops* trawlers.

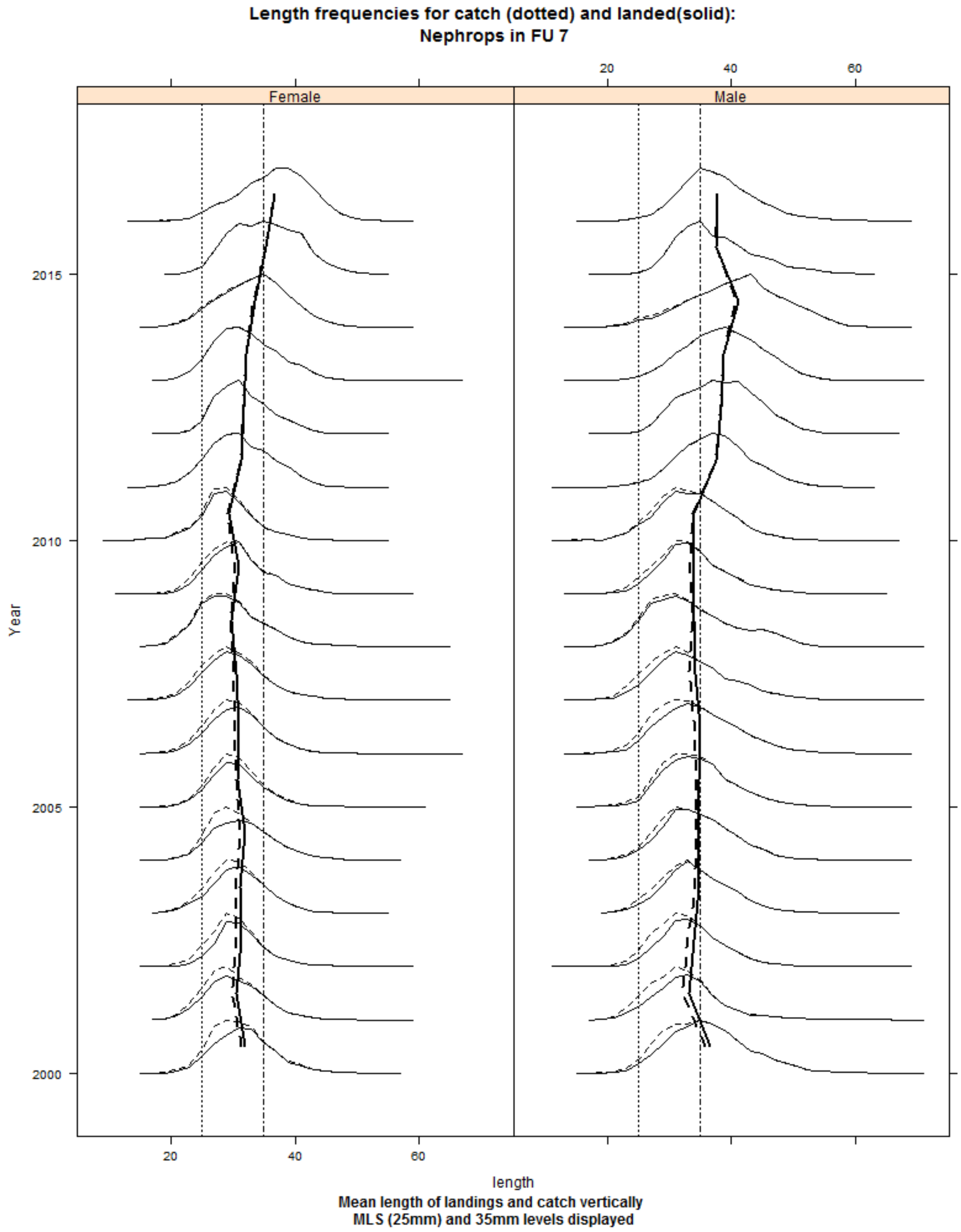
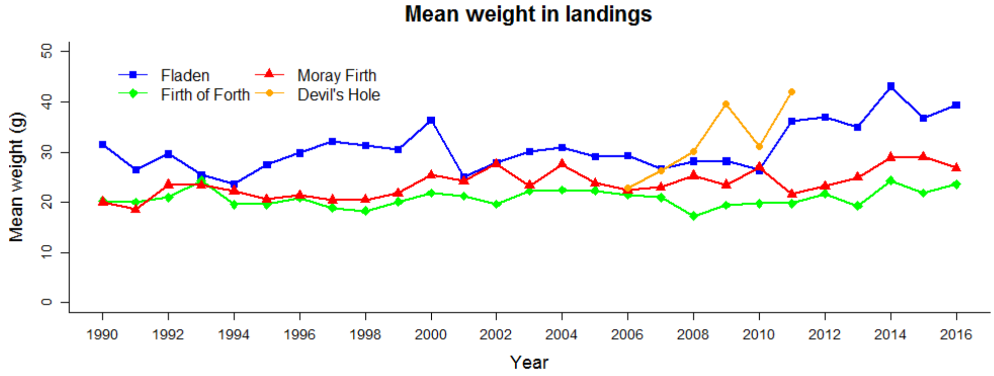


Figure11.5.3. *Nephrops* Fladen Ground (FU 7): Length composition of catch of males (right) and females left from 2 000 (bottom) to 2016 (top). Mean sizes of catch and landings are displayed vertically.



11.5.4. *Nephrops*, (FUs 7–9 and 34, Fladen, Firth of Forth, Moray Firth and Devil's Hole). Individual mean weight (g) in the landings from 1990–2016 (Scottish market sampling data). FU 34 data only shown for 2006–2011.

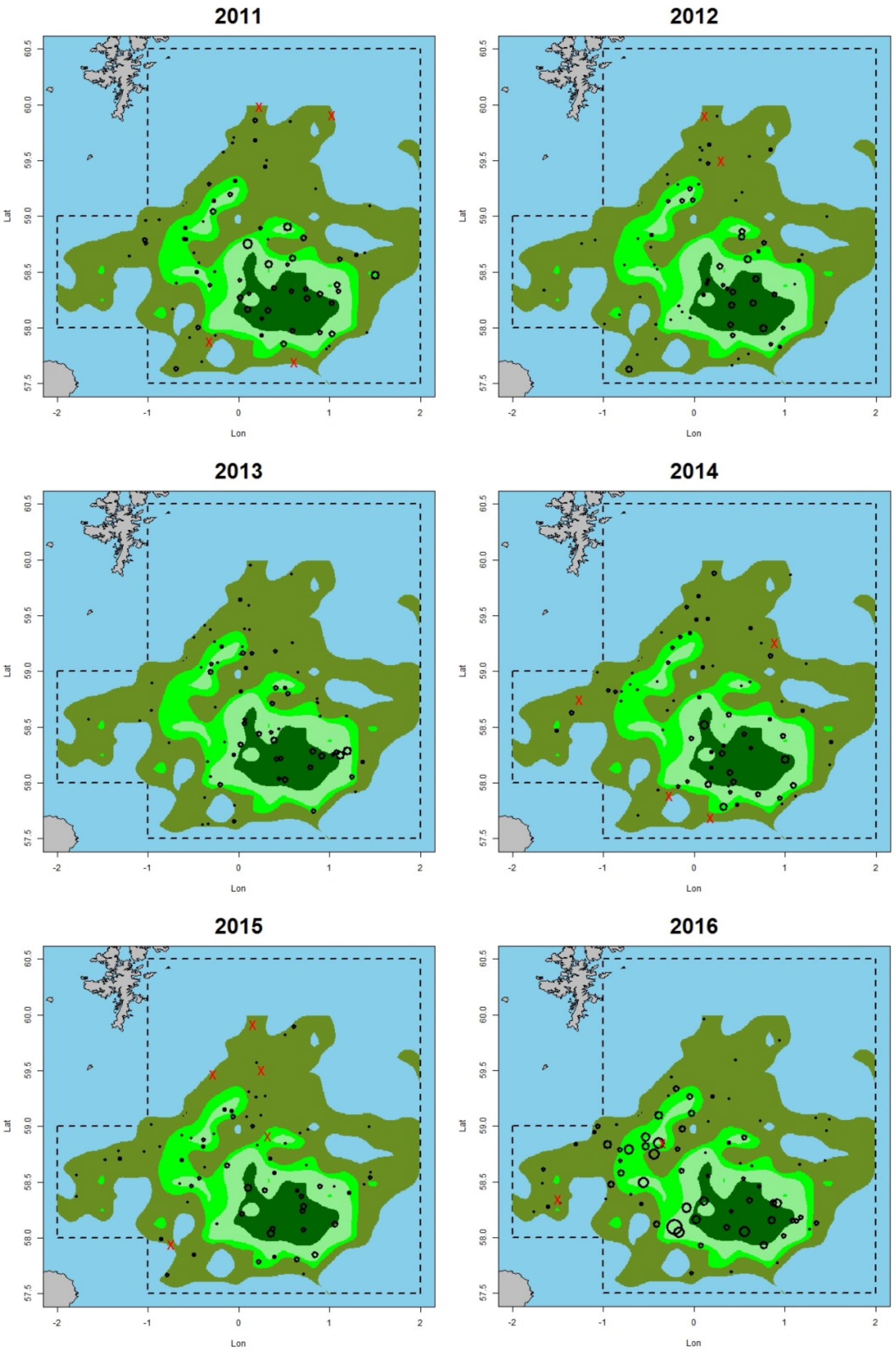


Figure 11.5.5. ***Nephrops*****, Fladen (FU 7): TV survey distribution and relative density (2011–2016). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

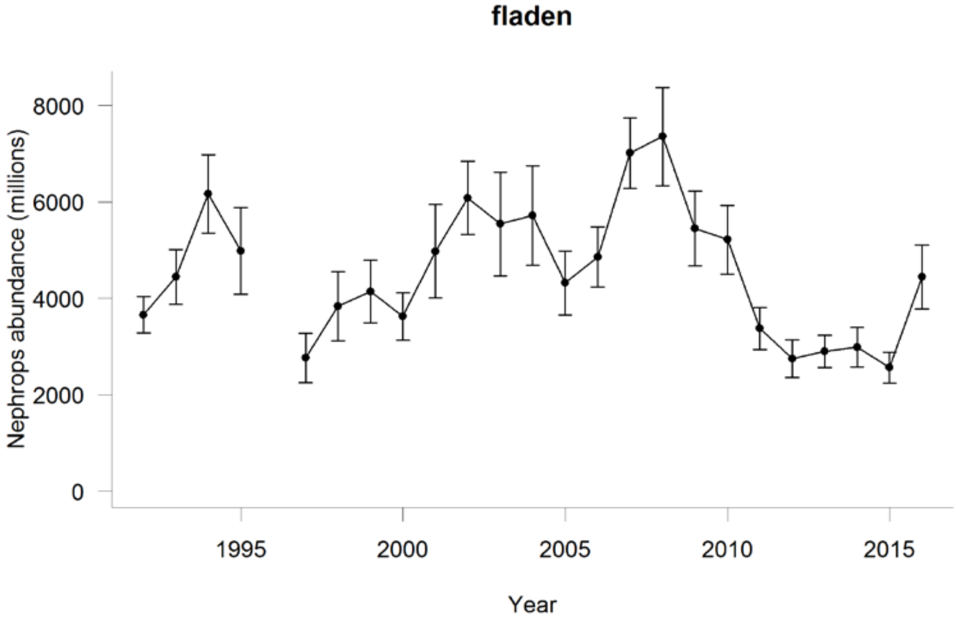


Figure 11.5.6. *Nephrops*, Fladen (FU 7): Time series of TV survey abundance estimates with 95% confidence intervals, 1992–2016.

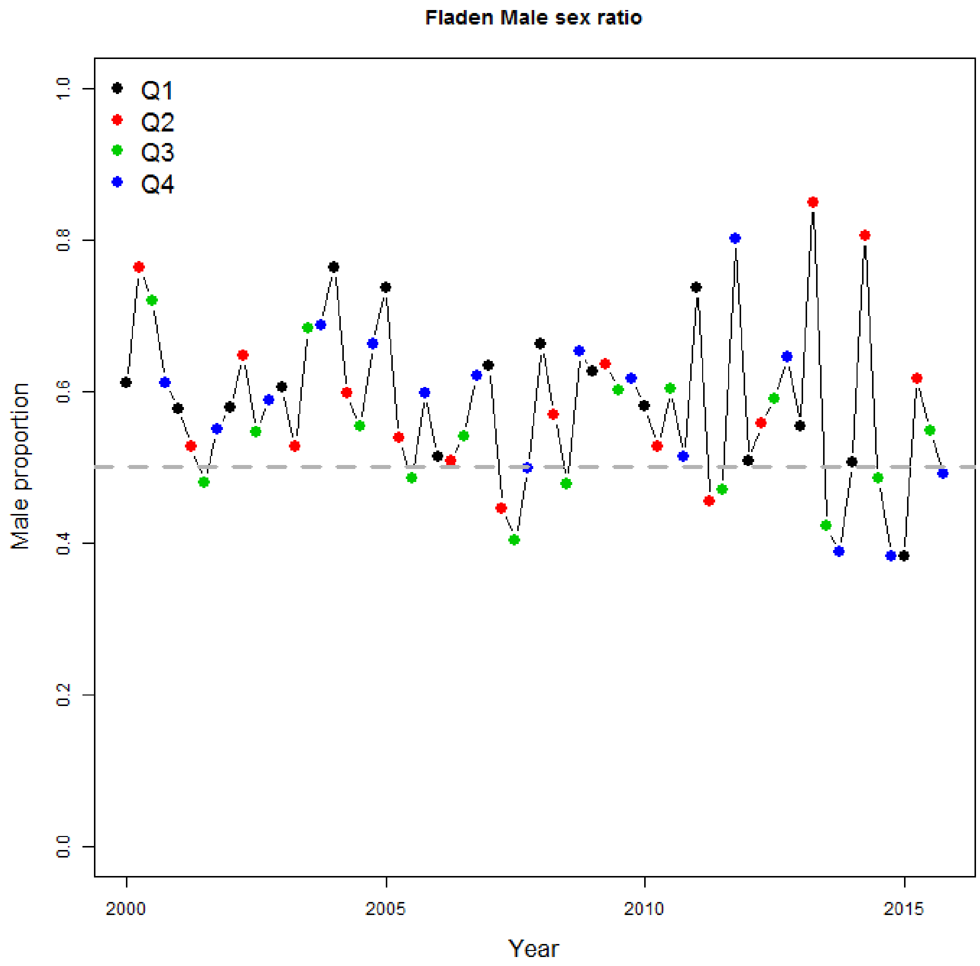


Figure 11.5.7. ***Nephrops*, Fladen (FU 7): Quarterly sex ratio (by number) in catches.**

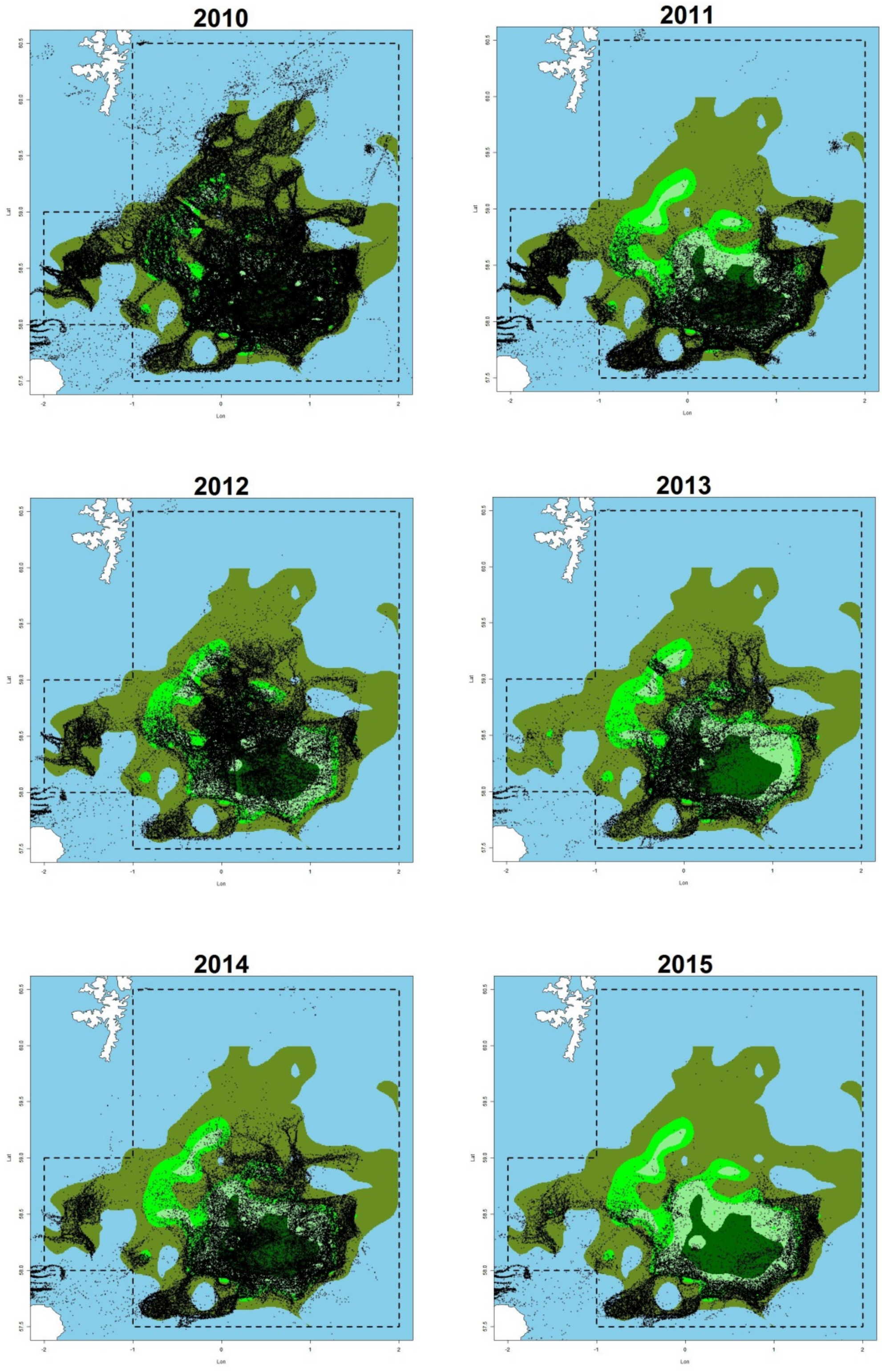


Figure 11.5.8. ***Nephrops*, Fladen (FU 7): VMS distribution of vessels in Fladen (2010–2015). Points in figure correspond to fishing pings (speed<5 km) associated with trips made by otter trawlers landing more than 25% of *Nephrops* by weight.**

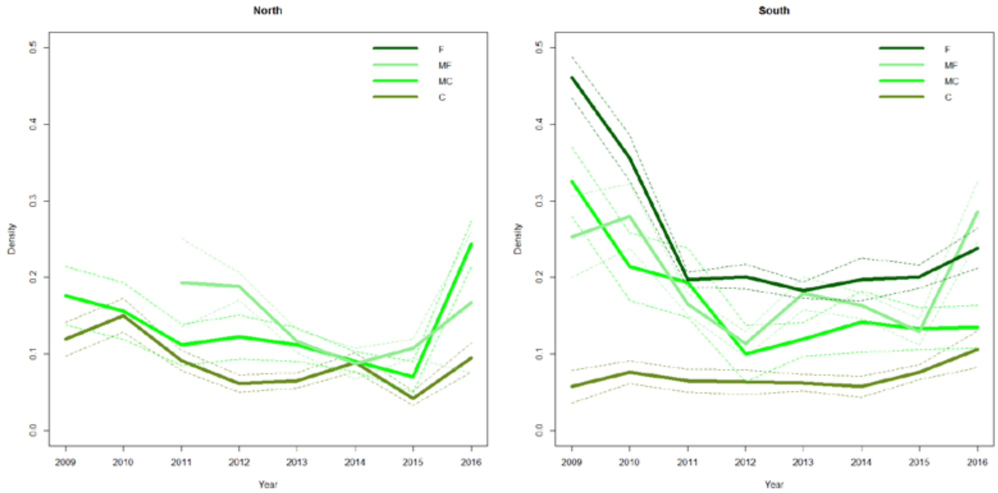


Figure 11.5.9. ***Nephrops*****, Fladen (FU 7): UWTV density by sediment type in the North (left plot) and South (right plot) of Fladen (split at the 58.75 N latitude line). F: fine sediment (silt & clay >80%); MF: medium fine sediment (55%< silt & clay< 80); MC: medium coarse sediment (40%< silt & clay< 55); C: coarse sediment (silt & clay <40%).**

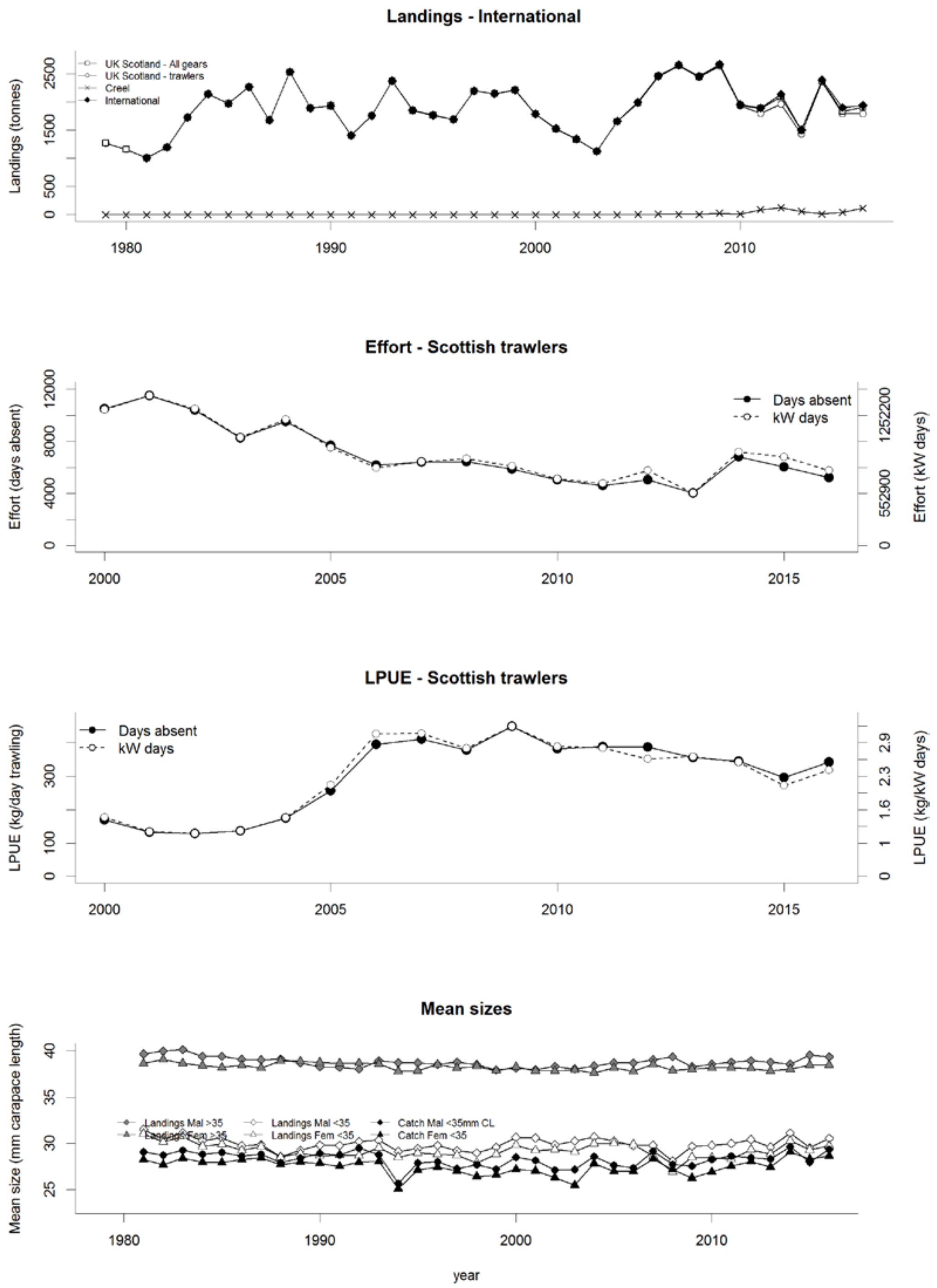
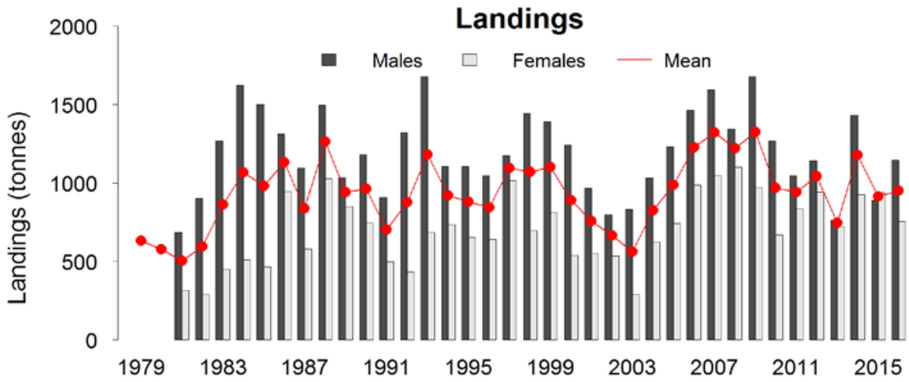


Figure 11.6.1. ***Nephrops*, Firth of Forth (FU 8): Long term landings and mean sizes. Note that the effort and lpue from Scottish trawlers cover a shorter period 2000–2016.**



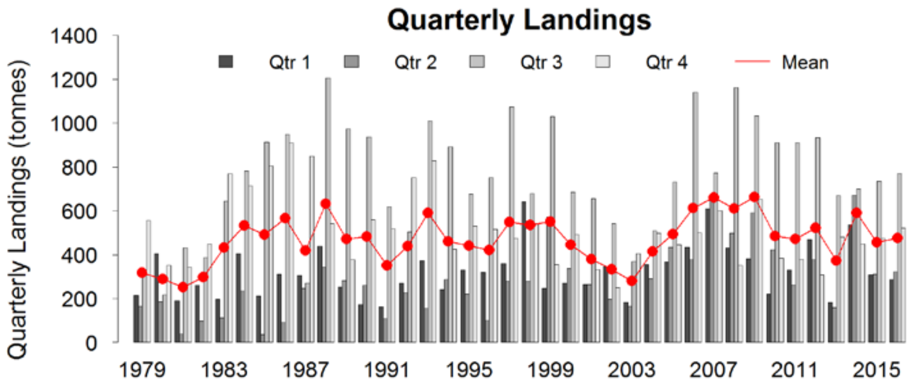


Figure 11.6.2. ***Nephrops*, Firth of Forth (FU 8): Landings by quarter and sex from Scottish *Nephrops* trawlers.**

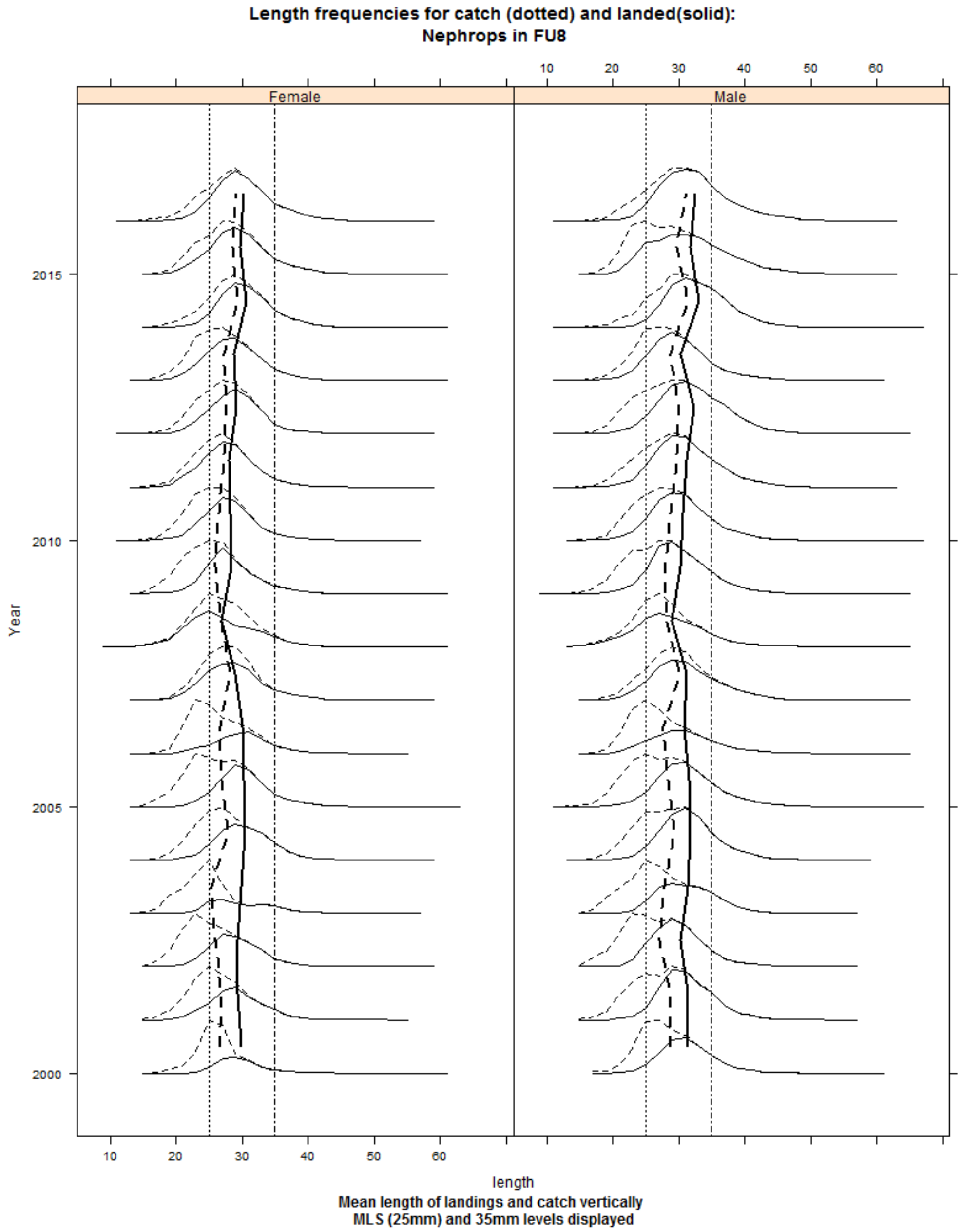


Figure 11.6.3. ***Nephrops*** **Firth of Forth (FU 8): Length composition of catch of males (right) and females left from 2 000 (bottom) to 2016 (top). Mean sizes of catch and landings are displayed vertically.**

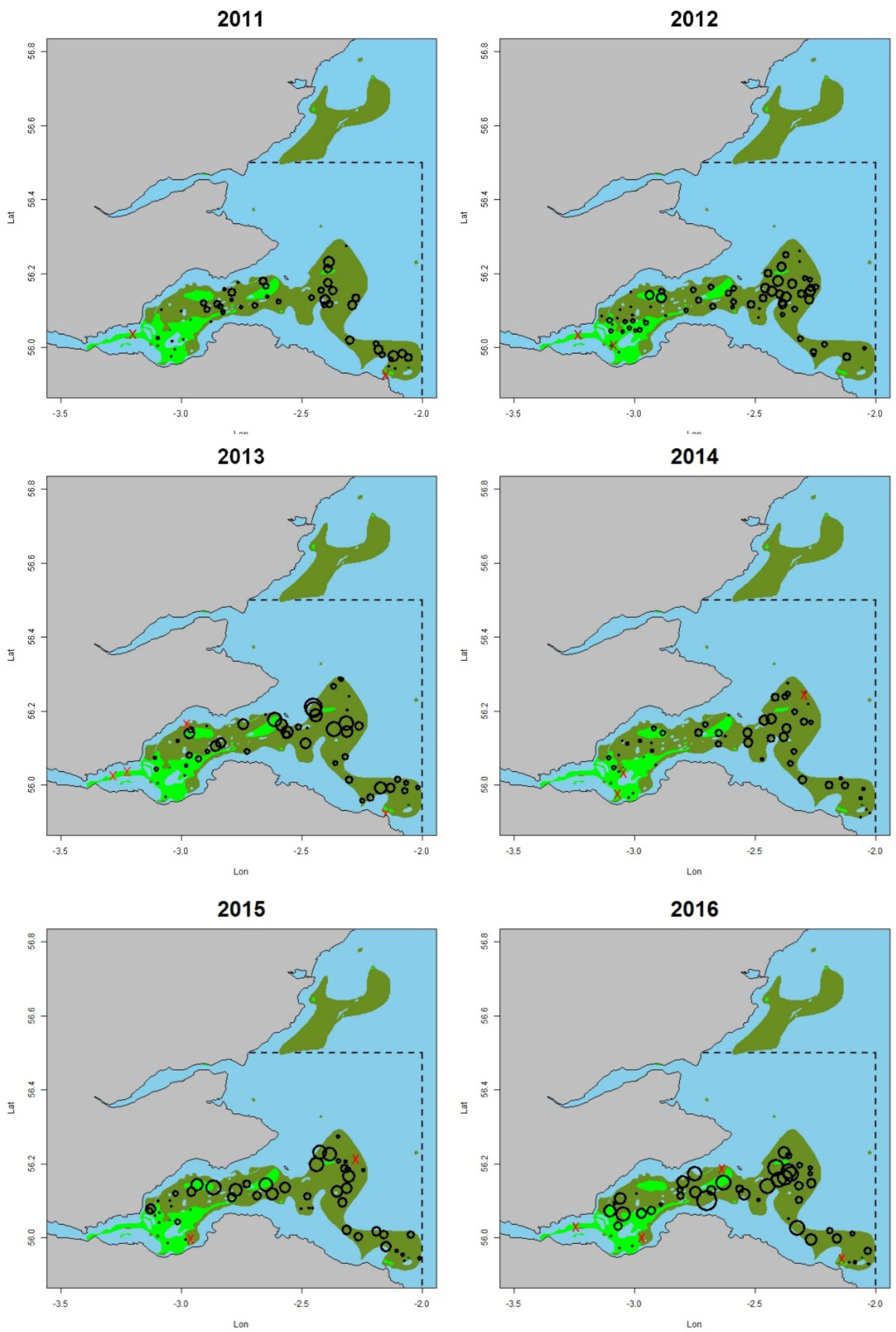


Figure 11.6.4. ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2011–2016). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

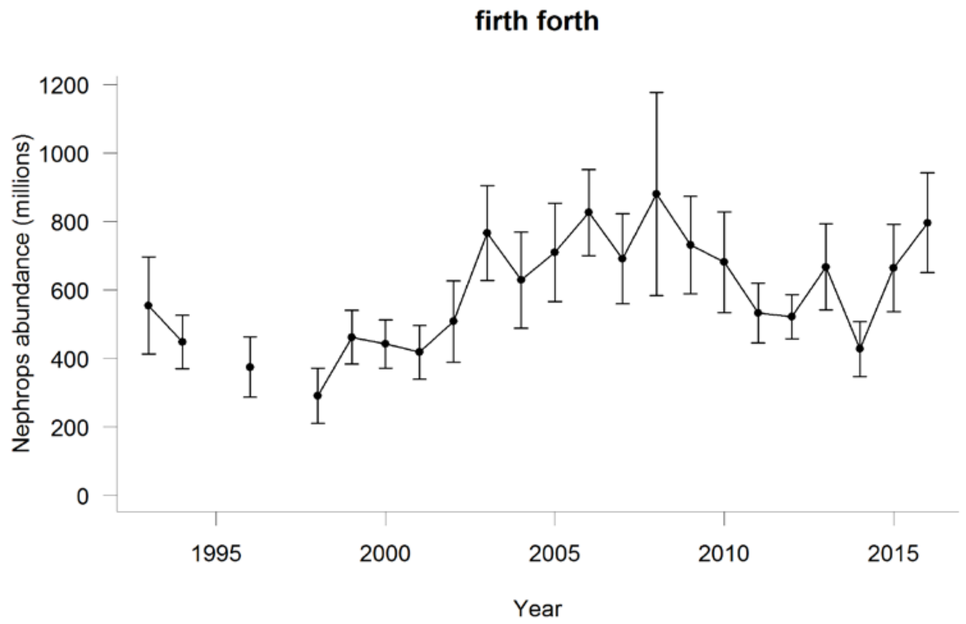


Figure 11.6.5. ***Nephrops*, Firth of Forth (FU 8): Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2016**

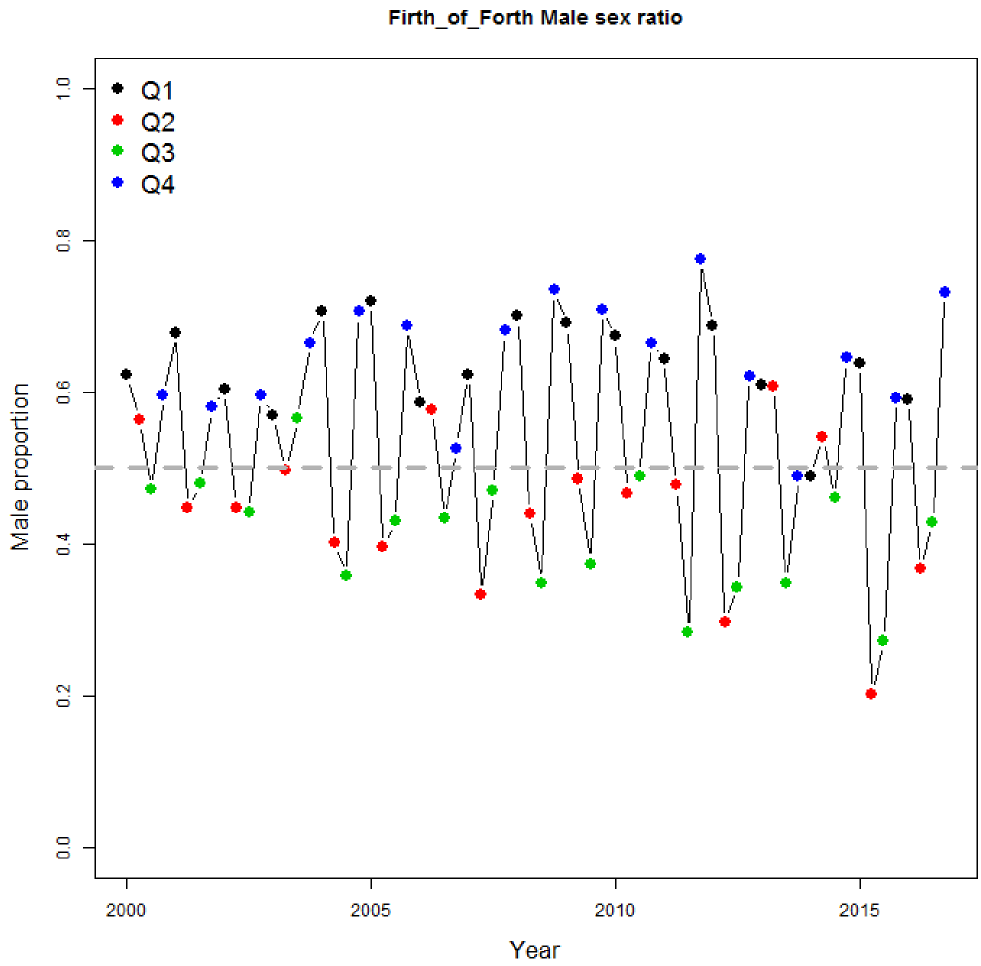


Figure 11.6.6. *Nephrops*, Firth of Forth (FU 8): Quarterly sex ratio (by number) in catches.

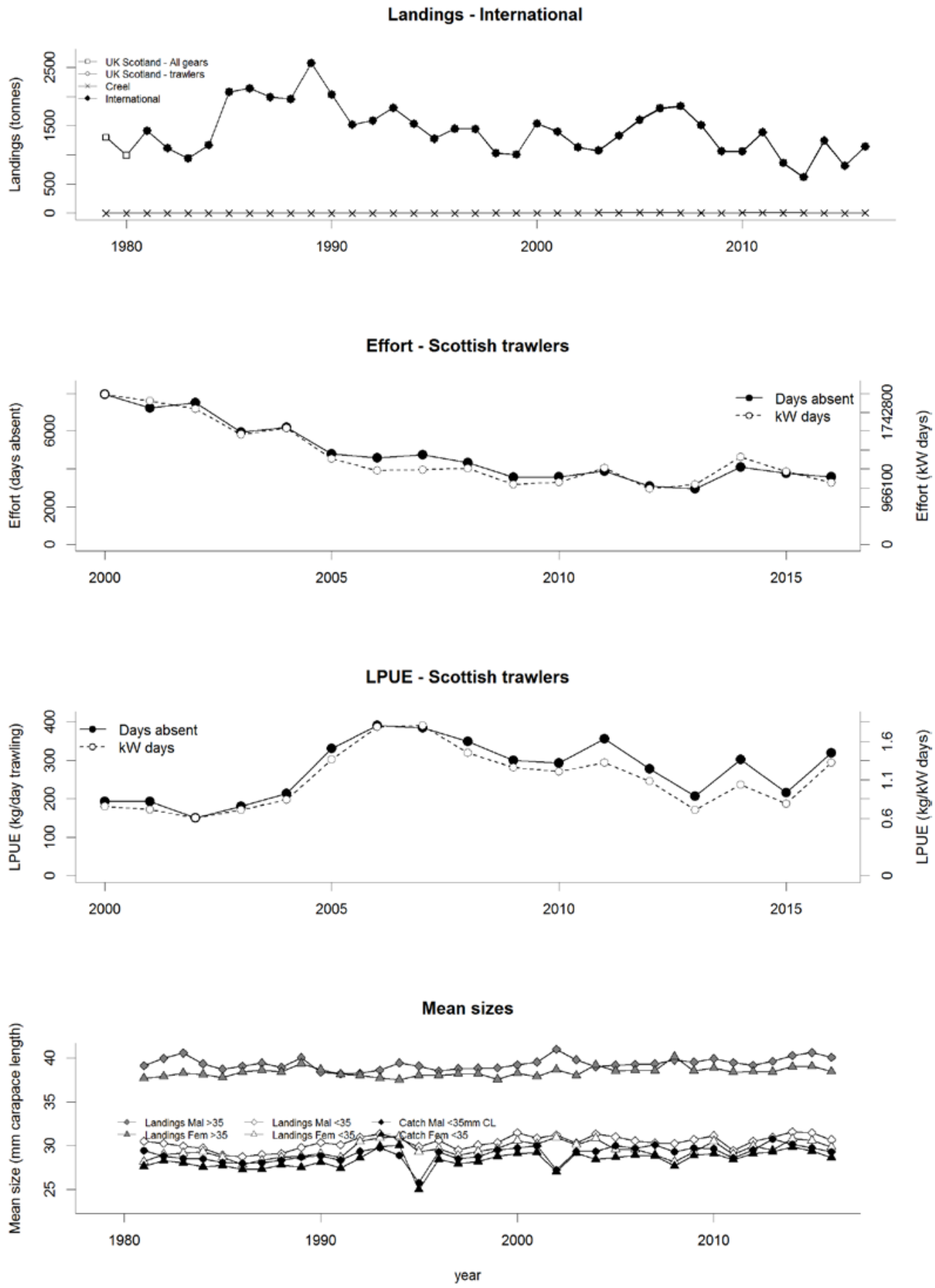
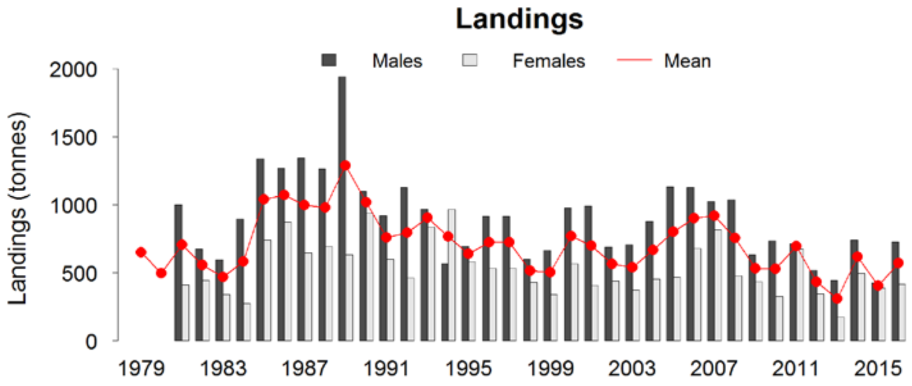


Figure 11.7.1 ***Nephrops*, Moray Firth (FU 9): Long term landings and mean sizes. Note that the effort and lpue from Scottish trawlers cover a shorter period 2000–2016.**



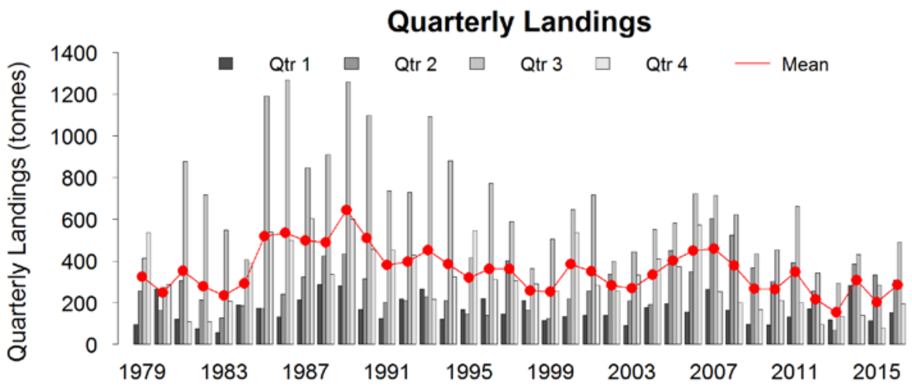


Figure 11.7.2 ***Nephrops*****, Moray Firth (FU 9): Landings by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

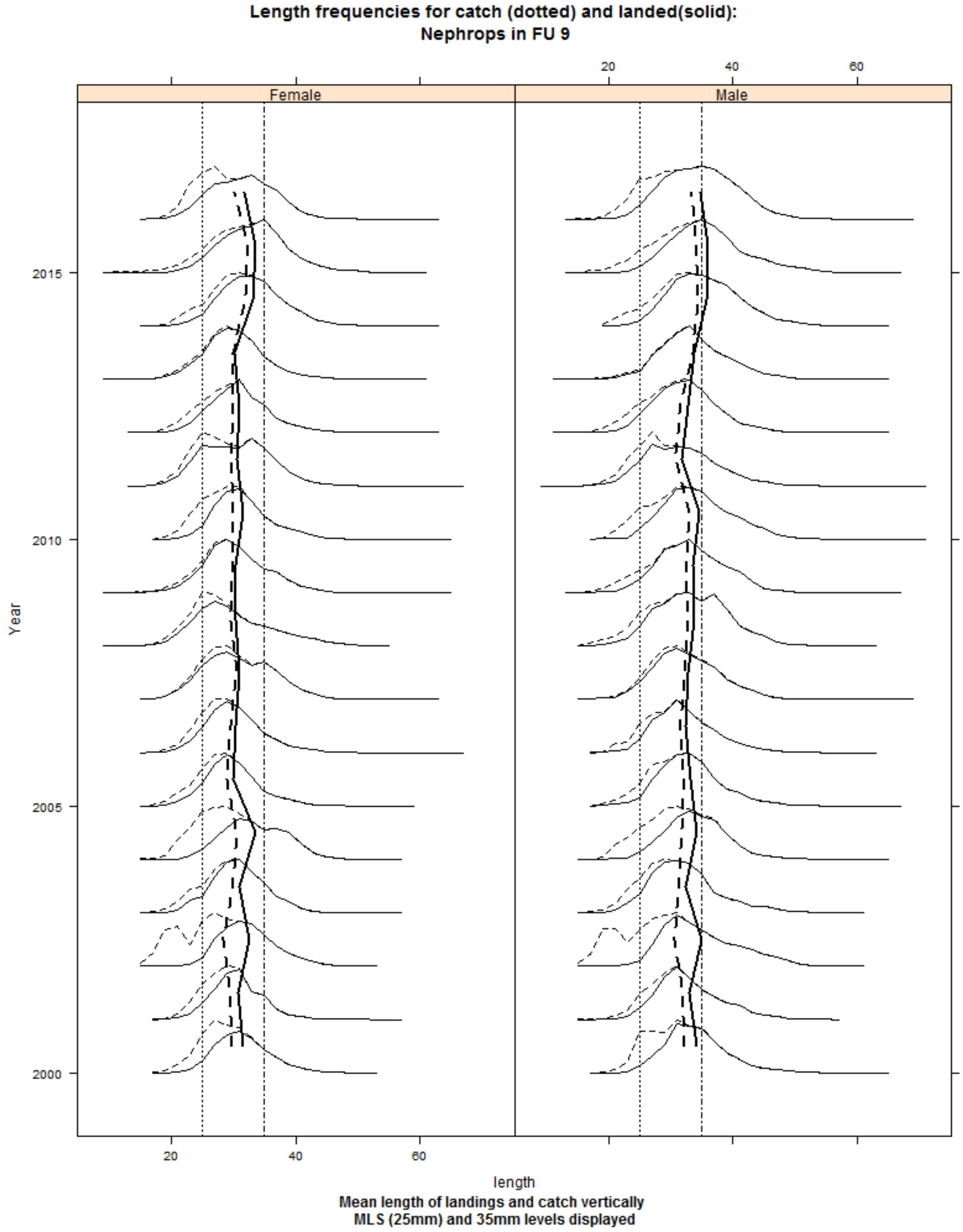


Figure 11.7.3. ***Nephrops*** **Moray Firth (FU 9): Length composition of catch of males (right) and females left from 2 000 (bottom) to 2016 (top). Mean sizes of catch and landings are displayed vertically.**

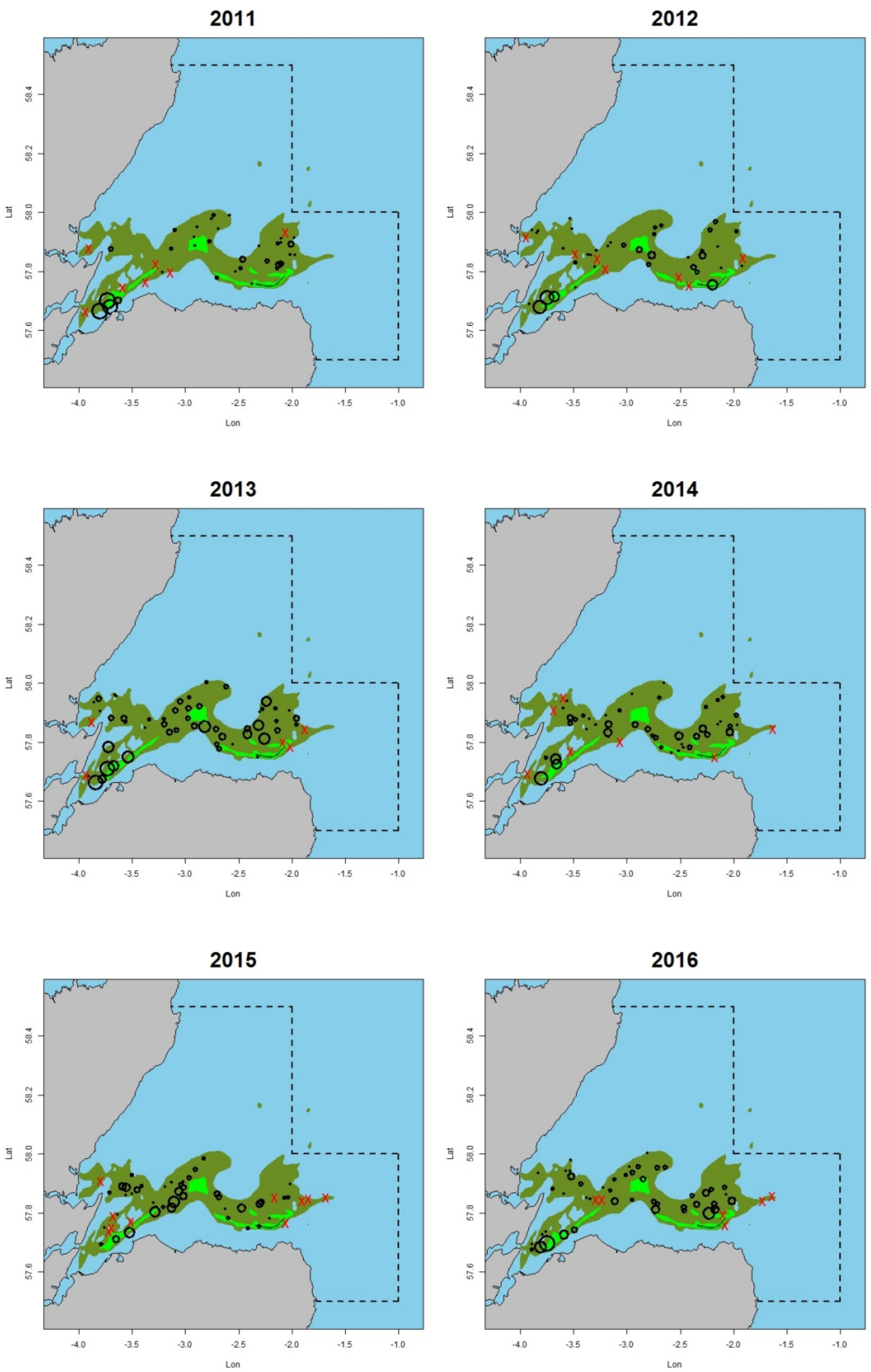


Figure11.7.4. ***Nephrops*, Moray Firth (FU 9): TV survey distribution and relative density (2011–2016). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

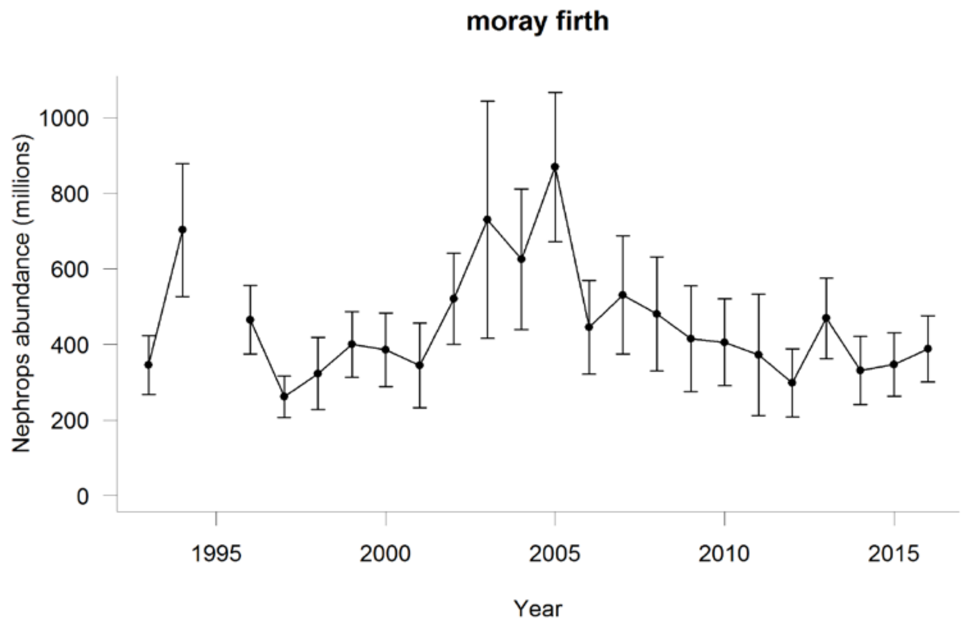


Figure 11.7.5. ***Nephrops*, Moray Firth (FU 9): Time series of TV survey abundance estimates with 95% confidence intervals, 1993–2016.**

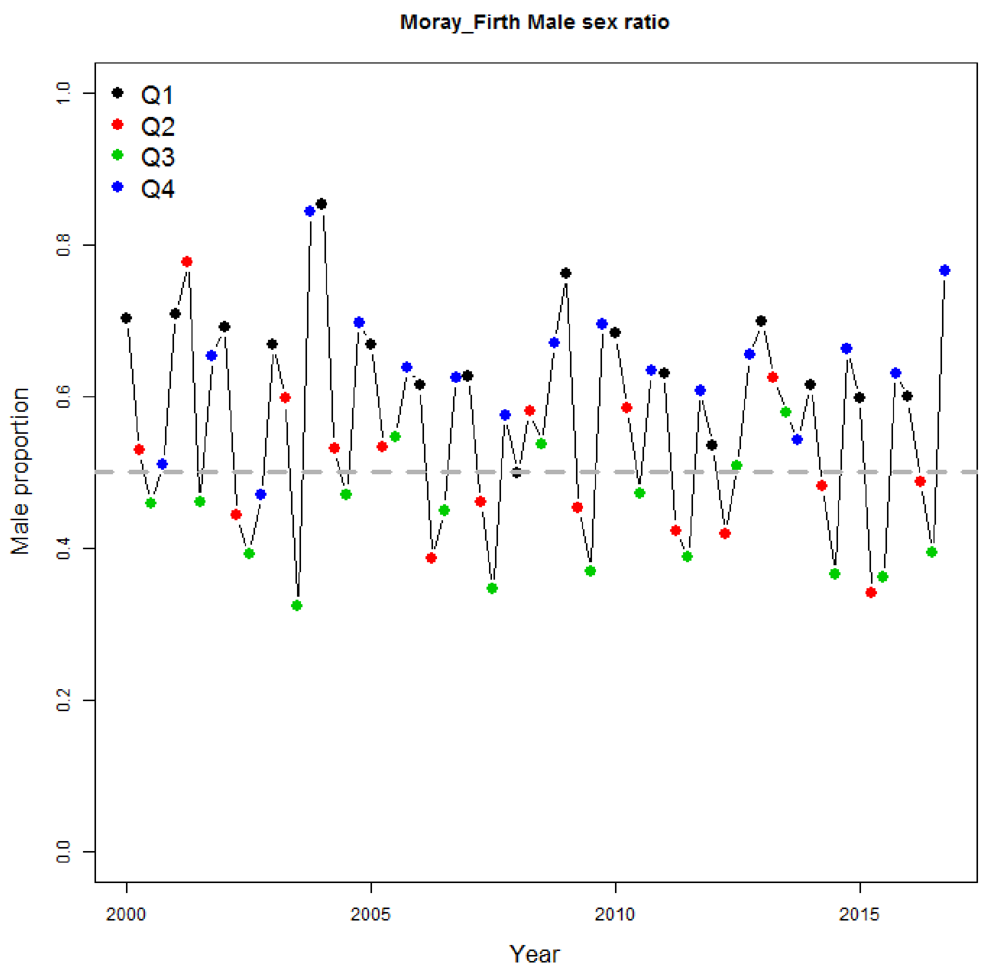


Figure 11.7.6. ***Nephrops*, Moray Firth (FU 9): Quarterly sex ratio (by number) in catches.**

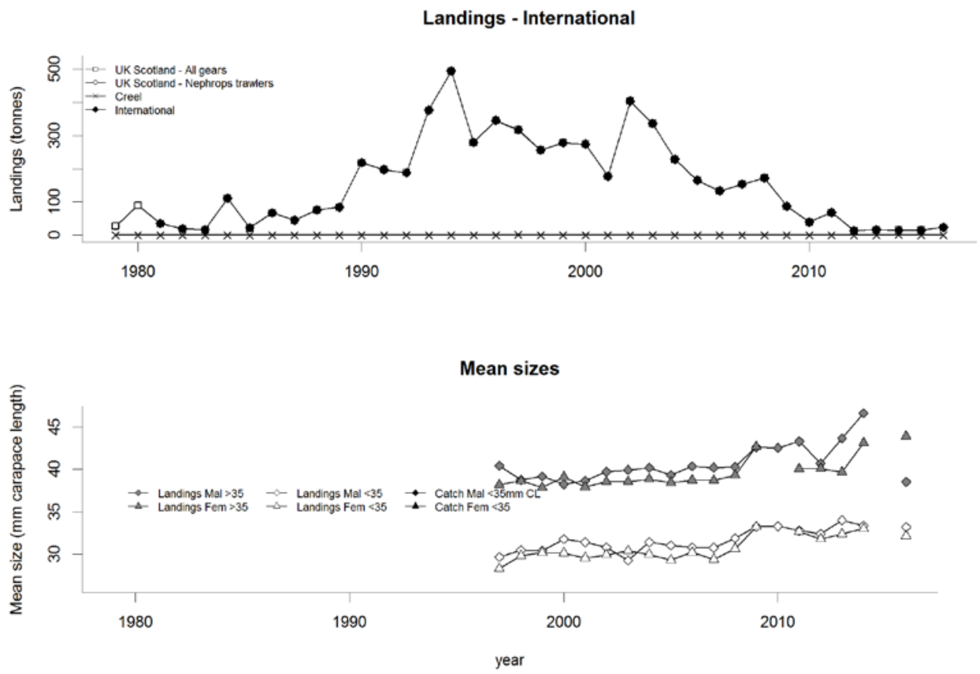


Figure 11.8.1. ***Nephrops*****, Noup (FU 10): Long-term landings and mean sizes (no females in samples in 2010 and no samples in 2015).**

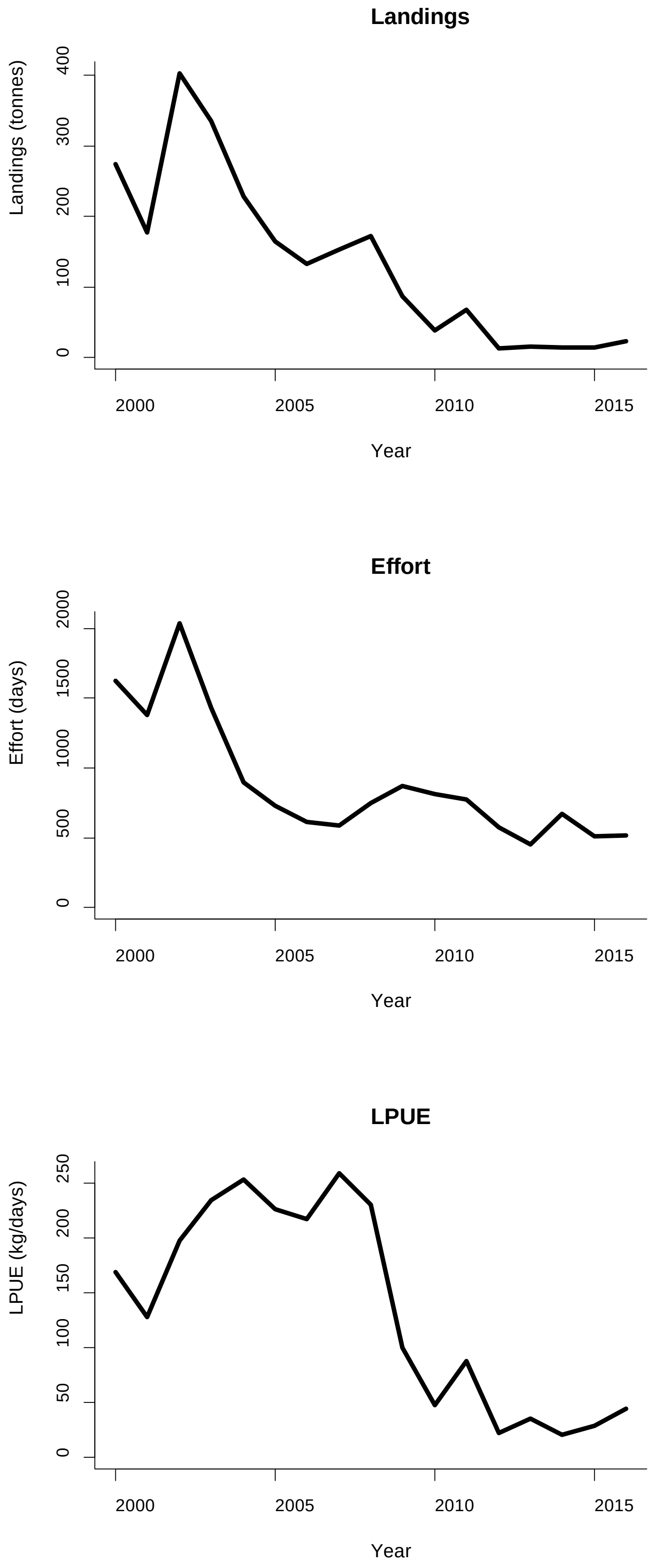


Figure 11.8.2. *Nephrops*, Noup (FU 10): Effort (days) and lpue (kg/day), data from year 2 000.

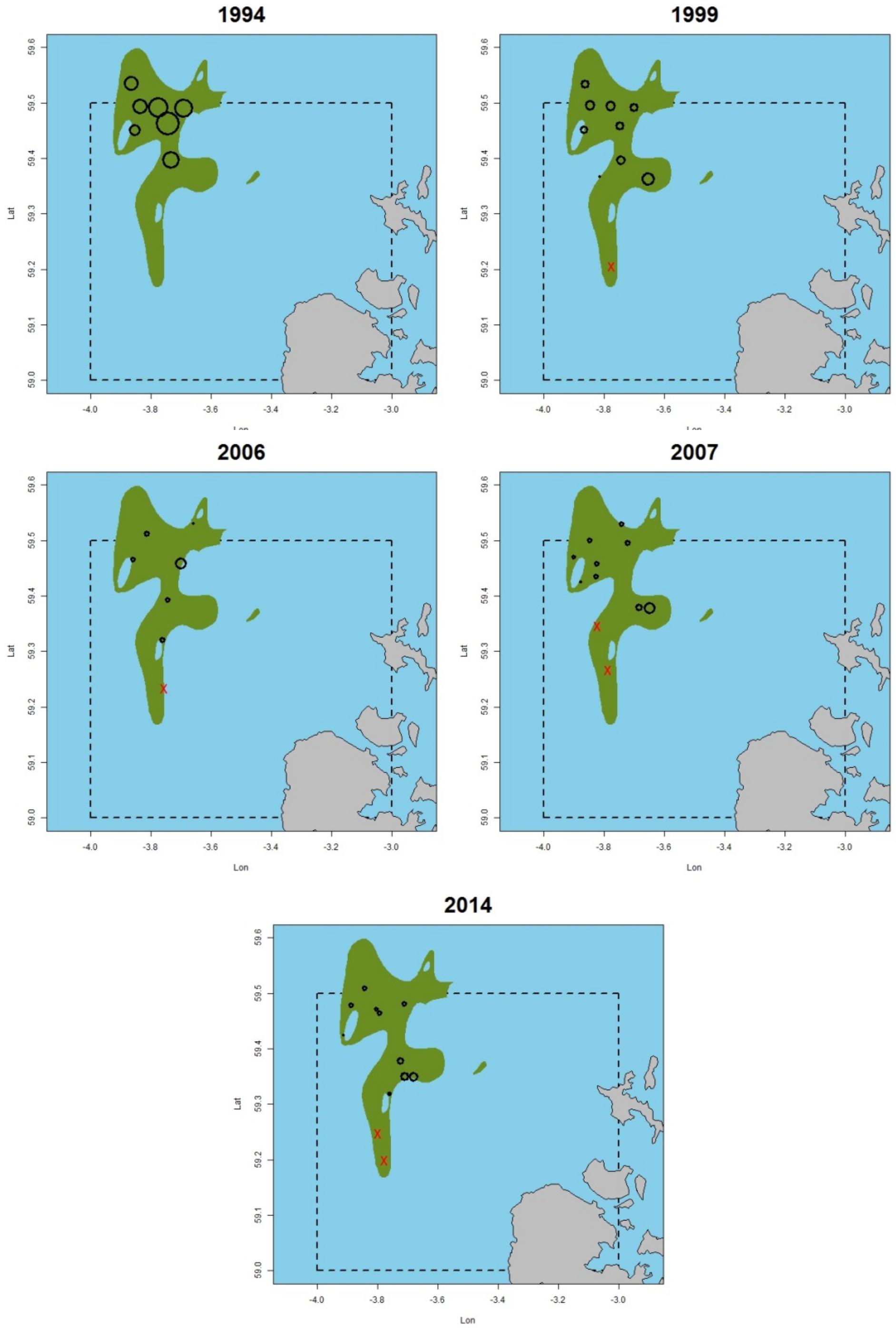


Figure 11.8.3. ***Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007 & 2014). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

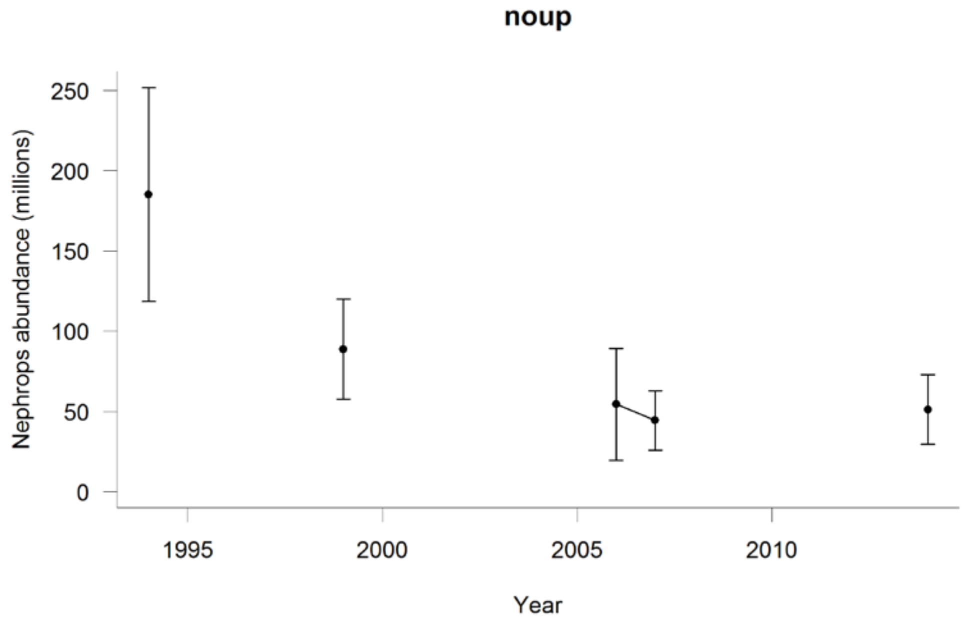


Figure 11.8.4. ***Nephrops*****, Noup (FU 10): Time series of TV survey abundance estimates (absolute conversion factor =1.35, from Fladen), with 95% confidence intervals, 1994, 1999, 2006–2007 & 2014.**

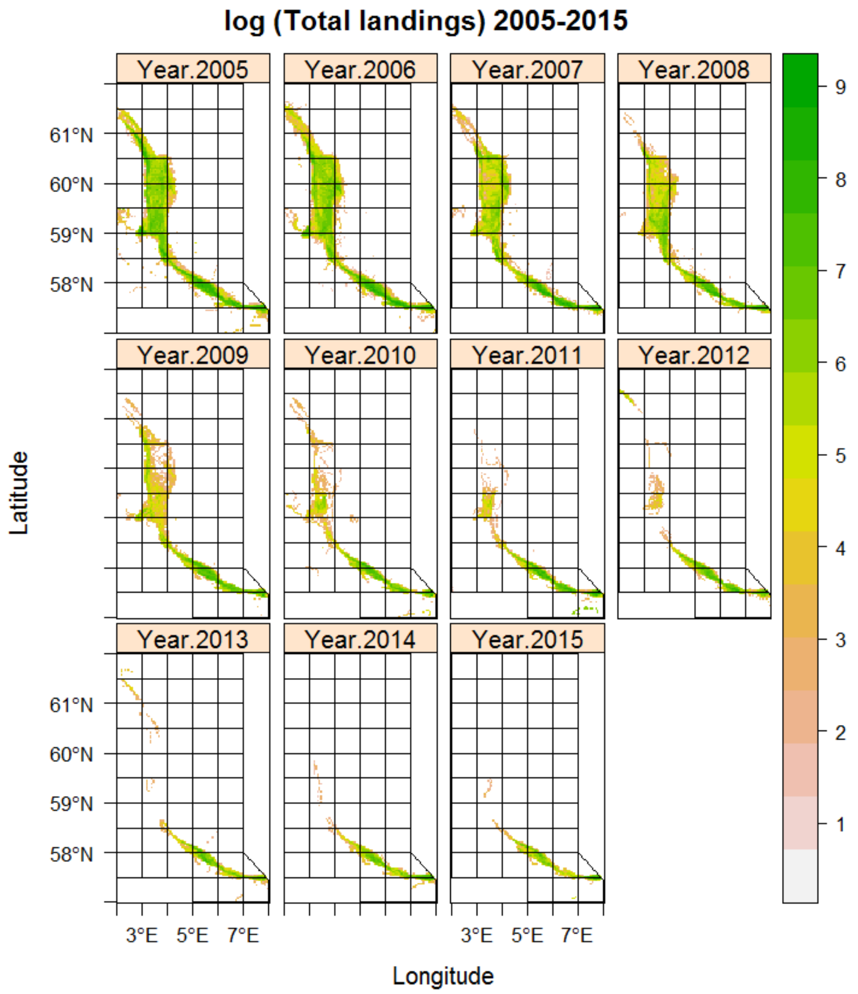
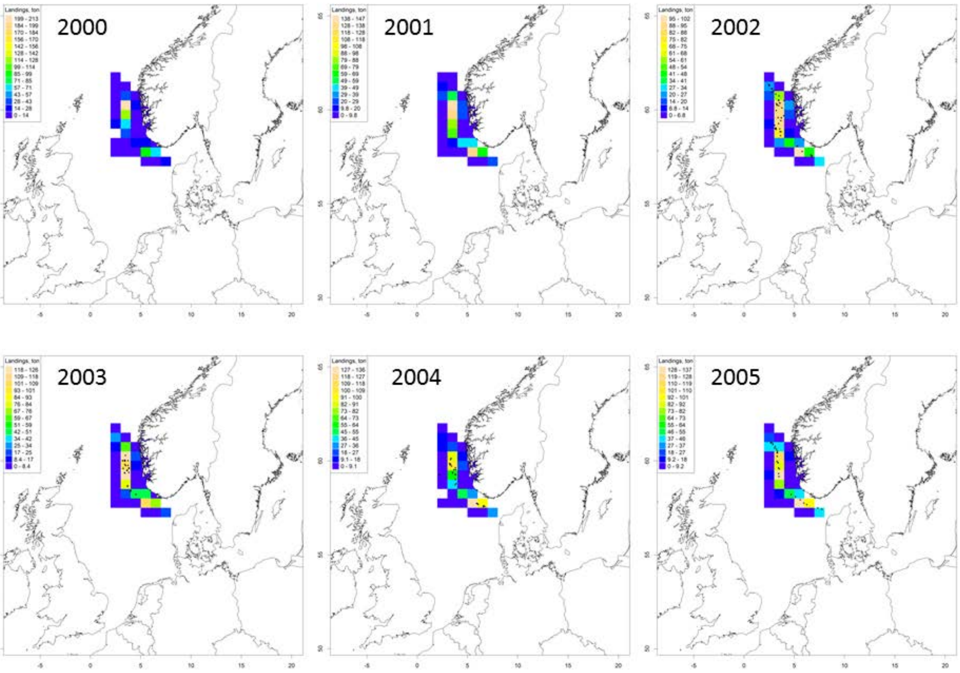
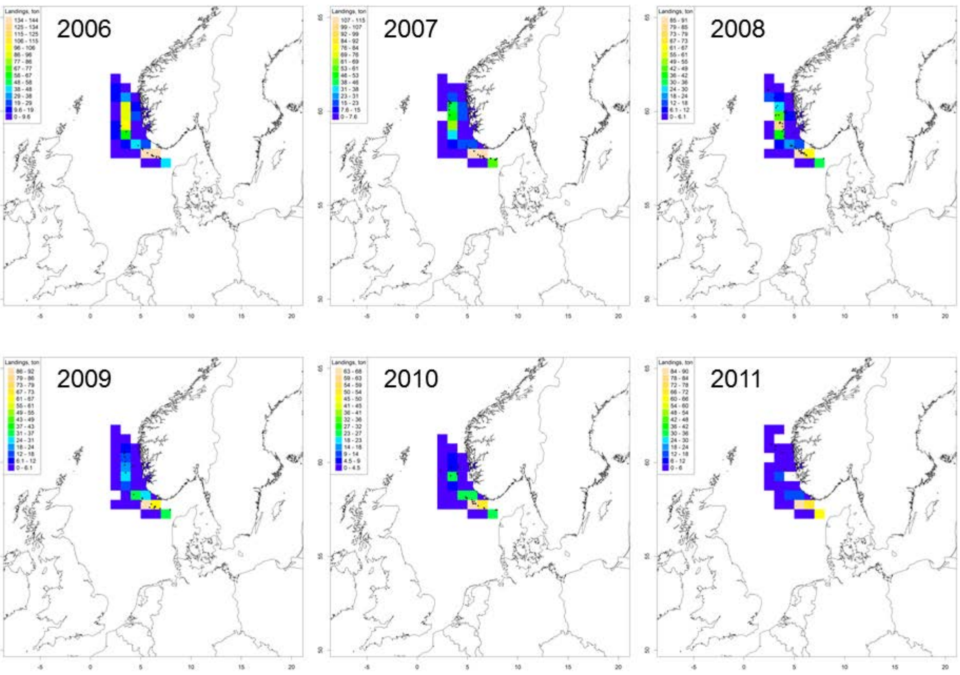


Figure 11.9.1. ***Nephrops*** **Norwegian Deep (FU 32): ln (total Danish landings from mixed fishery), where** ***Nephrops*** **ratio in landings >0.05. Grid cells are approximately 3 by 3 km (geographic grid of 1 x 2 minutes). The area of FU 32 is redefined to conform to the updated border between Skagerrak and the Norwegian Deep, which follows the TAC of** ***Nephrops*** **within EU.**


2000
2001
2002
2003
2004
2005


2006
2007
2008
2009
2010
2011

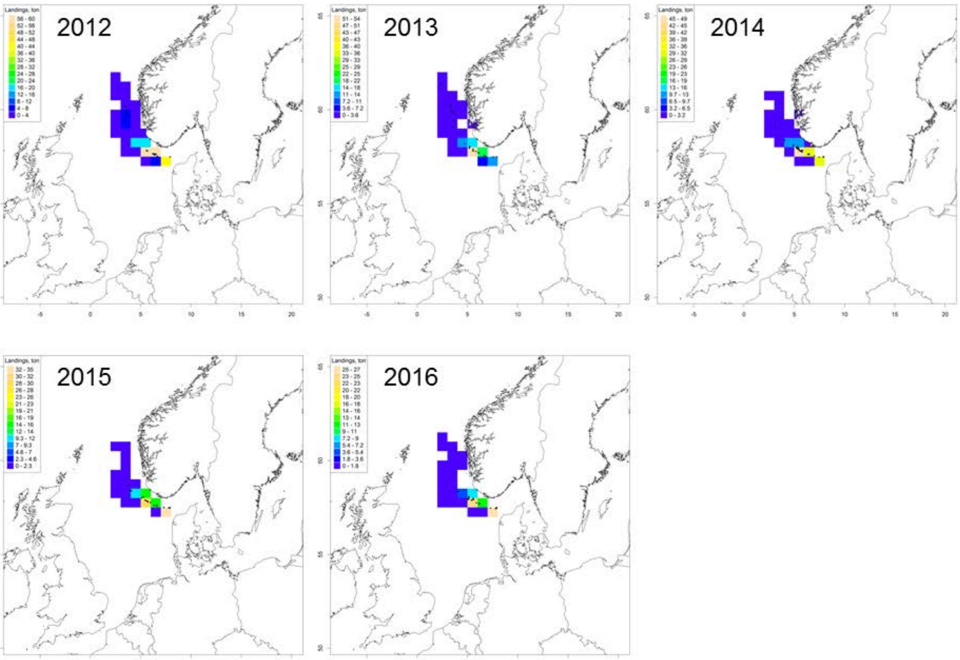


Figure 11.9.2. ***Nephrops*** **Norwegian Deep (FU 32). Danish landings of** ***Nephrops*** **per ICES square. Dots represent hauls with** ***Nephrops*** **in at-sea-sampling program. Note, scales differ between annual plots.**

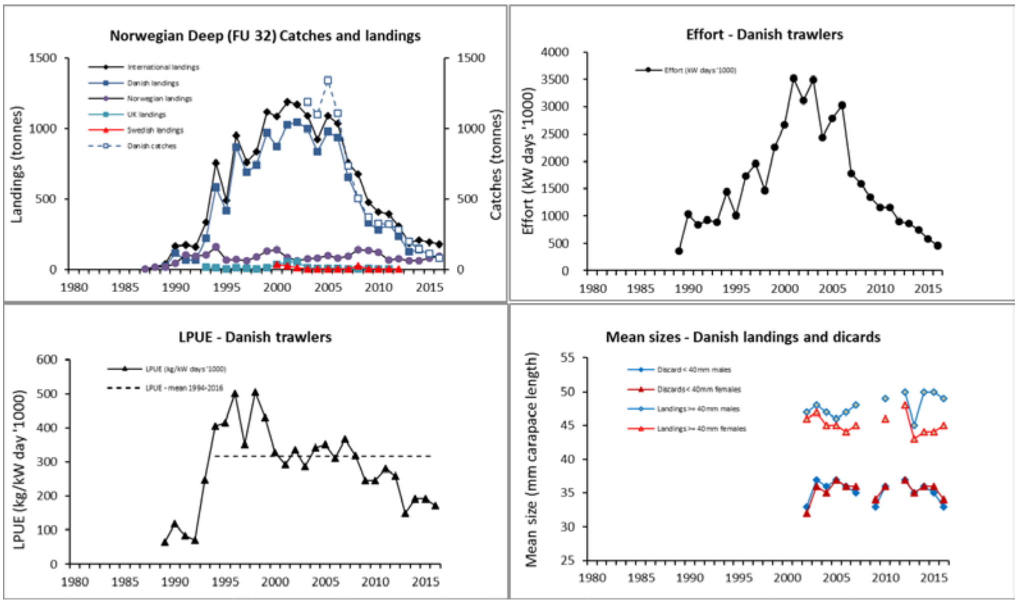


Figure 11.9.3. ***Nephrops*** **Norwegian Deep (FU 32). Catches and landings, Danish effort, Danish LPUE, and mean size in Danish discards (< 39 mm) and landings (≥ 40 mm).**

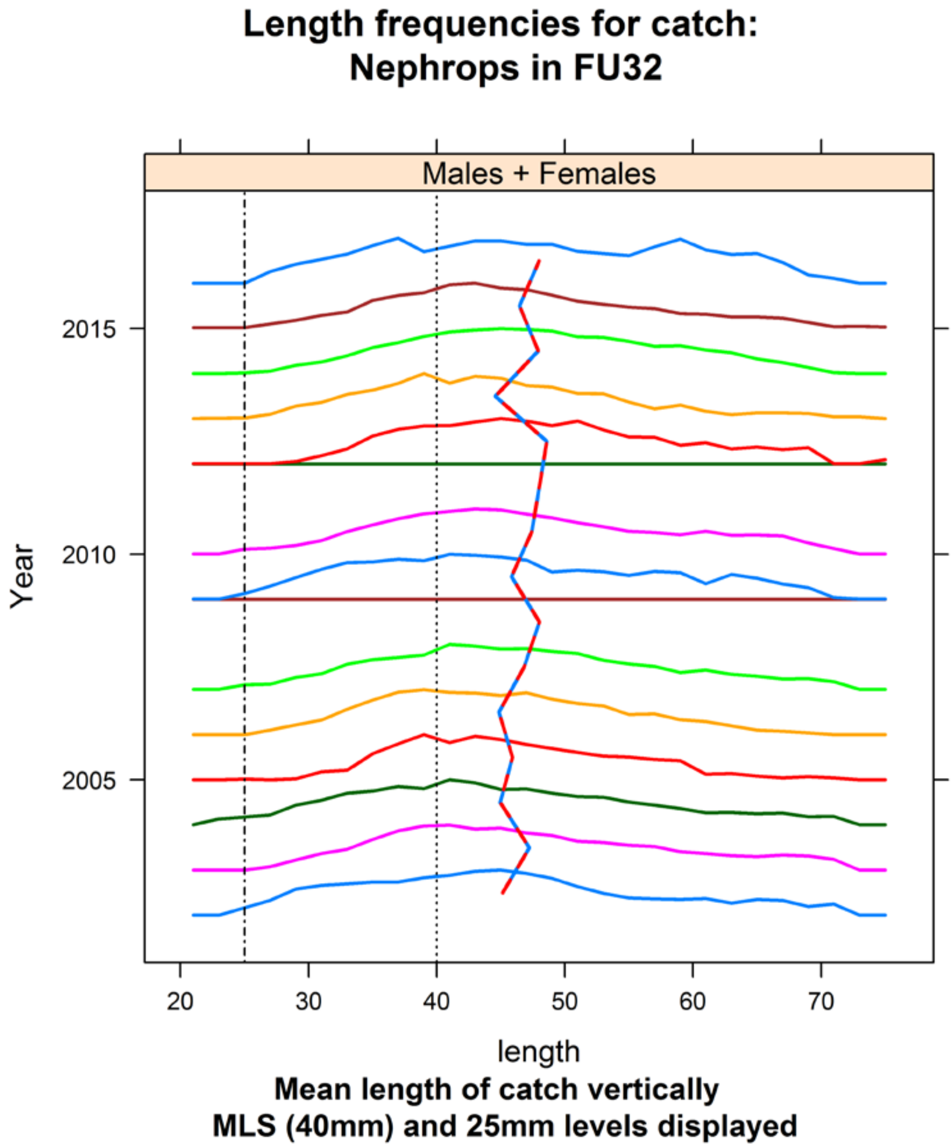


Figure 11.9.4. ***Nephrops*** **Norwegian Deep (FU 32): Size distribution in Danish catches.**

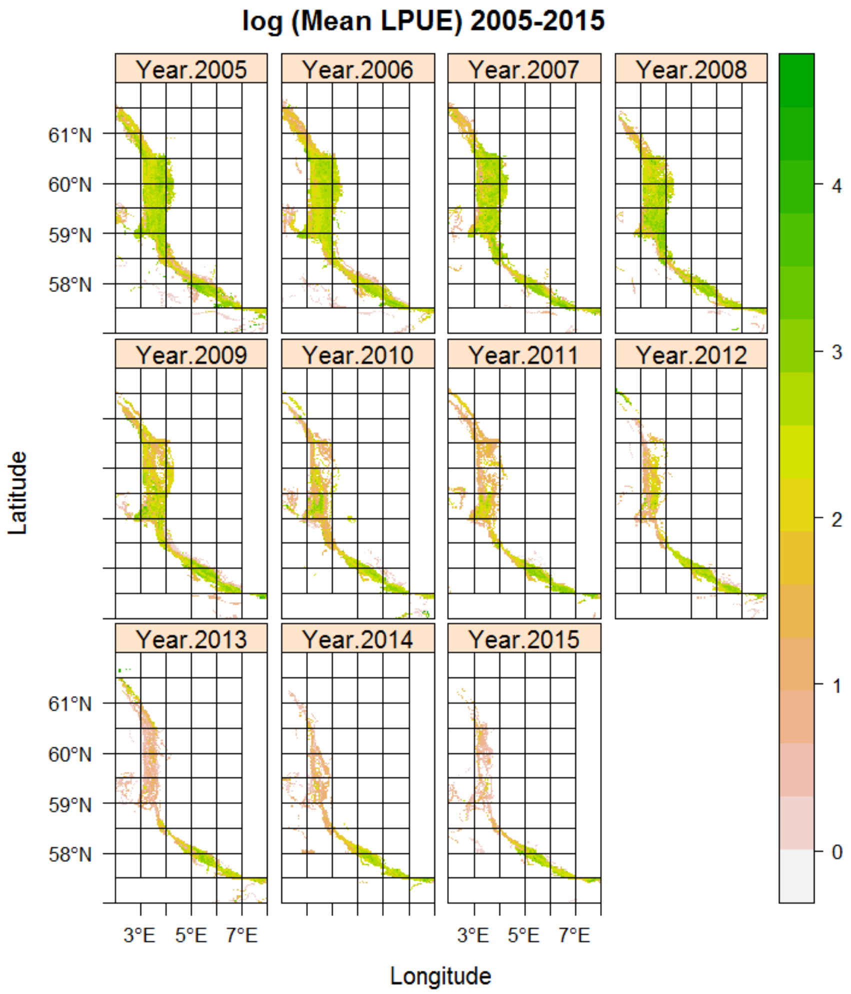


Figure 11.9.5. ***Nephrops*** **Norwegian Deep (FU 32): ln (median Danish nominal lpue + 1) for 2005–2015. Grid cells are approximately 3 by 3 km (geographic grid of 1 x 2 minutes). The area of FU 32 is redefined to conform to the updated border between Skagerrak and the Norwegian Deep, which follows the TAC of** ***Nephrops*** **within EU.**

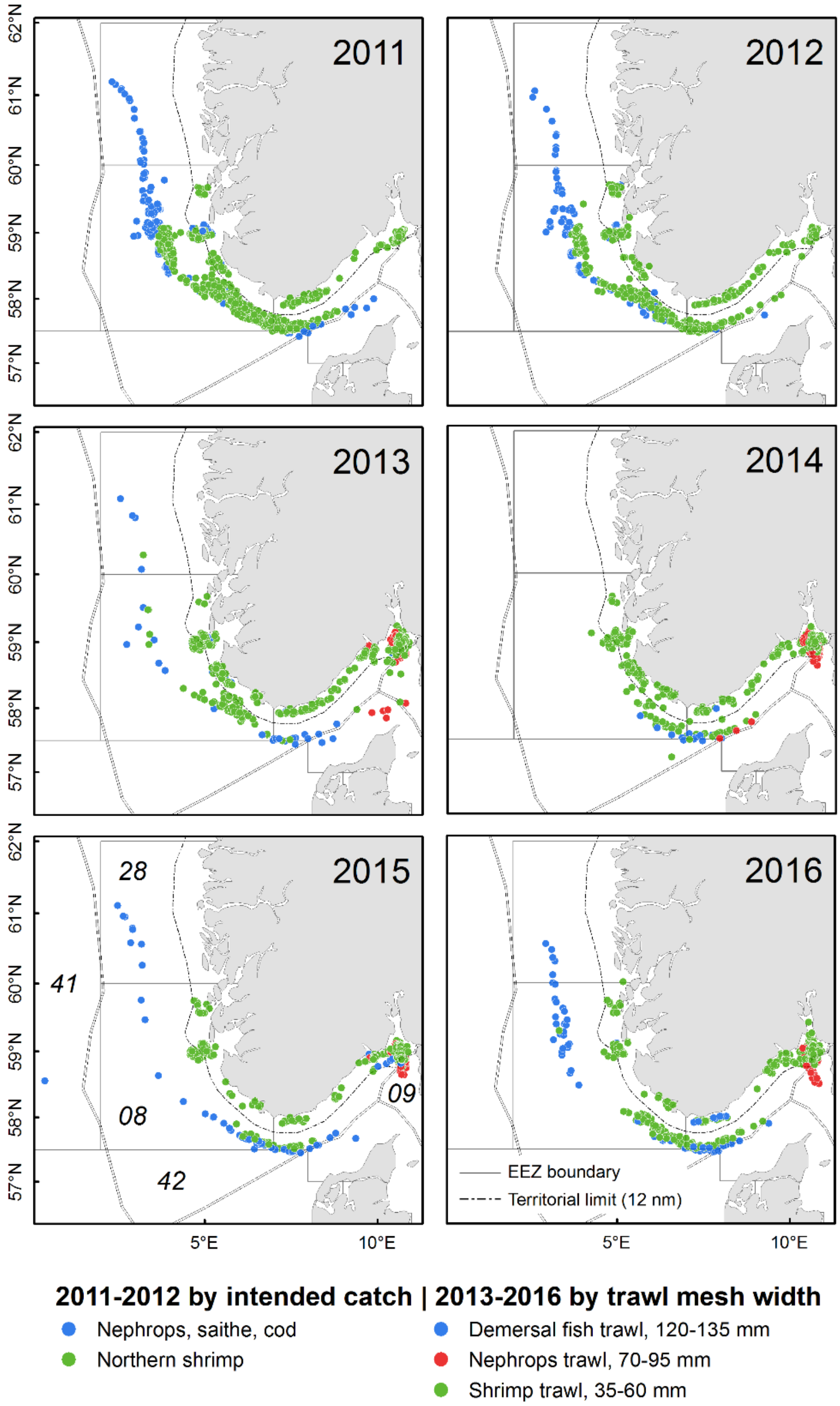


Figure 11.9.6. *Nephrops* Norwegian Deep (FU 32): Positions of trawl hauls with *Nephrops* in the catch from Norwegian bottom trawlers ≥ 15 m, 2011–2016.

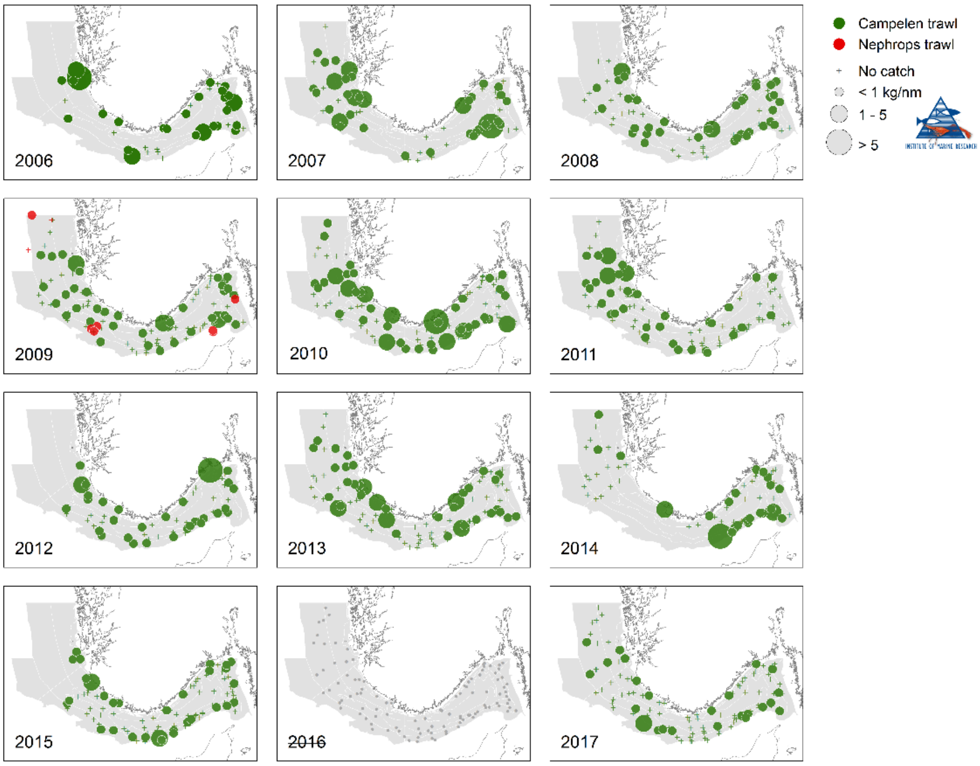


Figure 11.9.7. *Nephrops* Norwegian Deep (FU 32): Distribution of *Nephrops* in Norwegian shrimp survey, 2006–2017. The 2016-data are omitted from the time series due to technical problems with the trawl gear at this year's survey.

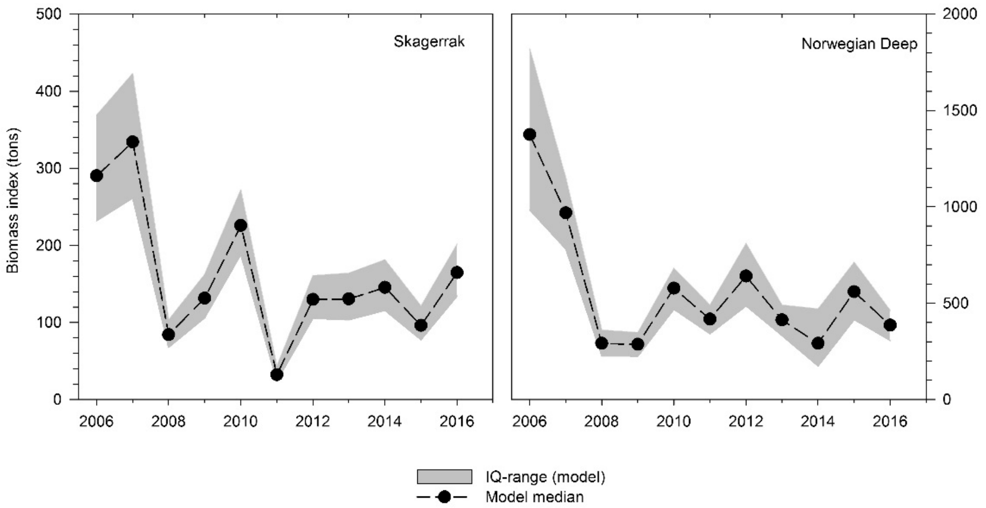


Figure 11.9.8. ***Nephrops*** **Norwegian Deep (FU 32): Stock size indices (2006–2017) from the Skagerrak and Norwegian Deep, based on trawl catches of the Norwegian shrimp survey. The 2016–data are omitted from the time series due to technical problems with the trawl gear at this year's survey.**

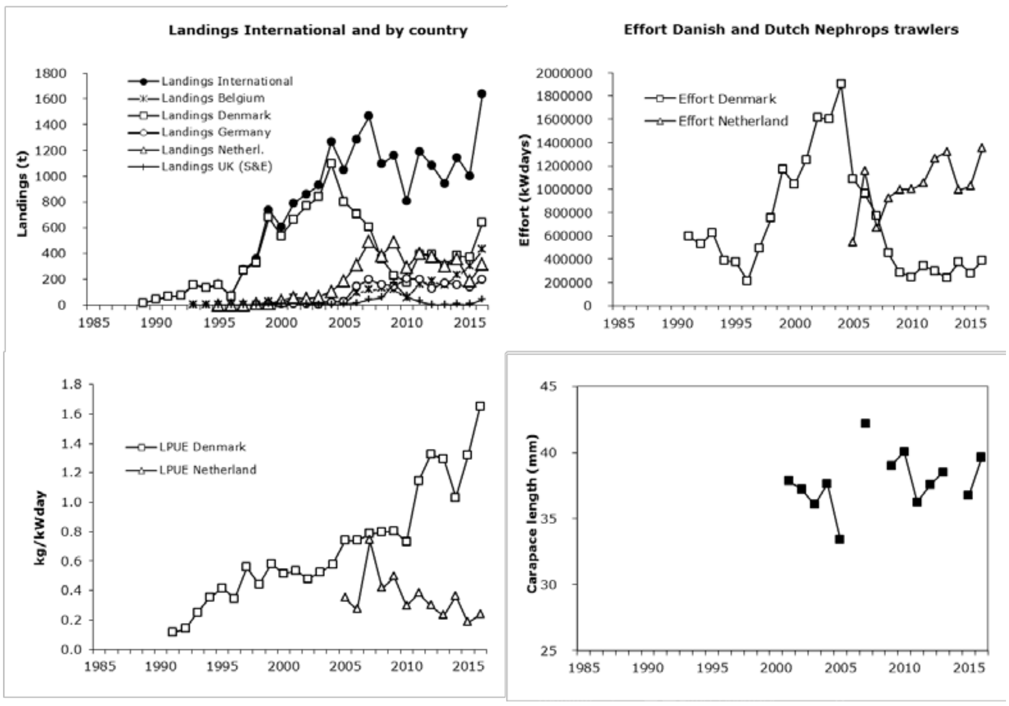


Figure 11.10.1. ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

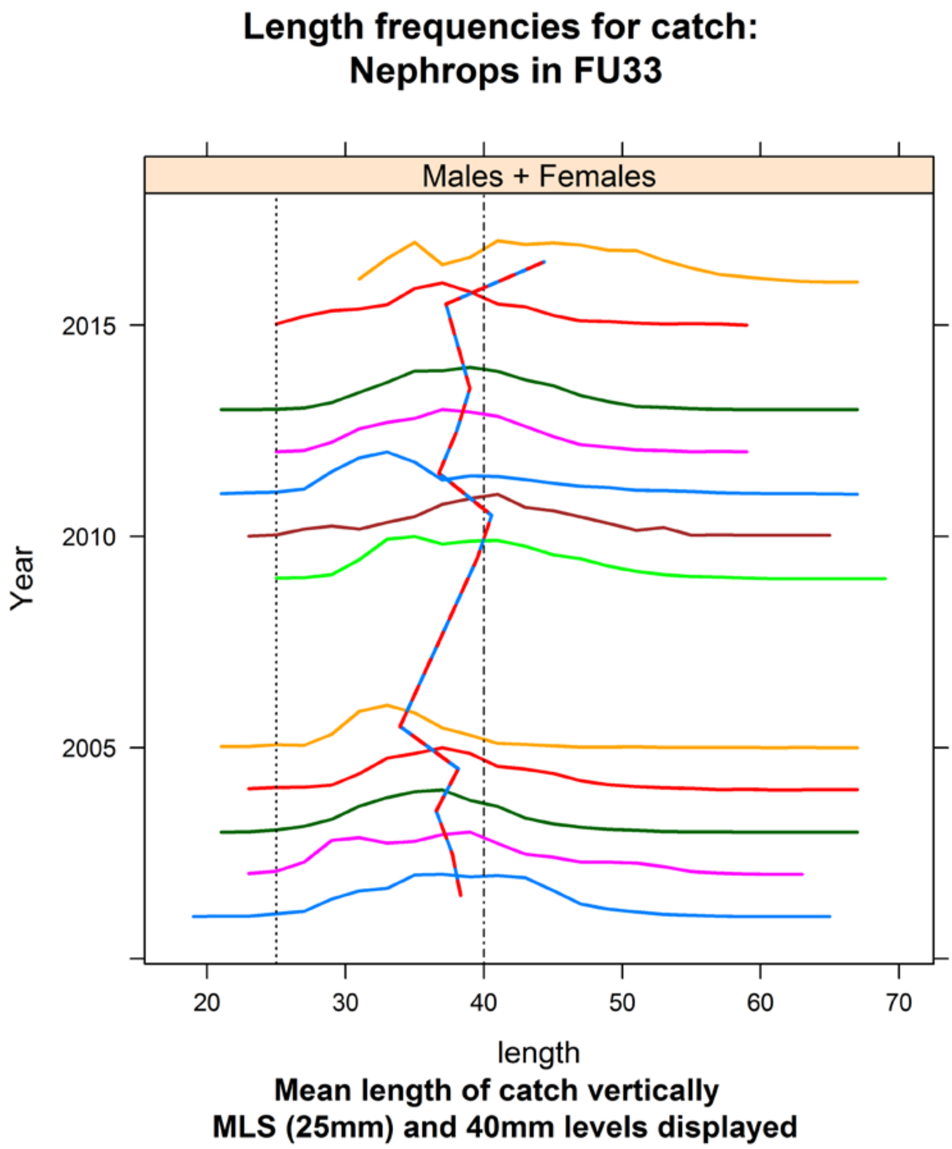


Figure 11.10.2. ***Nephrops*** **in FU 33 (Off Horn's Reef): Size distribution in Danish catches.**

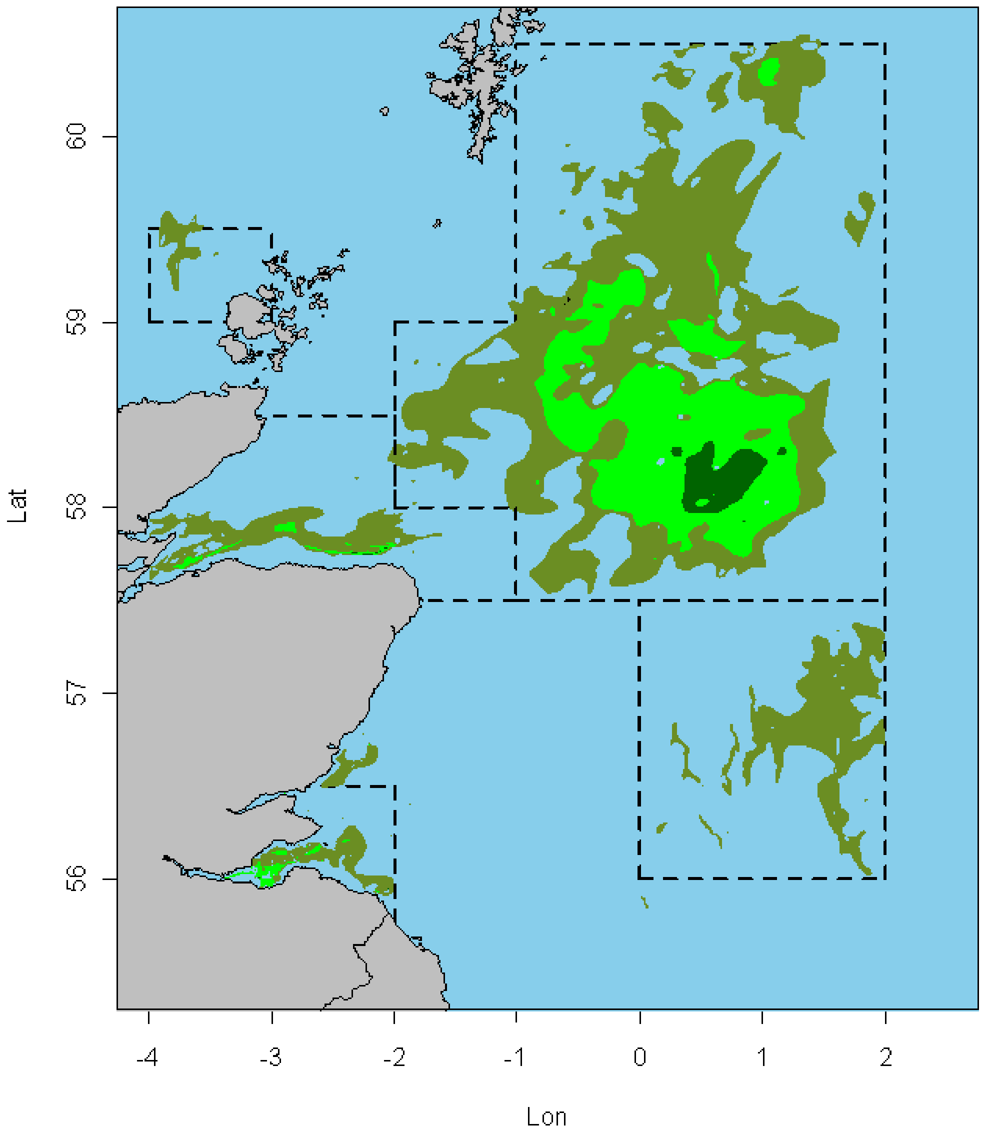


Figure 11.11.1. ***Nephrops*, Devil's Hole (FU 34): British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive, muddy sand, lime green, sandy mud, dark green-mud.**

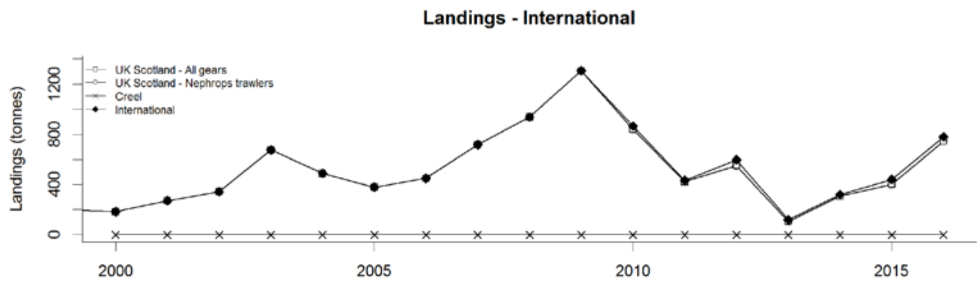


Figure 11.11.2. ***Nephrops*, Devil's Hole (FU 34): International landings, data from year 2000.**

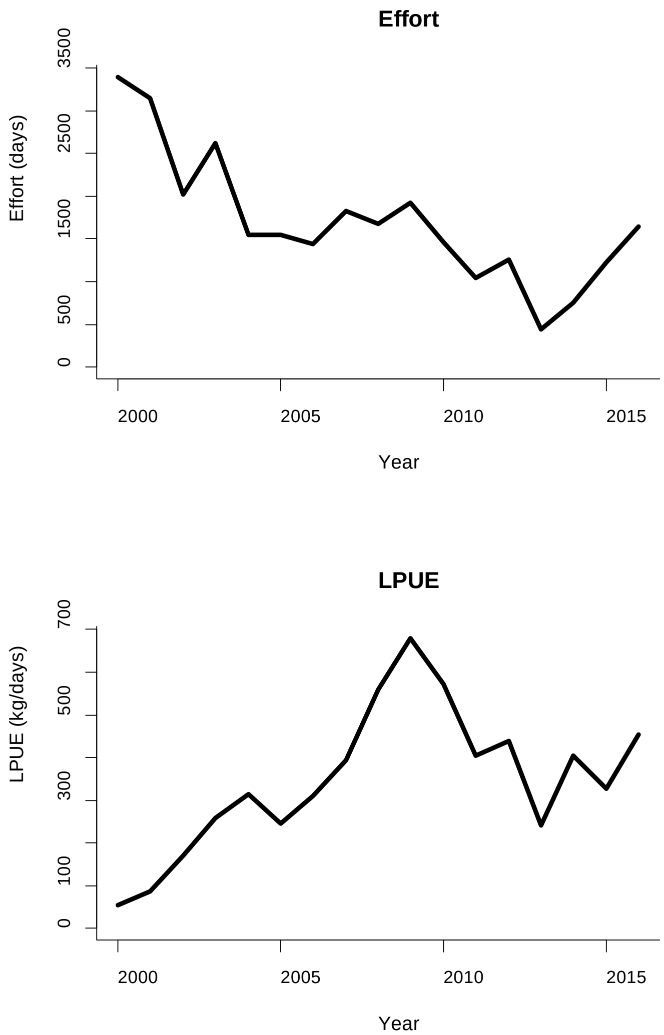


Figure 11.11.3. ***Nephrops*, Devil's Hole (FU 34): Effort (days) and lpue (kg/day), data from year 2000.**

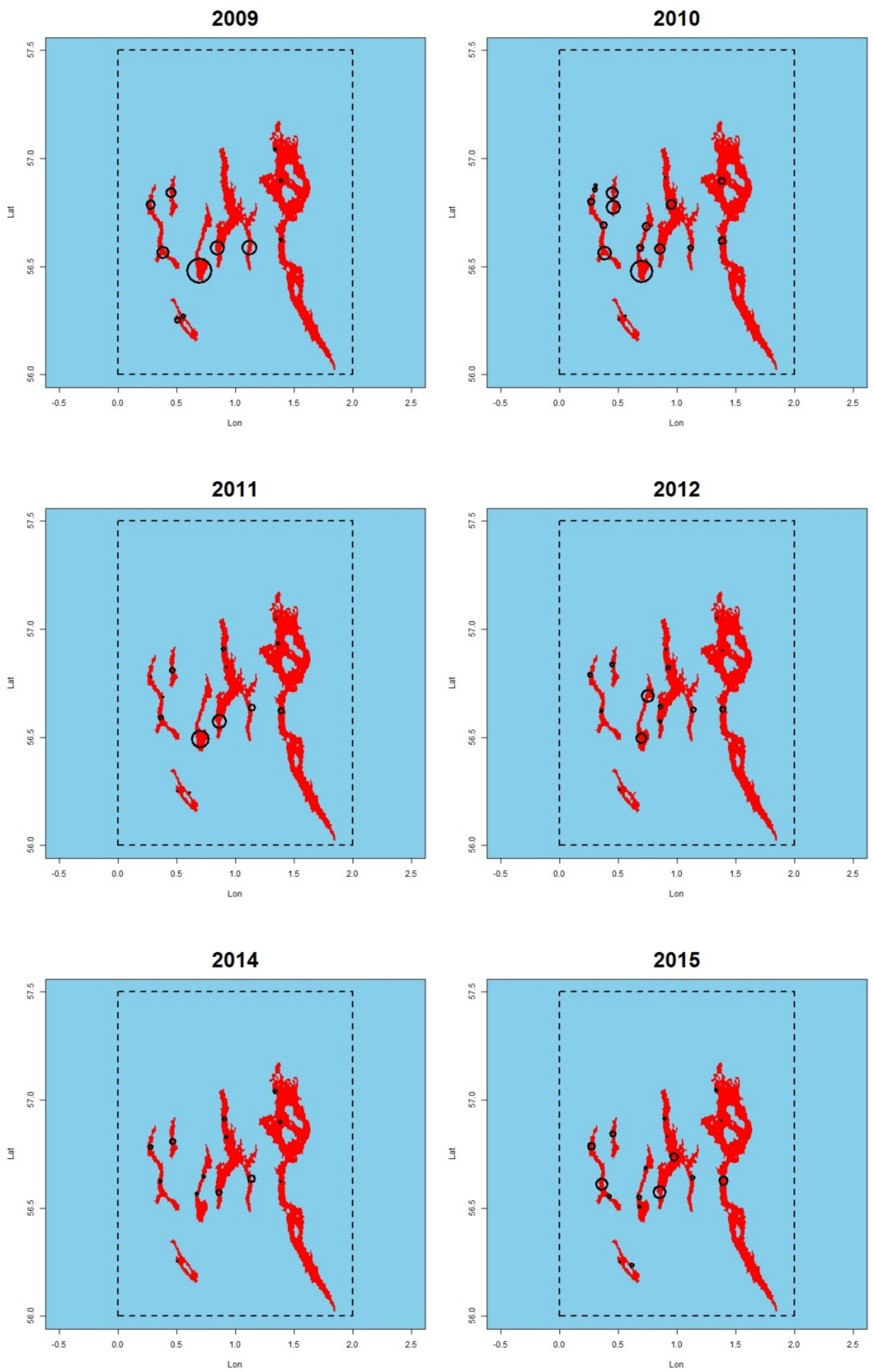


Figure 11.11.4. ***Nephrops*, Devil's Hole (FU 34): UWTV survey distribution and relative density (2009–2015). Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius.**

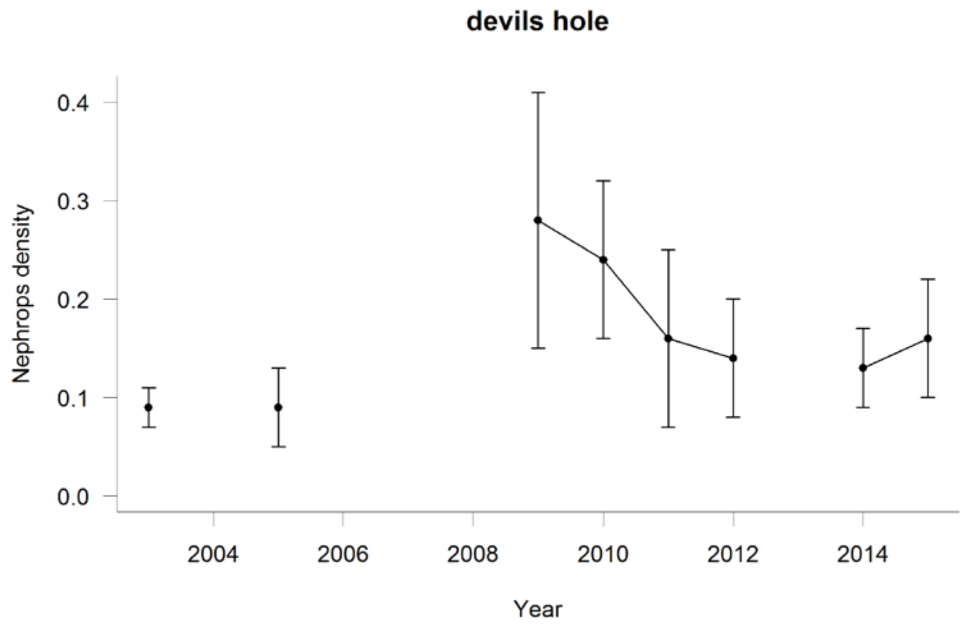


Figure 11.11.5. ***Nephrops*****, Devil's Hole (FU 34): Time series of UWTV survey density estimates with 95 % confidence intervals, 2003, 2005, 2009–2015.**

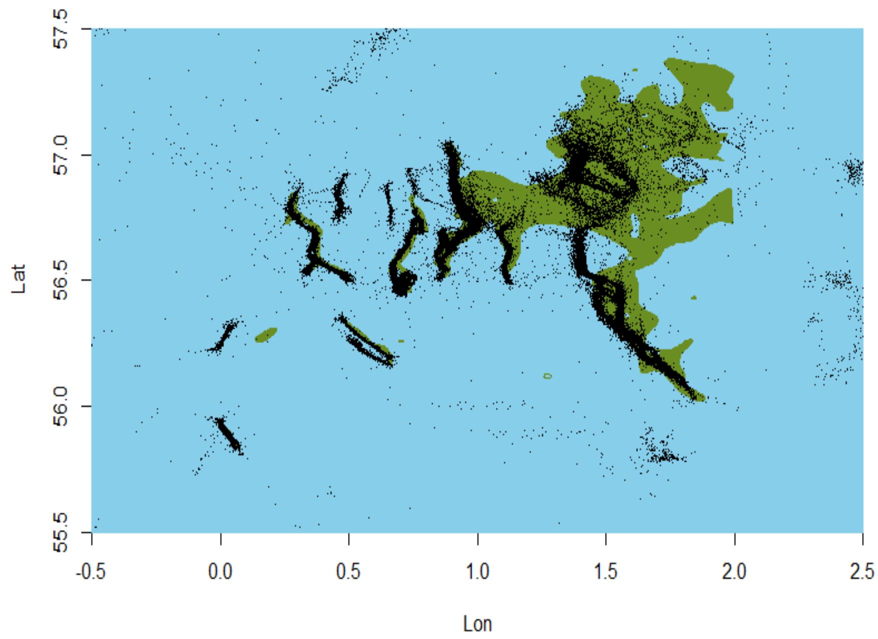


Figure 11.11.6. ***Nephrops*****, Devil's Hole (FU 34): Comparison of BGS sediment map with VMS data from Scottish trawlers (2007–2011) filtered for** ***Nephrops*** **landings >30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

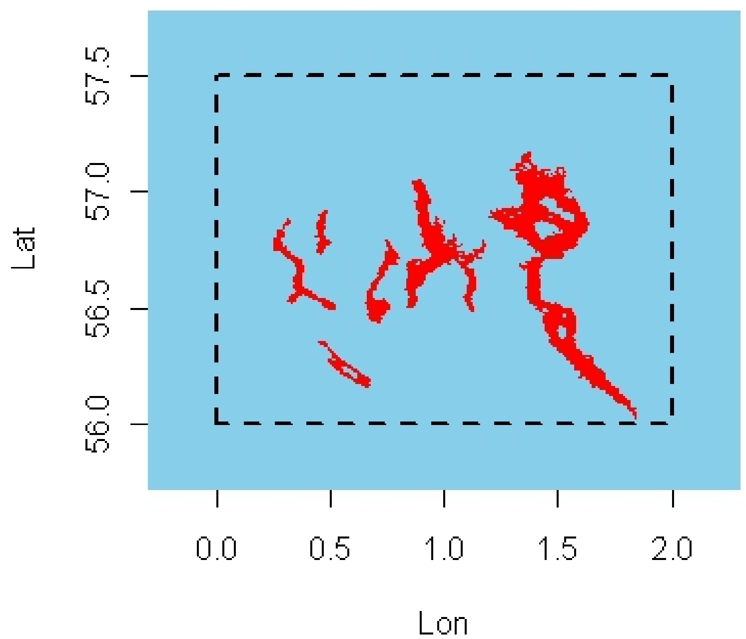


Figure 11.11.7. ***Nephrops*****, Devil's Hole (FU 34). Union of 2007–2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for** ***Nephrops*** **landings >30 % of total, speeds of 0.5–3.8 knots and mesh size 70–99 mm.**

This Section was added to the report in Autumn 2017.

12 Norway Pout in ICES Subarea 4 and Division 3.a (September 2017)

Introduction: Benchmark assessment

The September 2017 assessment of Norway pout in the North Sea and Skagerrak is an update assessment based on the August 2016 ICES WKPOUT benchmark assessment (ICES WKPOUT, ICES 2016). In the benchmark assessment, a new assessment model has been introduced (Seasonal Stochastic Assessment Model, SESAM, instead of the Seasonal XSA, SXSA), the assessment year has been changed (from the calendar year to 1 October to 1 October and accordingly also now including quarter 3 in the assessment year compared to quarter 2 in previous assessments), the overall assessment period has been changed (cutting off the original first assessment year 1983), the plus-group in the assessment has been changed (from 4+ to 3+), and the assessment tuning fleets have been changed (removing the quarter 1, 3, and 4 commercial tuning fleets and keeping the same survey fleets). The assessment biological parameter settings are the same according to the Inter-benchmark assessment in spring 2012 (ICES IBPNorwayPout, ICES 2012c) with respect to the population dynamic parameter settings for natural mortality, maturity at age and mean weight at age. The previous settings in the assessment were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100% mature for the 2+ group, and constant MWA assumed in stock. The new settings according to the inter-benchmark (from May 2012 onwards) include constant quarterly and yearly natural mortality, but with varying M by age, 20% maturity for the 1-group, and slightly changed levels of constant mean weight at ages in the stock which have been calculated from long term averages of mean weight at age in the catch. These parameters have impact on the predictions and estimates of the SSB because the stock consists of very few year classes. The assessment is a "real time" monitoring and management run up to 1 October 2017, and includes new information from 2nd half year 2016 and for the quarters 2, 3 and 3 in 2017. The assessment includes the new 3rd quarter 2017 survey information also covering the 0-group 2017 year class information, which is used real time in 3rd quarter. Consequently, the assessment does not backshift this survey information to 2nd quarter as done in the SXSA assessment run up to 1 July in the assessment year before the benchmark assessment in 2016.

Furthermore, a short term prognosis (Forecast) up to 1 November 2017 and 1 November 2018 is given for the stock based on the assessment. The catch projection is based on a changed forecast year from 1 November to 31 October.

12.1 General

12.1.1 Ecosystem aspects

Norway pout is a short-lived species and most likely a one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation or other natural mortality, and less by the fishery (Nielsen *et al.*, 2012). Recruitment is highly variable and influences SSB and total stock biomass (TSB) rapidly because of the short life span of the species (Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a, 2002b; see review in Nielsen 2016). Furthermore, 20% of age 1 is estimated mature and is included in the SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year influences the SSB in the following year. Also, Norway pout is to a limited extent exploited from age 0. Only limited knowledge is available on the influence of environmental factors, such as temperature, on the recruitment (Kempf *et al*. 2009; see review in Nielsen 2016, Section 7). On this basis, Norway pout should be managed as a short-lived species.

Stock definition: Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen *et al*., 2012, Lambert *et al*,, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 300 m (Raitt 1968; Sparholt *et al*., 2002b; see review in Nielsen 2016, Sections 2&4). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al*., 2009; Nash *et al*. 2012; Huse *et al.* 2008; See review in Nielsen 2016, Section 4).

Previously, it has been evaluated that around 10% of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al* (2009) show that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), gave no evidence for a stock separation in the whole northern area, and this conclusion is supported by the results in Lambert *et al.* (2009) and in Nash *et al.* (2012). (See also review in Nielsen 2016, Section 3).

Ecological role: The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short life span of the species (Nielsen *et al.*, 2012; ICES WGSAM 2011; ICES WGSAM 2014; Sparholt *et al.* 2002a,b; Lambert *et al.*, 2009). Norway pout natural mortality is likely influenced by spawning and maturity having implications its age specific availability to predators in the ecosystem and the fishery (Nielsen *et al*., 2012). With present fishing mortality levels in recent years the status of the stock is more determined by natural processes and less by the fishery, and in general the fishing mortality on 0-group Norway pout is low (Nielsen *et al*., 2012; ICES WGNSSK Reports; see review in Nielsen 2016, Section 5). There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. This stock is among other important as food source for the species saithe, haddock, cod, whiting, and mackerel and predation mortality is significant (ICES-SGMSNS 2006; ICES WGSAM 2011; ICES WGSAM 2014; Cormon *et al*., 2016; see review in Nielsen 2016, Section 6). Especially the more recent high abundance of saithe predators and the more constant high stock level of northern mackerel as likely predators on smaller Norway pout are likely to affect the Norway pout population dynamics significantly. Interspecific and intraspecific density patterns in Norway pout mortality and maturity has been documented (Nielsen *et al*., 2012; Lambert *et al.* 2009; Cormon *et al.* 2016; see review in Nielsen 2016). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES WGSAM 2011; ICES WGSAM 2014), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used based on the results from Nielsen *et al.* (2012).

Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

Ecosystem impacts of fishery: In order to protect other species (cod, haddock, whiting, saithe and herring as well as mackerel, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, bycatch regulations, minimum mesh size, and minimum landing size. A review of regulations on the Norway pout stock and be found in Nielsen *et al.* (2016a).

12.1.2 Fisheries

The fishery is nearly exclusively performed by Danish and Norwegian vessels using small mesh trawls in the north-western North Sea, especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. The Norway pout fishery is a mixed commercial, small meshed fishery conducted nearly exclusively by Denmark and Norway directed towards Norway pout as one of the target species together with Blue Whiting in the Norwegian fishery. The international commercial Norway pout fishery has been reviewed in Nielsen *et al.* (2016a) including a detailed analysis of the Danish commercial fishery, and a detailed description of the Norwegian fishery can be found in Johnsen *et al.* (2016). These papers include among other detailed analyses of quarterly and spatial distribution of the Norway pout fishery and catches, the bycatches and discard, the quota up-take and the fishery regulations. Furthermore, the Stock Annex also includes the long term trends in average exploitation pattern.

Landings have been relatively low since 2001, and the 2003–2004 landings were the lowest on record (Tables 12.2.1–2). The directed fishery for Norway pout was closed in 2005, in the first half of 2006, and in 2007 as well as in the first half of 2011 and 2012. In the periods of closures there have in some years been set bycatch quotas for Norway pout in the Norwegian mixed blue whiting fishery around 5 kt, as well as in a small experimental fishery in 2007 (1 kt). In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low. Catches were above 100 kt in 2010, but have in the period 2012–2017 been below 100 kt and the quota has not been taken in those years. The landings in 2015 and 2016 were 63,4 kt in both years. The fishery has in these periods mainly been based on the 2008, 2009, 2012, 2014, 2015 and 2016 year classes being around or above the long term average level. The TAC was not taken in 2008–2010 and 2012–2017, while the small TAC in 2011 was taken. This was likely due to targeting of other industrial species like sprat for which fishing costs are lower, but also high fishing (fuel) costs and bycatch regulations (mainly in relation to whiting and herring bycatch) have an impact (see details in Nielsen *et al.*, 2016a). Furthermore, late opening of the fishery at the end of quarter 3 in 2012, and individual quotas for the Danish fishery may also play a role in the uptake. Trends in yield are shown in Table 12.2.3a and Figure 12.3.5.

Bycatch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al.*, 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2); see also review in Nielsen *et al.*, 2016a). Bycatches of these species have been low in the recent decade, and in general, the bycatch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of bycatch of other species in the Norway pout fishery also appears from Table 12.2.1. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing bycatches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012; see also review in Nielsen *et al.*, 2016a; Johnsen *et al.*, 2016). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and bycatch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found in Nielsen *et al.*, (2016a) and in the Stock Annex.

The quality of the landings statistics in Norway and Denmark is described in the ICES WKPOUT (2016) and associated Annexes (Nielsen *et al.*, 2016a; Johnsen *et al.*, 2016). The quality seems to be relatively constant during the last 20 years and of a higher quality than in the years before. The discard level of Norway pout in the North Sea fisheries is considered to be low (Nielsen *et al.*, 2016a).

12.1.3 ICES advice

In September 2016 the advice on North Sea Norway pout was updated. Based on the estimates of SSB in September 2016, ICES classified the stock to show full reproductive capacity. Norway pout is a short-lived species. Recruitment is highly variable and strongly influences the spawning stock and total biomass. The default ICES approach to MSY-based management for short-lived species is an escapement strategy, i.e. to maintain SSB, with 95% probability, above B_{lim} after the fishery has taken place. The former F_{cap} and MSY $B_{escapement}$ reference points are no longer used because the forecast is now stochastic and uncertainties in the assessment and forecast are directly taken into account to ensure the SSB stays above B_{lim} with 95% probability. For the implementation of the escapement strategy, which aims to maintain the SSB above B_{lim} after the fishery has taken place, SSB is calculated for quarter 4 as a proxy for SSB at spawning time (quarter 1). Consequently, the B_{lim} has been adjusted in the benchmark assessment in 2016. The B_{lim} estimate in the 4th quarter is lower than the previous value of B_{lim} for the 1st quarter because the 0-group and many of the 1-group fish are not yet included in the estimate of SSB. The catch forecast is for the period 1 October–30 September. ICES considers that this forecast can be used directly for management purposes for the period 1 November 2016–31 October 2017. In recent years the escapement strategy has been practiced in reality in management. The ICES advice in September 2016 was that with catches up to 358 kt in the directed Norway pout fishery in the period 1 November 2016–31 October 2017 corresponding to an F around 0.62 the 5th percentile of the spawning-stock biomass in the 4th quarter 2017 will remain above a reference level of B_{lim} (39 450 t). The SSB is expected to remain high during 2016 and 2017 due to the high 2014 and 2016 recruitment, the growth and 20% mature as 1-group, and still considering the high natural mortality as well as the short life span of the stock.

According to the escapement strategy the fishery was closed 1 January 2012 because of the well below, nearly historical low, recruitment in 2010 and 2011. A small TAC of 6 kt was set for the second half year 2011 which was taken. Based on the high recruitment in 2012 the fishery was opened again for second half year 2012. Based on the high recruitment in 2012, 2014 and 2016, as well as a just below average recruitment in 2015, the fishery has remained open for all of 2013–2017. The quota uptake has been less than 30% in recent years and very low in 2015 (Nielsen *et al.*, 2016a). The quota uptake has again in 2016 been very low.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.43) as estimated from the assessment in September 2016.

There is biannual information available to perform real time monitoring and management of the stock. This can be carried out both with fishery independent and fishery dependent information as well as a combination of those. Real time advice (forecast) and management options for 2018 (up to 31 October) is provided for the stock in autumn 2017 as well.

Until and including 2015, ICES has provided advice according to three management strategies for the stock based on a management strategy evaluation made in 2007 (see Stock Annex). ICES advised in September 2015 - on the basis of precautionary limits and MSY limits - that in order to maintain the spawning stock biomass above B_{pa} = MSY $B_{escapement}$ by 1 January 2016 the directed Norway pout fishery should be maximum 390 kt in 2016 (with an F ceiling of 0.6 from MSE in 2013) under the escapement strategy (real time management), under the long term fixed TAC strategy a TAC on 50 000 t (corresponding to an F around 0.06), and under the long term fixed fishing mortality or fishing effort strategy (TAE) a TAC on 249 000 t corresponding to a fixed F = 0.35.

ICES advices that there is a need to ensure that the stock remains high enough to provide food for a variety of predator species. It is advised that bycatches of other species should also be taken into account in management of the fishery. Also it is advised that existing measures to protect other species should be maintained.

12.1.4 Management up to 2017

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the MSY approach for short lived species in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing on marine ecosystems.

ICES advised in 2005 real time management of this stock. In previous years the advice was produced in relation to a precautionary TAC, which was set to 198 000 t in the EC zone and 50 000 t in the Norwegian zone. On basis of the real time management advice from ICES, EU and Norway agreed to close the directed Norway pout fishery in 2005, first part of 2006, all of 2007 and in first part of 2011 and 2012. In 2005 and 2007, the TAC was 0 in the EC zone and 5 000 t in the Norwegian zone – the latter to allow for bycatches of Norway pout in the directed Norwegian blue whiting fishery. The final TAC set for 2008 was 115 kt, 116 kt (EU) for 2009, 162 kt for 2010, 6 kt for 2011, 95 kt for 2012, 323 kt for 2013, 252 kt for 2014, 313 kt for 2015 and 345 kt for 2016, however, the TACs were not taken during this period except for the small TAC in 2011. The TAC advice for 2017 has up to now been 358 kt. Fishery was closed in first half year 2011 and 2012. Bycatch regulations have sometimes been restrictive (e.g. in 2009 and 2010 mainly in relation to whiting bycatch).

In managing this fishery bycatches of other species have been taken into account. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and bycatch regulations to protect other species have been maintained.

Long term management strategies have been evaluated for this stock based on joint EU-Norway requests (see Section 12.11). ICES has evaluated and commented on three management strategies in 2007, although these have not been decided on. Long term management strategies have been evaluated again in September 2012 and June 2013 based on new joint EU-Norway requests (ICES, 2012b) in spring 2012 and spring 2013 to be available for the September 2012 and September 2013 ICES advice, respectively. These MSEs have been presented in special ICES reports (Vinther and Nielsen, 2012; 2013). No long term management strategies have been decided upon. With the changes introduced by the August 2016 Norway pout benchmark assessment (ICES WKPOUT 2016 and annexes) involving change of assessment model, change of assessment year, change of assessment period, removal of the commercial fishery tuning fleet in the assessment, change of the plus-group in the assessment from 4+ to 3+ and change of stock MSY reference level these MSEs cannot be used anymore for long term management plans of the stock (including the F-cap estimates made there).

Management strategy evaluation according to the new assessment and the revised reference levels as established from the benchmark assessment in August 2016 is planned for 2018 according to a joint EU-Norway request on this.

An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the Stock Annex.

12.2 Data available

12.2.2 Landings / catches

Data for annual nominal landings of Norway pout as officially reported to ICES are shown in Table 12.2.1. The landings equal the catches of Norway pout as discard in this small meshed fishery is negligible (see also Nielsen *et al.*, 2016a). Historical data for annual landings (catches) as provided by ICES (Working Group members) are presented in Table 12.2.2, and data for national landings (catches) by quarter of year and by geographical area are given in Table 12.2.3. Total observed and predicted (by the SESAM stochastic assessment model) catches by quarter is given in Table 12.2.3a. Both the Danish and Norwegian landings (catches) of Norway pout were low in 2007 and 2011. The landings were moderate in 2008–09, 2012, 2014, higher in 2013 and 2015–2016 and high in 2010, and the TAC was not reached in any of those years. The most recent catches have been included in the assessment. Catches for 3rd quarter 2017 include Danish and Norwegian catches up to 10th September 2016. Catches in the last three weeks of 3rd quarter 2017 are assumed to be relatively low and no guesses on that have been included in the assessment.

12.2.3 Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 2007 and 2008). Catch at age by quarter of year is shown in Table 12.2.4. Only very few biological samples were taken from the low Norway pout catches in 2005 and 2011, as well as in first half year 2006, 2007, and 2012. The data are in the InterCatch database.

As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches, the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery for those years. As no age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches the catch at age numbers from Danish fishery is calculated from Danish total catch weight divided by mean weight at age from the Norwegian fishery in 2010.

12.2.4 Weight at age

Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight at age in the catch is shown in Table 12.2.5 and the historical levels, trends and seasonal variation in this is shown in Figure 12.2.1. Mean landings weight at age from Danish and Norwegian fishery from 2005–2008 as well as for 2011 are uncertain because of the few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005–2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight at age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight at age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight at age data is available from both Danish and Norwegian fishery in 2009, second half 2010, second half 2011, second half 2012, and all of 2013, 2014, 2015, 2016 as well as for quarter 1 to quarter 3 2017.

Mean weight at age in the stock is given in Table 12.2.6. The inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduced revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009). The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. This has resulted in slightly changed levels of constant mean weight at ages in the stock which have been calculated partly from long term averages of mean weight at age in the catch. In the Stock Annex and in Nielsen (2016) a summary is given of the inter-benchmark revisions in 2012 of the population dynamic parameters in the assessment. No major revision of mean weight at age in the stock has been performed compared to the values used in previous assessments. The estimation of mean weights at age in the catches and the used mean weights in the stock in the assessment is described in Nielsen (2016) and in the Stock Annex. The data are in the InterCatch database.

12.2.5 Maturity and natural mortality

The inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM 2011; ICES WGSAM 2014). In Nielsen (2016) and in the Stock Annex a summary is given of the inter-benchmark revisions of the population dynamic parameters used in the assessment where maturity and natural mortality used in the assessment is described. Proportion mature and natural mortality by age and quarter used in the assessment is given in Table 12.2.6.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a paper by Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, the variable natural mortality between ages have been introduced in the 2012 ICES IBPNorwayPout inter-benchmark assessment (ICES, 2012c) and the present assessment. The revision of the natural mortality parameter is based on results in Nielsen *et al*. (2012) and the ICES WGSAM 2011 and ICES WGSAM 2014 multi-species assessment reports. The revised values are shown in Table 12.2.6.

12.2.6 Summary of Inter-benchmark assessment on population dynamic parameters

A summary of the ICES Spring 2012 inter-benchmark assessment with revised weight, maturity and natural mortality parameters at age included in the assessment is given in Nielsen (2016) and in the Stock Annex as well as in the ICES IBPNorwayPout inter-benchmark assessment report (ICES, 2012c).

12.2.7 Catch, Effort and Research Vessel Data

Description of catch, effort and research vessel data used in the assessment is given below, in the ICES WKPOUT 2016 Benchmark Report and its annexes, as well as in the Stock Annex (see also Table 12.3.1).

12.2.7.1.1 Commercial fishery data

Catch information for 1984–2017 is included in this assessment as presented in Tables 12.2.1–12.2.5 and Figure 12.2.1. Catches in all of 2005, 1st quarter 2009, first half year 2011 and 2012, and first quarter 2013 were nearly 0 and only very limited information exists about this catch. Consequently, there has been assumed and used low catches of 0.1 million individuals per age (for age groups 1–3) per quarter in the assessment for 2005 and 2011. The fishing effort and catch efficiency (catch per unit of effort) and of the Danish and Norwegian commercial fishery according to year and quarter of year are shown in Tables 12.2.7 and 12.2.8, respectively, and according to year and fishing vessel engine horse power category in Tables 12.2.9 and 12.2.10, respectively. Furthermore, trends herein are shown in Nielsen *et al.* (2016a) and in Johnsen *et al.* (2016).

No commercial fishery tuning fleet is included in the assessment from 2016 onwards based on the decisions made in the Norway pout benchmark assessment in September 2016 (ICES WKPOUT 2016).

12.2.7.1.2 Research vessel data

Fishery independent survey data used as tuning fleets in the present assessment is given in Table 12.2.11 and Figure 12.2.2 (see also Table 12.3.1).

Survey indices series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (International Bottom Trawl Survey 1st and 3rd quarter) and the EGFS (English Ground Fish Survey, 3rd quarter) and SGFS (Scottish Ground Fish Survey, 3rd quarter), Table 12.2.11. The new survey data from the 1st quarter 2017 IBTS and the 3rd quarter 2016 IBTS research surveys have been included in the September 2017 assessment as well as the 3rd quarter 2017 EGFS and SGFS research survey information. The survey data time series including the new information is presented in Table 12.2.11, as well as trends in survey indices in Figure 12.2.2. Surveys covering the Norway pout stock are described in detail in ICES WKPOUT (2016), Nielsen (2016) and in Johnsen and Søvik (2016) as well as in the Stock Annex. Survey data time series used in tuning of the Norway pout stock assessment are described below.

From 2009 and onwards, the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted subarea averages. In 3rd quarter 2015–2016 test trials were conducted in the international third quarter IBTS with 15 min duration hauls compared to 30 min duration hauls. The new 15 min test hauls have been included in the index calculation for 3rd quarter 2015–16, and will potentially affect the Norway pout indices for the SGFS and the combined IBTS Q3 index. It has been necessary to include the 15 min hauls in the SGFS 2015–16 as extensive areas (of the total SGFS survey area) are only covered with this type of hauls. Only one 15 min test haul was included in the EGFS 2015 and none in 2016. There has been no continuation of the tow duration experiment in the Q3 surveys in 2017 and, accordingly, no new 15 min hauls have been conducted and included in the Q3 2017 SGFS and EGFS survey indices (and consequently in the combined Q3 IBTS survey index). Analyses of this is on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices. Preliminary analyses indicate no significant differences in catch rates of Norway pout between the 15 min hauls and the 30 min hauls in the SGFS, however, the variability is very high and there are only very few observations available. Long time series and many observations are necessary to make statistical robust evaluation of potential differences. In September 2015, the EGFS survey indices were revised as to incorporate the relevant primes within the Norway pout area following the IBTS Manual (2015), i.e. in the selection of the prime stations to be included in the Norway pout index calculation. The revision is described in detail in an ICES working document to ICES WGNSSK 2015 (Silva, 2015 – see reference list). This has changed the EGFS indices for Norway pout for all years and ages since 1992. Especially, the indices for the 0-group have changed significantly without any obvious trends over time. However, the perception of the dynamics in the stocks (e.g. strong year classes as 0-group and also as older ages in the cohorts) seems not to have changed in relative terms for this survey. Consequently, there is consistency in this to the previous EGFS indices and in relation to the other survey indices also for Norway pout. In the EGFS Q3, an additional haul has been taken (prime 77 – DATRAS haul number 147) fished on behalf of the Scottish (SGFS) that falls inside ICES rectangle 40E8 and, therefore, inside the Norway pout index area according to the IBTS manual. This prime is expected to be fished from now on by the English (EGFS) so it will fall inside the English survey index instead of the Scottish survey index. In order to make the EGFS time series consistent over time it has been decided to exclude the Prime 77 haul in the 2017 index used in the assessment. By comparison it appears that the survey trends seem similar with or without prime 77 in the EGFS for 2017. With respect to the SGFS 2017 Q3 index, around 5 survey days was lost in 2017 due to vessel issues. Hence, there were only 76 hauls in 2017 compared to 99 hauls in 2016. In 2016, there was almost a 50/50 split by ICES Subarea with 50 hauls undertaken in 4A and 49 in 4B in the SGFS. In 2017, this was slightly more unbalanced with 43 hauls taking place in 4A and 33 in 4B. Finally, it should be noted that in the 2014 IBTS Q1 survey, less hauls were conducted in the northern part of the North Sea than usual. This did not result in change in the perception of the stock dynamics.

The survey data time series including the new information are presented in Table 12.2.11.

12.2.7.2 Revision of assessment tuning fleets

The revision of the tuning fleets used in the benchmark 2004 assessment - as used in the 2005–2006 and 2007–2015 assessments – and the additional revisions of the tuning fleets in the benchmark 2016 assessment – as used in the September 2016 and future assessments - is summarised in Table 12.3.1. Details of the revision are described in the Stock Annex and in the ICES WKPOUT 2016 Report and its annexes.

The overall assessment period has been changed by cutting off the first assessment year (1983), so the assessment period is from 1984–2017, and the assessment tuning fleets have been changed by removing the quarter 1, 3, and 4 commercial tuning fleets and keeping the same survey fleets. The assessment biological parameter settings are the same according to the Inter-benchmark assessment in spring 2012 (ICES IBPNorway Pout, ICES 2012c) with respect to the population dynamic parameter settings in the assessment for natural mortality, maturity at age and mean weight at age in the stock (see also Table 12.3.1).

12.3 Catch at Age Data Analyses

12.3.2 Review of assessment

The September 2016 assessment was accepted and no overall or specific recommendations and comments were given here. The assessment has been performed correctly. In the 2014 assessment review it was only noted that potential area specific assessment should be considered in relation to a benchmark assessment.

12.3.3 Final Assessment

A seasonal extension to the State-space Assessment Model (SAM) was used during this September 2017 assessment (SESAM), and in the benchmark 2016 Norway pout assessments reported in ICES WKPOUT (2016). In the latter, the SESAM assessment model was evaluated and compared with the assessment model previously used (Seasonal extended survivors analysis SXSA). It was found that this new model (SESAM) estimates very similar trends in SSB and fishing mortality compared to SXSA. The SESAM model was preferred by the ICES WKPOUT (2016) benchmark assessment group due to its ability to incorporate process and observation error and estimate uncertainties in all quantities, including the forecast.

The method is described in detail in Nielsen and Berg (2016; WD6 of the ICES WKPOUT (2016)), and the source code, input data and output is available online at www.stockassessment.org under “NorPoutBench2016”, and for the current September 2017 assessment under “NorPoutSep2017” at the same website.

In brief, the model is the same as the SAM model, except that the time step used is one quarter of a year rather than a full year. Recruitment is assumed to occur in quarter 3 only. The logarithm of the fishing mortality at age and quarter is assumed to follow a multivariate random walk with lag 4 and correlated increments, i.e. the log F-at-age in a given quarter is given by the log F-vector in the same quarter one year earlier plus a correlated noise term with mean zero.

The observation equations in SESAM are also extended to deal with zero observations (both surveys and catches), which are usually treated as missing values in SAM. This is done by introducing a detection limit for each fleet, and defining the likelihood of a zero observation to be the probability of obtaining a value less than the detection limit. The detection limit is set to 0.5 times the smallest positive observation by fleet.

A special option was included to down-weight the influence of large jumps in log F on the estimated random walk variance due to periods where the fishery was closed. This option reduced the estimated log F process variance considerably.

In the ICES WKPOUT (2016) benchmark a number of variants of the SESAM model were investigated and compared to the previous assessment model, SXSA. These variants included the use (or not) of commercial CPUE data, omission of the earliest years of data from the assessment, alternative settings for the detection threshold used to handle zero-valued data, and omitting the years of fishery closure when estimating the random walk variance on fishing mortality.

The final SESAM model also used in this September 2016 assessment excludes commercial CPUE data, omits 1983 data from the assessment, use age 3+-group, and omits the years of fishery closure from the random walk variance calculation. In relation to evaluation of stock sustainability and forecast B_{lim} is set equal to B_{loss} based on quarter 4 SSB values to align with the new fishing season (1st November –31st October). The short-term forecast is stochastic, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season.

Stock indices and assessment settings used in the assessment are presented in Tables 12.3.1–12.3.2.

Results of the SESAM analysis are presented in Tables 12.3.1–12.3.2 (assessment model parameters, settings, and options), Table 12.3.3 (population numbers at age (recruitment)), Table 12.3.4 (fishing mortalities by year and quarter), Table 12.3.5 (diagnostics), and Table 12.3.6 (stock summary). The summary of the results of the assessment are shown in Table 12.3.6 and Figures 12.3.1 (spawning stock biomass, SSB), 12.3.2 (total stock biomass, TSB), 12.3.3 (fishing mortality, F_{bar}), 12.3.4 (recruitment), 12.3.5 (yield, catches), and 12.3.6–12.3.7 (stock-recruitment plots for quarter 1 and quarter 2, respectively). Model diagnostics (retrospective plots, residuals, etc.) from the SESAM September 2016 assessment are given in Figures 12.3.8–12.3.11.

Fishing mortality has generally been lower than natural mortality and has decreased in the recent 20 years below the long term yearly average (0.43). Fishing mortality for the 1st and 2nd quarter has in general decreased in recent years, while fishing mortality for 3rd and especially 4th quarter, that historically constitutes the main part of the annual F, has also decreased moderately during the last 20 years. Fishing mortality in 2005, first part of 2006, 2007, 2008, 2011, and in first part of 2012 was close to zero due to the closure of the Norway pout fishery in those periods. Fishing mortality was moderate in 2009 and 2010 and on a higher level in second half 2012 and in 2013–2016, and the TACs have not been fished up in any of these recent years. In recent years the quota uptake has been below 30% (see Nielsen *et al.*, 2016a), and in 2016 the quota uptake has also been very low. The low TAC of 6kt in 2011 was taken in second half year resulting in a very low F in 2011.

Spawning stock biomass (SSB) has since 2001 decreased continuously until 2005 but has in recent years increased again due to the strong 2008, 2009, 2012, 2014, and 2016 year classes, and the lowered fishing mortality. The stock biomass fell to a level well below B_{lim} in 2005 which is the lowest level ever recorded. By 1st January 2007 and 2008 the stock was at B_{pa} (= MSY $B_{escapement}$) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1st January 2009, 2010, 2011, 2012, 2014, 2015, 2016 and 2017 has been above B_{pa} (i.e. the stock show full reproductive capacity).

The recruitment in 2010 was very low and at the same level as the low 2003 and 2004 year classes where these three year classes are the lowest on record since the mid-1980s.

The recruitment in 2008, 2009, 2012, 2014 and 2016 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 was slightly below long term average (44 billion), but because of the strong 2012, 2014 and 2016 year classes the SSB has been well above B_{pa} (= MSY $B_{escapement}$) by 1st January 2014, 2015, 2016 and 2017 even with a high yearly TAC in 2014-2017 considering growth, high natural mortality, and 20% maturation at age 1. Because of the nearly average recruitment in 2015 and 2017 and the strong 2016 recruitment the stock is expected to remain above B_{pa} by the end of 2017.

12.3.4 Comparison with 2015 and 2016 assessments

The final, accepted September 2015 SXSA assessment run was compared to the inter-benchmark May 2012 and the update September 2014 and May 2014 Scenario 2 SXSA assessments. The results of the comparative runs between the September 2015 and the September 2014 and May 2014 assessments are shown in the ICES WGNSSK 2015 Report. The resulting outputs of these assessments showed to be identical giving similar perception of stock status and dynamics.

The WKPOUT 2016 benchmarking comparison of the SESAM and SXSA May 2014 assessments are presented in the ICES WKPOUT 2016 Report. The overall conclusions were that the two assessments give the same perception of stock dynamics with respect to abundance (SSB) and recruitment over time. There was some variability in the estimates of fishing mortality especially in the middle of the assessment period, however, the SXSA estimates lies within the confidence intervals of the SESAM estimates of fishing mortality.

In Figures 12.3.1, 12.3.3 and 12.3.4 the SESAM September 2017 assessment estimates of spawning stock biomass, fishing mortality, and recruitment are shown, respectively, in comparison to the corresponding SXSA May 2014 assessment estimates. It also appears from this comparison that the conclusions are the same as above for the comparison of the two 2014 assessments, i.e. that the two assessments give the same perception of stock dynamics.

The retrospective analysis based on the SESAM September 2017 assessment is shown in Figure 12.3.8. There is a tendency towards the retrospective analyses do not fully converge even though being at the same level and showing the same perceptions of the stock dynamics. It should be noted that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments. In the benchmark May 2014 assessment it is estimated to 40 kt while in the present September 2017 assessment it is estimated to 30 kt.

12.4 Historical stock trends

The assessment and historical stock performance is consistent with previous years assessments, i.e. the perception of stock dynamics of the SSB and recruitment over time are consistent, while there is some variability between models in the estimates of the average fishing mortality of ages 1 and 2 over time especially in the middle of the assessment period, however, the SXSA estimates of fishing mortality is within the confidence limits of the SESAM estimates of fishing mortality. However, based on the Inter-Benchmark in spring 2012 with revised estimates of natural mortality, maturity at age and mean weight at age for the stock in the assessment there is a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10% in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter. This is shown in the ICES IBPNorwayPout Report (ICES 2012c) and the Stock Annex.

12.5 Recruitment Estimates

The long-term average recruitment (age 0, 2nd quarter) is 40 billions (arithmetic mean) for the period 1984–2017 (Table 12.3.6). Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species and because 20% reach maturity as 1-group. The recruitment reached historical minima in 2003–2004 as well as in 2010. The recruitment in 2008, 2009, 2012, 2014 and 2016 was high. Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 has been slightly below long term average (44 billion).

12.6 Short-term prognoses

The short-term forecast is stochastic based on the SESAM September 2017 assessment, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season. The SESAM is, like the SXSA, a quarterly based model estimating biomass at the start of each quarter of the year.

Short-term projections are carried out as follows.

1. Assume values for M, weight-at-age in the catches and in the stock, and maturity-at-age for the projection period. Since all of those quantities except weight-at-age in the catches are assumed constant over time, only weight-at-age requires special treatment. A procedure for forecasting catch weights is described in ICES WKPOUT 2016 (WD6; Nielsen and Berg 2016), but see also below.

2. Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years.

3. Assume that log Ft = log Ft-4 + log Gt, for all future values of t where Gt is some chosen vector of multipliers of the F-process. If Gt = 1 for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year.

4. Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution.

It should be noted that the short term forecast only uses the observed 2017 recruitment (Q3 2017) in the SSB estimate by 4th quarter 2018. The recruits in 2018 do not become a part of SSB by 4th quarter (1st October) 2018 because they have not reached maturity yet by 4th quarter 2018, but will do that by 1st January 2019 (20% mature as 1-group here). However, the forecast is just run up to 4th quarter 2018, and the recruits in 2018 is accordingly not used (and shall not be that) in the forecast SSB estimate in Q4 2018.

5. Find Gt such that the fifth (or any other) percentile of the catches (total mass) in the projections equal some desired level such as B_{lim} (optional).

Forecasting weight-at-age in the catches.

There is substantial variation in weight-at-age in the commercial catches from year to year, which means that usual methods of using running averages will be quite sensitive to the bandwidth of the running average. This is important, since TAC estimates calculated in step 5 above depend directly on the catch weight-at-age.

The following model is used:

$$E(\sqrt{CW_{a,q,t}}) = \mu_{a,q} + s(cohort, a) + U_t$$

where $\mu_{a,q}$ is a mean for each combination of quarter and age, s( ) is tensor product smoothing spline, and U_t are normal distributed random effects. The square root transform is used to achieve variance homogeneity in the residuals. See Figure 1 in ICES WKPOUT 2016 (WD6; Nielsen and Berg 2016).

The projected mean weight at ages in the catch used in the forecast are shown in Table 12.6.1.

Forecasts:

The first forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1st October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1st October as explained below in Section 12.7. The purpose of the first forecast is to calculate the catch of Norway pout from 1st October 2017 to 31st October 2018 with F scaled such that the fifth percentile of the SSB distribution one year ahead (1st October 2018) equals B_{lim}, i.e. where the probability of SSB being below B_{lim} by 1st October in the forecast year is less than 5%. The results of the first forecast are presented in Table 12.6.2 and Figure 12.6.1, and this results in a catch up to 151 kt (151 955 t) in the directed Norway pout fishery in the period 1st October 2017 to 31st October 2018 which corresponds to an $F_{bar(1–2)}$ of 0,225 and an SSB at 115 kt (115 260 t) by 1st October 2018.

The purpose of the second forecast is to calculate the catch of Norway pout from 1st October 2017 to 31st October 2018 with F scaled to zero. The results of the second forecast are presented in Table 12.6.3 and Figure 12.6.2 resulting in no catch in the directed Norway pout fishery in the period 1st October 2017 to 31st October 2018 which corresponds to an $F_{bar(1–2)}$ of 0,00 and an SSB at 161 kt by 1st October 2018.

The purpose of the third forecast is to calculate the catch of Norway pout from 1st October 2017 to 31st October 2018 with F scaled to F status quo for previous year up to 1st October 2017. The results of the third forecast are presented in Table 12.6.4 and Figure 12.6.3 where catches up to 131 kt can be taken in the directed Norway pout fishery in the period 1st October 2017 to 31st October 2018 which corresponds to an $F_{bar(1–2)}$ of 0,188 and an SSB at 121 kt by 1st October 2018.

The purpose of the fourth forecast is to calculate the catch of Norway pout from 1st October 2017 to 31st October 2018 with F scaled such that the median of the SSB distribution one year ahead (1st October 2018) equals B_{lim}. The results of the fourth forecast are presented in Table 12.6.5 and Figure 12.6.4 where catches up to 372 kt can be taken in the directed Norway pout fishery in the period 1st October 2017 to 31st October 2018 which corresponds to an $F_{bar(1–2)}$ of 1,215 and an SSB of 39 kt by 1st October 2018.

The purpose of the fifth forecast is to calculate the catch of Norway pout from 1st October 2017 to 31st October 2018 with F scaled such that SSB one year ahead (1st October 2018) equals B_{pa}. The results of the fifth forecast are presented in Table 12.6.6 and Figure 12.6.5 where catches up to 308 kt can be taken in the directed Norway pout fishery in the period 1st October 2017 to 31st October 2018 which corresponds to an $F_{bar(1–2)}$ of 0,718 and an SSB of 65 kt (= B_{pa}) by 1st October 2018.

12.7 Medium-term projections

No medium-term projections are performed for this stock. The stock contains only a few age groups and is highly influenced by recruitment.

12.8 Biological reference points

As explained in the ICES WKPOUT 2016 Report, Section 3.8, the benchmark has recommended that the $B_{lim} = B_{loss}$ should be the lowest SSB estimated in quarter 4, because this is closest to the beginning of the fishing season (1st November), and would be the most appropriate to use as a B_{lim} reference point, because the probability of SSB being below B_{lim} can then be evaluated immediately after the fishing season for which a TAC is being calculated. It was argued that the quarter 4 SSB (an existing output of the SESAM model) was adequate for this purpose because any attempt to calculate an SSB corresponding to 1st November would require further assumptions and would effectively only be an interpolation between the quarter 4 and subsequent quarter 1 SSBs, thus unnecessarily complicating the calculation of the SSB. The forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1st October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1st October. Accordingly, it is recommended that this TAC is used for the management year 1st November–31st October. This is an approximation and will be sustainable unless radical changes occur in the seasonal fishing pattern used in the forecast. In the period between 1st October and 1st November in the forecast year, a new assessment will be provided.

In Table 12.6.7 quarterly minima of the estimated SSB time series (1984–2016) are shown from the SESAM Benchmark Assessment Baseline Run from the Norway pout benchmark assessment under ICES WKPOUT 2016. The estimates are quarterly minima estimated at the beginning of the season. The lowest observed biomasses in the assessment period are in 2005. The estimates are B_{loss} estimates which equals B_{lim} according to the ICES WKPOUT 2016 benchmark assessment which by 1st October is B_{lim}= 39 450 t.

The B_{lim} SSB estimate in Q4 is low because of the 0-group and many of the 1-group fish are not in the SSB yet at that time. However, in the forecast there is a change in maturity and an age class shift by 1st January, i.e. the 0-group becomes 1-group and 20% of those become mature, and the 1-group becomes 2-group and 100% of those become mature. This is in the forecast calculated into the SSB available for spawning in 1st quarter of the forecast year.

The fishing pattern has not changed in the most recent years. Accordingly, the use of B_{lim} by Q4 should be sustainable.

It should be noted that there is a tendency towards the retrospective analyses do not fully converge even though being at the same level. It should also be noted that there is quite some difference between estimates of the B_{loss} level in the start of Q4 in 2005 between assessments. In the benchmark May 2014 assessment it is estimated to 40 kt (39 450 t) while in the present September 2017 assessment it is estimated to 30 kt (30 750 t).

	Type	Value	Technical basis
MSY	MSY	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
Approach	F_{MSY}	Undefined	None advised
	B_{lim}	39 450 t, quarter 4	$B_{lim} = B_{loss}$, the lowest observed biomass in 2005
Precautionary	B_{pa}	65 000 t, quarter 4	$= B_{lim}\ e^{0.3*1.65}$
Approach	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

No F-based reference points are advised for this stock.

Norway pout is a short lived species and most likely a one time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a,b; Lambert *et al.*, 2009). Furthermore, 20% of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to a limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short lived species.

On this basis, advice on yield in the forecast year where the probability of SSB being below B_{lim} by 1st October in the forecast year is less than 5% is considered sustainable. That is where F is scaled such that the fifth percentile of the SSB distribution one year ahead (1st October in forecast year) equals B_{lim}.

B_{pa} has been calculated from

$$B_{pa} = B_{lim}\ e^{0.3*1.65}\ \ (SD)$$

An SD estimate around 0.3–0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2–0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS, 1999). The relationship between the B_{lim} and B_{pa} (39 450 and 65 000 t) is 0.6.

It is obvious that the Norway pout, being a short-lived species, has no well-defined break point (inflection) in the SSB-R relationship (ICES IBPNorwayPout Report, ICES 2012c; ICES WKPOUT 2016) and therefore there is no clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high recruitment observed at B_{loss} as well as more observations above than below the inflection point).

The $B_{lim} = B_{loss} = 39\ 450$ t (quarter 4) is based on the lowest observed SSBs in 2005.

12.9 Quality of the assessment

The estimates of the SSB, recruitment and the average fishing mortality of the 1- and 2-group are consistent with the estimates of previous years' assessment. The overall perception of stock dynamics with respect to abundance (SSB) and recruitment over time is the same. There is some variability in the estimates of fishing mortality especially in the middle of the assessment period, however, the previous year estimates of fishing mortality lies within the confidence intervals of the SESAM estimates of fishing mortality.

The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the assessment taking into account the seasonality in fishery, use of seasonal based fishery independent information, and using most recent information about recruitment. The assessment provides stock status and year class strengths of all year classes in the stock up to the end of third quarter of the assessment year. The assessment method gives a good indication of the stock status the 1st October the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

12.10 Status of the stock

Based on the estimates of SSB in September 2017, ICES classifies the stock at full reproductive capacity.

With an F scaled such that the fifth percentile of the SSB distribution by 1st October 2018 equals B_{lim}, i.e. where the probability of SSB being below B_{lim} by 1st October 2018 is less than 5% then catches up to 151 kt (151 955 t) can be taken in the directed Norway pout fishery in the period 1st October 2017–31st October 2018. This is due to the very strong 2014 and 2016 recruitment and the just slightly below long term average recruitment (44 billion) in 2015 and 2017, growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.43). Targeted fishery for Norway pout was closed in 2005, first half year 2006, in all of 2007, as well as in first half of 2011 and 2012 and fishing mortality and effort has accordingly reached historical minima in these periods (Table 12.3.6). The fishery was open for the second half 2006, 2011 and 2012 as well as in all of the years 2008–2010 and 2013–2017. Here, the fishing mortality was low in 2008 and 2011, moderate in 2009 and 2010, and on a higher level in 2013–2016, but still well below the long term average.

The recruitment reached historical minima in 2003–2004 and the 1987, 2002, 2006, and 2010 year classes were weak. The recruitment in 2008, 2009, 2012, 2014 and 2016 was high, well above the long term average (44 billion). Recruitment in 2011 and 2013 was also very low, and the recruitment in 2015 and 2017 has been slightly below the long term average (Table 12.3.6).

12.11 Management considerations

There are no management objectives for this stock.

From the results of the forecast presented here with a F scaled such that the fifth percentile of the SSB distribution by 1st October 2018 equals B_{lim}, i.e. where the probability of SSB being below B_{lim} by 1st October 2018 is less than 5%, then catches up to 151 kt (151 955 t) can be taken in the directed Norway pout fishery in the period 1st October

2017 to 31st October 2018 which corresponds to an $F_{bar(1-2)}$ of 0,225 and an SSB at 115 kt (115 260 t) by 1st October 2018. This is due to the nearly average recruitment in 2015 and 2017 and the strong 2016 recruitment, as well as, growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Norway pout is a short lived species and most likely a one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt *et al.* 2002a,b; Lambert *et al.*, 2009). Furthermore, 20% of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short lived species.

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES WGSAM, 2014; 2011; ICES-SGMSNS, 2006). Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and bycatch regulations to protect other species have been maintained. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the Stock Annex.

Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. Existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade, and in general, the bycatch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of bycatch of other species in the Norway pout fishery also appears from Table 12.2.1. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is still ongoing. ICES suggests, that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. The implementation of these technical measures shall be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in Nielsen *et al.* (2016a) and in the Stock Annex.

12.11.2 Long term management strategies

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F = 0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES does not recommend any particular one of the strategies.

The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The variable TAC escapement strategy as evaluated in 2007 has higher long term yield compared to the fixed fishing mortality strategy (and the fixed TAC strategy), but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better.

There should be no shift in management strategies between years. In recent years the escapement strategy has been practiced.

A detailed description of the long term management strategies and management plan evaluations can be found in the Stock Annex and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30, Section 5.3) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports as well as in Vinther and Nielsen (2012, 2013). Long term fixed E or F management strategy and a long term fixed TAC strategy for Norway pout was performed in 2007. ICES has again in September–October 2012 and April–May 2013 (Vinther and Nielsen, 2012, 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information. In September 2012 ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100–250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the result that an initial TAC between 25–50 kt and a fixed F = 0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference between the MSE 1 and 2–3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2–3), while the minimum TAC in MSE 1 can be applied all year. As a follow up on this, ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1st November–31st October rather than from 1st January to 31st December, and one annual advice from the September assessment, with the result that a minimum TAC up to 20 kt with maximum TAC of 100 kt ($F_{max/cap}$ = 0.8) or with maximum TAC of 200 kt ($F_{max/cap}$ = 0.6) will be long term sustainable with some level of F control according to those F_{cap} levels.

With the changes introduced by the September 2016 Norway pout benchmark assessment (ICES WKPOUT 2016 and annexes) involving change of assessment model, change of assessment year, change of assessment period, removal of the commercial fishery tuning fleet in the assessment, change of the plus-group in the assessment from

4+ to 3+ and change of stock MSY reference level the above Management Strategy Evaluations cannot be used anymore for long term management plans of the stock including the F_{cap} estimates there and initial and minimum TACs.

Management strategy evaluation according to the new benchmark assessment and the revised reference levels as established from the benchmark assessment in August 2016 is planned for 2018 according to a joint EU-Norway request on this.

12.12 Other issues

Recommendations for future assessments:

There are indications of age reading differences between countries of Norway pout otoliths, and a full scale otolith exchange program has been launched by ICES in 2016–2017. The otolith exchange program and check of age readings as well as the final analyses and reporting of the results are ongoing.

Data needs:

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality.

The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. This also implies need for information on prey switching dynamics of North Sea fish predators which also are foraging on Norway pout. Biological interactions with respect to intra-specific and inter-specific relationships for Norway pout stock dynamics and important predator stock dynamics have been reviewed and further analysed in Nielsen (2016; Section 6) and there is referred to the general conclusions here.

12.13 References

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Table 12.2.1. Norway pout in 4 and 3.a. Nominal landings ('000 tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas 4 and 3.a in the period 2006–2016, as officially reported to ICES, EU and FAO. Bycatches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	18	24	156	-	51	2	118	6.945	538	2.220	929 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Norway	2	-	-	209	711	-	-	147	9	41	82 *
Sweden	-	-	-	-	10	-	-	1	1	1	3 *
Germany	-	-	4	-	-	-	-	-	-	-	-
Total	20	24	160	209	772	2	118	7.093	548	2.262	1.014

*Preliminary.

Norway pout ICES area IVa

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	39.531	59	32.158	19.226	71.032	4.038	25.431	31.375	27.894	10.760	22.716 *
Faroe Islands	-	-	-	-	-	-	-	-	-	5.270	3.156 *
Netherlands	-	-	-	22	18	-	-	-	-	17	7 *
Germany	15	-	-	-	-	-	-	-	-	22	27 *
Norway	13.618	4.712	6.650	36.961	64.303	3.189	4.528	45.839	18.647	43.742	35.959 *
Sweden	-	-	10	-	+	1	3 *	4	1	12	1 *
UK(Scotland)	-	-	-	-	29	-	6 *	-	8	3	12 *
Total	53.164	4.771	38.818	56.209	135.353	7.228	29.962	77.218	46.542	59.823	61.866

*Preliminary.

Norway pout ICES area IVb

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	394	-	244	595	229	32	9	43	16	53	2244 *
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-
Germany	19	-	-	75	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	1	- *
Norway	2	-	-	82	620	21	59 *	615	8	577	11 *
Sweden	-	-	-	-	-	-	-	0	0	714	1 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	6	-	18 *
Total	415	0	244	752	849	53	68	658	30	1.345	2.274

*Preliminary.

Norway pout ICES area IVc

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	-	-	-	-	-	-	-	-	-	-	1
France	-	+	+	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	0	0	1

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	39.943	83	32.558	19.821	71.312	4.072	25.558	38.363	28.448	13.033	25.890
Faroe Islands	0	0	0	0	0	0	0	0	0	5.270	3.156
Norway	13.622	4.712	6.650	37.252	65.634	3.210	4.587	46.601	18.664	44.360	36.052
Sweden	0	0	10	0	10	1	3	5	2	727	5
Netherlands	0	0	0	22	18	0	0	0	0	18	7
Germany	34	0	4	75	0	0	0	0	0	22	27
UK	0	0	0	0	0	0	0	0	6	0	18
Total nominal landings	53.599	4.795	39.222	57.170	136.974	7.283	30.148	84.969	47.120	63.430	65.155
By-catch of other species and other	-6.973	-	-3.084	-2.670	-11.019	-759	-3.075	-2.869	-2.950	-30	-1.755
ICES estimate of total landings (IV+IIIaN	46.626	-	36.138	54.500	125.955	6.524	27.073	82.100	44.170	63.400	63.400
Agreed TAC	95.000	0****	114.616 x	116.279 x	162.950 x	4.500 x	70.683 x	165.700 x	128.250 x	150.000 x	150.000 x

* provisional / preliminary

** provisional / preliminary

*** 781 ton from trial fishery (directed fishery); 160 ton from by-catches in other fisheries

**** A by-catch qouta of 5000 t has been set.

***** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

+ Landings less than 1

n/a not available

x EU TAC

Table 12.2.2. Norway pout in 4 and 3.a. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, 3.aS) by country, for 1961–2016 (Data provided by ICES WGNSSK Working Group members). (Norwegian landing data include landings of bycatch of other species). Includes bycatch of Norway pout in other (small meshed) fisheries).

Year	Denmark		Faroes	Norway	Sweden	UK (Scotland)	Others	Total
	North Sea	Skagerrak						
1961	20,5	-	-	8,1	-	-	-	28,6
1962	121,8	-	-	27,9	-	-	-	149,7
1963	67,4	-	-	70,4	-	-	-	137,8
1964	10,4	-	-	51	-	-	-	61,4
1965	8,2	-	-	35	-	-	-	43,2
1966	35,2	-	-	17,8	-	-	+	53,0
1967	169,6	-	-	12,9	-	-	+	182,5
1968	410,8	-	-	40,9	-	-	+	451,7
1969	52,5	-	19,6	41,4	-	-	+	113,5
1970	142,1	-	32	63,5	-	0,2	0,2	238,0
1971	178,5	-	47,2	79,3	-	0,1	0,2	305,3
1972	259,6	-	56,8	120,5	6,8	0,9	0,2	444,8
1973	215,2	-	51,2	63	2,9	13	0,6	345,9
1974	464,5	-	85,0	154,2	2,1	26,7	3,3	735,8
1975	251,2	-	63,6	218,9	2,3	22,7	1	559,7
1976	244,9	-	64,6	108,9	+	17,3	1,7	437,4
1977	232,2	-	48,8	98,3	2,9	4,6	1	387,8
1978	163,4	-	18,5	80,8	0,7	5,5	-	268,9
1979	219,9	9	21,9	75,4	-	3	-	329,2
1980	366,2	11,6	34,1	70,2	-	0,6	-	482,7
1981	167,5	2,8	16,4	51,6	-	+	-	238,3
1982	256,3	35,6	12,3	88	-	-	-	392,2
1983	301,1	28,5	30,7	97,3	-	+	-	457,6
1984	251,9	38,1	19,11	83,8	-	0,1	-	393,01
1985	163,7	8,6	9,9	22,8	-	0,1	-	205,1
1986	146,3	4	2,5	21,5	-	-	-	174,3
1987	108,3	2,1	4,8	34,1	-	-	-	149,3
1988	79	7,9	1,3	21,1	-	-	-	109,3
1989	95,7	4,2	0,8	65,3	+	0,1	0,3	166,4
1990	61,5	23,8	0,9	77,1	+	-	-	163,3
1991	85	32	1,3	68,3	+	-	+	186,6
1992	146,9	41,7	2,6	105,5	+	-	0,1	296,8
1993	97,3	6,7	2,4	76,7	-	-	+	183,1
1994	97,9	6,3	3,6	74,2	-	-	+	182
1995	138,1	46,4	8,9	43,1	0,1	+	0,2	236,8
1996	74,3	33,8	7,6	47,8	0,2	0,1	+	163,8
1997	94,2	29,3	7,0	39,1	+	+	0,1	169,7
1998	39,8	13,2	4,7	22,1	-	-	+	57,7
1999	41	6,8	2,5	44,2	+	-	-	94,5
2000	127	9,3	-	48	0,1	-	+	184,4
2001	40,6	7,5	-	16,8	0,7	+	+	65,6
2002	50,2	2,8	3,4	23,6	-	-	-	80,0
2003	9,9	3,4	2,4	11,4	-	-	-	27,1
2004	8,1	0,3	-	5	-	-	0,1	13,5
2005	0.9*	-	-	1	-	-	-	1,9
2006	35,1	0,1	-	11,4	-	-	-	46,6
2007	2.0**	-	-	3,7	-	-	-	5,7
2008	30,4	-	-	5,7	+	-	+	36,1
2009	17,5	-	-	37,0	+	-	+	54,5
2010	64,9	0,2	-	60,9	+	+	+	126,0
2011	3,3	-	-	3,2	+	+	+	6,5
2012	22,3	0,1	-	4,6	+	+	+	27,0
2013	29,0	6,2	-	46,9	+	+	+	82,1
2014	25,0	0,5	-	18,7	+	+	+	44,2
2015	10,8	2,2	5,3	44,4	0,7	+	+	63,4
2016	23,2	0,9	3,2	36,1	+	+	+	63,4

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.

** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 12.2.3. Norway pout in 4 and 3.a. National landings ('000 tonnes) by quarter of year 2000–2017 and by area and country. (Data provided by Working Group members. Norwegian landing data include landings of bycatch of other species). (Bycatch of Norway pout in other (small meshed) fisheries included)

Year	Quarter	Denmark									Norway		Total
	Area	IIIaN	IIIaS	Div. IIIa	IVaE	IVaW	IVb	IVc	Div. IV	Div. IV + IIIaN	IVaE	Div. IV	Div. IV + IIIaN
2000	1	0	11	12	3.726	1.038	-	-	4.764	4.765	5440	5440	10.205
	2	929	15	944	684	22	227	-	933	1.862	9779	9779	11.641
	3	7.380	139	7.519	1.708	5.613	515	-	7.836	15.216	28428	28428	43.644
	4	947	209	1.157	1.656	111.732	76	-	113.464	114.411	4334	4334	118.745
	Total	9.257	375	9.631	7.774	118.406	818	-	126.998	136.255	47.981	47981	184.236
2001	1			302	7.341	9.734	103	72	17.250	17.250	3838	3838	21.088
	2			2.174	31	30	269	-	330	330	9268	9268	9.598
	3			2.006	15	154	191	-	360	360	2263	2263	2.623
	4			3.059	2.553	19.826	329	-	22.708	22.708	1426	1426	24.134
	Total			7.541	9.940	29.744	892	72	40.648	40.648	16.795	16795	57.443
2002	1	-	1	1	4.869	1.660	114	-	6.643	6.643	1896	1896	8.539
	2	883	161	1.045	56	9	22	-	87	970	5563	5563	6.533
	3	1.567	213	1.778	2.234	14.739	104	-	17.077	18.644	14147	14147	32.791
	4	393	100	492	1.787	24.273	335	-	26.395	26.788	2033	2033	28.821
	Total	2.843	475	3.316	8.946	40.681	575	-	50.202	53.045	23.639	23639	76.684
2003	1	-	1	1	615	581	22	-	1.218	1.218	1976,86	1976,86	3.195
	2	246	160	406	76	-	22	-	98	344	2773,5	2773,499	3.117
	3	2.984	1.005	3.989	172	1.613	89	-	1.874	4.858	5989,37	5989,366	10.847
	4	188	547	735	-	6.270	457	-	6.727	6.915	643,592	643,592	7.559
	Total	3.418	1.713	5.131	863	8.464	590	-	9.917	13.335	11.383	11383,32	24.718
2004	1	316	-	316	87	650	-	-	737	1.053	989	989	2.042
	2	-	-	-	-	-	7	-	7	7	660	660	667
	3	14	-	14	289	1.195	9	-	1.493	1.507	2484	2484	3.991
	4	13	-	13	93	5683	107	-	5.883	5.896	865	865	6.761
	Total	343	-	343	469	7.528	123	-	8.120	8.463	4.998	4.998	13.461
2005	1	-	-	-	9	0	-	-	9	9	12	12	21
	2	-	-	-	151	-	0	-	151	151	352	352	503
	3	-	-	-	781	0	0	-	781	781	387	387	1.168
	4	0	-	-	0	0	0	-	-	-	211	211	211
	Total	-	-	-	941	-	-	-	941	941	962	962	1.903
2006	1	-	-	-	75	83	-	-	158	158	2.205	2205	2.363
	2	-	-	-	-	-	15	-	15	15	2.846	2846	2.861
	3	114	-	114	-	649	20	-	669	783	5.749	5749	6.532
	4	3	-	3	-	34.262	-	-	34.262	34.265	605	605	34.870
	Total	117	-	117	75	34.994	35	-	35.104	35.221		11.405	46.626
2007	1	-	-	-	561	789	-	-	1.350	1.350	74	74	1.424
	2	-	-	-	4	-	-	-	4	4	1.097	1097	1.101
	3	1	2	3	-	-	-	-	-	1	2.429	2429	2.430
	4	-	-	-	-	682	-	-	682	682	155	155	837
	Total	1	2	3	565	1.471	-	-	2.036	2.037		3.755	5.792
2008	1	125	-	125	19	86	123	-	228	353	7	7	360
	2	-	-	-	-	-	30	-	30	30	1.803	1803	1.833
	3	-	-	-	-	6.102	-	-	6.102	6.102	3.582	3582	9.684
	4	-	-	-	-	22.686	1.239	-	23.925	23.925	336	336	24.261
	Total	125	-	125	19	28.874	1.392	-	30.285	30.410		5.728	36.138
2009	1	1	-	1	22	515	-	-	537	538	2	2	540
	2	-	-	-	-	-	-	-	-	-	4.026	4026	4.026
	3	2	-	2	-	11.567	-	-	11.567	11.569	31.251	31251	42.820
	4	-	-	-	-	5.399	4	-	5.403	5.403	1.736	1736	7.139
	Total	3	-	3	22	17.481	4	-	17.507	17.510	37.015	37.015	54.525
2010	1	-	-	-	-	194	-	-	194	194	104	104	298
	2	157	-	157	-	478	59	-	537	694	17.906	17906	18.600
	3	37	-	37	-	33.618	213	-	33.831	33.868	41.883	41883	75.751
	4	8	-	8	-	30.276	38	-	30.314	30.322	984	984	31.306
	Total	202	-	202	-	64.566	310	-	64.876	65.078	60.877	60.877	125.955
2011	1	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	-	-	-	-	188	188	188
	3	-	-	-	-	456	5	-	461	461	3.004	3004	3.465
	4	-	-	-	-	2.853	-	-	2.853	2.853	18	18	2.871
	Total	-	-	-	-	3.309	5	-	3.314	3.314	3.210	3.210	6.524
2012	1	-	-	-	-	15	-	-	15	15	12	12	27
	2	-	-	-	-	-	-	-	-	-	280	280	280
	3	2	-	2	-	62	8	-	70	72	395	395	467
	4	125	-	125	-	22.204	-	-	22.204	22.329	3.900	3.900	26.229
	Total	127	-	127	-	22.281	8	-	22.289	22.416	4.587	4.587	27.003
2013	1	-	-	-	-	59	-	-	59	59	18	18	77
	2	6	-	6	-	409	-	-	409	415	10.045	10.045	10.460
	3	4.791	-	4.791	5	3.260	43	-	3.308	8.099	16.350	16.350	24.449
	4	1.366	-	1.366	-	25.211	-	-	25.211	26.577	20.537	20.537	47.114
	Total	6.163	-	6.163	5	28.939	43	-	28.987	35.150	46.950	46.950	82.100
2014	1	-	-	-	-	1.318	-	-	1.318	1.318	6	6	1.324
	2	62	-	62	-	-	2	-	2	64	3.146	3.146	3.210
	3	492	-	492	-	5.606	20	-	5.626	6.118	7.252	7.252	13.370
	4	-	-	-	-	18.006	-	-	18.006	18.006	8.260	8.260	26.266
	Total	554	-	554	-	24.930	22	-	24.952	25.506	18.664	18.664	44.170
2015	1	-	-	-	21	305	-	-	326	326	268	268	594
	2	2	-	2	-	549	-	-	549	551	6.812	6.812	7.363
	3	2.217	1	2.218	10	3.221	19	-	3.250	5.467	21.335	21.335	26.802
	4	-	-	-	-	6.689	-	-	6.689	6.689	15.945	15.945	22.634
	Total	2.219	1	2.220	31	10.764	19	-	10.814	13.033	44.360	44.360	57.393
2016	1	-	-	-	-	514	-	-	514	514	575	575	1.089
	2	244	1	245	-	267	-	-	267	511	8.296	8.296	8.807
	3	673	1	674	5	2.222	51	-	2.278	2.951	20.897	20.897	23.848
	4	-	-	-	3	20.135	-	-	20.138	20.138	6.286	6.286	26.424
	Total	917	2	919	8	23.138	51	-	23.197	24.114	36.054	36.054	60.168
2017	1	-	-	-	-	703	-	-	703	703	30	30	733
	2	105	-	105	-		-	-	-	105	3.470	3.470	3.575
	3	-	-	-	6	149	17	-	172	172	9.079	9.079	9.251

Table 12.2.3a. Norway pout in 4 and 3.aN (Skagerrak). Observed and SESAM model predicted total catches in tonnes by quarter (millions).

	YEAR	OBSERVED	PREDICTED
1	1984.00	56790	63617
2	1984.25	56532	38177
3	1984.50	152291	120292
4	1984.75	110942	100496
5	1985.00	57467	47663
6	1985.25	15509	15986
7	1985.50	62489	70810
8	1985.75	92017	64955
9	1986.00	37773	24872
10	1986.25	7657	8684
11	1986.50	45085	37866
12	1986.75	89993	40659
13	1987.00	33883	30118
14	1987.25	15435	8849
15	1987.50	38729	38951
16	1987.75	60847	76715
17	1988.00	22181	20661
18	1988.25	3559	5537
19	1988.50	21793	16748
20	1988.75	61762	32941
21	1989.00	15379	11787
22	1989.25	13234	12031
23	1989.50	55066	41997
24	1989.75	82880	50750
25	1990.00	27984	25321
26	1990.25	39713	25261
27	1990.50	26156	30252
28	1990.75	45242	46686
29	1991.00	42722	33164
30	1991.25	20786	22404
31	1991.50	62518	58584
32	1991.75	64380	60093
33	1992.00	64218	51852
34	1992.25	27973	26862

	YEAR	OBSERVED	PREDICTED
35	1992.50	114122	85032
36	1992.75	96177	83008
37	1993.00	36214	47104
38	1993.25	29291	27855
39	1993.50	62290	66384
40	1993.75	53470	57222
41	1994.00	34575	30015
42	1994.25	15373	15373
43	1994.50	53799	46446
44	1994.75	79838	43644
45	1995.00	36942	28301
46	1995.25	28019	21229
47	1995.50	69763	59025
48	1995.75	97048	59806
49	1996.00	21888	25746
50	1996.25	13366	15088
51	1996.50	74631	68134
52	1996.75	46194	39191
53	1997.00	15320	15916
54	1997.25	8708	8422
55	1997.50	78809	63414
56	1997.75	54100	48355
57	1998.00	19502	17985
58	1998.25	11836	12083
59	1998.50	20866	29802
60	1998.75	22830	24403
61	1999.00	7827	7260
62	1999.25	12533	8398
63	1999.50	41445	27280
64	1999.75	30497	31632
65	2000.00	10207	11163
66	2000.25	11589	12947
67	2000.50	44173	40582
68	2000.75	119001	68375
69	2001.00	21400	16328
70	2001.25	11778	9305

	YEAR	OBSERVED	PREDICTED
71	2001.50	4630	12037
72	2001.75	26565	31254
73	2002.00	8553	7594
74	2002.25	6686	4511
75	2002.50	32922	19073
76	2002.75	28947	23626
77	2003.00	3190	3156
78	2003.25	3106	2007
79	2003.50	10833	11476
80	2003.75	7518	7218
81	2004.00	2040	1644
82	2004.25	667	581
83	2004.50	4018	5026
84	2004.75	6762	7323
85	2005.00	8	5
86	2005.25	8	5
87	2005.50	13	9
88	2005.75	13	10
89	2006.00	2205	1814
90	2006.25	2848	2341
91	2006.50	6551	8003
92	2006.75	34949	27166
93	2007.00	1428	614
94	2007.25	1100	1192
95	2007.50	2430	3619
96	2007.75	838	1693
97	2008.00	361	299
98	2008.25	1840	1642
99	2008.50	8532	6038
100	2008.75	24111	4911
101	2009.00	538	202
102	2009.25	2105	2963
103	2009.50	36661	24559
104	2009.75	6509	8668
105	2010.00	198	246
106	2010.25	40322	8925

	YEAR	OBSERVED	PREDICTED
107	2010.50	57487	31544
108	2010.75	33071	18797
109	2011.00	0	0
110	2011.25	222	1019
111	2011.50	3749	6330
112	2011.75	2872	5985
113	2012.00	29	39
114	2012.25	281	506
115	2012.50	469	1322
116	2012.75	26168	15887
117	2013.00	79	109
118	2013.25	10460	3362
119	2013.50	24444	14869
120	2013.75	47126	54364
121	2014.00	1324	416
122	2014.25	3212	3986
123	2014.50	13384	17049
124	2014.75	26244	21257
125	2015.00	594	568
126	2015.25	7364	6324
127	2015.50	26804	30758
128	2015.75	22655	32891
129	2016.00	1089	739
130	2016.25	8846	7155
131	2016.50	23849	23072
132	2016.75	26457	27073
133	2017.00	735	565
134	2017.25	3474	4735
135	2017.50	9357	7795

Table 12.2.4. Norway pout in 4 and 3.aN (Skagerrak). Catch in numbers at age by quarter (millions). SOP is given in tonnes. Data for 1990 were estimated within the SXSA program used in the 1996 assessment.

Age	Year	1984				1985				1986			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	1	2231	0	0	6	678	0	0	0	5572
1		2.759	2252	5290	3492	2.264	857	1400	2991	396	260	1186	1791
2		1.375	1165	1683	734	1.364	145	793	174	1069	87	245	39
3		143	269	8	0	192	13	19	0	72	3	6	0
4+		0	0	0	0	1	0	0	0	3	0	0	0
SOP		56790	56532	152291	110942	57464	15509	62489	92017	37889	7657	45085	89993
Age	Year	1987				1988				1989			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	8	227	0	0	741	3146	0	0	159	4854
1		2687	1075	1627	2151	249	95	183	632	1736	678	1672	1741
2		401	60	171	233	700	74	250	405	48	133	266	93
3		12	0	0	5	20	0	0	0	6	6	5	13
4+		1	0	0	0	0	0	0	0	0	0	0	0
SOP		33894	15435	38729	60847	22181	3559	21793	61762	15379	13234	55066	82880
Age	Year	1990				1991				1992			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	20	993	0	0	734	3486	0	0	879	954
1		1840	1780	971	1181	1501	636	1519	1048	3556	1522	3457	2784
2		584	572	185	116	1336	404	215	187	1086	293	389	267
3		20	19	6	4	93	19	22	18	118	20	1	2
4+		10	0	0	0	6	0	0	0	3	0	0	0
SOP		28287	39713	26156	45242	42776	20786	62518	64380	64224	27973	114122	96177
Age	Year	1993				1994				1995			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	96	1175	0	0	647	4238	0	0	700	1692
1		1942	813	1147	1050	1975	372	1029	1148	3992	1905	2545	3348
2		699	473	912	445	591	285	421	134	240	256	47	59
3		15	58	19	2	56	29	71	0	6	32	3	3
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		36206	29291	62290	53470	34575	15373	53799	79838	36942	28019	69763	97048
Age	Year	1996				1997				1998			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	724	2517	0	0	109	343	0	0	94	339
1		535	560	1043	650	672	99	3090	1922	261	210	411	531
2		772	201	1002	333	325	131	372	207	690	310	332	215
3		14	38	37	0	79	119	105	35	47	18	2	13
4+		0	0	0	0	0	0	0	0	8	24	0	0
SOP		21888	13366	74631	46194	15320	8708	78809	54100	19562	12026	20866	22830
Age	Year	1999				2000				2001			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	41	1127	0	0	73	302	0	0	32	368
1		202	318	1298	576	653	280	1368	4616	220	133	122	267
2		128	220	338	160	185	207	266	245	845	246	27	439
3		73	93	35	23	3	48	20	6	35	100	1	1
4+		1	0	0	0	0	0	0	0	0	0	0	0
SOP		7833	12535	41445	30497	10207	11589	44173	119001	21400	11778	4630	26565
Age	Year	2002				2003				2004			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	340	290	0	0	7	1	0	0	14	57
1		485	351	621	473	59	64	191	54	13	4	51	100
2		148	24	284	347	76	49	121	161	55	16	51	78
3		17	5	24	26	22	25	16	32	9	6	7	2
4+		0	0	0	0	0	0	0	1	0	0	0	0
SOP		8553	6686	32922	28947	3190	3106	10842	7549	2040	667	4018	6762
Age	Year	2005				2006				2007			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		*	*	*	*			10	368	0	0	0	0
1		*	*	*	*	30	56	130	1086	20	41	32	10
2		*	*	*	*	52	45	65	50	43	26	16	6
3		*	*	*	*	9	24	7	1	0	0	2	1
4+		*	*	*	*	0	0	0	0	0	0	0	0
SOP		8	8	13	13	2205	2848	6551	34949	1428	1100	2430	838
Age	Year	2008				2009				2010			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	1179	0	0	58	12	0	0	0	0
1		5	54	166	438	50	36	621	169	6	799	1118	716
2		10	41	115	31	1	47	613	27	1	905	738	331
3		0	0	0	0	0	5	9	1	0	17	15	0
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		361	1840	8532	24111	538	2105	36661	6509	198	40322	57487	33071
Age	Year	2011				2012				2013			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	1	0	0	1	135	0	0	8	76
1		0	1	44	23	1	5	8	404	5	631	805	1287
2		0	5	69	61	0	2	4	185	0	39	131	199
3		0	0	4	0	0	2	1	10	0	4	18	27
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		0	222	3749	2872	29	281	469	26168	79	10460	24444	47126
Age	Year	2014				2015				2016			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	141	884	0	0	14	33	0	0	13	480
1		10	33	197	522	46	365	1064	934	19	260	492	406
2		51	60	167	115	6	23	164	33	40	160	291	339
3		1	2	3	0	1	2	2	5	2	10	7	0
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		1324	3212	13384	26244	594	7364	26804	22655	1089	8847	23849	26455
Age	Year	2017											
	Quarter	1	2	3									
0				0									
1		38	130	529									
2		1	43	28									
3		0	14	5									
4+		0	0	0									
SOP		735	3475	9355									

In 2007-08: Catch numbers from Norwegian fishery calculated from Norwegian total catch weight divided by mean weight at age from Danish Fishery.

Table 12.2.5. Norway pout in 4 and 3.aN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1984–2017, from Danish and Norwegian catches combined. See footnote concerning data from 2005–2008 and 2010–2013. The mean weights at age weighted with catch number by area, quarter and country (DK, N).

Year		1984				1985				1986			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			6,54	6,54			8,37	6,23				7,20
	1	6,55	8,97	17,83	20,22	7,86	12,56	23,10	26,97	6,69	14,49	28,81	26,90
	2	24,04	22,66	34,28	35,07	22,7	28,81	36,52	40,90	29,74	42,92	43,39	44,00
	3	39,54	37,00	34,10	46,23	45,26	43,38	58,99		44,08	55,39	47,60	
	4					41,80				82,51			
Year		1987				1988				1989			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			5,80	7,40			9,42	7,91			7,48	6,69
	1	8,13	12,59	20,16	23,36	9,23	11,61	26,54	30,60	7,98	13,49	26,58	26,76
	2	28,26	31,51	34,53	37,32	27,31	33,26	39,82	43,31	26,74	28,70	35,44	34,70
	3	52,93			46,60	38,38				39,95	44,39		46,50
	4	63,09				69,48							
Year		1990				1991				1992			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			6,40	6,67			6,06	6,64		8,00	6,70	8,14
	1	6,51	13,75	20,29	28,70	7,85	12,95	30,95	30,65	8,78	11,71	26,52	27,49
	2	25,47	25,30	32,92	38,90	20,54	28,75	44,28	43,10	25,73	31,25	42,42	44,14
	3	37,72	40,35	39,40	52,94	35,43	49,87	67,25	59,37	41,80	49,49	50,00	50,30
	4	68,00				44,30				43,90			
Year		1993				1994				1995			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			4,40	8,14			5,40	8,81			5,01	7,19
	1	9,32	14,76	25,03	26,24	8,56	15,22	29,26	31,23	7,70	10,99	25,37	24,6
	2	24,94	30,58	35,19	36,44	25,91	29,27	38,91	49,59	24,69	22,95	33,40	39,57
	3	46,50	48,73	55,40	70,80	42,09	46,88	53,95		50,78	37,69	45,56	57,00
	4												
Year		1996				1997				1998			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			3,88	5,95			3,61	10,18			4,82	8,32
	1	8,95	12,06	27,81	28,09	7,01	11,69	20,14	22,11	8,76	12,55	23,82	24,33
	2	21,47	25,72	40,90	38,81	23,11	26,40	31,13	32,69	22,16	25,27	31,73	30,93
	3	37,58	37,94	50,44	56,00	39,11	34,47	44,03	38,62	34,84	32,18	44,92	33,24
	4									42,40	40,00		
Year		1999				2000				2001			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			2,84	7,56			7,21	13,86			6,34	7,90
	1	8,98	12,40	22,16	25,60	10,05	15,65	23,76	22,98	8,34	16,79	27,00	30,01
	2	25,84	24,15	32,66	37,74	19,21	25,14	38,90	34,48	21,50	23,57	39,54	35,51
	3	36,66	35,24	43,98	51,63	32,10	41,30	39,61	50,04	39,84	37,63	54,20	55,70
	4	46,57	46,57										
Year		2002				2003				2004			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			7,28	7,20			9,12	9,79			9,80	7,89
	1	8,59	16,40	27,13	27,47	11,58	13,13	28,33	15,98	11,54	14,63	31,02	31,75
	2	25,98	30,39	43,37	36,87	22,85	26,19	38,01	31,87	27,41	26,22	38,44	39,31
	3	32,30	40,10	54,11	41,28	34,96	39,89	46,24	45,79	41,52	34,80	49,50	49,80
	4							70,00	70,00				
Year		2005				2006				2007			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			9,8	7,89			8,90	8,90			8,9	8,9
	1	11,97	14,65	31,02	31,75	14,80	14,70	27,42	26,92	7,8	7,8	45,00	45,00
	2	27,90	26,24	38,44	39,31	27,20	26,24	39,16	47,80	29,86	29,86	57,07	57,07
	3	41,36	34,80	49,50	49,80	40,60	34,80	49,80	48,50	41,52	34,80	56,22	56,22
	4												
Year		2008				2009				2010			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0				9,9			6,6	8,5				
	1	11,0	11,0	26,8	24,40	10,2	19,3	28,0	32,7	25,60	15,51	25,37	27,75
	2	29,8	29,8	35,6	56,0	24,0	25,8	30,1	32,0	37,20	29,99	38,55	39,88
	3	56,0	56,0				39,8	51,5	55,7		47,00	45,50	62,20
	4												
Year		2011				2012				2013			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0				8,90			6,58	6,66			4,30	9,56
	1		20,33	22,14	30,50	27,24	22,81	28,86	38,52	12,44	14,48	22,97	27,68
	2		37,75	37,50	35,61	36,24	40,54	40,30	49,59	32,87	30,21	38,87	46,38
	3		52,00	52,00	52,00	37,22	46,77	48,33	59,15	42,40	40,71	45,24	57,93
	4												
Year		2014				2015				2016			
Quarter of year		1	2	3	4	1	2	3	4	1	2	3	4
Age	0			5,31	6,46			8,22	5,69			15,00	12,53
	1	8,69	26,06	30,12	30,00	7,53	17,82	21,14	22,61	14,90	16,54	26,91	32,26
	2	23,51	36,53	39,44	42,37	29,30	32,97	25,04	34,80	19,08	26,21	34,99	34,1
	3	50,63	42,77	39,30		46,20	46,61	47,97	41,68	30,76	35,91	34,05	
	4												
Year		2017											
Quarter of year		1	2	3									
Age	0												
	1	18,30	16,35	16,23									
	2	26,89	22,63	23,56									
	3	27,48	26,67	24,60									
	4												

Mean weights at age from Danish and Norwegian landings from 2005-2008 uncertain because of few observations and use of values from 2004 and from adjacent quarters in the same year where observations have been missing. No mean weight at age data delivered by Norway in 2007-2008.
In general, mean weights at age are uncertain for quarters and countries where only very few fish have been caught. This problem is met by always calculating and using weighted mean weights at age, i.e. weighted by the catch number by country (Denmark and Norway) and quarter of year.

Table 12.2.6. Norway pout in 4 and 3.aN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment. (Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0,29
1	9	14	28	28	0,2	0,29
2	26	25	38	40	1	0,39
3	43	38	51	58	1	0,44

Table 12.2.7. Norway pout in 4 and 3.aN (Skagerrak). Danish fishing effort (number of fishing days) and catch per unit of effort (CPUE in tonnes / fishing day) per year and quarter of year (1987–2016) for main Danish fishery (metiér) catching Norway pout. (Data for fishing trips where the catch has consisted of at least 70% Norway pout).

Year	Metier	Effort (no fishing days) per quarter					CPUE (ton per fishing day) per quarter				
		1	2	3	4	Yearly	1	2	3	4	Yearly
1987	OTB_DEF_16-31_0_0	84		1240	2057	3381	12		53	136	71
1988		38		164	1773	1975	27		101	132	107
1989		28		664	940	1632	99		98	54	73
1990		49		134	914	1097	33		30	84	51
1991		18		395	972	1385	5		140	103	99
1992		136		1123	1645	2904	17		130	152	112
1993		153	6	1864	1718	3741	33	2	62	107	64
1994		35		543	1645	2223	2		91	131	89
1995		26		529	1591	2146	6		139	176	127
1996		6		520	521	1047	1		73	107	73
1997				733	1363	2096			137	99	115
1998		10		116	286	412	17		30	30	28
1999				192	869	1061			40	68	56
2000				140	2377	2517			107	168	142
2001		121			527	648	142			122	132
2002				488	790	1278			78	94	89
2003				72	252	324			19	52	36
2004		44		52	196	292	23		26	111	76
2006				39	1056	1095			57	137	117
2008		6		309	292	607	5		139	162	121
2009		20		176	35	231	46		165	181	148
2010			14	749	361	1124		74	169	295	210
2011				24	73	97			54	123	88
2012	OTB_DEF_16-31_2_35				549	549				123	123
2013			21	157	805	983		41	30	99	62
2014		33		263	681	977	28		66	47	50
2015		6	27	86	130	249	19	3	58	57	38
2016		6	10	27	263	306	43	5	44	46	34

Table 12.2.8. Norway pout in 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2016) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	Q1	Q2	Q3	Q4	Yearly	Q1	Q2	Q3	Q4	Yearly
2011	OTB_DEF_16-31_0_0	0	1	23	0	24		10	24,1		23,5
2011	OTB_DEF_16-31_2_40	1	5	77	2	85	0,7	20,2	28,5	0,1	27,0
2012	OTB_DEF_16-31_0_0	0	0	3	24	27			15,7	35,4	33,2
2012	OTB_DEF_16-31_2_40	7	3	2	78	90	0,1	0,1	0,1	36,9	32,0
2013	OTB_DEF_16-31_0_0	0	101	163	99	363		31,3	29,9	47,2	35,0
2013	OTB_DEF_16-31_2_40	8	227	345	227	807	0,2	30,3	30,9	60,8	38,9
2014	OTB_DEF_16-31_0_0	0	62	64	57	183		18,2	35,1	33,9	29,0
2014	OTB_DEF_16-31_2_40	0	41	123	146	310		26,0	34,7	37,4	34,8
2015	OTB_DEF_16-31_0_0	0	130	308	71	509		38,3	37,8	38,7	38,0
2015	OTB_DEF_16-31_2_40	7	39	242	197	485	21,2	39,9	41,3	54,2	46,2
2016	OTB_DEF_16-31_0_0	1	227	223	44	495	45	25,0	25,0	24,4	25,0
2016	OTB_DEF_16-31_2_40	24	82	403	92	601	22,0	20,5	35,7	40,7	33,9

Table 12.2.9. Norway pout in 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton per fishing day) per year and vessel horse power (HP) class (1987–2016) for main Danish fishery (metiér) catching Norway pout.

Year	Metier	Effort (no fishing days) per Vessel HP Class					CPUE (ton per fishing day) per vessel hp class				
		500-1000	1000-1500	1500-2000	>=2000	Yearly	500-1000	1000-1500	1500-2000	>=2000	Yearly
1987	OTB_DEF_16-31_0_0	2625	706	32	18	3381	117	129	82	4	83
1988		913	1000	53	9	1975	128	178	279	72	164
1989		897	707	14	14	1632	111	126	5	6	62
1990		615	448	24	10	1097	105	100	27	1	58
1991		671	688	26		1385	148	172	73		131
1992		1965	845	73	21	2904	195	239	73	18	131
1993		1773	1862	93	13	3741	117	122	63	12	78
1994		1009	1114	66	34	2223	165	221	94	14	123
1995		1068	884	167	27	2146	294	259	159	58	192
1996		452	544	32	19	1047	109	122	125	15	93
1997		1229	778	47	42	2096	192	206	58	55	128
1998		163	232		17	412	61	46		10	39
1999		619	357	51	34	1061	106	89	36	80	78
2000		1449	802	138	128	2517	205	188	110	202	177
2001		322	266		60	648	185	301		71	186
2002		738	393	135	12	1278	131	144	77	30	96
2003		172	115	24	13	324	64	45	43	48	50
2004		165	109		18	292	71	116		111	100
2006		465	464	166		1095	132	183	93		136
2008		320	287			607	189	213			201
2009		111	120			231	199	324			262
2010		279	606	239		1124	349	299	206		285
2011			97			97		121			121
2012	OTB_DEF_16-31_2_35	122	314	89	24	549	123	155	119	94	491
2013		331	504	108	40	983	81	144	84	64	372
2014		425	474	78		977	55	53	53		161
2015		21	228			249	66	52			117
2016		81	139	77	9	306	45	39	37	55	176

Table 12.2.10. Norway pout in 4 and 3.aN (Skagerrak). Fishing effort (number of fishing days) and catch per unit of effort (CPUE in ton / fishing day) per year (2011–2016) and quarter of year for main Norwegian fishery (metiérs) catching Norway pout.

		Fishing days					CPUE (ton/fishing day)				
Year	Metier	500-1000	1000-1500	1500-2000	> 2000	Yearly	500-1000	1000-1500	1500-2000	> 2000	Yearly
2011	OTB_DEF_16-31_0_0	0	24	0	0	24		23,5			23,5
2011	OTB_DEF_16-31_2_40	5	20	0	60	85	0,2	18,3		32,1	27,0
2012	OTB_DEF_16-31_0_0	0	17	4	6	27		34,8	13,8	41,7	33,2
2012	OTB_DEF_16-31_2_40	35	28	0	27	90	11,6	26,9		63,8	32,0
2013	OTB_DEF_16-31_0_0	0	273	75	15	363		34,4	30,9	65,3	35,0
2013	OTB_DEF_16-31_2_40	12	162	130	503	807	0,2	23,2	34,1	46,0	38,9
2014	OTB_DEF_16-31_0_0	0	142	16	25	183		25,5	16,6	56,4	29,0
2014	OTB_DEF_16-31_2_40	83	58	67	102	310	41,4	14,6	36,6	39,8	34,8
2015	OTB_DEF_16-31_0_0	0	228	106	175	509		33,7	42,7	40,8	38,0
2015	OTB_DEF_16-31_2_40	9	5	103	368	485	0,1	1,5	49,7	46,9	46,2
2016	OTB_DEF_16-31_0_0	0	224	108	163	495		25,9	22,3	25,5	25,0
2016	OTB_DEF_16-31_2_40	9	1	100	491	601	0,2	0,5	35,4	34,2	33,9

Table 12.2.11 Norway pout in 4 and 3.aN (Skagerrak). Research vessel indices (CPUE in catch in number per trawl hour) of abundance for Norway pout.

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1971	1,556	22	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	2,578	872	3	-	-	-	-	-	-	-	-	-	-	-	-
1973	4,207	438	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	25,557	391	24	-	-	-	-	-	-	-	-	-	-	-	-
1975	4,573	1,880	4	-	-	-	-	-	-	-	-	-	-	-	-
1976	4,411	371	2	-	-	-	-	-	-	-	-	-	-	-	-
1977	6,093	274	42	-	-	-	-	-	-	-	-	-	-	-	-
1978	1,479	575	47	-	-	-	-	-	-	-	-	-	-	-	-
1979	2,738	316	75	-	-	-	-	-	-	-	-	-	-	-	-
1980	3,277	550	29	-	-	-	-	-	1,928	346	12	-	-	-	-
1981	1,092	377	15	-	-	-	-	-	185	127	9	-	-	-	-
1982	4,537	262	59	-	-	-	-	8	991	44	22	-	-	-	-
1983	2,258	592	7	-	-	-	-	13	490	91	1	-	-	-	-
1984	4,994	982	75	-	-	-	-	2	615	69	8	-	-	-	-
1985	2,342	1,429	73	-	-	-	-	5	636	173	5	-	-	-	-
1986	2,070	383	20	-	-	-	-	38	389	54	9	-	-	-	-
1987	3,171	481	61	-	-	-	-	7	338	23	1	-	-	-	-
1988	124	722	15	-	-	-	-	14	38	209	4	-	-	-	-
1989	2,019	255	172	-	-	-	-	2	382	21	14	-	-	-	-
1990	1,295	748	39	-	-	-	-	58	206	51	2	-	-	-	-
1991	2,450	712	130	-	-	-	-	10	732	42	6	7,301	1,039	189	2
1992	5,071	885	32	2,975	6,116	1,710	303	12	1,715	221	24	2,559	4,318	633	48
1993	2,682	2,644	258	3,706	3,582	1,706	108	2	580	329	20	4,104	1,831	608	53
1994	1,839	374	66	9,487	1,148	147	25	136	387	106	6	3,196	704	102	14
1995	5,940	785	77	5,478	8,374	282	62	37	2,438	234	21	2,860	4,440	597	69
1996	923	2,631	228	8,241	1,326	378	9	127	412	321	8	4,554	763	362	12
1997	9,699	1,527	670	441	6,295	372	102	1	2,154	130	32	490	3,447	236	46

Year	IBTS/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1998	1,010	5,336	265	1,391	377	340	3	2,628	938	127	5	2,931	801	748	12
1999	3,527	597	667	10,985	1,175	40	29	3,603	1,784	179	37	7,844	2,367	201	94
2000	8,095	1,535	65	2,267	9,730	264	2	2,094	6,656	207	23	1,644	7,869	281	11
2001	1,302	2,863	235	2,243	1,434	1344	31	759	727	710	26	2,088	1,274	862	27
2002	1,793	809	880	4,939	1,137	58	18	2,559	1,192	151	123	1,974	766	64	48
2003	1,239	575	94	323	572	75	5		779	126	1	1,812	1,063	146	7
2004	894	375	34	278	557	109	6	1,767	719	175	19	773	647	153	12
2005	690	133	37	3,395	414	67	15		343	132	18	2,679	404	97	16
2006	3,369	142	26	1,813	1,996	124	20	731	1,285	69	9	1,391	1,809	191	12
2007	1,286	778	23	1,610		720	43		1,023	395	8	4,151	1,201	447	11
2008	2,353	512	180	628	1,181	411	104	3,073	1,263	263	57	3,035	1,643	274	58
2009	5,480	1,633	151	4,871	1,340	306	5	1,127	1,750	202	16	5,899	2,562	254	11
2010	4,941	1,466	138	103	3,500	559	13	5,003	5,101	930	29	833	4,757	861	22
2011	541	2.252	304	290	4,257	1,050	40	3,456	226	935	38	1,801	474	1123	60
2012	997	336	532	3,946	555	99	59	5,835	1,070	159	216	6,416	875	179	130
2013	4,466	519	97	498	505	117	19	1,449	3,099	111	22	1,287	2,829	124	13
2014	812	939	52	10,157	2,592	268	17	1,895	524	146	0	10,238	514	224	8
2015	6,681	493	141	1,415	483	60	15	10,067	6,358	114	0	3,511	4,051	76	20
2016	2,417	915	25	7,199	4,320	314	4	1,759	1,700	288	0	8,965	1,397	278	8
2017	4,357	401	174	1,280	1,710	134	38	24,317	1,810	73	1				
					5,061			9,882							
								14,668							
								7,104							

[1]International Bottom Trawl Survey, arithmetic mean catch in no./h in standard area. In general the quarter 1 (Q1) and quarter 3 (Q3) IBTS indices have been revised in 2012 and 2014 and 2015 (see documentation on ICES DATRAS). [2]English groundfish survey (EGFS): Arithmetic mean catch no./h. Data for 1996, 2001, 2002, and 2003 have been revised compared to the 2003 assessment. In 2007, numbers for 1997 and 1998 as well as 2002 has been adjusted based on new automatic calculation and processing process has been introduced. In September 2015, the EGFS Survey index was for all years and ages radically revised in order to incorporate the relevant primes within the Norway pout index area following the ICES IBTS manual (2015). [3]Minor GOV sweep changes in 2006 for the EGFS. [4]Scottish groundfish surveys (SGFS), arithmetic mean catch no./h. Survey design changed in 1998 and 2000. The SGFS survey area changed slightly in 2009 and onwards, which is evaluated to have no main effect for the Norway pout indices as the indices are weighted by Subarea. SGFS data for the full area, i.e. indices based on all hauls, are included in the presented indices.

Table 12.3.1. Norway pout in 4 & 3.aN (Skagerrak). Stock indices and tuning fleets used in final 2004 benchmark assessment, in the 2005–2015 assessments, as well as in the 2016–2017 assessments, compared to the 2003 assessment. (Changes from previous period marked with grey).

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-15 ASSESSMENTS	2016-17 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2017)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM (1984-2017)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	3+ (SESAM) (1984-2017)
FLT01: comm Q1						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	1	1	1	1	
	Ages	1-3	1-3	1-3	1-3	
FLT01: comm Q2			NOT USED	NOT USED	NOT USED	NOT USED
	Year range	1982-2003				
	Quarter	2				
	Ages	1-3				
FLT01: comm Q3						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	3	3	3	3	
	Ages	0-3	1-3	1-3	1-3	
FLT01: comm Q4						
	Year range	1982-2003	1982-2004	1982-2004	1983-2004, 2006	NOT USED
	Quarter	4	4	4	4	
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)	
FLT02: ibtsq1						
	Year range	1982-2003	1982-2006	1982-2006	1983-2015	1984-2017
	Quarter	1	1	1	1	1
	Ages	1-3	1-3	1-3	1-3	1-3
FLT03: egfs						
	Year range	1982-2003	1992-2005	1992-2005	1992-2015	1992-2017
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT04: sgfs						
	Year range	1982-2003	1998-2006	1998-2006	1998-2015	1998-2017
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED				
	Year range		1991-2005	1991-2005	1991-2014	1991-2016
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

Table 12.3.2. Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal stochastic assessment model. Settings and tuning fleets.

SURVIVORS ANALYSIS OF: Norway pout stock in September 2017

Run: September 2017

The following parameters were used:

Year range:	1984 - 2017
Seasons per year:	4
The last season in the last year is season:	3
Youngest age:	0
Oldest age:	2
Plus age:	3
Recruitment in season:	3
Spawning in season:	1

The following tuning fleets were included:

Fleet 2:	ibtsq1	(Age 1-3)
Fleet 3:	egfsq3	(Age 0-1)
Fleet 4:	sgfsq3	(Age 0-1)
Fleet 5:	ibtsq3	(Age 2-3)

Table 12.3.3. Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated stock numbers in start of quarterly and yearly season.

Time\Age	0	1	2	3
1984	0	43094	9515	400
1984.25	0	29536	5149	223
1984.5	39328	20289	2845	125
1984.75	0	11172	1070	70
1985	0	20879	5236	377
1985.25	0	13917	2448	197
1985.5	25995	9874	1420	115
1985.75	0	5566	528	65
1986	0	13587	2615	201
1986.25	0	9202	1314	109
1986.5	51422	6665	801	66
1986.75	0	4134	370	39
1987	0	28522	2247	177
1987.25	0	20034	1156	97
1987.5	10650	14718	710	59
1987.75	0	9689	356	36
1988	0	5499	4846	137
1988.25	0	4014	2815	78
1988.5	43493	3035	1854	48
1988.75	0	2152	1083	29
1989	0	23691	1296	519
1989.25	0	16981	808	313
1989.5	44964	12149	501	189
1989.75	0	7855	259	116
1990	0	24170	4527	191
1990.25	0	17183	2545	111
1990.5	56957	11966	1396	64
1990.75	0	8067	755	39
1991	0	31069	5048	400
1991.25	0	21912	2772	223
1991.5	93070	15929	1624	129
1991.75	0	10913	883	80
1992	0	51218	7149	507
1992.25	0	36047	4195	304
1992.5	49615	25881	2662	190
1992.75	0	16969	1482	117
1993	0	26866	10493	862
1993.25	0	18706	5911	516
1993.5	42409	13157	3493	316
1993.75	0	8274	1709	190
1994	0	22538	4919	900

Time\Age	0	1	2	3
1994.25	0	15487	2825	520
1994.5	125023	10965	1740	312
1994.75	0	7214	937	190
1995	0	69176	4680	647
1995.25	0	50046	2845	407
1995.5	48916	36144	1750	258
1995.75	0	24906	1035	162
1996	0	25969	16445	708
1996.25	0	19027	10204	436
1996.5	102916	13863	6550	271
1996.75	0	9520	3747	168
1997	0	57301	6599	2358
1997.25	0	41937	4209	1475
1997.5	21845	31838	2740	933
1997.75	0	22052	1544	580
1998	0	12125	15180	1258
1998.25	0	8994	9617	771
1998.5	38451	6629	6157	473
1998.75	0	4791	3680	298
1999	0	21789	3359	2391
1999.25	0	16331	2230	1513
1999.5	89933	12146	1432	944
1999.75	0	8537	813	583
2000	0	51282	5882	813
2000.25	0	38602	3888	508
2000.5	23589	29412	2545	316
2000.75	0	20958	1568	200
2001	0	12710	13520	983
2001.25	0	9165	8464	615
2001.5	24011	6632	5399	387
2001.75	0	4798	3555	247
2002	0	13630	3228	2227
2002.25	0	10063	2036	1380
2002.5	18659	7315	1335	866
2002.75	0	4986	797	541
2003	0	9785	3158	760
2003.25	0	6946	2035	471
2003.5	8079	4923	1314	292
2003.75	0	3370	780	183
2004	0	4418	2309	553
2004.25	0	3219	1523	351
2004.5	7729	2408	1011	224
2004.75	0	1706	630	142
2005	0	4295	1156	454

Time\Age	0	1	2	3
2005.25	0	3192	787	297
2005.5	29561	2380	535	194
2005.75	0	1797	362	126
2006	0	16524	1373	323
2006.25	0	12220	934	209
2006.5	20930	9105	620	133
2006.75	0	6709	379	84
2007	0	11652	4334	250
2007.25	0	8725	2887	164
2007.5	31003	6490	1912	107
2007.75	0	4833	1261	69
2008	0	17345	3667	894
2008.25	0	13075	2519	575
2008.5	50187	9824	1697	369
2008.75	0	7366	1092	234
2009	0	29845	5370	859
2009.25	0	22551	3615	545
2009.5	71260	17292	2396	343
2009.75	0	12888	1412	216
2010	0	41018	9879	1045
2010.25	0	31465	7132	671
2010.5	6803	23383	4843	425
2010.75	0	16584	3014	269
2011	0	3839	11674	2085
2011.25	0	2872	7671	1337
2011.5	11409	2187	5178	860
2011.75	0	1634	3406	549
2012	0	6452	1215	2617
2012.25	0	4858	832	1717
2012.5	53020	3690	574	1125
2012.75	0	2813	389	728
2013	0	29661	1886	686
2013.25	0	22109	1306	440
2013.5	14140	15916	877	280
2013.75	0	10966	536	177
2014	0	7703	6466	373
2014.25	0	5630	4130	237
2014.5	85274	4101	2599	149
2014.75	0	2898	1480	93
2015	0	46114	1871	853
2015.25	0	33211	1219	540
2015.5	34097	23601	778	339
2015.75	0	15609	426	209
2016	0	18338	10004	364

Time\Age	0	1	2	3
2016.25	0	13145	6516	233
2016.5	79343	9203	4123	146
2016.75	0	6150	2447	91
2017	0	43597	3892	1439
2017.25	0	31949	2582	928
2017.5	37204	23478	1680	592
2017.75	0	17245	1082	378

Table 12.3.4. Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Estimated fishing mortalities by quarter of year. (The last 2017 quarter 4 F-value is a projection of F based on the population estimate by end of 3rd quarter).

Year\Age	0	1	2	3+
1984	0.000	0.348	0.979	0.559
1984.25	0.000	0.332	0.870	0.521
1984.5	0.013	1.205	2.375	0.502
1984.75	0.241	1.854	3.093	0.107
1985	0.001	0.487	1.368	0.781
1985.25	0.000	0.212	0.555	0.332
1985.5	0.013	1.167	2.299	0.486
1985.75	0.241	1.857	3.098	0.107
1986	0.001	0.406	1.142	0.652
1986.25	0.000	0.146	0.382	0.229
1986.5	0.008	0.751	1.480	0.313
1986.75	0.160	1.230	2.053	0.071
1987	0.000	0.359	1.008	0.575
1987.25	0.000	0.121	0.318	0.190
1987.5	0.006	0.563	1.108	0.234
1987.75	0.219	1.686	2.814	0.097
1988	0.000	0.248	0.696	0.398
1988.25	0.000	0.093	0.244	0.146
1988.5	0.004	0.369	0.727	0.154
1988.75	0.128	0.988	1.649	0.057
1989	0.000	0.179	0.504	0.288
1989.25	0.000	0.186	0.487	0.292
1989.5	0.006	0.578	1.139	0.241
1989.75	0.134	1.029	1.717	0.059
1990	0.000	0.261	0.734	0.419
1990.25	0.000	0.305	0.801	0.480
1990.5	0.005	0.445	0.876	0.185
1990.75	0.097	0.743	1.241	0.043
1991	0.000	0.301	0.846	0.483
1991.25	0.000	0.215	0.565	0.339
1991.5	0.005	0.451	0.887	0.188

Year\Age	0	1	2	3+
1991.75	0.085	0.655	1.093	0.038
1992	0.000	0.260	0.730	0.417
1992.25	0.000	0.166	0.435	0.260
1992.5	0.005	0.462	0.909	0.192
1992.75	0.089	0.681	1.138	0.039
1993	0.000	0.228	0.640	0.365
1993.25	0.000	0.175	0.458	0.274
1993.5	0.006	0.590	1.162	0.246
1993.75	0.109	0.836	1.396	0.048
1994	0.000	0.248	0.698	0.399
1994.25	0.000	0.153	0.401	0.240
1994.5	0.005	0.498	0.980	0.207
1994.75	0.068	0.522	0.872	0.030
1995	0.000	0.151	0.423	0.242
1995.25	0.000	0.136	0.357	0.214
1995.5	0.003	0.272	0.536	0.113
1995.75	0.053	0.406	0.678	0.023
1996	0.000	0.100	0.281	0.161
1996.25	0.000	0.078	0.204	0.122
1996.5	0.004	0.374	0.735	0.155
1996.75	0.044	0.338	0.565	0.020
1997	0.000	0.079	0.221	0.126
1997.25	0.000	0.046	0.122	0.073
1997.5	0.004	0.376	0.740	0.156
1997.75	0.051	0.396	0.662	0.023
1998	0.000	0.079	0.222	0.127
1998.25	0.000	0.075	0.197	0.118
1998.5	0.003	0.270	0.532	0.112
1998.75	0.047	0.360	0.601	0.021
1999	0.000	0.061	0.170	0.097
1999.25	0.000	0.095	0.249	0.149
1999.5	0.004	0.351	0.691	0.146
1999.75	0.059	0.457	0.763	0.026
2000	0.000	0.061	0.171	0.097
2000.25	0.000	0.069	0.180	0.108
2000.5	0.002	0.216	0.426	0.090
2000.75	0.073	0.562	0.940	0.033
2001	0.000	0.082	0.230	0.131
2001.25	0.000	0.063	0.166	0.100
2001.5	0.001	0.096	0.189	0.040
2001.75	0.055	0.422	0.704	0.024
2002	0.000	0.079	0.223	0.127
2002.25	0.000	0.052	0.137	0.082
2002.5	0.003	0.280	0.552	0.117

Year\Age	0	1	2	3+
2002.75	0.077	0.593	0.990	0.034
2003	0.000	0.042	0.119	0.068
2003.25	0.000	0.037	0.097	0.058
2003.5	0.002	0.229	0.451	0.095
2003.75	0.045	0.343	0.574	0.020
2004	0.000	0.030	0.084	0.048
2004.25	0.000	0.016	0.043	0.026
2004.5	0.002	0.156	0.306	0.065
2004.75	0.046	0.355	0.593	0.021
2005	0.000	0.000	0.000	0.000
2005.25	0.000	0.000	0.001	0.000
2005.5	0.000	0.000	0.001	0.000
2005.75	0.000	0.000	0.001	0.000
2006	0.000	0.021	0.081	0.032
2006.25	0.000	0.039	0.146	0.078
2006.5	0.000	0.115	0.366	0.075
2006.75	0.035	0.620	1.047	0.029
2007	0.000	0.008	0.017	0.005
2007.25	0.000	0.018	0.051	0.022
2007.5	0.000	0.029	0.079	0.014
2007.75	0.001	0.023	0.038	0.001
2008	0.000	0.003	0.007	0.002
2008.25	0.000	0.020	0.056	0.024
2008.5	0.000	0.066	0.179	0.032
2008.75	0.003	0.079	0.129	0.003
2009	0.000	0.002	0.003	0.001
2009.25	0.000	0.019	0.054	0.024
2009.5	0.000	0.171	0.467	0.083
2009.75	0.003	0.079	0.128	0.003
2010	0.000	0.001	0.001	0.000
2010.25	0.000	0.038	0.106	0.046
2010.5	0.000	0.137	0.375	0.066
2010.75	0.005	0.137	0.221	0.005
2011	0.000	0.001	0.001	0.000
2011.25	0.000	0.005	0.014	0.006
2011.5	0.000	0.052	0.141	0.025
2011.75	0.004	0.117	0.189	0.004
2012	0.000	0.001	0.001	0.000
2012.25	0.000	0.008	0.022	0.010
2012.5	0.000	0.032	0.087	0.015
2012.75	0.019	0.524	0.847	0.018
2013	0.000	0.001	0.002	0.001
2013.25	0.000	0.035	0.098	0.043
2013.5	0.000	0.153	0.416	0.074

Year\Age	0	1	2	3+
2013.75	0.029	0.799	1.292	0.028
2014	0.000	0.005	0.011	0.003
2014.25	0.000	0.032	0.091	0.039
2014.5	0.000	0.210	0.574	0.102
2014.75	0.019	0.532	0.861	0.019
2015	0.000	0.005	0.012	0.004
2015.25	0.000	0.040	0.114	0.049
2015.5	0.000	0.263	0.718	0.127
2015.75	0.015	0.418	0.676	0.015
2016	0.000	0.005	0.011	0.003
2016.25	0.000	0.049	0.137	0.060
2016.5	0.000	0.177	0.482	0.085
2016.75	0.015	0.415	0.672	0.015
2017	0.000	0.002	0.006	0.002
2017.25	0.000	0.031	0.087	0.038
2017.5	0.000	0.074	0.202	0.036
2017.75	0.015	0.415	0.672	0.015

Table 12.3.5. Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Estimated catchabilities by survey tuning fleet.

Index	Fleet number	Age	Catchability	Low	High
1	2	1	0.12866	0.08596	0.19257
2	2	2	0.21863	0.13479	0.35463
3	2	3	0.22630	0.10514	0.48711
4	3	0	0.06844	0.04246	0.11031
5	3	1	0.20570	0.12577	0.33642
6	4	0	0.14553	0.08812	0.24032
7	4	1	0.20198	0.12048	0.33860
8	5	2	0.19848	0.10635	0.37043
9	5	3	0.09224	0.04030	0.21113

Table 12.3.5 (cont.). Norway pout in 4 and 3.aN (Skagerrak). Baseline run with SESAM seasonal model. Diagnostics of the SESAM baseline assessment. Likelihood values.

Model	Negative log likelihood	Number of parameters
Base	1121.72	19
Current	1121.72	19

Table 12.3.6. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2017. Estimated yearly and quarterly recruitment (millions), spawning stock biomass SSB (t), total stock biomass TSB (t) and fishing mortality for ages 1–2 (F12).

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1984				331445	181890	481000	641724	388218	895231	1.382	0.896	2.133
1984.25				210746	115659	305833	494292	285439	703145			
1984.5	39328	23413	66059	222732	119469	325996	628514	345101	911927			
1984.75				102716	49602	155830	326164	166965	485363			
1985				183560	101316	265804	333886	204519	463253	1.380	0.856	2.227
1985.25				104475	55358	153592	238074	136698	339451			
1985.5	25995	15576	43384	113091	60897	165285	310577	173578	447576			
1985.75				52719	24037	81402	164047	82820	245274			
1986				97867	51662	144072	195695	114284	277106	0.949	0.570	1.580
1986.25				60404	30349	90458	148746	82049	215442			
1986.5	51422	29979	88200	69325	36124	102527	202621	110608	294635			
1986.75				37730	17321	58139	120421	60937	179905			
1987				114584	65724	163443	319945	177774	462115	0.997	0.556	1.789
1987.25				81833	44468	119197	274157	144897	403416			
1987.5	10650	6045	18764	105527	57454	153600	399892	209723	590061			
1987.75				64775	32527	97024	258568	128773	388362			
1988				136526	60733	212319	176121	90563	261680	0.627	0.376	1.045
1988.25				83903	34575	133230	122437	61659	183215			
1988.5	43493	25913	73000	92182	38029	146335	152886	79193	226579			
1988.75				55765	19947	91583	98813	47936	149691			
1989				95806	51502	140109	266381	145997	386765	0.727	0.428	1.237
1989.25				76621	39892	113350	239639	128920	350357			
1989.5	44964	26775	75507	92125	48805	135444	335114	178433	491795			
1989.75				56340	27760	84919	213441	109129	317753			
1990				164311	90469	238152	338334	197510	479157	0.676	0.402	1.137
1990.25				110430	59093	161768	275383	154049	396717			
1990.5	56957	33349	97276	119500	61825	177174	358818	192402	525233			
1990.75				72807	34805	110809	234148	119848	348448			
1991				198140	108578	287703	421834	238852	604817	0.627	0.372	1.055
1991.25				133051	69553	196549	343402	184492	502312			
1991.5	93070	55338	156528	152340	78751	225930	470930	247392	694467			
1991.75				94511	45125	143897	312773	157662	467884			
1992				291182	160818	421545	659953	373828	946078	0.598	0.357	0.999
1992.25				206600	108911	304288	552653	299142	806163			
1992.5	49615	29655	83011	247249	127935	366562	764882	406003	1123762			
1992.75				150904	71466	230341	490284	249858	730711			
1993				345143	175729	514557	538579	303067	774092	0.686	0.361	1.301
1993.25				218468	105522	331414	398044	217141	578947			
1993.5	42409	24626	73033	224455	108045	340864	487605	264591	710619			
1993.75				120757	48252	193263	286249	139917	432581			
1994				199527	90759	308294	361801	186222	537380	0.547	0.298	1.003

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
1994.25				133783	55285	212281	282460	137508	427413			
1994.5	125023	71602	218301	143146	60846	225446	362457	176707	548206			
1994.75				84596	30062	139130	228883	100559	357207			
1995				267396	130459	404334	765465	372336	1158594	0.370	0.196	0.697
1995.25				211592	98365	324819	692030	324313	1059746			
1995.5	48916	27639	86574	266196	122223	410169	989087	455614	1522561			
1995.75				175341	75284	275398	673463	296615	1050312			
1996				486176	210621	761731	673151	325303	1020998	0.334	0.173	0.647
1996.25				322554	133347	511761	505216	238772	771659			
1996.5	102916	58244	181853	347531	140991	554072	624803	293835	955771			
1996.75				207213	67083	347344	397617	163564	631670			
1997				362446	157050	567842	775015	367786	1182245	0.330	0.167	0.653
1997.25				279644	117764	441524	682238	317493	1046983			
1997.5	21845	12264	38911	324772	143730	505813	961534	448110	1474958			
1997.75				205658	79737	331580	646711	274033	1019389			
1998				451627	179373	723882	538928	236185	841670	0.292	0.152	0.562
1998.25				300553	114282	486824	386892	167691	606093			
1998.5	38451	22139	66782	307799	114180	501417	440382	193054	687711			
1998.75				188437	58094	318780	284259	111261	457258			
1999				218860	84474	353247	375741	172440	579043	0.355	0.181	0.696
1999.25				170584	62986	278182	327362	148630	506093			
1999.5	89933	51541	156923	174634	68097	281170	417566	193092	642040			
1999.75				109003	37514	180492	279742	118099	441386			
2000				271862	122615	421109	641093	307213	974973	0.328	0.162	0.663
2000.25				215253	95332	335174	585836	274317	897355			
2000.5	23589	13296	41852	267825	118047	417603	856066	389170	1322962			
2000.75				179097	72643	285551	598268	255597	940938			
2001				400178	153395	646960	491688	208120	775256	0.244	0.120	0.498
2001.25				264347	96022	432672	352333	146874	557793			
2001.5	24011	13607	42369	272328	97205	447450	404963	171723	638204			
2001.75				180528	58897	302158	276484	111767	441202			
2002				194293	70121	318465	292426	123304	461548	0.363	0.166	0.794
2002.25				144039	48205	239874	240643	98458	382828			
2002.5	18659	9955	34972	141959	50987	232931	288260	124052	452469			
2002.75				88203	27518	148888	187926	74469	301383			
2003				126954	45815	208094	197409	81440	313378	0.237	0.106	0.529
2003.25				91106	32175	150037	157787	65653	249921			
2003.5	8079	4392	14862	94709	35038	154380	193165	83417	302913			
2003.75				58672	18721	98623	126069	49447	202692			
2004				87783	31641	143924	119594	48518	190670	0.198	0.083	0.470
2004.25				63347	21867	104826	94249	37710	150789			
2004.5	7729	4274	13978	65918	23476	108361	114088	47066	181110			
2004.75				41952	13247	70658	76086	28977	123195			
2005				54779	19317	90240	85703	35206	136201	0.000	0.000	0.001

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2005.25				42191	14659	69722	72832	30003	115660			
2005.5	29561	16346	53462	44954	16518	73391	92563	39400	145726			
2005.75				30742	11233	50252	66691	28121	105262			
2006				76984	36186	117781	195955	89946	301965	0.304	0.121	0.769
2006.25				63127	29026	97227	180443	81307	279579			
2006.5	20930	11411	38388	78286	35283	121289	260389	114842	405937			
2006.75				53572	22487	84657	187752	77885	297618			
2007				139331	49790	228872	223224	91801	354647	0.033	0.015	0.070
2007.25				101281	36473	166088	185037	76287	293788			
2007.5	31003	16987	56584	115346	41801	188891	245153	100762	389544			
2007.75				78626	27241	130011	175302	69416	281187			
2008				158648	65967	251328	283533	125920	441147	0.067	0.032	0.142
2008.25				123100	50279	195922	248623	108361	388885			
2008.5	50187	27031	93179	139141	56497	221786	335620	143408	527831			
2008.75				94093	35937	152249	241429	97108	385749			
2009				222329	95427	349232	437212	197444	676979	0.116	0.050	0.265
2009.25				171735	74022	269448	388222	173419	603025			
2009.5	71260	39179	129610	202892	87569	318215	548745	241224	856266			
2009.75				133450	51281	215618	391210	156779	625640			
2010				362626	150272	574981	657954	292387	1023522	0.127	0.058	0.277
2010.25				287351	113424	461277	589418	251127	927709			
2010.5	6803	3678	12584	336127	127697	544557	803791	332313	1275270			
2010.75				219087	74267	363907	550780	212864	888697			
2011				382174	141760	622587	409811	158142	661481	0.065	0.029	0.145
2011.25				265539	96799	434279	293110	112800	473420			
2011.5	11409	6357	20478	269623	95995	443251	313373	120905	505840			
2011.75				176270	57435	295105	208947	75589	342306			
2012				146658	50892	242423	193109	77284	308934	0.190	0.079	0.455
2012.25				118318	38819	197816	164955	65210	264700			
2012.5	53020	28994	96955	108895	37291	180499	182690	76596	288784			
2012.75				71855	23922	119788	128130	52779	203482			
2013				127992	54607	201376	341549	146675	536423	0.349	0.137	0.890
2013.25				107741	45786	169696	319990	136517	503463			
2013.5	14140	7719	25901	131425	57592	205259	449751	198383	701120			
2013.75				86571	36784	136357	305900	134621	477179			
2014				190434	67295	313573	245892	98236	393549	0.289	0.119	0.704
2014.25				128619	47775	209462	182665	77685	287646			
2014.5	85274	43798	166029	133405	50587	216223	215432	95090	335775			
2014.75				79059	24204	133915	137027	53392	220661			
2015				163894	63362	264426	495912	192382	799442	0.281	0.111	0.712
2015.25				137205	54991	219418	456032	185033	727030			
2015.5	34097	17613	66008	169451	71221	267681	641485	270085	1012884			
2015.75				107215	40274	174157	419396	164372	674420			
2016				297679	105985	489374	429710	174112	685308	0.243	0.094	0.632

Time	Recruits	Low	High	SSB	Low	High	TSB	Low	High	F12	Low	High
2016.25				206086	73923	338250	332274	138096	526453			
2016.5	79343	42036	149759	219727	76627	362826	403800	166870	640730			
2016.75				133920	36691	231149	256926	91387	422465			
2017				233344	81966	384722	547246	218722	875770			
2017.25				187606	65980	309232	494315	193069	795561			
2017.5	37204	15226	90906	220119	80211	360027	689685	259983	1119387			
2017.75				152162	51685	252640	497075	169895	824255			

Table 12.3.6 (cont). Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Table. Baseline run with SESAM September 2017. Long term arithmetic means of yearly recruitment (millions), quarterly spawning stock biomass SSB (t), quarterly total stock biomass TSB (t) and yearly fishing mortality for ages 1–2 (F_{bar} = F12) for the period 1984–2017. (Numbers are given for start of the season).

	VALUE
Avg. recruitment	43861.36
Avg SSB Q 1	223015.78
Avg SSB Q 2	159506.72
Avg SSB Q 3	176903.92
Avg SSB Q 4	110127.90
Avg TSB Q 1	402105.18
Avg TSB Q 2	332405.53
Avg TSB Q 3	439608.45
Avg TSB Q 4	289617.14
Avg. FBAR	0.43

Table 12.6.1. Norway pout in 4 and 3.aN (Skagerrak). Projected mean weight at age used in the forecast by quarter of year.

Age/Quarter	1	2	3	4
0	8.451	12.259	9.549	10.337
1	10.042	14.161	25.422	28.239
2	21.032	23.528	31.009	36.378
3	29.482	29.478	34.867	41.928

Table 12.6.2. Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year ahead (1st October 2018) equals B_{lim}.

Basis:

F (2017 up to Q4) = estimated from in year assessment 1st October 2017, F(age, quarter1, 2, 3 2017), Table 5.3.4.

SSB (2017 up to Q4) = estimated from in year assessment 1st October 2017 (start Q4) = 152162 tonnes;

R(2017) = estimated / observed from in year assessment 1st July 2017 (age 0 in start of Q3) = 37 204 million;

Biological parameters (2017–2018): Assume values for M, weight-at-age in the stock, and maturity-at-age for the projection period to be similar to the same parameter values used in the assessment. Assume projected mean weight at ages in the catches by quarter as given in Table 5.6.1.

F, R (Q4 2017–Q4 2018): (i) Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years. (ii) Assume that log F_t = log F_{t-4} + log G_t, for all future values of t where G_t is some chosen vector of multipliers of the F-process. If G_t = 1 for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year. (iii) Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. This is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution. (iv) Find G_t such that the fifth (or any other) percentile of the catches (total mass) in the projections equals some desired level such as B_{lim} (optional).

	F12	SSB	SSB 5th quantile	median catch
2017.75	0.66	154.53	90.86	129719.67
2018	0.00	266.77	103.89	674.34
2018.25	0.07	183.79	71.47	7533.52
2018.5	0.17	185.11	66.76	14027.85
2018.75		115.26	39.45	
Sum				151955.39

Table 12.6.3. Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2017 to 1st October 2018. Basis: Same as above.

YEAR	F12	SSB	SSB 5th quantile	median catch
2017.75	0.00	154.53	90.86	0.00
2018	0.00	330.69	180.30	0.00
2018.25	0.00	230.36	118.98	0.00
2018.5	0.00	240.05	114.39	0.00
2018.75		161.11	73.81	
Sum				0.00

Table 12.6.4. Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year up to 1st October 2017. Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2017.75	0.55	154.53	90.86	112081.26
2018	0.00	274.67	115.70	588.22
2018.25	0.06	189.94	77.28	6618.45
2018.5	0.14	192.65	73.35	12490.44
2018.75		121.04	44.43	
Sum				131778.38

Table 12.6.5. Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year ahead (1st October 2018) equals B_{lim}. Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2017.75	3.54	154.53	90.86	336073.29
2018	0.03	132.52	24.09	1557.21
2018.25	0.38	94.43	18.92	15149.80
2018.5	0.91	79.09	13.17	19766.80
2018.75		39.45	6.36	
Sum				372547.09

Table 12.6.6. Norway pout in 4 and 3.aN (Skagerrak). Forecast of fishing mortality, SSB and median catch (t) with F scaled such that SSB one year ahead (1st October 2018) equals B_{pa}. Basis: Same as above.

	F12	SSB	SSB 5th quantile	median catch
2017.75	2.09	154.53	90.86	271395.93
2018	0.02	183.51	36.61	1366.90
2018.25	0.23	128.52	28.45	14099.14
2018.5	0.53	118.52	22.73	21755.22
2018.75		65.00	11.73	
Sum				308617.20

Table 12.6.7. Norway pout in 4 and 3.aN (Skagerrak). The quarterly minima of the estimated SSB time series (1984-2016) from the SESAM Benchmark Assessment Baseline Run from the Norway pout benchmark assessment under ICES WKPOUT 2016. The estimates are quarterly minima estimated at the beginning of the season. The estimates are B_{loss} estimates which equals B_{lim} according to the ICES WKPOUT 2016 benchmark assessment which by 1st October is B_{lim}=39 450 t.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

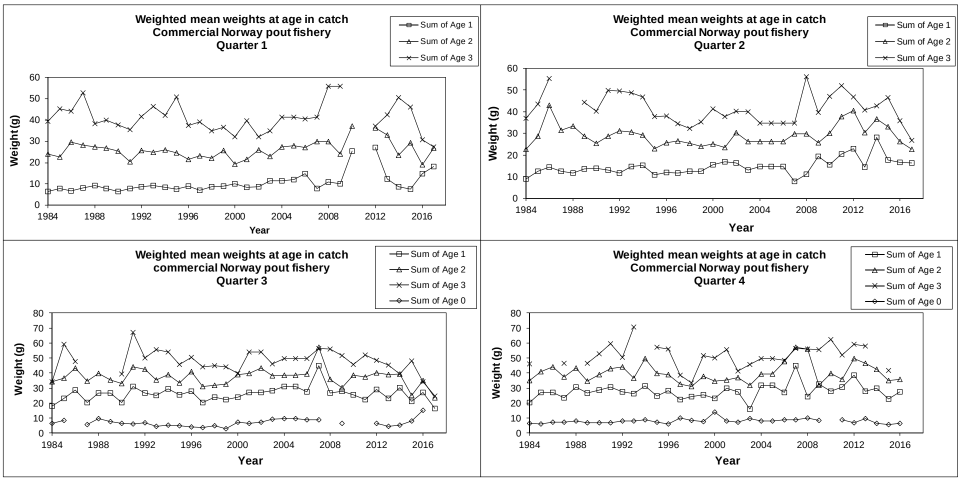


Figure 12.2.1. Norway pout in 4 and 3.aN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1984–2017.

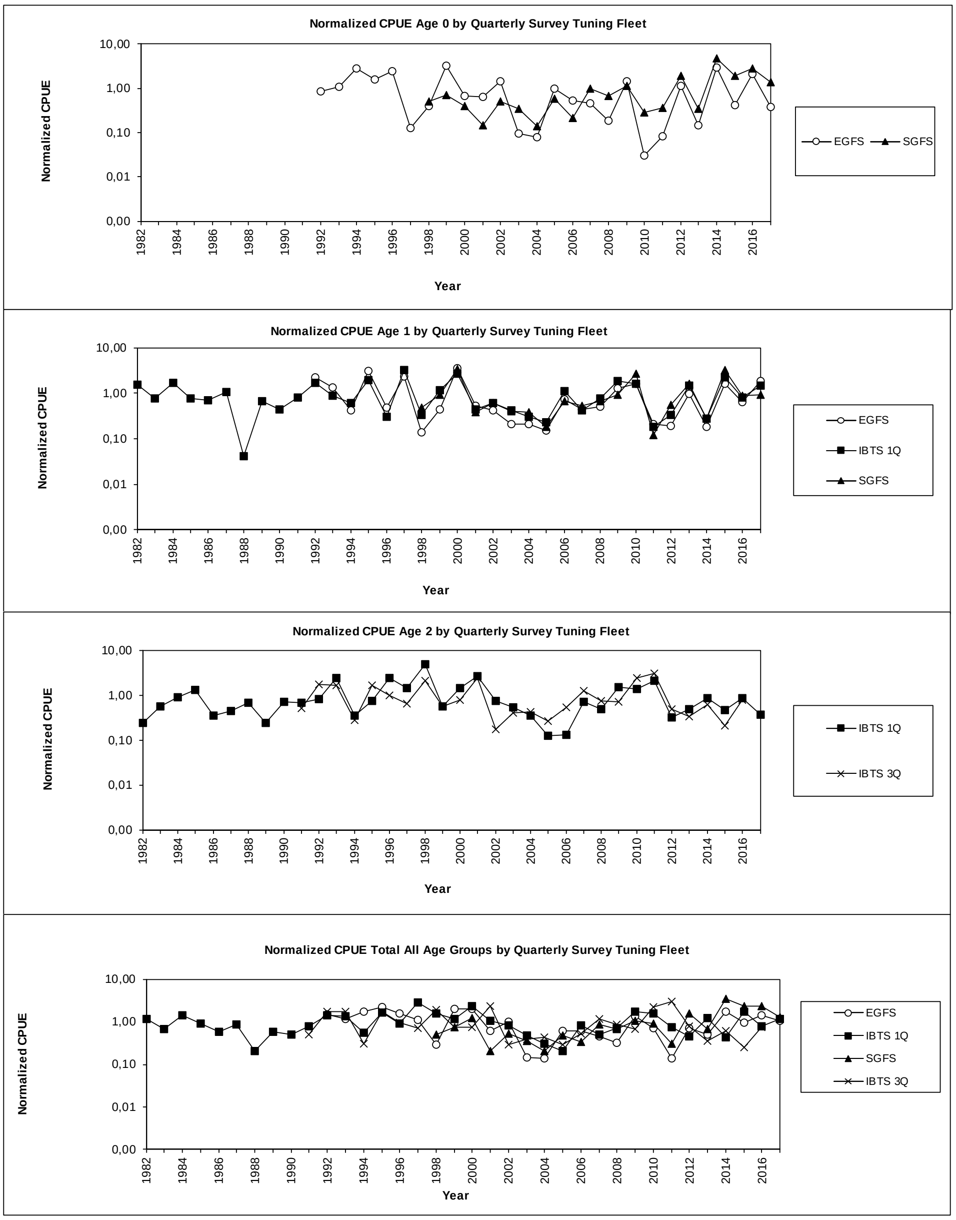


Figure 12.2.2. Norway pout in 4 and 3.aN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly survey tuning fleet used in the Norway pout assessment for each age group and all age groups together.

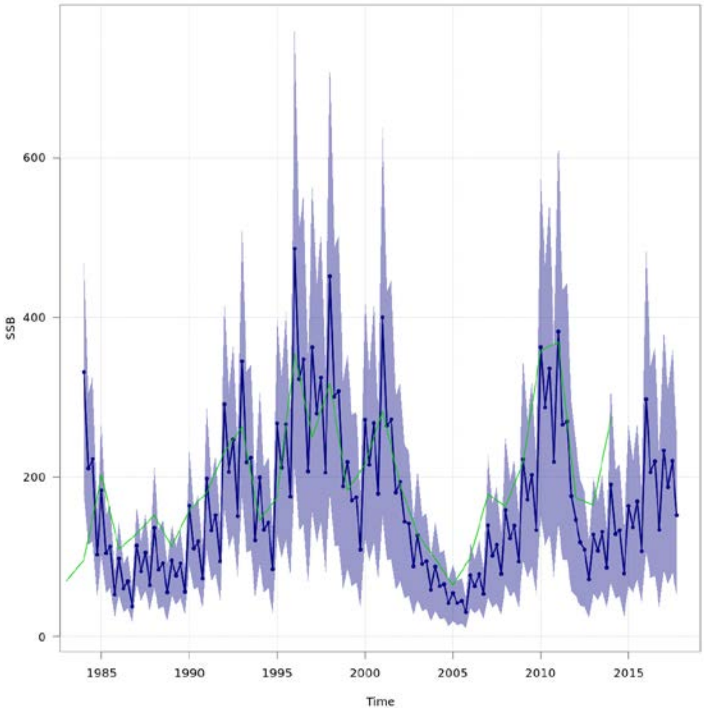


Figure 12.3.1. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: SSB (t), quarterly. SESAM baseline run September 2017. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only – connecting lines are interpolations).

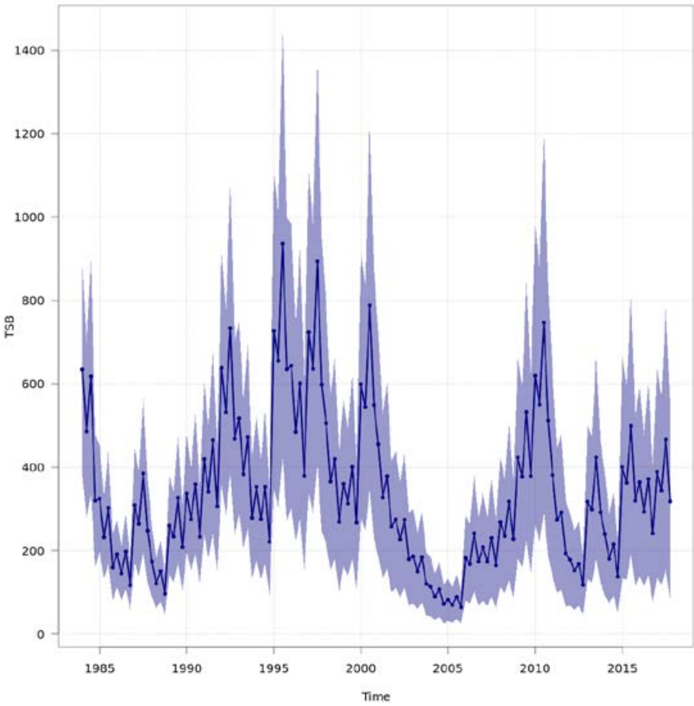


Figure 12.3.2. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: TSB (t), quarterly. SESAM baseline run September 2017.

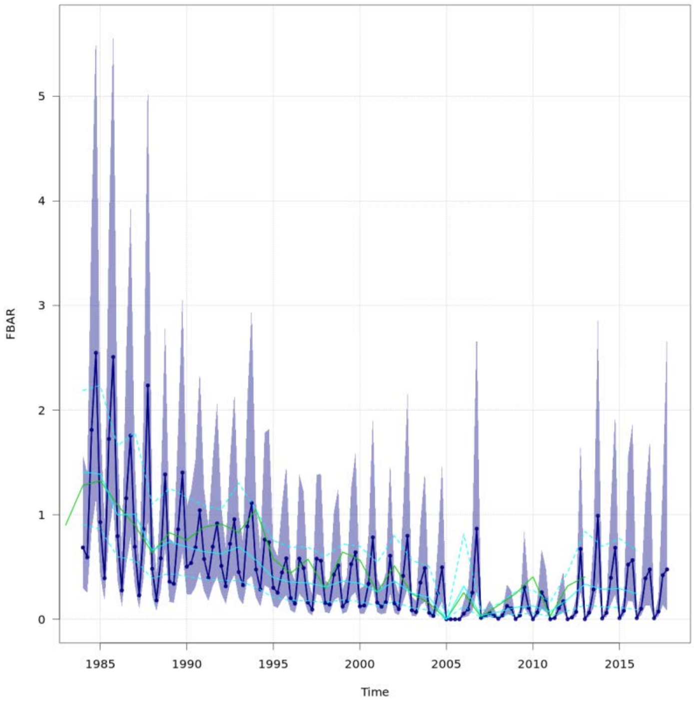


Figure 12.3.3. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: F1–2 = F_{bar}, quarterly. SESAM baseline run September 2017. Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

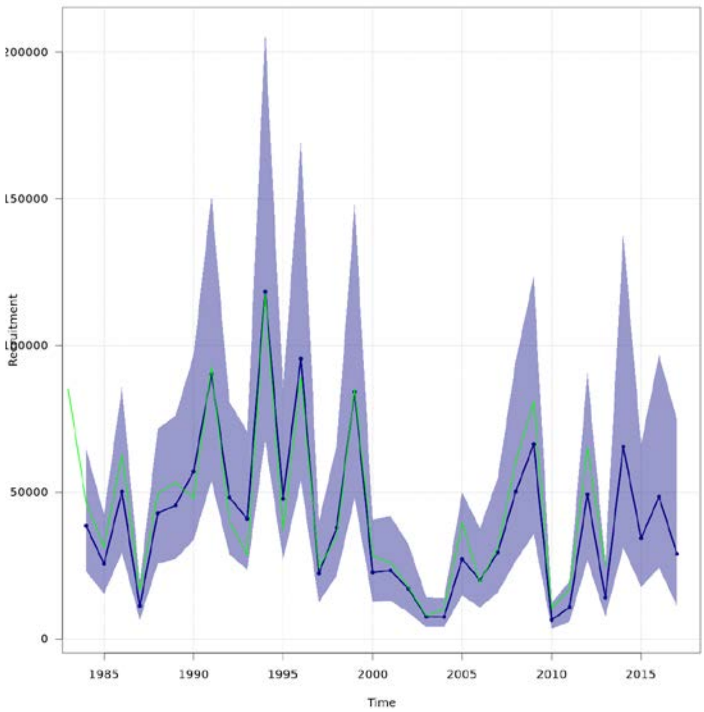


Figure 12.3.4. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Recruitment (millions), yearly. SESAM baseline run September 2017. Blue is SESAM, green is SXSA.

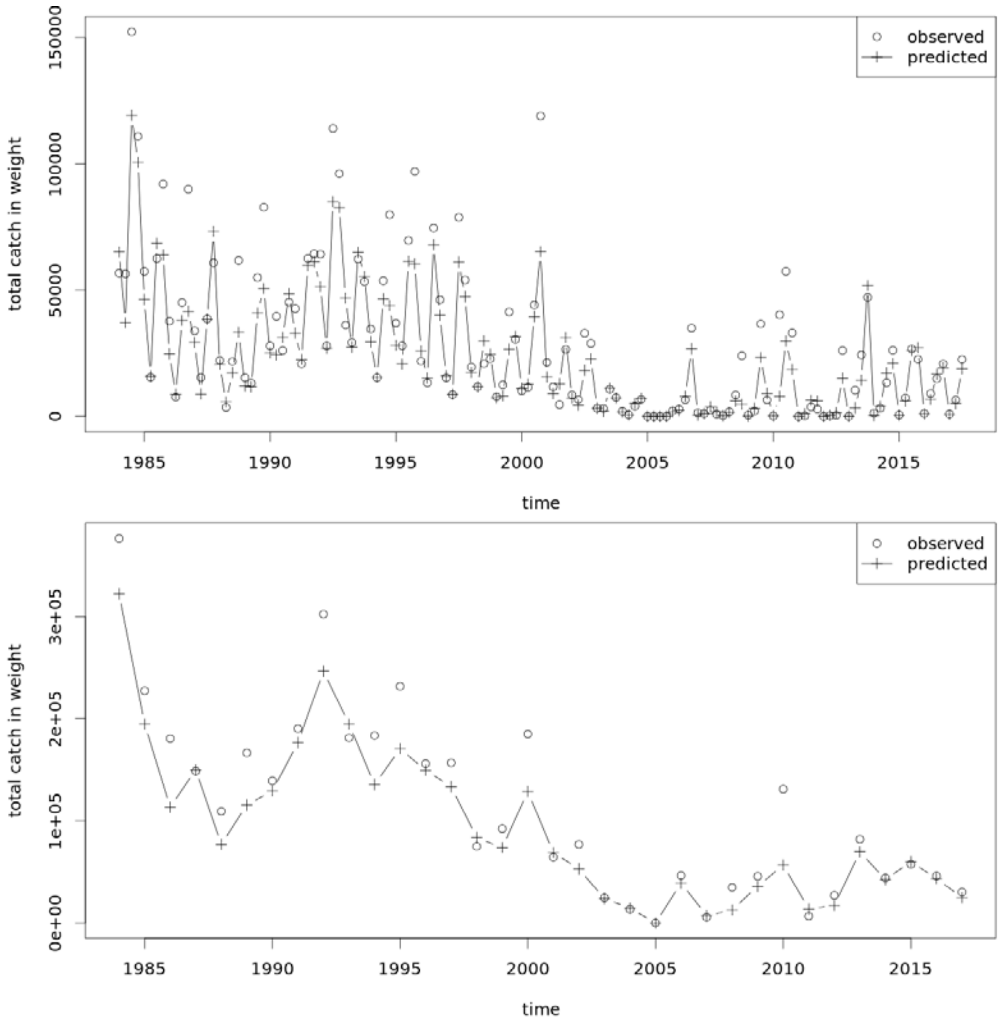


Figure 12.3.5. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Yield = Total Catch (t), quarterly and yearly. SESAM baseline run September 2017.

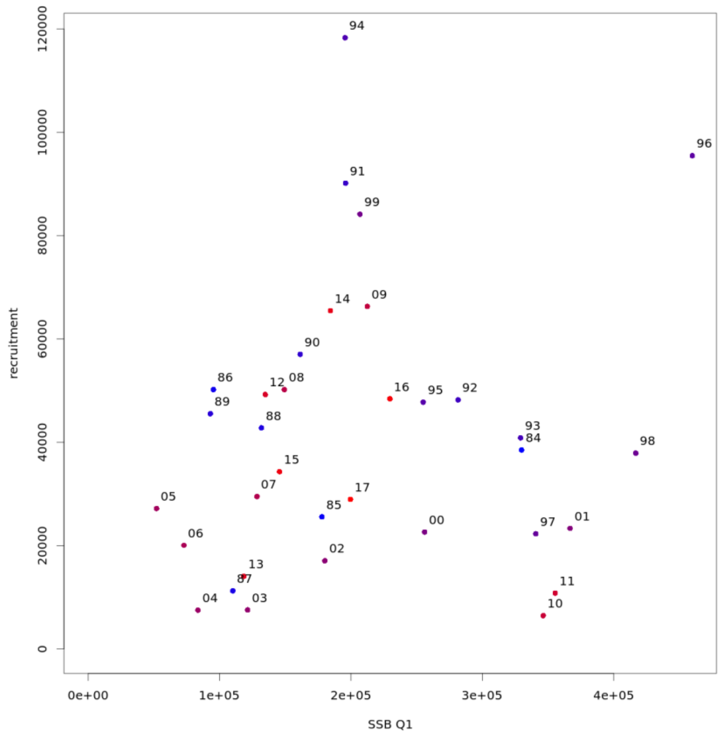


Figure 12.3.6. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 1. SESAM baseline run September 2017.

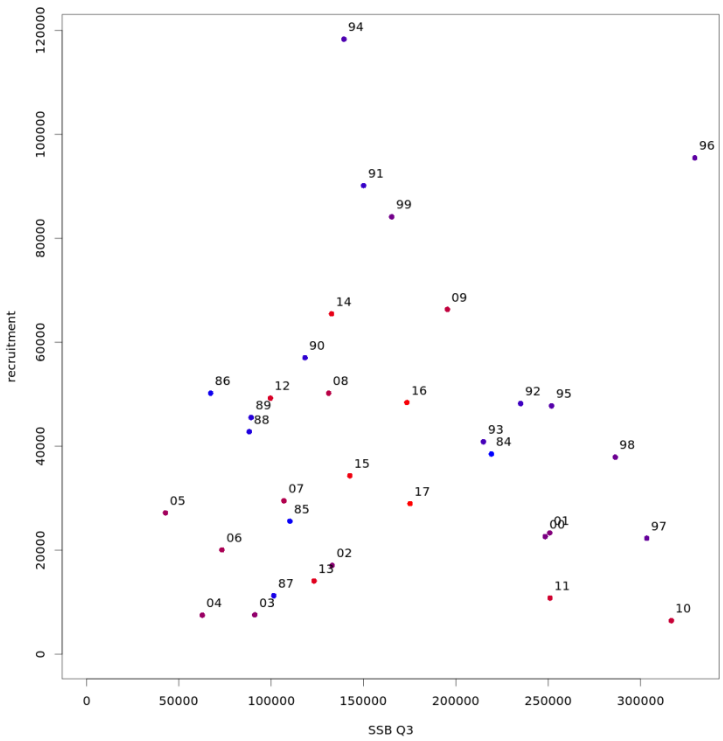


Figure 12.3.7. Norway pout in 4 and 3.aN (Skagerrak). Stock Summary Plots: Stock (SSB) – Recruitment Plot Quarter 3. SESAM baseline run September 2017.

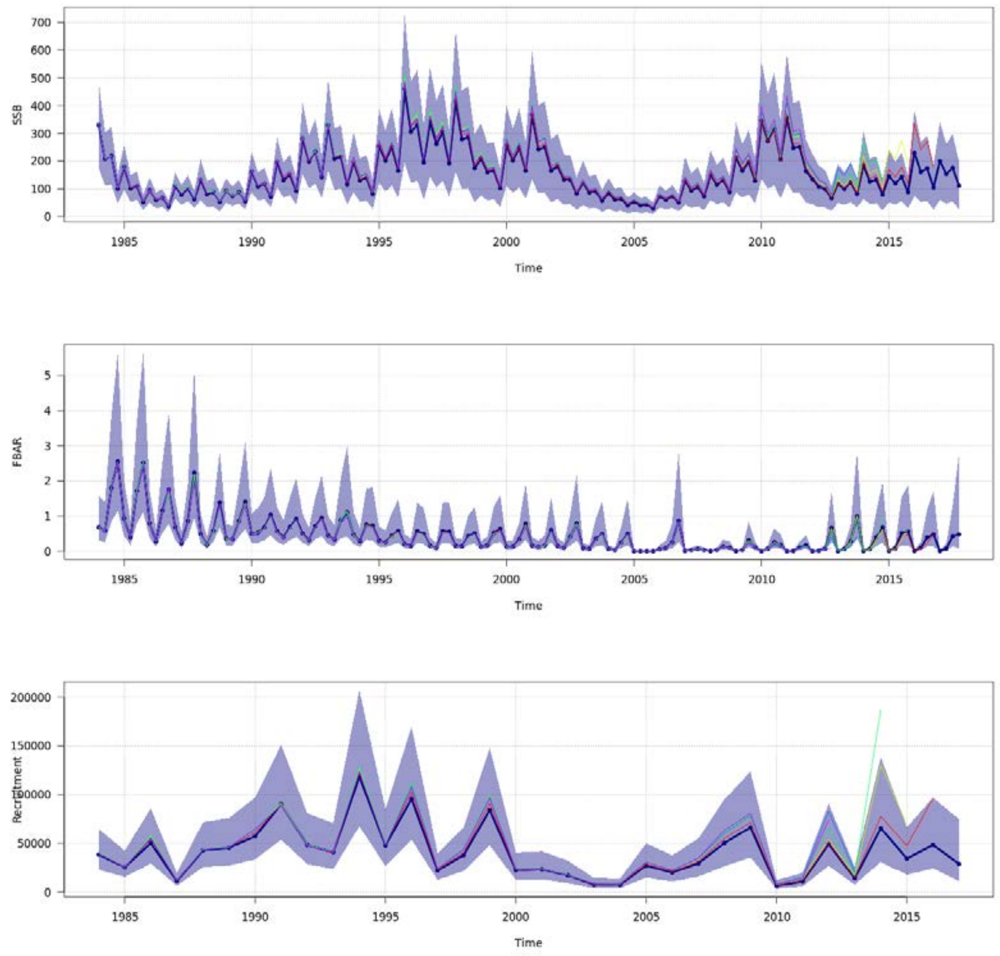


Figure 12.3.8. Norway pout in 4 and 3.aN (Skagerrak). Retrospective plots of baseline SESAM assessment September 2017, with terminal assessment year ranging from 2005–2017.

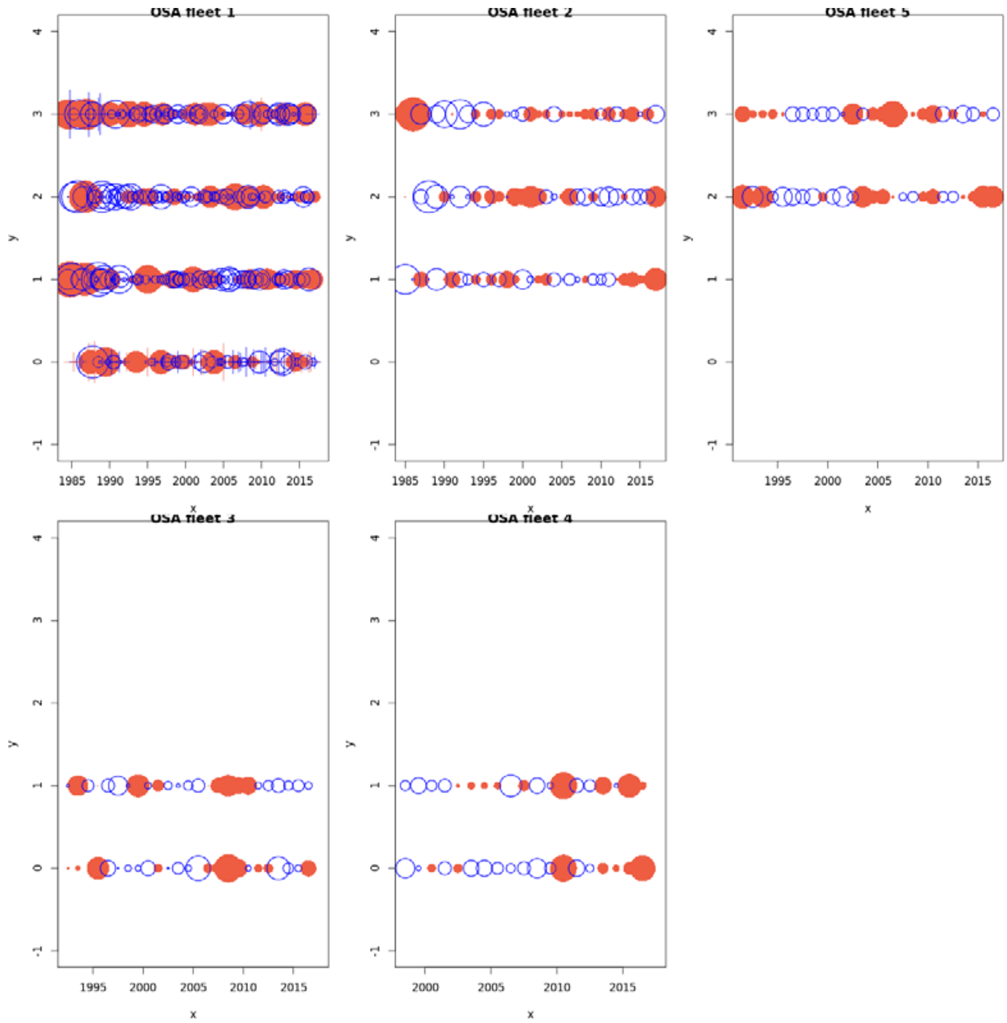


Figure 12.3.9. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet: One step ahead residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2017.

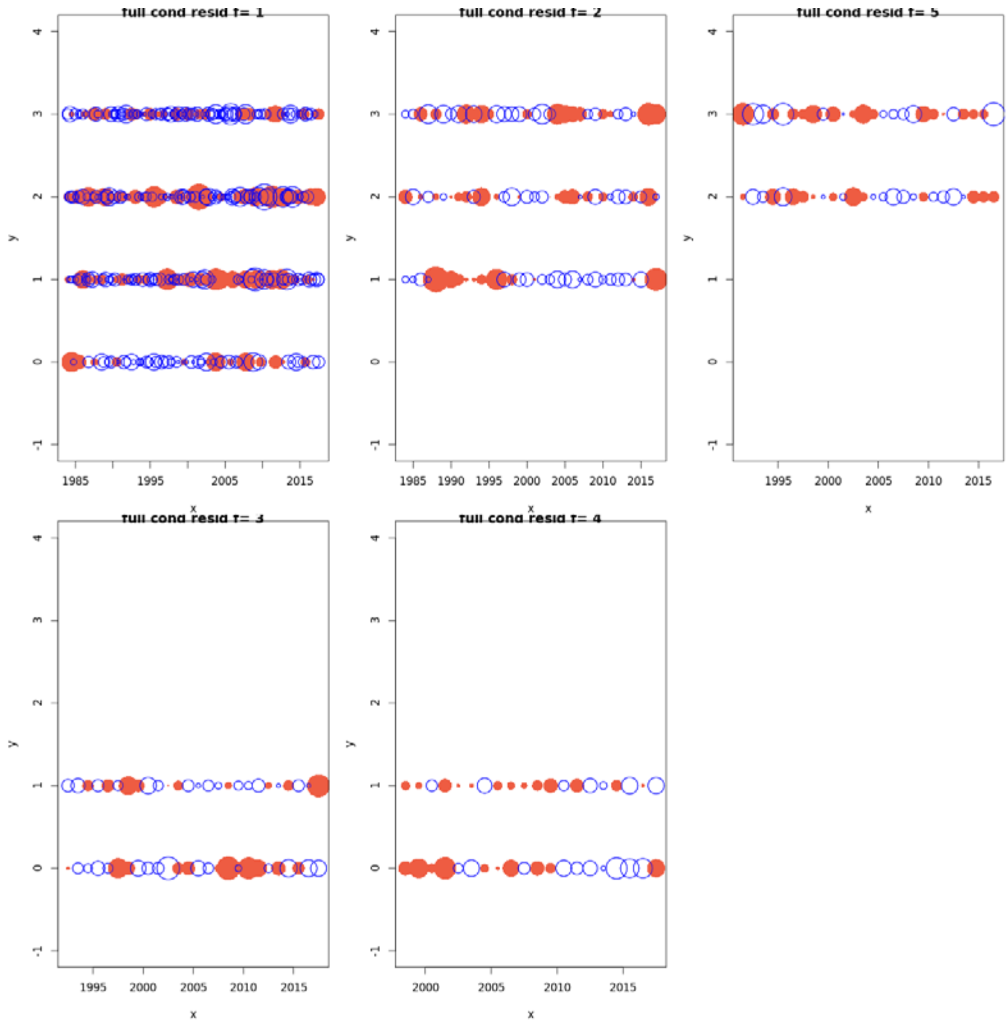


Figure 12.3.10. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots: Full conditional residuals or auxiliary residuals (see Berg and Nielsen, 2016). SESAM baseline run September 2017.

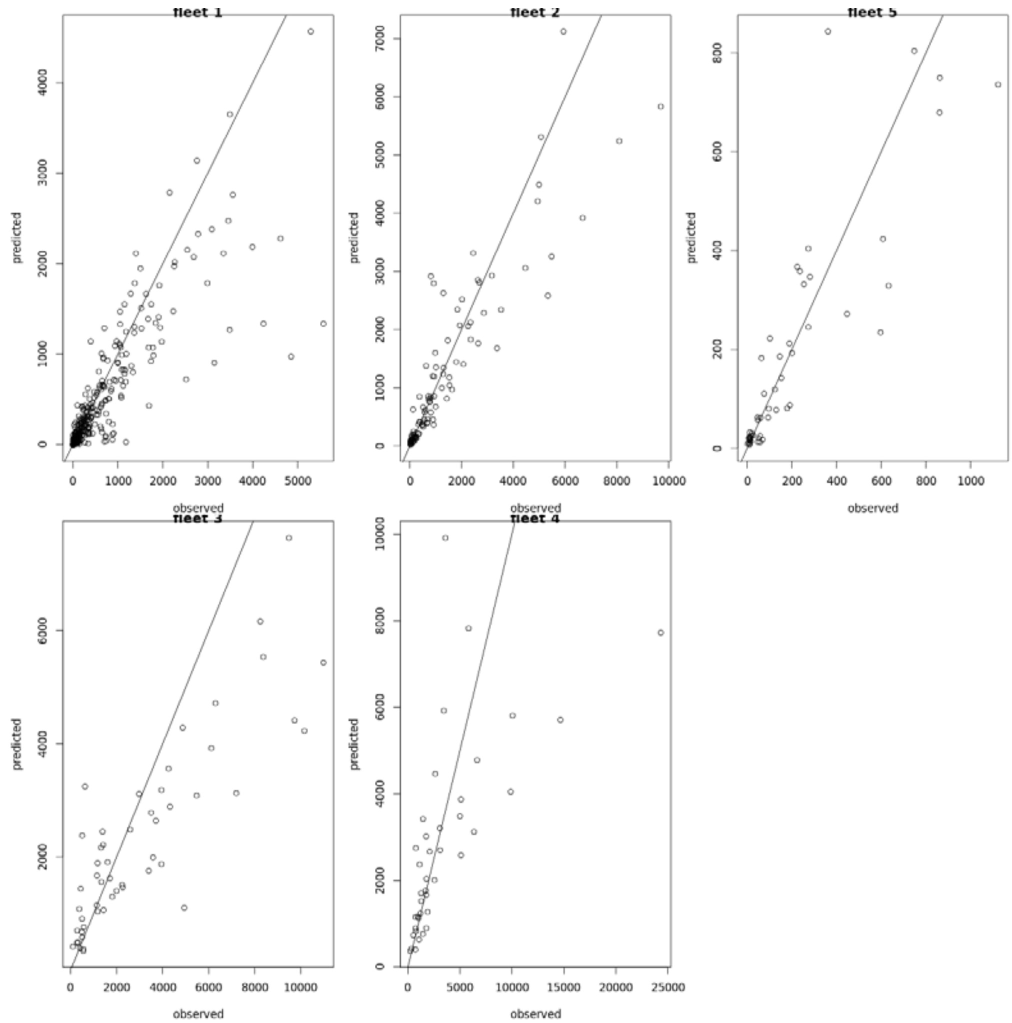


Figure 12.3.11. Norway pout in 4 and 3.aN (Skagerrak). Assessment Diagnostics Plots by fleet. SESAM baseline run September 2017.

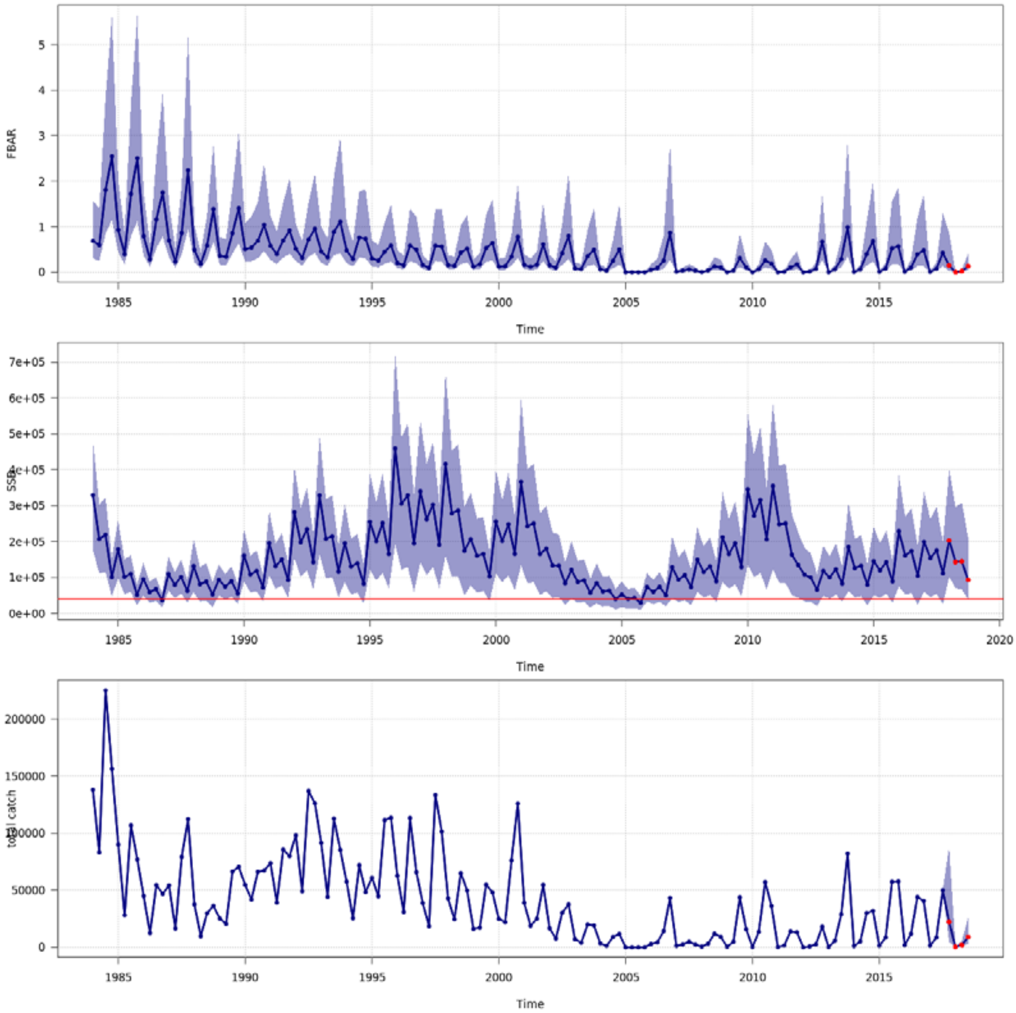


Figure 12.6.1. Norway pout in 4 and 3.aN (Skagerrak). Forecast (first) of fishing mortality, SSB and median catch (t) with F scaled such that the fifth percentile of the SSB distribution one year ahead (1st October 2018) equals B_{lim}.

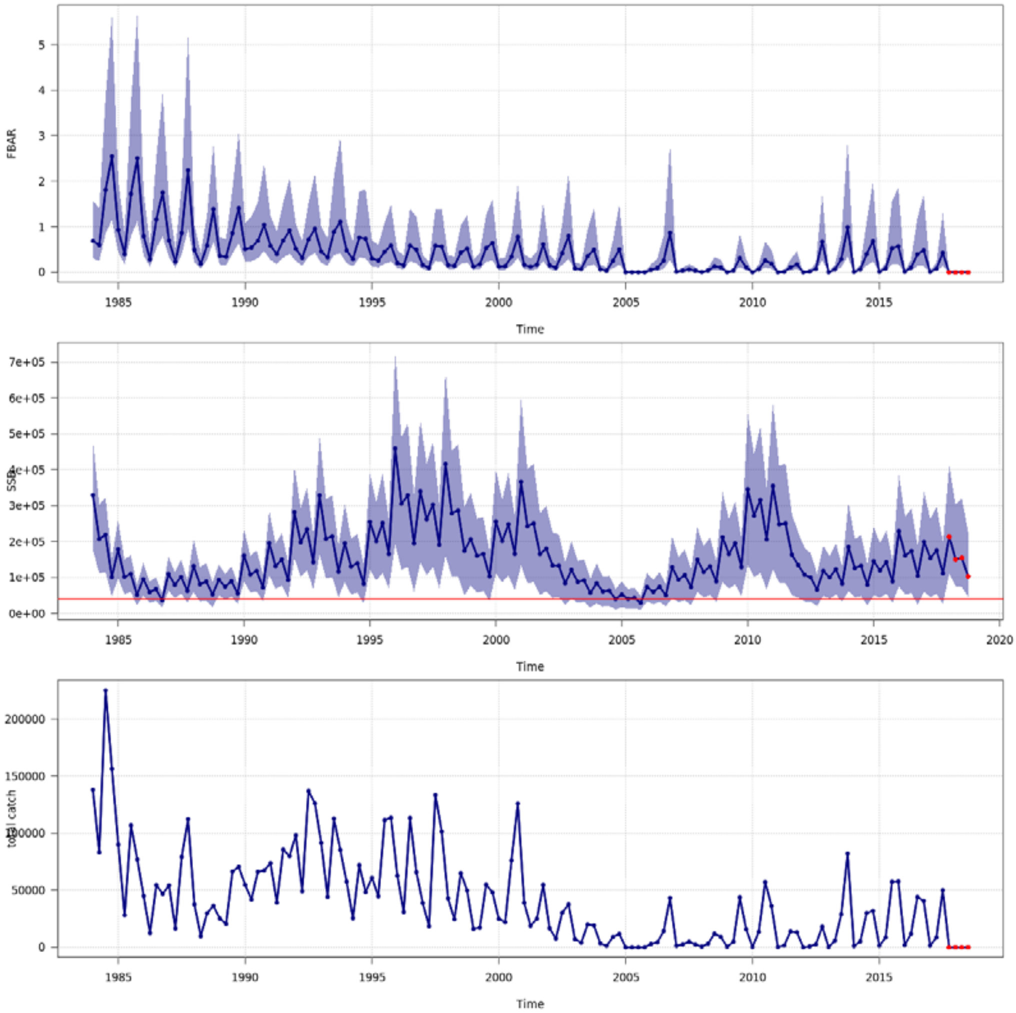


Figure 12.6.2. Norway pout in 4 and 3.aN (Skagerrak). Forecast (second) of fishing mortality, SSB and median catch (t) with F scaled to zero (no catch) for the period 1st October 2017 to 1st October 2018.

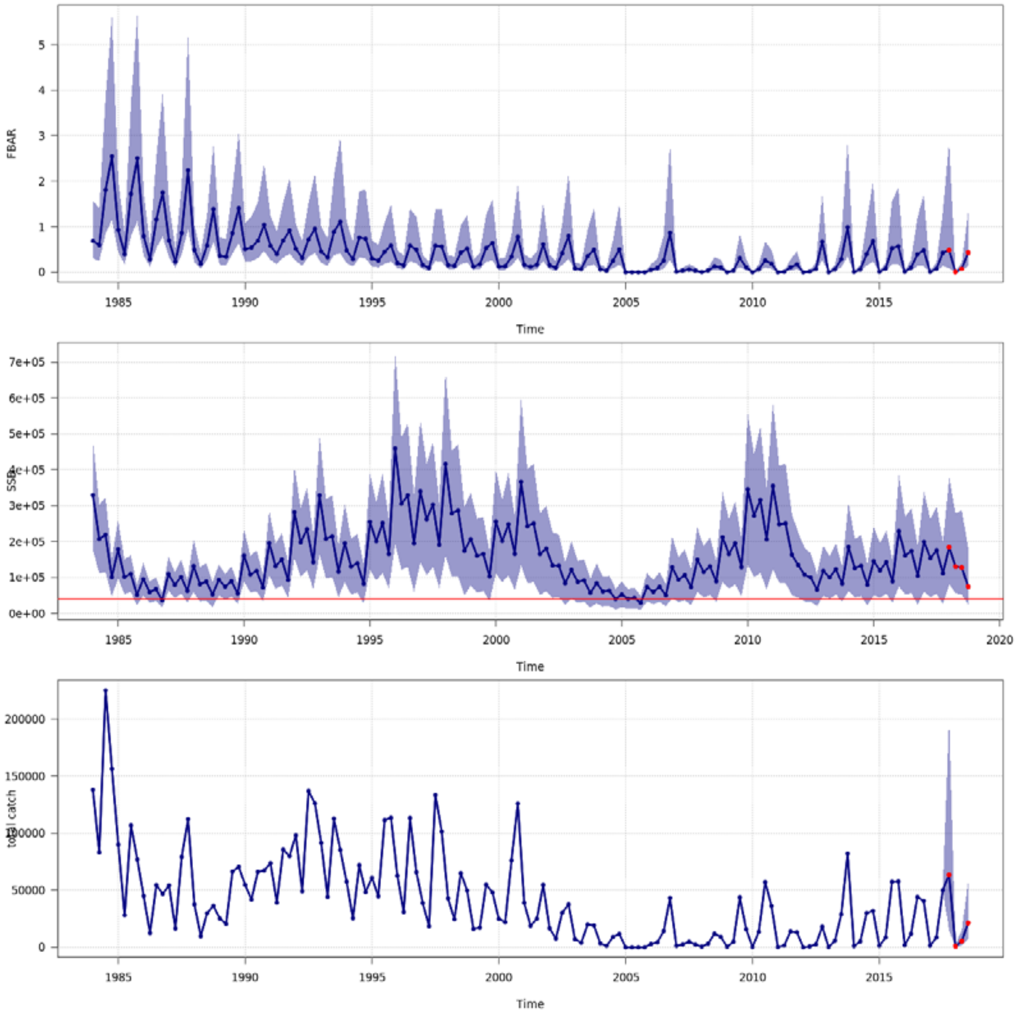


Figure 12.6.3. Norway pout in 4 and 3.aN (Skagerrak). Forecast (third) of fishing mortality, SSB and median catch (t) with F scaled to F status quo for the previous year to 1st October 2017.

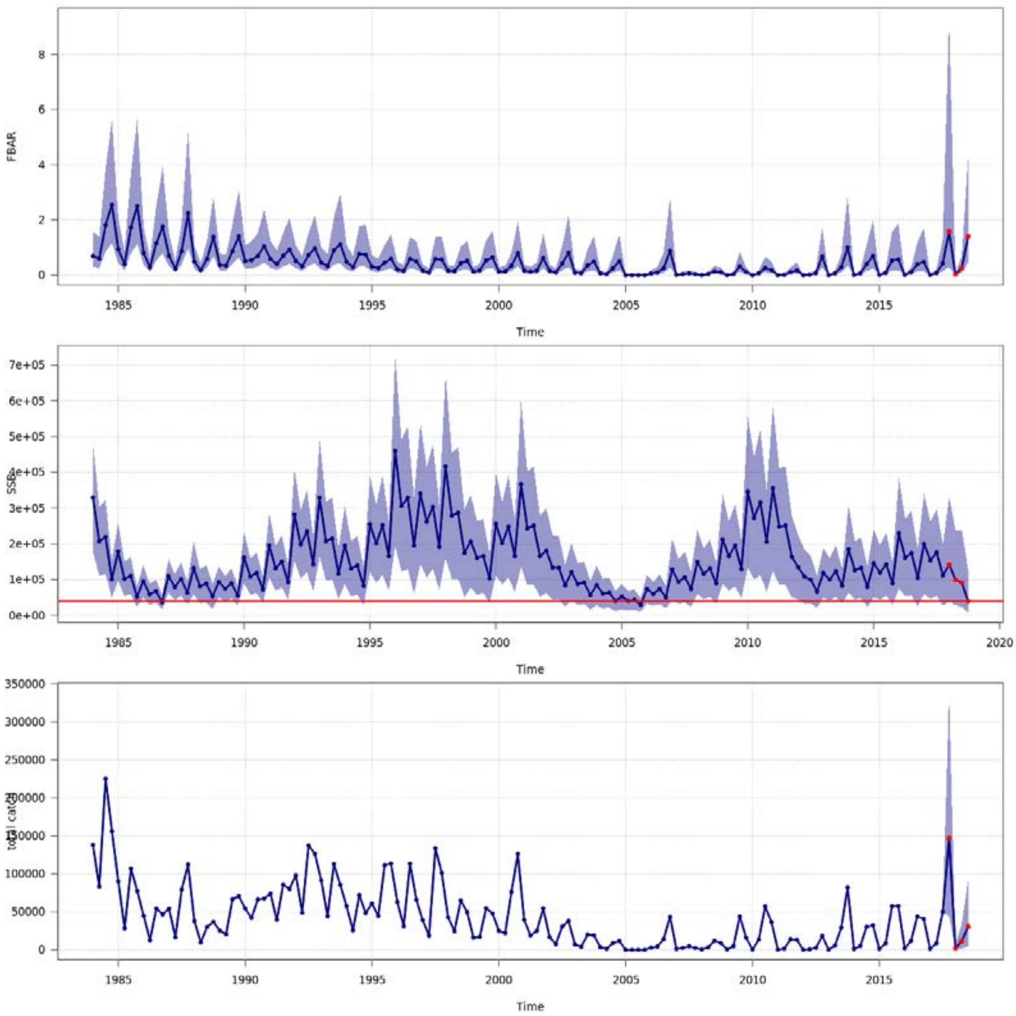


Figure 12.6.4. Norway pout in 4 and 3.aN (Skagerrak). Forecast (fourth) of fishing mortality, SSB and median catch (t) with F scaled such that the median of the SSB distribution one year ahead (1st October 2018) equals B_{lim}.

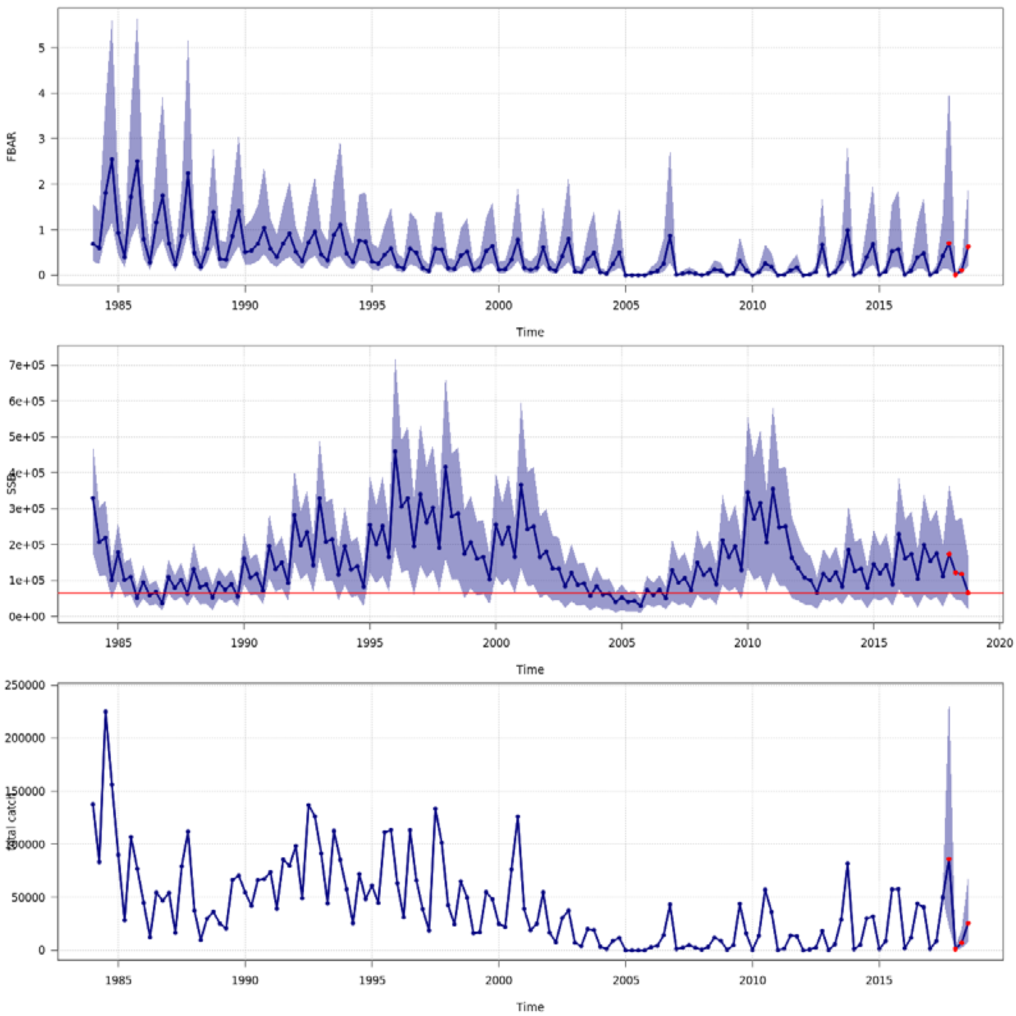


Figure 12.6.5. Norway pout in 4 and 3.aN (Skagerrak). Forecast (fifth) of fishing mortality, SSB and median catch (t) with F scaled such that the SSB distribution one year ahead (1st October 2018) equals B_{pa}.

13 Plaice in Skagerrak (3aN)

Plaice in Subdivision 20 is now included with Plaice in Subarea 4 (Section 14).

14 Plaice in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)

In 2017 the Stock Annex was updated. Therefore only a comprehensive description of the stock assessment results and deviations from the stock annex are presented within this Section of the report. In 2017 the stock had a benchmark assessment. Decisions from the benchmark in 2017 are also included in the report.

14.1 General

14.1.1 Stock structure

Plaice in the Skagerrak (Subdivision 20) is considered to have two components: an Eastern and Western. The latter occurs in a mix with plaice migrating in from the North Sea (Ulrich *et al.*, 2013) and the predominance of catches occurs on summer feeding aggregations in the Western Skagerrak. In a benchmark (WKPLE 2015, ICES 2015) it was decided that plaice in the Skagerrak would be assessed together with the North Sea stock.

In addition, as in previous years, part of the catches in the 7.d area in the first quarter are included in the North Sea plaice assessment, since North Sea plaice migrates into the area in that season (ICES 2010). This year, 50% of the mature animals from 7.d in Q1 were added to the North Sea stock, whereas before, 50% of the total catches were added.

14.1.2 Ecosystem considerations

Available information on ecosystem aspects can be found in the Stock Annex. In addition, the ICES Working Group on the Ecosystem Effects of Fishing Activities (WGECO ICES 2014b) met in April 2014 and addressed a specific question in relation to North Sea plaice, in response to a request from WGNSSK in 2013:

"According to WGNSSK estimates, the North Sea is currently ongoing a plaice outburst without precedent. However, plaice is not included in multispecies models, so the consequences of this outburst on the North Sea ecosystem are unclear and would potentially require additional focus".

WGECO addressed the trends shown in the stock assessment of plaice, which show how increasing fishing pressure on the stock has progressively moved SSB away from the desired state (in the 1980s and 1990s), and then how management has rectified this situation in recent years, which has brought the North Sea plaice stock in a situation unlike any other over the whole 58 year period for which data is available. The group investigated a possible relationship of these trends with abundance of benthic biomass, which is a predominant food source for plaice. Q1 IBTS data showed a two-fold increase in demersal benthivore biomass over the last 29 year period of the survey, and that species composition of the demersal benthivore guild has changed as well. The data showed that predation loading by plaice on benthic invertebrates increased by a factor of 14.8 in just eleven years (2000–2011).

The increase in the consumption of benthic invertebrate prey by the whole demersal benthivore guild, and particularly by plaice, raises the question as to whether the abundance of benthic invertebrate prey might be becoming limiting. If the biomass of demersal benthivorous fish is approaching its carrying capacity, then growth rates in the dominant species in the guild might start to decline (which is in this case plaice growth rates). Computed growth coefficients for the 1956 to 2002 cohorts showed a strong declining linear trend over the whole period (albeit with clear systematic variation in the residuals), and this has been related to increasing water temperature in the North Sea. However, fitting a 4th order polynomial function to the data suggested a marked decline in cohort growth towards the end of the time-series. This is perhaps indicative of plaice becoming food limited, possibly suggesting that B_{MSY} targets for the stock might be marginally too high to be supported by available benthic invertebrate food supplies. However, this evidence is by no means conclusive as polynomial functions are known to show a tendency for marked swings at the extremes of the data range. The situation will become clearer in a few years' time when data for more recent cohorts can be added to the analysis.

14.1.3 Fisheries

A basic description of the fisheries is available in the Stock Annex. In recent years, the adoption of innovative gears, which are often aimed at reduction of fuel consumption and reduction of bottom disturbance, may be contributing to changes in fishing patterns however. In 2011, approximately 30 derogation licenses for Pulse trawls were taken into operation, which increased to 42 in 2012. An additional 42 derogation licenses have been extended in spring 2014. At the same time, possible amendments to EU regulations which would permanently legalize the use of pulse gears for the whole fleet are ongoing. Potential future impact either on the plaice stock itself or the stock assessment is unknown. ICES recommends that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls are undertaken.

14.1.4 ICES Advice

The information in this section is taken from the ICES advice sheet 2017:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 134 238 tons.

Since this stock is only partially under the EU landing obligation, ICES is not in a position to advice on landings corresponding to the advised catch.

14.1.5 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages of which the first stage should be deemed a recovery plan and its second stage a management plan. ICES has evaluated the plan as in agreement with the precautionary approach (Miller and Poos 2010; Simmonds 2010). A subsequent evaluation in 2012 (Coers *et al.*, 2012) addressed amendments to the plan in the context of moving towards stage two of the plan. These amendments do not affect the current advice for plaice.

In 2016, the European Commission has informed ICES that agreement has not been reached between the EU and Norway on a method to split the joint advice between the North Sea and Skagerrak. Therefore, advice is provided based on the MSY approach.

However, using the EU multiannual plan based on plaice in the North Sea does not raise immediate concerns, given the status of the combined stock. When the new management plan for plaice is developed it should, as the current management plan, take the mixed fisheries of plaice and sole into account.

14.2 Data available

14.2.1 Landings

During the benchmark of the eastern channel (7.d) plaice stock (WKFLAT) it was decided that 50% of Q1 mature fish catches taken in the eastern channel are actually plaice from the North Sea stock migrating in and out of the area. Before 2015, 50% of the Q1 eastern channel (7.d) plaice landings were included in the assessment of the North Sea plaice stock. Since 2015, 50% of the mature fish in the landings in Q1 and of the mature fish in the discards in Q1 were added to the North Sea stock and the time series was updated, such that in previous years also 50% of the mature catches from Q1 were added. See the stock annex for plaice in division 7.d for further details.

During the benchmark on plaice (WKPLE ICES 2015) it was decided that plaice from the Skagerrak would be added to the North Sea stock. Since then, the assessment has been a combined assessment with Skagerrak plaice.

Since 2016, large mesh trawlers (TR1 and BT1) with low discard rates were under landing obligation in Subarea 4. A total of 20t BMS landings were reported to ICES in 2016. Due to the low amount, BMS was treated as discards in the assessment. Total ICES estimated landings (including 7.d and subdivision 20) of North Sea plaice in 2016 was 92 744 tons. Of these 81 059 tons came from the Subarea 4, 10 900 tons came from subdivision 20, and 785 tons came from 7.d. The landings in Subarea 4 increased 8% (of 2015) and reached 62% of the 129 917 tons TAC for 2016. The landings in Subdivision 20 increased 11% (of 2015) and reached 62% of the 17 639 tons TAC for 2016. Total landings (in tons) are presented in Table 14.2.1 and landings in numbers at age in Table 14.2.2 and Figure 14.2.2.

14.2.2 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2016, as is described in the stock annex. From Belgium, discards data have been available as well but were only used in the assessment since 2012 when it became available in InterCatch. See section 14.2.7 for more information on the use of InterCatch for raising discards rates across metiers and countries. The Dutch discards data for 2009 and 2010 were derived from a combination of the observer programme that has been running since 2000, and a new self-sampling programme. The estimates from both programmes were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet. Since 2011, estimates were derived exclusively from the self-sampling data. There is an on-going project within WMR to validate these estimates by examining matched (same vessel and haul) trips where both observer estimates and self-sampling estimates are derived.

To reconstruct the number of plaice discards at age before 2000, catch numbers at age data was reconstructed in 2005 based on a model-based analysis of growth, selectivity of the 80-mm beam trawl gear, and the availability of undersized plaice on the fishing grounds. Discards numbers at age are presented in Table 14.2.3. Figure 14.2.1 presents a time series of landings, catches and discards from these different sources. Age distributions of discards are presented in Figure 14.4.2 and Table 14.2.3. The total discards weight has been gradually decreasing since our first year of observed discards 2000. The discards ratio are illustrated in Figure 14.2.15. Since 2010, the majority of discards were age 1 and 2.

14.2.3 Catch

The total catch at age as used in the assessment including all landings and all discards are presented in Table 14.2.4. These include catch of NS plaice in the 1st quarter from 7.d and catch from the subdivision 20. Landings-at-age, discards-at-age and catch-at-age plots are presented in figures 14.2.2 and 14.2.3.

14.2.4 Weight-at-age

Stock weights at age are presented in Table 14.2.5. Stock weight at age has varied considerably over time, especially for the older ages. Landing, discards and catch weights at age are presented in Table 14.2.6, 14.2.7 and 14.2.8 respectively. Catch weights at age are derived from the discards and landings weights at age according to the relative contributions of each to the overall catch for each age. Figure 14.2.4 presents the stock, discards, landings and catch weights at age. Notably, there has been a long-term decline in the observed stock weight at age.

14.2.5 Maturity and natural mortality

During the benchmark in 2017, natural mortality and maturity were re-assessed using both survey and commercial data (WKNSEA report). The mortality rates based on Hoenig's Tmax-based estimator (Hoenig 1983) were thought to be the best for this stock, but did not deviate greatly from the previous estimate based on Beverton (1963) (0.1 $year^{-1}$ for all ages and years). Therefore, natural mortality was not changed from previous values. A new time-varying maturity ogive was estimated using Dutch commercial landings 1957–2015, but the new ogives had marginal effect on the estimated SSB. Therefore, the previously-used, time-invariant maturity ogive (Table 14.2.9) was chosen.

14.2.6 Catch, effort and survey data

During the benchmark in 2017, alternate survey indices were explored. In addition to the Beam Trawl Surveys (BTS) and sole net (SNS) surveys used in the assessment prior to the benchmark, the International Bottom Trawl Survey (IBTS) quarters 1 and 3 were included:

- Beam Trawl Survey combined for RV Tridens and ISIS (BTS-combined); (1996–2016); Age 1–9 (plus age);
- Beam Trawl Survey RV Isis (BTS–Isis) for the older part of the time series; (1985–1995); Age 1–8;
- Sole Net Survey 1 (SNS1); (1970–1999); Age 1–6
- Sole Net Survey 2 (SNS2); (2000–2016); Age 1–6
- IBTS–Q1 plaice index; 2007–2016; Age 1–7;
- IBTS–Q3 plaice index; 1997–2016; Age 1–9.

The most important surveys for demersal fish species in the greater North Sea area are the different BTS (3rd Quarter) and the IBTS (1st and 3rd Quarter). While the different BTS cover areas 4.b, 4.c and the Channel, the IBTS also covers area 4.a and the Skagerrak and Kattegat (3.a).

Since 2017, both BTS and IBTS age-structured survey indices were estimated using delta-GAM method (Berg *et al.*, 2014), rather than the in-house estimates provided by the survey group. Since the smoother for historical years will deviate with each increasing data year, the sensitivity of such indices based on such method needs to be investigated next year.

Table 14.2.10 and Figure 14.2.5 show the index values for the years that they are used in the assessment. Of the BTS-combined and IBTS–Q3 survey index, ages 1–9 are used for tuning the North Sea plaice assessment. Of the IBTS–Q1 survey index, ages 1–7 are used. Of the BTS–Isis older survey index, ages 1–8 are used. And of the Sole Net Survey (SNS1 & SNS2) ages 1–6 are used in the assessment, while the 0–group index is used in the RCT3 analysis for recent recruitment estimates. The internal consistency of the survey indices used for tuning appears relatively high for the Beam trawl surveys, but low for the SNS surveys (Figures 14.2.6–14.2.10). The log-catch curves of ages 1–6 for the surveys are illustrated in Figure 14.2.14. In general, SNS has a low selectivity for older ages. Compared to BTS, IBTS has a higher selectivity for older ages. Overall, all surveys show relatively consistent catch selectivity over the time series, except for IBTS–Q1 where the time series is too short to validate. A gradually increasing catch selectivity for all 1–6 ages are observed for BTS-combined and IBTS–Q3. Assuming the survey gear selectivity does not change over the time, such trend is likely due to the decreasing mortality.

Since 2011 there is an annual survey of plaice and sole using commercial vessels and gears (Reijden *et al.*, 2016). This survey takes place in the same season as the BTS surveys. Length structured catch per unit effort estimates and age-length keys are collected during this survey.

An additional survey index is used for recruitment estimates in the RCT3 analysis (Table 14.5.1): Demersal Fish Survey (DFS) age–0

Several commercial lpue series consisting of an effort series and landings-at-age series are available for usage as tuning fleets. These include time series for the Dutch beam trawl fleet and the UK beam trawl fleet (excluding all flag vessels). Because WKFLAT 2009 recommended to exclude lpue series from the final assessment run upon which management advice is based, they have not been included in the assessment.

14.2.7 InterCatch

Since 2012, national research institutes submitted landings and discard estimates by métier and quarter in InterCatch. Figure 14.2.11 and 14.2.12 show the landings and discards coverage by country and by métier in Subarea 4 and Subdivision 20. Approximately 57% and 76% of the landings in weight are sampled in Subarea 4 and Subdivision 20 respectively, to obtain information on age-composition (Note that the UK vessels of the TBB_DEF_70–99_mm métier are exclusively Dutch owned flag vessels and de facto are thus sampled in the Dutch market sampling programme). Of the metiers for which discards are monitored in sampling programmes, the largest part of these discards is covered in the TBB_DEF_70–99_mm fleet. In most discards monitoring programmes, age composition information is also collected. Approximately 77% and 34% of the discards in weight are sampled in Subarea 4 and Subdivision 20, respectively. To raise the amount of discards for landings that had no discards allocated and to raise the landings and discards for which no age distribution was known, the same following allocation scheme was used. Allocations to calculate the age structure were done separately for discards and landings. The métiers that covered most of the catches each had their own group (OTB 70–119, OTB > 120, TBB 70–119, TBB > 120 and OTB & TBB CRU, see table below). Other countries that had sampled the métiers were used to allocate discard and age structure to the unsampled fleets. All other métiers were grouped into one group. All métiers except the métiers for crustaceans (_CRU) were used to allocate discards and age structure to this group. All allocations were done per quarter. If age structures were present for data for the whole year only, these were added to all quarters. If there were no samples in a specific quarter, all other quarters were used. No discards were sampled for TBB > 120, therefore OTB > 120 was used for this group.

Allocation scheme to raise discards and age structures to unsampled fleets.

Unsampled fleet*	Sampled fleet**
OTB 70–119	OTB 70–119
OTB > 120	OTB > 120
TBB 70–119	TBB 70–119
TBB > 120	TBB > 120 (OTB > 120)
OTB & TBB CRU	OTB & TBB CRU
Others	All métiers, excluding métiers for crustaceans (_CRU)

* Unsampled fleet are those fleets for which no dicards or age structure is known.
** Sampled fleet are those fleets for which the discard rate or age structure is known.

14.2.8 Data analyses

The assessment of North Sea plaice by AAP was carried out using the FLR (FLCore v. 2.3 and FLXSA v.2.0), splines and mgcv packages in R version 3.2.5.

Since 2013, ICES does not operate with external review groups anymore. Audits were done by internal reviewers (members of the WGNSSK group) and potential issues were directly discussed between the auditors and the stock assessor. Therefore there is no written review to be presented here.

14.3 Assessment

A series of assessments were conducted during the benchmark to explore the combination of surveys and model settings (ICES 2017). In this report, we only present the assessment with the final model setting.

Final AAP assessment

The settings for the final assessment that is used for the catch option table is given below:

Stock	PLE.27.420
Year	2016
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + DE fleets and BE (since 2012)
Fleets (years; ages)	BTS-Isis-early 1985–1995; 1–8 BTS-combined 1996–2016; 1–9 SNS1 1970–1999; 1–6 SNS2 2000-2016 (excl. 2003); 1–6 IBTS-Q1 2007–2016; 1–7 IBTS-Q3 1997–2016; 1–9
Plus group	10
Last data year	2016
Suevey selectivity independent of ages for ages >=	6

Age at which the catchability for the F-at-age reaches a plateau >=	9
F tensor spline age knots	6
F tensor spline year knots	26

The estimated parameters are presented in Table 14.3.1. The estimated fishing mortality and stock numbers are shown in Tables 14.3.2 and Figure 14.3.1, respectively. Model diagnostics including catch (landing and discards), survey residuals (raw residual, not standardized) and retrospective plots are illustrated in Figure 14.3.2–14.3.4. There is no strong cohort patterns in the catch residuals, however, the models lightly underestimates catches in age 2. This is likely caused by the lack of fitting from age 1 to 2 by the F-at-age smoother. The retrospective plots do not exhibit negative or positive pattern.

14.3.1 Final assessment results

Figure 14.2.1 illustrates the trends in reported catch, landing and discards. Reported landings gradually increased up to the late 1980s and then rapidly declined until 1995, in line with the decrease in TAC. The landings show a general decline from 1987 onwards, increasing slowly but steadily in recent years. Discards were particularly high in 1997 and 1998 (reconstructed), and in 2001 and 2003 (observed), resulting from strong year classes. Figure 14.3.1 and Table 14.3.4 present the model estimated mean F(2–6), SSB, and recruitment since 1957. Fishing mortality increased until the late 1990s and reached its highest observed level in 1997. Since the early 2000's, fishing mortality has been rapidly decreasing. Since 2007 it has been below the fishing mortality target established in the management plan. It is currently (2016) estimated at 0.202, around the Fmsy. Over the last five years SSB has been rapidly increasing and is currently (2016) estimated at 836 066 kt. Recruitment varies inter-annually around the long term geometric mean of approximately 1 million recruits. It appears to have been lower on average during the 1960's and 1970's, then above average in the 1980's and fluctuating around the average since the 1990's.

The stock dynamics are partly affected by the occurrence of strong year-classes. However, Figure 14.2.3–14.2.3 and 14.2.13–14.2.14 do not exhibit strong year-class in recent years. The increased stock size in recent years is therefore most likely the direct consequence of reduced fishing mortality.

The predominant age in the landings is currently age–4 (in 2016 as well as in the past decade, see figure 14.2.2). Notably, during the time series, this was only also observed in the 1960's. In contrast, the predominant age in the landings in the 1970's, 1980's and 1990's, was age–3. The age distribution in the landings in recent years furthermore shows more similarity with the 1960's in that age–5 and age–6 fish are relatively abundant in the landings in comparison to the rest of the time series and age-2 fish are notably underrepresented in the landings. These shifts in age distribution may be explained by the still relatively low exploitation level in the 1960's, which subsequently substantially increased over the next three decades and since the early 2000's has shown a dramatic decline. Changes in spatial distribution of fishing effort and shifts in spatial distribution of the fish may also have affected these changes. The 'lack' of age-2 fish in the landings in the 1960's as well as in recent years may be for a number of reasons. When considering the age distribution in the catches age–2 fish were also lacking in the catches in the 1960's, while this is not the case in recent years. One possible explanation may be the occurrence of high grading (discarding of smaller fish in order to allow for landing higher numbers of large fish for which a higher price may be received or to avoid exhaustion of quota). The latter seems unlikely since the TAC has not been fully utilised in recent years. Another explanation may be that plaice have become mature at younger ages than in the past since this shift in maturation also leads to mature fish being of a smaller size at age, because growth rate diminishes after maturation. Grift *et al.* 2003 observed that this may occur due to fisheries-induced genetic change: those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This could cause age–2 fish to be discarded more abundantly in recent years because a larger fraction of them being under the minimum size in comparison to the past.

14.3.2 The Fishers' North Sea Stock Survey

The Fishers' North Sea Stock Survey (FNSSS) was carried out using a questionnaire circulated to North Sea fishermen in five countries: Belgium, Denmark, England, the Netherlands, and Scotland. Fishermen were asked to record their perceptions of changes in their economic circumstances, as well as in the state of selected fish stocks. No real relationship was apparent between the plaice abundance index derived from the Fishers' North Sea Stock Survey and the ICES estimates of the North Sea plaice spawning stock biomass.

14.4 Recruitment estimates

In the short term forecasts, assumptions are made on a number of things (see also section 14.5). One of the more difficult things to predict is the strength of incoming year classes (abundance of ages 0–2) in the assessment year. A number of options are considered as follows:

Age–0: More specifically, the abundance estimate of age–1 fish in the year after the assessment year, i.e. in the TAC–year, needs to be assumed and no data is available from surveys or otherwise. Therefore, the geometric mean of the time series is used.

Age–1: The RCT3 analysis is run which combines DFS and SNS survey data and the assessment results to predict the abundance of age–1. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise, the geometric mean is used.

Age–2: The RCT3 analysis is run which combines DFS, BTS and SNS survey data and the assessment results to predict the abundance of age–2. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise the AAP survivors estimate is used.

Input to the RCT3 analysis is presented in Table 14.4.1. The results for age–1 and age–2 abundance estimates are presented in Table 14.4.2, and in Table 14.4.3 respectively. For year class 2016 (age 1 in 2017), the values predicted by the SNS–0 survey and VPA through RCT3 have similar values and both have a low prediction standard error than DFS–0. The RCT3 value was used for the short-term forecasts. For year class 2015 (age 2 in 2017), the estimates from BTS–1 and SNS–0 (comparable to the VPA mean) have a relatively low standard error (compared to the other surveys). However, AAP is relatively strong in predicting age–2 survivors. Hence, the WG decided to use the AAP estimate rather than the RCT3 estimate for the 2015 year class. The recruitment estimates from the different sources are summarized in the text table below. Underlined values were used in the forecast.

Year class	Age in 2017	AAP survivors	RCT3	GM 1957-2013	Accepted estimate
2015	2	967855	801152	706596	AAP survivors
2016	1		1055007	969504	RCT3
2017	0			969504	GM 1957–2013
2018				969504	GM 1957–2013

14.5 Short-term forecasts

Short-term prognoses were carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2016 (the last data year) into 2017 (the intermediate year in which the assessment is done); into 2018 (the TAC year) and finally into 2019 (the 'result' of the TAC year). For these years, a number of assumptions were made. Weight-at-age in the stock, weight-at-age in the catch and weight at age in the discards are taken to be the average over the last 3 years. The exploitation pattern (selectivity of the fishery) was taken to be the mean value of the last three years. The relative proportions of landings versus discards in the catch were taken to be the mean of the last three years.

In the intermediate year F is assumed to be equal to the estimate for F in 2016 ("F–status quo" or F_{sq}). The option of assuming F to correspond to the TAC being fully landed was considered, but abandoned as an option to pursue considering the fact that the TAC has not been fully utilised in previous years. No results for this option are presented here further for that reason. Population numbers in the intermediate year for ages 2 and older are taken from the AAP survivor estimates. Numbers at age 1 in 2017 are taken from the RCT3 output and age 1 from 2018 are taken from the long-term geometric mean (1957–2013). Input to the short term forecast is presented in Table 14.5.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	F(2–6) 2017	SSB2017	Recruitment 2017	Landings 2017	Discards 2017
F2017 = F2016 (Fsq)	0.202	936773 t	1055007 t	96767 t	40869 t

Resulting management options for 2017 are given in Table 14.5.2.

14.6 Biological reference points

14.6.1 Precautionary approach reference points

The current precautionary approach reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks (Figure 14.4.2). Therefore, ICES considered that B_{lim} can be set at B_{loss} = 160 000 tons and that B_{pa} can then be set at 230 000 tons using A multiplier of 1.44. F_{lim} was set at F_{loss} (0.74). F_{pa} was proposed to be set at 0.6 which is the 5th percentile of F_{loss} and gave a 50% probability that SSB is around B_{pa} in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 tons.

14.6.2 F_{MSY} reference points

In 2010 ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 2014 the joint ICES MYFISH Workshop (WKMSYREF3 ICES 2014) held place to consider the basis for F_{MSY} ranges. The workshop was convened in response to a request from the European Commission for advice on potential intervals above and below F_{MSY}. This resulted in an F_{MSY} range for North Sea plaice of 0.13–0.27. The point value of F_{MSY} was set at 0.19.

This values differs from the previous value of Fmsy = 0.25 (range 0.2–0.3, Miller and Poos 2010).

14.6.3 Update of F_{lim} and F_{pa} values in 2016

In 2016 (ICES 2016), an updated calculation of F_{lim} is proposed as the F that, in equilibrium from a long-term stochastic projection, gives 50% probability of SSB>B_{lim}. The value of F_{pa} is estimated as the F value such that when F is estimated to be at F_{pa}, the probability that true F<F_{lim} is at least 95%. Thus $F_{pa} = F_{lim} / \exp(1.645*\sigma)$, where σ is estimated standard deviation of ln(F) in the final assessment year. In case of plaice where a σ is not available, a default value is used $F_{pa} = F_{lim} /1.4$. The last 10 years of the 2014 stock assessment object (data year 2004–2013) was retrieved and the distribution of recruitment at SSB was simulated using EqSIM, setting B_{lim} = 160000. The estimated 10 years plaice SSB are all far higher than B_{lim}. The estimated F_{lim} is 0.63 and the corresponding F_{pa} = 0.45 using the default ratio of 1.4. The updated values of both F_{lim} and F_{pa} deviate from their original values, most likely due to the inclusion of Skagerrak (Subdivision 20) data in the recent years where the original reference point was not derived from.

14.6.4 Update of reference point in 2017 benchmark

A full update of the precautionary and MSY based reference points was conducted during 2017 benchmark, using the same method as described in Section 14.6.3.

The reference points used prior to 2017 benchmark are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	230000 t	Default to value of B_{pa}	
	F_{MSY}	0.19	Combined stock	ICES (2014)
Precautionary approach	B_{lim}	160000 t	B_{loss} = 160000 t, the lowest observed biomass in 1997 as assessed in 2004	ICES (2004)
	B_{pa}	230000 t	1.44 × B_{lim}	ICES (2004)
	F_{lim}	0.63	The F that in equilibrium will maintain the stock above B_{lim} with a 50% probability	ICES (2016a)
	F_{pa}	0.45	$F_{pa} = F_{lim} \times \exp(-1.645\sigma_F)$; $\sigma_F = 0.20$	ICES (2016a)

A series of discussions have been carried out on the value of the new MSY $B_{trigger}$: F has been below (at) F_{MSY} in more than 5 years, which triggers a revision of MSY $B_{trigger}$. According to ICES guidelines the new MSY $B_{trigger}$ should in this case be the 5th percentile of the current SSB. The benchmark came up with an alternative solution: "Estimating SSB from a period with a substantially lower fishing mortality and higher SSB i.e. year 1962" (i.e. 481.5 kt). This deviation from the guidelines was questioned within the WG. The ADG that followed the WG noted that SSB has not stabilized, and could increase even more or decline as a consequence of e.g. density dependent growth or maturity. The ADG decided to follow the guidelines because they felt there was insufficient reason to deviate from the guidelines. The MSY $B_{trigger}$ value shown in the table below reflects this decision. MSY $B_{trigger}$ is therefore the maximum of the following: B_{pa}, or the

5th percentile of current SSB (SSB from the benchmark final run divided by 1.4 = 564 599 tons).

The updated reference points are listed as below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	564599 t	Fifth percentile of current SSB (SSB2015/1.4) as estimated at the benchmark.	WKNSEA 2017 report, WKMSYREF4
	F_{MSY}	0.210	Estimated by application of EqSIM evaluation	WKNSEA 2017 report, WKMSYREF4
	$F_{MSY\ lower}$	0.146	Estimated by application of EqSIM evaluation	WKNSEA 2017 report, WKMSYREF4
	F = $F_{MSY\ upper}$	0.30	Estimated by application of EqSIM evaluation	WKNSEA 2017 report, WKMSYREF4
Precautionary approach	B_{lim}	207288 t	Break-point of hockey stick stock-recruit relationship	WKNSEA 2017 report, WKMSYREF4
	B_{pa}	290203 t	$B_{pa} = B_{lim} \times \exp(1.645 \times 0.2) \approx 1.4 \times B_{lim}$	WKNSEA 2017 report, WKMSYREF4
	F_{lim}	0.516	Estimated by application of EqSIM evaluation	WKNSEA 2017 report, WKMSYREF4
	F_{pa}	0.369	$F_{pa} = F_{lim} \times \exp(-1.645 \times 0.2) \approx F_{lim} / 1.4$	WKNSEA 2017 report, WKMSYREF4

And the proposed MSY reference points:

Reference point	Value
FMSY without Btrigger	0.21
FMSY lower without Btrigger	0.146
FMSY upper without Btrigger	0.30
FP.05 (5% risk to Blim without Btrigger)	0.43
FMSY with Btrigger	0.21
FMSY lower with Btrigger	0.15
FMSY upper with Btrigger	0.30
FP.05 (5% risk to Blim with Btrigger)	0.77
MSY	104113 t
Median SSB at FMSY	1104120 t
Median SSB lower precautionary (median at FMSY upper precautionary)	690328 t
Median SSB upper (median at FMSY lower)	1616173 t

14.7 Quality of the assessment

Although discards form a substantial part of total plaice catches, for which estimates are less certain than for landings, the assessment at present includes 14 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years. Discards data are now for instance available from Denmark (beam trawls, otter trawls, Scottish seines and Danish seines, gillnets and long liners); the United Kingdom (for beam trawls up to 2007); Germany (beam trawls, otter trawls, gillnets); Belgium (beam trawls, otter trawls, Scottish seines) and the Netherlands (beam trawls and otter trawls). The improvement of retrospective patterns observed in the recent years might have beneficiated from increased coverage of discards estimates from the main fishing nations, through self-sampling and observers programs.

A self-sampling programme by the Dutch beam trawl fleet has been in place since 2004. This sampling programme indicates spatial and temporal trends in discarding (higher discards are observed in coastal regions and late summer), but it was considered inappropriate for overall estimates of discarding because of differences in the implementations of sampling methods. In 2009, a new self-sampling programme was launched to address this. For the 2009 and 2010 assessments, discarded numbers-at-age for the Netherlands have been estimated using data from both the self-sampling and the observer programmes. It is noted that estimates of discard numbers in 2010 differed between the two programmes. Mid 2011 the programme was redesigned again, to allow for better comparison between self-sampling and observer estimates through paired measurements. From 2011 onwards, Dutch discard estimates are derived exclusively from the self-sampling programme, while observer estimates are used for validation of the self-sampling data only. Preliminary analyses suggest that the self-sampling estimates are as reliable as those from the observer programme. Further analyses will be conducted in 2013 as more data from ‘matched trips’ (self-sampling and observer estimates from the same vessel trip) become available.

If the introduction of the landing obligation for the fisheries on sole and plaice in 2016 will affect the quality of catch data available to ICES, the quality of the assessment and advice by ICES may particularly be affected in the case of plaice, given that (substantial) discards are included in the assessment. It is unclear how these programs will continue under a landing obligation.

14.8 Status of the stock

The stock is well within precautionary boundaries. SSB in 2016 is estimated around 836 066 thousand tonnes which is well above Bpa (290 203 tons). Fishing mortality in 2016 is estimated to be at a value of 0.202 (below Fpa of 0.369, below the long term management target F of 0.30 and around Fmsy of 0.210). Fishing mortality of the human consumption part of the catch is estimated to be 0.099.

14.9 Management considerations

Plaice is mainly taken by beam trawlers in a mixed fishery with sole in the southern and central part of the North Sea. There are a number of EC regulations that affect the fisheries on plaice and sole in the North Sea, e.g. as a basis for setting the TAC, limiting effort, minimum landing size and minimum mesh size.

14.9.1 Multiannual plan North Sea

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007). This plan is written for the North Sea stock and does not take the merging with the Skagerrak into account. The plan describes two stages: to be deemed a recovery plan during its first stage and a management plan during its second stage. ICES has evaluated this management plan in 2010 and considers it to be precautionary (ICES 2010a). Objectives are defined for these two stages; to rebuild the stocks to within safe biological limits and to exploit the stocks at MSY respectively. In

2015 WKMSYREF3 estimated Fmsy to be between 0.13 and 0.27. ICES identified the point estimate for the North Sea stock to be 0.19 (ADGMSYREF3).

Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years. The plaice stock has been within safe biological limits (F = 0.6) as defined by the plan since 2005. The sole stock has been within safe biological limits in terms of fishing mortality and SSB has been above the biomass limit (Bpa = 35 kt) in the latest years. According to the management plan (Article 3.2), this signals the end of stage one. Consequently, utilisation of the plan as a basis for advice is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). In 2012, ICES evaluated a proposal by the Netherlands for an amended management plan, which could serve as the 'stage 2' plan (Coers et al. 2012). ICES concluded that the plan, subject to those amendments, is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY). However, implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Since the management plan is now in stage 2, the EU regulation stipulates that the stocks should be managed on the basis of MSY. For plaice, the ICES Fmsy estimate is 0.21, which is below the target F (0.3) defined in the plan. Considering that the plan specifies that fishing mortality in stage 2 should not be below the target of 0.3 (which coincides with the upper bound of a range of Fmsy values suggested by ICES), the current advice for plaice is still on the basis of moving towards the target of 0.3, rather than on the basis of Fmsy point estimate of 0.21 (albeit that the TAC change is restricted to a maximum 15% change). This apparent conflict in the basis for TAC setting in the management plan should be addressed.

This management plan is written for the North Sea stock. No specific management plan exists for the Skagerrak. The North Sea management plan should be updated including the Skagerrak. The forecast and advice are given for both areas with a combined TAC.

14.9.2 Effort regulations (North Sea)

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In 2009, the effort management programme switched from a days-at-sea to a kW–day system (EC regulation 43/2009), in which different amounts of kW–days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. A minor part of the fleets exploiting sole, i.e. otter trawls (OTB) with a mesh size equal to or larger than 100 mm included in 14.2.1, have since 2009 been affected by the regulation. The beam trawl fleet (BT2) was affected by this regulation only once in 2009 but not afterwards.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, likely due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. 25 vessels were decommissioned in 20014. In addition, the current sole and plaice long-term management plan specifically reduces effort as a management measure. However, the evaluation of amendments to the plan in 2012 showed that the plan is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY) also without reductions of effort (Coers *et al.*, 2012).

Fishing effort of the beam trawl fleet has shifted towards the southern North Sea to target sole over the past decade. Juvenile plaice tend to be relatively abundant there, leading to relatively high discarding rates of small plaice. This shift was amongst others driven by a number of economic factors, such as the prices for sole and plaice respectively and fuel costs, which meant that the sole fishery was the most profitable fishery. With the recent substantial increases in biomass of the plaice stock, and thus to be expected increased catch rates, targeting plaice further North may become more economically favourable again. With the relatively low fishing mortality levels in recent years, it is also to be expected that a larger proportion of the population will be made up of older fish, of which the fishery could potentially benefit, since larger plaice receive higher prices on the market than small plaice. However, this benefit may be reduced if weight at age are decreasing, which seems to be the case in the plaice stock. At present, the beam trawl fleet is limited in its ability to move northwards (where larger plaice are more abundant) by effort restrictions for the BT1 fleet, which are imposed on the basis of the North Sea cod management plan. This trade-off between objectives in the cod and flatfish plans deserves some attention. Ongoing work in the Netherlands on the levels of cod catch rates (which are considered to be low) in the beam trawl fisheries should help quantification of this trade-off. The introduction of the landing obligation will likely provide an additional strong driver for at least part of the beam trawl fleet to focus on a more northerly plaice fishery, to avoid the complications of the high unwanted bycatches of undersized plaice in the South. For effort regulations in the Skagerrak see section 07.

14.9.3 Technical measures

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea where sole has become relatively more abundant, affect both sole and plaice. The minimum mesh size of 80 mm selects sole at the minimum landing size. However, this mesh size generates high discards of plaice with a larger minimum landing size than sole. For the overall fleet the discards ratio has been slightly decreasing since 2003 and at present is approximately 40% by weight. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. Furthermore, the size selectivity of the fleet may lead to a shift in the age and size at maturation. For example, in recent years plaice and sole have become mature at younger ages and at smaller sizes than in the past (Grift *et al*., 2003). The introduction of the Omega (mesh size) meter in 2010 has led to a slight increase in the effective mesh size in the fishery.

Technical management measures have caused a shift towards two categories of vessels: 2000 HP (the maximum engine power allowed) and 300 HP. The 300 HP vessels are allowed to fish within the 12–nautical mile coastal zone and in the Plaice Box. The Plaice Box is a partially closed area along the continental coast that was implemented in phases, starting in 1989. The area has been closed to most categories of vessels >300 HP all year round since 1995. The most recent EU-funded evaluation by Beare *et al*. (2010) reported the Plaice Box as having very little impact on the plaice stock.

Large scale adoption of innovative gears, for instance if EU regulations would permanently legalize the use of pulse gears could cause changes in fishing patterns in the near future (see section 14.1.3).

14.9.4 Frequency of assessment

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment.

The North Sea Plaice assessment succeeded in all four criteria when evaluated in 2015 (ICES WGNSSK 2015). Therefore the North Sea Plaice stock is a candidate for less frequent assessments. The perception of the stock and the retrospective pattern in the stock did not change since last year.

Table 14.2.1. Plaice in Subarea 4 and Subdivision 20 (7.d Q1 not included): Official landings in thousands.

North Sea														Skagerrak	
YEAR	Belgium	Denmark	France	Ger-many	Nether-lands	Norway	Swe-den	UK	Others	Total	Un- allocated	ICES estimate	TAC NS	Total	TAC_SK
1982	6755	24532	1046	3626	41208	17	6	20740		97930	56616	154546	140000		
1983	9716	18749	1185	2397	51328	15	22	17400		100812	43218	144030	164000		
1984	11393	22154	604	2485	61478	16	13	16853		114996	41153	156149	182000		
1985	9965	28236	1010	2197	90950	23	18	15912		148311	11527	159838	200000		
1986	7232	26332	751	1809	74447	21	16	17294		127902	37445	165347	180000		
1987	8554	21597	1580	1794	76612	12	7	20638		130794	22876	153670	150000	15694	
1988	11527	20259	1773	2566	77724	21	2	24497	43	138412	16063	154475	175000	12858	
1989	10939	23481	2037	5341	84173	321	12	26104		152408	17410	169818	185000	7710	
1990	13940	26474	1339	8747	78204	1756	169	25632		156261	-21	156240	180000	12078	
1991	14328	24356	508	7926	67945	560	103	27839		143565	4438	148003	175000	8685	
1992	12006	20891	537	6818	51064	836	53	31277		123482	1708	125190	175000	11823	11200
1993	10814	16452	603	6895	48552	827	7	31128		115278	1835	117113	175000	11407	11200
1994	7951	17056	407	5697	50289	524	6	27749		109679	713	110392	165000	11334	11200
1995	7093	13358	442	6329	44263	527	3	24395		96410	1946	98356	115000	10766	11200
1996	5765	11776	379	4780	35419	917	5	20992		80033	1640	81673	81000	10517	11200
1997	5223	13940	254	4159	34143	1620	10	22134		81483	1565	83048	91000	10292	11200
1998	5592	10087	489	2773	30541	965	2	19915	1	70365	1169	71534	87000	8431	11200
1999	6160	13468	624	3144	37513	643	4	17061		78617	2045	80662	102000	8719	11200
2000	7260	13408	547	4310	35030	883	3	20710		82151	-1001	81150	97000	8826	11200
2001	6369	13797	429	4739	33290	1926	3	19147		79700	2147	81847	78000	11653	9400
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000	8789	6400
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250	9110	1400
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000	9090	9500
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000	6764	7600
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441	9565	7600
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261	8747	8500
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000	8657	9300
2009	3474	NA*	NA*	2931	29142	1116	1	13143	-	NA*	-	54973	55500	6748	9300
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825	9057	9300
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400	8251	7900
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410	7611	7900
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070	6911	9142
2014	7105	12003	276	4203	29306	577	5	17370	-	69179	1668	70847	111631	9004	10056
2015	5522	14401	223	5171	32074	169	7	17240	-	74807	156	74963	128376	10171	10056
2016	6659	16398	169	4371	32227	94	9	18731	-	78659	2400	81059	131714	10883	11766
2017													129917		17639

* Official estimates not available.

Table 14.2.2. Plaice in Subarea 4 and Subdivision 20: Landings (SOP corrected) in numbers by age (including 1st quarter of 7.d) in thousands).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0	4792	66428	49659	35282	9867	12248	10026	5522	12059
1958	0	7581	23612	65979	36274	20836	8696	8507	6497	13981
1959	0	16914	31085	26040	41988	23432	14173	6547	6739	16530
1960	0	5998	62285	51359	21462	27510	14280	9073	5121	15253
1961	0	2299	33913	68965	33209	12958	14909	9900	6089	14889
1962	0	2075	34677	64548	48387	19939	8757	8733	5081	12373
1963	0	4424	21886	78412	55414	32413	13096	6965	7183	16912
1964	0	14818	40789	65219	57837	37368	15937	6644	4010	17012
1965	0	9913	42438	53486	43919	30320	18464	8602	4237	17686
1966	0	4220	66196	52428	37336	27870	16801	10981	6585	15201
1967	0	6101	30905	115157	42204	22490	16496	8163	6861	11397
1968	0	9750	41883	39251	127220	17638	10642	10396	4039	13754
1969	3	15892	47819	38185	37657	107955	11016	6440	8669	17029
1970	74	16850	49861	54712	39642	34174	76862	6149	4078	14459
1971	20	30568	49876	34580	26919	23659	17471	30711	6626	17468
1972	2296	37561	63958	54402	23695	17479	14787	11211	19111	16094
1973	1332	33342	62095	76769	44397	14517	9335	10347	6392	25194
1974	2305	23972	57595	43677	42588	20391	8300	6554	5773	22790
1975	1042	29877	65465	33211	27004	22509	12613	6292	4362	20923
1976	2892	34497	79621	98846	14129	10156	9352	6553	3022	12871
1977	3225	57061	43359	66120	83841	9157	5922	5030	4068	9206
1978	1102	58412	60114	52398	48310	34240	5728	3232	2333	7201
1979	1316	57933	118662	48879	47805	39864	24187	4154	2802	9272
1980	996	66095	136274	79035	25548	18321	14018	8621	1898	5497
1981	259	103354	125928	59565	36670	12750	9805	8295	5005	6091
1982	3373	48354	212188	71167	29191	16975	7704	5551	4539	8775
1983	1214	119696	115332	100473	29591	12960	8238	4224	3013	8308
1984	108	63507	280481	62835	41492	15417	6842	5593	2729	6551
1985	120	72806	146839	201629	37939	17106	7441	3780	2813	5830
1986	1669	66935	165986	106461	101684	27971	9839	4704	2834	7083
1987	1	85153	118416	120782	81304	44590	13539	4669	2346	5610
1988	1	15200	253815	85347	59950	31492	19347	6198	3434	6402
1989	1254	46810	108272	238243	58767	21667	11605	8025	2321	5806
1990	1546	33766	104796	119829	169465	29946	9053	4689	3803	4206
1991	1425	43064	87196	122233	76075	78728	15410	5390	3215	5634
1992	3386	43769	86358	81470	88534	37542	30444	7229	3295	6976
1993	3416	53555	99805	80856	63275	35042	14745	11500	3704	5883
1994	1375	44554	105863	86992	47577	27680	17279	6661	5449	5458
1995	7779	36761	82649	84778	47911	24572	14746	5285	2495	3896
1996	1103	43346	68155	52961	37285	19160	12400	5881	2799	4989
1997	897	43122	88687	49362	31750	18673	9518	5037	3054	4400
1998	197	30594	74441	62339	22793	9151	5703	2870	1983	3360

	age									
year	1	2	3	4	5	6	7	8	9	10
1999	549	8690	158088	47391	31778	14077	4038	2625	1597	3234
2000	2603	15656	40819	171994	25935	12586	2979	1135	953	2121
2001	4523	37095	58678	57195	101524	11492	4739	1212	650	2364
2002	1229	15868	60204	55511	44243	43066	6527	2256	794	1638
2003	700	44801	50607	54864	34689	20311	18128	1774	689	880
2004	544	12049	119093	39053	23766	13309	5152	4774	460	569
2005	2948	18885	29734	90989	20175	10900	5905	2760	2303	647
2006	363	20214	79934	34221	51057	8057	5589	2301	1318	1408
2007	1436	21357	41941	55949	20379	21837	3095	2011	604	1303
2008	400	13190	52382	45336	34035	7566	8066	978	735	936
2009	1563	12420	61907	42545	24886	18544	3400	4260	587	821
2010	2114	19874	49030	69702	25181	12622	9766	1866	2520	1267
2011	407	12977	45353	62017	51581	14815	6643	6984	1261	2743
2012	163	6164	60603	62070	44968	32037	7556	3402	3482	1924
2013	550	10530	63366	77056	42315	29486	15349	3955	2468	3795
2014	7	5384	40649	77966	52266	21932	12955	8387	2472	3440
2015	0	3844	42673	67065	60967	32309	12793	8902	4055	4834
2016	0	4179	39190	85205	60972	39883	19146	7710	5310	5125

Table 14.2.3. Plaice in Subarea 4 and Subdivision 20: Discards in numbers by age (including 1st quarter of 7.d) in thousands.

	age							
year	1	2	3	4	5	6	7	8
1957	32356	45596	9220	909	961	25	0	0
1958	66199	73552	23655	2572	2137	65	0	0
1959	116086	127771	46402	11407	4737	106	0	0
1960	73939	167893	44948	997	1067	519	0	0
1961	75578	144609	89014	538	1612	130	0	0
1962	51265	181321	87599	21716	799	186	0	0
1963	90913	136183	129778	9964	2112	188	0	0
1964	66035	153274	64156	33825	3011	323	0	0
1965	43708	426021	59262	3404	923	267	0	0
1966	38496	163125	349358	14399	1402	125	0	0
1967	20199	133545	87532	152496	623	260	0	0
1968	73971	72192	46339	26530	22436	58	0	0
1969	85192	67378	16747	19334	773	2024	0	0
1970	123569	152480	27747	1287	5061	161	0	0
1971	69337	96968	42354	2675	426	81	0	0
1972	70002	55470	33899	5714	567	73	0	0
1973	132352	49815	4008	673	1289	67	0	0
1974	211139	308411	3652	285	611	109	0	0
1975	244969	280130	190536	4807	253	123	0	0
1976	183879	140921	71054	18013	174	41	0	0
1977	256628	103696	79317	33552	9317	129	0	0
1978	226872	154113	27257	10775	1244	570	0	0
1979	293166	215084	57578	18382	589	310	0	0
1980	226371	122561	932	687	193	86	0	0
1981	134142	193241	1850	373	431	55	0	0
1982	411307	204572	4624	1109	216	98	0	0
1983	261400	436331	30716	2235	804	72	0	0
1984	310675	313490	52651	24529	1492	69	0	0
1985	405385	229208	35566	2221	200	78	0	0
1986	1117345	490965	48510	26470	1451	146	0	0
1987	361519	1374202	180969	1427	1348	248	0	0
1988	348597	608109	459385	61167	882	177	0	0
1989	213291	485845	193176	85758	7224	115	0	0
1990	145314	279298	168674	28102	5011	177	0	0
1991	183126	301575	141567	40739	5528	939	0	0
1992	138755	219619	94581	34348	4307	880	0	0
1993	96371	154083	48088	11966	1635	216	0	0
1994	62122	95703	35703	1038	822	144	0	0
1995	118863	82676	15753	860	663	120	0	0
1996	111250	331065	27606	3930	451	116	0	0
1997	128653	510918	193828	588	271	108	0	0
1998	104538	646250	191631	53354	297	33	0	0

	age							
year	1	2	3	4	5	6	7	8
1999	127321	208401	231769	54869	278	58	0	0
2000	103468	171213	51092	64971	1230	241	263	167
2001	30346	352452	186900	74744	54276	152	45	1
2002	310442	178402	78296	13940	2834	718	109	1
2003	67798	523336	56580	20184	4358	419	5756	1
2004	233682	183508	127876	10650	1975	450	41	1
2005	93936	332157	46454	23763	4494	6007	287	6
2006	220982	226944	117342	9785	2369	251	736	195
2007	77687	210407	73043	13942	1594	7028	190	1644
2008	135504	255948	37983	5356	1785	336	8852	885
2009	148666	193174	68975	9471	2007	1108	138	3220
2010	167387	180364	59943	22776	2699	1736	2074	283
2011	117902	153773	62696	37050	12949	2924	143	2273
2012	91961	313013	123821	32986	9439	1547	226	7
2013	128227	156837	125878	24797	4679	1033	219	15
2014	293515	192537	116178	55315	19141	2610	478	67
2015	83433	288990	130826	38858	12591	2367	521	209
2016	79202	144049	133284	48501	21078	7479	2068	1857

Table 14.2.4. Plaice in Subarea 4 and Subdivision 20: Catch in numbers by age (including 1st quarter of 7.d) in thousands.

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	32356	50388	75648	50568	36243	9892	12248	10026	5522	12059
1958	66199	81133	47267	68551	38411	20901	8696	8507	6497	13981
1959	116086	144685	77487	37447	46725	23538	14173	6547	6739	16530
1960	73939	173891	107233	52356	22529	28029	14280	9073	5121	15253
1961	75578	146908	122927	69503	34821	13088	14909	9900	6089	14889
1962	51265	183396	122276	86264	49186	20125	8757	8733	5081	12373
1963	90913	140607	151664	88376	57526	32601	13096	6965	7183	16912
1964	66035	168092	104945	99044	60848	37691	15937	6644	4010	17012
1965	43708	435934	101700	56890	44842	30587	18464	8602	4237	17686
1966	38496	167345	415554	66827	38738	27995	16801	10981	6585	15201
1967	20199	139646	118437	267653	42827	22750	16496	8163	6861	11397
1968	73971	81942	88222	65781	149656	17696	10642	10396	4039	13754
1969	85195	83270	64566	57519	38430	109979	11016	6440	8669	17029
1970	123643	169330	77608	55999	44703	34335	76862	6149	4078	14459
1971	69357	127536	92230	37255	27345	23740	17471	30711	6626	17468
1972	72298	93031	97857	60116	24262	17552	14787	11211	19111	16094
1973	133684	83157	66103	77442	45686	14584	9335	10347	6392	25194
1974	213444	332383	61247	43962	43199	20500	8300	6554	5773	22790
1975	246011	310007	256001	38018	27257	22632	12613	6292	4362	20923
1976	186771	175418	150675	116859	14303	10197	9352	6553	3022	12871
1977	259853	160757	122676	99672	93158	9286	5922	5030	4068	9206
1978	227974	212525	87371	63173	49554	34810	5728	3232	2333	7201
1979	294482	273017	176240	67261	48394	40174	24187	4154	2802	9272
1980	227367	188656	137206	79722	25741	18407	14018	8621	1898	5497
1981	134401	296595	127778	59938	37101	12805	9805	8295	5005	6091
1982	414680	252926	216812	72276	29407	17073	7704	5551	4539	8775
1983	262614	556027	146048	102708	30395	13032	8238	4224	3013	8308
1984	310783	376997	333132	87364	42984	15486	6842	5593	2729	6551
1985	405505	302014	182405	203850	38139	17184	7441	3780	2813	5830
1986	1119014	557900	214496	132931	103135	28117	9839	4704	2834	7083
1987	361520	1459355	299385	122209	82652	44838	13539	4669	2346	5610
1988	348598	623309	713200	146514	60832	31669	19347	6198	3434	6402
1989	214545	532655	301448	324001	65991	21782	11605	8025	2321	5806
1990	146860	313064	273470	147931	174476	30123	9053	4689	3803	4206
1991	184551	344639	228763	162972	81603	79667	15410	5390	3215	5634
1992	142141	263388	180939	115818	92841	38422	30444	7229	3295	6976
1993	99787	207638	147893	92822	64910	35258	14745	11500	3704	5883
1994	63497	140257	141566	88030	48399	27824	17279	6661	5449	5458
1995	126642	119437	98402	85638	48574	24692	14746	5285	2495	3896
1996	112353	374411	95761	56891	37736	19276	12400	5881	2799	4989
1997	129550	554040	282515	49950	32021	18781	9518	5037	3054	4400
1998	104735	676844	266072	115693	23090	9184	5703	2870	1983	3360

	age									
year	1	2	3	4	5	6	7	8	9	10
1999	127870	217091	389857	102260	32056	14135	4038	2625	1597	3234
2000	106071	186869	91911	236965	27165	12827	3242	1302	953	2121
2001	34869	389547	245578	131939	155800	11644	4784	1213	650	2364
2002	311671	194270	138500	69451	47077	43784	6636	2257	794	1638
2003	68498	568137	107187	75048	39047	20730	23884	1775	689	880
2004	234226	195557	246969	49703	25741	13759	5193	4775	460	569
2005	96884	351042	76188	114752	24669	16907	6192	2766	2303	647
2006	221345	247158	197276	44006	53426	8308	6325	2496	1318	1408
2007	79123	231764	114984	69891	21973	28865	3285	3655	604	1303
2008	135904	269138	90365	50692	35820	7902	16918	1863	735	936
2009	150229	205594	130882	52016	26893	19652	3538	7480	587	821
2010	169501	200238	108973	92478	27880	14358	11840	2149	2520	1267
2011	118309	166750	108049	99067	64530	17739	6786	9257	1261	2743
2012	92124	319177	184424	95056	54407	33584	7782	3409	3482	1924
2013	128777	167367	189244	101853	46994	30519	15568	3970	2468	3795
2014	293522	197921	156827	133281	71407	24542	13433	8454	2472	3440
2015	83433	292834	173499	105923	73558	34676	13314	9111	4055	4834
2016	79202	148228	172474	133706	82050	47362	21214	9567	5310	5125

Table 14.2.5. Plaice in Subarea 4 and Subdivision 20: Stock weight at age (kg).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.038	0.102	0.157	0.242	0.325	0.485	0.719	0.682	0.844	0.918
1958	0.041	0.093	0.180	0.272	0.303	0.442	0.577	0.778	0.793	0.945
1959	0.045	0.106	0.173	0.264	0.329	0.470	0.650	0.686	0.908	0.897
1960	0.038	0.111	0.181	0.272	0.364	0.469	0.633	0.726	0.845	0.918
1961	0.037	0.098	0.185	0.306	0.337	0.483	0.579	0.691	0.779	0.911
1962	0.036	0.096	0.173	0.301	0.424	0.573	0.684	0.806	0.873	1.335
1963	0.041	0.103	0.176	0.273	0.378	0.540	0.663	0.788	0.882	0.961
1964	0.024	0.113	0.184	0.296	0.373	0.477	0.645	0.673	0.845	0.973
1965	0.031	0.068	0.198	0.294	0.333	0.43	0.516	0.601	0.722	0.578
1966	0.031	0.099	0.127	0.305	0.403	0.455	0.503	0.565	0.581	0.848
1967	0.029	0.104	0.179	0.205	0.442	0.528	0.585	0.650	0.703	0.833
1968	0.055	0.094	0.175	0.287	0.344	0.532	0.592	0.362	0.667	0.746
1969	0.047	0.158	0.188	0.266	0.344	0.390	0.565	0.621	0.679	0.635
1970	0.043	0.113	0.236	0.274	0.369	0.410	0.468	0.636	0.732	0.747
1971	0.051	0.109	0.251	0.344	0.413	0.489	0.512	0.583	0.696	0.707
1972	0.056	0.158	0.218	0.407	0.473	0.534	0.579	0.606	0.655	0.759
1973	0.037	0.134	0.237	0.308	0.468	0.521	0.566	0.583	0.617	0.690
1974	0.049	0.105	0.217	0.416	0.437	0.524	0.570	0.629	0.652	0.690
1975	0.063	0.141	0.187	0.388	0.483	0.544	0.610	0.668	0.704	0.762
1976	0.082	0.169	0.226	0.308	0.484	0.550	0.593	0.658	0.694	0.743
1977	0.064	0.184	0.265	0.311	0.405	0.551	0.627	0.690	0.667	0.759
1978	0.064	0.151	0.319	0.373	0.411	0.467	0.547	0.630	0.704	0.773
1979	0.062	0.179	0.258	0.365	0.414	0.459	0.543	0.667	0.764	0.826
1980	0.049	0.163	0.289	0.428	0.444	0.524	0.582	0.651	0.778	1.025
1981	0.041	0.140	0.239	0.421	0.473	0.536	0.570	0.624	0.707	0.849
1982	0.048	0.128	0.250	0.351	0.490	0.589	0.631	0.679	0.726	0.828
1983	0.045	0.128	0.242	0.381	0.494	0.559	0.624	0.712	0.754	0.791
1984	0.048	0.129	0.216	0.413	0.464	0.571	0.649	0.692	0.787	0.898
1985	0.048	0.146	0.232	0.320	0.452	0.536	0.635	0.656	0.764	0.869
1986	0.043	0.126	0.245	0.311	0.440	0.533	0.692	0.779	0.888	0.971
1987	0.036	0.105	0.200	0.383	0.401	0.503	0.573	0.711	0.747	0.817
1988	0.036	0.097	0.172	0.264	0.426	0.467	0.547	0.644	0.706	0.897
1989	0.039	0.101	0.192	0.247	0.362	0.484	0.553	0.616	0.759	0.837
1990	0.043	0.108	0.176	0.261	0.343	0.422	0.555	0.647	0.701	0.760
1991	0.048	0.131	0.184	0.260	0.342	0.401	0.463	0.633	0.652	0.744
1992	0.043	0.121	0.199	0.270	0.318	0.403	0.500	0.573	0.683	0.730
1993	0.050	0.119	0.208	0.315	0.330	0.391	0.490	0.587	0.633	0.723
1994	0.053	0.141	0.214	0.290	0.360	0.404	0.462	0.533	0.653	0.702
1995	0.050	0.142	0.254	0.336	0.399	0.448	0.509	0.584	0.678	0.789
1996	0.044	0.117	0.229	0.368	0.390	0.462	0.488	0.554	0.660	0.791
1997	0.035	0.115	0.233	0.359	0.439	0.492	0.521	0.543	0.627	0.734
1998	0.038	0.081	0.207	0.333	0.474	0.577	0.581	0.648	0.656	0.642
1999	0.044	0.091	0.150	0.319	0.437	0.524	0.586	0.644	0.664	0.620

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	0.051	0.106	0.165	0.219	0.408	0.467	0.649	0.695	0.656	0.744
2001	0.061	0.122	0.202	0.233	0.331	0.452	0.560	0.641	0.798	0.816
2002	0.048	0.118	0.213	0.301	0.319	0.403	0.446	0.612	0.685	0.781
2003	0.057	0.111	0.227	0.269	0.344	0.391	0.464	0.600	0.714	0.960
2004	0.047	0.116	0.201	0.306	0.384	0.430	0.489	0.495	0.780	0.921
2005	0.053	0.106	0.216	0.237	0.378	0.422	0.434	0.527	0.621	0.815
2006	0.052	0.130	0.190	0.316	0.354	0.424	0.439	0.506	0.583	0.688
2007	0.047	0.093	0.235	0.238	0.337	0.394	0.458	0.412	0.526	0.512
2008	0.048	0.114	0.196	0.274	0.355	0.429	0.484	0.627	0.598	0.449
2009	0.052	0.114	0.194	0.344	0.373	0.412	0.472	0.540	0.565	0.576
2010	0.053	0.116	0.179	0.340	0.361	0.401	0.448	0.572	0.568	0.655
2011	0.039	0.100	0.187	0.209	0.355	0.483	0.438	0.422	0.530	0.580
2012	0.052	0.093	0.142	0.188	0.331	0.393	0.484	0.479	0.480	0.518
2013	0.043	0.107	0.153	0.208	0.320	0.354	0.434	0.493	0.662	0.468
2014	0.048	0.104	0.158	0.202	0.312	0.380	0.439	0.484	0.458	0.615
2015	0.024	0.065	0.120	0.207	0.279	0.323	0.379	0.435	0.465	0.457
2016	0.030	0.066	0.117	0.198	0.260	0.329	0.380	0.434	0.479	0.514

Table 14.2.6. Plaice in Subarea 4 and Subdivision 20: Landings weight at age (kg).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	0.000	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	0.000	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.750	1.000
1960	0.000	0.200	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.094
1961	0.000	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.071
1962	0.000	0.211	0.248	0.300	0.400	0.541	0.570	0.692	0.777	1.127
1963	0.000	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.028
1964	0.000	0.250	0.273	0.312	0.388	0.487	0.628	0.700	0.737	1.005
1965	0.000	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.887
1966	0.000	0.232	0.270	0.348	0.436	0.484	0.559	0.624	0.690	0.933
1967	0.000	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.978
1968	0.000	0.267	0.298	0.331	0.366	0.517	0.590	0.596	0.686	0.911
1969	0.217	0.294	0.310	0.333	0.359	0.412	0.573	0.655	0.658	0.893
1970	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.892
1971	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.891
1972	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.939
1973	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.842
1974	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.926
1975	0.249	0.300	0.330	0.420	0.495	0.587	0.636	0.703	0.783	1.019
1976	0.265	0.295	0.338	0.375	0.513	0.594	0.641	0.705	0.741	0.980
1977	0.254	0.323	0.353	0.380	0.418	0.556	0.647	0.721	0.715	0.978
1978	0.244	0.315	0.369	0.397	0.438	0.491	0.609	0.687	0.776	0.950
1979	0.235	0.311	0.349	0.388	0.429	0.474	0.550	0.675	0.796	0.960
1980	0.238	0.286	0.344	0.401	0.473	0.545	0.588	0.662	0.772	1.013
1981	0.237	0.274	0.329	0.416	0.505	0.558	0.604	0.642	0.725	1.007
1982	0.279	0.262	0.311	0.424	0.514	0.608	0.664	0.712	0.738	0.984
1983	0.200	0.250	0.300	0.383	0.515	0.604	0.677	0.771	0.815	0.984
1984	0.231	0.263	0.283	0.364	0.480	0.591	0.677	0.726	0.839	1.036
1985	0.245	0.264	0.290	0.335	0.445	0.563	0.667	0.730	0.807	1.021
1986	0.221	0.269	0.303	0.339	0.405	0.473	0.668	0.750	0.856	1.014
1987	0.000	0.249	0.299	0.345	0.378	0.472	0.574	0.728	0.835	0.993
1988	0.000	0.254	0.278	0.341	0.418	0.478	0.590	0.680	0.808	1.017
1989	0.236	0.280	0.308	0.331	0.385	0.515	0.591	0.668	0.785	0.940
1990	0.271	0.284	0.297	0.315	0.364	0.441	0.586	0.690	0.761	1.010
1991	0.227	0.286	0.292	0.302	0.360	0.452	0.526	0.666	0.743	0.924
1992	0.251	0.263	0.290	0.312	0.330	0.415	0.530	0.607	0.719	0.891
1993	0.249	0.273	0.288	0.319	0.343	0.408	0.512	0.630	0.720	0.856
1994	0.229	0.263	0.284	0.333	0.375	0.417	0.491	0.610	0.731	0.906
1995	0.272	0.277	0.301	0.335	0.375	0.420	0.474	0.593	0.734	0.906
1996	0.240	0.279	0.304	0.346	0.415	0.465	0.490	0.553	0.712	0.858
1997	0.208	0.271	0.313	0.355	0.410	0.474	0.541	0.574	0.616	0.912
1998	0.151	0.260	0.306	0.384	0.452	0.546	0.613	0.673	0.687	0.899
1999	0.245	0.253	0.280	0.347	0.415	0.416	0.538	0.637	0.748	0.804

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	0.228	0.267	0.283	0.312	0.378	0.461	0.597	0.689	0.752	0.888
2001	0.238	0.267	0.291	0.307	0.360	0.412	0.582	0.701	0.796	0.799
2002	0.237	0.264	0.289	0.311	0.336	0.430	0.477	0.644	0.760	0.904
2003	0.232	0.252	0.285	0.320	0.353	0.389	0.482	0.635	0.763	0.857
2004	0.214	0.246	0.281	0.328	0.391	0.429	0.508	0.560	0.797	0.872
2005	0.272	0.265	0.280	0.330	0.382	0.426	0.465	0.555	0.617	0.910
2006	0.253	0.267	0.282	0.322	0.383	0.389	0.457	0.477	0.531	0.748
2007	0.263	0.268	0.303	0.343	0.364	0.432	0.507	0.486	0.587	0.632
2008	0.249	0.269	0.309	0.341	0.400	0.446	0.531	0.720	0.640	0.638
2009	0.176	0.260	0.308	0.355	0.415	0.481	0.531	0.608	0.668	0.792
2010	0.206	0.265	0.308	0.348	0.418	0.476	0.516	0.625	0.682	0.649
2011	0.235	0.242	0.281	0.341	0.414	0.504	0.604	0.521	0.556	0.804
2012	0.236	0.258	0.305	0.351	0.380	0.436	0.518	0.558	0.558	0.680
2013	0.031	0.242	0.281	0.313	0.364	0.417	0.494	0.600	0.607	0.680
2014	0.207	0.252	0.285	0.318	0.368	0.418	0.479	0.543	0.628	0.650
2015	NA	0.251	0.284	0.321	0.359	0.409	0.473	0.487	0.582	0.600
2016	NA	0.249	0.271	0.296	0.350	0.385	0.450	0.531	0.556	0.684

Table 14.2.7. Plaice in Subarea 4 and Subdivision 20: Discards weight at age (kg).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.104	0.146	0.181	0.206	0.244	0.244	0.231	0.000	0.000
1958	0.047	0.096	0.158	0.188	0.200	0.244	0.000	0.000	0.000	0.000
1959	0.051	0.107	0.155	0.186	0.197	0.231	0.000	0.000	0.000	0.000
1960	0.045	0.112	0.159	0.188	0.204	0.212	0.244	0.000	0.000	0.000
1961	0.044	0.100	0.160	0.194	0.204	0.220	0.220	0.000	0.000	0.000
1962	0.042	0.098	0.155	0.193	0.213	0.221	0.221	0.231	0.000	0.000
1963	0.048	0.105	0.156	0.188	0.205	0.231	0.221	0.231	0.000	0.000
1964	0.032	0.114	0.160	0.192	0.204	0.221	0.244	0.231	0.000	0.000
1965	0.038	0.072	0.166	0.192	0.212	0.221	0.231	0.000	0.000	0.000
1966	0.038	0.101	0.125	0.194	0.205	0.231	0.231	0.244	0.000	0.000
1967	0.036	0.105	0.158	0.169	0.220	0.220	0.244	0.244	0.000	0.000
1968	0.060	0.096	0.156	0.191	0.192	0.244	0.220	0.000	0.000	0.000
1969	0.052	0.146	0.162	0.186	0.211	0.212	0.000	0.231	0.000	0.000
1970	0.049	0.114	0.179	0.189	0.196	0.000	0.220	0.231	0.000	0.000
1971	0.057	0.110	0.183	0.200	0.212	0.000	0.000	0.231	0.000	0.000
1972	0.061	0.147	0.173	0.211	0.211	0.244	0.000	0.000	0.000	0.000
1973	0.043	0.131	0.179	0.195	0.211	0.244	0.000	0.000	0.000	0.000
1974	0.054	0.106	0.173	0.212	0.220	0.231	0.244	0.000	0.000	0.000
1975	0.068	0.136	0.162	0.206	0.221	0.244	0.244	0.000	0.000	0.000
1976	0.085	0.153	0.176	0.195	0.220	0.000	0.244	0.000	0.000	0.000
1977	0.069	0.160	0.186	0.196	0.198	0.220	0.000	0.000	0.000	0.000
1978	0.069	0.143	0.197	0.205	0.211	0.213	0.231	0.000	0.000	0.000
1979	0.066	0.158	0.185	0.204	0.220	0.231	0.221	0.244	0.000	0.000
1980	0.055	0.149	0.191	0.212	0.231	0.000	0.000	0.000	0.000	0.000
1981	0.048	0.135	0.179	0.212	0.220	0.000	0.000	0.000	0.000	0.000
1982	0.054	0.126	0.182	0.203	0.231	0.244	0.244	0.000	0.000	0.000
1983	0.051	0.126	0.180	0.205	0.211	0.244	0.000	0.000	0.000	0.000
1984	0.053	0.127	0.172	0.211	0.205	0.000	0.244	0.000	0.000	0.000
1985	0.054	0.139	0.177	0.197	0.231	0.244	0.000	0.000	0.000	0.000
1986	0.049	0.124	0.181	0.196	0.220	0.244	0.244	0.000	0.000	0.000
1987	0.043	0.105	0.166	0.205	0.220	0.231	0.000	0.000	0.000	0.000
1988	0.043	0.098	0.153	0.185	0.220	0.244	0.000	0.000	0.000	0.000
1989	0.046	0.102	0.163	0.181	0.196	0.000	0.000	0.000	0.000	0.000
1990	0.051	0.111	0.157	0.186	0.212	0.231	0.000	0.000	0.000	0.000
1991	0.055	0.130	0.161	0.185	0.203	0.221	0.231	0.231	0.000	0.000
1992	0.050	0.122	0.167	0.188	0.204	0.212	0.231	0.244	0.000	0.000
1993	0.056	0.121	0.171	0.197	0.211	0.231	0.244	0.000	0.000	0.000
1994	0.060	0.140	0.175	0.194	0.213	0.244	0.244	0.221	0.000	0.000
1995	0.058	0.141	0.186	0.201	0.220	0.232	0.232	0.244	0.000	0.000
1996	0.052	0.122	0.179	0.205	0.221	0.232	0.000	0.000	0.000	0.000
1997	0.044	0.117	0.178	0.203	0.221	0.244	0.000	0.000	0.000	0.000
1998	0.047	0.086	0.170	0.199	0.220	0.000	0.244	0.000	0.000	0.000
1999	0.053	0.097	0.143	0.197	0.220	0.000	0.000	0.000	0.000	0.000

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	0.059	0.110	0.151	0.174	0.244	0.000	0.203	0.000	0.000	0.000
2001	0.068	0.122	0.167	0.178	0.197	0.244	0.000	0.244	0.000	0.000
2002	0.056	0.119	0.170	0.182	0.172	0.208	0.003	0.000	0.000	0.000
2003	0.064	0.113	0.174	0.185	0.198	0.204	0.221	0.000	0.000	0.000
2004	0.054	0.117	0.164	0.183	0.189	0.192	0.196	0.000	0.000	0.000
2005	0.061	0.109	0.170	0.175	0.215	0.205	0.210	0.176	0.000	0.000
2006	0.060	0.128	0.164	0.193	0.198	0.204	0.212	0.220	0.000	0.000
2007	0.055	0.098	0.177	0.178	0.188	0.199	0.225	0.200	0.000	0.000
2008	0.056	0.116	0.163	0.186	0.187	0.230	0.220	0.191	0.000	0.000
2009	0.060	0.116	0.164	0.199	0.202	0.212	0.210	0.220	0.000	0.000
2010	0.060	0.117	0.159	0.199	0.190	0.198	0.211	0.234	0.001	0.000
2011	0.047	0.104	0.162	0.171	0.192	0.196	0.199	0.211	0.000	0.000
2012	0.052	0.093	0.142	0.188	0.198	0.206	0.215	0.215	0.000	0.000
2013	0.051	0.081	0.127	0.151	0.170	0.194	0.228	0.346	0.000	0.000
2014	0.025	0.089	0.132	0.162	0.180	0.212	0.300	0.370	0.255	0.000
2015	0.026	0.078	0.122	0.149	0.164	0.185	0.173	0.218	0.404	0.291
2016	0.048	0.079	0.124	0.150	0.151	0.179	0.166	0.192	0.251	0.500

Table 14.2.8. Plaice in Subarea 4 and Subdivision 20: Catch weight at age (kg).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.110	0.194	0.257	0.349	0.455	0.533	0.589	0.396	0.998
1958	0.047	0.106	0.189	0.256	0.329	0.452	0.513	0.615	0.665	0.992
1959	0.051	0.120	0.192	0.260	0.345	0.472	0.592	0.623	0.750	1.000
1960	0.045	0.115	0.204	0.287	0.377	0.480	0.601	0.683	0.724	1.094
1961	0.044	0.101	0.180	0.301	0.402	0.506	0.604	0.671	0.812	1.071
1962	0.042	0.099	0.181	0.273	0.397	0.538	0.570	0.692	0.777	1.127
1963	0.048	0.110	0.175	0.304	0.392	0.531	0.624	0.667	0.715	1.028
1964	0.032	0.126	0.204	0.271	0.379	0.485	0.628	0.700	0.737	1.005
1965	0.038	0.076	0.214	0.313	0.381	0.469	0.539	0.663	0.726	0.887
1966	0.038	0.104	0.148	0.315	0.428	0.483	0.559	0.624	0.690	0.933
1967	0.036	0.111	0.190	0.235	0.422	0.543	0.597	0.662	0.738	0.978
1968	0.060	0.116	0.223	0.275	0.340	0.516	0.590	0.596	0.686	0.911
1969	0.052	0.174	0.272	0.284	0.356	0.408	0.573	0.655	0.658	0.893
1970	0.049	0.131	0.268	0.352	0.394	0.441	0.499	0.672	0.744	0.892
1971	0.057	0.160	0.277	0.388	0.444	0.512	0.542	0.607	0.699	0.891
1972	0.067	0.207	0.290	0.407	0.486	0.540	0.608	0.646	0.674	0.939
1973	0.045	0.205	0.334	0.403	0.478	0.538	0.605	0.627	0.677	0.842
1974	0.056	0.121	0.343	0.404	0.472	0.552	0.609	0.693	0.707	0.926
1975	0.069	0.152	0.205	0.393	0.492	0.585	0.636	0.703	0.783	1.019
1976	0.088	0.181	0.262	0.347	0.509	0.592	0.641	0.705	0.741	0.980
1977	0.071	0.218	0.245	0.318	0.396	0.551	0.647	0.721	0.715	0.978
1978	0.070	0.190	0.315	0.364	0.432	0.486	0.609	0.687	0.776	0.950
1979	0.067	0.190	0.295	0.338	0.426	0.472	0.550	0.675	0.796	0.960
1980	0.056	0.197	0.343	0.399	0.471	0.542	0.588	0.662	0.772	1.013
1981	0.048	0.183	0.327	0.415	0.502	0.556	0.604	0.642	0.725	1.007
1982	0.056	0.152	0.308	0.421	0.512	0.606	0.664	0.712	0.738	0.984
1983	0.052	0.153	0.275	0.379	0.507	0.602	0.677	0.771	0.815	0.984
1984	0.053	0.150	0.265	0.321	0.470	0.588	0.677	0.726	0.839	1.036
1985	0.054	0.169	0.268	0.333	0.444	0.562	0.667	0.730	0.807	1.021
1986	0.049	0.141	0.275	0.311	0.402	0.472	0.668	0.750	0.856	1.014
1987	0.043	0.113	0.219	0.343	0.375	0.471	0.574	0.728	0.835	0.993
1988	0.043	0.102	0.197	0.276	0.415	0.477	0.590	0.680	0.808	1.017
1989	0.047	0.118	0.215	0.291	0.364	0.512	0.591	0.668	0.785	0.940
1990	0.053	0.130	0.211	0.290	0.360	0.440	0.586	0.690	0.761	1.010
1991	0.056	0.149	0.211	0.273	0.349	0.449	0.526	0.666	0.743	0.924
1992	0.055	0.145	0.226	0.275	0.324	0.410	0.530	0.607	0.719	0.891
1993	0.063	0.160	0.250	0.303	0.340	0.407	0.512	0.630	0.720	0.856
1994	0.064	0.179	0.257	0.331	0.372	0.416	0.491	0.610	0.731	0.906
1995	0.071	0.183	0.283	0.334	0.373	0.419	0.474	0.593	0.734	0.906
1996	0.054	0.140	0.268	0.336	0.413	0.464	0.490	0.553	0.712	0.858
1997	0.045	0.129	0.220	0.353	0.408	0.473	0.541	0.574	0.616	0.912
1998	0.047	0.094	0.208	0.299	0.449	0.544	0.613	0.673	0.687	0.899
1999	0.054	0.103	0.199	0.267	0.413	0.414	0.538	0.637	0.748	0.804

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	0.063	0.123	0.210	0.274	0.372	0.452	0.565	0.601	0.752	0.888
2001	0.090	0.136	0.197	0.234	0.303	0.410	0.577	0.701	0.796	0.799
2002	0.057	0.131	0.222	0.285	0.326	0.426	0.469	0.644	0.760	0.904
2003	0.066	0.124	0.226	0.284	0.336	0.385	0.419	0.635	0.763	0.857
2004	0.054	0.125	0.220	0.297	0.376	0.421	0.506	0.560	0.797	0.872
2005	0.067	0.117	0.213	0.298	0.352	0.347	0.453	0.554	0.617	0.910
2006	0.060	0.139	0.212	0.293	0.375	0.383	0.428	0.457	0.531	0.748
2007	0.059	0.114	0.223	0.310	0.351	0.375	0.491	0.357	0.587	0.632
2008	0.057	0.123	0.248	0.325	0.389	0.437	0.368	0.469	0.640	0.638
2009	0.061	0.125	0.232	0.327	0.399	0.466	0.518	0.441	0.668	0.792
2010	0.062	0.132	0.226	0.311	0.396	0.442	0.463	0.574	0.682	0.649
2011	0.048	0.115	0.212	0.277	0.369	0.453	0.595	0.445	0.556	0.804
2012	0.052	0.096	0.196	0.294	0.348	0.425	0.509	0.557	0.558	0.680
2013	0.051	0.091	0.179	0.274	0.345	0.409	0.490	0.599	0.607	0.680
2014	0.025	0.093	0.172	0.253	0.318	0.396	0.473	0.542	0.628	0.650
2015	0.026	0.080	0.162	0.258	0.326	0.394	0.461	0.481	0.582	0.600
2016	0.048	0.084	0.157	0.243	0.299	0.352	0.422	0.465	0.556	0.684

Table 14.2.9 Plaice in Subarea 4 and Subdivision 20: Natural mortality at age and maturity at age.

age	1	2	3	4	5	6	7	8	9	10
natural mortality	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
maturity	0	0.5	0.5	1	1	1	1	1	1	1

Table 14.2.10 Plaice in Subarea 4 and Subdivision 20: Survey tuning indices.

BTS–Isis	**age**								
year	1	2	3	4	5	6	7	8	9
1985	137	173.9	36.1	11	1.27	0.973	0.336	0.155	0.091
1986	667	131.7	50.2	9.21	3.78	0.4	0.418	0.147	0.07
1987	226	764.2	33.8	4.88	1.84	0.607	0.252	0.134	0.078
1988	680	147	182.3	9.99	2.81	0.814	0.458	0.036	0.112
1989	468	319.3	314.7	47.3	5.85	0.833	0.311	0.661	0.132
1990	185	146.1	79.3	26.35	5.47	0.758	0.189	0.383	0.239
1991	291	159.4	34	13.57	4.31	5.659	0.239	0.204	0.092
1992	361	174.5	29.3	5.96	3.75	2.871	1.186	0.346	0.05
1993	189	283.4	62.8	14.27	1.13	1.13	0.584	0.464	0.155
1994	193	77.1	34.5	10.59	2.67	0.6	0.8	0.895	0.373
1995	266	40.6	13.2	7.53	1.11	0.806	0.33	1.051	0.202

BTS–Combined	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1996	26759.6	25949.6	5794.9	1533.7	1173.0	606.1	3714.9	52.6	14.3
1997	45897.0	96923.3	6737.0	1446.0	570.4	411.8	72.5	267.6	414.1
1998	341414.9	83834.3	9534.2	2674.1	664.6	386.1	230.6	196.7	73.3
1999	44266.9	18310.7	29752.9	2813.1	1110.4	257.6	95.4	87.0	41.0
2000	42116.5	22415.9	9121.4	10054.0	624.5	223.4	111.0	99.1	16.5
2001	28600.8	20460.4	6834.6	3493.5	3462.7	2614.7	90.9	73.1	55.1
2002	133179.5	16836.2	6767.3	3715.5	2076.9	1537.8	263.0	127.8	43.4
2003	31956.5	46174.9	6686.1	3361.5	1601.1	930.6	914.5	614.7	54.7
2004	44684.8	13805.0	16999.4	29414.2	1504.7	869.6	480.0	715.5	43.8
2005	37599.4	28190.7	45014.2	6820.3	906.7	1030.6	367.4	80.9	841.4
2006	41399.7	17126.4	9910.8	2380.5	3777.3	585.1	736.7	100.4	131.6
2007	83862.9	22501.5	10474.5	7984.2	1689.7	2523.5	281.6	614.5	74.5
2008	66896.5	47117.5	12277.0	6329.4	4391.1	932.5	1403.7	290.9	454.5
2009	64412.6	23487.0	19155.1	5051.8	30814.2	2529.7	640.2	14214.3	274.7
2010	79927.6	29101.2	13501.5	10020.0	3047.1	1697.8	1725.5	582.4	964.0
2011	124219.7	43303.6	17602.1	9113.7	6019.2	1937.4	902.8	1596.3	235.7
2012	58133.9	660114.3	37381.8	15040.3	7905.2	4929.4	1552.2	1163.9	1526.4
2013	868514.3	53497.6	37560.7	18739.5	7024.5	4105.2	3074.2	1227.2	749.7
2014	140561.5	63030.2	265614.5	20362.3	85314.7	3536.3	2211.6	1692.0	952.4
2015	51289.8	67943.7	32622.0	16010.7	12400.7	6440.5	2190.4	1587.3	1465.0
2016	80551.7	323114.9	31019.5	17053.4	9116.8	6353.1	3503.0	1615.1	1037.0

SNS1							SNS2						
	age							age					
year	1	2	3	4	5	6	year	1	2	3	4	5	6
1970	9311	9732	3273	770	170	37.5	2000	22855	2493	891	983	17	2.0
1971	13538	28164	1415	101	50	23.6	2001	11511	2898	370	176	691	105.8
1972	13207	10780	4478	89	84	0.0	2002	30809	1103	265	65	69	30.7
1973	65643	5133	1578	461	15	5.7	2003	NA	NA	NA	NA	NA	NA
1974	15366	16509	1129	160	82	7.0	2004	18202	1350	1081	51	27	29.7
1975	11628	8168	9556	65	15	0.0	2005	10118	1819	142	366	8	19.0
1976	8537	2403	868	236	0	2.3	2006	12164	1571	385	52	54	0.0
1977	18537	3424	1737	590	213	0.0	2007	14175	2134	140	52	0	7.4
1978	14012	12678	345	135	45	13.6	2008	14706	2700	464	179	34	6.7
1979	21495	9829	1575	161	17	42.2	2009	14860	2019	492	38	20	0.0
1980	59174	12882	491	180	24	7.8	2010	11947	1812	529	55	10	0.0
1981	24756	18785	834	38	32	4.7	2011	18349	1143	308	75	60	28.0
1982	69993	8642	1261	88	8	8.7	2012	5893	2929	682	82	30	15.0
1983	33974	13909	249	71	6	1.3	2013	15395	3021	1638	428	89	31.1
1984	44965	10413	2467	42	0	0.0	2014	17313	2258	514	458	58	16.4
1985	28101	13848	1598	328	17	1.5	2015	16727	5040	1882	478	200	97.5
1986	93552	7580	1152	145	30	6.6	2016	10385	2434	1086	522	223	131.7
1987	33402	32991	1227	200	30	16.7							
1988	36609	14421	13153	1350	88	12.1							
1989	34276	17810	4373	7126	289	113.6							
1990	25037	7496	3160	816	422	48.8							
1991	57221	11247	1518	1077	128	74.4							
1992	46798	13842	2268	613	176	52.0							
1993	22098	9686	1006	98	60	58.8							
1994	19188	4977	856	76	23	2.7							
1995	24767	2796	381	97	38	0.0							
1996	23015	10268	1185	45	47	0.0							
1997	95901	4473	497	32	0	13.3							
1998	33666	30242	5014	50	10	0.0							
1999	32951	10272	13783	1058	17	0.0							

IBTS–Q3	1	2	3	4	5	6	7	8	9
1997	3134.9	4111.6	2510.4	699.4	287.5	236.9	137.4	125.2	86.0
1998	1012.2	5170.6	1653.1	800.9	290.8	129.9	85.7	93.9	45.8
1999	9014.2	2275.4	4169.2	683.2	266.5	120.3	45.4	46.1	31.8
2000	917.8	1756.4	1893.0	2055.9	210.7	117.9	55.6	44.5	14.9
2001	1159.7	3282.0	2037.0	1076.7	1079.5	160.2	79.9	66.1	55.2
2002	6150.2	2907.7	2272.7	1209.1	625.0	410.0	100.6	95.5	47.2
2003	1324.9	4967.3	1611.2	975.4	427.9	254.2	274.2	53.9	59.2
2004	24314.2	2533.4	3854.8	885.6	565.1	283.8	185.2	231.5	46.6
2005	1923.1	4814.4	1536.4	2206.1	374.1	454.7	227.9	81.3	229.1
2006	2160.8	3124.3	3643.0	1044.6	1149.5	363.9	387.7	153.5	85.5
2007	5641.5	47114.7	3589.6	3060.6	764.0	1212.8	320.8	440.1	117.2
2008	61914.9	10842.3	48714.0	32114.6	2029.1	675.1	719.0	304.9	269.1
2009	2742.3	5079.5	7374.2	2640.2	1587.8	1101.1	441.1	707.9	194.2

2010	3127.9	4966.7	5172.1	46014.2	1502.0	1062.7	1046.1	459.9	633.2
2011	6649.1	91714.8	7059.4	4571.9	3197.4	1183.2	834.8	1037.9	263.0
2012	2752.1	11611.5	11253.2	6272.3	3441.4	2335.3	1125.4	873.9	886.3
2013	2802.8	6962.5	9480.1	6121.8	3106.3	1917.4	14914.2	697.4	461.6
2014	5455.5	9123.5	7516.1	6177.8	3047.4	1396.5	1029.4	7314.0	463.9
2015	1672.3	7362.9	7951.5	5723.1	4310.4	2370.3	1249.2	915.3	752.8
2016	3704.4	61114.1	7917.7	5495.3	2591.5	1854.8	1335.4	856.8	701.5

IBTS–Q1	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2007	2215.3	5496.3	5570.5	5743.2	1810.6	886.2	479.9
2008	2373.3	11164.6	7031.8	3447.5	23314.8	716.9	493.8
2009	2833.6	7416.3	12021.4	4219.3	1982.6	806.9	433.2
2010	1406.2	5775.6	9059.7	7807.2	3153.4	1259.4	796.9
2011	1151.5	6172.1	6379.5	6150.4	4832.3	1609.6	862.2
2012	1957.7	140014.4	14630.1	7017.2	4657.4	3044.9	1223.5
2013	1312.7	5431.2	9455.3	6523.7	3004.8	1632.0	850.3
2014	2475.3	7375.1	8714.9	8327.0	4476.1	1662.9	901.9
2015	787.2	10232.8	10533.0	8456.4	5664.5	2440.3	10714.5
2016	2064.5	5529.3	9019.7	7092.9	4704.0	2253.4	1194.8

Table 14.3.1. Plaice in Subarea 4 and Subdivision 20: Estimated parameters from AAP model in final run.

Number of parameters = 282 Objective function value = 266.568.

Maximum gradient component = 0.000477482.

logsigmaC:

-0.707721 -0.485392 0.0411859

logsigmaU:

-0.391340 -0.278685 0.0366055

-0.539180 -0.485945 0.0578208

-1.28104 0.404339 -0.0204004

-1.16775 0.103872 0.0314076

-0.433556 -0.451902 0.0471794

-0.472822 -0.634491 0.0843967

log_sel_coff1:

-1.14372 -0.802924 -0.894763 -1.40567 -1.31223 -0.498457 -0.411577 -0.344476 0.158041 0.187664 -0.288307 -0.0888866 0.0293378 -0.0956918 -0.389544 -0.186466 -0.691900 -0.958133 -0.542640 -0.671899 -0.181053 -0.674545 -0.448024 -1.18197 -0.762164 -1.18652 -0.278517 0.171075 0.144735 0.454657 0.198719 0.292289 0.291658 0.447557 0.444935 0.545860 0.788377 0.620910 0.586380 0.816087 0.614030 0.780671 0.516271 1.21966 0.431890 0.926288 0.595980 0.458304 -0.0830602 -0.181185 -0.201443 -0.335022 0.0250597 0.173960 0.200605 0.297473 0.296713 0.158693 0.298957 0.613500 0.504057 0.564478 0.695269 0.761985 0.718896 0.823936 0.766790 0.711335 0.863279 0.906358 0.997011 0.720144 0.447977 0.0739758 -0.235293 -0.164077 -0.239253 -0.183807 -0.338895 0.0848159 0.153429 0.368727 0.245769 0.308087 0.271237 0.464649 0.370091 0.555328 0.464672 0.430965 0.647893 0.922357 0.819242 1.03701 0.755914 1.07514 0.868146 0.860348 0.382665 -0.172256 -0.732696 -0.636719 -0.665247 -0.655814 -0.252789 -0.244566 -0.118437 0.0446417 -0.0726797 0.0493301 0.177121 0.233649 0.278822 0.241487 0.398187 0.185774 0.335884 0.640195 0.432317 0.825062 0.797601 0.769141 0.488376 0.525460 0.0576809 -0.531320 -0.959231 -1.36469 -1.47054 -1.16804 -0.432501 -0.169071 -0.447922 -0.136071 -0.245255 -0.261951 0.0475596 0.173797 0.228249 -0.0156761 0.0645419 0.167811 0.0152606 0.395181 0.184716 0.637401 0.409894 0.600755 0.178485 0.0216027 -0.919684 -1.34575 -2.34115 -2.03143 -2.42139 -2.27756

log_sel_cofU:

-14.11315 -7.74827 -14.72950 -9.93534 -10.7768 -10.6394

-2.74829 -2.62348 -3.31724 -3.45885 -3.81481 -3.96454

-3.34137 -3.39776 -4.51645 -7.02821 -14.25137 -14.64551

-4.20382 -5.18473 -6.55043 -7.52105 -14.60582 -14.70045

-5.91736 -5.04477 -4.50380 -4.44283 -4.82130 -4.58843

-6.46637 -5.07822 -4.15930 -4.13579 -4.23570 -4.64157

log_initpop:

12.5088 12.7972 12.3127 11.8947 11.0178 11.0444 10.8074 10.3777 11.1389 13.0717 13.4737 13.6838 13.5787 13.6860 13.3292 13.3289 14.7056 13.4118 13.2704 12.9587 12.9420 13.4132 13.4178 12.9869 12.8141 14.1239 13.8924 13.5915 13.4366 13.8456 13.6829 13.7218 13.8927 13.8257 14.4787 14.1255 14.0645 14.4067 15.2946 14.4850 14.3602 14.0180 13.9206 13.8197 13.6389 13.1450 13.2580 13.8849 13.8198 14.6522 13.5605 13.4988 13.7283 13.3080 14.3219 13.2511 14.1016 13.6568 13.6324 14.1215 13.9865 13.8982 14.1182 14.2691 14.0568 14.1871 14.3485 13.8095 13.9757

Table 14.3.2. Plaice in Subarea 4 and Subdivision 20: Harvest (F) at age.

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0.096	0.169	0.262	0.311	0.257	0.210	0.225	0.227	0.197	0.197
1958	0.112	0.213	0.312	0.328	0.292	0.252	0.228	0.223	0.232	0.232
1959	0.127	0.252	0.353	0.342	0.324	0.290	0.234	0.220	0.250	0.250
1960	0.136	0.262	0.361	0.349	0.339	0.310	0.244	0.217	0.231	0.231
1961	0.132	0.253	0.353	0.352	0.344	0.319	0.260	0.219	0.199	0.199
1962	0.115	0.253	0.372	0.362	0.353	0.339	0.285	0.232	0.192	0.192
1963	0.091	0.271	0.436	0.382	0.374	0.380	0.314	0.255	0.220	0.220
1964	0.073	0.281	0.491	0.402	0.394	0.410	0.329	0.273	0.256	0.256
1965	0.067	0.258	0.471	0.411	0.397	0.396	0.315	0.267	0.261	0.261
1966	0.072	0.232	0.416	0.403	0.388	0.366	0.294	0.251	0.241	0.241
1967	0.095	0.241	0.385	0.381	0.377	0.361	0.292	0.244	0.223	0.223
1968	0.140	0.284	0.384	0.355	0.369	0.379	0.311	0.252	0.219	0.219
1969	0.187	0.324	0.390	0.342	0.361	0.391	0.333	0.272	0.232	0.232
1970	0.204	0.329	0.390	0.351	0.359	0.380	0.345	0.300	0.265	0.265
1971	0.197	0.319	0.400	0.386	0.377	0.374	0.351	0.325	0.305	0.305
1972	0.191	0.323	0.435	0.448	0.429	0.399	0.361	0.339	0.331	0.331
1973	0.197	0.342	0.479	0.515	0.491	0.435	0.374	0.345	0.345	0.345
1974	0.228	0.367	0.497	0.538	0.507	0.443	0.382	0.357	0.361	0.361
1975	0.287	0.392	0.482	0.509	0.474	0.421	0.385	0.373	0.376	0.376
1976	0.353	0.414	0.463	0.478	0.452	0.412	0.384	0.372	0.369	0.369
1977	0.388	0.432	0.464	0.477	0.475	0.443	0.385	0.347	0.332	0.332
1978	0.370	0.448	0.494	0.500	0.512	0.484	0.394	0.329	0.296	0.296
1979	0.304	0.464	0.562	0.537	0.521	0.494	0.418	0.344	0.287	0.287
1980	0.241	0.475	0.644	0.580	0.508	0.473	0.441	0.378	0.300	0.300
1981	0.219	0.471	0.678	0.616	0.503	0.444	0.429	0.391	0.327	0.327
1982	0.238	0.451	0.642	0.633	0.518	0.425	0.386	0.367	0.351	0.351
1983	0.272	0.430	0.584	0.628	0.540	0.425	0.357	0.338	0.349	0.349
1984	0.295	0.419	0.545	0.605	0.556	0.453	0.367	0.326	0.316	0.316
1985	0.304	0.429	0.542	0.590	0.578	0.511	0.415	0.343	0.296	0.296
1986	0.303	0.468	0.591	0.606	0.623	0.600	0.495	0.399	0.333	0.333
1987	0.289	0.511	0.663	0.643	0.676	0.690	0.575	0.471	0.409	0.409
1988	0.256	0.498	0.681	0.664	0.700	0.711	0.584	0.484	0.436	0.436
1989	0.217	0.433	0.625	0.650	0.680	0.658	0.521	0.425	0.383	0.383
1990	0.200	0.399	0.583	0.619	0.659	0.636	0.490	0.394	0.355	0.355
1991	0.218	0.443	0.610	0.593	0.668	0.713	0.558	0.452	0.421	0.421
1992	0.244	0.498	0.649	0.584	0.687	0.813	0.676	0.563	0.533	0.533
1993	0.231	0.448	0.610	0.603	0.681	0.777	0.718	0.624	0.552	0.552
1994	0.183	0.352	0.548	0.647	0.657	0.657	0.671	0.605	0.479	0.479
1995	0.139	0.340	0.599	0.693	0.653	0.622	0.642	0.580	0.447	0.447
1996	0.115	0.451	0.836	0.727	0.686	0.723	0.672	0.583	0.498	0.498
1997	0.112	0.565	1.041	0.751	0.738	0.838	0.686	0.570	0.541	0.541
1998	0.133	0.478	0.854	0.769	0.783	0.799	0.618	0.503	0.477	0.477
1999	0.164	0.345	0.593	0.769	0.798	0.690	0.533	0.433	0.382	0.382

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	0.170	0.321	0.540	0.735	0.765	0.651	0.512	0.410	0.342	0.342
2001	0.152	0.402	0.663	0.673	0.692	0.680	0.542	0.418	0.338	0.338
2002	0.154	0.497	0.768	0.603	0.607	0.670	0.544	0.395	0.289	0.289
2003	0.199	0.496	0.680	0.538	0.525	0.565	0.470	0.317	0.193	0.193
2004	0.245	0.442	0.549	0.477	0.447	0.440	0.369	0.237	0.126	0.126
2005	0.217	0.400	0.498	0.420	0.371	0.346	0.282	0.184	0.101	0.101
2006	0.164	0.370	0.481	0.364	0.301	0.274	0.219	0.148	0.089	0.089
2007	0.153	0.331	0.420	0.309	0.239	0.210	0.175	0.117	0.064	0.064
2008	0.181	0.283	0.326	0.262	0.193	0.160	0.145	0.091	0.039	0.039
2009	0.187	0.237	0.266	0.239	0.173	0.134	0.122	0.074	0.028	0.028
2010	0.135	0.202	0.254	0.243	0.181	0.132	0.104	0.065	0.031	0.031
2011	0.095	0.183	0.261	0.254	0.199	0.139	0.091	0.059	0.038	0.038
2012	0.095	0.184	0.260	0.250	0.204	0.141	0.083	0.052	0.037	0.037
2013	0.121	0.195	0.249	0.237	0.196	0.137	0.080	0.047	0.029	0.029
2014	0.139	0.198	0.240	0.231	0.190	0.135	0.083	0.047	0.025	0.025
2015	0.122	0.185	0.238	0.239	0.194	0.139	0.094	0.054	0.027	0.027
2016	0.093	0.164	0.239	0.256	0.203	0.147	0.109	0.065	0.031	0.031

Table 14.3.3. Plaice in Subarea 4 and Subdivision 20: Stock numbers (thousands).

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	475276	270700	361194	222495	146494	60950	62591	49386	32134	68795
1958	710510	390783	206813	251371	147517	102528	44686	45229	35610	74968
1959	876603	574693	285679	136925	163827	99635	72110	32187	32732	79375
1960	789141	698368	404298	181690	87999	107258	67452	51659	23372	79005
1961	878551	623388	486084	255063	115980	56714	71151	47836	37609	73513
1962	614870	696404	438092	309095	162255	74427	37311	49628	34762	82418
1963	614690	495908	489500	273179	194675	103168	47980	25385	35610	87548
1964	2435440	507719	342081	286438	168645	121194	63829	31706	17793	89432
1965	667809	2047640	346822	189448	173322	102947	72742	41548	21841	75098
1966	579750	565221	1431990	195894	113701	105432	62665	48022	28787	67596
1967	424497	488035	405458	855027	118455	69774	66133	42272	33816	68548
1968	417472	349147	347058	249759	528632	73491	44019	44698	29972	74119
1969	668795	328368	237833	213922	158449	330890	45512	29182	31435	75696
1970	671843	501844	214797	145736	137517	99904	202490	29508	20117	76863
1971	436656	495934	326834	131573	92814	86868	61790	129823	19790	67319
1972	367347	324302	326144	198269	80951	57600	54050	39362	84852	58117
1973	1361240	274568	212425	191101	114608	47710	34984	34081	25384	92919
1974	1079870	1010970	176473	119057	103310	63489	27930	21784	21840	75827
1975	799278	777592	633726	97110	62934	56313	36879	17242	13793	61625
1976	684635	542567	475472	354088	52815	35458	33462	22707	10747	46852
1977	1030590	435068	324527	270751	198558	30404	21248	20617	14168	36043
1978	875828	632554	255642	184612	152040	111727	17672	13089	13188	32605
1979	910524	547616	365825	141105	101346	82438	62302	10788	8526	30810
1980	1080290	608159	311506	188646	74590	54451	45503	37117	6922	26723
1981	1010250	768191	342077	148058	95524	40620	30713	26503	23011	22543
1982	1941050	734361	434077	157116	72370	52263	23583	18101	16226	29726
1983	1363380	1384900	423296	206640	75503	38994	30920	14499	11344	29278
1984	1282770	939956	815515	213536	99808	39828	23057	19573	9358	25929
1985	1806160	864014	559433	428022	105505	51804	22905	14449	12779	23286
1986	4389140	1205880	509266	294484	214737	53552	28126	13690	9279	24269
1987	1953250	2933270	683492	255305	145354	104247	26596	15518	8310	21766
1988	1724090	1323660	1592940	318826	121441	66872	47305	13546	8765	18082
1989	1224500	1207450	728015	729846	148527	54586	29708	23870	7556	15714
1990	1110790	891580	708905	352650	344901	68072	25570	15963	14116	14360
1991	1004210	822672	541245	358022	171802	161412	32624	14173	9742	18065
1992	838128	730412	477807	266036	179073	79673	71556	16892	8162	16512
1993	511439	594078	401535	225933	134254	81524	31986	32931	8701	13101
1994	572617	367488	343598	197400	111815	61497	33922	14113	15960	11363
1995	1071900	431643	233901	179771	93568	52445	28861	15692	6977	15317
1996	1004330	843745	277868	116258	81341	44066	25487	13744	7954	12900
1997	2308750	809656	486083	109025	50853	37051	19356	11778	6939	11469
1998	774939	1867230	416485	155262	46561	21988	14499	8816	6029	9697
1999	728518	613911	1047600	160488	65138	19254	8945	7075	4823	8836

	age									
year	1	2	3	4	5	6	7	8	9	10
2000	916459	559556	393500	523640	67337	26546	8739	4748	4151	8439
2001	601963	699920	367367	207445	227197	28362	12521	4741	2851	8090
2002	1659280	467837	423761	171318	95758	102887	12998	6592	2823	7062
2003	568719	1286580	257517	177844	84809	47215	47634	6828	4018	6699
2004	1331210	421666	708920	118098	94004	45379	24281	26943	4500	7998
2005	853271	942424	245308	370347	66335	54403	26450	15195	19231	9974
2006	832698	621382	571665	134855	220240	41399	34844	18044	11438	23879
2007	1357950	639450	388546	319702	84788	147460	28493	25330	14085	29236
2008	1186450	1054550	415563	231073	212479	60433	108186	21641	20394	36761
2009	1086170	896178	719042	271376	160827	158563	46609	84678	17882	49752
2010	1353540	815425	639605	498826	193259	122370	125453	37314	71177	59498
2011	1574020	1069570	602881	449124	354065	145853	97013	102260	31647	114646
2012	1272860	1294900	805896	420106	315358	262456	114800	80134	87256	127444
2013	1449990	1047670	974743	562057	295940	232669	206220	95611	68830	187264
2014	1704070	1162340	779776	687589	401218	220151	183572	172245	82543	225021
2015	993983	1341460	862513	555221	493745	300175	174016	152797	148697	271340
2016	1173720	795848	1009080	615409	395465	368070	236311	143357	131042	370080

Table 14.3.4. Plaice in Subarea 4 and Subdivision 20: Stock summary table.

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1957	475276	342134.0	78237.35	70860.05	7377	0.242	0.202	0.093	0.21
1958	710510	3552214.2	88845.15	74170.13	14675	0.280	0.204	0.175	0.21
1959	876603	361917.9	105477.64	78311.41	27166	0.312	0.198	0.217	0.22
1960	789141	379580.6	117937.13	88710.47	29227	0.324	0.238	0.202	0.23
1961	878551	390555.0	119263.46	852014.01	34055	0.324	0.219	0.252	0.22
1962	614870	4816914.1	126441.91	90415.30	36027	0.336	0.213	0.258	0.19
1963	614690	439846.6	141192.68	103030.16	38163	0.369	0.230	0.318	0.23
1964	2435440	430217.9	147332.38	110794.23	36538	0.396	0.252	0.278	0.26
1965	667809	383317.5	151059.22	105249.62	45810	0.387	0.274	0.263	0.27
1966	579750	405150.5	163126.96	98912.10	64215	0.361	0.225	0.288	0.24
1967	424497	473182.2	1552414.90	104435.49	50813	0.349	0.201	0.257	0.22
1968	417472	456929.0	148915.45	120195.98	28719	0.354	0.224	0.226	0.26
1969	668795	402002.0	1443514.15	121074.56	23284	0.362	0.263	0.182	0.30
1970	671843	371011.4	136131.30	111280.24	24851	0.362	0.265	0.218	0.30
1971	436656	362809.1	143445.74	119071.37	24374	0.371	0.279	0.213	0.33
1972	367347	365750.2	150863.97	131675.87	19188	0.407	0.327	0.172	0.36
1973	1361240	300366.8	149304.32	132214.82	17089	0.452	0.402	0.117	0.44
1974	1079870	2963414.3	154231.98	112946.72	41285	0.470	0.394	0.185	0.38
1975	799278	303465.8	166400.02	94964.52	71435	0.455	0.299	0.356	0.31
1976	684635	330751.8	1808114.62	125065.31	55753	0.444	0.318	0.275	0.38
1977	1030590	328753.6	168425.10	110052.40	58373	0.458	0.300	0.289	0.33
1978	875828	3244514.2	175763.75	126685.46	49078	0.488	0.371	0.239	0.39
1979	910524	300491.2	168686.69	117183.57	51503	0.516	0.375	0.275	0.39
1980	1080290	320390.3	184372.71	150636.80	33736	0.536	0.471	0.157	0.47
1981	1010250	293391.9	187134.60	153225.81	33909	0.542	0.477	0.158	0.52
1982	1941050	286215.1	195859.42	147892.86	47967	0.534	0.455	0.189	0.52
1983	1363380	3390014.0	213457.17	144697.28	68760	0.521	0.423	0.230	0.43
1984	1282770	365103.6	223935.71	160240.21	63695	0.516	0.390	0.217	0.44
1985	1806160	394411.5	240804.53	177890.72	62914	0.530	0.441	0.215	0.45
1986	4389140	414899.4	282564.63	167832.83	114732	0.577	0.442	0.273	0.40
1987	1953250	481114.1	324917.12	161607.49	163310	0.637	0.456	0.441	0.34
1988	1724090	425330.7	319500.42	170276.01	149224	0.651	0.408	0.462	0.40
1989	1224500	441343.4	281979.68	182593.74	99386	0.609	0.400	0.397	0.41
1990	1110790	394926.0	241829.68	168872.85	72957	0.579	0.408	0.358	0.43
1991	1004210	364115.9	225840.50	151633.33	74207	0.606	0.412	0.383	0.42
1992	838128	315700.1	204756.06	142104.24	62652	0.646	0.450	0.377	0.45
1993	511439	2744314.6	175652.43	139204.20	36448	0.624	0.498	0.265	0.51
1994	572617	226610.2	140232.16	118405.49	21827	0.572	0.492	0.189	0.52
1995	1071900	222254.1	130767.43	108604.42	22163	0.581	0.511	0.166	0.49
1996	1004330	211544.1	147747.61	102060.84	45687	0.685	0.544	0.320	0.48
1997	2308750	212126.5	173184.79	89874.29	83311	0.787	0.536	0.618	0.42
1998	774939	229506.2	167449.17	72036.29	95413	0.737	0.449	0.536	0.31
1999	728518	214731.9	158921.87	90576.74	68345	0.639	0.418	0.342	0.42
2000	916459	234641.8	155155.00	106487.25	48668	0.602	0.434	0.297	0.45

year	recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1957	475276	342134.0	78237.35	70860.05	7377	0.242	0.202	0.093	0.21
2001	601963	235083.4	138340.56	70189.74	68151	0.622	0.322	0.434	0.30
2002	1659280	213590.9	145041.68	89072.05	55970	0.629	0.417	0.445	0.42
2003	568719	231607.7	141966.12	69324.12	72642	0.561	0.355	0.408	0.30
2004	1331210	223537.8	135310.29	78062.97	57247	0.471	0.301	0.349	0.35
2005	853271	251804.9	119484.85	63640.82	55844	0.407	0.215	0.341	0.25
2006	832698	280354.6	118405.26	66900.80	51504	0.358	0.212	0.313	0.24
2007	1357950	284013.6	104467.65	60272.77	44195	0.302	0.162	0.284	0.21
2008	1186450	360136.4	109835.66	61320.54	48515	0.245	0.155	0.203	0.17
2009	1086170	445984.7	113539.26	66393.52	47146	0.210	0.125	0.181	0.15
2010	1353540	549922.9	119380.27	76330.59	43050	0.202	0.119	0.161	0.14
2011	1574020	5687614.3	122566.04	78019.74	44546	0.207	0.112	0.160	0.14
2012	1272860	605786.7	130830.30	81366.68	49464	0.208	0.111	0.178	0.13
2013	1449990	694432.1	135173.41	91167.81	44006	0.203	0.117	0.174	0.13
2014	1704070	809921.5	132310.00	81220.89	51089	0.199	0.093	0.185	0.10
2015	993983	770555.6	135700.65	91175.09	44526	0.199	0.101	0.181	0.12
2016	1173720	836066.4	139769.25	94622.98	45146	0.202	0.099	0.172	0.11

Table 14.4.1. Plaice in Subarea 4 and Subdivision 20: Input table for RCT3 analysis.

Year–class	age 1 AAP	age 2 AAP	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1975	684635	435068	NA	NA	3423.8	NA	NA	NA
1976	1030590	632554	NA	NA	126714.0	NA	NA	NA
1977	875828	547616	NA	NA	98214.8	NA	NA	NA
1978	910524	608159	NA	NA	12882.3	NA	NA	NA
1979	1080290	768191	NA	NA	18785.3	NA	NA	NA
1980	1010250	734361	NA	NA	8642.0	NA	NA	NA
1981	1941050	1384900	NA	NA	139014.6	NA	NA	NA
1982	1363380	939956	NA	NA	10412.8	NA	NA	NA
1983	1282770	864014	NA	NA	13847.8	NA	NA	NA
1984	1806160	1205880	NA	NA	7580.4	NA	NA	NA
1985	4389140	2933270	NA	NA	32991.1	NA	NA	NA
1986	1953250	1323660	NA	NA	14421.1	NA	NA	NA
1987	1724090	1207450	NA	NA	17810.2	NA	NA	NA
1988	1224500	891580	NA	NA	7496.0	NA	NA	NA
1989	1110790	822672	NA	NA	11247.2	NA	NA	NA
1990	1004210	730412	NA	NA	13841.8	NA	NA	439.6
1991	838128	594078	NA	NA	9685.6	NA	NA	332.4
1992	511439	367488	NA	NA	4976.6	NA	NA	180.3
1993	572617	431643	NA	NA	2796.4	NA	NA	217.0
1994	1071900	843745	NA	NA	102614.2	NA	25949.58	283.4
1995	1004330	809656	NA	NA	4472.7	26759.58	96923.33	146.1
1996	2308750	1867230	NA	NA	30242.2	45897.04	83834.29	619.6
1997	774939	613911	NA	NA	10272.1	341414.87	18310.67	229.2
1998	728518	559556	NA	NA	2493.4	44266.94	22415.94	NA
1999	916459	699920	NA	22855.0	28914.5	42116.52	20460.37	NA
2000	601963	467837	24213.5	11510.5	1102.7	28600.80	16836.16	124.9
2001	1659280	1286580	996214.0	30809.2	NA	133179.54	46174.93	313.2
2002	568719	421666	31202.0	NA	1349.7	31956.50	13805.04	122.9
2003	1331210	942424	NA	18201.6	18114.9	44684.76	28190.67	2314.6
2004	853271	621382	13537.2	101114.4	1571.0	37599.42	17126.45	126.7
2005	832698	639450	27390.6	12164.2	2133.9	41399.71	22501.51	85.9
2006	1357950	1054550	51124.2	14174.5	2700.4	83862.91	47117.48	1614.0
2007	1186450	896178	40580.9	14705.8	20114.7	66896.51	23487.02	914.3
2008	1086170	815425	50179.3	14860.0	1811.5	64412.58	29101.17	129.7
2009	1353540	1069570	532514.8	11946.9	1142.5	79927.63	43303.63	141.9
2010	1574020	1294900	49347.2	183414.6	29214.6	124219.66	660114.33	179.6
2011	1272860	1047670	52643.0	5893.4	3021.3	58133.93	53497.57	93.0
2012	1449990	1162340	45027.1	15394.9	22514.3	868514.33	63030.22	181.1
2013	NA	NA	44327.5	17312.7	5040.4	140561.54	67943.67	1614.5
2014	NA	NA	11722.3	16726.5	2434.3	51289.83	323114.90	1014.0
2015	NA	NA	30494.5	10384.8	NA	80551.65	NA	100.2
2016	NA	NA	44111.0	NA	NA	NA	NA	714.5

Table 14.4.2. Plaice in Subarea 4 and Subdivision 20. RCT3 results for age 1 in 2017 (year–class 2016).

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 42 years : 1975 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
    index  slope intercept     se rsquare  n indices prediction se.pred
     SNS0 0.9644     3.675 0.3417  0.5500 12  10.694      13.99  0.3902
     SNS1 2.1695    -6.816 0.8595  0.1135 13      NA         NA      NA
     SNS2 0.9144     6.037 0.7798  0.2392 37      NA         NA      NA
    BTSC1 1.1243     1.662 0.4027  0.4749 18      NA         NA      NA
    BTSC2 0.7775     5.812 0.2874  0.6256 19      NA         NA      NA
     DFS0 2.3267     1.703 1.1643  0.1088 21   4.363      11.85  1.3321
 VPA Mean     NA        NA     NA      NA 38      NA      13.93  0.4301
 WAP.weights
     0.52393
          NA
          NA
          NA
          NA
     0.04495
     0.43112

                   WAP logWAP int.se
yearclass:2016 1055007  13.87 0.2824
```

Table 14.4.3. Plaice in Subarea 4 and Subdivision 20: RCT3 results for age 2 in 2017 (year-class 2015).

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 42 years: 1975–2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2015
    index  slope intercept     se rsquare  n indices prediction se.pred
     SNS0 1.0178    2.8548 0.3563 0.56081 12  10.325      13.36  0.4114
     SNS1 2.6750  -11.9152 1.0779 0.08302 13   9.248      12.82  1.2463
     SNS2 1.0962    4.1558 0.9777 0.16779 37      NA         NA      NA
    BTSC1 1.1797    0.8043 0.4234 0.47258 18  11.297      14.13  0.4709
    BTSC2 0.7789    5.5438 0.2649 0.68298 19      NA         NA      NA
     DFS0 2.7379   -0.7088 1.3854 0.08876 21   4.607      11.91  1.5396
 VPA Mean     NA        NA     NA      NA 38      NA      13.62  0.4334
 WAP.weights
      0.3515
      0.0383
          NA
      0.2683
          NA
      0.0251
      0.3168

                  WAP logWAP int.se
Year–class: 2015 801152  13.59 0.2439
```

Table 14.5.1. Plaice in Subarea 4 and Subdivision 20: Input to the short term forecast (F values presented are for Fsq).

2017_ssb	2017_f2–6	2017_f_dis2–3	2017_f_hc2–6	2017_recruits	2017_landings	2017_discards	2017_catch	2017_TAC			
936773	0.202	0.181	0.098	1055007	96767	40869	137588	148502			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2017	0.119	0.12	0	1055007	0.03	0.07	0.03	0.03	0	0.1
2	2017	0.184	0.18	0	967855	0.09	0.25	0.08	0.08	0.5	0.1
3	2017	0.241	0.18	0.06	611043	0.16	0.28	0.13	0.13	0.5	0.1
4	2017	0.244	0.09	0.15	718703	0.25	0.31	0.15	0.2	1	0.1
5	2017	0.197	0.05	0.15	431151	0.31	0.36	0.16	0.28	1	0.1
6	2017	0.142	0.02	0.13	292176	0.38	0.4	0.19	0.34	1	0.1
7	2017	0.097	0.01	0.09	287580	0.45	0.47	0.21	0.4	1	0.1
8	2017	0.056	0	0.05	191648	0.5	0.52	0.26	0.45	1	0.1
9	2017	0.028	0	0.03	121499	0.59	0.59	0.3	0.47	1	0.1
10	2017	0.028	0	0.03	439512	0.64	0.64	0	0.53	1	0.1
1	2018	0.119	0.12	0	969504	0.03	0.07	0.03	0.03	0	0.1
2	2018	0.184	0.18	0	NA	0.09	0.25	0.08	0.08	0.5	0.1
3	2018	0.241	0.18	0.06	NA	0.16	0.28	0.13	0.13	0.5	0.1
4	2018	0.244	0.09	0.15	NA	0.25	0.31	0.15	0.2	1	0.1
5	2018	0.197	0.05	0.15	NA	0.31	0.36	0.16	0.28	1	0.1
6	2018	0.142	0.02	0.13	NA	0.38	0.4	0.19	0.34	1	0.1
7	2018	0.097	0.01	0.09	NA	0.45	0.47	0.21	0.4	1	0.1
8	2018	0.056	0	0.05	NA	0.5	0.52	0.26	0.45	1	0.1
9	2018	0.028	0	0.03	NA	0.59	0.59	0.3	0.47	1	0.1
10	2018	0.028	0	0.03	NA	0.64	0.64	0	0.53	1	0.1
1	2019	0.119	0.12	0	969504	0.03	0.07	0.03	0.03	0	0.1
2	2019	0.184	0.18	0	NA	0.09	0.25	0.08	0.08	0.5	0.1
3	2019	0.241	0.18	0.06	NA	0.16	0.28	0.13	0.13	0.5	0.1
4	2019	0.244	0.09	0.15	NA	0.25	0.31	0.15	0.2	1	0.1
5	2019	0.197	0.05	0.15	NA	0.31	0.36	0.16	0.28	1	0.1
6	2019	0.142	0.02	0.13	NA	0.38	0.4	0.19	0.34	1	0.1
7	2019	0.097	0.01	0.09	NA	0.45	0.47	0.21	0.4	1	0.1
8	2019	0.056	0	0.05	NA	0.5	0.52	0.26	0.45	1	0.1
9	2019	0.028	0	0.03	NA	0.59	0.59	0.3	0.47	1	0.1
10	2019	0.028	0	0.03	NA	0.64	0.64	0	0.53	1	0.1

Table 14.5.2. Plaice in Subarea 4 and Subdivision 20: Results from the short term forecast assuming $F_{2017} = F_{2016}$ (rescaled).

basis	Catch 2018*	Landing 2018	Discards 2018	F(2–6) 2018	F_landing (2–6) 2018	F_discards (2–6) 2018	SSB 2018	SSB 2019	ssb_change**	TAC_change***
Ftar	185365	131326	54039	0.300	0.15	0.27	959446	924610	-4	-11
Fmsy	134238	94866	39372	0.210	0.10	0.19	959446	975653	2	-35
Fmsy_low	97936	69100	28836	0.150	0.07	0.13	959446	1012025	5	-53
Fmsy_high	185365	131326	54039	0.300	0.15	0.27	959446	924610	-4	-11
Fpa	222046	157619	64427	0.369	0.18	0.33	959446	888129	-7	7
Flim	293603	209275	84328	0.516	0.25	0.46	959446	817332	-15	42
SSB>Bpa	857697	649264	208433	3.272	1.60	2.94	959446	290203	-70	338
SSB>Blim	957871	739503	218368	4.779	2.33	4.29	959446	207288	-78	399
SSB>MSYBtrig	554590	403229	151361	1.265	0.62	1.14	959446	564599	-41	172
TACsq	208027	147556	60471	0.342	0.17	0.31	959446	902057	-6	0
15%_TAC_inc	239026	169832	69194	0.402	0.20	0.36	959446	871283	-9	15
15%_TAC_dec	176909	125281	51628	0.285	0.14	0.26	959446	933037	-3	-15
Fsq*0	0	0	0	0.000	NA	NA	959446	1112041	16	-100
Fsq*0.25	33144	23343	9801	0.050	0.02	0.04	959446	1077179	12	-84
Fsq*0.5	66882	47134	19748	0.101	0.05	0.09	959446	1043215	9	-68
Fsq*0.9	117527	82993	34534	0.182	0.09	0.16	959446	992384	3	-43
Fsq*1	129504	91500	38004	0.202	0.10	0.18	959446	980391	2	-38
Fsq*1.1	141281	99876	41405	0.222	0.11	0.20	959446	968610	1	-32
Fsq*1.25	158578	112197	46381	0.252	0.12	0.23	959446	951326	-1	-24
Fsq*1.5	187004	132498	54506	0.303	0.15	0.27	959446	922978	-4	-10
Fsq*1.75	213725	151644	62081	0.353	0.17	0.32	959446	896393	-7	3
Fsq*2	239869	170439	69430	0.404	0.20	0.36	959446	870447	-9	15

* "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2014–2016. Both Wanted and unwanted catch refer to Subarea 4 and Subdivision 20, calculated as the projected total stock wanted catch (including 7.d) deducted by the catch of plaice from Subarea 4 taken in Division 7d in 2018. The subtracted value (946 t of wanted catch and 459 tons of unwanted catch) is estimated based on the plaice catch advice for Division 7.d for 2017, using the recent 11 year average (2006–2016) proportion of plaice from Subarea 4 in the annual plaice landings in Division 7.d. TAC change restrictions of 15% are applied after subtracting the Division 7.d catches.

** SSB 2019 relative to SSB 2018.

*** Wanted catch in 2018 relative to the combined wanted TAC of Subarea 4 and Subdivision 20 in 2017 (147 556 tons), ignoring that large mesh trawlers (TR1 and BT1) with low discard rates are under landing obligation since 2016.

Table 14.5.3. Plaice in Subarea 4 and Subdivision 20: Detailed STF table by age, assuming F = Fsq, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n
2017																
1	2017	0.119	0.12	0	1055007	0.03	0.07	0.03	0.03	0	0.1	112996	3729	1	0	112994
2	2017	0.184	0.18	0	967855	0.09	0.25	0.08	0.08	0.5	0.1	155172	13319	3544	888	151628
3	2017	0.241	0.18	0.06	611043	0.16	0.28	0.13	0.13	0.5	0.1	124845	20429	30478	8534	94367
4	2017	0.244	0.09	0.15	718703	0.25	0.31	0.15	0.2	1	0.1	148610	37360	91909	28645	56701
5	2017	0.197	0.05	0.15	431151	0.31	0.36	0.16	0.28	1	0.1	73622	23120	56539	20297	17084
6	2017	0.142	0.02	0.13	292176	0.38	0.4	0.19	0.34	1	0.1	36786	14007	32709	13214	4078
7	2017	0.097	0.01	0.09	287580	0.45	0.47	0.21	0.4	1	0.1	25199	11391	23752	11100	1447
8	2017	0.056	0	0.05	191648	0.5	0.52	0.26	0.45	1	0.1	9915	4917	9171	4772	744
9	2017	0.028	0	0.03	121499	0.59	0.59	0.3	0.47	1	0.1	3190	1878	3190	1878	0
10	2017	0.028	0	0.03	439512	0.64	0.64	0	0.53	1	0.1	11540	7439	11539	7439	1
2018																
1	2018	0.119	0.12	0	969504	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837
2	2018	0.184	0.18	0	847277	0.09	0.25	0.08	0.08	0.5	0.1	135840	11660	3103	778	132738
3	2018	0.241	0.18	0.06	728435	0.16	0.28	0.13	0.13	0.5	0.1	148830	24354	36333	10173	112496
4	2018	0.244	0.09	0.15	434426	0.25	0.31	0.15	0.2	1	0.1	89829	22583	55555	17315	34273
5	2018	0.197	0.05	0.15	509293	0.31	0.36	0.16	0.28	1	0.1	86966	27310	66786	23976	20180
6	2018	0.142	0.02	0.13	320234	0.38	0.4	0.19	0.34	1	0.1	40319	15352	35850	14483	4469
7	2018	0.097	0.01	0.09	229435	0.45	0.47	0.21	0.4	1	0.1	20104	9088	18950	8856	1155
8	2018	0.056	0	0.05	236272	0.5	0.52	0.26	0.45	1	0.1	12224	6062	11307	5883	917
9	2018	0.028	0	0.03	163987	0.59	0.59	0.3	0.47	1	0.1	4306	2534	4305	2534	1
10	2018	0.028	0	0.03	493621	0.64	0.64	0	0.53	1	0.1	12961	8354	12959	8354	1
2019																
1	2019	0.119	0.12	0	969504	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837
2	2019	0.184	0.18	0	778609	0.09	0.25	0.08	0.08	0.5	0.1	124831	10715	2851	715	121980
3	2019	0.241	0.18	0.06	637684	0.16	0.28	0.13	0.13	0.5	0.1	130288	21320	31807	8906	98481
4	2019	0.244	0.09	0.15	517886	0.25	0.31	0.15	0.2	1	0.1	107086	26921	66228	20641	40858
5	2019	0.197	0.05	0.15	307846	0.31	0.36	0.16	0.28	1	0.1	52567	16508	40369	14493	12198
6	2019	0.142	0.02	0.13	378273	0.38	0.4	0.19	0.34	1	0.1	47626	18134	42347	17108	5279
7	2019	0.097	0.01	0.09	251468	0.45	0.47	0.21	0.4	1	0.1	22035	9961	20769	9706	1265
8	2019	0.056	0	0.05	188501	0.5	0.52	0.26	0.45	1	0.1	9753	4836	9021	4694	732
9	2019	0.028	0	0.03	202170	0.59	0.59	0.3	0.47	1	0.1	5308	3125	5307	3124	1
10	2019	0.028	0	0.03	578614	0.64	0.64	0	0.53	1	0.1	15192	9793	15190	9793	2

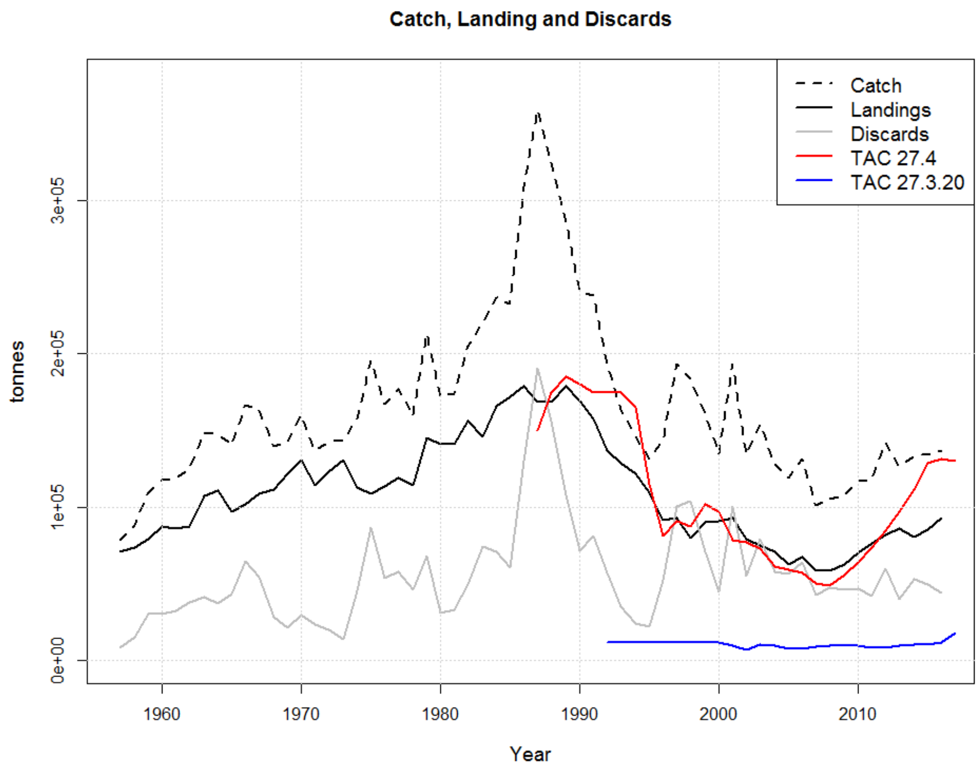


Figure 14.2.1. Plaice in Subarea 4 (including Subdivision 20 and 7.d Q1): Time series of catch (dashed line), landings (solid black line) and discards (gray line) estimates. Landings TAC for Subarea 4 (red) and Subdivision 20 (blue) are also plotted. Discards before 2000 were reconstructed using a model based method.

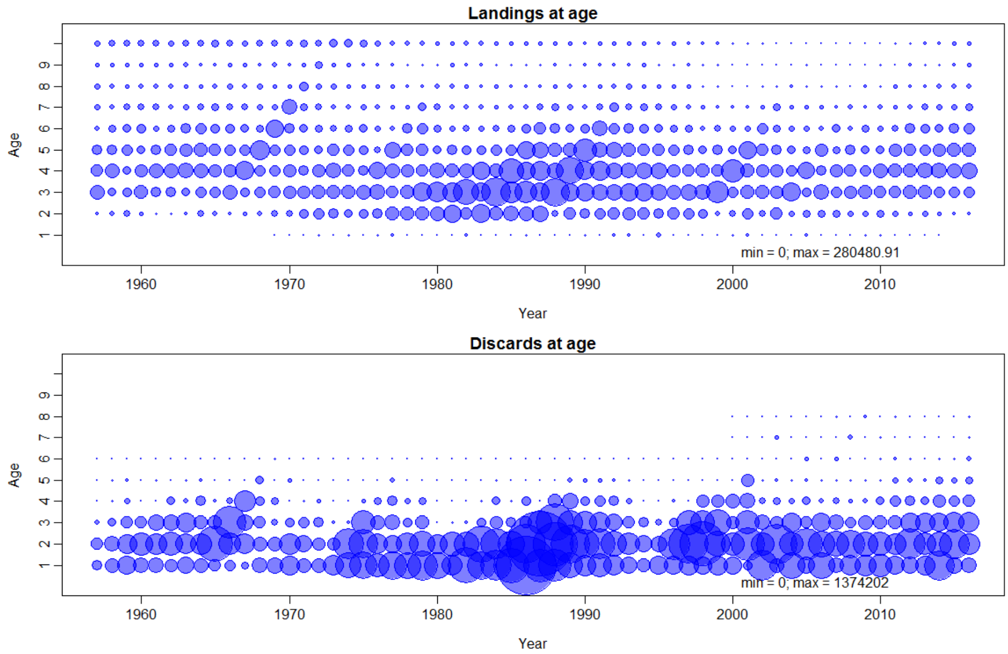


Figure 14.2.2. Plaice in Subarea 4 and Subdivision 20: Discards numbers-at-age (top) and landings numbers-at-age (down). Discards before 2000 were reconstructed using a model based method.

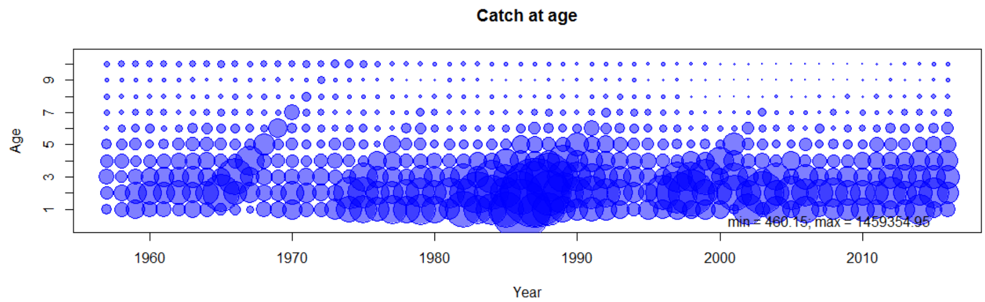


Figure 14.2.3. Plaice in Subarea 4 and Subdivision 20. Catch numbers-at-age: Discards before 2000 were reconstructed using a model based method.

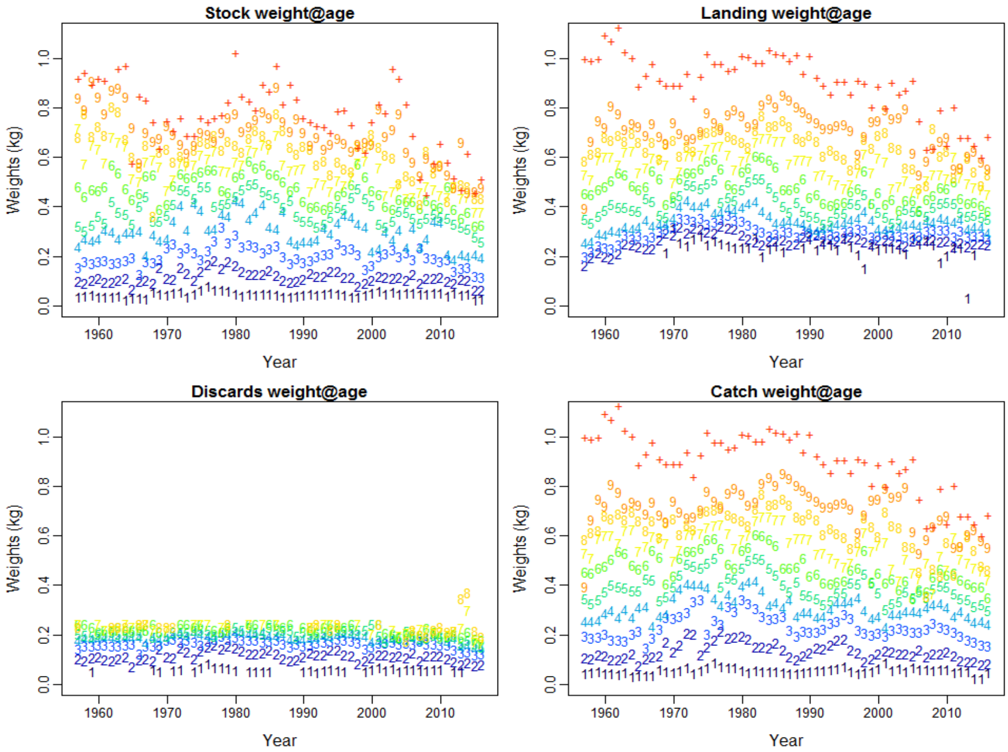


Figure 14.2.4. Plaice in Subarea 4 and Subdivision 20: Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

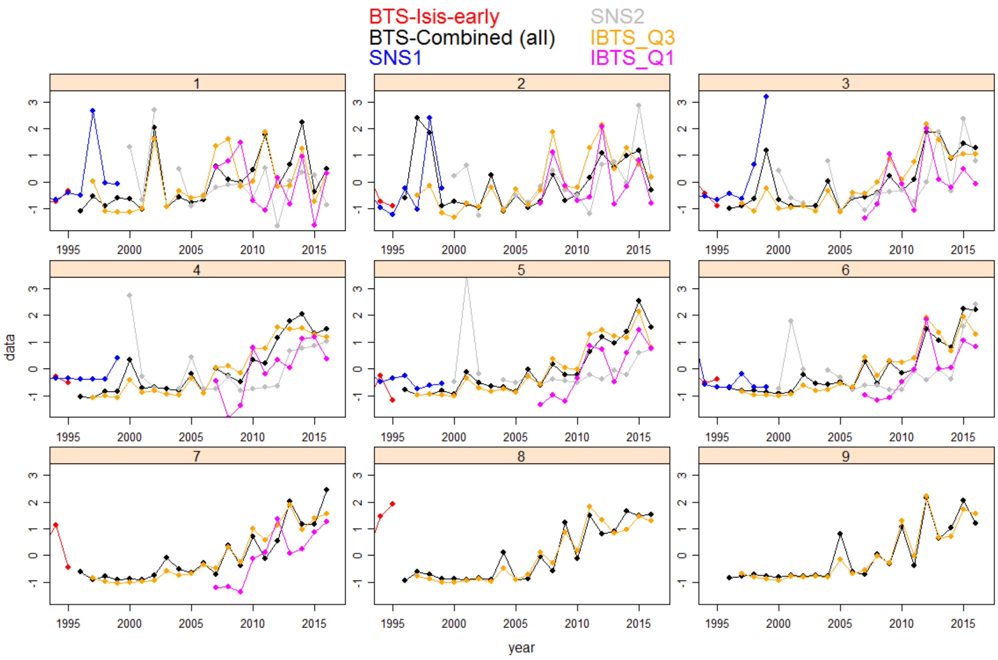


Figure 14.2.5. Plaice in Subarea 4 and Subdivision 20. Standardized survey tuning indices used for tuning stock assessment model: BTS–combined (black), BTS–Isis-early (red) SNS–1 (1984–1999, blue), SNS–2 (2000-2015, grey), IBTS–Q3 (yellow) and IBTS–Q1 (pink). Note: only ages used in the assessment are presented. The BTS–combined index combines BTS–Tridens and BTS–Isis indices.

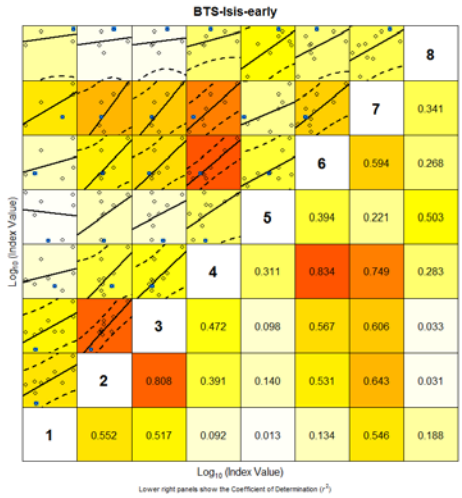


Figure 14.2.6. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the BTS-Isis-early survey index.

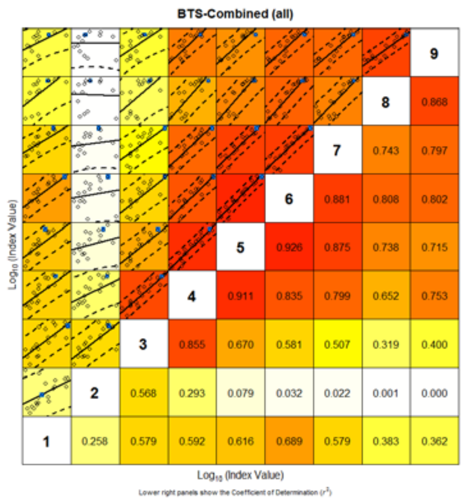


Figure 14.2.7. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the BTS–Combined survey index.

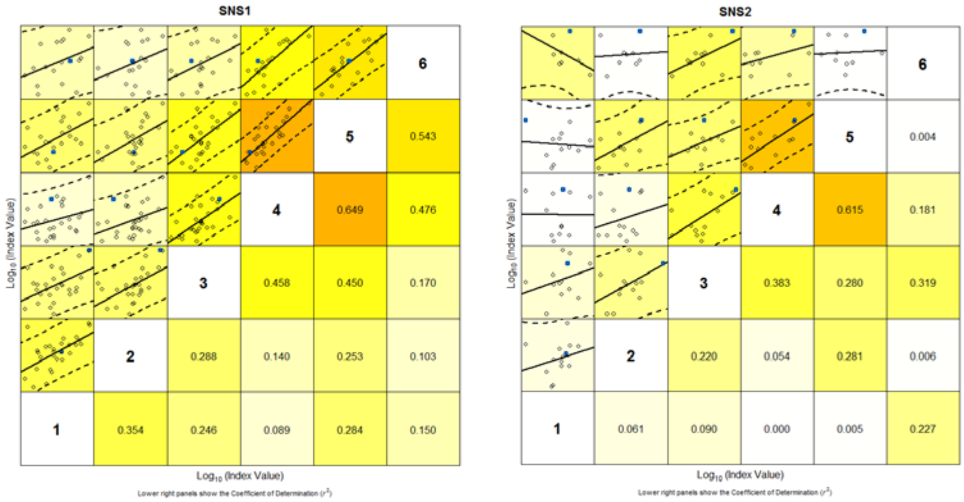


Figure 14.2.8: Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the SNS–1 (1984–1999, left) and the SNS–2 (2000–2015, right) survey indices.

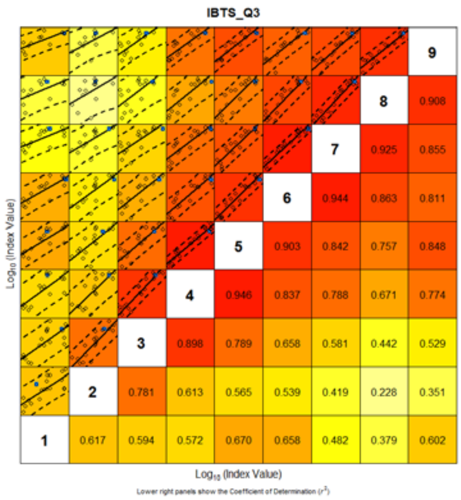


Figure 14.2.9. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the IBTS–Q3 survey indices.

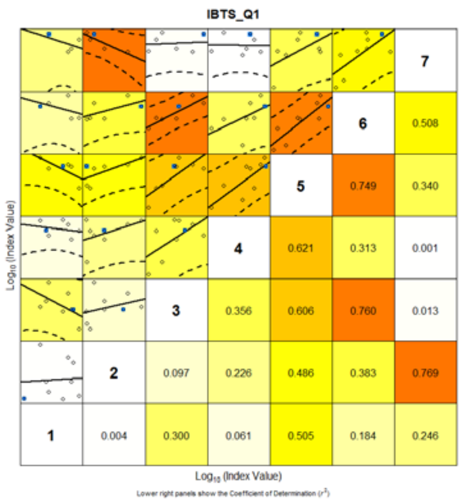
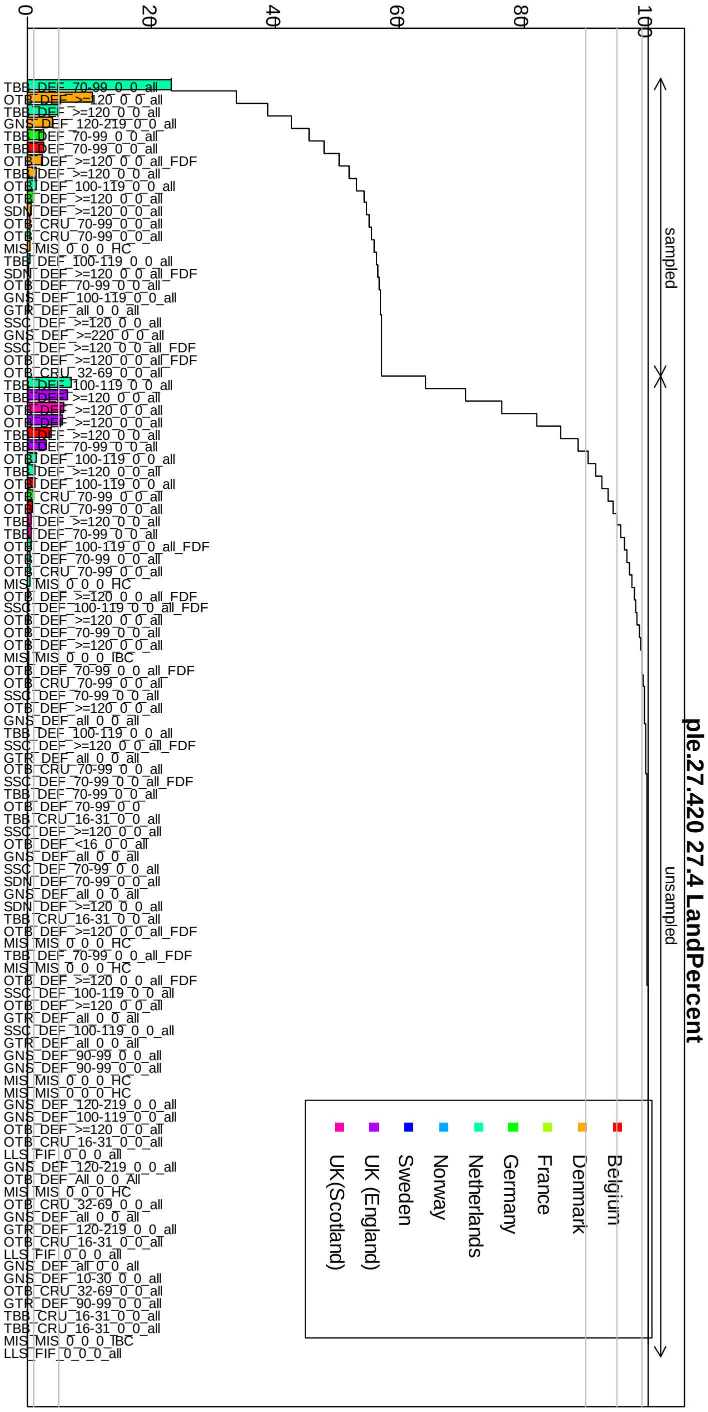
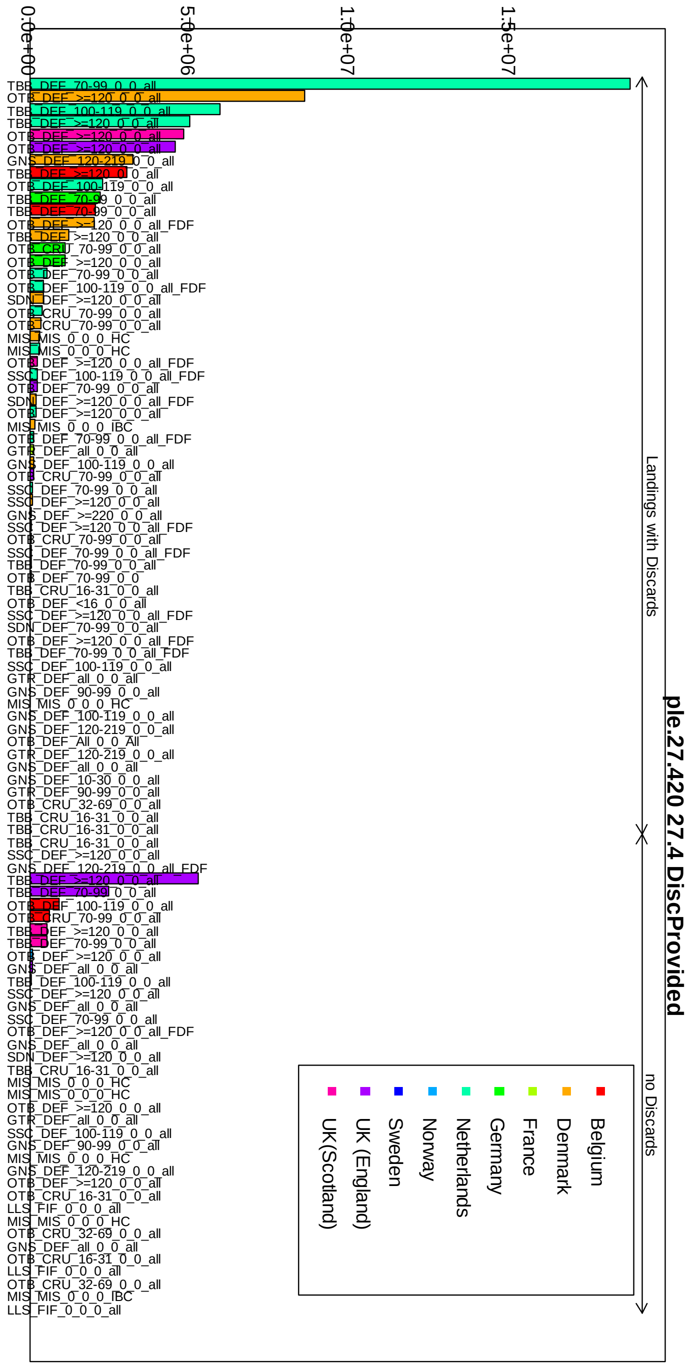


Figure 14.2.10. Plaice in Subarea 4 and Subdivision 20: Internal consistency plot for the IBTS–Q1 survey indices.

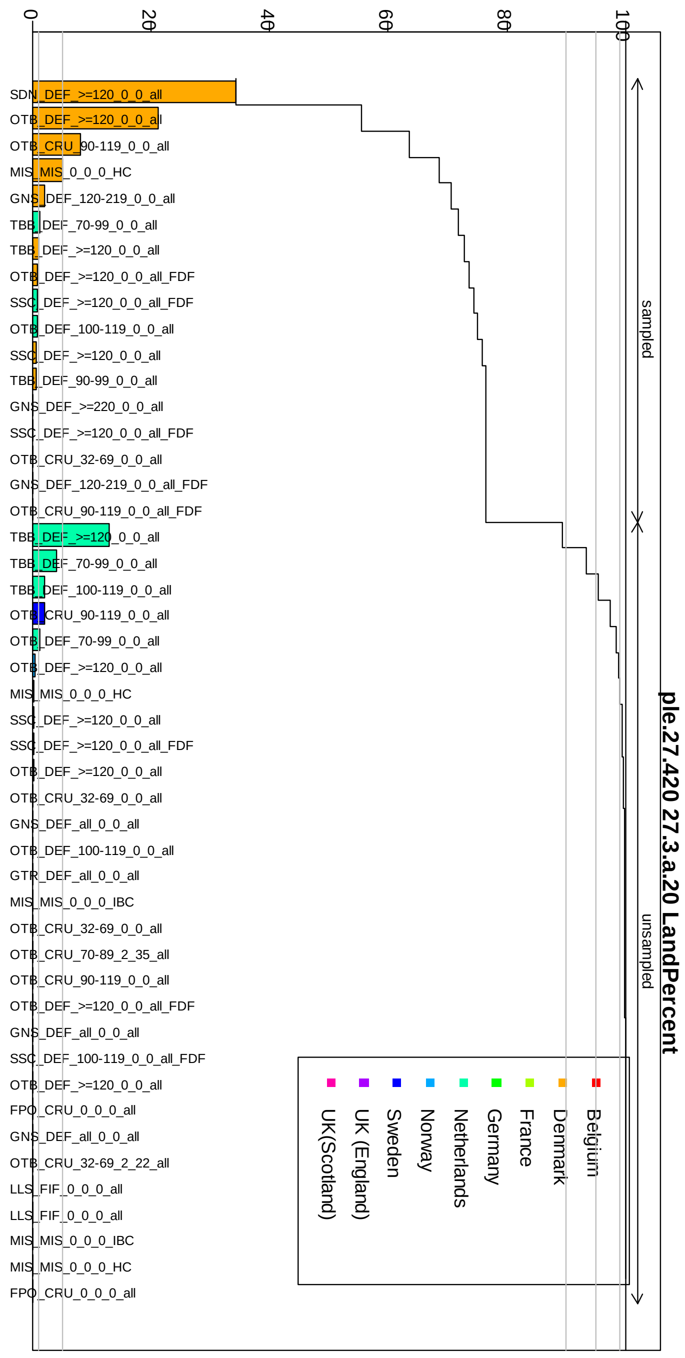

ple.27.420 27.4 LandPercent
0
20
40
60
80
100
sampled
unsampled
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(a)

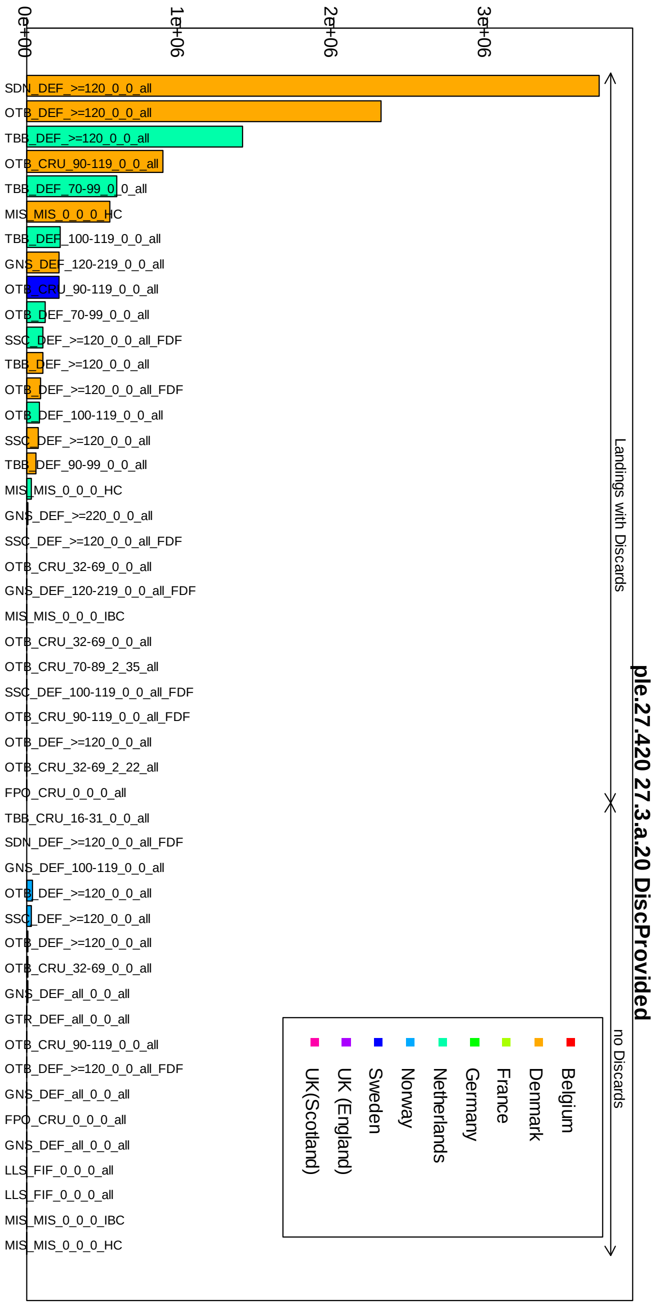


(b)

Figure 14.2.11. Summary of data upload in Intercatch for Subarea 4: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.


ple.27.420 27.3.a.20 LandPercent
0
20
40
60
80
100
sampled
unsampled
SDN_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_90-119_0_0_all
MIS_MIS_0_0_0_HC
GNS_DEF_120-219_0_0_all
TBB_DEF_70-99_0_0_all
TBB_DEF_>=120_0_0_all
OTB_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all_FDF
OTB_DEF_100-119_0_0_all
SSC_DEF_>=120_0_0_all
TBB_DEF_90-99_0_0_all
GNS_DEF_>=220_0_0_all
SSC_DEF_>=120_0_0_all_FDF
OTB_CRU_32-69_0_0_all
GNS_DEF_120-219_0_0_all_FDF
OTB_CRU_90-119_0_0_all_FDF
TBB_DEF_>=120_0_0_all
TBB_DEF_70-99_0_0_all
TBB_DEF_100-119_0_0_all
OTB_CRU_90-119_0_0_all
OTB_DEF_70-99_0_0_all
OTB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
SSC_DEF_>=120_0_0_all
SSC_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
OTB_CRU_32-69_0_0_all
GNS_DEF_all_0_0_all
OTB_DEF_100-119_0_0_all
GTR_DEF_all_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_32-69_0_0_all
OTB_CRU_70-89_2_35_all
OTB_CRU_90-119_0_0_all
OTB_DEF_>=120_0_0_all_FDF
GNS_DEF_all_0_0_all
SSC_DEF_100-119_0_0_all_FDF
OTB_DEF_>=120_0_0_all
FPO_CRU_0_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_32-69_2_22_all
LLS_FIF_0_0_0_all
LLS_FIF_0_0_0_all
MIS_MIS_0_0_0_IBC
MIS_MIS_0_0_0_HC
FPO_CRU_0_0_0_all
Belgium
Denmark
France
Germany
Netherlands
Norway
Sweden
UK (England)
UK(Scotland)

(a)



(b)

Figure 14.2.12. Summary of data upload in Intercatch for Subdivision 20: (a) Percentage of landings. Sampled and unsampled refers to availability of age-composition information. (b) Percentage of landings provided with discards, by country by métier.

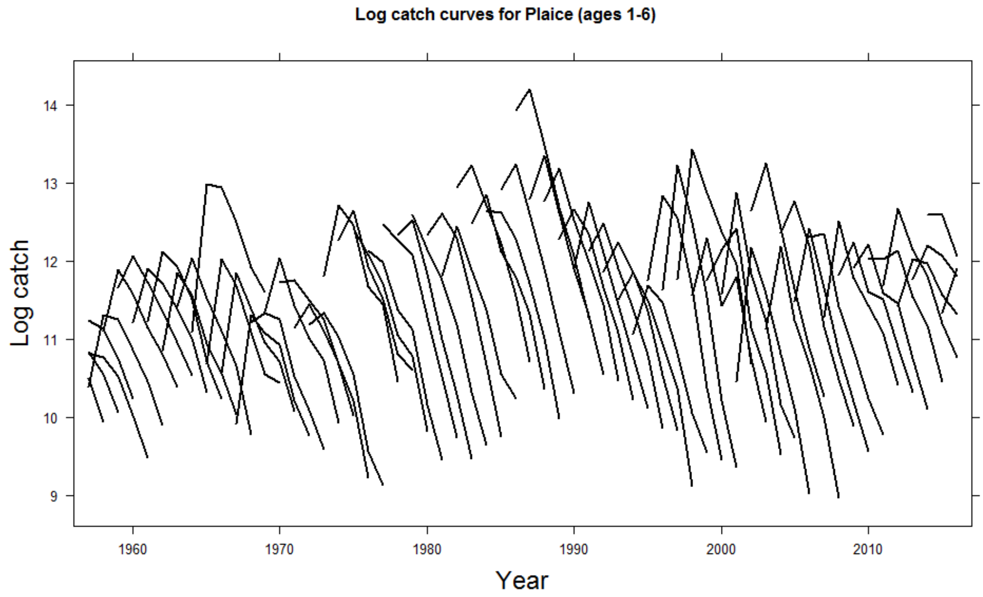


Figure 14.2.13. Catch curves for catches in age 1–6.

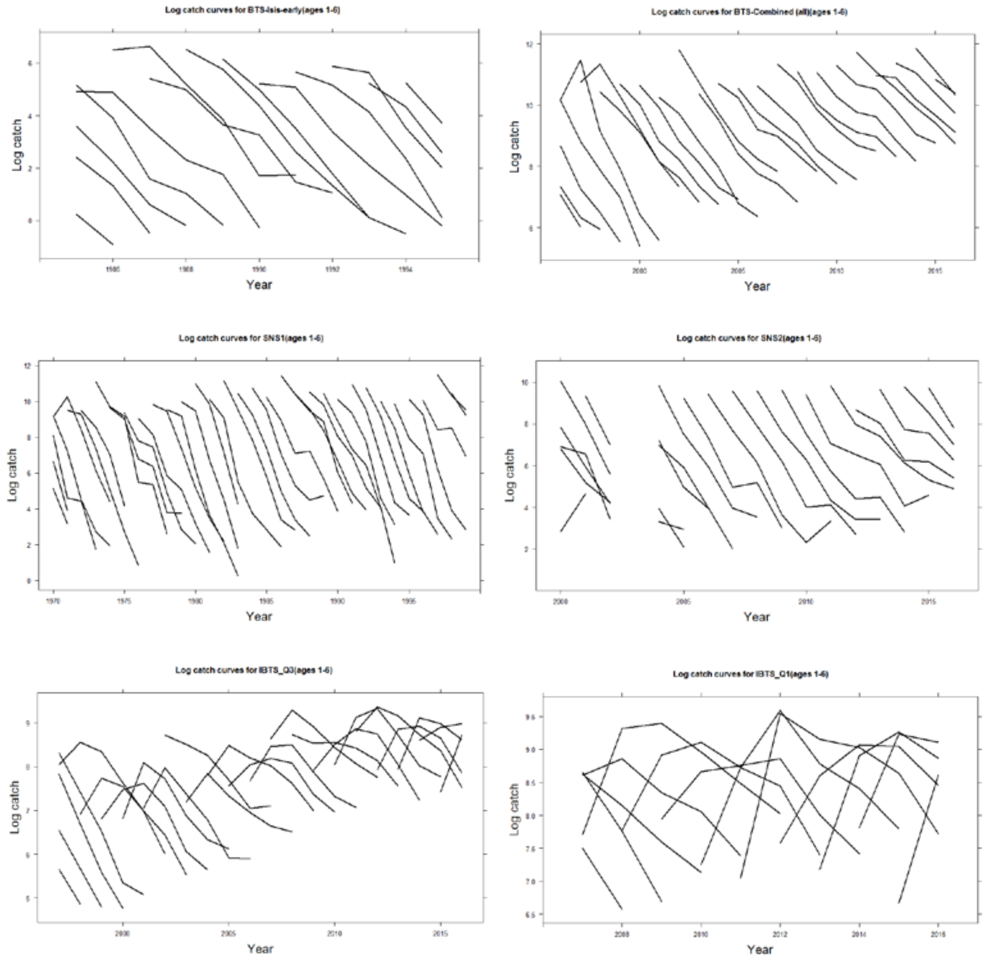


Figure 14.2.14. Catch curves for Surveys in age 1–6.

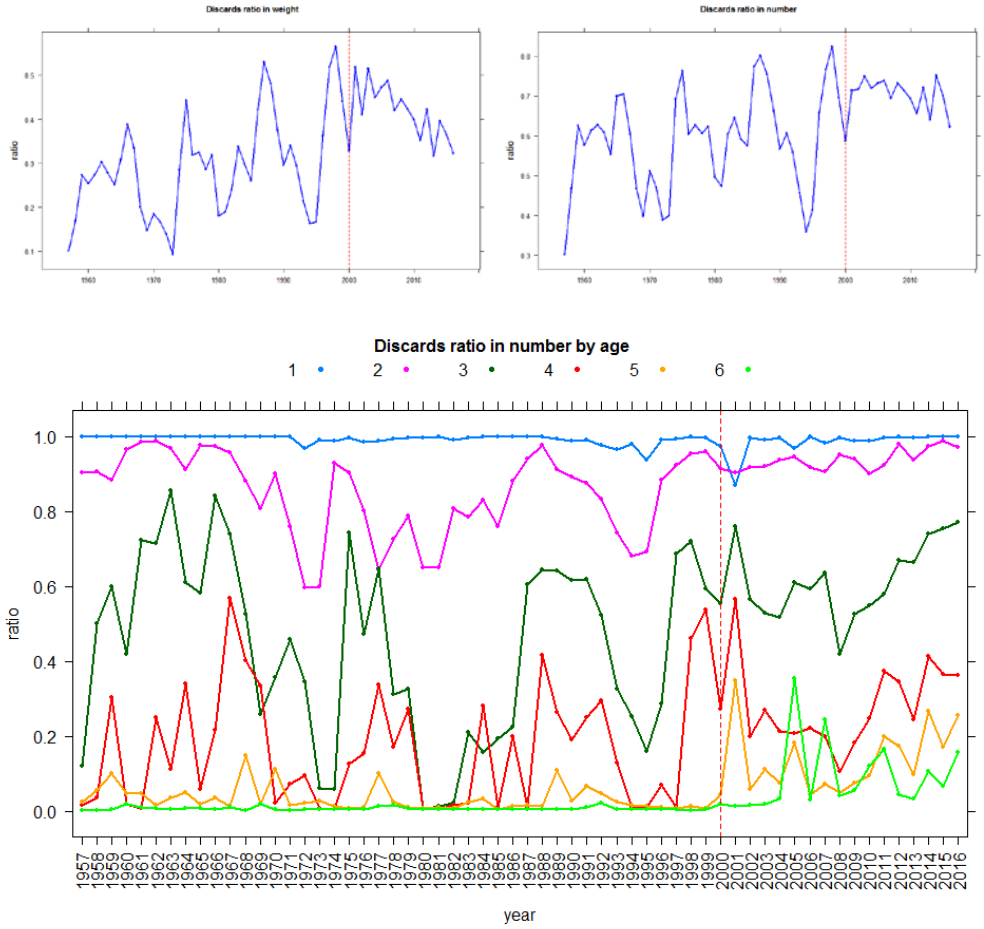
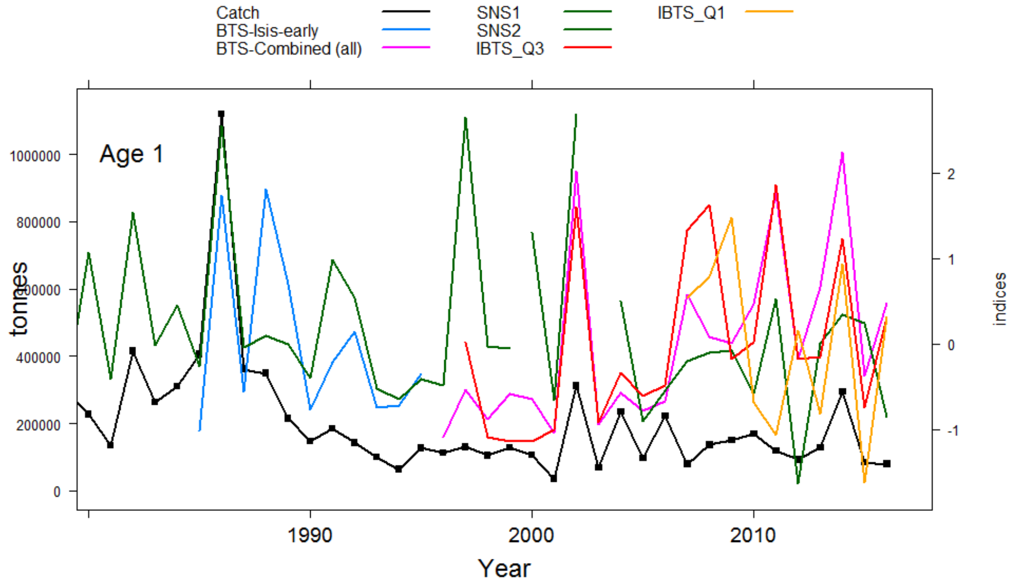
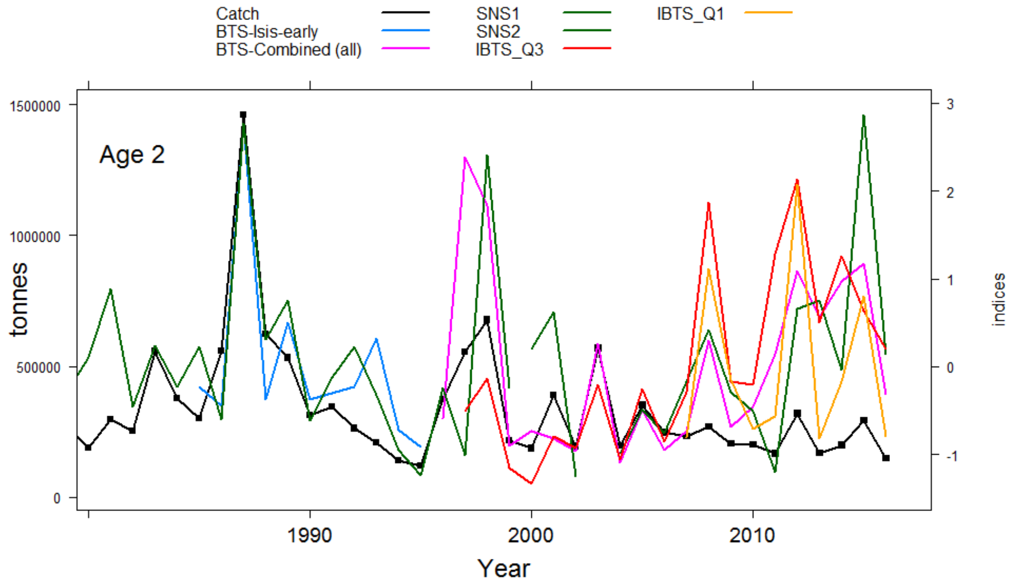
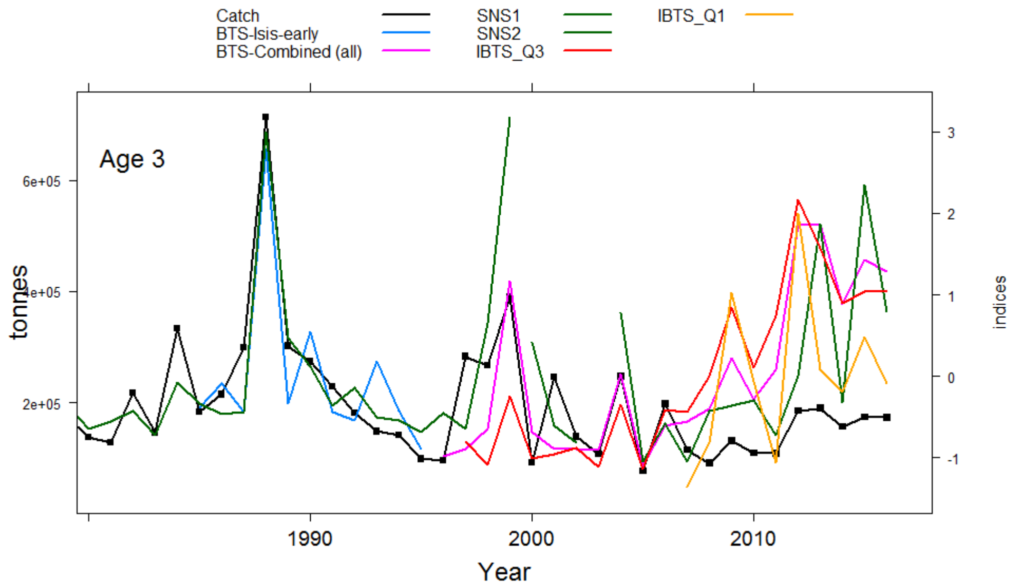


Figure 14.2.15. Discards ratio. Discards before 2000 were reconstructed using a model based method.


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 1
tonnes
indices
Year
1990
2000
2010
0
200000
400000
800000
1000000
-1
0
1
2


Catch
BTS-Isis-early
BTS-Combined (all)
SNS1
SNS2
IBTS_Q3
IBTS_Q1
Age 2
tonnes
indices
Year
1990
2000
2010
0
500000
1000000
1500000
-1
0
1
2
3



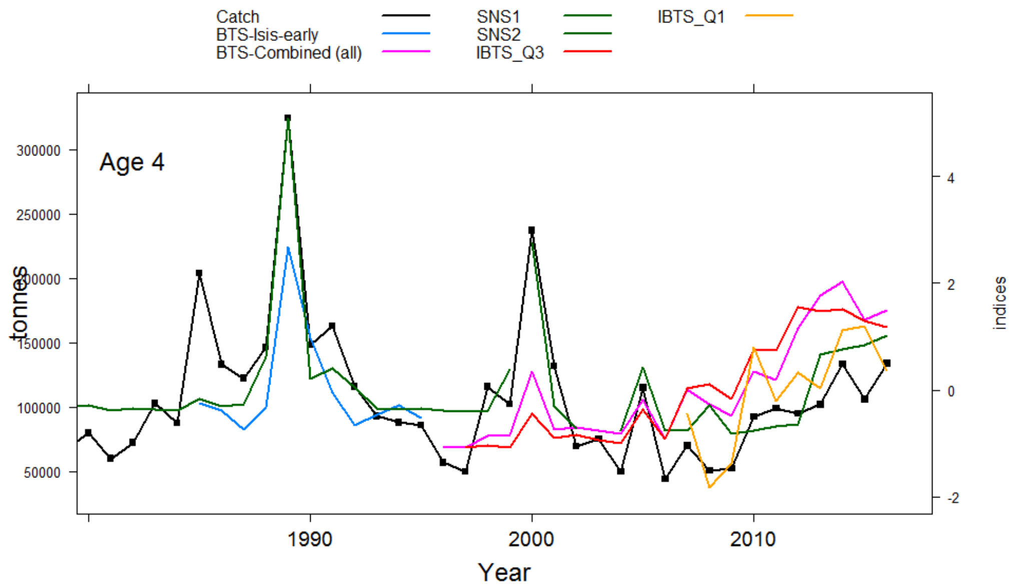


Figure 14.2.16: Catches vs. standardized survey indices by age (1–4).

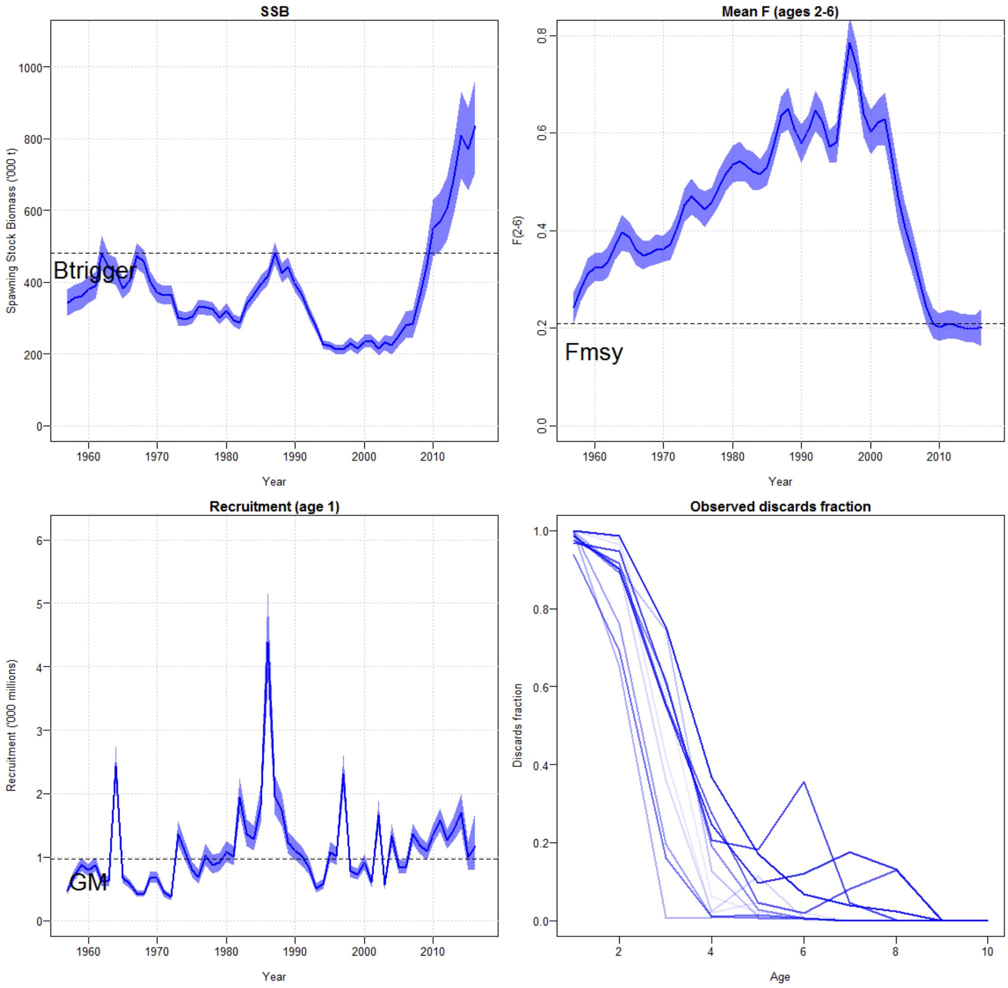


Figure 14.3.1. Stock assessment output for ple.27.420. SSB (top left), fishing mortality (top right), recruitment (bottom left) estimates of the assessment and the observed discards fraction (bottom right).

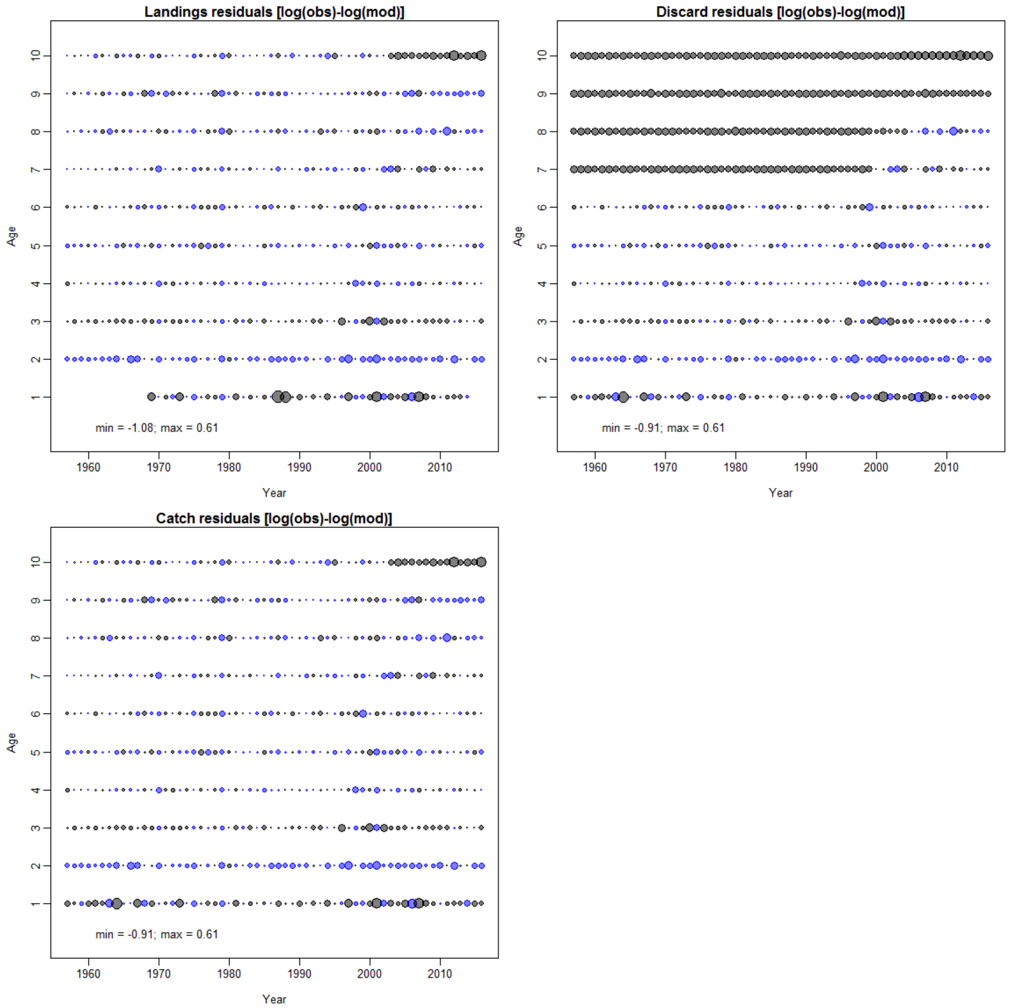


Figure 14.3.2. Landing, discard and catch residuals (not standardized): Positive values are in blue and negative values are in black.

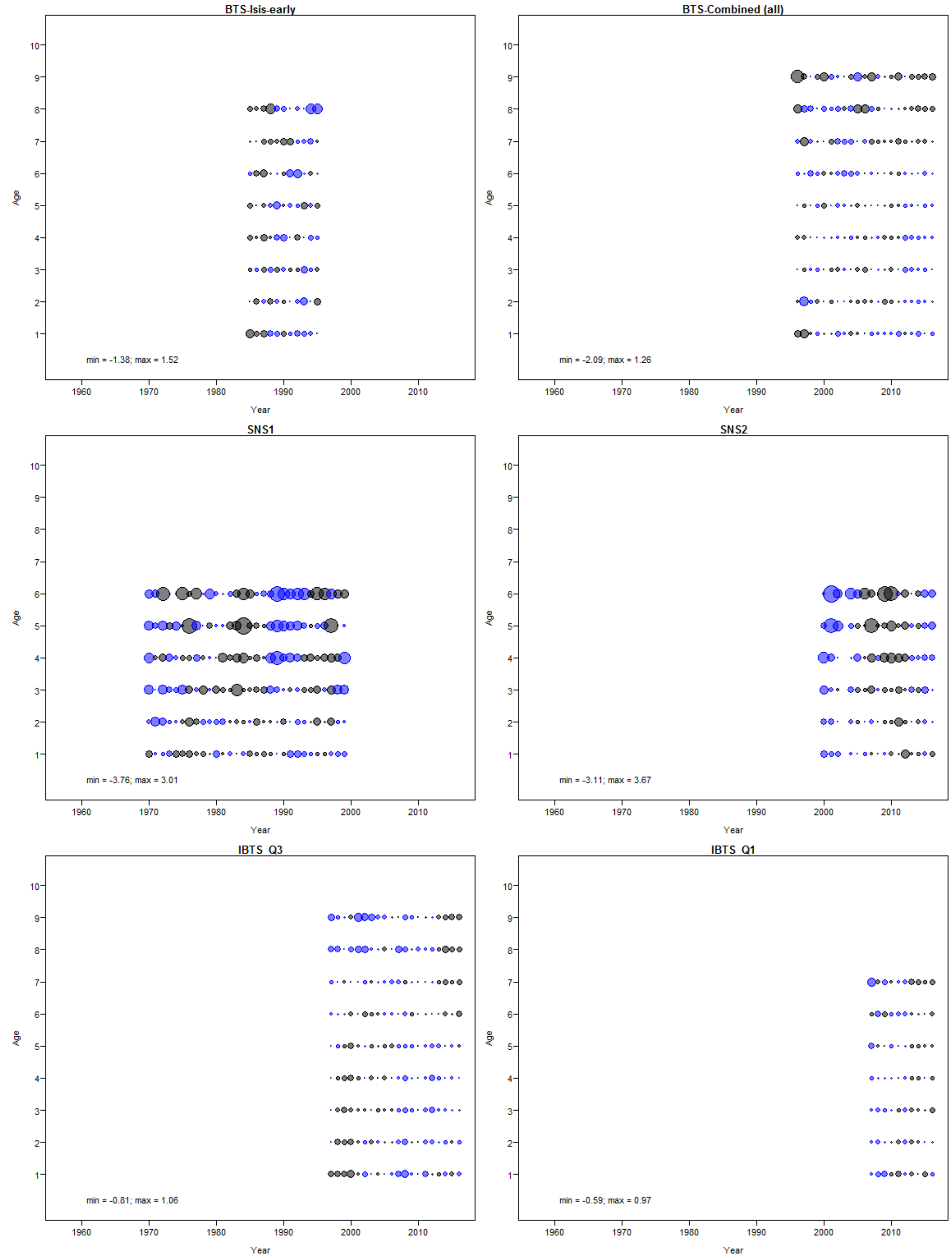


Figure 14.3.3. Survey residuals (not standardized). Positive values are in blue and negative values are in black.

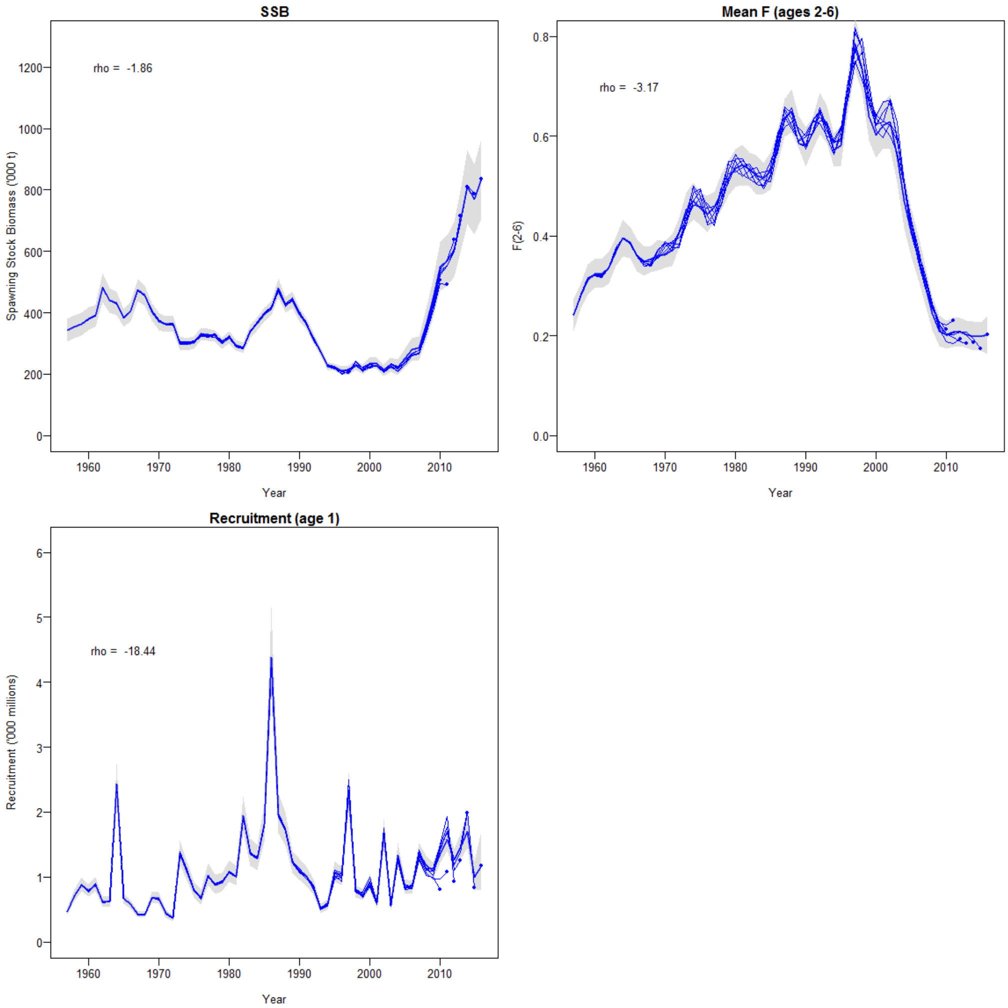


Figure 14.3.4. Retrospective pattern of the final AAP run with respect to SSB, recruitment and F.

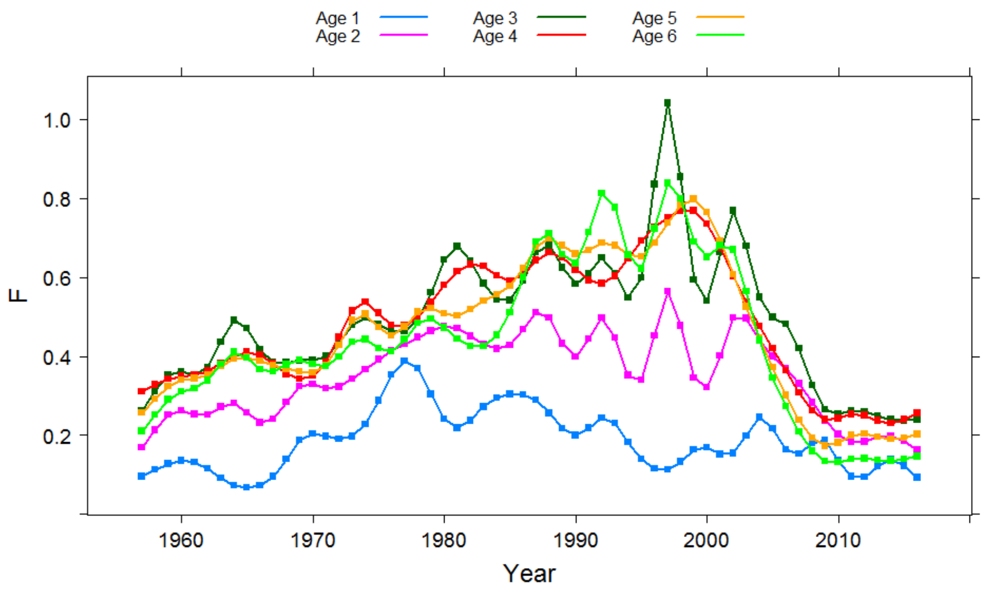


Figure 14.3.5. Estimated fishing mortality by age.

15 Plaice in Division 7.d

This stock is in category 1. This year, the assessment of plaice in Division 7d was made following methodological information described in the Stock Annex revised during ICES WKPLE 2015 and WGNSSK 2015. The Short Term Forecast procedure had to be modified this year, and the Stock Annex was revised accordingly.

15.1 General

15.1.1 Stock definition

A summary of available information can be found in the stock annex.

15.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2016. All available information on ecological aspects can be found in the Stock Annex.

15.1.3 Fisheries

Plaice is mainly caught in two offshore fisheries, i.e. the beam trawl sole fishery and the mixed demersal fishery using otter trawls. There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. All available information on the fisheries can be found in the Stock Annex.

15.1.4 ICES advices for previous years

2015 advice: ICES advises that when the MSY approach is applied, catches of the Division VIId plaice stock in 2016 should be no more than 16 923 tons. If discard rates do not change from the average (2012–2014), this implies landings of the Division VIId plaice stock of no more than 10 855 tons. Assuming the same proportion of the Division VIIe and Subarea IV plaice stocks is taken in Division VIId as during 2003–2014, this will correspond to catches of plaice in Division VIId in 2016 of no more than 19 506 tons. If discard rates do not change from the average (2012–2014), this implies landings of plaice in Division VIId of no more than 12 512 tons.

2016 advice: ICES advises that when the MSY approach is applied, catches of the Division 7.d plaice stock in 2017 should be no more than 12 805 tonnes. If discard rates do not change from the average of the last three years (2013–2015), this implies landings of no more than 7550 tons. Assuming the same proportion of the Division 7.e and Subarea 4 plaice stocks is taken in Division 7.d as during 2003–2015, this will correspond to catches of plaice in Division 7.d in 2017 of no more than 14 864 tons. If discard rates do not change from the average of the last three years (2013–2015), this implies landings of no more than 8764 tons.

15.1.5 Management

There are no explicit management objectives for this stock.

The TACs have been set to for **the combined ICES Divisions 7d & 7e**.

The minimum landing size for plaice is 27 cm, which is not in accordance with the minimum mesh size of 80 mm, permitted for catching plaice by beam and otter trawling. Fixed nets are required to use 90 mm mesh as an absolute minimum.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

15.2 Data available

15.2.1 Catch

Landings data as reported to ICES are shown in Figure 15.2.1.1, Figure 15.2.1.2 as well as in Table 15.2.1.1 together with the total landings estimated by the Working Group. The 2016 landings of 4 638 tons are slightly higher than the catch level of the past 10 years (between 3 500 and 4 400 tons). For the first time, Belgium (48%) is the highest contributor to the total 7d landings in 2016, with France contributing for 33% and UK for 17%. The landings are significantly higher for the quarter 1 (and 3 to a lesser extent), mainly due to the seasonal activity of the Belgian beam trawl fleet (figure 15.2.1.2).

Routine discard monitoring began following the introduction of the EU data collection regulations. Based on the sampling intensity (WKPLE 2015), a discards time series starting in 2006 has been included in the assessment.

Following the ICES WKFLAT 2010 and WKPLE 2015 conclusions, 65% of the first quarter catches were removed. These 65% were estimated during ICES WKFLAT 2010, based on published tagging results and some previous studies (e.g. Burt et al. 2006, Hunter et al. 2004, Kell *et al*. 2004) showing that 50% of the fish caught during the first quarter are fish coming from area IV to spawn. The same study also shown that 15% of the fish caught during the first quarter were fishes from area 7e. Following the ICES WKPLE 2015 conclusions, only mature individuals are removed, both from landings and discards. Table 15.2.1.2 shows the Quarter 1 landings and discards and the corresponding removals. Removing this part of the catches allows for assessing the stock resident biomass**.** All the following figures will take into account this Quarter 1 removal.

15.2.2 InterCatch

UK, France, the Netherlands and Belgium have been providing landings data under the ICES InterCatch format since 2011, and InterCatch was used to produce the input data. Age distributions were provided by France, Belgium and England, accounting for 88% of the landings (Figure 15.2.2.1). Belgium has not always been able to provide landings data per quarter: for 2004, 2005, 2006, 2011, catch data were provided per semester or year. Since 2013 they are provided per year for the TBB fleet. But they now provide it at least for quarter 1 on a separate excel spreadsheet. Allocations to calculate age structures for the remaining landings were done per quarter, using the groups below.

Unsampled fleet*	Sampled fleet**
All nets	All nets
All OTB, TBB and Seines	All OTB, TBB and Seines
Others (MIS and LLS)	All métiers

* Unsampled fleet are those fleets for which no age structure is known.
** Sampled fleet are those fleets for which the age structure is known.

Discards data have also been provided under the ICES InterCatch format by France, Belgium, and the UK since WKPLE (ICES 2015). In 2015, 85% of landings had associated discards data imported to InterCatch. The discard volumes of the remaining strata have been raised using the grouping below (all quarters were pooled). As a result, the raised discards account for 18% of the total discards.

Unsampled fleet*	Sampled fleet**
TBB	TBB
GNS-GTR	GNS GTR
OTB	OTB
Seines (SDN and SSC)	Seines (SDN)
Others (MIS and LLS)	All métiers

* Unsampled fleet are those fleets for which no discards data have been provided.
** Sampled fleet are those fleets for which the discards volumes are known.

Age distributions were provided by France, Belgium and England, accounting for 81% of the total discards (imported + raised).

15.2.3 Age compositions

Age compositions of the landings and of the discards are presented in Table 15.2.3.3 and Figure 15.2.3.1, and Table 15.2.3.4 and Figure 15.2.3.2 respectively.

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2016 in Figure 15.2.3.3.

Figure 15.2.3.4 presents the discards at age ratios (i.e. discards numbers / landings numbers) per age over the sampled period 2006–2016. From 2012, the ratio is higher for the ages 1 to 4. The ratio for age 5 also increased to more than 20% in 2015–2016.

15.2.4 Weight-at-age

Weights at age in the landings, in the discards and in the stock are presented in Table 15.2.4.1, 15.2.4.2 and 15.2.4.3 respectively and in Figure 15.2.3.1. Stock weights are assumed to be the Q2 landings weights. These weights at age do not show specific trends, apart from a general decrease in landing weights in 2013-2016 for ages 5, 6 and 7.

15.2.5 Maturity and natural mortality

The maturity ogive used in the assessment is given in the table below.

Age	1	2	3	4	5	6	7
Proportion of mature	0	0.15	0.53	0.96	1	1	1

New age-specific natural mortality rates have been estimated from Peterson and Wroblewski's relationship during the 2015 WKPLE benchmark, as detailed in the Stock Annex.

Age	1	2	3	4	5	6	7
Natural mortality	0.3531	0.3132	0.292	0.2749	0.2594	0.2474	0.2329

15.2.6 Surveys

The survey series used in the assessment are the French Ground Fish Survey (FR GFS) and the UK beam trawl survey (UK BTS) (Figure 15.2.6.1 and Table 15.2.6.1). The International Young fish survey is also presented, although not used in the assessment. They are fully described in the stock annex.

Both time series were re-calculated in 2016 and the impact of those changes were assessed at the last WGNSSK (ICES 2016).

The consistencies between ages are good for the UK-BTS survey, and correct for ages 3 to 5 (Figure 15.2.6.2).

15.3 Assessment

The model used is the Aart and Poos model (AAP, Aarts and Poos, 2009, for more details please refer to the Stock Annex).

Year of assessment:		2017
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
UK Beam Trawl Survey	Age range	1–6
Year range		1988 onwards
FR Ground Fish Survey	Age range	1-6
Year range		1988 onwards
Catch/Landings		
Age range:		1–7+
Landings data:		1980–2016
Discards data		2006-2016
Model settings		
Fbar:		3–6
Age from which F is constant (qplat.Fmatrix)		6
Dimension of the F matrix (Fage.knots)		4
Ftime.knots		14
Wtime.knots		5
Age from which q is constant (qplat.surveys)		5

15.3.1 Results

The landings and discards estimated by the model are presented in Figure 15.3.1.1 and the residuals in Tables 15.3.1.1 and 15.3.1.2. Given the observed trend in the discard at age ratio (see section 15.2.3), the average discard at age ratio over 2006–2011 is used to estimate the discards prior to 2006; while the actual discard at age ratios are used in the assessment to estimate the discards for the last 5 years (2012 to 2016).

The survey residuals are shown in Figure 15.3.1.2 and Table 15.3.1.3 for the two surveys. There are opposite trends in the residuals of the UK BTS and French GFS (the two surveys covering the entire geographical area of the stock) appearing in the most recent years for ages 1 and 2.

The final outputs are given in Table 15.3.1.4 (fishing mortalities) and Table 15.3.1.5 (stock numbers). A summary of the assessment results is given in Table 15.3.1.6 and trends in fishing mortality, recruitment, spawning stock and total catches are shown in Figure 15.3.1.3. Retrospective patterns for the final run are shown in Figure 15.3.1.4.

The 1986 year class dominated the history of this stock until the late 2000s (Figure 15.3.1.5 and 15.3.1.3). A second peak occurred with the 1997 year class, although estimated to be at 75% of the 1986 year class. The ephemeral peak of SSB in 1999 has been followed by years of stability at a low level. From 2006 onwards, a series of high recruitments occurred, reaching a maximum in 2011, which caused to biomass to increase until 2014 then stabilize and decrease slightly in 2016 (Figure 15.3.1.3). The last recruitment (2015) is significantly lower than the series before.

15.4 Biological reference points

F_{MSY} was estimated in 2015 using the procedure advised during WKMSYREF3 2014 (WGNSSK, 2015). Three stock-recruitment relationships were assessed which led to the selection of the hockey-stick and the Beverton and Holt models. Then, F_{MSY} was determined using the eqsim method from the R library MSY.

In 2016, Flim and Fpa were calculated according to the recommendations from ACOM (ICES 2016).

15.5 Short-term forecasts

Weight-at-age in the stock and in the catch were taken to be the average estimated weights over the last 3 years. The exploitation pattern, as well as the discards/landings numbers ratio, were taken to be the mean value of the last three years. Population numbers at age 2 and older in 2014 are AAP survivors estimates.

15.5.1 Recruitment estimates

Considering the retrospective patterns observed, the recruitment is assumed to be poorly estimated.

For 2016 and the previsions (2017 and 2018), the recruitment was calculated as the geometric mean recruitment over the whole period 1980–2016 (red line in Figure 15.5.1.2), instead of over the period y–5 to y–2 (i.e. 2011–2014 this year, blue line) recommended in the stock annex. This decision was made during the group given the drop in the recruitment over the last two years.

15.5.2 Calculation of the 7D resident stock

This year, F for the intermediate year is set as equal to F in 2016 (status quo). The landings in 2015 and 2016 were significantly lower than the TAC (in 2015, prorata of it in 2016, see Figure 15.2.1.1), leading to the decision that the usual fully taken TAC assumption was inappropriate.

15.5.3 Management options tested

15.5.3.1 Calculation of STF

Potential TACs for 2017 were calculated using F_{MSY} and Fpa. Alternative options were also tested. Results are presented in Table 15.5.3.1.1 for the resident stock.

Following the MSY approach would lead to catches in 2018 for the resident stock of 10 952 tons, corresponding to estimated landings of 7 132 tons.

These options are then calculated for the total 7d stock (including the migratory components from 4 and 7e) using the long term average of the migratory landings over the total annual landings (Figure 15.5.3.1). Note that the proportion of the migratory landings has increased this year due to a higher proportion for the landings made in Q1.

Following the MSY approach would lead to catches in 2018 for the plaice in 7d of 12 378 tons, corresponding to estimated landings of 8 335 tons.

15.6 Quality of the assessment

The sampling for plaice in 7d are considered to be at a reasonable level.

The quality of the assessment is considered to have improved in 2015 following the change of assessment model and the inclusion of discards. Some concerns however were expressed during the group about the change of natural mortality rate values which leads to a significant change in the perception of this stock. The assessment was therefore externally reviewed, and the new mortality rates maintained. (The plaice 4 was benchmarked in 2017; a change in natural mortality values was explored but not adopted (ICES 2017).

A fishery on the spawners takes place during the first quarter of the year, yielding an age distribution different from the rest of the year. It is unknown whether there is major inter-annual variability in the immigration from the North Sea to these spawning grounds, which could distort any catch-based analysis. Any migration events taking place in the first quarter cannot be represented in the surveys in the second semester.

Both landings-at-age and tuning fleets information are highly dependent on the accuracy of the spatial declaration of the fishing activity as an important component of the fisheries operates on the borderline to ICES subdivision IVc.

15.7 Status of the stock

Results of the assessment indicate that F is at low values, while SSB has increased in recent years, and is now slightly declining (but still at historically high levels).

15.8 Management considerations

The stock identity of plaice in the Channel is unclear and may raise some issues.

The TAC is combined for Divisions 7d and 7e. Plaice in 7e is considered at risk of being harvested unsustainably (F above Fmsy).

The plaice stock in 7d is mostly harvested in a mixed fishery with sole in 7d.

Due to the minimum mesh size (80 mm) in the mixed beam and otter trawl fisheries, a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

Table 15.2.1.1. Plaice in 7d: Nominal landings (tons) as officially reported to ICES, 1976–2014.

Year	BEL	FRA	UK(E+W)	Others	Tot Off. Land.	Unalloc.	Tot. Land. 7d (1)	Estim.discards 7d (2)	Tot. land. rep. in 7e (1)	Agreed TAC (3)
1976	147	1439	376		1962	1	1963		640	
1977	149	1714	302		2165	81	2246		702	
1978	161	1810	349		2320	156	2476		784	
1979	217	2094	278		2589	28	2617		977	
1980	435	2905	304		3644	-994	2650		1215	
1981	815	3431	489		4735	34	4769		1746	
1982	738	3504	541	22	4805	60	4865		1938	
1983	1013	3119	548		4680	363	5043		1754	
1984	947	2844	640		4431	730	5161		1813	
1985	1148	3943	866		5957	65	6022		1751	
1986	1158	3288	828		5274	1560	6834		2161	
1987	1807	4768	1292		7867	499	8366		2388	8300
1988	2165	5688	1250		9103	1317	10420		2994	9960
1989	2019	3713	1383		7115	1643	8758		2808	11700
1990	2149	4739	1479		8367	680	9047		3058	10700
1991	2265	4082	1566		7913	-100	7813		2250	10700
1992	1560	3099	1572	1	6232	105	6337		1950	9600
1993	877	2792	1102		4771	560	5331		1691	8500
1994	1418	3199	1007	9	5633	488	6121		1471	9100
1995	1157	2598	814		4569	561	5130		1295	8000
1996	1112	2630	856		4598	795	5393		1321	7530
1997	1161	3077	1078		5316	991	6307		1654	7090
1998	854	3276	700		4830	932	5762		1430	5700
1999	1306	3388	743		5437	889	6326		1616	7400
2000	1298	3183	754		5235	779	6014		1678	6500
2001	1346	2962	660		4968	298	5266		1379	6000
2002	1204	3450	841	1	5496	281	5777		1608	6700
2003	998	2893	756	3	4650	-564	4086		1478	5970
2004	954	2766	582	10	4312	438	4750		1402	6060
2005	832	2432	421	21	3706	285	3991		1370	5150
2006	1024	1935	550	16	3525	121	3646	749	1466	5151
2007	1355	2017	463	10	3845	156	4001	1252	1184	5050
2008	1386	1740	471	12	3609	255	3864	936	1144	5050
2009	1002	1892	612	16	3522	38	3560	1528	1043	4646
2010	1123	2190	517	62	3892	519	4411	2511	2240	4274
2011	1067	1994	472	60	3593	56	3649	2025	1192	4665
2012	1045	1962	542	63	3612	111	3723	3336	1339	5062
2013	1295	2159	641	87	4182	-55	4127	2955	1526	6400
2014	1389	2229	633	76	4327	-7	4320	3886	1339	5322
2015	1605	1664	390	53	3712	15	3727	2821	1408	6223
2016	2244	1557	795	60	4656	-18	4638	3603		12446

[1]As provided to ICES through InterCatch

[2]Raised with InterCatch from BE, UK and FR estimated discards data.

[3]TAC´s for Divisions 7 d,e. Since 2016, a catch advice is given rather than a landing advice.

Table 15.2.1.2. Plaice in 7d: Nominal landings, estimated discards, and quarter 1 removals.

Year	Total Landings	Q1 Remov.	Landings as used by WG (1)	Estim. discards	Discards Q1 remov.	Discards as used by WG (1)
1980	2650	427	2223			
1981	4769	760	4009			
1982	4865	825	4040			
1983	5043	950	4093			
1984	5161	912	4249			
1985	6022	1022	5000			
1986	6834	1161	5673			
1987	8366	1360	7006			
1988	10420	1635	8785			
1989	8758	1665	7093			
1990	9047	1698	7349			
1991	7813	1451	6362			
1992	6337	1118	5220			
1993	5331	852	4479			
1994	6121	1074	5047			
1995	5130	934	4196			
1996	5393	963	4430			
1997	6307	1127	5180			
1998	5762	931	4832			
1999	6326	1058	5268			
2000	6015	1494	4522			
2001	5266	886	4380			
2002	5777	931	4846			
2003	4086	476	3610			
2004	4750	544	4206			
2005	3991	506	3485			
2006	3646	421	3225	749	21	727
2007	4001	620	3381	1252	32	1220
2008	3864	586	3278	936	48	888
2009	3560	436	3124	1528	56	1473
2010	4411	501	3910	2511	99	2412
2011	3649	358	3291	2025	99	1926
2012	3723	544	3179	3336	293	3043
2013	4127	523	3604	2955	260	2696
2014	4320	645	3675	3886	561	3325
2015	3727	771	2956	2821	453	2368
2016	4638	1020	3618	3603	514	3090

[1]Takes into account the removal of 65% of the Quarter 1 landings or discards.

Table 15.2.3.1. Plaice in 7d: Landings in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

age							
year	1	2	3	4	5	6	7
1980	53	2598	1253	370	324	50	133
1981	16	2403	5866	1643	192	106	238
1982	265	1369	5964	2262	505	138	179
1983	92	2977	2761	4048	617	151	214
1984	350	1838	6310	1928	1242	356	312
1985	142	5614	5347	3346	274	409	300
1986	679	4799	6072	2510	965	375	247
1987	25	8350	6481	2379	833	287	512
1988	16	4923	16239	3357	741	362	561
1989	826	3574	6238	6477	1770	392	497
1990	1632	2581	7550	4099	2386	535	572
1991	1542	5758	4700	3099	1614	1123	429
1992	1665	6085	3841	1183	786	697	745
1993	740	7473	3295	863	359	313	581
1994	1242	3570	6015	2131	563	280	781
1995	2592	4264	2532	2006	611	152	591
1996	1119	4762	3113	1060	951	326	585
1997	550	4168	6184	2382	724	506	722
1998	464	4323	7467	2335	360	94	289
1999	741	1737	10493	4583	696	121	223
2000	1383	6177	3432	3992	752	150	142
2001	2682	4070	3589	1385	1253	203	145
2002	902	6876	4553	1390	1144	603	288
2003	0	3597	2103	1380	350	356	758
2004	922	2718	4573	760	400	219	527
2005	86	2602	2153	1975	449	245	508
2006	191	2801	3081	1626	987	166	379
2007	529	2986	2379	1237	534	395	274
2008	293	3844	2512	1125	584	218	258
2009	491	2975	3112	848	402	242	240
2010	530	4238	3367	1465	392	278	287
2011	93	4436	3557	964	316	59	119
2012	18	1266	3780	1845	524	195	171
2013	9	756	3666	3294	1158	247	156
2014	76	759	2015	3731	1848	468	202
2015	3	600	1523	1483	1933	940	642
2016	12	233	2115	2220	1431	1719	1028

Table 15.2.3.2. Plaice in 7d. Discards in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

year	1	2	3	4	5	6	7
2006	553	2541	1826	70	10	1	0
2007	1227	5531	1776	278	0	2	0
2008	2368	2893	631	163	38	8	1
2009	2032	5679	1988	114	17	26	3
2010	2023	11797	3243	336	28	3	2
2011	2480	8872	1559	155	14	19	1
2012	1423	10296	7943	1235	52	0	0
2013	2040	5395	9367	1818	89	9	1
2014	4380	6222	8481	3445	493	79	10
2015	4420	8316	4958	1478	761	276	40
2016	1767	6524	7917	1801	589	227	27

Table 15.2.4.1. Plaice in 7d: Weights in the landings.

	1	2	3	4	5	6	7
1980	0.31439	0.31744	0.5077	0.63794	0.80073	1.15887	1.43872
1981	0.23054	0.28842	0.3598	0.44758	0.6868	0.83921	1.03182
1982	0.23742	0.26262	0.34208	0.41767	0.62021	0.77041	1.19328
1983	0.25367	0.28227	0.33282	0.40052	0.51687	0.78388	1.17753
1984	0.21111	0.26728	0.30443	0.36423	0.46027	0.62427	0.85249
1985	0.24125	0.26404	0.28589	0.40556	0.4768	0.54138	0.82009
1986	0.23065	0.31229	0.3378	0.41435	0.55723	0.49599	0.82261
1987	0.2501	0.28099	0.35871	0.47529	0.57493	0.78019	0.96679
1988	0.27934	0.25638	0.30709	0.41327	0.53573	0.62852	0.92558
1989	0.19932	0.26575	0.31831	0.3669	0.46904	0.64257	1.07336
1990	0.20864	0.26573	0.3384	0.39237	0.50137	0.63319	1.09115
1991	0.22348	0.27513	0.3089	0.38737	0.45094	0.55225	1.0089
1992	0.18102	0.2755	0.3501	0.42668	0.50625	0.58184	0.79086
1993	0.21684	0.26809	0.33117	0.42579	0.49971	0.5825	0.85251
1994	0.24814	0.27571	0.29409	0.36353	0.47585	0.58818	0.99575
1995	0.21495	0.26721	0.30862	0.38454	0.47821	0.67837	0.93169
1996	0.22815	0.3097	0.29938	0.40881	0.49037	0.6638	1.11494
1997	0.20063	0.25406	0.30044	0.33471	0.44561	0.58172	1.02408
1998	0.16748	0.25701	0.28124	0.40132	0.52877	0.80263	1.17482
1999	0.20366	0.25328	0.24295	0.31635	0.47659	0.77639	1.13307
2000	0.21654	0.25629	0.27303	0.29604	0.39228	0.60254	0.95256
2001	0.23283	0.27289	0.32812	0.40068	0.48406	0.69523	1.13258
2002	0.2461	0.24804	0.29939	0.36431	0.42438	0.54452	0.81943
2003	NA	0.28622	0.3761	0.48531	0.64257	0.65378	0.87182
2004	0.24467	0.29736	0.39867	0.49765	0.68809	0.78562	0.99318
2005	0.29038	0.31848	0.35137	0.45228	0.56756	0.66576	1.10896
2006	0.26078	0.27936	0.30636	0.36449	0.44742	0.55673	0.85001
2007	0.18198	0.31841	0.39818	0.47736	0.54608	0.61288	0.95916
2008	0.23962	0.29281	0.35094	0.43377	0.5493	0.64711	0.97517
2009	0.24041	0.29083	0.34983	0.49837	0.52618	0.65998	1.07319
2010	0.23179	0.30462	0.35903	0.45088	0.51169	0.65817	0.84652
2011	0.1591	0.26359	0.3541	0.48737	0.63683	0.82035	1.07628
2012	0.20444	0.29674	0.35771	0.45189	0.55855	0.71549	1.06209
2013	0.1454	0.26339	0.32057	0.39501	0.4977	0.73778	1.07662
2014	0.17632	0.26041	0.29535	0.37295	0.51386	0.70388	0.98627
2015	0.12573	0.22679	0.3035	0.34607	0.41311	0.53777	0.8417
2016	0.20264	0.31723	0.31916	0.35554	0.41488	0.46016	0.67328

Table 15.2.4.2. Plaice in 7d. Weights in the discards.

year	1	2	3	4	5	6	7
2006	0.100	0.138	0.166	0.206	0.259	0.566	NA
2007	0.103	0.139	0.157	0.163	0.284	0.214	NA
2008	0.118	0.153	0.188	0.222	0.219	0.383	NA
2009	0.125	0.138	0.169	0.450	0.731	1.302	0.268
2010	0.104	0.135	0.167	0.180	0.237	0.381	0.369
2011	0.096	0.155	0.174	0.216	0.215	0.228	1.352
2012	0.093	0.130	0.166	0.193	0.213	0.607	NA
2013	0.083	0.128	0.155	0.188	0.249	0.464	0.421
2014	0.090	0.123	0.137	0.232	0.247	0.302	0.385
2015	0.039	0.106	0.156	0.174	0.220	0.274	0.622
2016	0.171	0.165	0.155	0.175	0.181	0.203	0.403

Table 15.2.4.3. Plaice in 7d: Weights in the stock.

year	1	2	3	4	5	6	7
1980	0.171	0.332	0.482	0.622	0.751	0.870	1.197
1981	0.110	0.216	0.317	0.414	0.506	0.594	0.924
1982	0.105	0.208	0.308	0.406	0.502	0.596	0.869
1983	0.097	0.192	0.286	0.379	0.470	0.560	0.854
1984	0.082	0.164	0.248	0.333	0.420	0.507	0.738
1985	0.084	0.171	0.259	0.348	0.440	0.533	0.778
1986	0.101	0.205	0.311	0.420	0.532	0.646	0.850
1987	0.122	0.242	0.361	0.479	0.596	0.712	0.929
1988	0.084	0.168	0.254	0.340	0.427	0.514	0.715
1989	0.079	0.162	0.250	0.342	0.439	0.541	0.855
1990	0.085	0.230	0.322	0.346	0.465	0.549	1.118
1991	0.143	0.219	0.275	0.335	0.375	0.472	0.958
1992	0.088	0.241	0.336	0.421	0.477	0.521	0.725
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.727
1994	0.165	0.198	0.276	0.331	0.383	0.493	0.866
1995	0.124	0.257	0.286	0.354	0.442	0.707	0.855
1996	0.178	0.229	0.263	0.347	0.354	0.474	0.934
1997	0.059	0.202	0.256	0.266	0.417	0.530	0.902
1998	0.072	0.203	0.273	0.361	0.530	0.670	0.873
1999	0.072	0.172	0.213	0.351	0.429	0.644	0.904
2000	0.068	0.184	0.204	0.246	0.355	0.554	0.928
2001	0.093	0.206	0.274	0.338	0.404	0.624	1.104
2002	0.102	0.206	0.281	0.379	0.467	0.558	0.809
2003	NA	0.306	0.403	0.528	0.673	0.592	0.961
2004	0.280	0.366	0.508	0.571	0.701	0.788	0.861
2005	0.174	0.299	0.377	0.489	0.672	0.683	1.010
2006	0.220	0.270	0.343	0.419	0.506	0.637	0.938
2007	0.063	0.247	0.391	0.543	0.579	0.656	0.825
2008	0.121	0.245	0.301	0.368	0.448	0.462	1.005
2009	NA	0.268	0.358	0.487	0.476	0.719	1.036
2010	NA	0.280	0.354	0.415	0.455	0.561	0.719
2011	0.189	0.238	0.402	0.535	0.737	0.791	0.908
2012	NA	0.253	0.298	0.424	0.517	0.629	0.938
2013	0.174	0.252	0.277	0.479	0.454	0.886	0.995
2014	0.157	0.256	0.243	0.381	0.518	0.756	1.042
2015	0.154	0.253	0.256	0.287	0.363	0.436	0.782
2016	0.25754	0.29437	0.32643	0.36815	0.48066	0.51592	0.71946

Table 15.2.6.1. Plaice in 7d: Tuning fleets.

UK BTS						
1989 2016						
1 1 0.5 0.75						
1 6						
1	3.8	15.8	28.9	31.7	4.0	1.7
1	9.2	9.4	11.1	11.7	12.6	1.5
1	16.8	14.5	11.5	8.7	8.6	4.6
1	22.4	21.3	6.6	6.6	7.2	5.4
1	4.6	20.2	8.0	2.8	2.9	2.4
1	9.4	8.5	10.1	6.0	2.0	0.6
1	14.5	6.2	3.8	5.7	2.2	0.8
1	22.1	17.3	1.7	1.0	2.0	1.3
1	48.2	28.6	11.0	1.3	1.6	0.5
1	30.6	37.9	12.1	5.0	0.6	0.6
1	12.8	10.7	28.8	4.6	1.6	0.3
1	19.5	30.2	18.8	20.5	5.0	1.3
1	27.9	20.3	14.1	9.8	14.8	2.7
1	37.9	25.9	12.5	5.5	2.6	5.3
1	10.6	39.7	9.8	4.4	2.3	1.1
1	52.9	22.5	20.7	4.8	1.2	0.3
1	15.6	36.2	12.8	10.0	3.2	1.1
1	30.1	28.9	16.8	5.9	4.3	1.3
1	53.1	28.9	12.2	6.2	3.2	2.9
1	39.6	40.6	10.5	4.3	3.8	1.8
1	77.7	39.5	20.9	5.9	3.2	2.3
1	64.2	64.7	17.7	9.2	3.1	1.7
1	115.1	112.2	39.6	10.3	7.0	2.9
1	24.7	81.1	56.0	18.7	4.2	3.3
1	32.3	61.0	88.2	45.0	10.2	3.4
1	145.3	156.5	50.7	62.1	26.8	9.0
1	38	178.7	63.2	30.2	33.4	15.7
1	12.5	101.4	102.9	37.9	21.3	23.2

Table 15.2.6.1. (cont.) Plaice in 7d: Tuning fleets.

FR GFS						
1993 2016						
1 1 0.75 1						
1 6						
1	232.04	867.4	345	125.8	32	8.66
1	468.69	347.5	148	67.6	26.2	11.65
1	30.31	336.5	364	142.1	101.1	27.19
1	772.65	243.8	181	26.6	12.9	15.07
1	537.67	800.7	267	245.8	20.8	8.55
1	551.31	415.3	406	93.7	29.3	0
1	66.49	529.1	254	392	76.1	12.41
1	2347.63	653.6	655	201.1	192.6	50.45
1	62.33	290.8	187	81.6	75.1	35.37
1	36.13	584.9	303	189.7	69.8	51.4
1	698.12	304	460	81.8	16.8	17.21
1	67.8	388.3	281	137	40	4.34
1	105.13	405.9	746	360	114.2	32.07
1	2163.19	684.3	447	152	61.4	32.69
1	46.64	446	395	237.2	105.1	33.52
1	120.29	235	642	140.1	46.8	12.23
1	48.65	293.8	223	94.6	27.8	6.82
1	36.36	745.5	467	109.5	29	7.46
1	729.93	1973.9	2370	734.3	116.8	12.96
1	224.96	557.3	1504	1282	257.9	97.02
1	304.35	716.4	567	1148.2	288.4	88.07
1	75.67	556.2	470	542.7	708.6	172.21
1	4.18	96.8	683	556.5	152.8	173.23
1	10.39	44.9	243.12	367.0	136.91	93.37

Table 15.3.1.1. Plaice in 7d: Landings Residuals.

age	1	2	3	4	5	6	7
1980	-0.73174448	0.77095736	-0.45298337	-0.29517203	0.22581044	-0.03238793	-0.11377518
1981	-1.40717628	0.19264566	0.3971328	0.3392755	-0.11462881	-0.18445404	0.29464787
1982	0.53146958	0.20139556	-0.09073021	-0.06687583	0.0595111	0.35433945	-0.29967969
1983	-0.53384887	0.18228663	-0.28552861	0.09063953	-0.30889588	-0.21334371	-0.05539978
1984	0.72418811	-0.37640761	-0.19676433	0.14493336	0.14202114	0.14169129	0.27364366
1985	-0.38823121	0.61758256	-0.28431583	0.23696337	-0.51881112	-0.06248711	0.00012297
1986	0.59063837	0.3042004	-0.10294513	0.17114974	0.16905509	0.53043037	-0.54603373
1987	-2.09734758	0.39238218	-0.15563107	0.03814348	0.07413861	-0.38597549	0.2443848
1988	-2.26216743	0.47674792	0.158413	-0.03697333	-0.19868404	-0.02422972	0.09466567
1989	1.45111216	0.371411	-0.3297872	-0.17866378	0.29604463	0.01968661	-0.03146522
1990	1.24932126	0.04933059	0.21602194	-0.08313739	-0.1312972	-0.02484227	0.17924353
1991	-0.10927572	0.51400466	0.21037591	0.26702482	0.06807561	-0.06000617	-0.14399006
1992	-0.70830779	0.02673374	0.23935353	0.00911773	-0.02999359	0.04979518	-0.01341286
1993	-0.87884809	0.13986183	-0.16044349	-0.08208286	-0.17603737	-0.12048233	-0.16217552
1994	0.0940013	0.24787319	0.28433789	0.36503338	0.3622544	0.32902337	0.19940555
1995	0.84803216	0.67540345	-0.03205231	-0.0895706	-0.14242048	-0.32697036	-0.13712754
1996	0.36513666	0.3315956	0.12350881	-0.23358798	-0.02577052	-0.08677322	-0.1671851
1997	-0.76749171	0.12835569	0.19433791	0.61514179	0.44750801	0.34954418	0.21231805
1998	-0.47061231	-0.35984191	0.31643282	0.02235834	0.00102951	-0.22254285	-0.26485196
1999	-0.19808944	-0.57399253	0.18500804	0.52611229	0.08965879	0.38554672	0.15237067
2000	0.05040382	0.74302166	-0.24405579	-0.18901149	-0.0989604	-0.10092268	0.11176354
2001	0.89648262	0.0013475	-0.11181875	-0.44547622	-0.20283506	-0.29594234	-0.13856736
2002	-0.12269773	0.57845609	-0.0403103	-0.01003502	0.54724102	-0.05055485	0.01052478
2003	-5.44268174	-0.20642215	-0.6527837	0.13338765	-0.1928415	0.07363345	0.19947444
2004	2.04861645	0.59389128	-0.25738003	-0.353013	0.00062459	-0.09208345	-0.16295401
2005	0.21155152	0.6125488	-0.38112676	-0.06399977	0.10713445	0.05657778	0.00448956
2006	0.75466114	0.63915742	-0.32662026	0.16307477	0.19048085	-0.27936169	-0.0038005
2007	0.93924397	0.43727629	-0.57462107	-0.32968095	0.07745146	-0.03302822	-0.04922014
2008	-0.11050032	0.2678634	-0.4453895	-0.15457657	0.08188709	-0.0512341	-0.24632633
2009	0.31607632	-0.05877277	-0.37471052	-0.15334534	0.07828101	0.01472419	-0.12383301
2010	0.41828933	0.19285659	-0.39367125	0.24033538	0.33936718	0.5473832	0.10713292
2011	-1.33557445	0.05968498	-0.60924598	-0.4533375	-0.10739842	-0.6859607	-0.62395909
2012	-0.01122366	-0.06963372	-0.08602732	0.06949045	0.06724304	0.29222407	-0.14518828
2013	-0.06348078	0.05881403	-0.13107191	0.00299418	0.18267948	0.16871541	-0.33451654
2014	-0.0230006	0.06680055	0.43210412	-0.01532841	0.11914355	0.20046078	-0.41000087
2015	-0.07999128	-0.14364698	-0.06811544	-0.22025695	-0.20928668	0.17101658	0.10291407
2016	-0.02567466	-0.02916411	0.09958648	0.06067518	0.08042025	0.00973231	-0.25707207

Table 15.3.1.2. (cont.) Plaice in 7d: Discards Residuals.

	1	2	3	4	5	6	7
2006	-0.0270268	0.0398359	-0.0107224	-0.7924884	-0.7861539	0.056044	0.3885365
2007	-0.062843	0.5515115	-0.0274396	0.3605355	-2.6780295	0.0369085	0.5370106
2008	0.134765	-0.5180771	-0.9864925	0.1003504	0.8874149	1.6626365	0.9959888
2009	-0.109052	0.0856408	0.0163034	0.0290949	0.514191	2.6976418	1.9647492
2010	-0.0860319	0.7145736	0.407869	0.9508703	1.2452792	1.2234106	1.8820767
2011	0.0910233	0.2507973	-0.5948779	-0.0930743	0.3752241	3.0587406	1.4276368
2012	0.009369	-0.0692385	-0.0858014	0.0704993	0.0868525	1.4237303	3.8703659
2013	-0.0274043	0.0595015	-0.1308652	0.0036618	0.1941954	0.270653	0.4363843
2014	-0.0178527	0.067461	0.4324121	-0.0149385	0.1213691	0.2138649	-0.3089841
2015	0.0164007	-0.142897	-0.0676623	-0.2193232	-0.2077806	0.1750361	0.1280974
2016	0.00397	-0.0273931	0.0998896	0.0614026	0.0823837	0.014342	-0.2200957

Table 15.3.1.3. Plaice in 7d: Survey residuals.

UK BTS						
age	1	2	3	4	5	6
1989	-1.42883076	-0.6498788	-0.02967794	0.38974658	-0.08063721	0.12863284
1990	-0.54046808	-0.65371798	-0.47548813	-0.15299103	0.18118061	-0.34015414
1991	-0.39950591	-0.06739111	0.1568706	0.04798	0.20315214	-0.18943087
1992	-0.2979515	-0.02430955	-0.16572882	0.39132632	0.4776093	0.31373919
1993	-1.15011886	-0.22876862	-0.30124837	-0.23014974	0.17812796	-0.05696014
1994	-0.31079753	-0.41644058	-0.23784342	0.19631317	0.06488385	-0.69257944
1995	-0.4260522	-0.67206247	-0.52042172	0.06120323	-0.05649307	-0.22242842
1996	-0.16577143	-0.30034332	-1.20885565	-0.76724522	-0.1149476	0.12126672
1997	0.03286673	-0.01143582	-0.10048396	-0.47865889	0.54493088	-0.56073762
1998	0.3107813	-0.32429723	-0.31090743	0.07360602	-0.18046999	0.43505194
1999	-0.34997946	-0.83447683	-0.09951591	-0.42490282	-0.21698926	-0.06413576
2000	-0.07713534	0.46383214	0.2528605	0.32701896	0.34522972	0.14593726
2001	0.35906036	-0.00043109	0.3525187	0.3884442	0.65896802	0.31967367
2002	0.25063711	0.32402328	0.28146272	0.24799049	-0.25920291	0.18725623
2003	-0.3734504	0.22017618	0.0826275	0.12297987	0.04644722	-0.47253922
2004	1.02299363	0.18249347	0.13813502	0.18268657	-0.5165132	-1.20621801
2005	-0.07995551	0.41328797	0.0826632	0.15238887	0.4124771	0.0015978
2006	0.62483183	0.31323926	0.10442048	0.01776748	-0.09347372	0.14357256
2007	0.91101328	0.4167193	-0.03156615	-0.18237699	-0.01832205	0.07006228
2008	0.37477598	0.50672965	-0.02327896	-0.34304373	-0.09755859	-0.0500926
2009	0.61042617	0.20877264	0.38894945	0.10994676	-0.08810344	-0.12798099
2010	-0.08268987	0.21179934	-0.13180284	0.23228135	0.00223664	-0.23350934
2011	0.17875929	0.22382687	0.08791636	-0.06531909	0.45509921	0.35109794
2012	-0.66696551	-0.43704006	-0.1662291	-0.10044835	-0.4593505	0.14869455
2013	-0.4393998	-0.03502562	-0.08449337	0.14418291	-0.22316014	-0.2441166
2014	0.7992218	0.87344935	0.03476507	0.07401328	0.09570176	0.07246874
2015	0.09364928	0.7610734	0.22489231	0.01741074	-0.07014841	0.00569083
2016	0.52519227	0.86045757	0.47820759	0.21377862	0.15142032	0.02377928

Table 15.3.1.3. (cont.) Plaice in 7d: Survey Residuals.

FR GFS						
age	1	2	3	4	5	6
1993	1.3951058	0.0883962	0.098771	0.0181316	-0.5746499	-0.502904
1994	0.6004945	-0.1080145	-0.6737228	-0.4612943	-0.083832	0.825392
1995	-0.0099225	0.8170977	0.7387728	0.7706371	0.4645877	2.0357989
1996	-0.5058875	-0.5268371	-0.7941323	-0.329206	0.006207	0.9360744
1997	0.0958396	-0.3621182	0.6698039	0.2152237	0.4283408	1.8067193
1998	0.178832	-0.546247	-0.6147712	-0.2559196	-1.1047121	1.3013343
1999	0.6368908	-0.259352	0.1270894	0.2012467	-0.0960769	1.6178295
2000	0.7127071	0.9660678	0.2523094	0.38321	0.6540553	0.9989874
2001	-0.0163131	-0.3208103	-0.2171009	0.2465962	-0.4514043	-0.280808
2002	0.2483804	0.2389616	0.6921922	0.6119445	0.6790448	-0.1027338
2003	0.2190584	0.0881922	-0.1103961	-0.6489916	0.0986565	0.2770642
2004	0.2544229	0.0919019	-0.3304822	0.1301967	-0.9186418	1.1334986
2005	0.4082603	0.8088021	1.0260555	0.37414	0.7113039	1.0312571
2006	0.9840805	0.43199	-0.0698267	0.1489731	-0.0614426	0.6783021
2007	0.2799145	0.4291588	0.5719466	0.4273376	0.3174691	-0.6388031
2008	-0.5977106	0.6737375	0.214588	-0.1618681	-0.8605472	0.2369919
2009	-0.8165874	-0.6604783	-0.4552257	-0.5143033	-1.1611533	-0.2385531
2010	-0.3959819	-0.4344808	-0.6954826	-0.7972774	-0.9739599	0.0238252
2011	0.2542841	0.6368018	0.5874566	0.12374	-0.8577275	1.633469
2012	-0.3177484	-0.16006	0.5249455	0.2763334	0.5985394	0.3307933
2013	-0.1049099	-0.4487476	0.0322539	-0.2481547	-0.124966	-0.5153274
2014	-0.6172391	-0.6653175	-0.0472574	0.2540228	-0.0978227	-0.6582404
2015	-1.7077954	-0.532853	-0.0528113	-0.6056988	-0.4775773	-0.6658375
2016	-0.9010462	-0.8857571	-0.6991713	-0.745333	-0.4126944	-1.0408958

Table 15.3.1.4. Plaice in 7d: Fishing mortality (F) at age.

	1	2	3	4	5	6	7
1980	0.014537	0.132643	0.401721	0.313612	0.172136	0.099653	0.099653
1981	0.017479	0.142702	0.437792	0.39287	0.236727	0.139625	0.139625
1982	0.020529	0.158	0.485334	0.466132	0.299065	0.183649	0.183649
1983	0.023007	0.185227	0.556643	0.496265	0.319003	0.212944	0.212944
1984	0.024143	0.225306	0.649757	0.470048	0.285235	0.21493	0.21493
1985	0.023502	0.252225	0.709297	0.431025	0.248581	0.206656	0.206656
1986	0.021129	0.229226	0.662619	0.41995	0.248955	0.209217	0.209217
1987	0.019434	0.17942	0.544305	0.440358	0.290771	0.22892	0.22892
1988	0.022798	0.157364	0.459189	0.460683	0.340518	0.256055	0.256055
1989	0.041431	0.197036	0.459774	0.446919	0.34553	0.276157	0.276157
1990	0.100791	0.321051	0.526066	0.403682	0.303606	0.27507	0.27507
1991	0.231052	0.50724	0.593286	0.357082	0.251967	0.244628	0.244628
1992	0.368965	0.610127	0.588684	0.325828	0.215458	0.193588	0.193588
1993	0.393979	0.579251	0.54945	0.32441	0.205928	0.158297	0.158297
1994	0.293185	0.491092	0.545763	0.373238	0.238178	0.16291	0.16291
1995	0.169997	0.409702	0.608612	0.494385	0.334306	0.226123	0.226123
1996	0.102634	0.346576	0.672851	0.643228	0.46994	0.327556	0.327556
1997	0.088141	0.303208	0.63555	0.686843	0.531566	0.366024	0.366024
1998	0.114265	0.283453	0.513539	0.58229	0.455642	0.291429	0.291429
1999	0.168635	0.297707	0.435344	0.462253	0.345522	0.206431	0.206431
2000	0.210657	0.365545	0.472792	0.40654	0.272738	0.163997	0.163997
2001	0.190817	0.463827	0.616497	0.40167	0.237463	0.156054	0.156054
2002	0.119226	0.476516	0.743925	0.403401	0.223656	0.168034	0.168034
2003	0.051659	0.330388	0.671524	0.37797	0.222543	0.192558	0.192558
2004	0.021862	0.194803	0.511613	0.337863	0.22495	0.218647	0.218647
2005	0.014533	0.144795	0.423176	0.307442	0.220775	0.228132	0.228132
2006	0.019552	0.171323	0.445658	0.29619	0.203644	0.208211	0.208211
2007	0.033868	0.244385	0.52177	0.289514	0.177948	0.171984	0.171984
2008	0.041983	0.288425	0.560026	0.270859	0.149686	0.135221	0.135221
2009	0.029736	0.237956	0.499675	0.237534	0.124211	0.10534	0.10534
2010	0.017531	0.163756	0.393451	0.203486	0.105661	0.083206	0.083206
2011	0.013073	0.115295	0.294437	0.178242	0.095727	0.068108	0.068108
2012	0.014198	0.092415	0.222976	0.162564	0.093141	0.059504	0.059504
2013	0.020119	0.085929	0.180099	0.153325	0.095528	0.057552	0.057552
2014	0.033207	0.093599	0.162241	0.148387	0.101339	0.063495	0.063495
2015	0.059753	0.115059	0.160354	0.146127	0.109743	0.077879	0.077879
2016	0.112257	0.150265	0.166026	0.145157	0.120074	0.100727	0.100727

Table 15.3.1.5. Plaice in 7d: Stock number from the assessment.

	1	2	3	4	5	6	7
1980	67505.6	30343.2	10013.4	2425.28	1995.29	666.27	1876.53
1981	34777.2	46738.7	18668.4	4707.26	1245.13	1180.05	1616.9
1982	66766.2	24007.9	28467.7	8464.99	2232.53	690.33	1708.82
1983	60511.9	45950.6	14400.8	12309.1	3731.11	1162.96	1402.65
1984	61886.1	41543.2	26822.5	5798.15	5264.43	1905.23	1456.67
1985	78758	42438.4	23297.1	9839.29	2545.66	2780.52	1904.99
1986	156349	54042.8	23167	8052.07	4491.82	1394.74	2677.06
1987	95478	107540	30188.2	8389.73	3716.86	2460.11	2320.47
1988	62850.5	65783	63139.2	12305.5	3794.49	1952.3	2671.23
1989	41406.8	43157.7	39484.1	28023.7	5453.53	1896.35	2514.33
1990	42274.4	27908	24896.4	17514.4	12591.6	2711.85	2350.84
1991	71953.5	26850.7	14221.6	10335.2	8217.31	6529.48	2701.29
1992	94178.6	40119.7	11358.3	5520	5080.33	4486.96	5077.47
1993	47037.6	45747.1	15312.1	4428.97	2799.52	2877.2	5536.5
1994	38331.8	22284	18007.3	6209.57	2249.38	1600.67	5045.34
1995	61370.9	20085.4	9579.98	7329.55	3003.43	1245.3	3966.99
1996	68993.2	36373.5	9367.01	3661.83	3140.65	1510.36	2920.62
1997	121852	43740.5	18068.4	3357.66	1352.07	1379.04	2243.34
1998	59664.2	78380	22691	6722.86	1186.85	558.2	1764.75
1999	50362.9	37388.7	41471.9	9538.42	2638.27	528.64	1219.34
2000	59785.8	29889.9	19502.9	18851.1	4220.59	1311.93	998.93
2001	54410.6	34022.1	14568.7	8539.21	8819.2	2257.23	1377.85
2002	78593.8	31583.7	15030.5	5524.97	4014.44	4885.97	2184.7
2003	39789.1	49007.2	13777.3	5018.14	2592.9	2254.98	4198.89
2004	47720.2	26544.8	24741.4	4945.12	2415.7	1458.1	3739.77
2005	42482.4	32798.8	15347.2	10420.4	2477.97	1355.19	2934.39
2006	40363.5	29413.6	19935.4	7061.49	5382.88	1395.93	2398.77
2007	53951.6	27806.6	17409.8	8968.69	3689.04	3084.78	2164.73
2008	69153.4	36639.3	15299	7258.43	4716.78	2169.11	3105.11
2009	106298	46583.4	19290.2	6139.01	3889.21	2852.91	3236.56
2010	174432	72486.9	25795.2	8222.06	3400.86	2413.06	3850.18
2011	239677	120410	43230.7	12226.9	4712.57	2149.57	4048.69
2012	120358	166188	75377.5	22624	7187.15	3008.4	4067.63
2013	125592	83360.4	106443	42369.7	13508.9	4599.99	4683.79
2014	164784	86472.1	53739.3	62452.6	25533.9	8625.49	6157.17
2015	88918.2	111981	55319.3	32098.3	37823.1	16209	9746.03
2016	19770.4	58842.5	70117.2	33104.5	19483.7	23809.3	16867.5

Table 15.3.1.6 Plaice in 7d: Summary table (Outputs from the model).

Year	Recruitment Age 1	High	Low	SSB (tonnes)	High	Low	Landings tonnes	Discards tonnes	F ages 3–6	High	Low
1980	67505600	87960220	51811116	8222	10408	6037	1877	498	0.247	0.331	0.162
1981	34777200	46228880	26177093	10887	13210	8564	3170	803	0.302	0.383	0.22
1982	66766200	87986620	50668515	13295	16005	10585	4567	878	0.359	0.454	0.263
1983	60511900	80939720	45276345	13409	16116	10702	4511	1022	0.396	0.499	0.294
1984	61886100	82264920	46550825	13439	16162	10716	5040	1309	0.405	0.497	0.313
1985	78758000	102119600	60724347	13416	16103	10729	4960	1392	0.399	0.49	0.308
1986	156349000	199039780	122852533	13311	15776	10846	4736	1579	0.385	0.471	0.299
1987	95478000	120648910	75611223	15842	18475	13209	5462	2012	0.376	0.452	0.3
1988	62850500	80039860	49400706	20745	24141	17349	7307	1868	0.379	0.459	0.3
1989	41406800	54051900	31707230	22487	26014	18960	7413	1497	0.382	0.459	0.306
1990	42274400	58115050	30755373	19475	22749	16201	6056	1421	0.377	0.449	0.305
1991	71953500	106963190	48424444	15456	18375	12537	4684	2233	0.362	0.437	0.287
1992	94178600	145251210	61070243	12611	15175	10047	4224	3773	0.331	0.395	0.267
1993	47037600	74354540	29774274	11391	13671	9111	3913	2923	0.31	0.367	0.252
1994	38331800	57699280	25463466	10575	12583	8567	3368	1720	0.33	0.393	0.267
1995	61370900	83570010	45096504	9226	10946	7507	3160	1453	0.416	0.484	0.348
1996	68993200	90902250	52389423	8014	9535	6493	3346	1512	0.528	0.615	0.442
1997	121852000	156520140	94945659	8252	9798	6706	3879	1991	0.555	0.653	0.457
1998	59664200	77705400	45767065	10626	12486	8766	4630	2327	0.461	0.548	0.374
1999	50362900	69481790	36504105	14002	16424	11580	5276	1968	0.362	0.442	0.283
2000	59785800	86246090	41483042	15193	17861	12525	5004	1948	0.329	0.401	0.257
2001	54410600	77996560	37933124	13871	16511	11231	4524	1976	0.353	0.428	0.278
2002	78593800	105109720	58761373	12580	15156	10004	4302	1908	0.385	0.476	0.294
2003	39789100	50008090	31636285	12012	14523	9501	3994	1471	0.366	0.453	0.279
2004	47720200	58550210	38884850	12426	15053	9799	3861	864	0.323	0.404	0.243
2005	42482400	51112280	35320542	12870	15669	10071	3285	644	0.295	0.375	0.215
2006	40363500	48589560	33551471	13529	16478	10580	3542	741	0.288	0.364	0.213
2007	53951600	64013160	45485824	13937	17062	10812	3716	902	0.29	0.366	0.215
2008	69153400	84594120	56521705	13836	17047	10625	3629	1343	0.279	0.352	0.205
2009	106298000	126740120	89152708	14495	17849	11141	3607	1393	0.242	0.303	0.18
2010	174432000	210485910	144469833	17304	21153	13455	3789	1393	0.196	0.249	0.144
2011	239677000	293103190	195970614	24313	29409	19217	4619	1819	0.159	0.202	0.117
2012	120358000	147735680	98009530	37292	44963	29621	3100	3240	0.135	0.168	0.101
2013	125592000	160139410	98538242	51445	62288	40602	3888	2840	0.122	0.154	0.089
2014	164784000	220320810	123150197	58096	71008	45184	3546	2816	0.119	0.15	0.088
2015	88918200	136061190	58054645	57382	70728	44036	3467	2627	0.124	0.156	0.091
2016	19770400	39609330	9867285	55038	68985	41091	3823	2969	0.133	0.177	0.089

Table 15.5.3.1.1. Plaice in 7d: Management options for 2016 and their effects on the resident stock.

Variable	Value	Source	Notes
F ages 3–6 (2017)	0.133	AAP	Correspond to F_{2016} (status quo assumption)
SSB (2018)	55798	AAP	Short term forecast (STF), tonnes
Rage1 (2017)	68579.11	GM 1980-2016	Thousands individuals
Rage1 (2018)	68579.11	GM 1980-2016	Thousands individuals
Catch (2017)	6498	AAP	t (resident stock)
Landings (2017)	4232	AAP	t (resident stock)
Discards (2017)	2266	AAP	projection based on the 2014–2016 discard ratio (by age)

	Total catch (2018)	Wanted catch* (2018)	Unwanted catch* (2018)	F_{total} (2018)	SSB (2019)	% SSB change	% change in wanted catch
F_{MSY}	10592	7132	3459	0.25	46483	-17	97
F = 0	0	0	0	0	57879	4	-100
F_{pa}	14602	9850	4752	0.36	42258	-24	172
F_{lim}	19212	12987	6225	0.5	37469	-33	259
SSB (2019) = B_{lim}	38522	26291	12231	1.352	18447	-67	627
SSB (2019) = B_{pa}	30793	20932	9861	0.942	25826	-54	479
SSB (2019) = MSY $B_{trigger}$	30793	20932	9861	0.942	25826	-54	479
F = F_{2017}	5908	3971	1937	0.133	51483	-8	10
F = $F_{MSY\ lower}$	7844	5276	2568	0.18	49408	-11	46
F = $F_{MSY\ upper}$	13899	9373	4526	0.34	42994	-23	159

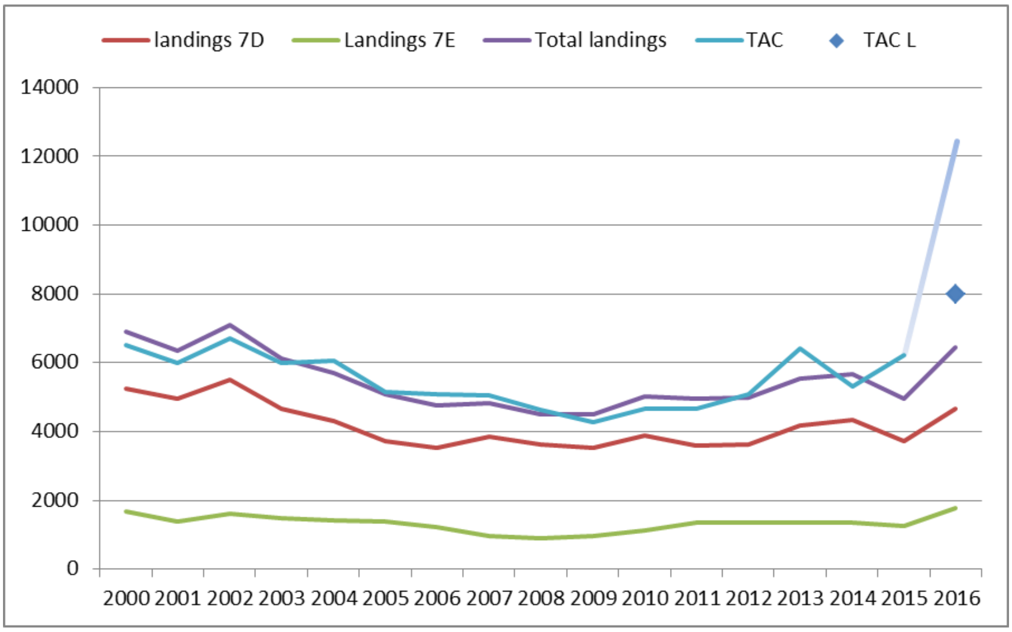


Figure 15.2.1.1. Plaice in 7d. Official landings in 7d and 7e compared to the TAC: in 2016, the advice was given on catch rather than landings. The blue diamond illustrates the level of the landings associated with the catch TAC, using the discard/landings ratio between the advised catch and advised ratio (Advice sheet 2015 for 2016).

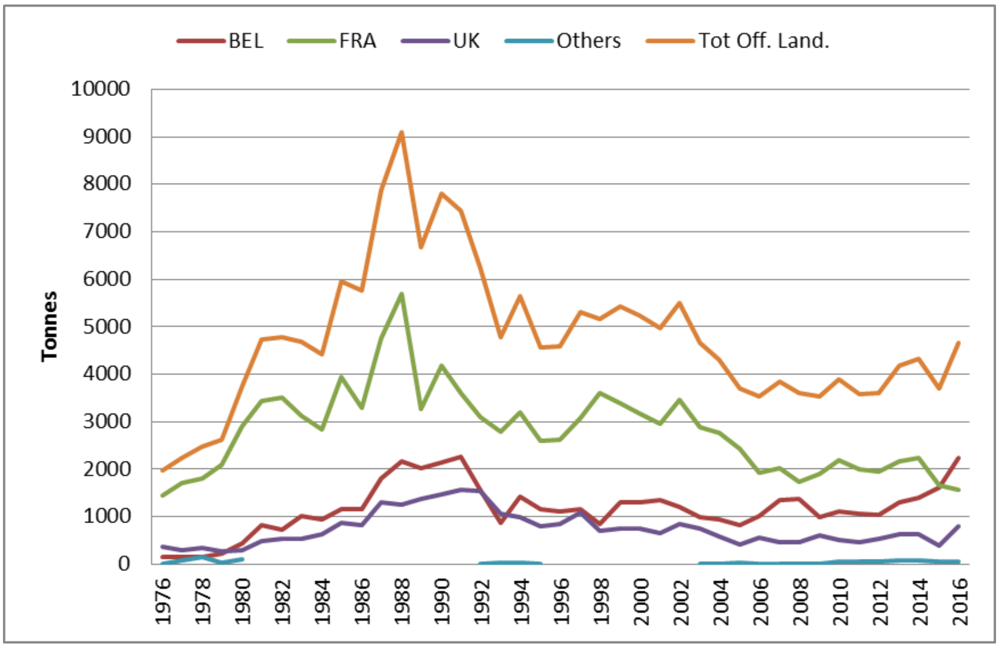


Figure 15.2.1.2. Plaice in 7d: Official landings.

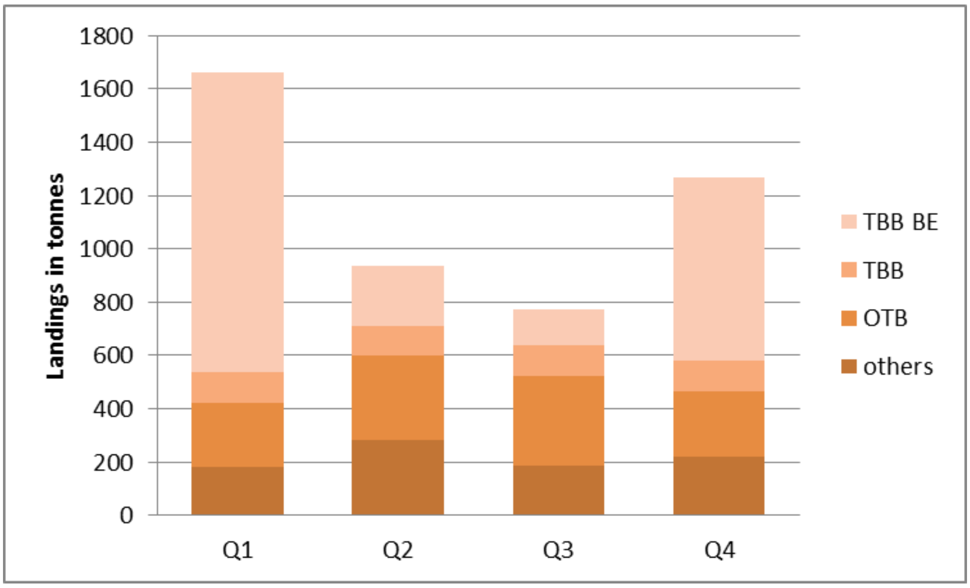


Figure 15.2.1.3. Plaice in 7d: Landings per quarter.

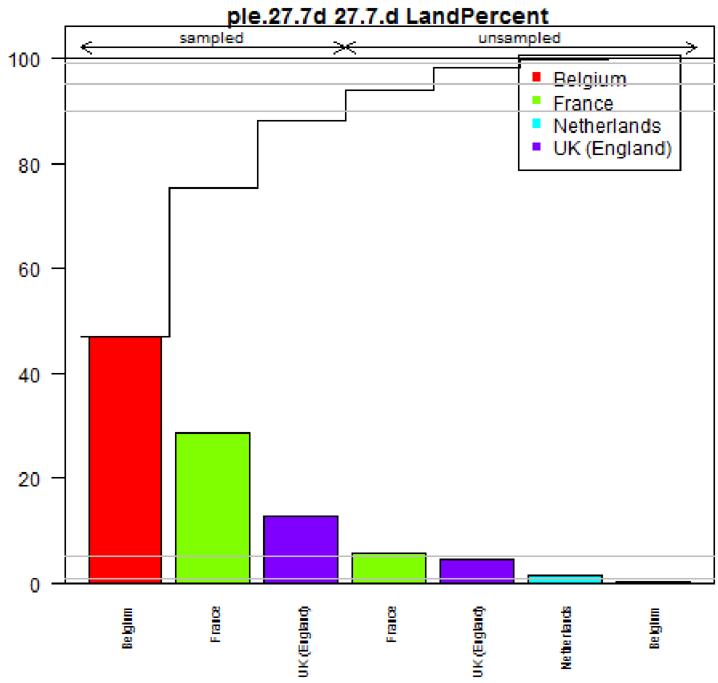


Figure 15.2.2.1. Proportions of total landings per country with and without age distribution provided.

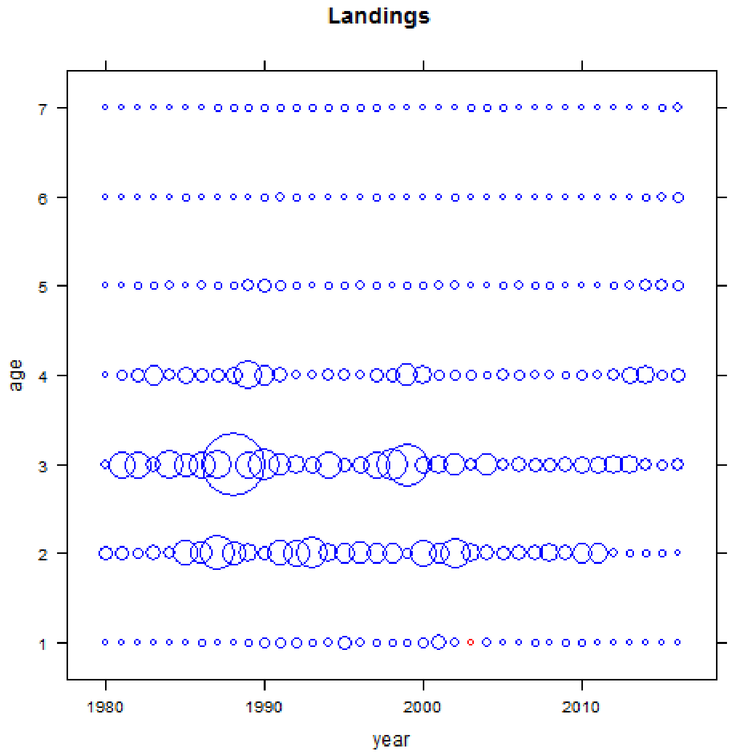


Figure 15.2.3.1. Plaice in 7d: Age composition of the landings.

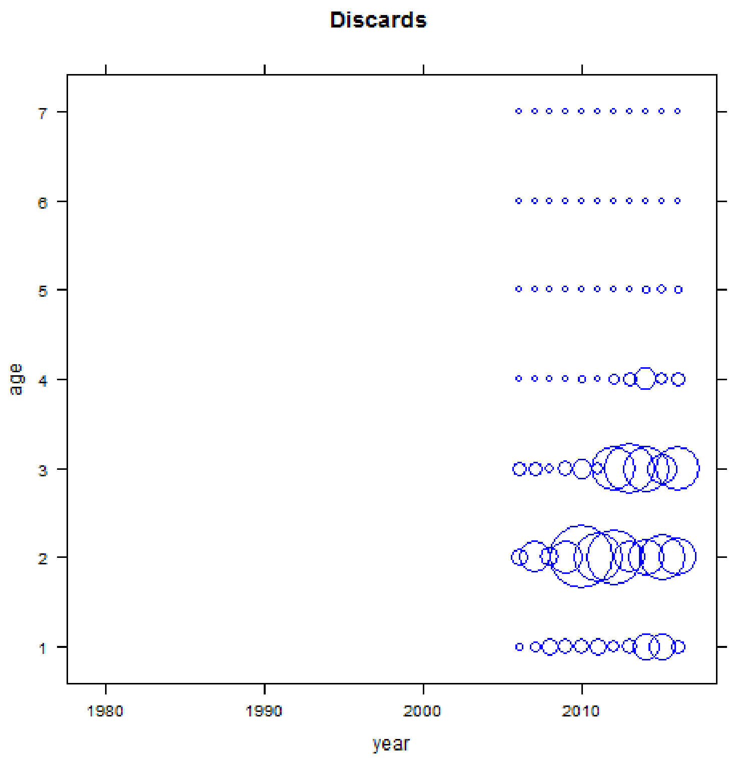
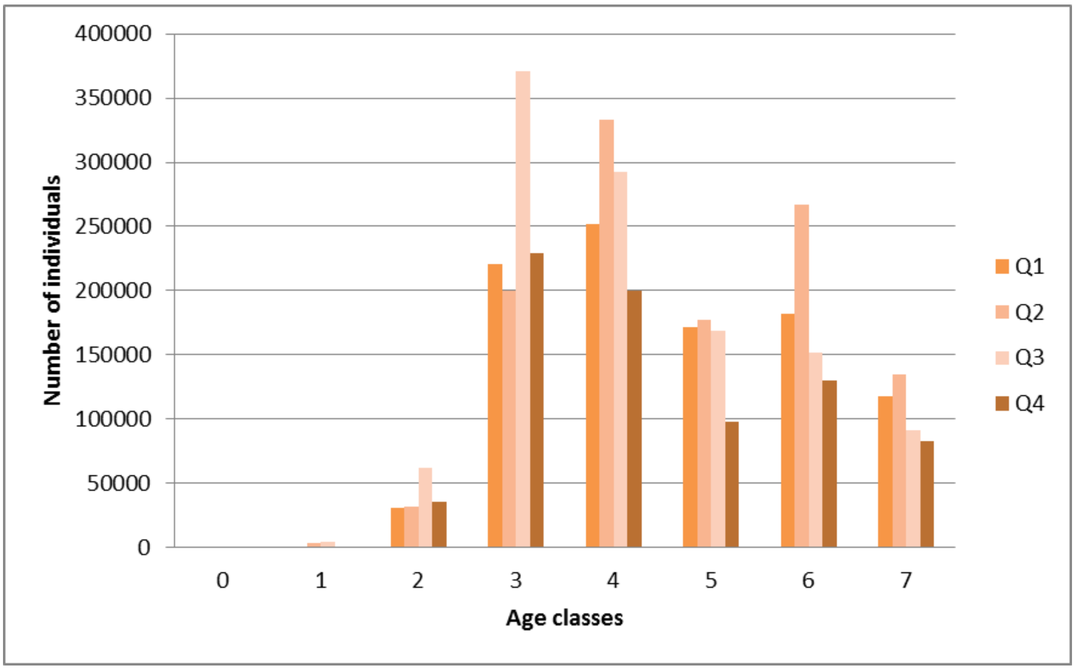


Figure 15.2.3.2. Plaice in 7d: Age composition of the discards.

Landings



Discards

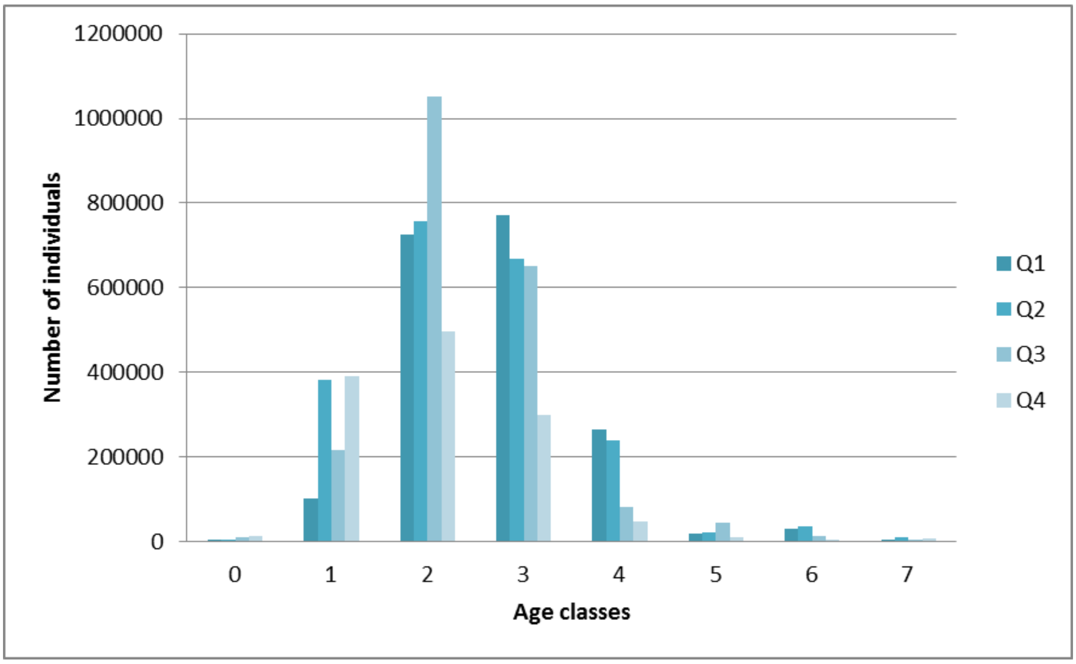
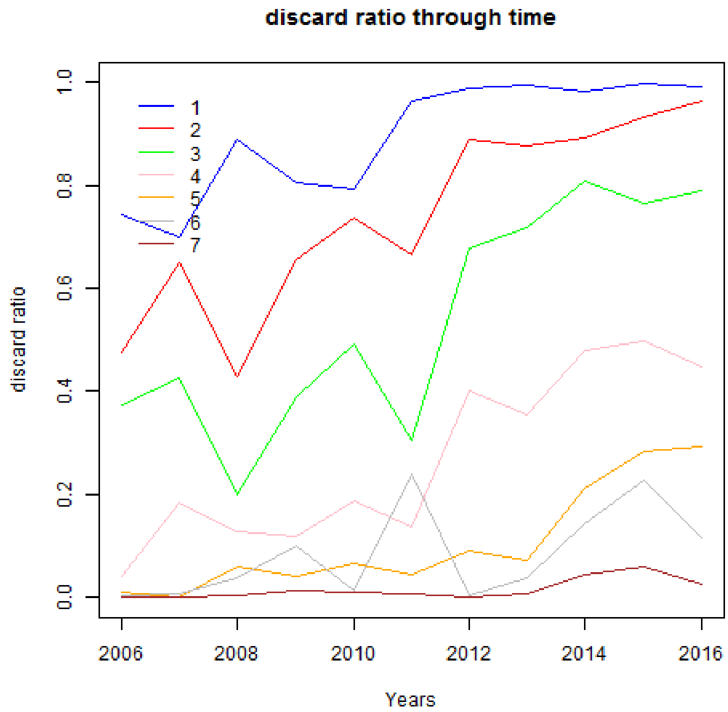


Figure 15.2.3.3. Plaice in 7d: 2016 Age distribution in the sampled landings and discards per quarter.



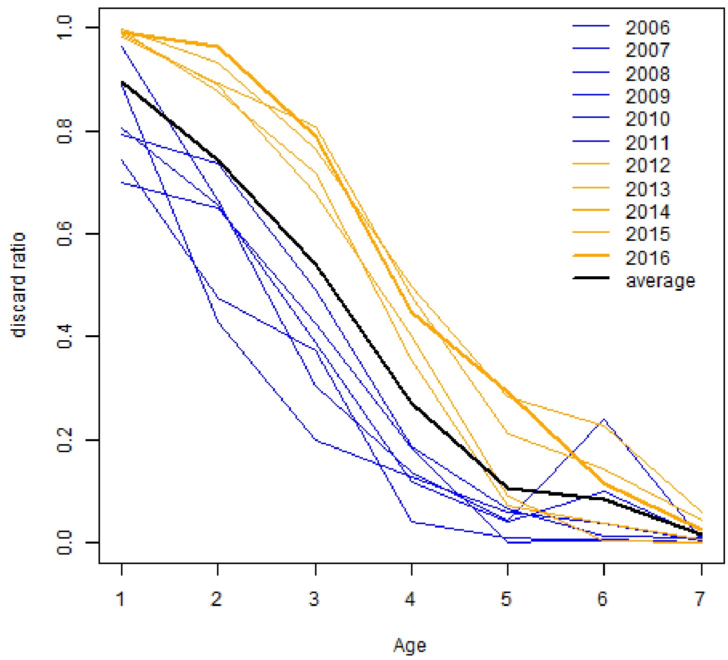


Figure 15.2.3.4. Plaice in 7d: Discards at age ratio (discards numbers/landings numbers) per age and through time.

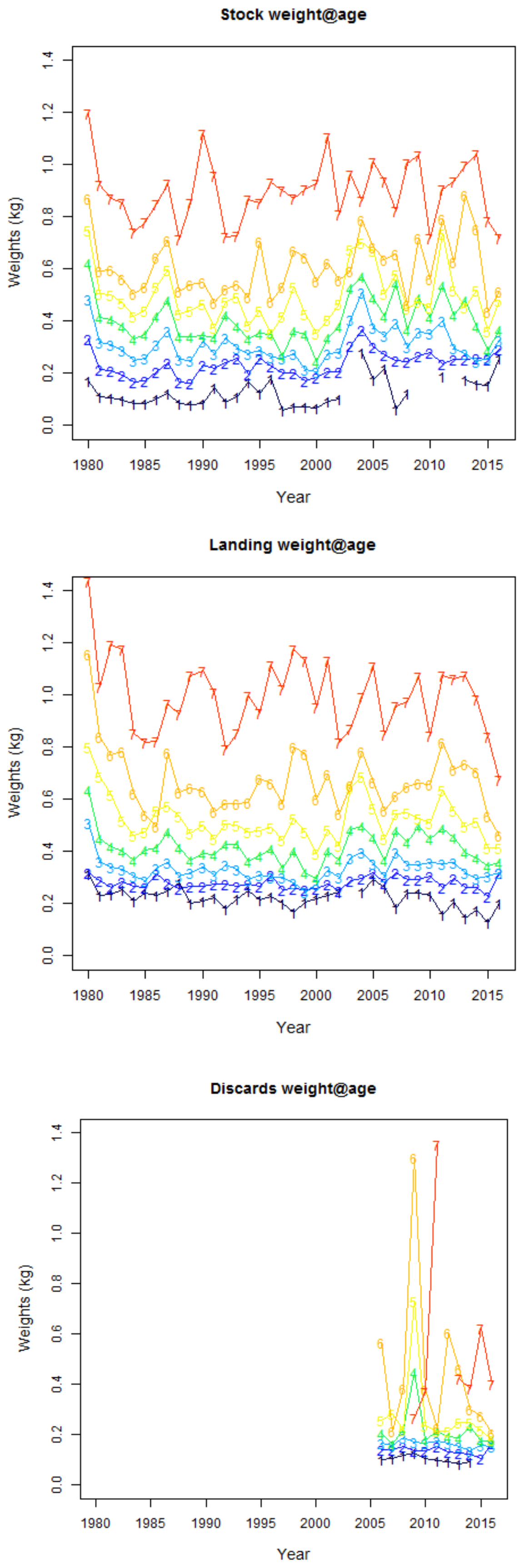


Figure 15.2.4.1. Plaice in 7d: Stock, Catch and discard weights.

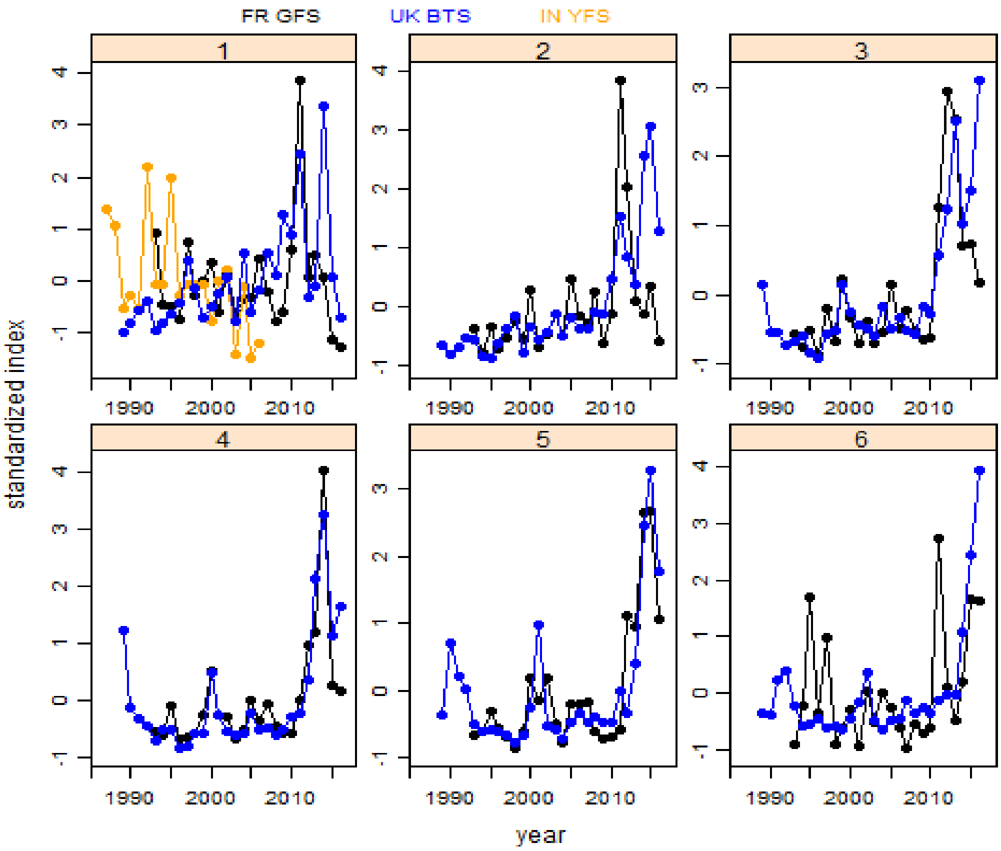


Figure 15.2.6.1. Plaice in 7d: Survey Consistency: mean standardized indices by surveys for each age.

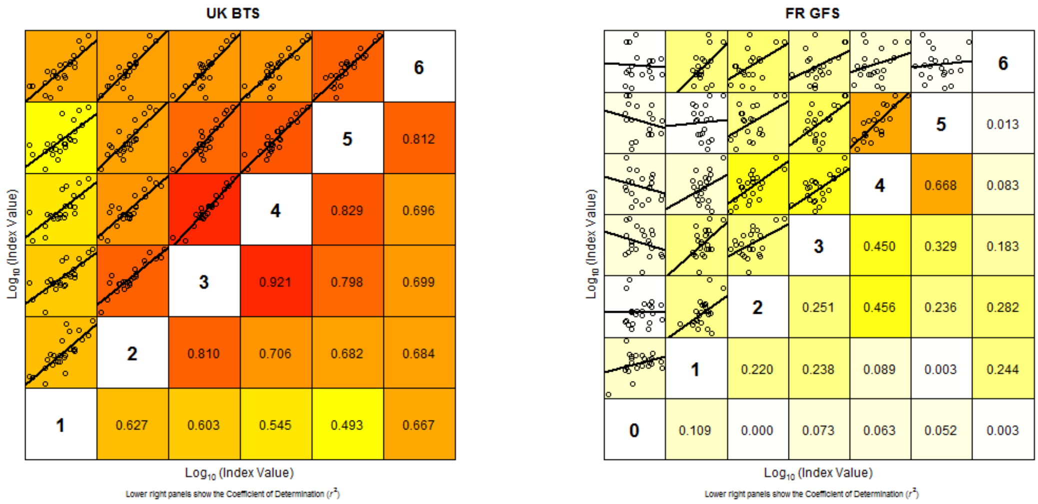
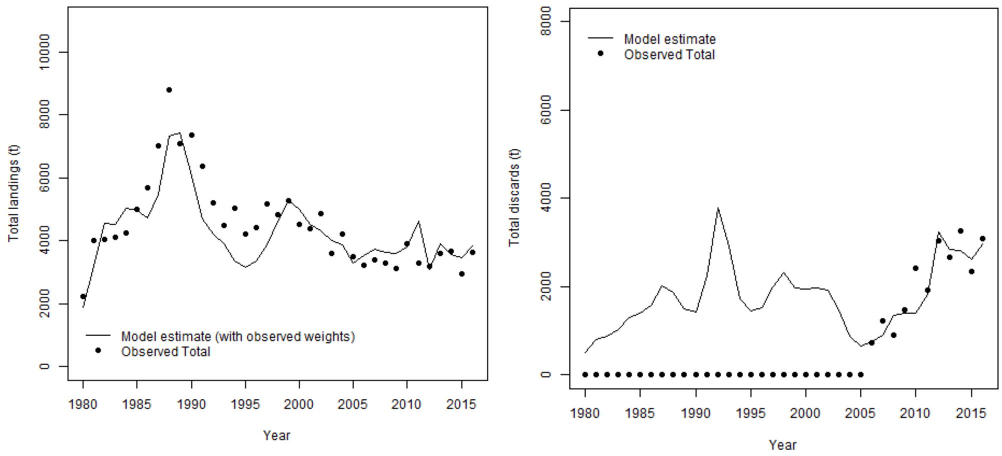


Figure 15.2.6.2. UK BTS and FR GFS indices consistencies.



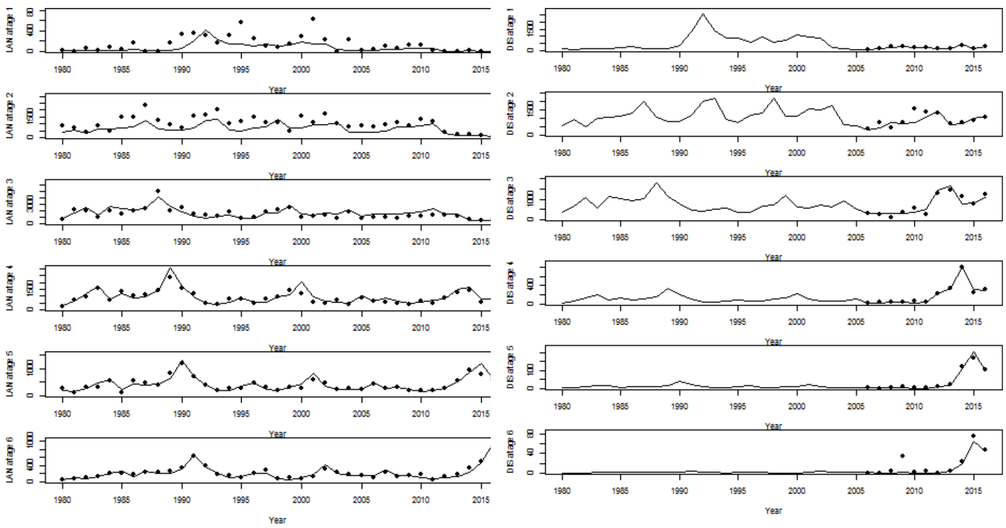
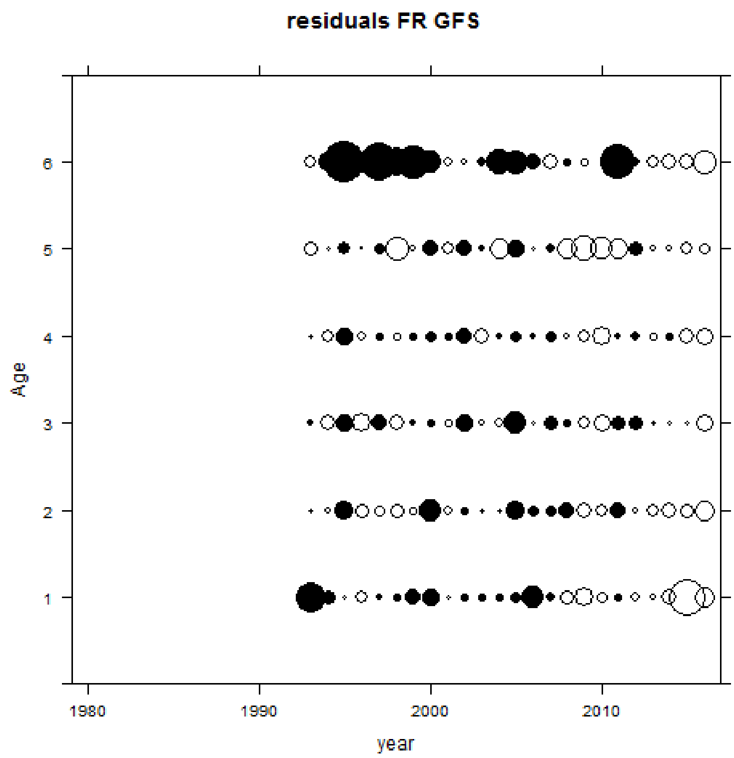


Figure 15.3.1.1. Plaice in 7d: Landings (left) and discards (right) time series: observed (dots) vs modelled (line), and per age (from 1 to 6: bottom panels).



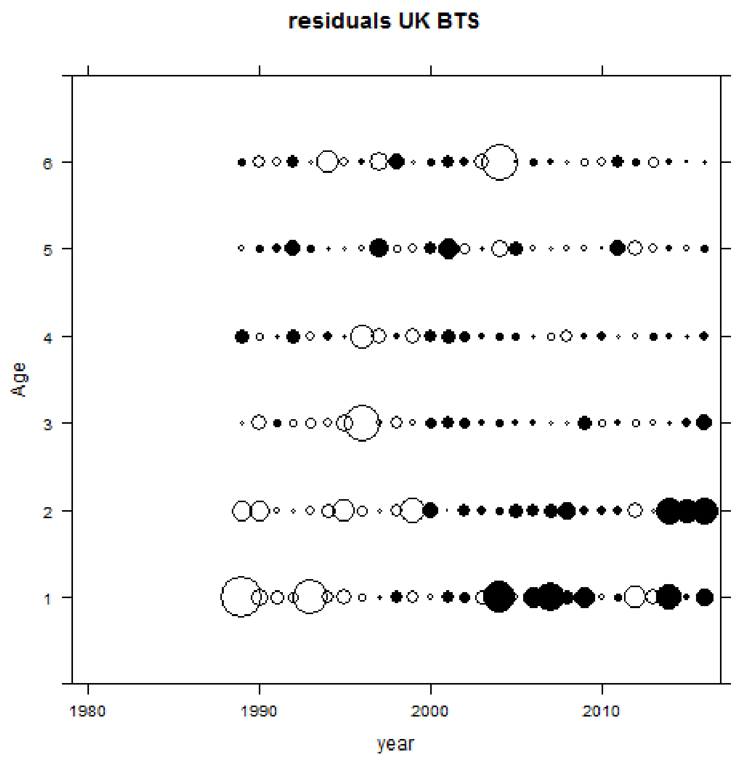


Figure 15.3.1.2. Plaice in 7d: Survey residuals from the AAP assessment.

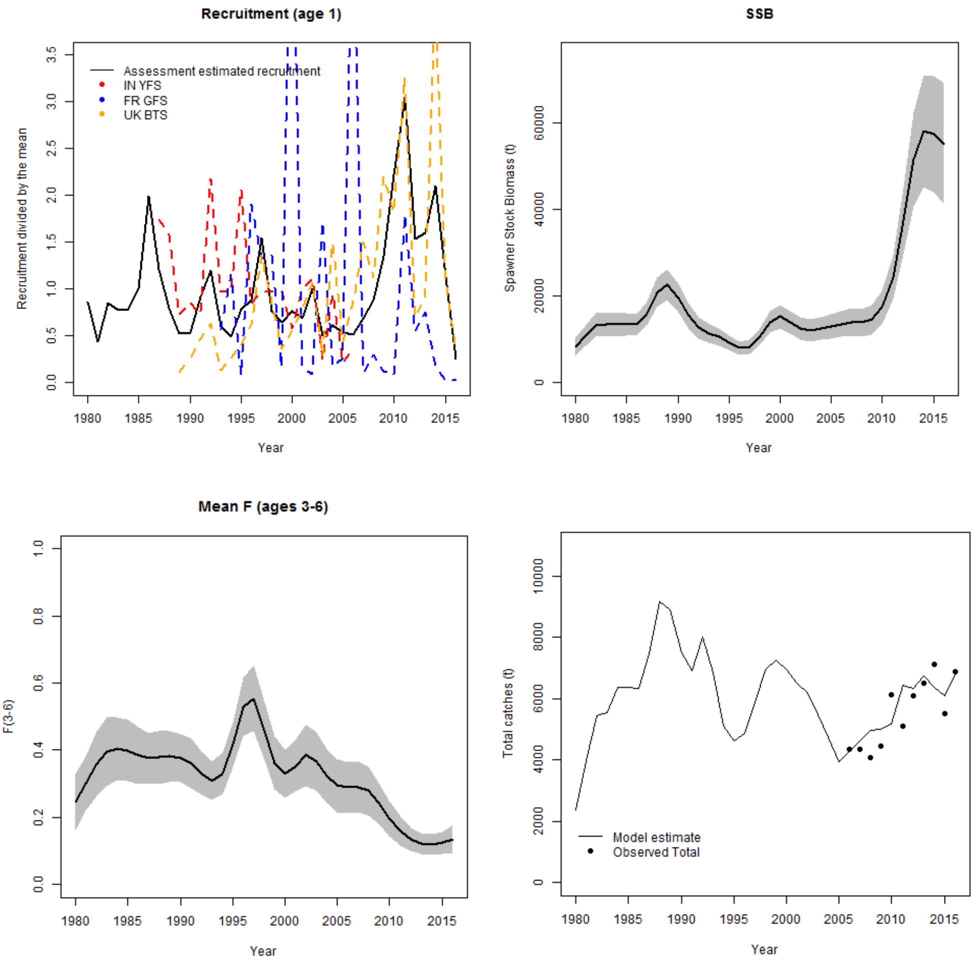


Figure 15.3.1.3. Plaice in 7d: Summary of assessment results.

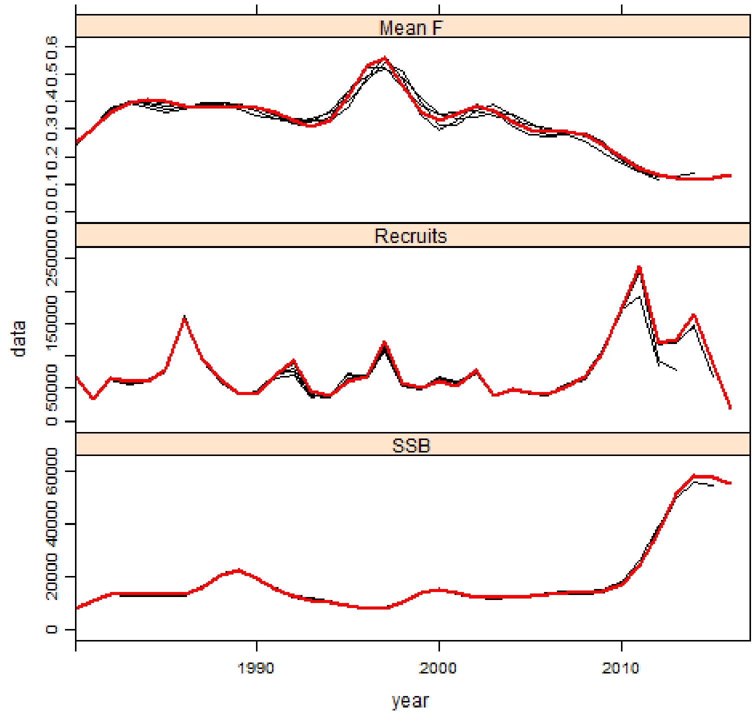


Figure 15.3.1.4: Plaice in 7d. Retrospective patterns.

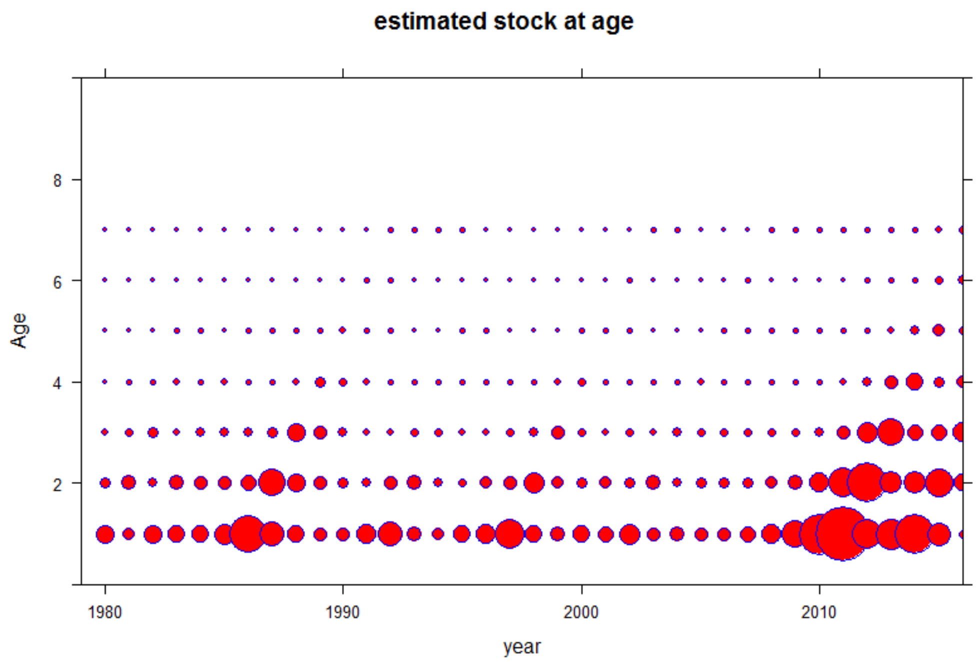


Figure 15.3.1.5: Plaice in 7d. Estimated stock numbers.

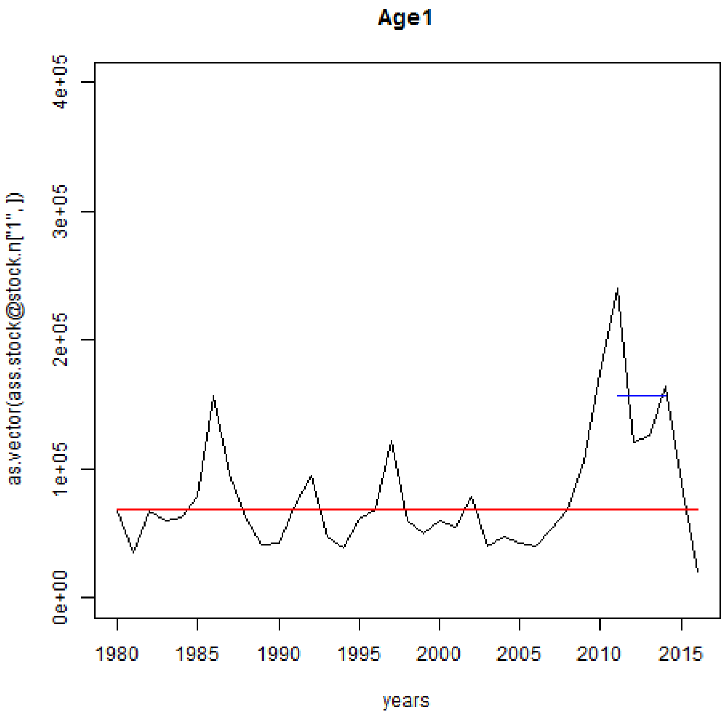


Figure 15.5.1.2. Plaice in 7d: Number of individuals of age 1 as estimated by the assessment model(black), with the geometric mean over the whole time series (red), and the geometric mean over 2011–2014 (blue).

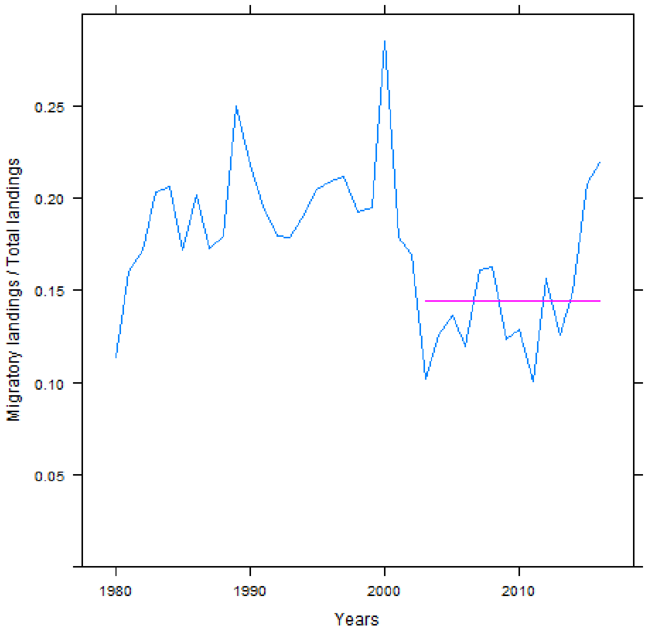


Figure 15.5.3.1. Plaice in 7d: Time series of the proportion of the catch of fish coming from 7e and IV over the 7d catch, and the average used.

16 Pollack (*Pollachius pollachius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat)

16.1 General biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0–group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >35 cm, at 3–4years of age and growth after age 3 is about 7 cm per year (Heino *et al.,* 2012). Pollack feeds mainly on fish, and incidentally on crustaceans and cephalopods.

16.2 Stock identity and possible assessment areas

WGNEW (ICES 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including 7.d and 3.a). In the ICES advice, it was, however, decided to include 7.d Pollack in the Celtic Seas Ecoregion.

16.3 Management

For 4 and 3.a there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

16.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis - or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2016 in Division 3.a (Skagerrak/Kattegat) and Subarea 4 (North Sea) are shown in Table 16.1. Figure 16.1 shows total landings in Subarea 4 and Division 3.a from 1977–2016. Two periods with high landings can be seen, and over the entire period total landings for both areas have declined. In Division 3.a landings have been low but stable since 2000, while in Subarea 4 landings have fluctuated over the same period and stabilised the last five years. Swedish fishers targeted pollack from the 1940s until mid–1980s when landings sometimes amounted to over 1000 tons. From the 1980s pollack started to decline severely and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast.

Nowadays, no fishery is targeting pollack, and it is mainly, possibly exclusively, a bycatch in various commercial fisheries. Norwegian catches peak in the months of March and April, and this may be associated with spawning aggregations. In 2016, 44% of the total landings were caught with gillnet and 40% with otter trawls in Division 3.a. In Subarea 4 21% of the total landings were made with gillnets and 68% with otter trawls. The geographical distribution of Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower. Discards are now considered by ICES to be known to take place and raised discards were estimated at 5.7 tonnes in total between area 3 and 4 in 2016 (see Table 16.2 for total catches and Table 16.3 for estimated discards). Discard numbers were raised for all nations. 70 % of the discards were reported by bottom trawl fleets with Sweden the country reporting the largest number of discards 56 % of total).

Pollack is also frequently caught in recreational fisheries. Regularly collected data about these catches are not available to the working group. Norwegian recreational fishing data collected in 2009 suggests that catches of pollack south of 62^0 north may range between 13–30 tons (Vølstad *et al.* 2011).

16.5 Survey data/recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the cpue was much higher in the 1970s. They are distributed mainly over the northern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat. Time series of abundance (average number per hour) in the IBTS are shown for Subarea 4 and Division 3.a separately, for quarter 1 (from 1983 onwards) and quarter 3 (from 1996 onwards) (Figure 16.2). The catches are small, and rather irregular, and no clear patterns emerge in 3 and 4.

16.5.1 Biological sampling

There has been some collection of length data in Subarea 4 and Division 3.a by Norway in the most recent years. Preliminary analysis of this data indicates that length ranges of pollack caught in gill net fisheries differ with mesh size and location. The majority of fish caught in western Norwegian fjords had a size range of 60–80 cm (Figure 16.3) compared to 50–70 cm in the Skagerrak (Figure 16.4).

16.5.2 Analysis of stock trends

In previous years the study by Cardinale *et al.* (2012), which analysed the spatial distribution and stock trends for the period 1906–2007, based on IBTS–Q1 and commercial catches, was used to assess the stock for Division 3.a (Skagerrak and Kattegat) and it was found that there had a been large decline in stock size from approximately 1960 to 2000. However, during routine IBTS surveys in Subarea 4 and Subarea 3, pollack catches seem rather irregular and with no clear pattern. A spatial analysis of Norwegian fisheries data from 2013, showing total Pollack catches by ICES rectangle, indicates that the surveys do not cover the geographic distribution of the species adequately in both Subarea 4 and subdivision 3.a (Figures 16.5 and 16.6). The surveys may therefore not be very well suited for monitoring this species as trends in standardised cpue likely are not a reliable indicator for the status of the stock. However, if the stock increases, it is arguably expected that present trawl survey (e.g. IBTS) would be able to detect such a stock trend in a consistent manner (Cardinale *et al.*, 2012).

16.5.3 Data requirements

In order to get a better understanding of growth and maturity WGNEW recommended that the collection of otoliths and maturity should be continued during these surveys for a few years. WGNSSK recommends also that the Norwegian biological data from commercial catches should be processed.

Table 16.1. Pollack in Subarea 4 and Division 3.a: Landings (tons) by country as officially reported to ICES 1977–2015.

				ICES Division 3.a				
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Official Total
1977	10	1764	4	3	449	706		2936
1978	1	2077	4		556	794		3432
1979	13	1898	<0.5		824	1066		3801
1980	13	1860			987	1584	<0.5	4444
1981	5	1661			839	1187	1	3693
1982	1	1272			575	417	<0.5	2265
1983	2	972			438	288		1700
1984	2	930	<0.5		371	276		1579
1985	-	824	<0.5		350	356		1530
1986	4	759	<0.5		374	271		1408
1987	6	665			342	246		1259
1988	4	494			350	136		984
1989	3	554			313	152		1022
1990	8	1842	<0.5		246	253		2349
1991	2	1824			324	281		2431
1992	8	1228			391	320		1947
1993	6	1130	1		364	442		1943
1994	5	645	<0.5		276	238		1164
1995	10	497			322	271		1100
1996		680			309	273		1262
1997		364	<0.5		302	178		844
1998		299			330	105		734
1999		192			342	88		622
2000		199			268	33		500
2001		201	1		253	46		501
2002		228	3		202	44		477
2003		168	3	1	236	17		425
2004		140	2	4	179	34		359
2005		160	5	7	173	153		498
2006		103	10	3	178	36		330
2007		172	9		245	38		464
2008		166	5		247	33		451
2009		208	7		220	38		473
2010		313	8	1	195	35		552
2011		193	7		168	28		395
2012		200	7		171	37		414
2013		210	3		172	35		420
2014		191	5	1	156	30		383
2015		190	14	1	138	48		389*
2016		151	7	1	133	46		338*

***Preliminary**

	ICES Subarea 4										
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
1977	121	275		75	142	38	419	9	0	442	1521
1978	102	249		98	154	21	492	2	0	471	1589
1979	62	333		72	64	8	563	11	31	429	1573
1980	82	407		66	58	2	1095		38	355	2103
1981	59	500		173	21	2	1261		12	362	2390
1982	46	431		59	40	1	1169	33	23	270	2072
1983	58	481		79	44	1	1081		57	300	2101
1984	52	402		108	37	0	880	2	106	315	1902
1985	14	308		69	23	0	686		51	363	1514
1986	44	550		45	21	0	602		67	362	1691
1987	21	427		988	21	0	471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273		0	21	4	568		37	269	1203
1990	44	924		0	34	3	651		126	366	2148
1991	31	1464		0	48	4	887		153	684	3271
1992	49	794		18	59	7	1051		141	1310	3429
1993	46	1161		8	161	19	1429		217	1561	4602
1994	42	635		12	55	14	845		113	872	2588
1995	56	532	1	7	84	18	1203		175	1525	3601
1996	13	366		4	99	13	909		82	945	2431
1997	20	272	1	1	115	11	733		82	1185	2420
1998	21	265		7	44	5	567		75	780	1764
1999	21	288		0	62	5	768		72	636	1852
2000	45	291		24	38	5	880		91	877	2251
2001	36	156		6	40	1	860		63	809	1971
2002	27	234		6	112	0	879		68	711	2037
2003	13	191		9	82	1	971		36	837	2140
2004	28	162		5	57	0	517		16	612	1397
2005	26	173		3	128	3	511		46	477	1367
2006	18	152		4	80	1	545		12	587	1399
2007	18	192		130	137	2	754		43	905	2181
2008	15	150		129	114	1	840		46	999	2294
2009	13	121	2	6	50	1	668		32	658	1551
2010	12	163		10	129	0	599		32	540	1485
2011	12	106	0	10	67	0	580	0	35	489	1299
2012	17	123	0	3	102	1	433		42	443	1164
2013	17	128	0	2	66	4	371	0	29	463	1080
2014	24	121		32	145	1	476		40	377	1215
2015	19	183		2	237	2	473		50	625	1591*
2016	21	127		2	107	2	440		36	430	1166*

*** Preliminary**

Table 16.2. Pollack in Subarea 4 and Division 3.a: Catches (tons) by country as estimated by the Working Group 2013–2015.

ICES Division 3.a				
	2013	2014	2015	2016
Denmark	214	192	192	152
Germany	11	6	35	7
Netherlands	<0.5	0	0	1
Norway	174	156	138	135
Sweden	36	30	46	47
ICES Total	435	384	413	343
Official Total	420	383	389*	338*
Diff Ices-Off	15	1	24	5

*** Preliminary**

ICES Subarea 4				
	2013	2014	2015	2016
Belgium	17	24	20	21
Denmark	150	122	183	127
France	2	32	2	2
Germany	59	145	216	107
Netherland.	3	1	2	2
Norway	379	481	466	440
Sweden	29	41	50	36
UK	456	377	626	423
Ices Total	1103	1227	1567	1159
Official Total	1080	1215	1591*	1166*
Diff Ices-Off	23	12	-22	-7

*** Preliminary**

Table 16.3. Pollack in Subarea 4 and Division 3.a. Discards (tons) by country estimated by the Working Group, 2015.

			ICES Division 3.a					
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Total
2013		1.949	0.139		1.795	1.528		5.41
2014		0.62	0.008		0.441	0.473		1.54
2015		2.026	0.385		0.667	0.094		3.17
2016		1.436	0.021	0.002	1.706	1.685		4.85

	ICES Subarea 4										
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
2013	0.111	22.785		0.050	0.229	1.320	7.967		0.662	8.923	42.05
2014	0.181	0.973		0.241	0.154	0.009	5.200		0.309	4.461	12.16
2015		0.069		0.005	0.075	0.001	0.691		0.090	1.59	2.52
2016	<0.001	0.109		0.001	0.073	<0.001	0.357		0.021	0.278	0.84

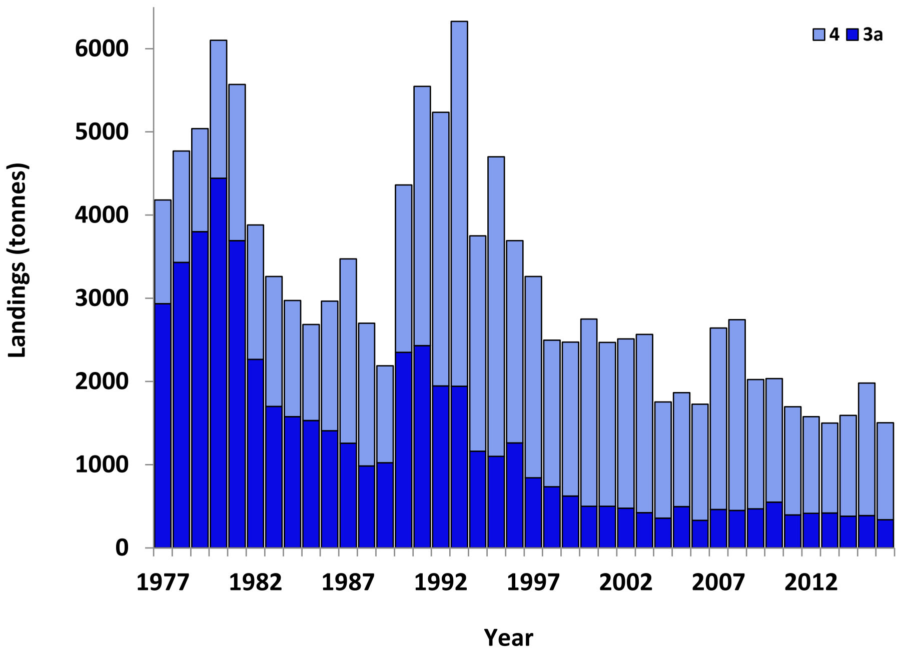


Figure 16.1. Pollack: Total landings of pollack from 2007–2016 in Division 3.a and Subarea 4 as officially reported to ICES.

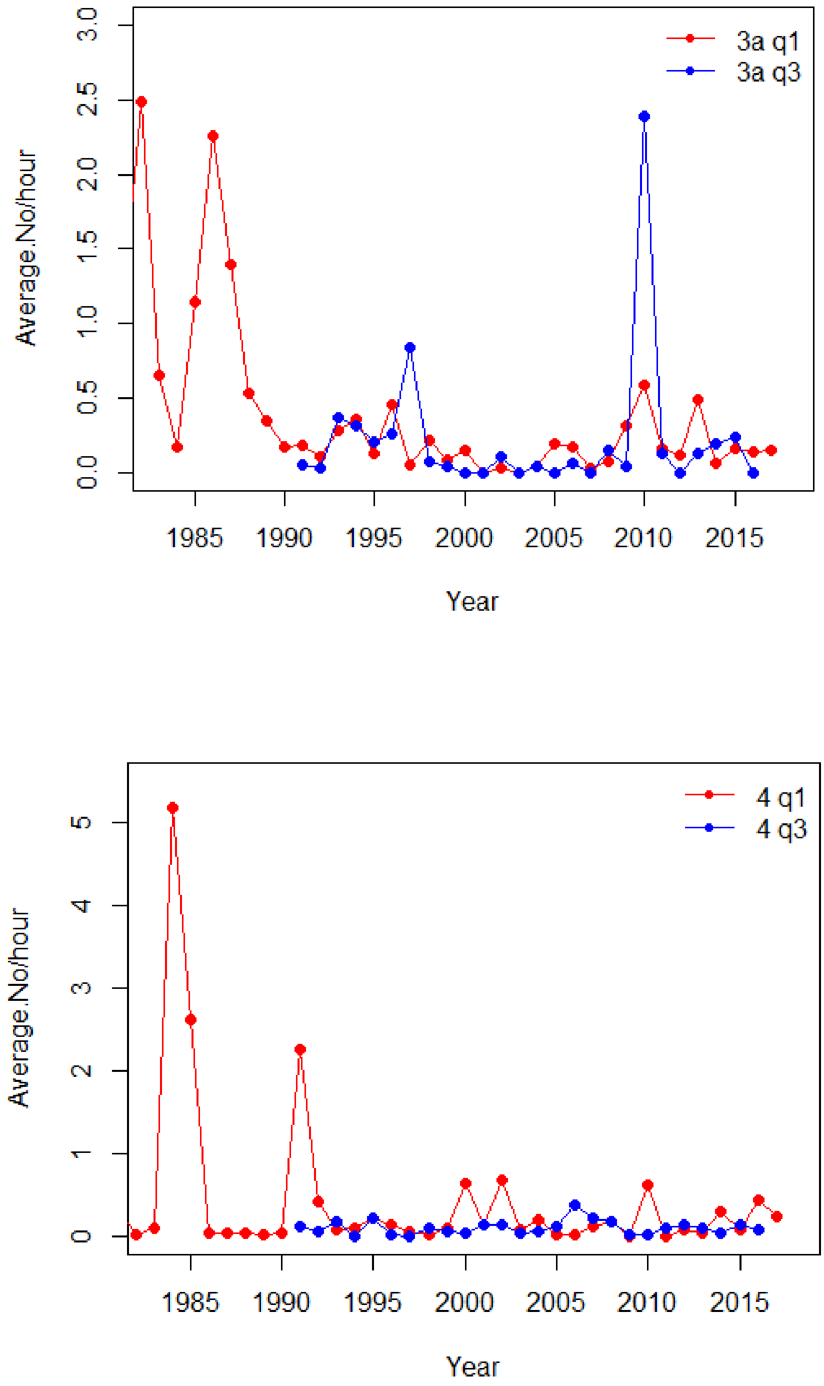


Figure 16.2. Time series of catches of pollack from 1983–2016 in ICES divison 3.a (top graph) and Subarea 4 in the IBTS Q1 (red) and Q3 (blue) surveys, shown as numbers caught per hour with the GOV–trawl. Data from Datras.

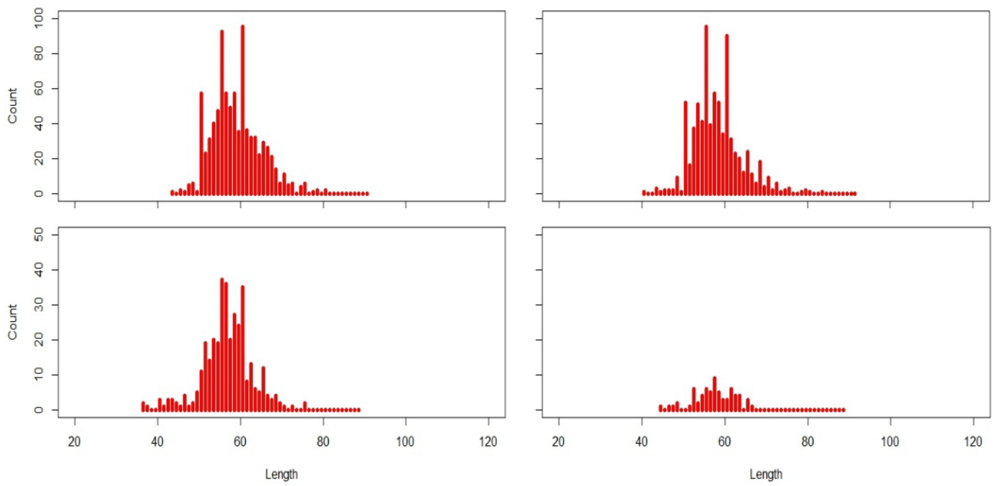


Figure 16.3. Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 3.a. The data is aggregated for gillnets with a 63 mm mesh size.

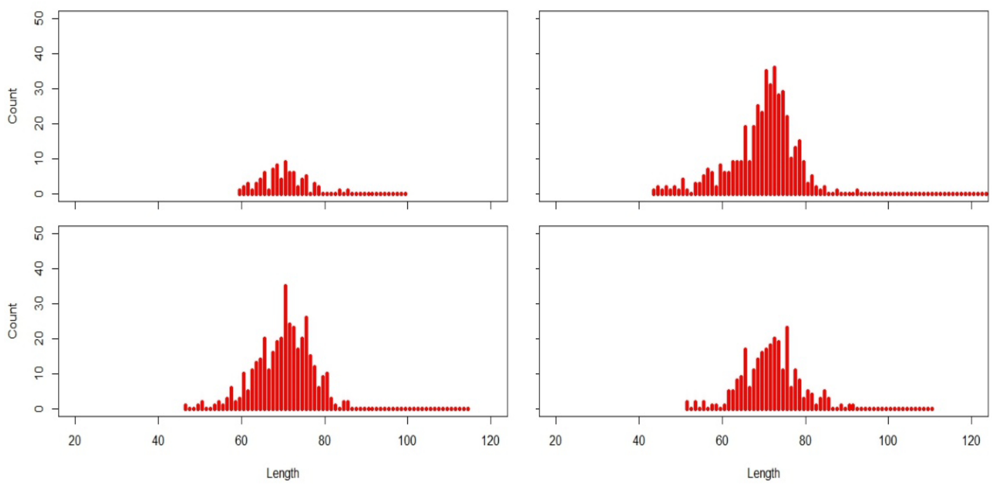


Figure 16.4. Length distributions of pollack sampled by the Norwegian reference fleet in the years 2010 (top left panel), 2011 (top right panel), 2012 (bottom left panel) and 2013 (bottom right panel), Area 4. The data is aggregated for gillnets with a 70 mm mesh size.

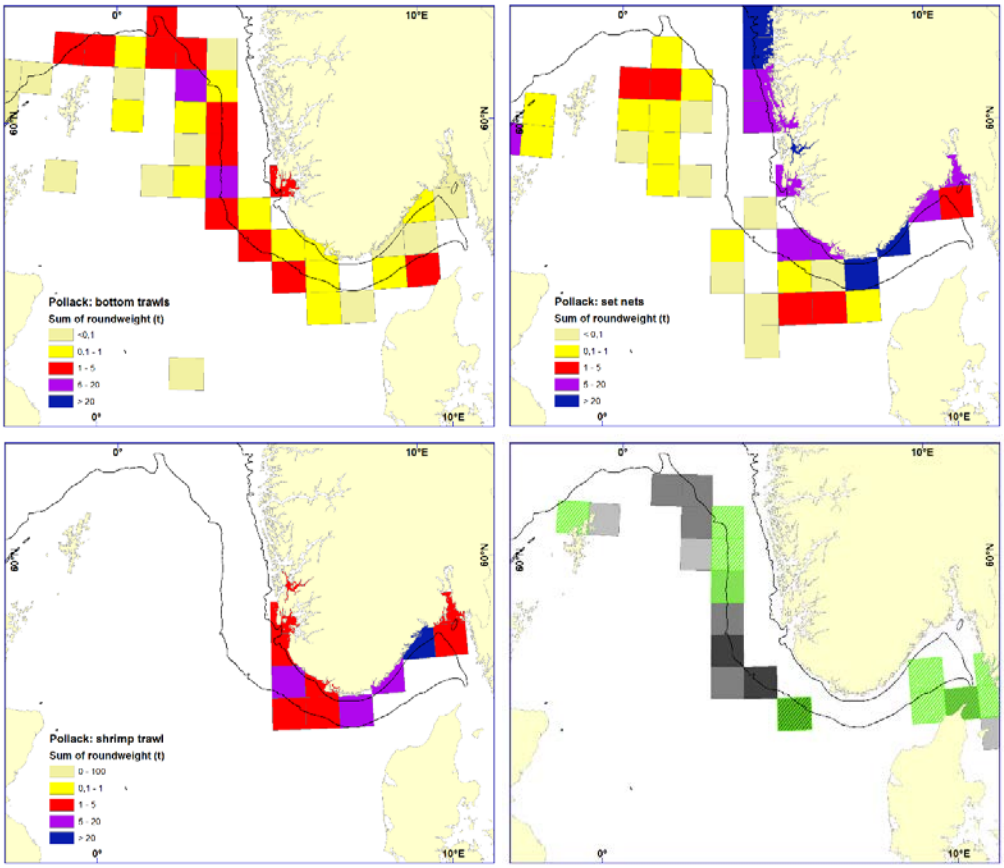


Figure 16.5. Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

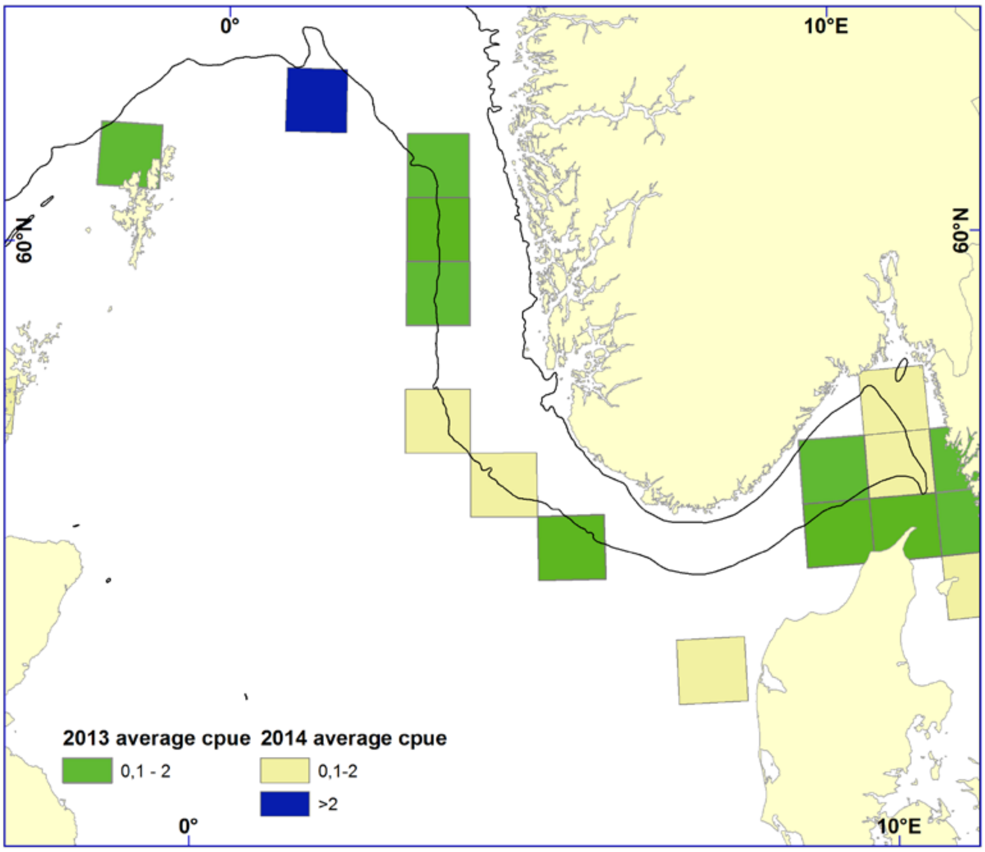


Figure 16.6. Pollack catches from IBTS surveys in 2013 (green) and 2014.

17 Saithe (*Pollachius virens*) in Subarea 4, 6 and Division 3.a (North Sea, Rockall, West of Scotland, Skagerrak and Kattegat)

The assessment of saithe in Division 3.a and Subareas 4 and 6 is presented as an update assessment, following the protocol specified by the 2016 meeting of WKNSEA (ICES 2016b) and a revision after the WGNSSK 2016 meeting, which was to provide a solution to the uncertainty in the assessment and forecast due to the highly uncertain and fluctuating survey indices. The forecast for this stock was updated in autumn 2016 because new information from the IBTS–Q3 survey triggered the re-opening criterion.

17.1 General

17.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

17.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK in 2017. A summary of available information, prepared during WKBENCH 2011 (ICES WKBENCH, 2011), can be found in the Stock Annex. No ecosystem aspects were discussed during WKNSEA 2016 (ICES 2016b).

17.1.3 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex.

Saithe are predominantly taken in the trawler fisheries by Norway, Germany, and France. Changes in the fishing pattern of these three fleets began in 2009, but all fleets appear to have largely reverted to their original fishing patterns (see Stock Annex). For the German and Norwegian fleets, this is mainly along the shelf edge in Subarea 4 and Division 3.a, while French fleets fish along the northern shelf and west of Scotland (Subareas 4 and 6). A restructuring of the German fleet began in recent years and, in 2016, two vessels switched from otter trawls to paired trawls.

The Scottish fleets catch a large amount of saithe in Subareas 4 and 6, which is then discarded due to lack of quota. Discards can also be high in a few Danish and Swedish fisheries in the Skagerrak because these fleets do not have quota allocations.

17.1.4 ICES Advice

The information in this section is taken from the Advice summary sheet 2016, section 6.3.38.

Advice for 2017

ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 140 653 tons.

Since this stock is only partially under the EU landing obligation, ICES is not in a position to advice on landings corresponding to the advised catch.

17.2 Management

Changes to the stock assessment and reference points in 2016 imply a need to re-evaluate the management plan to ascertain if it can still be considered precautionary under the new stock perception. Until such an evaluation is conducted, advice will follow protocol, i.e., given according to the ICES MSY approach.

17.3 Data available

17.3.1 Catch

Official landings and discards data for each country participating in the fishery are presented in Tables 17.3.1 and 17.3.2, together with the corresponding WG estimates and the agreed international quota ("total allowable catch" or TAC). ICES estimates of landings are higher in Subarea 6 and lower in Subarea 4 than official estimates. This is likely due to discrepancies between logbooks and landings as to where a vessel fished on a given trip. Ninety-six percent of the discards were reported and only 4% were raised within InterCatch (Table 17.3.3). While Norway has a no landings obligation policy for all métiers and in all areas, discarding is not monitored and discard information is not collected. Norwegian discards for the trawler fleet were raised using discard information from the French and German trawler fleets (i.e., the targeted fishery), while discards for other fleets (all counties) were raised using a stratification by quarter and area. Discard observations for landings from the fleets landing the majority of saithe are not available. (Figure 17.3.1).

The full time series of catch, landings, and discards is summarized in Table 17.3.4 and illustrated in Figure 17.3.2. Catch has been relatively stable from 1990 through 2008 and then declined slightly. The WG estimates of saithe discards (as a proportion of total catch) has remained relatively constant since 2003. Discard estimates were lowest for the period when the saithe trawler fleet changed its exploitation pattern (2009–2011). Prior to 2002, discards were estimated using a constant age-specific discarding rate (see ICES 2016b). High discards, particularly in 2016, were due to reported discarding by Scottish fisheries.

From 2016 onwards, saithe fishing in the bottom trawl fleet was covered by the EU Landing Obligation. Very few BMS landings and logbook reported discards were reported into InterCatch, despite saithe being under the landings obligations for certain métiers in 2016. BMS landings were 0.23% of the total catch and all logbook reported discards were 0 tonnes. Some nations did not report BMS landings despite having recorded official BMS landings because of doubt that it is the total amount. Instead, these nations have allowed BMS landings to be included in the raised discard information, making it impossible to differentiate between the two categories.

17.3.2 Age compositions

International catch and discard data was collated and catch-at-age was generated using InterCatch. Age composition in the landings was based on samples, provided by Denmark, France, Scotland, Germany, and Norway, which account for 81% of the total landings (Table 17.3.5, Figure 17.3.3). Although a large number of fleets do not provide samples for the landings, these do not contribute a large proportion of the catch. However, the number of samples taken, especially in the targeted trawl fisheries, is an issue (Table 17.3.6, but also see ICES 2016b). Age compositions for the unsampled landings have been determined by averaging within a quarter and an area (Division 3.a or combined Subareas 4/6), similar to that described in ICES (2016b; Figures 17.3.4–17.3.6, Table 17.3.7). This is because the fleets, particularly the target trawl fishery, are targeted the spawning fish in the first two quarters, while a wider range of age classes is captured in the latter part of the year. Smaller and younger fish are generally found in Division 3.a.

Ninety-five percent of the discards were sampled for age distributions (Table 17.3.5). Only two countries submitted age information for discards, Denmark and Scotland. While the proportion of discards sampled for age distribution were high (Table 17.3.7, Figures 17.3.7–17.3.9), the number of age samples was low (Table 17.3.6). Because of this, a stratification by quarter was used when estimating the age disaggregation for discards.

Total catch-at-age data are given in Table 17.3.8, while catch-at-age data for each catch component are given in Tables 17.3.9 and 17.3.10. Age 3 fish make up a smaller portion of the landings in recent years (Figure 17.3.10). The last strong year class in the catch appears to be the 2009 year class as seen in the discards in 2012 at age 3 and landings in 2013 at age 4. A slightly stronger year class appears to be entering the discards in 2016.

17.3.3 Weight-at-age

Weight-at-age from the catch and catch components for ages 3–10+ are presented in Tables 17.3.11–17.3.13 and Figure 17.3.11. Catch weights are used as stock weights. There was a decreasing trend in mean weight for ages 6 and older, but that has stopped or been reversed (Figure 17.3.11). Weights-at-age for ages 3–5 have been relatively stable, with some variation, over the last decade. Discard weights since 2009 appear to be increasing, however, there was a slight decrease in the last year.

17.3.4 Maturity and natural mortality

The following maturity ogive, revised during the 2016 benchmark, is used for all years (see Stock Annex for details):

Age	1	2	3	4	5	6	7	8+
Proportion mature	0.0	0.0	0.0	0.2	0.65	0.84	0.97	1.0

A natural mortality rate of 0.2 is used for all ages and years.

17.3.5 Catch, effort and research vessel data

Indices used in the final assessment are included in Table 17.3.14. Data for the Norwegian, French, and German commercial trawler fleets were combined into one standardized CPUE index, which is then tuned to the exploitable biomass (see Stock Annex for details). One fisheries-independent survey index was included for tuning of the assessment; the survey is the IBTS quarter 3, ages 3–8, 1992–2015 (“IBTS-Q3”). Indices used for the exploratory assessments are included in Table 17.3.15.

17.4 Data analyses

The assessment of North Sea saithe was carried out using a state-space stock assessment model (SAM; stockassessment.org). Two exploratory models are included. The first uses the combined standardized cpue index as in the final assessment model, but the IBTS–Q3 index omits the single large catch of saithe (detailed below). The second exploratory model includes the DATRAS–Q3 index as used in the final assessment model, but the cpue index omits German data for 2016 (detailed below).

17.4.1 Exploratory survey-based analyses

The saithe are distributed over the northern North Sea shelf and along the Norwegian Trench into the Skagerrak during the IBTS–Q3 (Figure 17.4.1). A large amount of age 3 and age 4 fish were captured along the top of the North Sea shelf. One catch in ICES rectangle 50F0 was particularly large at 6.8 tons per hour of trawling.

Numbers-at-age for saithe ages 3 to 8 (IBTS–Q3) on the log–scale, linked by cohort is shown in Figure 17.4.2. A strong year effect is apparent in 2007, 2011, 2013, and 2015; this is reflected in the sharp increase in age 4 when compared to earlier cohorts. Within-cohort correlations between ages for the survey index is also presented in Figure 17.4.3. The catch numbers correlate poorly between cohorts for ages 3 and 4, but are stronger for subsequent ages.

Trends by age for the IBTS–Q3 index are shown in Figure 17.4.4. Abundance of age 3 and 4 is very low in 2014, but have increased in 2015 and again in 2016. Abundance of age 3 in 2016 is the highest observed in the time series. When the single large catch of saithe is removed from the index estimation, abundance of age 3 in 2016 is still higher than in 2015 (Figure 17.4.5). IBTS–Q3 indices used in the final and exploratory assessment are given in Tables 17.4.1 and 17.4.2.

17.4.2 Exploratory catch-at-age-based analyses

Catch curves for total catches show that age 3 is only partially recruited to the fishery for the latter cohorts (from around the mid–1990s), but fully recruited for many of the earlier cohorts (Figure 17.4.6). The catch curves in recent years are less steep than for earlier cohorts, which indicates a change in exploitation occurred. This may be partially explained by declines in catches by the Norwegian purse seine fishery, which occurred in the early 1990s; purse seiners mainly target younger fish. The minimum landing size (40 cm in the North Sea) changed around this time, which would also cause a change in exploitation (targeting age 3 to targeting age 4 fish).

The outcome of WKNSEA 2016 was to remove the 3 cpue series for the targeted trawl fisheries, partially due to concerns over using information in the catch-at-age matrix in both the cpue and in the catch-at-age and because more weight was given to 3 indices within the former assessment model (artificially giving higher weighting to the cpue indices). A standardized combined cpue index was created for the French, German, and Norwegian trawl fleet targeting saithe, which was then tuned to the exploitable biomass, removing the need to use the information in the catch-at-age matrix twice (see ICES 2016b for details).

The partial year effects for each of the main fleets show that cpue declined in 2016 for all, but the decline was most pronounced for the German fleet (Figure 17.4.7). Fleet restructuring has been occurring for several years within the German fleet and 2016 saw 2 vessels change to paired trawls (they are no longer included in the Otter trawl cpue index). Due to concerns that the German cpue index may not be representative in 2016, an exploratory model was run without 2016 information from the German fleet. The cpue indices for the final and exploratory assessment are given in Tables 17.4.1 and 17.4.2. The fit of the cpue to the exploitable biomass shows a decline in 2016 when all fleet information is included, but after omitting the 2016 German fleet information, the fit shows a slight increase (Figure 17.4.8).

17.4.3 Assessments

The assessment was an update assessment. Settings used in the final and exploratory assessments are given in Table 17.4.3. SOP correction of the catches has been done on all revised catches (2002–current assessment year).

17.4.4 Exploratory assessment with alternative indices

Assessment omitting the 2016 large catch of saithe from the IBTS–Q3 indices

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 365.41. Estimated catchabilities for the Q3 index were higher than the cpue index (Q3 range 0.032 to 0.094; cpue 0.003). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.794).

Estimated fishing mortality-at-age are given in Table 17.4.4 and Figure 17.4.9. Estimated population numbers-at-age are in Table 17.4.5. The log catchability residuals are shown in Figure 17.4.10.

The historic stock and fishery trends, including 95% confidence intervals for the exploratory assessment are in Figure 17.4.11. The single large catch of saithe was predominantly fish aged 3–4. Removing this station resulted in lower SSB, higher $F_{4–7}$, and much lower recruitment estimates than in the final assessment model.

Assessment omitting German fleet information in 2016

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 367.57. Estimated catchabilities for the Q3 index were higher than the cpue index (Q3 range 0.032 to 0.094; cpue 0.003). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.796).

Estimated fishing mortality-at-age are given in Table 17.4.6 and Figure 17.4.9. Estimated population numbers-at-age are in Table 17.4.7. The historic stock and fishery trends, including 95% confidence intervals for the exploratory assessment are in Figure 17.4.12. Because the trend in cpue did not decline after removing the German fleet information in 2016 (Figure 17.4.8), SSB was estimated to be 9% higher and $F_{4–7}$ was estimated to be slightly lower than the final assessment model; recruitment estimates showed little change (Figure 17.4.12).

17.4.5 Final assessment

Thirty parameters were estimated in the SAM model; the negative log-likelihood value was 367.95. Estimated catchabilities for the Q3 index were higher than the cpue index, and not that different from the exploratory model (Q3 range 0.032 to 0.095; cpue 0.003). The correlation from the AR1 autocorrelation, which was the correlation random walks for the fishing mortalities, was high (0.792).

Estimated fishing mortality-at-age are given in Table 17.4.8 and Figure 17.4.13. Estimated population numbers-at-age are in Table 17.4.9.

The residuals are shown in Figure 17.4.14. After accounting for the correlation between ages within years, the IBTS–Q3 residuals show less of a pattern. Even after accounting for the correlation, the series is still largely positive at the end of the series, when the increase in abundance for most ages is beginning to be apparent. The retrospective analysis shows that SSB, F, and recruitment are fairly well estimated for the last 5 years (Figure 17.4.15).

17.5 Historic stock trends

The historic stock and fishery trends from the final assessment are presented in Figure 17.5.1 and Table 17.5.1. Because of the benchmark, historic perception of the stock has changed. Recruitment has been highly variable, but shows an overall decline since the mid–1990s. Recruitment has been increasing in the past years and is around the median for the period 2003 assessment year as used in the forecast. The decline in SSB reversed in 2010 and SSB is now around levels seen in the late 1990s and early 2000s. The final year estimate of SSB is above B_{pa} and MSY $B_{trigger}$. Fishing mortality has generally declined since the mid–1980s. Currently, fishing mortality is well below F_{MSY}.

17.6 Recruitment estimates

Currently, no survey provides an estimate of incoming recruitment. The 2003–2016 median value (110 million) used in the short-term forecast is below the estimated recruitment for 2016.

17.7 Short-term forecasts

A short-term forecast was carried out based on the final assessment.

Weight-at-age in the stock and catch were the mean values for the last 3 years. The exploitation pattern (selectivity pattern) was chosen as the mean exploitation pattern over the last three years. A TAC constraint for the intermediate year was chosen, i.e., the fishing mortality for 2017 was determined such that the landings without adjustment for the landings obligation in 2016 matched the TAC. Population numbers-at-age for ages 4 and older in 2015 were survivor estimates, while numbers at age 3 were the median estimate of recruitment for the years 2003–2016. The short-term projection was run in SAM.

The input data for the short term forecast are given in Table 17.7.1. Assuming that the landings in 2017 are scaled to the TAC in 2017 results in an F_{2015} of 0.381 and a SSB in 2017 of 257 329 t. Reference points and their technical basis are in Table 17.7.2.

The management options are given in Table 17.7.3. Because reference points were re-estimated after the benchmark, the management plan is no longer valid; therefore, the MSY approach is used. Total catch in 2018 is 118 460 tons, where wanted catch is 103 731 tons; this is a 2% decrease in TAC

The contribution of the 2008–2014 year classes to landings in 2017 are shown in Table 17.7.4. The 2014, 2013, and 2012 year classes contribute the most to the forecasts. The last 2 year classes (2015 and 2014) which are the age 3 and age 4 fish contribute 27% to the landings in the forecast.

17.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

17.9 Quality of the assessment and forecast

Many of the issues noted after the benchmark and last year's assessment still exist.

The commercial cpue indices may introduce biases into the assessment if changes in fishing patterns occur, as seen in 2009–2011. Factors, such as vessel experience and fishing behaviour, likely contribute to the variability in cpue for all fleets, but these factors are not captured in the cpue model. There are conflicting signals between the survey and fishable biomass index.

The scientific survey used in the assessment does not cover the whole stock distribution; however, it is considered generally representative. The number of observations (trawl stations) where saithe is low, can be influenced by occasional large catches, and the resulting survey index is uncertain. This occurred in 2016.

The poor reliability of the recruitment estimate is a major problem for the saithe assessment. There is no survey that adequately covers the recruiting age class.

The fraction of fish age 3 migrating into the survey area (and the fishery) is low and varying between years with no obvious trend. Observations of saithe at age 3 are not suitable for predicting year class strength. This means that assumed recruitment values are highly uncertain and a substantial portion (27%) of the advised wanted catch in 2018 is based on the recruitment assumptions for 2017 and 2018.

17.10 Status of the stock

The general perception of the status of the saithe stock is slightly less optimistic than last year.

17.11 Management considerations

The assessment is sensitive to relatively small changes in the input data. Because this stock suffers from 'poor data', the assessment is relatively uncertain. Recruitment is currently at a low level and it appears the strong recruitment pulses are more sporadic than in the past.

The reported landings have been relatively stable since the early 1990s. Landings have been lower than the TAC since 2002. Despite the reductions in the TAC between 2013 and 2016, the TAC was taken fully in 2015, but not in 2016. After the benchmark, the perception of the stock changed and the suggested TAC (autumn update) for 2017 was a 96% increase.

Information from fishers' survey (Napier, 2014) has been moved to the Stock Annex.

Bycatch of other demersal fish species does occur in the target trawl fishery for saithe. Saithe is also taken as unintentional bycatch in other fisheries, and discards do occur. Bycatch (not including BMS landings) of saithe in all fisheries in 2016 was estimated to be approximately 13% of the official catch.

17.11.1 Evaluation of the management plan

Because reference points were re-estimated after the benchmark, the management plan is no longer valid; therefore, the MSY approach is used.

Table 17.3.1. Saithe in Subareas 4 and 6 and Division 3.a: Nominal landings (tons) of saithe, 2004–2016, as officially reported to ICES and estimated by the Working Group.

SUBAREA 4 AND DIVISION 3A

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*
Belgium	22	28	15	18	7	27	15	2	1	3	4	6	16
Denmark	7991	7498	7470	5443	8066	8802	8018	6331	5171	5691	5056	4508	3109
Faroe Isl.	558	463	60	15	108	841	146	2	8	3	0	0	0
France	13628	11830	16953	15083	15881	7203	4582*	13856*	14093*	8475	7906	11612	10842
Germany	9589	12401	14397	12791	14140	13410	11193	10234	8052	9687	8562	7954	6196
Greenland	403	1042	924	564	888	927	0	0	0	0	0	0	0
Ireland	1	0	0	0	0	1	0	0	0	0	0	0	0
Lithuania	0	149	0	0	0	0	0	0	0	0	0	0	0
Netherlands	3	40	28	5	3	16	3	24	34	168	0	64	87
Norway	62783	68122	61318	45396	61464	57708	52712	46809	33288	35701	37463	35691	30951
Poland	0	1100	1084	1384	1407	988	654	584	0	0	0	0	0
Russia	0	35	2	5	5	13	0	0	0	0	0	0	0
Sweden	2249	2132	1745	1381	1639	1363	1545	1335	1306	1401	1272	1157	980
UK (E/W/NI)	457	960									687	8888**	1707
UK (Scotland)	5924	6170	9128**	9625**	11804**	12584**	11887**	10250**	7287**	10379**	7686		6769
Total reported	103608	111970	113124	91710	115412	103883	90755	89427	69240	71508	68318	69879	62526
Unallocated	−3646	−427	3988	1908	−3979	1646	4345	277	645	317	319	726	1871
ICES estimate	99962	111543	117112	93618	111433	105529	95100	89704	70510	71825	68662	69153	60655
TAC	190000	145000	123250	135900	135900	125934	107000	93600	79320	91220	77536	66006	65696

***Preliminary.**

****Scotland+E/W/NI combined.**

SUBAREA 6

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	0	0	0	0	0	0	0	0	0	0	20	0	1035
Faroe Islands	34	25	76	32	23	60	24	5	6	25	0	3	0
France	3053	3954	6092	4327	4170	2102	2008	2357	2612	3814	2904	3484	2298
Germany	4	373	532	580	148	298	257	0	9	0	0	0	91
Ireland	95	168	267	322	288	407	520	359	364	313	128	105	185
Netherlands	0	0	3	36	1	0	0	0	0	0	0	6	12
Norway	16	20	28	377	78	68	121	240	5	715	442	677	968
Russia	6	25	7	2	50	4	2	0	0	0	0	1	0
Spain	2	3	6	3	4	8	18	31	13	21	0	15	60
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	240
UK (E/W/NI)	37	133									97		123
UK (Scotland)	1563	2922	2748**	1424**	2955**	3491**	3168**	4500**	4549**	3646**	3191	3286**	2493
Total reported	4810	7623	9759	7103	7717	6438	6118	7492	7558	8534	6842	7577	5849
Unallocated	−296	−1884	−1191	−317	−483	525	722	−92	−351	−472	−60	-1578	-1609
ICES estimate	4514	5739	8568	6786	7234	6963	6840	7400	7162	8062	6831	9155	7458
TAC	20000	15044	12787	14100	14100	13066	11000	9570	8230	9464	8045	6848	6816

***Preliminary.**

****Scotland+E/W/NI combined.**

SUBAREAS 4 AND 6 AND SUBDIVISION 3A

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ICES estimate	108418	119593	125680	100404	118667	112492	101940	97104	77672	79887	75419	78307	68113
TAC	210000	160044	136037	150000	150000	139000	118000	103170	87550	100684	85581	72854	72512

Table 17.3.2. Saithe in Subareas 4 and 6 and Division 3.a: Nominal discards and, in parenthesis, BMS landings (tons) of saithe, 2004–2016, as a combination of reported and estimated, where unreported discards were estimated following the protocol of WKNSEA 2016 (ICES WKNSEA 2016). Discard information for Norway might be more accurate if stated as BMS landings because Norway has been under a landings obligation for several decades. However, the amounts landed are poorly documented and therefore data were estimated for Norway using discarding ratios from other nations (see ICES WKNSEA 2016).

SUBAREA 4 AND DIVISION 3A

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	0.1	0.1	0.1	1	0.1	0	1	0	0.3	0.3	0.1	0	3
Denmark	841	441	752	622	665	84	163	358	135	198	64	220	150
Faroe Isl.	0	2	0.7	0.2	2	17	4	0.1	0.1	0	0	0	0
France	0	0	0	0	2	7	4	1	0.2	3	32	1	7
Germany	77	19	15	43	50	33	16	13	13	71	12	8	0
Greenland	12	5	21	3	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0.5	0	0.2	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0.2	0	0	0	0.2	0.3	4	74	1	0.1	1
Norway	45	56	123	940	324	69	1090	39	1721	258	231	76	(174)
Poland	0	10	10	3	16	1	36	2	0	0	0	0	0
Portugal	0	0	5	3	0	0	0	0	0	0	0	0	
Russia	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0
Sweden	112	25	291	55	184	168	496	34	83	17	96	55	0
UK (E/W/NI)	11	26	20	14	44	14	137	319	62	491	3	20	0
UK (Scotland)	6350	5974	5671	10144	6092	3382	2124	3070	4377	5279	5386	4227	9925
Total reported	7464	6557	6909	11828	7378	3774	4071	3858	6395	6391	5824	4604	10087 (176*)

***Preliminary.**

SUBAREA 6

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	0	0	0	0	0	9	0	0	0	0	1	0	96
Faroe Islands	0	0.1	0.8	0.3	0.4	1	0.6	0.2	0	0	1	0	0
France	0	0	0	0	9	2	234	0.2	1	53	16	30	1
Germany	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Greenland	8	0.2	0	0.4	0	0	0	0	0	0	0	0	0
Ireland	21	313	2	93	5	1	6	19	5	5	2	2	1
Netherlands	0	0	0	2	0	0	0	0	0	0	0.1	0	(5)
Norway	0.1	0.1	0.2	2	1	0.1	14	0.1	1	0.2	1	0.4	(1)
Russia	0	0.1	0.1	0	0	0	0.1	0	0	0	0.2	0	0
Spain	0	0	0.1	0	0	0	0.4	1.1	0.1	0	0.2	132	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	60
UK (E/W/NI)	0.5	1.1	1	0	0.1	0	0	0	0.1	0	0.1	1	177
UK (Scotland)	590	1323	1670	486	966	516	157	482	2880	1339	491	240	0
Total reported	620	1637	1675	584	981	521	412	502	2887	1398	512	405	335 (6*)

***Preliminary.**

SUBAREAS 4 AND 6 AND DIVISION 3A

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ICES estimate discards	8085	8195	8584	12412	8359	4295	4484	4339	9282	7789	6336	5009	10421
ICES esimate BMS landings													181*

***Preliminary.**

Table 17.3.3. Saithe in Subareas 4 and 6 and Division 3.a: Catch data imported into InterCatch and proportion of sampling strata for discards raised within InterCatch.

Catch Category	Raised or Imported	Weight (tons)	Proportion
BMS landing	Imported data	181	100
Discards	Imported data	10420	96
Discards	Raised discards	454	4
Landings	Imported data	67902	100
Logbook registered discard	Imported data	0	0

Table 17.3.4. Saithe in Subareas 4 and 6 and Division 3.a: Working Group estimates of catch components by weight (000t). Landings obligations for Norway from 1988 but not sure saithe was in the landings obligation from the beginning; only have country specific landings from 2004 in InterCatch.

Year	Catches	Landings	BMS Landings	Discards	Proportion discards
1967	126743	113751		12992	10
1968	109144	88326		20818	19
1969	150301	130588		19713	13
1970	270779	234962		35817	13
1971	309202	265381		43821	14
1972	296444	261877		34567	12
1973	275150	242499		32651	12
1974	337025	298351		38674	11
1975	304619	271584		33035	11
1976	423416	343967		79449	19
1977	239915	216395		23520	10
1978	176868	155141		21727	12
1979	142655	128360		14295	10
1980	145300	131908		13392	9
1981	148249	132278		15971	11
1982	202126	174351		27775	14
1983	203022	180044		22978	11
1984	240557	200834		39723	17
1985	273671	220869		52802	19
1986	232786	198596		34190	15
1987	192391	167514		24877	13
1988	154248	135172		19076	12
1989	124584	108877		15707	13
1990	124419	103800		20619	17
1991	130950	108048		22902	17
1992	115534	99742		15792	14
1993	132610	111491		21119	16
1994	126760	109622		17138	14
1995	141205	121810		19395	14
1996	128925	114997		13928	11
1997	120082	107327		12755	11
1998	117219	106123		11096	9
1999	119652	110716		8936	7
2000	99336	91322		8014	8
2001	106160	95042		11118	10
2002	143580	122036		21544	15
2003	123821	112383		11438	9
2004	115472	107384		8088	7
2005	127069	118873		8196	6
2006	130235	121650		8585	7

2007	111883	99470		12413	11
2008	130207	121848		8359	6
2009	118052	113756		4296	4
2010	107488	103004		4484	4
2011	101960	97598		4362	4
2012	87143	77865		9278	11
2013	88224	80447		7777	9
2014	81830	75493		6337	8
2015	83310	78307		5003	6
2016	67902	78957	181*	10874	14

***Preliminary.**

Table 17.3.5. Saithe in Subareas 4 and 6 and Division 3.a: Amount (weight and proportion) of sampled or estimated age distributions of catch data imported or raised in InterCatch.

Catch Category	Raised Or Imported	Sampled Or Estimated	Weight (tonnes)	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	0	0
Landings	Imported_Data	Sampled_Distribution	54778	81
Landings	Imported_Data	Estimated_Distribution	13124	19
Discards	Imported_Data	Sampled_Distribution	10348	95
Discards	Raised_Discards	Estimated_Distribution	454	4
Discards	Imported_Data	Estimated_Distribution	73	1
BMS landing	Imported_Data	Estimated_Distribution	181	100

Table 17.3.6. Saithe in Subareas 4 and 6 and Division 3.a: Number of age sampling units and age measurements by catch category, fleet, quarter, nation, and area for 2016.

Catch Category	Fleet	Country	Season	Area	No. Age measurement	No. Age samples
Discards	OTB_DEF_>=120_0_0_all	Denmark	1	27.4	1	1
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	1	27.4	134	9
Discards	OTB_DEF_>=120_0_0_all_FDF	Denmark	1	27.4	1	2
Discards	GNS_DEF_120-219_0_0_all	Denmark	2	27.4	5	2
Discards	OTB_DEF_>=120_0_0_all	Denmark	2	27.4	21	3
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	2	27.4	189	10
Discards	OTB_DEF_>=120_0_0_all_FDF	Denmark	2	27.4	1	2
Discards	GNS_DEF_120-219_0_0_all	Denmark	3	27.4	49	2
Discards	OTB_DEF_>=120_0_0_all	Denmark	3	27.4	43	2
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	3	27.4	288	15
Discards	OTB_DEF_>=120_0_0_all_FDF	Denmark	3	27.4	5	2
Discards	SSC_DEF_>=120_0_0_all	Denmark	3	27.4	13	1
Discards	GNS_DEF_120-219_0_0_all	Denmark	4	27.4	38	1

Catch Category	Fleet	Country	Season	Area	No. Age measurement	No. Age samples
Discards	OTB_DEF_>=120_0_0_all	Denmark	4	27.4	3	1
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	4	27.4	240	14
Discards	OTB_DEF_>=120_0_0_all_FDF	Denmark	4	27.4	38	2
Discards	OTB_CRU_70-99_0_0_all	UK(Scotland)	2016	27.4	248	20
Discards	OTB_DEF_>=120_0_0_all_FDF	UK(Scotland)	2016	27.4	146	7
Discards	OTB_CRU_70-99_0_0_all	UK(Scotland)	2016	27.6	12	4
Discards	OTB_DEF_>=120_0_0_all	UK(Scotland)	2016	27.6	86	10
Discards	OTB_CRU_90-119_0_0_all	Denmark	1	27.3.a.20	38	17
Discards	OTB_DEF_>=120_0_0_all	Denmark	1	27.3.a.20	31	3
Discards	GNS_DEF_120-219_0_0_all_FDF	Denmark	2	27.3.a.20	6	1
Discards	OTB_CRU_32-69_0_0_all	Denmark	2	27.3.a.20	11	2
Discards	OTB_CRU_90-119_0_0_all	Denmark	2	27.3.a.20	25	11
Discards	OTB_DEF_>=120_0_0_all	Denmark	2	27.3.a.20	6	11
Discards	OTB_CRU_90-119_0_0_all	Denmark	3	27.3.a.20	5	11
Discards	GNS_DEF_120-219_0_0_all	Denmark	4	27.3.a.20	1	2
Discards	GNS_DEF_120-219_0_0_all_FDF	Denmark	4	27.3.a.20	1	1
Discards	OTB_CRU_90-119_0_0_all	Denmark	4	27.3.a.20	15	6
Landings	GNS_DEF_100-119_0_0_all	Denmark	1	27.4	260	5
Landings	GNS_DEF_120-219_0_0_all	Denmark	1	27.4	260	5
Landings	GNS_DEF_all_0_0_all	Norway	1	27.4	567	59
Landings	MIS_MIS_0_0_0_HC	Denmark	1	27.4	260	5
Landings	OTB_CRU_32-69_0_0_all	Denmark	1	27.4	260	5
Landings	OTB_DEF_>=120_0_0	France	1	27.4	0	0
Landings	OTB_DEF_>=120_0_0_all	Denmark	1	27.4	260	5
Landings	OTB_DEF_>=120_0_0_all	Norway	1	27.4	173	96
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	1	27.4	595	34
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	1	27.4	260	5
Landings	OTB_SPF_32-69_0_0_all	Denmark	1	27.4	260	5
Landings	SSC_DEF_>=120_0_0_all	Denmark	1	27.4	260	5
Landings	GNS_DEF_>=220_0_0_all	Denmark	2	27.4	254	7
Landings	GNS_DEF_100-119_0_0_all	Denmark	2	27.4	254	7
Landings	GNS_DEF_120-219_0_0_all	Denmark	2	27.4	254	7
Landings	GNS_DEF_all_0_0_all	Norway	2	27.4	289	41

Catch Category	Fleet	Country	Season	Area	No. Age measurement	No. Age samples
Landings	MIS_MIS_0_0_0_HC	Denmark	2	27.4	254	7
Landings	OTB_CRU_32-69_0_0_all	Denmark	2	27.4	254	7
Landings	OTB_DEF_>=120_0_0_all	Denmark	2	27.4	254	7
Landings	OTB_DEF_>=120_0_0_all	Germany	2	27.4	893	0
Landings	OTB_DEF_>=120_0_0_all	Norway	2	27.4	20	17
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	2	27.4	659	30
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	2	27.4	254	7
Landings	OTB_DEF_>=120_0_0_all_FDF	Germany	2	27.4	893	0
Landings	OTB_SPF_32-69_0_0_all	Denmark	2	27.4	254	7
Landings	SDN_DEF_>=120_0_0_all	Denmark	2	27.4	254	7
Landings	SDN_DEF_>=120_0_0_all_FDF	Denmark	2	27.4	254	7
Landings	SSC_DEF_>=120_0_0_all	Denmark	2	27.4	254	7
Landings	SSC_DEF_>=120_0_0_all_FDF	Denmark	2	27.4	254	7
Landings	TBB_DEF_>=120_0_0_all	Denmark	2	27.4	254	7
Landings	GNS_DEF_120-219_0_0_all	Denmark	3	27.4	299	8
Landings	GNS_DEF_all_0_0_all	Norway	3	27.4	163	31
Landings	MIS_MIS_0_0_0_HC	Denmark	3	27.4	299	8
Landings	OTB_CRU_32-69_0_0_all	Denmark	3	27.4	299	8
Landings	OTB_DEF_>=120_0_0	France	3	27.4	0	0
Landings	OTB_DEF_>=120_0_0_all	Denmark	3	27.4	299	8
Landings	OTB_DEF_>=120_0_0_all	Germany	3	27.4	678	0
Landings	OTB_DEF_>=120_0_0_all	Norway	3	27.4	19	10
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	3	27.4	469	21
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	3	27.4	299	8
Landings	OTB_DEF_>=120_0_0_all_FDF	Germany	3	27.4	678	0
Landings	OTB_SPF_32-69_0_0_all	Denmark	3	27.4	299	8
Landings	SDN_DEF_>=120_0_0_all	Denmark	3	27.4	299	8
Landings	SDN_DEF_>=120_0_0_all_FDF	Denmark	3	27.4	299	8
Landings	SSC_DEF_>=120_0_0_all	Denmark	3	27.4	299	8
Landings	SSC_DEF_>=120_0_0_all_FDF	Denmark	3	27.4	299	8
Landings	GNS_DEF_120-219_0_0_all	Denmark	4	27.4	137	2
Landings	GNS_DEF_all_0_0_all	Norway	4	27.4	589	56
Landings	MIS_MIS_0_0_0_HC	Denmark	4	27.4	137	2
Landings	OTB_CRU_32-69_0_0_all	Denmark	4	27.4	137	2
Landings	OTB_CRU_70-99_0_0_all	Denmark	4	27.4	137	2
Landings	OTB_DEF_>=120_0_0	France	4	27.4	0	0
Landings	OTB_DEF_>=120_0_0_all	Denmark	4	27.4	137	2
Landings	OTB_DEF_>=120_0_0_all	Germany	4	27.4	572	0

Catch Category	Fleet	Country	Season	Area	No. Age measurement	No. Age samples
Landings	OTB_DEF_>=120_0_0_all	Norway	4	27.4	19	3
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	4	27.4	363	18
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	4	27.4	137	2
Landings	OTB_DEF_>=120_0_0_all_FDF	Germany	4	27.4	572	0
Landings	OTB_SPF_32-69_0_0_all	Denmark	4	27.4	137	2
Landings	OTB_SPF_32-69_0_0_all	Germany	4	27.4	572	0
Landings	SDN_DEF_>=120_0_0_all_FDF	Denmark	4	27.4	137	2
Landings	SSC_DEF_>=120_0_0_all	Denmark	4	27.4	137	2
Landings	SSC_DEF_>=120_0_0_all_FDF	Denmark	4	27.4	137	2
Landings	OTB_CRU_70-99_0_0_all	UK(Scotland)	2016	27.4	30	2
Landings	OTB_DEF_>=120_0_0_all_FDF	UK(Scotland)	2016	27.4	166	6
Landings	OTB_DEF_>=120_0_0	France	1	27.6	0	0
Landings	OTB_DEF_>=120_0_0	France	2	27.6	0	0
Landings	OTB_DEF_>=120_0_0	France	3	27.6	0	0
Landings	OTB_DEF_100-119_0_0	France	3	27.6	0	0
Landings	OTB_DEF_>=120_0_0	France	4	27.6	0	0
Landings	OTB_DEF_>=120_0_0_all	UK(Scotland)	2016	27.6	391	16
Landings	GNS_DEF_120-219_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	GNS_DEF_120-219_0_0_all_FDF	Denmark	1	27.3.a.20	128	2
Landings	MIS_MIS_0_0_0_HC	Denmark	1	27.3.a.20	128	2
Landings	OTB_CRU_32-69_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	OTB_CRU_90-119_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	OTB_CRU_90-119_0_0_all_FDF	Denmark	1	27.3.a.20	128	2
Landings	OTB_DEF_>=120_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	1	27.3.a.20	128	2
Landings	SDN_DEF_>=120_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	SSC_DEF_>=120_0_0_all	Denmark	1	27.3.a.20	128	2
Landings	GNS_DEF_>=220_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	GNS_DEF_120-219_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	GNS_DEF_120-219_0_0_all_FDF	Denmark	2	27.3.a.20	61	3
Landings	MIS_MIS_0_0_0_HC	Denmark	2	27.3.a.20	61	3

Catch Category	Fleet	Country	Season	Area	No. Age measurement	No. Age samples
Landings	OTB_CRU_32-69_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	OTB_CRU_90-119_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	OTB_DEF_>=120_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	OTB_DEF_>=120_0_0_all	Germany	2	27.3.a.20	178	0
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	2	27.3.a.20	61	3
Landings	OTB_DEF_>=120_0_0_all_FDF	Germany	2	27.3.a.20	178	0
Landings	SDN_DEF_>=120_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	SSC_DEF_>=120_0_0_all	Denmark	2	27.3.a.20	61	3
Landings	OTB_DEF_>=120_0_0_all	Germany	3	27.3.a.20	285	0
Landings	OTB_DEF_>=120_0_0_all_FDF	Germany	3	27.3.a.20	285	0
Landings	GNS_DEF_120-219_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	GNS_DEF_120-219_0_0_all_FDF	Denmark	4	27.3.a.20	68	2
Landings	MIS_MIS_0_0_0_HC	Denmark	4	27.3.a.20	68	2
Landings	OTB_CRU_32-69_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	OTB_CRU_90-119_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	OTB_DEF_>=120_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	OTB_DEF_>=120_0_0_all_FDF	Denmark	4	27.3.a.20	68	2
Landings	SDN_DEF_>=120_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	SSC_DEF_>=120_0_0_all	Denmark	4	27.3.a.20	68	2
Landings	TBB_DEF_>=120_0_0_all	Denmark	4	27.3.a.20	68	2

Table 17.3.7. Saithe in Subareas 4 and 6 and Division 3.a: Amount (weight and proportion) of sampled or estimated age distributions of catch data imported or raised in InterCatch by ICES area.

Catch Category	Raised or Imported	Sampled Or Estimated	Area	Weight (tons)	Proportion
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.6	0	0
Landings	Imported_Data	Sampled_Distribution	27.6	4377	79
Landings	Imported_Data	Estimated_Distribution	27.6	1197	21
Discards	Imported_Data	Sampled_Distribution	27.6	177	98
Discards	Raised_Discards	Estimated_Distribution	27.6	2	1
Discards	Imported_Data	Estimated_Distribution	27.6	2	1
BMS landing	Imported_Data	Estimated_Distribution	27.6	5	100
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.4	0	0
Landings	Imported_Data	Sampled_Distribution	27.4	49563	82
Landings	Imported_Data	Estimated_Distribution	27.4	10996	18
Discards	Imported_Data	Sampled_Distribution	27.4	10074	96
Discards	Raised_Discards	Estimated_Distribution	27.4	442	4
Discards	Imported_Data	Estimated_Distribution	27.4	11	0
BMS landing	Imported_Data	Estimated_Distribution	27.4	176	100
Logbook Registered Discard	Imported_Data	Estimated_Distribution	27.3.a.20	0	0
Landings	Imported_Data	Estimated_Distribution	27.3.a.20	931	53
Landings	Imported_Data	Sampled_Distribution	27.3.a.20	838	47
Discards	Imported_Data	Sampled_Distribution	27.3.a.20	96	58
Discards	Imported_Data	Estimated_Distribution	27.3.a.20	60	36
Discards	Raised_Discards	Estimated_Distribution	27.3.a.20	10	6
BMS landing	Imported_Data	Estimated_Distribution	27.3.a.20	1	100

Table 17.3.8. Saithe in Subareas 4 and 6 and Division 3.a: Catch numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	26948	19395	16672	2358	1610	299	203	185
1968	36111	25387	14153	6166	433	247	127	147
1969	47014	21142	11869	7790	5795	810	642	151
1970	57920	91668	16102	12416	3932	1834	326	270
1971	108549	69105	35143	4848	4290	2910	1922	782
1972	74755	79033	27178	21711	3709	3014	1682	1625
1973	84484	45078	28822	16443	8511	2047	1391	2407
1974	104086	40345	15160	21179	14810	5321	1514	1977
1975	88613	30927	11077	7746	13792	9577	3591	2717
1976	323156	63447	12556	6401	4016	5488	3678	3528
1977	42701	65727	15839	5620	3814	3528	3909	4753
1978	54515	32608	19389	3390	1149	1057	788	3522
1979	25395	16999	12004	8906	2833	750	554	2112
1980	27203	14757	9677	6878	5714	1177	522	2327
1981	40705	9971	7235	3763	3368	3475	674	2564
1982	49595	48533	9848	6120	2166	1489	1007	1268
1983	43916	24637	27924	5813	4942	1529	1062	1342
1984	125848	38470	13910	13320	1673	1281	344	653
1985	208401	66489	14257	4878	3034	698	409	750
1986	86198	109080	16302	5509	2629	1490	457	910
1987	48545	116551	15019	3233	1829	1269	933	707
1988	50657	31577	37919	3918	1927	1130	796	687
1989	34408	36772	14156	11211	1572	757	430	493
1990	63454	23416	12154	4826	2803	762	288	368
1991	71710	35719	8016	3669	1733	976	376	463
1992	28617	40193	13691	3269	1539	712	531	426
1993	58813	24905	12715	3199	1583	1547	835	1037
1994	31034	48062	13992	4399	957	354	438	803
1995	41461	31130	15884	3864	3529	690	566	809
1996	17208	46468	12653	7915	3194	827	215	496
1997	23380	23077	32395	3763	2666	1036	299	292
1998	16113	37088	17570	16459	2253	1234	581	280
1999	14661	16588	28645	8588	10169	2401	914	665
2000	10985	20680	9597	12632	3190	3302	657	446
2001	24961	21100	24068	3429	3621	1814	1655	248
2002	17570	37489	14736	13731	2309	2544	1321	1575
2003	28296	31752	20631	6836	6855	1535	2000	2042
2004	13642	24479	15649	15220	2037	2164	1300	1066
2005	12690	15473	19060	20042	7956	1628	1188	1151
2006	17313	31972	10381	11286	8395	3824	1008	1281
2007	24614	13314	20919	7175	5564	3610	1218	930
2008	7620	30911	12540	14941	5088	3285	3551	3118
2009	7438	15507	14222	5847	8512	2994	1519	2945

2010	8766	9249	9440	6511	2671	4773	1679	2707
2011	12786	24269	8980	3674	2867	1208	1564	3877
2012	14334	13053	16948	4075	1977	1268	541	2611
2013	7267	30318	5312	7869	1890	1241	616	1658
2014	4055	14322	15195	3957	4124	1040	429	1389
2015	8369	8323	14259	8254	1862	1623	715	977
2016	7382	14241	9661	5729	2758	1430	853	1317

Table 17.3.9. Saithe in Subareas 4 and 6 and Division 3.a: Landings numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	17330	16220	15531	2303	1594	292	198	183
1968	23223	21231	13184	6023	429	242	123	145
1969	30235	17681	11057	7609	5738	791	626	150
1970	37249	76661	15000	12128	3894	1792	318	267
1971	69808	57792	32737	4736	4248	2843	1874	774
1972	48075	66095	25317	21207	3672	2944	1641	1607
1973	54332	37698	26849	16061	8428	2000	1357	2381
1974	66938	33740	14123	20688	14666	5199	1477	1955
1975	56987	25864	10319	7566	13657	9357	3501	2687
1976	207823	53060	11696	6253	3976	5362	3586	3490
1977	27461	54967	14755	5490	3777	3447	3812	4701
1978	35059	27269	18062	3312	1138	1033	768	3484
1979	16332	14216	11182	8699	2805	733	540	2089
1980	17494	12341	9015	6718	5658	1150	509	2302
1981	26178	8339	6739	3675	3335	3396	657	2536
1982	31895	40587	9174	5978	2145	1454	982	1254
1983	28242	20604	26013	5678	4893	1494	1036	1327
1984	80933	32172	12957	13011	1657	1252	335	646
1985	134024	55605	13281	4765	3005	682	399	742
1986	55435	91223	15186	5381	2603	1456	445	900
1987	31220	97470	13990	3158	1811	1240	910	700
1988	32578	26408	35323	3828	1908	1104	776	680
1989	22128	30752	13187	10951	1557	739	419	488
1990	40808	19583	11322	4714	2776	745	281	364
1991	46117	29871	7467	3583	1716	953	367	458
1992	18404	33614	12753	3193	1524	696	518	422
1993	37823	20828	11845	3125	1568	1511	814	1026
1994	19958	40193	13034	4297	947	346	427	794
1995	26664	26034	14797	3774	3494	674	552	800
1996	11066	38861	11786	7731	3163	808	210	491
1997	15036	19299	30177	3676	2640	1012	291	288
1998	10363	31017	16367	16077	2231	1206	567	277
1999	9429	13872	26684	8389	10070	2346	891	657
2000	7064	17295	8940	12339	3159	3226	641	441
2001	16052	17646	22421	3349	3586	1772	1614	245
2002	9131	31779	12286	13307	2245	2220	1199	1479
2003	13009	24646	20397	6836	6855	1535	2000	2042
2004	8037	20071	15649	15220	2037	2164	1300	1066
2005	9191	15473	19060	20042	7956	1628	1188	1151
2006	12200	26690	9986	11286	8395	3824	1008	1281
2007	15181	10163	19157	7078	5564	3610	1218	930
2008	6924	23230	10930	14196	4977	3276	3551	3118
2009	6607	14349	13827	5817	8419	2978	1505	2934

2010	7880	8859	9174	6394	2670	4762	1679	2669
2011	10150	22799	8852	3630	2860	1183	1563	3869
2012	7029	11712	15572	4016	1971	1267	537	2610
2013	4999	25516	4974	7645	1886	1241	616	1658
2014	3099	12117	13380	3737	4047	1036	429	1388
2015	6206	7392	13555	8021	1844	1621	715	975
2016	3508	10374	8756	5156	2732	1423	852	1317

Table 17.3.10. Saithe in Subareas 4 and 6 and Division 3.a: Discards numbers (thousands) at age for the age range used in the assessment.

Year/Age	3	4	5	6	7	8	9	10+
1967	9617	3175	1141	55	16	7	5	2
1968	12888	4156	969	143	4	6	3	2
1969	16779	3461	813	181	57	19	16	2
1970	20671	15007	1102	288	38	42	8	3
1971	38741	11313	2406	112	42	67	48	9
1972	26680	12938	1861	504	36	69	42	18
1973	30152	7380	1973	381	83	47	35	26
1974	37148	6605	1038	491	144	122	38	22
1975	31626	5063	758	180	135	220	89	30
1976	115333	10387	860	148	39	126	92	38
1977	15240	10760	1084	130	37	81	97	52
1978	19456	5338	1327	79	11	24	20	38
1979	9063	2783	822	207	28	17	14	23
1980	9709	2416	662	160	56	27	13	25
1981	14527	1632	495	87	33	80	17	28
1982	17700	7945	674	142	21	34	25	14
1983	15673	4033	1912	135	48	35	26	15
1984	44915	6298	952	309	16	29	9	7
1985	74378	10885	976	113	30	16	10	8
1986	30764	17857	1116	128	26	34	11	10
1987	17326	19080	1028	75	18	29	23	8
1988	18079	5169	2596	91	19	26	20	7
1989	12280	6020	969	260	15	17	11	5
1990	22647	3833	832	112	27	18	7	4
1991	25593	5847	549	85	17	22	9	5
1992	10213	6580	937	76	15	16	13	5
1993	20990	4077	871	74	15	36	21	11
1994	11076	7868	958	102	9	8	11	9
1995	14797	5096	1087	90	34	16	14	9
1996	6141	7607	866	184	31	19	5	5
1997	8344	3778	2218	87	26	24	7	3
1998	5751	6072	1203	382	22	28	14	3
1999	5233	2716	1961	199	99	55	23	7
2000	3920	3386	657	293	31	76	16	5
2001	8908	3454	1648	80	35	42	41	3
2002	8439	5710	2451	425	64	324	121	96
2003	15288	7106	234	0	0	0	0	0
2004	5605	4407	0	0	0	0	0	0
2005	3498	0	0	0	0	0	0	0
2006	5114	5282	394	0	0	0	0	0
2007	9433	3152	1762	97	0	0	0	0
2008	696	7682	1610	745	111	9	0	0
2009	831	1158	395	30	93	16	14	11

2010	886	390	266	117	1	11	0	38
2011	2636	1470	129	44	7	25	1	8
2012	7305	1341	1377	58	7	1	4	1
2013	2268	4801	339	224	4	0	0	1
2014	955	2205	1816	220	77	4	0	1
2015	2163	931	704	232	17	3	0	2
2016	3874	3867	905	573	26	7	1	0

Table 17.3.11. Saithe in Subareas 4 and 6 and Division 3.a: Catch weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.898	1.339	2.094	3.183	3.753	5.316	5.891	7.719
1968	1.234	1.624	1.979	3.007	4.039	4.428	6.136	7.406
1969	0.933	1.530	2.251	2.711	3.558	4.406	5.220	6.767
1970	0.908	1.416	2.049	2.716	3.599	4.463	5.687	6.845
1971	0.811	1.325	2.167	2.934	3.765	4.634	5.172	6.163
1972	0.780	1.175	1.952	2.367	3.793	4.228	4.630	6.326
1973	0.792	1.382	1.633	2.569	3.356	4.684	4.814	6.445
1974	0.831	1.534	2.372	2.751	3.428	4.498	5.713	7.857
1975	0.862	1.472	2.479	3.298	3.764	4.296	5.540	7.562
1976	0.678	1.287	2.250	3.068	4.034	4.383	5.112	7.147
1977	0.733	1.234	1.926	3.108	4.161	4.605	4.859	6.542
1978	0.793	1.304	2.145	3.338	4.521	4.900	5.449	7.400
1979	1.069	1.595	2.228	3.093	4.049	5.274	6.308	7.955
1980	0.921	1.790	2.380	3.028	4.089	5.126	5.939	8.148
1981	0.927	1.790	2.705	3.584	4.535	5.478	6.980	8.724
1982	1.048	1.548	2.518	3.218	4.206	5.125	5.905	8.823
1983	0.992	1.688	2.139	3.135	3.690	4.632	5.505	8.453
1984	0.767	1.586	2.286	2.688	3.895	4.665	6.183	8.474
1985	0.640	1.244	1.941	2.769	3.406	4.950	5.865	8.854
1986	0.670	1.018	1.786	2.430	3.571	4.209	5.651	8.218
1987	0.650	0.861	1.815	3.072	4.209	5.330	6.128	8.603
1988	0.752	0.964	1.379	2.789	4.023	5.254	6.322	8.649
1989	0.864	1.018	1.413	1.997	3.913	5.017	6.430	8.431
1990	0.815	1.175	1.575	2.245	3.241	4.858	6.315	8.416
1991	0.764	1.138	1.744	2.363	3.165	4.222	6.066	8.191
1992	0.930	1.169	1.599	2.240	3.667	4.330	5.412	7.045
1993	0.868	1.239	1.746	2.634	3.184	3.980	5.080	6.891
1994	0.911	1.100	1.594	2.432	3.617	4.787	6.548	8.326
1995	0.967	1.272	1.807	2.560	3.554	4.767	5.267	7.891
1996	0.933	1.167	1.798	2.366	2.951	4.705	6.092	8.382
1997	0.873	1.125	1.445	2.585	3.555	4.525	6.158	8.866
1998	0.861	0.949	1.386	1.743	2.948	3.883	4.996	7.227
1999	0.850	1.042	1.206	1.752	2.337	3.493	4.844	6.745
2000	0.992	1.107	1.532	1.683	2.593	3.084	4.773	7.461
2001	0.774	1.053	1.307	2.093	2.546	3.485	4.141	6.141
2002	0.776	1.014	1.495	1.791	2.961	3.761	4.638	5.750
2003	0.636	0.889	1.167	1.810	2.368	3.176	3.768	5.065
2004	0.794	1.010	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.715	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.904	1.012	1.489	1.906	2.424	3.058	4.318	5.734
2007	0.769	1.124	1.286	1.834	2.328	2.887	3.600	4.975
2008	0.916	1.065	1.488	1.692	2.210	2.792	3.206	4.565
2009	1.033	1.333	1.672	1.994	2.566	3.086	3.651	4.790
2010	1.037	1.474	2.033	2.597	3.163	3.488	3.968	5.223

2011	0.955	1.192	1.787	2.571	3.068	3.418	3.718	4.289
2012	0.910	1.287	1.383	2.196	3.221	3.536	4.181	4.482
2013	0.878	1.132	1.586	1.957	3.076	3.841	4.541	5.648
2014	1.091	1.265	1.568	2.334	2.607	4.010	5.530	6.679
2015	0.951	1.253	1.621	2.180	3.037	3.793	4.228	7.285
2016	0.937	1.239	1.611	2.231	2.888	3.450	4.331	6.208

Table 17.3.12. Saithe in Subareas 4 and 6 and Division 3.a: Landings weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.931	1.362	2.104	3.186	3.754	5.316	5.891	7.719
1968	1.278	1.652	1.989	3.009	4.040	4.428	6.136	7.406
1969	0.966	1.557	2.261	2.713	3.559	4.406	5.220	6.768
1970	0.941	1.441	2.059	2.718	3.600	4.463	5.687	6.845
1971	0.840	1.348	2.178	2.936	3.766	4.634	5.173	6.163
1972	0.808	1.196	1.961	2.369	3.794	4.228	4.630	6.326
1973	0.821	1.406	1.641	2.571	3.357	4.684	4.814	6.445
1974	0.861	1.561	2.383	2.753	3.429	4.498	5.713	7.857
1975	0.893	1.498	2.490	3.300	3.765	4.296	5.540	7.562
1976	0.702	1.309	2.260	3.071	4.035	4.383	5.112	7.147
1977	0.760	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.340	4.522	4.901	5.449	7.400
1979	1.107	1.623	2.238	3.095	4.050	5.274	6.308	7.955
1980	0.955	1.821	2.391	3.030	4.090	5.126	5.939	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.980	8.724
1982	1.086	1.575	2.529	3.220	4.207	5.125	5.905	8.823
1983	1.028	1.718	2.149	3.138	3.691	4.632	5.505	8.453
1984	0.795	1.614	2.297	2.690	3.896	4.665	6.183	8.474
1985	0.663	1.265	1.951	2.772	3.407	4.950	5.865	8.854
1986	0.694	1.035	1.794	2.432	3.572	4.209	5.651	8.218
1987	0.674	0.876	1.824	3.075	4.210	5.330	6.128	8.603
1988	0.779	0.981	1.386	2.791	4.024	5.254	6.322	8.649
1989	0.895	1.036	1.420	1.998	3.914	5.018	6.430	8.431
1990	0.844	1.196	1.583	2.247	3.242	4.858	6.315	8.416
1991	0.791	1.158	1.752	2.365	3.165	4.222	6.066	8.191
1992	0.964	1.189	1.607	2.242	3.668	4.330	5.413	7.046
1993	0.899	1.260	1.754	2.636	3.185	3.980	5.080	6.891
1994	0.944	1.119	1.601	2.434	3.618	4.787	6.548	8.326
1995	1.002	1.294	1.816	2.562	3.555	4.767	5.267	7.891
1996	0.967	1.187	1.807	2.368	2.952	4.705	6.092	8.382
1997	0.905	1.145	1.452	2.587	3.556	4.525	6.158	8.866
1998	0.892	0.966	1.393	1.744	2.949	3.883	4.996	7.227
1999	0.881	1.061	1.211	1.754	2.337	3.493	4.844	6.745
2000	1.027	1.127	1.539	1.684	2.594	3.084	4.773	7.462
2001	0.802	1.072	1.313	2.095	2.546	3.485	4.141	6.141
2002	0.923	1.035	1.478	1.769	2.947	3.426	4.407	5.674
2003	0.833	0.980	1.173	1.810	2.368	3.176	3.768	5.065
2004	0.918	1.084	1.392	1.896	2.860	3.687	4.814	7.059
2005	0.921	1.155	1.325	1.710	2.132	3.026	3.622	5.713
2006	0.945	1.069	1.514	1.906	2.424	3.058	4.318	5.734
2007	0.837	1.143	1.317	1.840	2.328	2.887	3.600	4.975
2008	0.944	1.193	1.565	1.720	2.226	2.795	3.206	4.565
2009	1.036	1.340	1.664	1.992	2.563	3.085	3.648	4.793
2010	1.036	1.479	2.034	2.597	3.164	3.488	3.968	5.199

2011	1.007	1.207	1.783	2.573	3.068	3.404	3.717	4.284
2012	1.015	1.321	1.408	2.201	3.223	3.536	4.177	4.482
2013	0.898	1.156	1.614	1.976	3.078	3.841	4.541	5.648
2014	1.126	1.300	1.607	2.384	2.617	4.013	5.530	6.679
2015	0.977	1.244	1.625	2.190	3.043	3.796	4.228	7.287
2016	0.998	1.292	1.628	2.283	2.892	3.453	4.333	6.208

Table 17.3.13. Saithe in Subareas 4 and 6 and Division 3.a: Discards weight-at-age (kg).

Year/Age	3	4	5	6	7	8	9	10+
1967	0.748	1.076	1.818	2.972	3.590	5.316	5.891	7.719
1968	1.028	1.306	1.719	2.808	3.864	4.428	6.136	7.406
1969	0.777	1.230	1.955	2.531	3.403	4.406	5.220	6.767
1970	0.757	1.139	1.780	2.536	3.442	4.463	5.687	6.845
1971	0.676	1.065	1.882	2.739	3.601	4.634	5.172	6.163
1972	0.650	0.945	1.695	2.210	3.628	4.228	4.630	6.326
1973	0.660	1.111	1.419	2.399	3.210	4.684	4.814	6.445
1974	0.692	1.233	2.060	2.568	3.279	4.498	5.713	7.857
1975	0.718	1.184	2.153	3.079	3.600	4.296	5.540	7.562
1976	0.565	1.035	1.954	2.865	3.858	4.383	5.112	7.147
1977	0.611	0.993	1.673	2.902	3.980	4.605	4.859	6.542
1978	0.661	1.049	1.862	3.116	4.325	4.900	5.449	7.400
1979	0.890	1.283	1.935	2.888	3.873	5.274	6.308	7.955
1980	0.768	1.439	2.067	2.827	3.911	5.126	5.939	8.148
1981	0.773	1.439	2.349	3.346	4.338	5.478	6.980	8.724
1982	0.873	1.245	2.186	3.004	4.023	5.125	5.905	8.823
1983	0.826	1.358	1.858	2.927	3.529	4.632	5.505	8.453
1984	0.639	1.276	1.985	2.510	3.726	4.665	6.183	8.474
1985	0.533	1.000	1.686	2.586	3.258	4.950	5.865	8.854
1986	0.558	0.818	1.551	2.269	3.416	4.209	5.651	8.218
1987	0.542	0.693	1.576	2.869	4.026	5.330	6.128	8.603
1988	0.626	0.775	1.198	2.604	3.848	5.254	6.322	8.649
1989	0.720	0.819	1.227	1.865	3.743	5.017	6.430	8.431
1990	0.679	0.945	1.368	2.097	3.100	4.858	6.315	8.416
1991	0.636	0.915	1.515	2.206	3.027	4.222	6.066	8.191
1992	0.775	0.940	1.389	2.092	3.508	4.330	5.412	7.045
1993	0.723	0.996	1.517	2.460	3.046	3.980	5.080	6.891
1994	0.759	0.884	1.384	2.271	3.459	4.787	6.548	8.326
1995	0.806	1.023	1.570	2.390	3.400	4.767	5.267	7.891
1996	0.778	0.938	1.562	2.209	2.823	4.705	6.092	8.382
1997	0.728	0.905	1.255	2.413	3.400	4.525	6.158	8.866
1998	0.717	0.764	1.204	1.627	2.820	3.883	4.996	7.227
1999	0.708	0.838	1.047	1.636	2.235	3.493	4.844	6.745
2000	0.826	0.890	1.330	1.571	2.480	3.084	4.773	7.461
2001	0.645	0.847	1.135	1.955	2.435	3.485	4.141	6.141
2002	0.616	0.896	1.580	2.483	3.469	6.058	6.935	6.927
2003	0.469	0.571	0.641	1.689	2.265	3.176	3.768	5.065
2004	0.617	0.676	1.203	1.769	2.735	3.687	4.814	7.059
2005	0.741	0.913	1.146	1.595	2.038	3.026	3.622	5.713
2006	0.808	0.724	0.859	1.778	2.318	3.058	4.318	5.734
2007	0.660	1.062	0.949	1.365	2.227	2.887	3.600	4.975
2008	0.633	0.680	0.967	1.161	1.495	1.820	3.206	2.797
2009	1.010	1.253	1.946	2.403	2.838	3.388	3.934	3.911
2010	1.046	1.374	1.987	2.561	3.025	3.351	3.968	6.895

2011	0.756	0.971	2.054	2.445	3.170	4.072	4.369	6.618
2012	0.808	0.997	1.101	1.831	2.675	3.411	4.804	5.313
2013	0.835	1.003	1.180	1.300	2.298	3.841	4.541	5.861
2014	0.977	1.072	1.274	1.487	2.077	3.223	5.530	7.568
2015	0.877	1.326	1.531	1.848	2.410	2.184	4.228	5.911
2016	0.882	1.096	1.440	1.764	2.384	2.864	2.634	4.282

Table 17.4.1. Saithe in Subareas 4 and 6 and Division 3.a: Data available for calibration of the final assessment. Indices include one commercial standardized cpue index (year effects), tuned to the exploitable biomass within SAM, and indices for age 3–8 from one research survey, the third quarter NS–IBTS.

IBTS–Q3 (DATRAS standard index)							**cpue**
Year	3	4	5	6	7	8	
1992	1.077	2.760	0.516	0.098	0.057	0.050	
1993	7.965	2.781	1.129	0.197	0.011	0.040	
1994	1.117	1.615	0.893	0.609	0.091	0.040	
1995	13.959	2.501	1.559	0.533	0.172	0.049	
1996	3.825	6.533	1.112	0.971	0.212	0.069	
1997	3.756	3.351	7.461	0.698	0.534	0.181	
1998	1.181	4.134	1.351	1.580	0.149	0.179	
1999	2.086	1.907	3.155	0.619	0.632	0.074	
2000	3.479	8.836	1.081	0.868	0.114	0.152	0.2341
2001	21.494	6.173	3.937	0.355	0.444	0.113	0.3502
2002	10.748	18.974	1.327	1.090	0.162	0.264	0.1439
2003	19.272	23.802	13.402	0.393	0.439	0.168	0.0723
2004	4.930	6.727	3.237	0.921	0.064	0.085	0.3102
2005	8.916	7.512	4.428	1.914	1.082	0.104	0.4029
2006	10.553	29.579	2.835	1.177	0.445	0.242	0.4403
2007	34.006	5.578	11.700	1.016	0.743	0.358	0.2550
2008	3.312	5.584	0.907	1.997	0.254	0.254	0.4412
2009	1.346	1.703	0.568	0.101	0.229	0.200	0.1948
2010	1.361	0.964	0.471	0.205	0.045	0.166	0.1222
2011	4.520	8.451	1.059	1.114	0.426	0.080	0.1142
2012	11.134	2.497	2.968	0.503	0.483	0.344	-0.0154
2013	14.701	16.279	1.830	1.858	0.308	0.146	0.0779
2014	1.649	3.923	2.822	0.481	0.520	0.114	0.0532
2015	11.001	5.613	4.611	1.581	0.289	0.285	0.1678
2016	37.740	17.307	3.212	2.644	0.929	0.192	0.0414

Table 17.4.2. Saithe in Subareas 4 and 6 and Division 3.a: Data available for calibration for the exploratory assessments. NS–IBTS Q3 indices for age 3–8, where the 2016 large catch of saithe was removed from the indices estimation and the cpue index, where the German cpue data for 2016 were excluded.

IBTS–Q3 (DATRAS STANDARD INDEX)							CPUE
Year	3	4	5	6	7	8	
1992	1.077	2.760	0.516	0.098	0.057	0.050	
1993	7.965	2.781	1.129	0.197	0.011	0.040	
1994	1.117	1.615	0.893	0.609	0.091	0.040	
1995	13.959	2.501	1.559	0.533	0.172	0.049	
1996	3.825	6.533	1.112	0.971	0.212	0.069	
1997	3.756	3.351	7.461	0.698	0.534	0.181	
1998	1.181	4.134	1.351	1.580	0.149	0.179	
1999	2.086	1.907	3.155	0.619	0.632	0.074	
2000	3.479	8.836	1.081	0.868	0.114	0.152	0.2480
2001	21.494	6.173	3.937	0.355	0.444	0.113	0.3642
2002	10.748	18.974	1.327	1.090	0.162	0.264	0.1541
2003	19.272	23.802	13.402	0.393	0.439	0.168	0.0824
2004	4.930	6.727	3.237	0.921	0.064	0.085	0.3200
2005	8.916	7.512	4.428	1.914	1.082	0.104	0.4126
2006	10.553	29.579	2.835	1.177	0.445	0.242	0.4511
2007	34.006	5.578	11.700	1.016	0.743	0.358	0.2656
2008	3.312	5.584	0.907	1.997	0.254	0.254	0.4520
2009	1.346	1.703	0.568	0.101	0.229	0.200	0.2038
2010	1.361	0.964	0.471	0.205	0.045	0.166	0.1297
2011	4.520	8.451	1.059	1.114	0.426	0.080	0.1231
2012	11.134	2.497	2.968	0.503	0.483	0.344	-0.00561
2013	14.701	16.279	1.830	1.858	0.308	0.146	0.08795
2014	1.649	3.923	2.822	0.481	0.520	0.114	0.06308
2015	11.001	5.613	4.611	1.581	0.289	0.285	0.1777
2016	18.821	11.393	2.927	2.405	0.810	0.166	0.1706

Table 17.4.3. Saithe in Subareas 4 and 6 and Division 3.a: Model configuration for the SAM assessment.

Min Age: 3
Max Age: 10
Max Age considered a plus group (Yes)
The following matrix describes the coupling of fishing mortality STATES, where rows represent fleets and columns represent ages:

1	2	3	4	5	6	7	7
0	0	0	0	0	0	0	0

Use correlated random walks for the fishing mortalities: (2=AR1)
2
Coupling of catchability PARAMETERS

0	0	0	0	0	0	0	0
1	2	3	4	5	6	0	0

Coupling of power law model EXPONENTS (if used)

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Coupling of fishing mortality RW VARIANCES

1	2	2	2	2	2	2	2
0	0	0	0	0	0	0	0

Coupling of log N RW VARIANCES

1	2	2	2	2	2	2	2

Coupling of OBSERVATION VARIANCES

1	1	1	1	1	1	1	1
2	2	2	2	2	2	0	0

Stock recruitment model code (random walk)
Years in which catch data are to be scaled by an estimated parameter
0
Fbar range: 4 to 7
Observation correlation coupling (0 = uncorrelated). Rows represent fleets, columns represent adjacent age groups, i.e. the first column is the correlation between the first and 2nd age group. An NA in all non-empty age groups for a fleet specifies unstructured correlation. NA's and positive numbers cannot be mixed within fleets.

0	0	0	0	0	0	0
NA	NA	NA	NA	NA	0	0

Table 17.4.4. Saithe in Subareas 4 and 6 and Division 3.a: Fishing mortalities at age from the exploratory assessment, where the 2016 single large catch of saithe was removed from the indices estimation.

YEAR\AGE	3	4	5	6	7	8	9+
1967	0.266	0.385	0.355	0.351	0.312	0.281	0.312
1968	0.238	0.345	0.302	0.284	0.245	0.221	0.248
1969	0.256	0.371	0.324	0.311	0.276	0.252	0.274
1970	0.304	0.418	0.352	0.326	0.283	0.253	0.267
1971	0.370	0.468	0.377	0.345	0.308	0.284	0.296
1972	0.446	0.521	0.404	0.367	0.331	0.306	0.310
1973	0.523	0.572	0.428	0.38	0.345	0.319	0.317
1974	0.635	0.662	0.495	0.435	0.397	0.364	0.350
1975	0.657	0.694	0.535	0.475	0.441	0.409	0.385
1976	0.748	0.774	0.608	0.530	0.485	0.444	0.408
1977	0.633	0.712	0.597	0.540	0.509	0.473	0.429
1978	0.502	0.586	0.492	0.439	0.416	0.388	0.354
1979	0.420	0.522	0.458	0.422	0.409	0.381	0.346
1980	0.405	0.521	0.478	0.453	0.448	0.424	0.386
1981	0.364	0.498	0.472	0.459	0.465	0.453	0.417
1982	0.431	0.584	0.553	0.521	0.509	0.482	0.435
1983	0.514	0.702	0.674	0.626	0.598	0.555	0.492
1984	0.588	0.793	0.725	0.628	0.561	0.504	0.442
1985	0.629	0.870	0.772	0.624	0.539	0.482	0.434
1986	0.591	0.897	0.821	0.653	0.563	0.51	0.476
1987	0.539	0.845	0.794	0.63	0.551	0.508	0.488
1988	0.527	0.831	0.803	0.645	0.565	0.52	0.501
1989	0.517	0.812	0.783	0.626	0.536	0.481	0.461
1990	0.502	0.784	0.749	0.589	0.498	0.437	0.418
1991	0.465	0.744	0.719	0.563	0.477	0.415	0.404
1992	0.411	0.693	0.695	0.557	0.480	0.417	0.408
1993	0.390	0.679	0.709	0.600	0.556	0.498	0.494
1994	0.319	0.595	0.629	0.536	0.509	0.462	0.466
1995	0.275	0.551	0.618	0.555	0.558	0.525	0.529
1996	0.218	0.465	0.545	0.504	0.503	0.477	0.474
1997	0.184	0.403	0.476	0.443	0.433	0.414	0.410
1998	0.184	0.402	0.486	0.458	0.436	0.418	0.407
1999	0.182	0.409	0.513	0.504	0.478	0.465	0.447
2000	0.157	0.362	0.454	0.444	0.403	0.381	0.363
2001	0.150	0.345	0.425	0.412	0.362	0.339	0.324
2002	0.144	0.334	0.422	0.439	0.399	0.390	0.399
2003	0.151	0.338	0.420	0.459	0.426	0.419	0.434
2004	0.131	0.303	0.367	0.403	0.372	0.365	0.371
2005	0.135	0.315	0.383	0.415	0.376	0.358	0.347
2006	0.151	0.340	0.402	0.424	0.382	0.363	0.347
2007	0.141	0.331	0.388	0.398	0.355	0.337	0.322
2008	0.159	0.385	0.468	0.470	0.414	0.391	0.363

2009	0.151	0.379	0.473	0.477	0.424	0.407	0.378
2010	0.136	0.359	0.456	0.459	0.415	0.409	0.379
2011	0.144	0.374	0.470	0.456	0.405	0.401	0.368
2012	0.121	0.337	0.430	0.417	0.368	0.371	0.345
2013	0.100	0.296	0.385	0.377	0.334	0.342	0.318
2014	0.085	0.263	0.352	0.346	0.307	0.320	0.302
2015	0.083	0.257	0.348	0.335	0.292	0.306	0.288
2016	0.074	0.238	0.326	0.312	0.275	0.298	0.289

Table 17.4.5. Saithe in Subareas 4 and 6 and Division 3.a: Estimated population numbers-at-age from the exploratory assessment, where the 2013 single large catch of saithe was removed from the indices estimation.

YEAR\AGE	3	4	5	6	7	8	9	10+
1967	141214	81555	57300	7168	4919	1156	756	692
1968	160806	92009	50358	31832	3738	2541	663	789
1969	283611	90541	54392	31030	20494	2839	1962	831
1970	293507	215298	49130	35315	18664	11717	1803	1640
1971	353486	191259	118763	24655	19411	11921	7828	2516
1972	224293	208870	102840	67162	14505	11361	7300	6503
1973	201193	111371	105129	63156	35692	8673	6335	8602
1974	199450	90664	48373	62556	41839	20494	5389	8537
1975	235105	76712	35500	24220	36056	25022	11950	8482
1976	402068	102730	29687	17397	12866	19054	13217	11556
1977	150134	148179	35697	12439	8663	7178	10709	13941
1978	120361	72453	58085	14259	5121	4007	3387	13113
1979	87621	53878	34784	29268	7800	2813	2208	9530
1980	85772	47073	25686	18710	16068	4036	1666	7675
1981	162213	41929	24886	12280	9623	8272	2140	5888
1982	141025	108001	22966	15033	6271	4817	3766	4076
1983	148885	69649	54747	11330	8253	3131	2523	3823
1984	255043	76270	30029	23811	4730	3476	1333	2795
1985	354609	108255	29519	12790	9463	2224	1593	2306
1986	289292	141746	32292	11792	6368	4481	1194	2266
1987	149495	163559	36391	10218	5146	3290	2291	1806
1988	137947	71554	61444	11444	4557	2597	1744	1940
1989	102796	69312	27733	21794	4717	2095	1247	1660
1990	150978	48095	25702	11146	8394	2314	1030	1417
1991	174056	71590	17434	10264	5273	3809	1242	1401
1992	104260	88737	26161	6824	5187	2865	2068	1492
1993	175018	59356	34116	9223	2923	3139	1811	2274
1994	117877	96978	28740	13530	3487	1422	1479	2175
1995	213971	66703	41980	13027	6462	1646	930	1952
1996	119361	148560	29920	19710	7042	2538	724	1369
1997	148666	79631	90036	13330	9363	3459	1143	1003
1998	87838	120820	45366	49154	7308	4702	1903	1083
1999	111546	55445	74133	22721	26866	4287	2440	1669
2000	97536	93446	29286	36962	11118	12880	2066	1809
2001	204560	67514	64273	14184	17847	6425	7077	1692
2002	162492	143641	35003	34434	8286	9830	3936	5159
2003	166582	123055	84792	16848	17492	5340	5387	5122
2004	117139	109622	76094	49054	8150	8388	3337	4826
2005	143280	75920	67744	50139	28162	5065	4612	4481
2006	101626	123637	42331	37302	27072	14366	3132	5017
2007	154144	55416	77615	24433	19990	15047	7304	4504
2008	73677	98269	31355	48577	15508	11352	10147	8380

2009	58888	51618	43542	14651	24993	9717	5984	10577
2010	89437	38324	28285	20240	7208	13307	5663	9875
2011	82269	78339	22849	14416	10216	3769	6679	10299
2012	138232	47826	47008	12147	7630	5136	2054	9623
2013	97782	104750	23673	26627	7073	4196	2757	6770
2014	61337	72591	57148	13637	14973	4271	2198	5663
2015	105699	46280	48538	30928	8208	7930	2779	4773
2016	124785	75647	30524	26880	16196	5226	4379	4942

Table 17.4.6. Saithe in Subareas 4 and 6 and Division 3.a: Fishing mortalities at age from the exploratory assessment, where the German cpue data for 2016 were excluded.

YEAR\AGE	3	4	5	6	7	8	9+
1967	0.265	0.385	0.356	0.352	0.312	0.281	0.312
1968	0.236	0.344	0.301	0.283	0.244	0.220	0.247
1969	0.254	0.370	0.323	0.311	0.276	0.251	0.274
1970	0.303	0.417	0.351	0.326	0.282	0.252	0.265
1971	0.370	0.467	0.376	0.344	0.307	0.283	0.295
1972	0.447	0.521	0.404	0.367	0.330	0.305	0.309
1973	0.525	0.572	0.428	0.379	0.344	0.318	0.316
1974	0.640	0.662	0.495	0.435	0.397	0.363	0.349
1975	0.660	0.694	0.535	0.474	0.441	0.408	0.384
1976	0.754	0.776	0.609	0.531	0.486	0.444	0.408
1977	0.635	0.712	0.598	0.541	0.511	0.474	0.430
1978	0.502	0.585	0.491	0.439	0.416	0.388	0.353
1979	0.418	0.521	0.458	0.421	0.408	0.380	0.345
1980	0.404	0.520	0.478	0.453	0.448	0.424	0.386
1981	0.361	0.496	0.471	0.459	0.465	0.454	0.417
1982	0.430	0.583	0.552	0.521	0.509	0.482	0.436
1983	0.514	0.702	0.674	0.627	0.600	0.557	0.493
1984	0.590	0.793	0.726	0.628	0.560	0.504	0.442
1985	0.632	0.872	0.773	0.623	0.539	0.481	0.434
1986	0.591	0.898	0.821	0.652	0.563	0.510	0.476
1987	0.538	0.844	0.794	0.63	0.550	0.508	0.488
1988	0.527	0.831	0.804	0.644	0.565	0.520	0.501
1989	0.517	0.812	0.783	0.626	0.535	0.481	0.460
1990	0.503	0.785	0.749	0.588	0.497	0.436	0.417
1991	0.466	0.745	0.719	0.561	0.476	0.414	0.402
1992	0.411	0.693	0.695	0.556	0.478	0.415	0.406
1993	0.390	0.680	0.710	0.600	0.557	0.498	0.494
1994	0.318	0.594	0.629	0.535	0.508	0.461	0.465
1995	0.274	0.551	0.618	0.555	0.559	0.526	0.529
1996	0.216	0.464	0.545	0.504	0.503	0.477	0.473
1997	0.182	0.401	0.475	0.442	0.431	0.413	0.407
1998	0.183	0.401	0.485	0.457	0.435	0.417	0.405
1999	0.181	0.408	0.513	0.504	0.478	0.464	0.444
2000	0.157	0.362	0.453	0.443	0.401	0.379	0.359
2001	0.150	0.345	0.424	0.411	0.360	0.336	0.320
2002	0.143	0.334	0.421	0.438	0.399	0.389	0.398
2003	0.151	0.338	0.419	0.459	0.427	0.419	0.434
2004	0.130	0.302	0.365	0.402	0.371	0.363	0.369
2005	0.135	0.314	0.381	0.414	0.374	0.356	0.344
2006	0.152	0.340	0.401	0.423	0.381	0.361	0.345
2007	0.141	0.330	0.385	0.396	0.353	0.335	0.319
2008	0.159	0.386	0.467	0.470	0.413	0.389	0.361
2009	0.150	0.378	0.470	0.475	0.422	0.405	0.377

2010	0.134	0.355	0.451	0.455	0.412	0.405	0.377
2011	0.141	0.370	0.464	0.451	0.401	0.397	0.366
2012	0.117	0.330	0.420	0.409	0.362	0.365	0.342
2013	0.094	0.286	0.371	0.365	0.325	0.334	0.313
2014	0.077	0.248	0.333	0.329	0.294	0.308	0.295
2015	0.072	0.235	0.320	0.310	0.272	0.286	0.275
2016	0.062	0.213	0.294	0.283	0.249	0.270	0.263

Table 17.4.7. Saithe in Subareas 4 and 6 and Division 3.a: Estimated population numbers-at-age from the exploratory assessment, where the German cpue data for 2016 were excluded.

YEAR\AGE	3	4	5	6	7	8	9	10+
1967	141502	81722	57335	7176	4922	1157	756	692
1968	161024	92188	50403	31885	3752	2552	665	790
1969	284966	90825	54509	31080	20528	2845	1967	835
1970	294492	215726	49249	35338	18706	11760	1809	1648
1971	354211	191803	118943	24750	19450	11948	7852	2521
1972	224070	209219	103124	67243	14550	11388	7320	6521
1973	200867	111327	105313	63280	35772	8698	6359	8623
1974	199023	90550	48416	62605	41849	20541	5402	8569
1975	234915	76498	35499	24243	36051	25007	11970	8501
1976	402429	102427	29644	17396	12873	19058	13220	11574
1977	150217	147817	35626	12424	8656	7168	10698	13946
1978	120283	72340	58023	14259	5126	4008	3389	13120
1979	87732	53917	34760	29257	7797	2816	2211	9547
1980	85798	47199	25709	18700	16056	4038	1667	7678
1981	162861	42047	24940	12294	9618	8262	2140	5878
1982	141132	108260	23003	15038	6276	4815	3767	4074
1983	148928	69833	54784	11335	8241	3130	2519	3825
1984	254660	76275	30081	23792	4733	3473	1333	2798
1985	353961	108046	29516	12803	9469	2225	1595	2307
1986	289912	141283	32271	11785	6368	4485	1194	2266
1987	149604	163335	36396	10229	5147	3287	2291	1805
1988	138069	71671	61351	11467	4561	2596	1741	1941
1989	102693	69357	27762	21771	4729	2098	1247	1662
1990	150630	48089	25726	11155	8407	2321	1033	1421
1991	174096	71335	17445	10276	5284	3824	1246	1405
1992	104542	88712	26027	6835	5195	2874	2078	1498
1993	175572	59384	34140	9207	2937	3134	1813	2279
1994	118335	97354	28623	13541	3494	1424	1479	2177
1995	213766	66985	42222	13007	6454	1651	929	1953
1996	119440	148443	30041	19764	7027	2540	726	1370
1997	150053	79727	89687	13396	9392	3456	1147	1007
1998	88550	121287	45344	49071	7345	4718	1906	1090
1999	112503	55878	74186	22814	26846	4297	2452	1677
2000	97831	94010	29479	37031	11180	12893	2077	1826
2001	203804	67736	64624	14279	17885	6464	7107	1717
2002	162175	142905	35111	34452	8317	9854	3955	5191
2003	167360	122951	84624	16897	17526	5343	5400	5144
2004	117468	110255	76289	49072	8182	8409	3337	4855
2005	143457	76356	68190	50354	28152	5079	4634	4507
2006	101183	123518	42707	37462	27198	14379	3142	5052
2007	153490	55482	77802	24635	20033	15113	7339	4536
2008	73558	98286	31490	48778	15655	11403	10193	8421
2009	59170	51647	43627	14685	25058	9830	6020	10624

2010	90573	38716	28345	20351	7232	13387	5718	9913
2011	83209	79192	23189	14539	10307	3785	6741	10348
2012	141328	48790	47731	12340	7709	5212	2070	9703
2013	101496	107205	24497	27225	7227	4262	2809	6851
2014	65480	75601	59057	14272	15467	4401	2253	5775
2015	119588	49265	51241	32598	8764	8319	2902	4939
2016	157786	87100	33059	29451	17760	5765	4730	5284

Table 17.4.8. Saithe in Subareas 4 and 6 and Division 3.a: Fishing mortalities at age for the final assessment model.

YEAR\AGE	3	4	5	6	7	8	9+
1967	0.265	0.384	0.356	0.352	0.312	0.282	0.313
1968	0.237	0.345	0.302	0.285	0.245	0.221	0.249
1969	0.254	0.370	0.324	0.311	0.276	0.252	0.275
1970	0.303	0.418	0.352	0.326	0.282	0.253	0.266
1971	0.370	0.467	0.376	0.345	0.307	0.283	0.296
1972	0.447	0.520	0.403	0.367	0.330	0.305	0.310
1973	0.525	0.572	0.427	0.379	0.344	0.318	0.316
1974	0.640	0.662	0.494	0.434	0.396	0.363	0.349
1975	0.660	0.694	0.534	0.474	0.441	0.408	0.384
1976	0.753	0.775	0.608	0.530	0.485	0.443	0.407
1977	0.634	0.711	0.597	0.540	0.510	0.474	0.429
1978	0.503	0.586	0.491	0.439	0.416	0.388	0.353
1979	0.419	0.521	0.458	0.422	0.409	0.381	0.345
1980	0.404	0.520	0.478	0.453	0.449	0.425	0.387
1981	0.362	0.496	0.471	0.459	0.466	0.455	0.418
1982	0.430	0.583	0.552	0.521	0.510	0.483	0.436
1983	0.513	0.701	0.673	0.627	0.599	0.557	0.493
1984	0.590	0.793	0.726	0.628	0.560	0.503	0.441
1985	0.632	0.873	0.773	0.623	0.538	0.481	0.433
1986	0.590	0.899	0.822	0.652	0.562	0.509	0.476
1987	0.537	0.845	0.795	0.629	0.550	0.508	0.488
1988	0.526	0.831	0.804	0.644	0.564	0.520	0.501
1989	0.517	0.812	0.783	0.626	0.535	0.480	0.460
1990	0.503	0.785	0.750	0.588	0.497	0.435	0.417
1991	0.466	0.746	0.719	0.561	0.475	0.414	0.403
1992	0.411	0.694	0.696	0.556	0.479	0.415	0.407
1993	0.390	0.679	0.709	0.599	0.556	0.498	0.494
1994	0.319	0.595	0.629	0.535	0.509	0.462	0.467
1995	0.274	0.551	0.618	0.555	0.560	0.526	0.530
1996	0.217	0.465	0.546	0.505	0.505	0.479	0.476
1997	0.183	0.403	0.477	0.444	0.434	0.416	0.411
1998	0.183	0.402	0.486	0.459	0.437	0.42	0.409
1999	0.181	0.408	0.513	0.504	0.480	0.467	0.449
2000	0.157	0.362	0.455	0.445	0.404	0.383	0.364
2001	0.150	0.346	0.426	0.413	0.362	0.34	0.324
2002	0.144	0.335	0.423	0.440	0.400	0.391	0.400
2003	0.151	0.339	0.420	0.460	0.428	0.42	0.436
2004	0.131	0.302	0.367	0.403	0.373	0.366	0.372
2005	0.135	0.315	0.382	0.416	0.376	0.359	0.348
2006	0.152	0.341	0.402	0.424	0.382	0.363	0.348
2007	0.142	0.332	0.388	0.397	0.354	0.337	0.322
2008	0.160	0.386	0.468	0.470	0.413	0.390	0.363
2009	0.151	0.380	0.473	0.477	0.423	0.406	0.378

2010	0.136	0.359	0.456	0.459	0.415	0.408	0.379
2011	0.143	0.375	0.472	0.457	0.405	0.401	0.369
2012	0.120	0.338	0.432	0.418	0.369	0.371	0.345
2013	0.098	0.296	0.386	0.378	0.334	0.342	0.319
2014	0.082	0.261	0.353	0.346	0.307	0.32	0.303
2015	0.079	0.253	0.347	0.334	0.290	0.304	0.289
2016	0.068	0.229	0.320	0.307	0.2700	0.295	0.288

Table 17.4.9. Saithe in Subareas 4 and 6 and Division 3.a: Estimated population numbers-at-age for the final assessment model.

YEAR\AGE	3	4	5	6	7	8	9	10+
1967	141514	81691	57277	7165	4913	1154	754	690
1968	160859	92165	50362	31839	3745	2546	663	787
1969	284822	90729	54455	31031	20484	2837	1960	831
1970	294503	215599	49203	35292	18675	11736	1803	1641
1971	354127	191801	118882	24734	19425	11928	7835	2511
1972	224106	209219	103148	67230	14543	11375	7308	6503
1973	200845	111342	105345	63310	35776	8695	6353	8605
1974	199013	90517	48427	62638	41867	20547	5401	8559
1975	234919	76493	35505	24261	36079	25023	11977	8497
1976	401972	102403	29646	17405	12884	19077	13234	11581
1977	150280	147784	35635	12430	8661	7174	10713	13963
1978	120225	72389	58040	14266	5129	4009	3391	13133
1979	87717	53869	34753	29245	7793	2815	2210	9548
1980	85814	47173	25688	18689	16042	4033	1665	7673
1981	162770	42053	24936	12288	9612	8252	2137	5872
1982	141141	108191	23004	15034	6273	4811	3762	4069
1983	149021	69838	54768	11336	8238	3129	2517	3823
1984	254611	76346	30104	23800	4735	3473	1334	2800
1985	353772	108050	29531	12809	9473	2226	1596	2309
1986	289914	141237	32261	11787	6371	4487	1194	2267
1987	149682	163377	36383	10228	5149	3289	2292	1806
1988	138104	71710	61324	11464	4562	2597	1742	1942
1989	102737	69402	27766	21765	4730	2099	1248	1662
1990	150580	48109	25735	11153	8407	2321	1033	1421
1991	174149	71305	17440	10279	5282	3824	1246	1405
1992	104585	88805	26001	6830	5199	2872	2078	1497
1993	175575	59319	34162	9202	2938	3133	1812	2276
1994	118405	97347	28625	13551	3495	1425	1478	2173
1995	213393	66960	42177	12998	6440	1653	928	1948
1996	119173	148203	30018	19732	7007	2532	726	1364
1997	149745	79410	89501	13375	9354	3435	1141	1000
1998	88800	120791	45188	48855	7327	4685	1890	1080
1999	112273	56009	73932	22764	26675	4278	2430	1659
2000	97570	93770	29467	36827	11157	12780	2059	1803
2001	202590	67606	64376	14243	17749	6443	7037	1695
2002	162163	142708	35034	34377	8292	9778	3937	5143
2003	167325	122700	84600	16829	17504	5301	5362	5108
2004	117047	110306	76216	48957	8146	8390	3309	4818
2005	142683	76212	68022	50247	27976	5048	4610	4464
2006	100788	123047	42665	37296	27185	14243	3119	5011
2007	152005	55325	77771	24638	19935	15106	7278	4500
2008	73322	97281	31302	48594	15635	11348	10157	8341
2009	58977	51538	43276	14588	25008	9837	5990	10562

2010	89587	38593	28176	20200	7175	13374	5707	9854
2011	81755	78115	22978	14377	10213	3744	6708	10272
2012	138077	47824	46884	12145	7580	5157	2044	9618
2013	98200	104416	23865	26511	7059	4167	2765	6760
2014	62041	73118	57185	13746	14912	4263	2190	5660
2015	110334	46382	48894	31041	8307	7910	2772	4768
2016	142625	79070	30246	27008	16356	5338	4382	4931

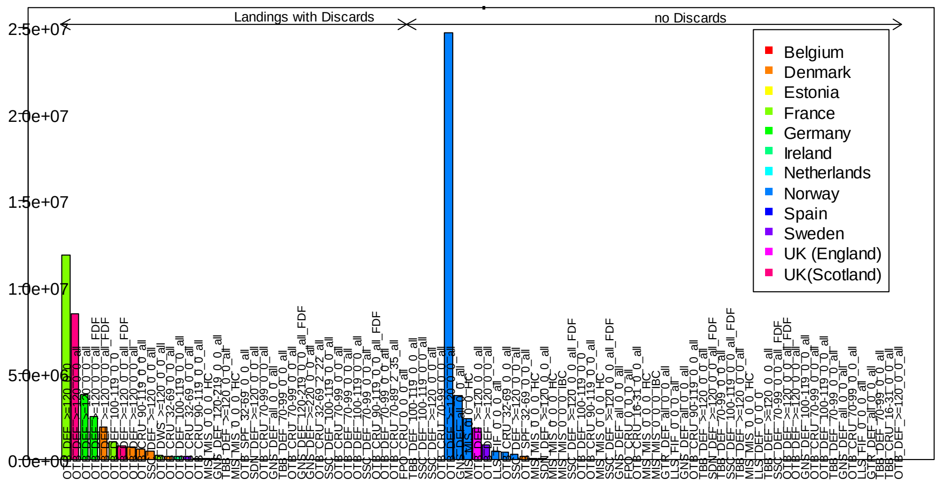


Figure 17.3.1. Saithe in Subareas 4 and 6 and Division 3.a: Summary of landings for fleets with and without discard estimates.

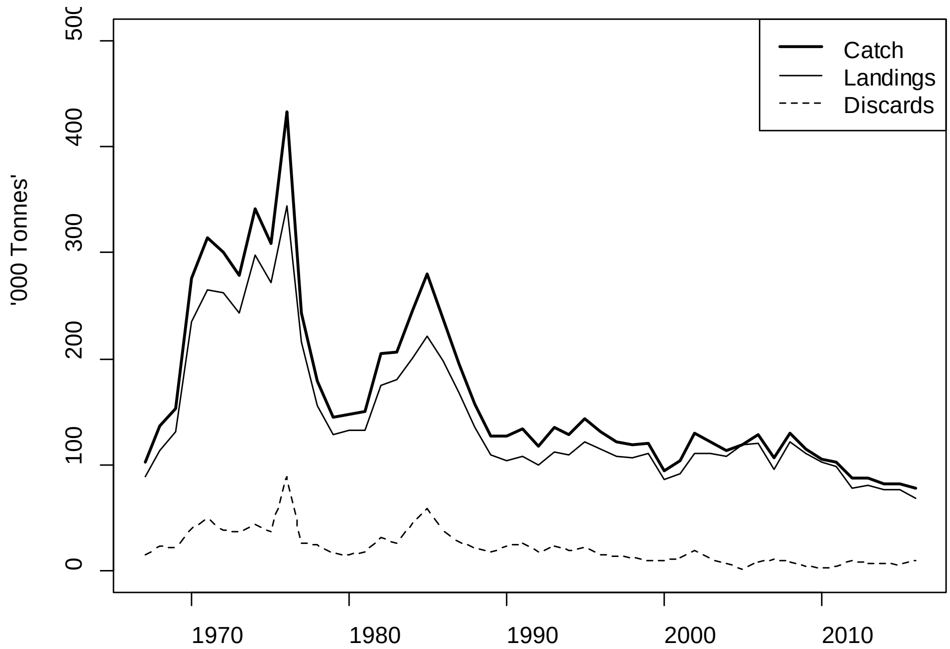


Figure 17.3.2. Saithe in Subareas 4 and 6 and Division 3.a: Yield by catch component.

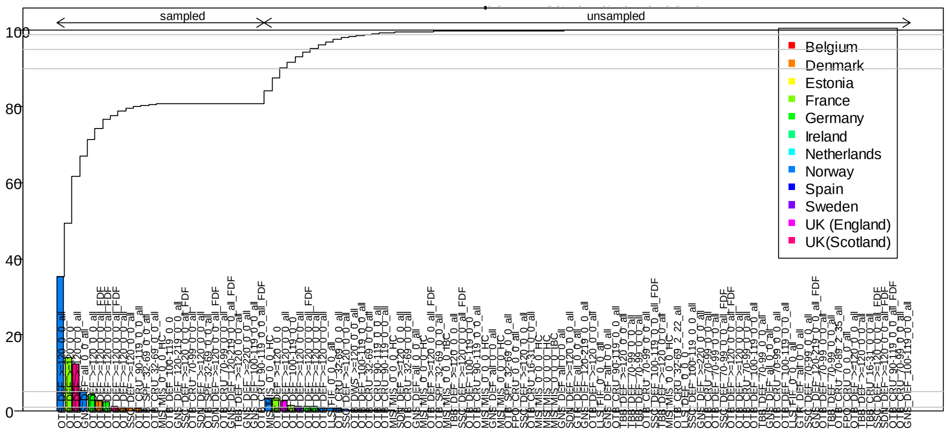


Figure 17.3.3. Saithe in Subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled by country and fleet in the full stock area.

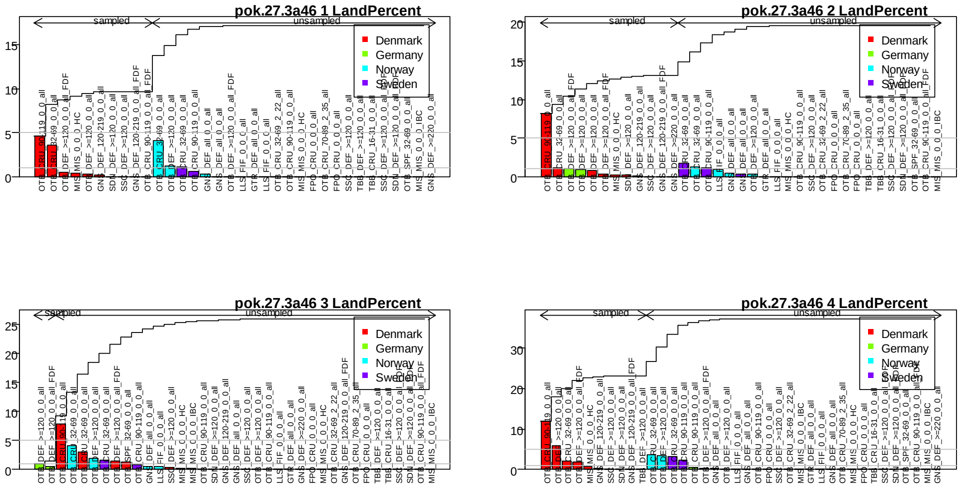


Figure 17.3.4. Saithe in Subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled by country, fleet, and quarter for saithe catches in Division 3.a.

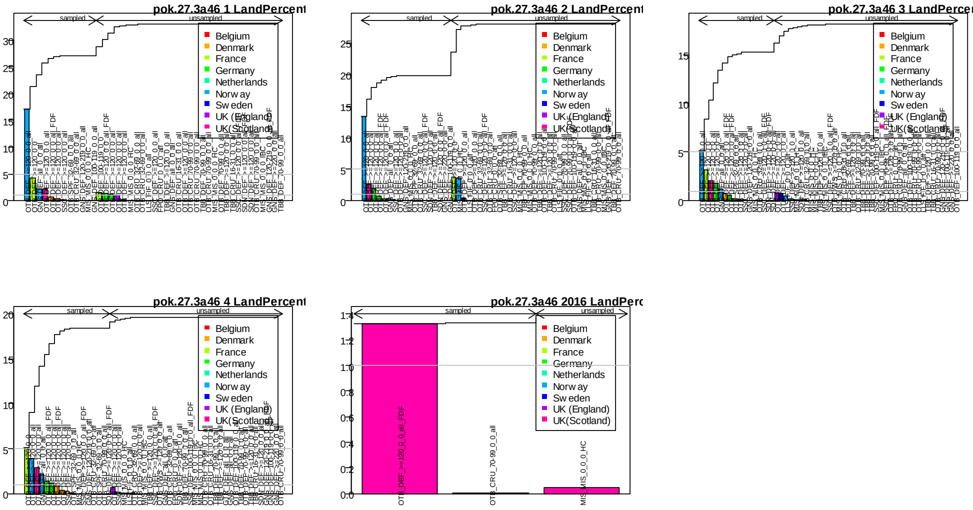


Figure 17.3.5. Saithe in Subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 4. Scotland reported by year, not quarter.

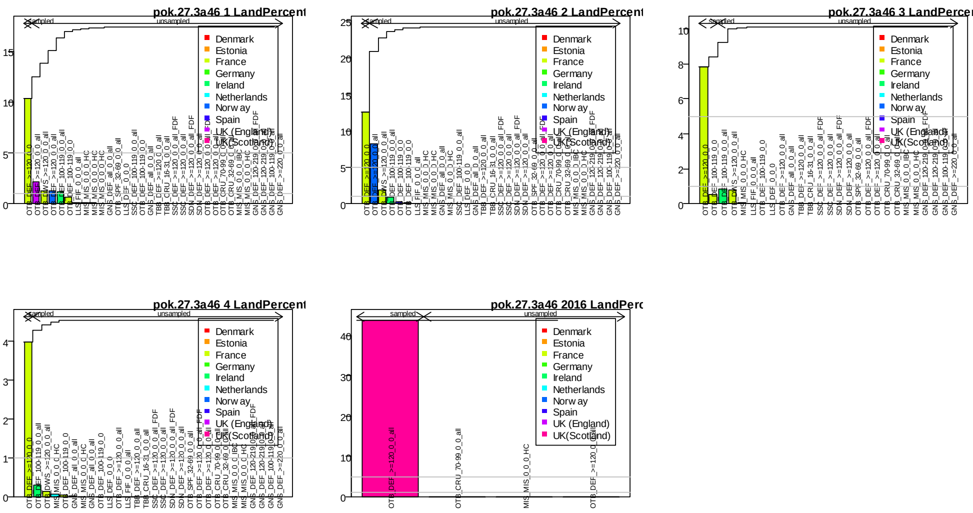


Figure 17.3.6. Saithe in Subareas 4 and 6 and Division 3.a: Overview of percent of landings sampled and unsampled catches by country, fleet, and quarter for saithe catches in Subarea 6. Scotland reported by year, not quarter.

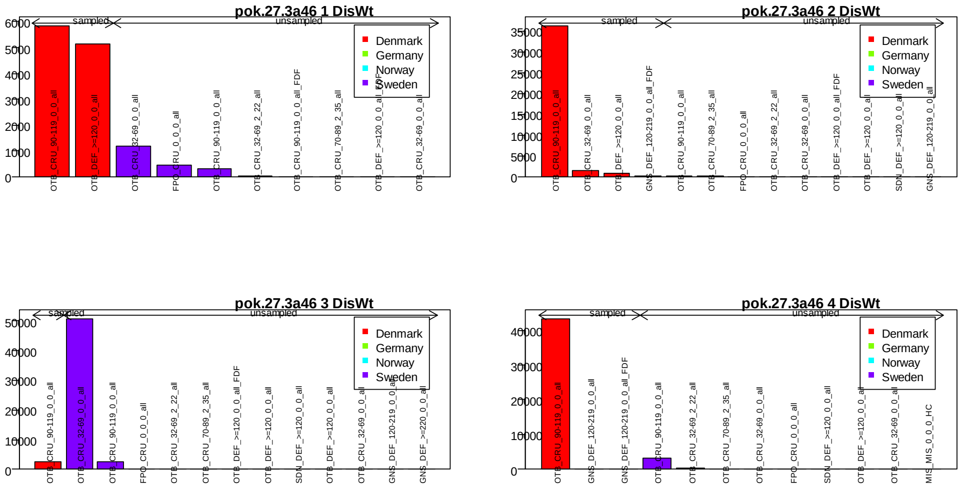


Figure 17.3.7. Saithe in Subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Division 3.a.

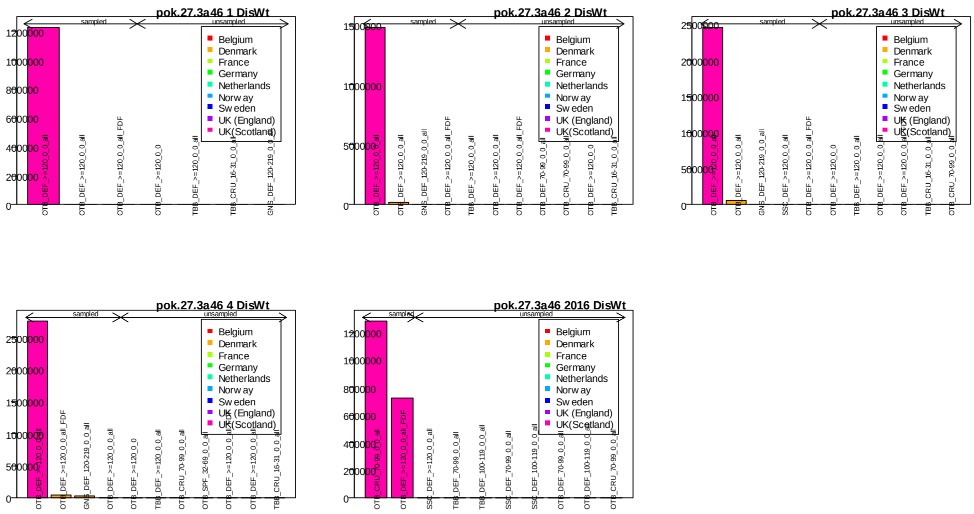


Figure 17.3.8. Saithe in Subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Subarea 4. Scotland submitted sample information by quarter and annual samples.

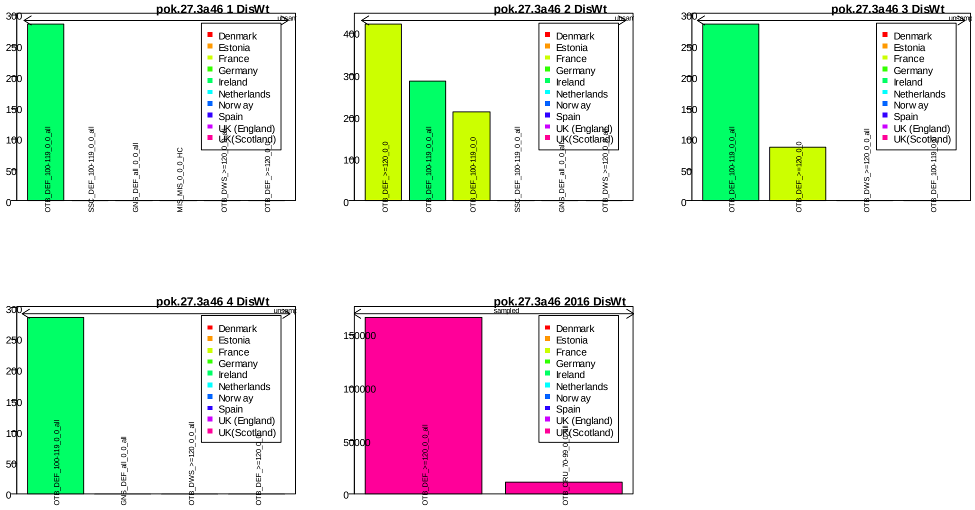


Figure 17.3.9. Saithe in Subareas 4 and 6 and Division 3.a. Amount of discards sampled and unsampled by quarter, metier, and country for Subarea 6. Scotland submitted sample information by quarter and annual samples.

Figure 17.3.10. Saithe in Subareas 4 and 6 and Division 3.a. (left) Landings-at-age for saithe ages 3–10+, 1990–2016; smallest bubble corresponds to 209 thousand individuals and largest to 46 million individuals. (Right) Discard weights at age for saithe ages 3–10+, 2000–2016 (min: 0, max: 15 million individuals).

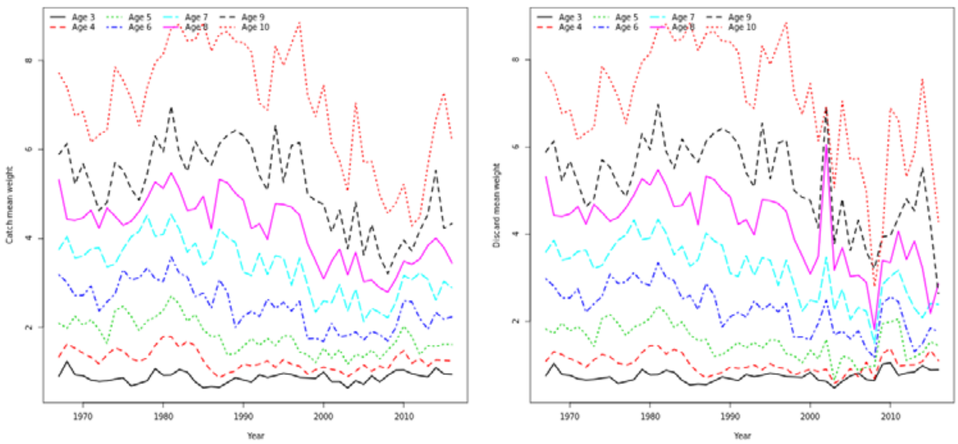


Figure 17.3.11. Saithe in Subareas 4 and 6 and Division 3.a. (left) Catch weight-at-age (kg) for saithe ages 3–10+, 1967–2016. Catch weight-at-age are also stock weight-at-age in the assessment. (Right) Discard weights-at-age (kg) for saithe ages 3–10+, 1967–2016.

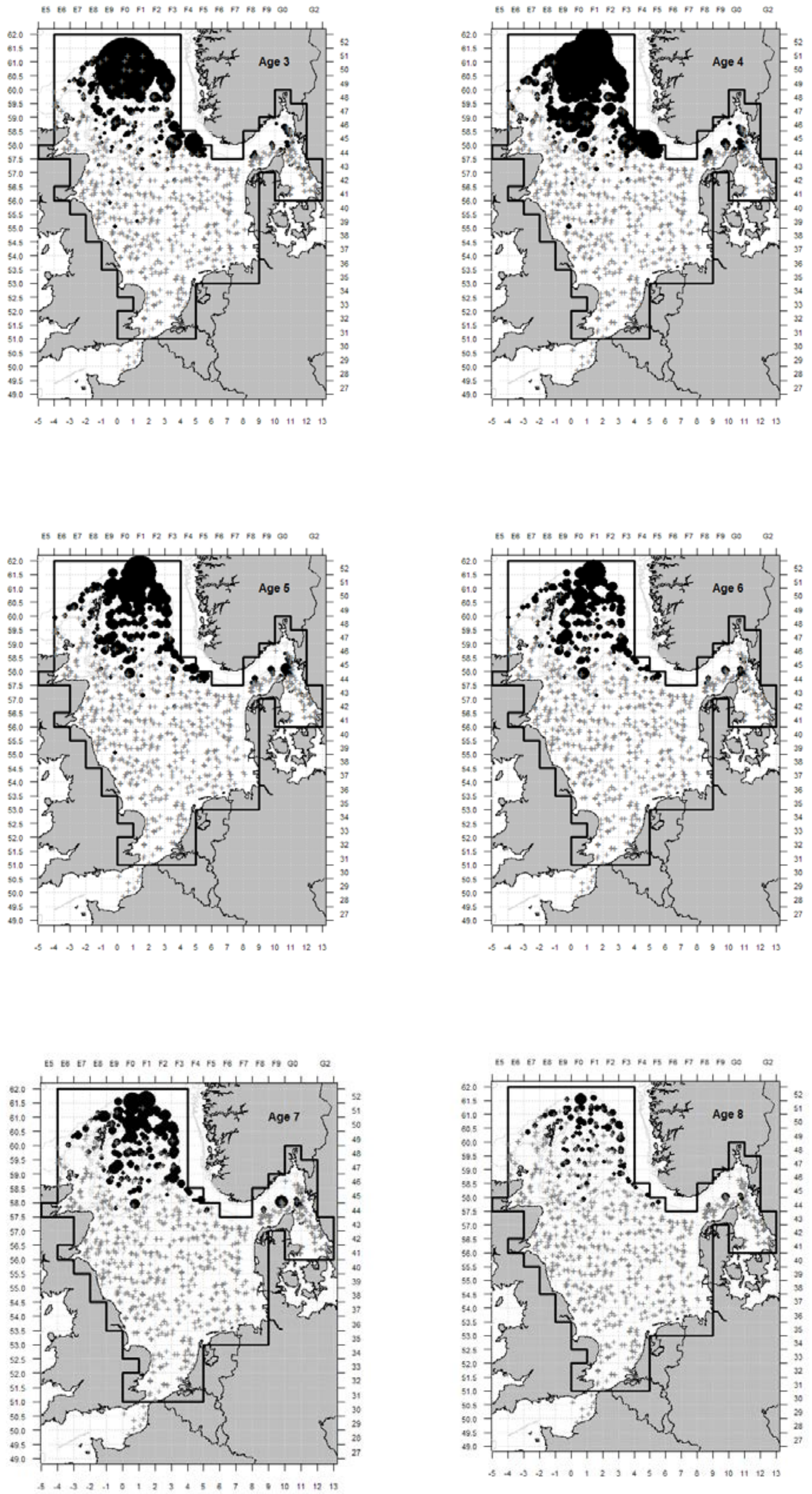


Figure 17.4.1. Saithe in Subareas 4 and 6 and Division 3.a. Distribution of saithe in the IBTS–Q3 survey in 2016 for ages 3 to 8. The single large catch of saithe is visible in ICES rectangle 50F0 in ages 3 and 4. Catches are scaled to the same scale for all ages.

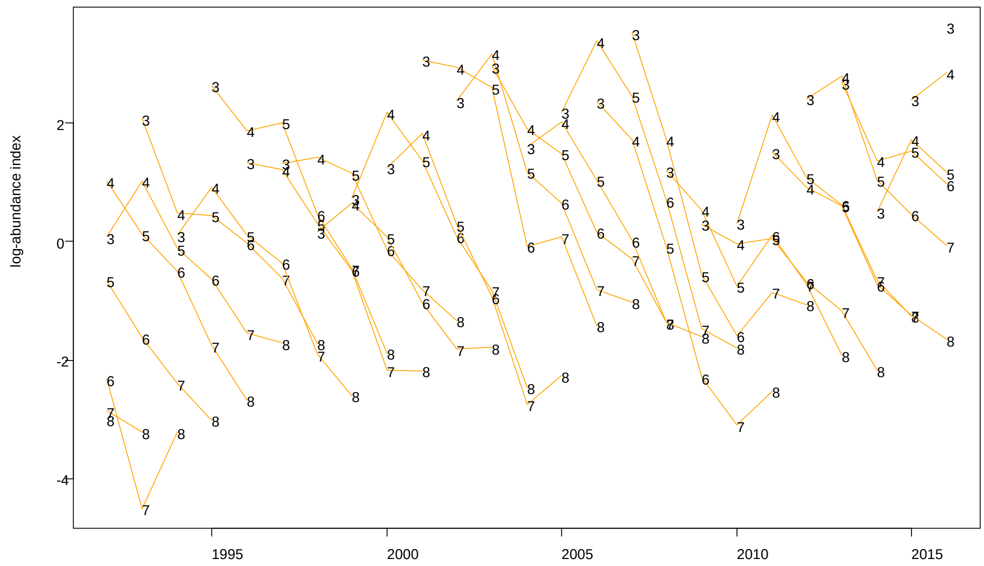


Figure 17.4.2. Saithe in Subareas 4 and 6 and Division 3.a: Log-catch curves by cohort from the research survey index, IBTS–Q3, for ages 3 to 8, 1992–2016.

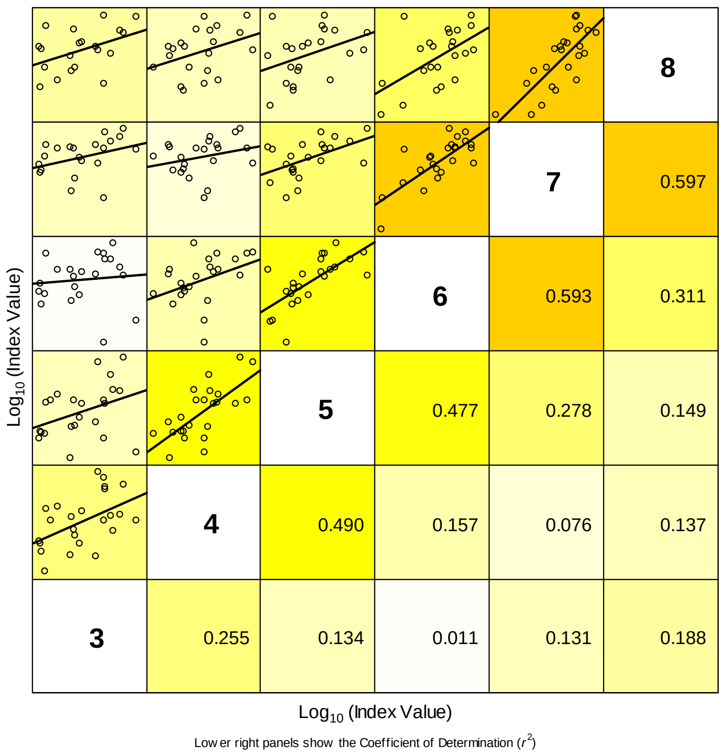


Figure 17.4.3. Saithe in Subareas 4 and 6 and Division 3.a.: Internal consistencies for IBTS–Q3, 1992–2016, ages 3 to 8.

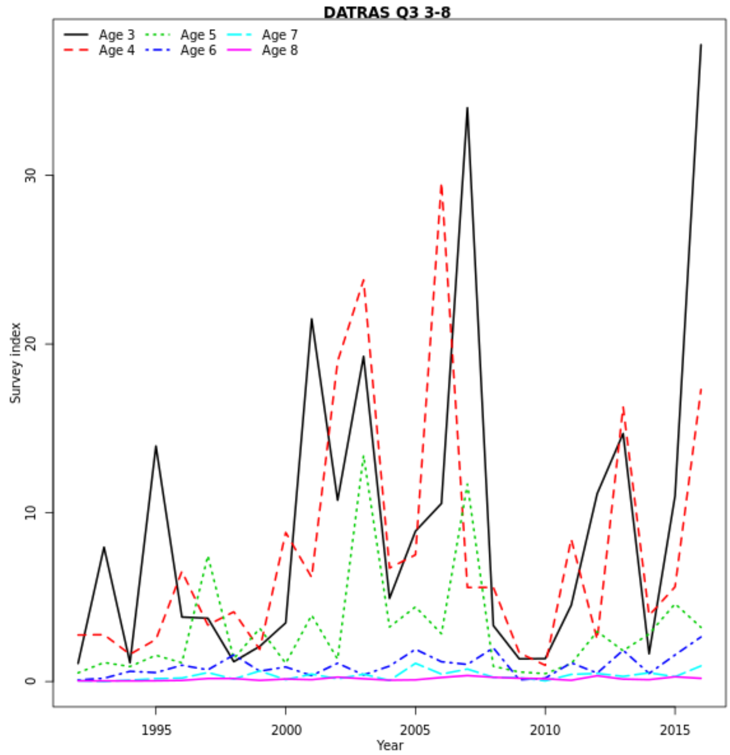


Figure 17.4.4. Saithe in Subareas 4 and 6 and Division 3.a: Standardised IBTS-Q3 research tuning series index, 1992–2016, ages 3 to 8.

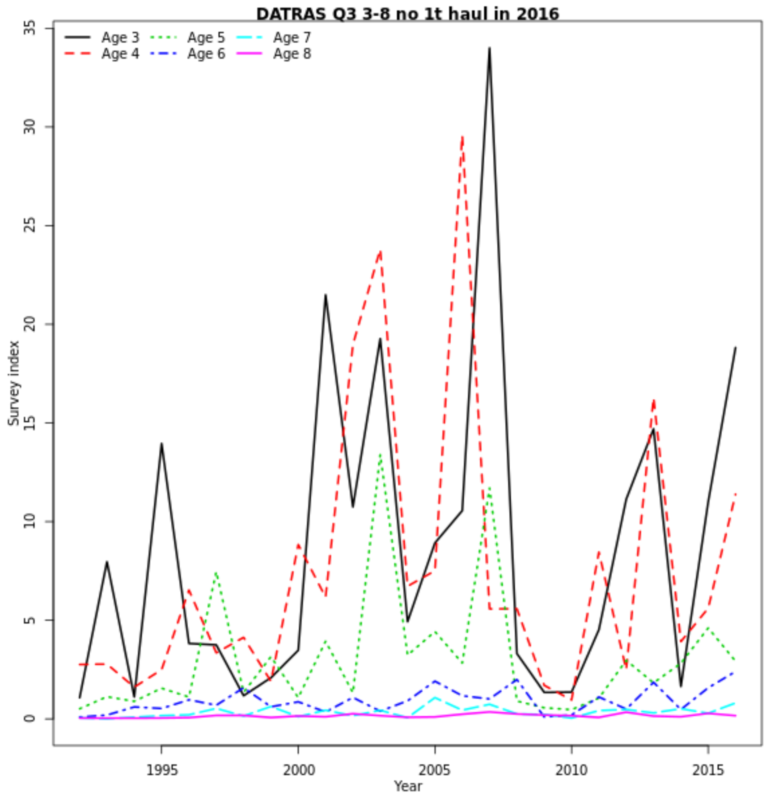


Figure 17.4.5. Saithe in Subareas 4 and 6 and Division 3.a. Standardised IBTS Q3 research tuning series index with the single large catch of saithe removed before the indices estimation, 1992–2016, ages 3 to 8.

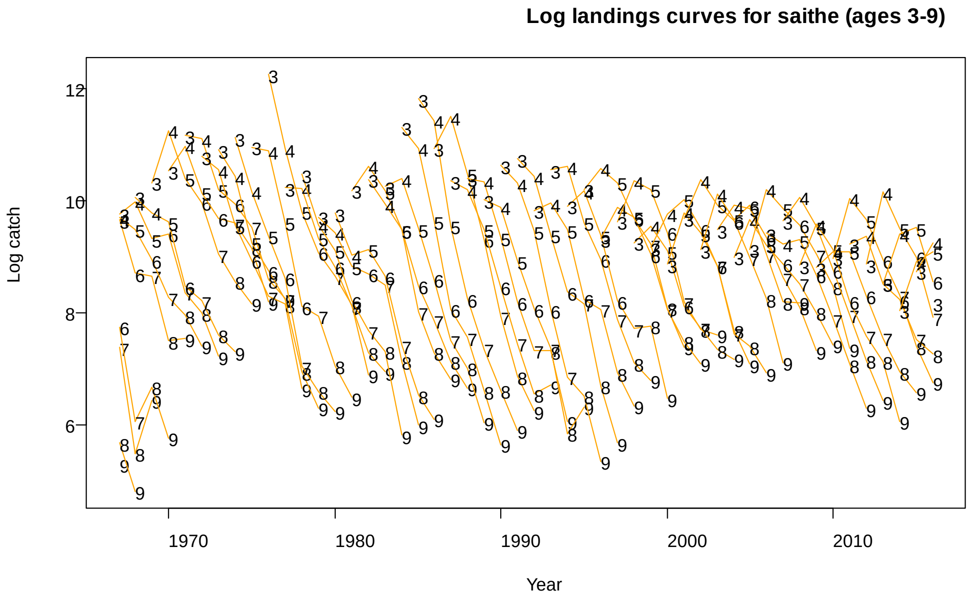


Figure 17.4.6. Saithe in Subareas 4 and 6 and Division 3.a.: Log-catch curves by cohort for landings, ages 3 to 9, 1967–2016.

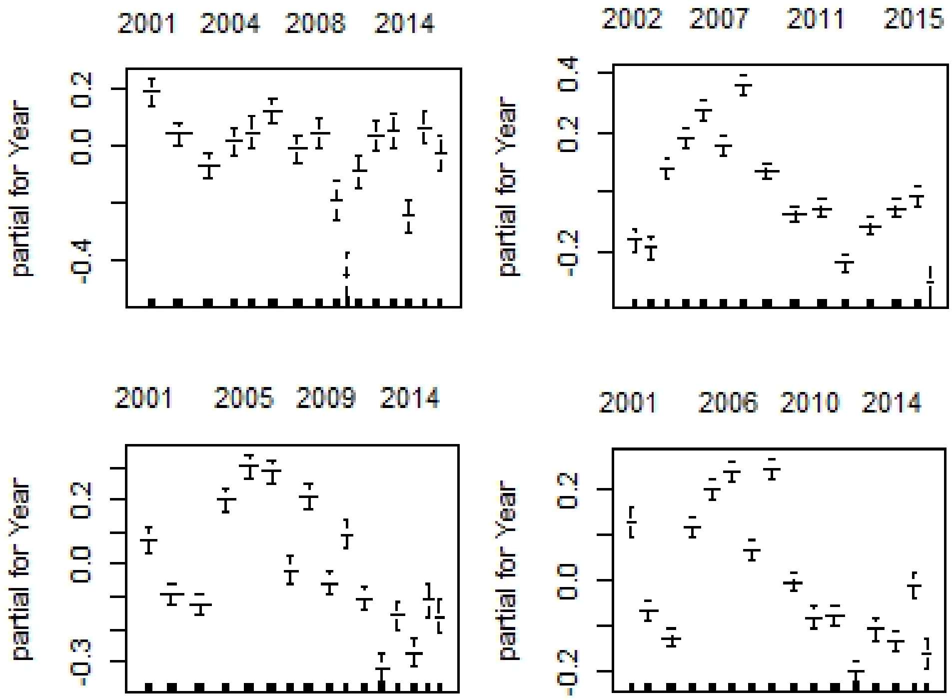


Figure 17.4.7. Saithe in Subareas 4 and 6 and Division 3.a.: Partial effects for (from top-left to bottom-right) the French-only, German-only, Norwegian-only, and combined cpue model.

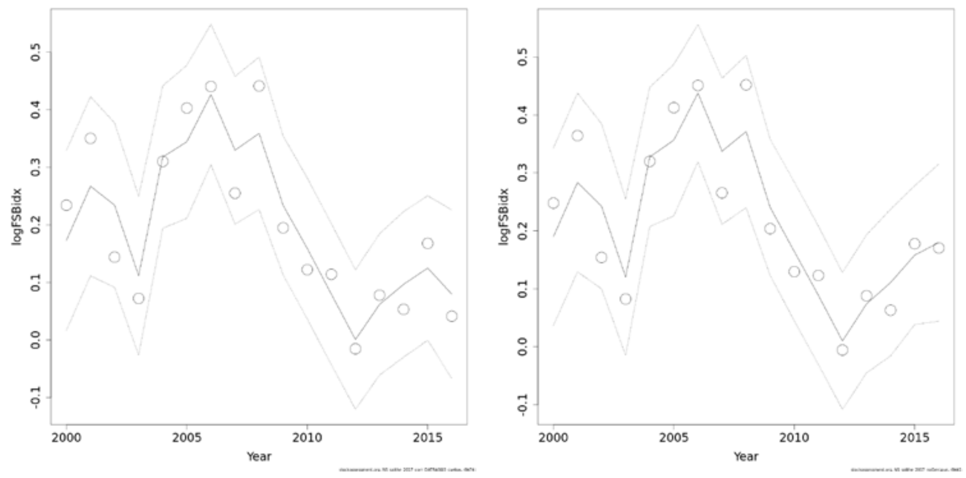


Figure 17.4.8. Saithe in Subareas 4 and 6 and Division 3.a.: Standardized combined cpue index (year effects) and fit of model after tuning to the exploitable biomass. Left: Fit for the final assessment model. Right: Fit for the exploratory assessment model, where the German data for 2016 were omitted.

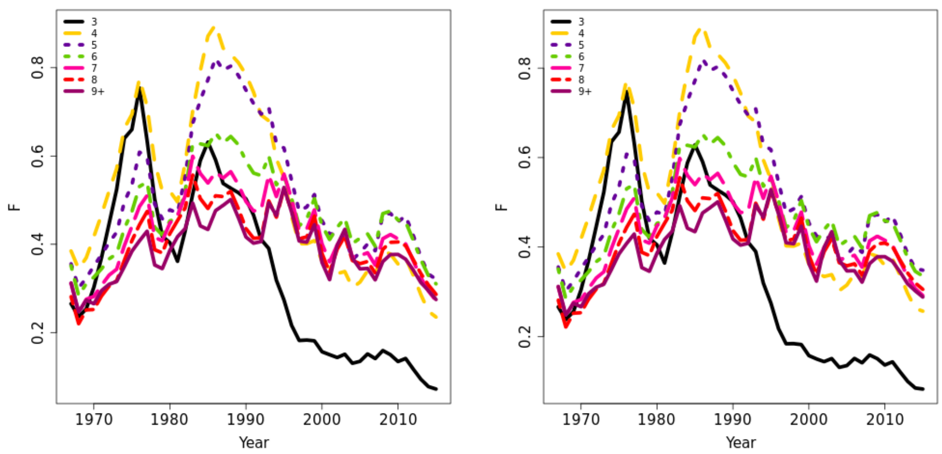


Figure 17.4.9. Saithe in Subareas 4 and 6 and Division 3.a.: Fishing mortality at age for the two exploratory models. Left: Exploratory assessment model, where the single large haul taken in IBTS Q3 2016 was omitted from the index estimation for all age groups. Right: Exploratory assessment model, where the German cpue index was omitted for 2016.

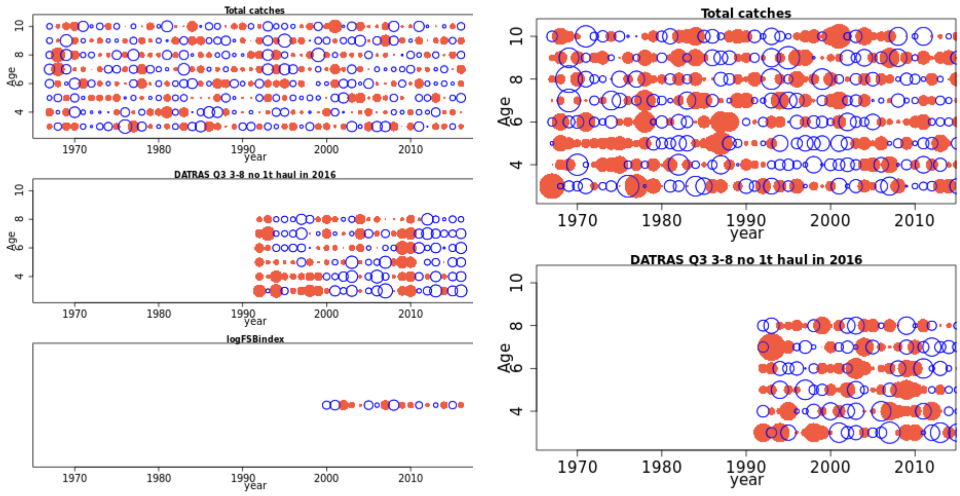


Figure 17.4.10. Saithe in Subareas 4 and 6 and Division 3.a.: Residual patterns for the exploratory assessment model, where the 2016 single large catch of saithe was omitted: (left) before correlation was taken into account between ages; (right) after accounting for the correlation between ages within years (residuals are one-step ahead). Open circles (blue) indicate positive residuals and filled red circles indicate negative residuals.

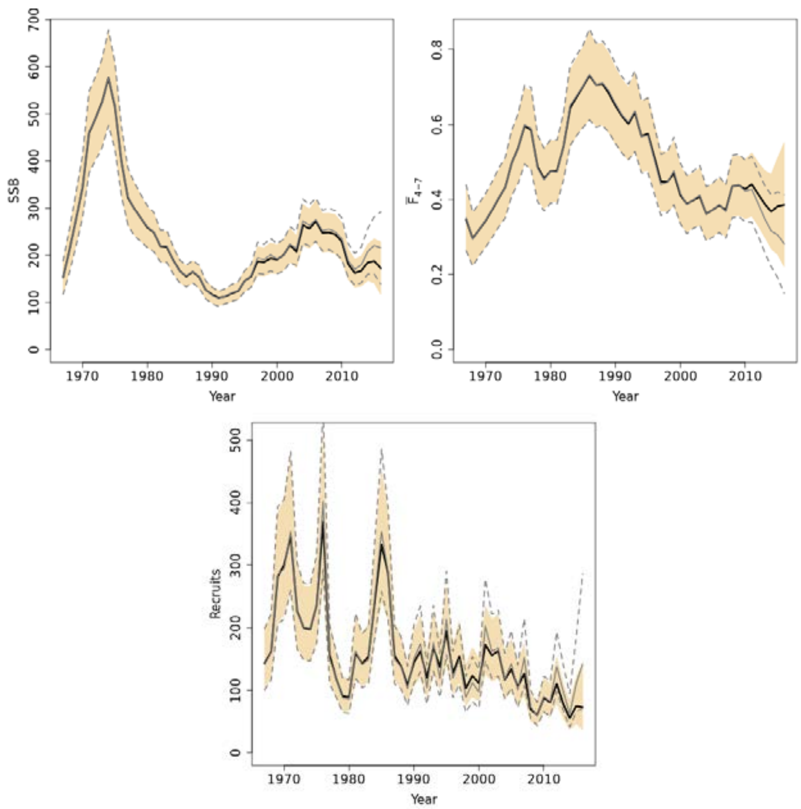


Figure 17.4.11. Saithe in Subareas 4 and 6 and Division 3.a.: Stock summary of trends in SSB, $F_{4\text{-}7}$, and recruitment for the exploratory model where the 2016 single large catch of saithe was omitted.

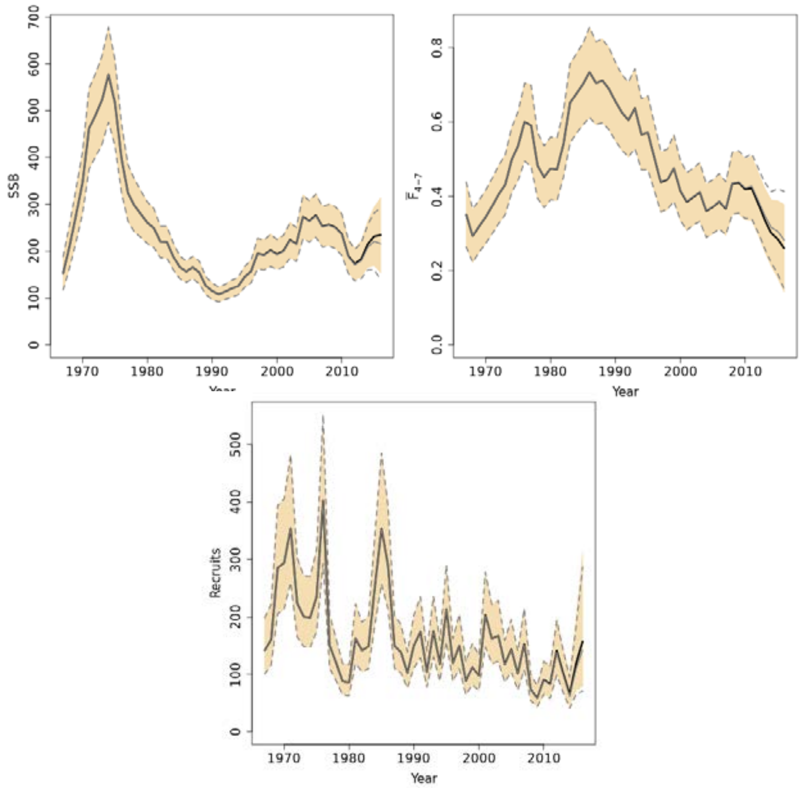


Figure 17.4.12. Saithe in Subareas 4 and 6 and Division 3.a.: Stock summary of trends in SSB, F_{4-7}, and recruitment for the exploratory model where the German fleet information in 2016 was omitted from the assessment.

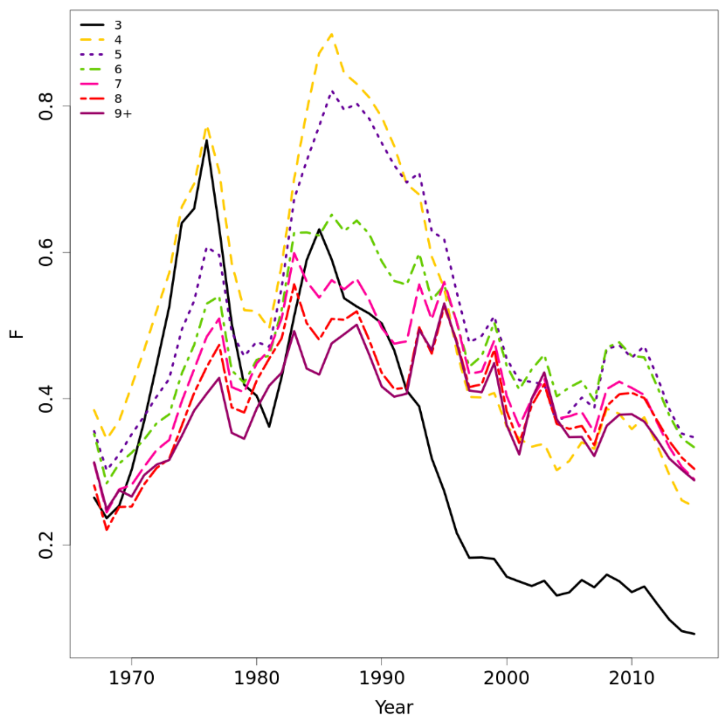


Figure 17.4.13. Saithe in Subareas 4 and 6 and Division 3.a.: Fishing mortality at age for the final assessment model.

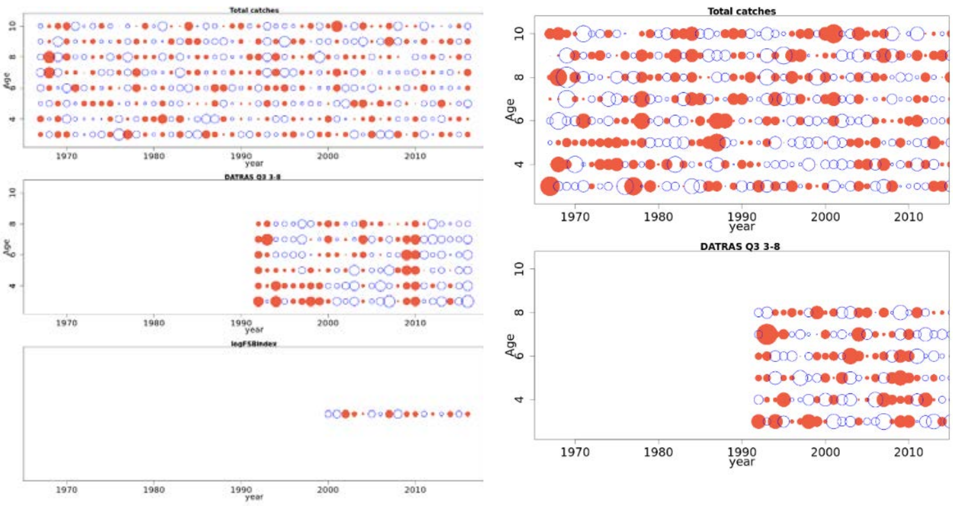


Figure 17.4.14. Saithe in Subareas 4 and 6 and Division 3.a.: Residual patterns for the final SAM model. Left: Before correlation taken into account between ages, within years in the Q3 index. Right: After accounting for the correlation between ages within years in the Q3 index. Open circles (blue) indicate positive residuals and filled red circles indicate negative residuals.

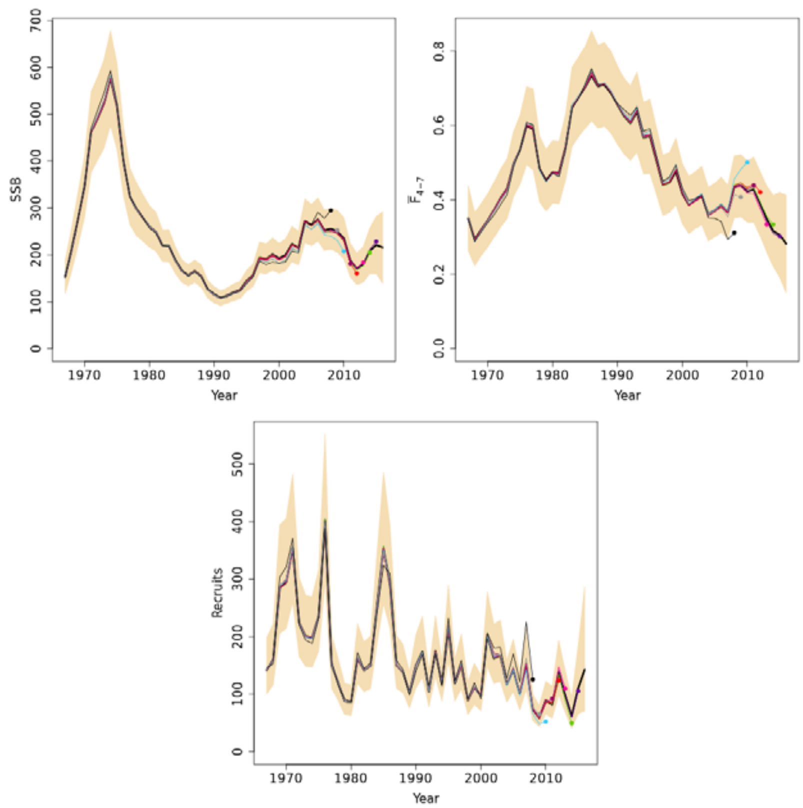


Figure 17.4.15. Saithe in Subareas 4 and 6 and Division 3.a.: Eight year retrospective pattern in SSB, F_{4-7}, and recruitment for the final assessment.

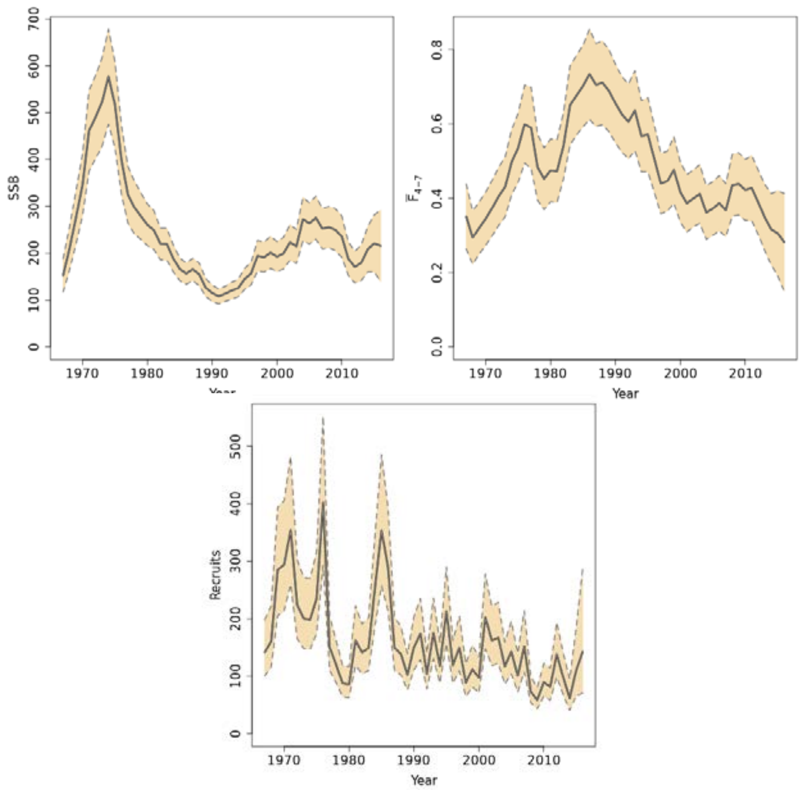


Figure 17.5.1. Saithe in Subareas 4 and 6 and Division 3.a: Stock summary of trends in SSB, F_{4-7}, and recruitment for the final assessment model.

18 Sole (*Solea solea*) in Subarea 4 (North Sea)

The assessment of sole in Subarea 4 is presented as an update assessment. The most recent benchmark assessment was carried out in February 2015 (ICES WKNSEA 2015). More details can be found in the most recent Stock Annex. Only a concise description of the methods are presented within this Section of the report. In 2017, there were no deviations from the Stock Annex.

18.1 General

18.1.1 Stock definition

See Stock Annex.

18.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at WGNSSK (2017). All available information on ecological aspects can be found in the Stock Annex.

18.1.3 Fisheries

See Stock Annex for a general comprehensive description of the fishery.

Many vessels in the beam trawl fleet, that is mainly catching sole in the North Sea, have adopted technological developments to their gears. These developments include electric pulse fishing, hydrodynamic fuel-saving wings, etc. The catch composition of these "advanced" gears are found to be different from the traditional beam trawl (van Marlen *et al.*, 2014). As of 2017, the operational use of these new gears can be distinguished using logbook and VMS data.

18.1.4 ICES Advice

The information in this section is taken from the update advice from section 6.3.49 in the Advice summary sheet 2016.

ICES stock advice

ICES advises that when the second stage of the EU management plan (Council Regulation No. 676/2007) is applied, catches in 2017 should be no more than 15 251 tons.

Issues relevant for the advice

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea affect both sole and plaice. The minimum mesh size of 80 mm generates high discards of plaice which have a larger minimum landing size than sole. The use of larger mesh sizes would reduce the catch of undersized plaice and sole, but would also result in loss of marketable sole in the short term (Cardinale and Hjelm, 2012).

Since 2011, the use of pulse trawls in the Dutch fishery has increased sharply to 74 vessels (of which 65 > 221 kW) and only few vessels operating with traditional beam trawls are now left. The increased use of pulse trawls and other adaptations like fuel-saving wings may affect catchability and selectivity of North Sea sole.

There is a long-term management plan for North Sea plaice and sole, which was evaluated by ICES to be in accordance with the precautionary approach. However, in 2016 ICES does not use this plan as the basis for the advice for plaice. The European Commission has informed ICES that agreement has not been reached between the EU and

Norway on a method to split the joint advice between the North Sea and Skagerrak. ICES continues to use the management plan as the basis of advice for sole.

Results from a North Sea mixed-fisheries analysis are presented in ICES (2016b). For 2017, assuming a strictly implemented discard ban (corresponding to the "Minimum" scenario), haddock would be the most limiting stock (assuming that the full advised catch is taken), constraining 36 out of 41 fleet segments (corresponding to 91% of the 2015 kW days of effort). Cod and eastern Channel sole would be limiting for fleets, corresponding to 5% and 4% of the 2015 effort, respectively. Conversely, in the "Maximum" scenario with *Nephrops* managed by separate TACs for the individual functional units (FUs), *Nephrops* would be considered the least limiting stocks in many FUs. *Nephrops* in FU 33, FU 5, FU 32, FU 7, and FU Others would be the least limiting stocks for fleets in these FUs, representing 32%, 16%, 10%, 4%, and 17% of the 2015 effort, respectively. Eastern Channel plaice and saithe would be least limiting for other fleet segments, representing 12% and 9% of the 2015 effort, respectively.

Results for the North Sea sole stock are also included as additional rows in the catch options table of this advice sheet.

18.1.5 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages; of which the first stage should be deemed a recovery plan and its second stage a management plan.

The plan was implemented in 2007. ICES has evaluated the plan and found it to be in agreement with the precautionary approach (ICES, 2010). A subsequent evaluation in 2012 (Coers *et al*., 2012) addressed amendments to the plan in the context of moving towards stage two of the plan.

As of December 2014, the management plan has officially moved to the stage two (EU 2014).

Mixed fishery advice

The information in this section is taken from the North Sea Advice overview section 6.3 in the ICES Advisory report 2008.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch. The exploitation of sole and plaice are closely connected as they are caught together in fisheries mainly targeting sole, which are more valuable. This means that the minimum mesh size is decided on the basis of the more valuable species (sole), resulting in substantial discards of undersized plaice. The mixed fisheries for flatfish are dominated by a mixed beam trawl fishery using 80 mm mesh in the southern North Sea where up to 80% in number of all plaice caught are being discarded. Additionally, a shift in the age and size at maturation of plaice has been observed (Grift *et al*., 2004): plaice become mature at younger ages and at smaller sizes in recent years than in the past. There is a risk that this is caused by a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This shift in maturation also leads to mature fish being of a smaller size-at-age. Measures to reduce discarding in the mixed beam trawl fishery would greatly benefit the plaice stock and future yields. In order to improve the selection pattern, mesh size increases or configuration changes (i.e. square mesh) would help reduce the discards. However, this would result in a short-term loss of marketable sole. Readjustment of minimum landing sizes corresponding to an improved selection pattern could be considered.

Improvements to gear selectivity, which would contribute to a reduction in catches of small fish, must take into account the effect on the other species within the mixed fishery. For instance, mesh enlargement in the flatfish fishery would reduce the catch of undersized plaice, but would also result in loss of marketable sole.

18.2 Data available

18.2.1 Landings

Annual landings by country and TACs are presented next to the landings submitted to InterCatch in Table 18.2.1. The TAC of 13 262 tons in 2016 was fully taken and slightly overshot compared to official landings of 12 651 tons, and landings reported to ICES of 14 127 tons. Landings in numbers by age that are input for the assessment model are presented in Table 18.2.2. A time series of total landings is shown on Figure 18.2.1.

18.2.2 Discards

Discards were included in the assessment after the most recent benchmark (WKNSEA, 2015). A time series from national discard monitoring programmes from 2002 onwards is used since then. Discards in numbers by age from 2002 until present are shown in Table 18.2.3. A time series of total discards is shown on Figure 18.2.2.

18.2.3 BMS landings

In 2016, 15 251 kg of BMS landings were reported to InterCatch. They are not raised.

18.2.4 Logbook registered discards

In 2016, no Logbook registered discards were reported to InterCatch.

18.2.5 InterCatch

Since 2012, InterCatch is used for raising the catch. Age distributions were provided for 89.02 % of the landings in 2016 (Figure 18.2.3).

Discards estimates for 2016 were available for 89.96 % of the landings (in weight) (Figure 18.2.3). This implies that 89.07 % of the discards were imported and 10.89 % was raised. Age distributions were given for 86.85 % of the discards (in weight).

First metiers for which yearly discard estimates had been imported were grouped with the same metiers with quarterly landings estimates. Then, discards were raised by grouping metiers with small meshes apart from metiers with larger mesh sizes, and by grouping passive gears apart from active gears. In the towed gear group a distinction was made between otter trawlers and seines, and beam trawlers. Beam trawlers and otter trawlers targeting crustaceans (CRU) with a mesh size smaller than 99 mm were grouped together. The remainder, which consisted of metiers which did not fit in any of the above groups or, were then raised with all available discard estimates.

18.2.6 Age compositions

The age composition of the landings and discards is presented in numbers in Table 18.2.2–3., and Figure 18.2.4.

For metiers where no age was available, age compositions were allocated using the same method as for the discard raising (described above). These allocations were done separately for discards and landings.

Both catch categories were separately exported from InterCatch. The SOP correction for the landings was 1 and was 0.999 for discards.

18.2.7 Weight-at-age

Weights at age in the landings for both sexes combined (Table 18.2.4) are measured weights from the various national market sampling programmes. Discard weights at age (Table 18.2.5) are derived from the various national discard programmes (observer and self-sampling).

Mean stock weights at age (Table 18.2.6.) are the average weights from the 2nd Quarter landings and discards and are derived from the InterCatch (Catch and Sample Data Table file as output from InterCatch).

Landing, discard, and mean stock weights at age are presented on Figure 18.2.5.

Stock weights of younger ages after 2012 are still slightly lower than stock weights before 2012. This is because before deriving the mean stock weights from InterCatch (since 2012), these weights were manually raised based on landings only. In that time series (1957–2011) a constant value (0.05) was taken for age 1 and age 2.

18.2.8 Maturity and natural mortality

A knife-edged maturity-ogive with full maturation at age 3 is assumed for North Sea sole (Table 18.2.7.). No new data was presented at in 2017.

Natural mortality at age (Table 18.2.7.) is assumed to be constant at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962–1963) (ICES FWG 1979). The estimate of 0.9 was based on an analysis of cpue in the fisheries before and after the severe winter (CM 1979/G:10).

18.2.9 Catch, effort and survey data

Two tuning series that take place in quarter 3 are used in the assessment. The BTS–ISIS (Beam Trawl Survey on the RV ISIS) and the SNS (Sole Net Survey) are both surveys conducted by the Netherlands. Catches of sole in the 2012 survey were extremely low and contradicted with the BTS, indicating problems with operating the gear properly on board of the vessel. The data from the SNS survey for the years 2003 and 2012 were not made available.

A standardised comparison of the two surveys that are used as tuning indices over the available time series is given in Figure 18.2.7.1. The internal consistency of the year class cohorts in these two surveys is presented in Figure 18.2.7.2.

An additional survey index (the combined Belgian, German, and Dutch DFS0) is used for recruitment estimates in the RCT3 analysis.

All survey indices of importance for the advice are presented in Table 18.2.8.

In autumn, when new data becomes available from the surveys in quarter 3, the advice can be revised if significant changes in the assumptions of recruitment made at the working group are observed.

18.3 Assessment

The model used is the Art and Poos model (AAP, Aarts and Poos (2009), for more details please refer to the Stock Annex).

Year of assessment:		2017
Assessment model:		AAP
Assessment software		FLR/ADMB
Fleets:		
BTS-ISIS	Age range Year range	1–9 1985-present
SNS	Age range Year range	1–6 1970-present
Catch/Landings		
Age range:		1–10+
Landings data:		1957-present
Discards data		2002-present
Model settings		
Fbar:		2–6
Age from which F is constant (qplat.Fmatrix)		8
Dimension of the F matrix (Fage.knots)		6
Ftime.knots		22
Wtime.knots		5
Age from which q is constant (qplat.surveys)		7

This is an update assessment with, in principle, only an update of historical data and addition of the commercial and survey data in the most recent year. The model settings, defined in the most recent benchmark by WKNSEA (2015), were applied.

The assessment summary is presented in Table 18.3.1. and in Figure 18.3.1. The retrospective performance of the assessment is shown in Figure 18.3.2.

18.4 Recruitment estimates

Recruitment estimation was carried out using RCT3. Input to the RCT3 model is presented in Table 18.4.1. Results are presented in Table 18.4.2. for age 1 and Table 18.4.3. for age 2. Average recruitment of 1–year old fish in the period 1957-2013 was around 112 million (geometric mean).

The results are summarized in the table below and the estimates used for the short-term forecast are underlined.

Year Class	Age in 2017	AAP thousands	RCT3 thousands	GM(1957–2013) thousands
2015	2	42068	57339	98980
2016	1		86425	112078
2017	Recruit (0)			112078

Additional recruitment information will be available from the 3rd quarter surveys (BTS–ISIS, SNS, and DFS). ICES will only issue an updated advice if these surveys provide a very different perspective on the short-term developments that were used during the working group.

18.5 Short-term forecasts

The short-term forecasts were carried out with FLR. The exploitation pattern (F) was taken to be the mean value of the last three years. Weight-at-age in the stock and weight-at-age in the catch were taken to be the mean of the last three years. Population numbers at ages 2 and older are AAP survivor estimates. Numbers at age 1 are taken from the RCT3 analysis and recruitment of the 2016 year class and later year-classes are taken from the long-term geometric mean (1957–2013: 112 million). Input to and results from the short term forecast are presented in Table 18.5.1.–3. for F = Fsq and Table 18.5.4–6. for catch = TAC.

For the intermediate year 2017, it was assumed that catches equal the TAC. The landings (ICES estimated and preliminary reported) in 2016 are close to the agreed TAC of 2016. Therefore the landings in 2017 are assuming that the TAC will be fully taken. This corresponds with the observations in recent years.

Figure 18.5.1–2. shows the relative contribution of assumptions under both scenario's.

18.6 Medium-term forecasts

No medium term projections were done this year.

18.7 Biological reference points

	Type	Value	Technical basis
MSY Approach	MSY Btrigger	37 000 t	Default to value of Bpa
	FMSY	0.20	Median of stochastic MSY analysis assuming a Hockeystick stock-recruit relationship.
	Fmsy-upper	0.37	
	Fmsy-lower	0.11	
Precautionary Approach	Blim	26 300 t	Breakpoint of segmented regression (ICES 2015)
	Bpa	37 000 t	Bpa = 1.4 * Blim
	Flim	0.62	EqSim run with no MSY Btrigger, realistic assessment.advice error, biological parameters (2003–2012) and fishery parameters (2009–2012)
	Fpa	0.44	Fpa = Flim / 1.4

F_{MSY} reference points

In 2010 ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock.

In 2014 the joint ICES MYFISH Workshop (WKMSYREF3 ICES 2014) held place to consider the basis for FMSY ranges of, among others, SOL4. The workshop convened again under the auspices of WKLIFE in March 2015. This eventually resulted in an F_{msy} range for sole of 0.13–0.27. The point value of F_{msy} was set at 0.2.

In 2016, F_{pa} and F_{lim} were defined according to ICES reference points guidelines (ACOM). An additional F_{pa} (sigma) was estimated by: $F_{pa} = F_{lim} / \exp(1.645^* \text{ sigma})$, where sigma is the standard deviation of ln(F) in the final assessment year. F_{pa}(sigma) was estimated as 0.48.

18.8 Quality of the assessment

The assessment was benchmarked recently in February 2015 (WKNSEA, 2015). Inclusion of discards in the catches and adding uncertainty estimates were the main goals. This was attained using the AAP–model.

Discards form a minor part of total sole catches, rates have stabilised in the last years. The assessment at present includes 16 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years. However, the impact of the landing obligation cannot be distinguished at present.

Most of the discards originate from the Netherlands. A self-sampling programme by the Dutch beam-trawl fleet has been in place since 2004. This sampling programme indicates spatial and temporal trends in discarding (higher discards are observed in coastal regions and late summer), but it was considered inappropriate for overall estimates of discarding because of differences in the implementations of sampling methods.

In 2009, a new self-sampling programme was launched to address this. Since 2011, Dutch discard estimates are derived exclusively from the self-sampling programme, while observer estimates are used for validation of the self-sampling data only. Preliminary analyses suggest that the self-sampling estimates are as reliable as those from the observer programme (Chen *et al*. (in press)).

At the working group the newest data year (2016) was added to the assessment. The assessment performed well and modelled landings, discards, and catch fitted well to observed landings, and discards (Figure 18.8.1–3.).

Residual plots of landings and discards are shown in Figure 18.8.4.–5. Residuals are small for younger ages in discards but tend to be higher for older ages. This is normal since older North Sea sole are not seen in discards.

Sigmas of the different data time series are shown in Figure 18.8.6.

18.9 Status of the stock

Fishing mortality was estimated at 0.215 in 2016 which is well within biological limits and near the point value of F_{msy} The SSB in 2016 was estimated at about 62636 tons which is well above both B_{lim} and B_{pa}.

18.10 Management considerations

Sole is mainly taken by beam trawlers in a mixed fishery for sole and plaice in the southern and central part of the North Sea. The long term management plan for plaice and sole in the North Sea specifies two distinct phases. The objective of stage one of the flatfish management plan was to bring both sole and plaice stocks within safe biological limits. This objective has been achieved for both stocks.

The management plan is in stage 2 now and action should be taken to specify the implementation in this stage. The multiannual plan states that, in its second stage, it shall ensure the exploitation of the stocks on the basis of maximum sustainable yield. An overall objective of the CFP is to exploit all fish stocks within F_{msy} ranges.

The majority of the sole catches are taken by beam trawlers in a mixed fishery with other flatfish and roundfish species. In general discards of other species in beam trawls are rather high. Due to measures resulting from the flatfish management plan, actions taken to reduce bycatch, disturbance to the sea bottom, and economic incentives (reduce fuel costs), overall effort in the beam fishery has been reduced in the past 16 years by 70%. The significant reduction of effort in the fleet must have contributed to reduce the impact of this fishery on the marine ecosystem.

18.11 Frequency of assessment

The frequency of assessments was discussed at the ACOM December 2014 meeting and the Committee decided to develop simple criteria to be used to identify stocks that would be candidates for less frequent assessments. A set of four criteria were suggested based on (1) the life span of the stock, (2) stock status, (3) relative importance of recruitment in the catch forecast and (4) the quality of the assessment.

At the working group in 2016 the four criteria were assessed. The North Sea sole assessment succeeded in all four criteria. Although the North Sea sole stock is consequently a candidate for less frequent assessments some precautions should be taken in to account:

- North Sea sole is subject to the landing obligation as of 2016, this implies careful proceeding with discard data that are input for the model.
- Furthermore, the main fleet targeting sole is subject to technological changes in their gears. How this technological change affects the selectivity of the fishing gears catching sole and subsequently the age composition of the stock has not been quantified.
- Finally, the assessment currently holds two tuning indices that are not encompassing the whole sole stock in the North Sea and are missing out on the main grounds where sole is found. The positive trend in the assessment and its basis thereof for the second criterion on the frequency of assessment should be therefore taken with caution.

Criterion	**North Sea sole**
(1) Life span (i.e. maximum normal age) of the species is larger than 5 years	Life span larger than 5 years
(2) The stock status in relation to the reference points is according to the MSY criteria F(latest assessment year) is <= F_{upper} (upper bound in F range) AND SSB (start of intermediate year) >= MSY B_{trigge}r	F(2015) = 0.20 < F_{upper} SSB(2015) = 49142 > $B_{trigger}$= B_{pa}= 37 000
(3) The average contribution to the catch in numbers of the recruiting year class in latest 5 years is less than 25% of the total catch in numbers.	The average contribution to the catch in numbers of the recruiting year class in latest 5 years is 19% of the total catch in numbers
(4) The retrospective pattern, based on a seven years peel of Mohn's Rho index, shows that F is consistently overestimated by less than 20%	Rho = -0.1 i.e. F is overestimated by 10%

Table 18.2.1. North Sea sole: Landings per country, total reported landings, ICES total landings, and TAC.

Year	BE	DK	FR	GE	NL	UK	Other	Total reported landings	ICES Total landings	TAC
1982	1900	524	686	266	17686	403	2	21467	21579	21000
1983	1740	730	332	619	16101	435		19957	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	26839	20000
1985	2390	692	875	303	14897	774	3	19934	24248	22000
1986	1833	443	296	155	9558	647	2	12934	18201	20000
1987	1644	342	318	210	10635	676	4	13829	17368	14000
1988	1199	616	487	452	9841	740	28	13363	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	21805	14000
1990	2389	1427	352	2296	18202	1614	263	26543	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	22651	23000
1997	1519	689	99	510	10241	479	204	13741	14901	18000
1998	1844	520	510	782	15198	549	339	19742	20868	19100
1999	1919	828	NA	1458	16283	645	501	21634	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	22641	22000
2001	1874	772	411	958	13345	597	394	18351	19944	19000
2002	1437	644	266	759	12120	451	292	15969	16945	16000
2003	1605	703	728	749	12469	521	363	17138	17920	15850
2004	1477	808	655	949	12860	535	544	17828	18757	17000
2005	1374	831	676	756	10917	667	357	15579	16355	18600
2006	980	585	648	475	8299	910	0	11933	12594	17670
2007	955	413	401	458	10365	1203	5	13800	14635	15000
2008	1379	507	714	513	9456	851	15	13435	14071	12800
2009	1353	NA	NA	555	12038	951	1	NA	13952	14000
2010	1268	406	621	537	8770	526	1.38	12129	12603	14100
2011	857	346	539	327	8133	786	2	10990	11485	14100
2012	593	418	633	416	9089	599	3	11752	11602	16200
2013	697	497	680	561	9987	867	0	13291	13137	14000
2014	920	314	675	642	9569	840	0	12547	13060	11900
2015	933	271	532	765	8899	804	0	12203	12867	11900
2016	767	355	362	861	9600	705	0	12651	14127	13262

Table 18.2.2. North Sea sole: Landings in numbers by age 1–10 (in thousands).

	1	2	3	4	5	6	7	8	9	10
1957	0	1472	10556	13150	3913	3041	6780	1803	529	6541
1958	0	1863	8482	14240	9547	3501	3023	4461	2264	6590
1959	0	3694	12139	10499	9060	5823	1217	2044	2598	5668
1960	0	11965	14043	16691	9248	8313	4815	1583	1049	7851
1961	0	972	50470	19403	12574	4760	3998	4338	847	7355
1962	0	1584	6173	58836	15254	10478	4797	4087	2074	7450
1963	0	670	8271	8485	45823	8420	6603	2403	3365	8316
1964	53	150	2041	5518	3680	16749	3020	1749	790	2913
1965	0	45180	1045	1534	4798	2381	11990	1494	1463	3077
1966	0	12145	132170	979	1168	3649	736	6255	694	2424
1967	0	3769	26260	87039	1998	548	1962	777	5160	2978
1968	1034	17093	13852	24894	48417	461	244	1639	323	6502
1969	404	24404	21884	5433	12638	25646	338	249	1214	5379
1970	1299	6141	25996	8236	1784	3231	11961	246	140	5234
1971	425	33765	14596	12909	4538	1459	2355	7300	194	4649
1972	354	7511	36356	6997	4911	1548	517	1218	4654	2772
1973	716	12459	13025	16493	4101	2368	1013	779	1241	5899
1974	100	15171	21248	5412	6965	1896	1563	649	396	4750
1975	267	23193	28833	11839	2110	3870	798	916	513	3481
1976	1064	3619	28571	14316	4923	987	1950	562	434	2721
1977	1780	22747	12299	15593	7580	1812	325	1133	261	2155
1978	27	24921	29163	6102	6610	4231	1730	608	643	1595
1979	9	8280	41681	16259	3033	3262	1769	826	244	1546
1980	650	1233	12762	18138	7444	1479	2241	1437	374	1227
1981	434	29983	3344	7046	8439	3757	973	909	786	932
1982	2697	26799	46375	1868	3584	4855	1701	623	613	1295
1983	391	34545	41551	21273	626	1383	1958	982	388	1181
1984	192	30839	44081	22631	8821	744	857	1047	526	897
1985	163	16449	42773	20079	9307	3520	207	375	631	965
1986	372	9304	18381	17591	7698	5480	2256	109	281	1671
1987	93	28896	21927	8851	6477	3102	1559	898	81	690
1988	10	13206	47135	15217	4377	3878	1549	890	523	317
1989	115	45652	17973	22295	4551	1627	1414	637	451	459
1990	854	11816	103380	9667	9099	3315	1032	1186	548	837
1991	118	12938	24985	76580	6609	3612	1706	707	718	1072
1992	965	6730	43713	15961	37745	2440	2995	730	393	1163
1993	53	49870	16575	31047	13709	23758	1472	1170	456	833
1994	709	7710	86349	13387	18513	5642	11174	458	905	897
1995	4766	12674	16700	68073	6262	7254	1981	5971	293	665
1996	170	18609	16005	16770	26946	3814	4725	932	3267	976
1997	1574	5987	23418	7253	5058	12667	1189	2303	330	1672
1998	242	56162	15011	14806	3466	1924	4727	787	1022	838
1999	284	15601	71730	8103	6049	1200	657	1964	328	804
2000	2329	14929	32425	42394	3257	2453	796	431	922	708

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2001	857	25045	20925	19260	16211	1383	808	266	163	701
2002	1046	10958	32570	12185	8145	6393	667	592	88	362
2003	1047	32295	17479	16072	5814	3902	2427	400	128	451
2004	516	14960	48003	9531	7462	2167	902	962	389	389
2005	1131	7254	22633	28875	4168	3861	1491	602	768	392
2006	7008	9966	10397	9606	10943	1617	1577	724	373	553
2007	315	39643	10820	6407	5706	5479	819	725	498	541
2008	1959	6325	37427	5996	2928	2393	2613	448	491	459
2009	1630	10417	10771	26548	3278	1652	1591	1532	312	864
2010	371	11659	13354	8530	13623	1817	907	809	1196	690
2011	44	11992	19788	8379	5070	6436	983	431	283	765
2012	1	6439	28605	11069	4285	2146	4072	587	286	1028
2013	0	2741	28189	21500	5643	2042	1532	2246	242	471
2014	371	8111	6916	22942	11440	2591	1808	620	840	459
2015	201	10512	16589	4738	14756	6157	1470	562	393	545
2016	119	6151	24249	11489	4475	8994	4495	774	278	140

Table 18.2.3. North Sea sole: Discards (including BMS) in numbers by age 1–10 (in thousands).

	1	2	3	4	5	6	7	8	9	10
2002	6461	12606	5212	1029	272	0	0	0	0	0
2003	1156	7152	5059	1212	381	0	0	0	0	0
2004	2936	12832	7449	1719	518	12	0	0	0	0
2005	2256	5622	4796	1258	375	63	22	0	0	0
2006	2390	5727	2705	654	197	28	18	7	0	0
2007	818	4923	3010	619	226	57	4	0	0	0
2008	1230	2704	1764	371	106	0	8	0	0	0
2009	2695	6480	3652	999	266	5	9	0	0	0
2010	5687	12164	6670	1544	493	31	10	2	2	0
2011	3457	10298	5482	1273	354	33	0	0	0	0
2012	1132	19556	9444	984	230	232	36	4	7	1
2013	4653	5733	12558	3649	340	125	19	3	0	0
2014	7162	5836	2371	3488	1366	238	198	6	0	0
2015	9454	9166	3913	1991	1528	415	15	50	8	1
2016	5145	5338	5048	1393	291	536	226	4	1	0

Table 18.2.4. North Sea sole: Landings weights (kg) at age 1–10.

	1	2	3	4	5	6	7	8	9	10
1957	0.155	0.154	0.177	0.204	0.248	0.279	0.29	0.335	0.436	0.40813
1958	0.155	0.145	0.178	0.22	0.254	0.273	0.314	0.323	0.388	0.41344
1959	0.155	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.42621
1960	0.155	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.4177
1961	0.155	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.41932
1962	0.155	0.155	0.165	0.208	0.241	0.295	0.32	0.321	0.334	0.41186
1963	0.155	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.48463
1964	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.4805
1965	0.155	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.47972
1966	0.155	0.177	0.19	0.18	0.301	0.332	0.429	0.399	0.449	0.50148
1967	0.155	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.49123
1968	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.50752
1969	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.52271
1970	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.5326
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.42	0.49	0.534	0.54714
1972	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.62907
1973	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.58575
1974	0.164	0.192	0.233	0.338	0.418	0.448	0.52	0.559	0.609	0.65327
1975	0.129	0.182	0.225	0.32	0.406	0.456	0.529	0.595	0.629	0.66935
1976	0.143	0.19	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.66472
1977	0.147	0.188	0.236	0.307	0.369	0.424	0.43	0.52	0.562	0.6194
1978	0.152	0.196	0.231	0.314	0.37	0.426	0.466	0.417	0.572	0.66635
1979	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.76296
1980	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.55	0.598	0.68412
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.63022
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.65568
1983	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.64225
1984	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.63382
1985	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.64476
1986	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.60955
1987	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.65696
1988	0.127	0.175	0.217	0.27	0.354	0.428	0.484	0.521	0.559	0.71241
1989	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.47	0.61107
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.61975
1991	0.127	0.186	0.21	0.263	0.315	0.436	0.443	0.467	0.507	0.55809
1992	0.146	0.178	0.213	0.258	0.298	0.38	0.409	0.46	0.487	0.55569
1993	0.097	0.167	0.196	0.239	0.264	0.3	0.338	0.441	0.496	0.60312
1994	0.143	0.18	0.202	0.228	0.257	0.3	0.317	0.432	0.409	0.51009
1995	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.59158
1996	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.37	0.39	0.59428
1997	0.151	0.18	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.4396
1998	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.50367
1999	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.45268
2000	0.145	0.17	0.2	0.248	0.29	0.299	0.323	0.368	0.402	0.42761

	1	2	3	4	5	6	7	8	9	10
2001	0.143	0.185	0.202	0.27	0.275	0.333	0.391	0.414	0.433	0.49344
2002	0.14	0.183	0.211	0.243	0.281	0.312	0.366	0.319	0.571	0.53635
2003	0.136	0.182	0.214	0.256	0.273	0.317	0.34	0.344	0.503	0.43054
2004	0.127	0.18	0.209	0.252	0.263	0.284	0.378	0.367	0.327	0.42456
2005	0.172	0.185	0.207	0.243	0.241	0.282	0.265	0.377	0.318	0.40057
2006	0.156	0.19	0.22	0.263	0.291	0.322	0.293	0.358	0.397	0.39622
2007	0.154	0.18	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.32644
2008	0.15	0.181	0.223	0.24	0.265	0.324	0.314	0.297	0.307	0.41748
2009	0.138	0.185	0.202	0.256	0.275	0.278	0.325	0.334	0.303	0.39787
2010	0.163	0.181	0.22	0.236	0.273	0.308	0.283	0.311	0.361	0.38068
2011	0.152	0.162	0.194	0.233	0.242	0.274	0.272	0.293	0.335	0.34695
2012	0.095	0.169	0.185	0.233	0.256	0.234	0.27	0.26	0.283	0.269
2013	0.125	0.169	0.185	0.224	0.253	0.266	0.297	0.278	0.309	0.466
2014	0.155	0.191	0.212	0.228	0.263	0.273	0.249	0.279	0.319	0.351
2015	0.145	0.169	0.205	0.24	0.263	0.274	0.304	0.293	0.33	0.31934
2016	0.143	0.175	0.200	0.236	0.265	0.275	0.273	0.294	0.325	0.397

Table 18.2.5. North Sea sole: Discard weights (kg) at age 1–10.

	1	2	3	4	5	6	7	8	9	10
2002	0.046	0.068	0.084	0.091	0.096	0.11	0.124	0.137	0.137	0
2003	0.054	0.087	0.1	0.107	0.114	0.11	0.124	0.137	0.137	0
2004	0.065	0.089	0.103	0.111	0.118	0.095	0.124	0.137	0.137	0
2005	0.068	0.089	0.104	0.109	0.114	0.103	0.107	0.137	0.137	0
2006	0.066	0.082	0.099	0.109	0.108	0.115	0.113	0.121	0.137	0
2007	0.066	0.087	0.098	0.102	0.107	0.104	0.121	0.136	0.136	0
2008	0.064	0.086	0.101	0.112	0.124	0.11	0.111	0.137	0.137	0
2009	0.066	0.089	0.101	0.106	0.114	0.126	0.104	0.137	0.137	0
2010	0.066	0.083	0.096	0.105	0.109	0.111	0.113	0.121	0.121	0
2011	0.053	0.081	0.093	0.104	0.113	0.104	0.11	0.122	0.126	0
2012	0.059	0.075	0.09	0.096	0.111	0.08	0.115	0.122	0.121	0.14
2013	0.041	0.075	0.086	0.1	0.117	0.09	0.112	0.117	0.121	0
2014	0.051	0.079	0.089	0.097	0.106	0.1	0.117	0.099	0.147	0
2015	0.032	0.076	0.095	0.087	0.105	0.117	0.132	0.124	0.159	0.199
2016	0.024	0.073	0.087	0.095	0.114	0.108	0.124	0.221	0.214	0.197

Table 18.2.6. North Sea sole: Stock weights (kg) at age 1–10 (kg): Mean weights of sampled catches in quarter 2 are exported from InterCatch.

	1	2	3	4	5	6	7	8	9	10
1957	0.025	0.07	0.147	0.187	0.208	0.253	0.262	0.355	0.39	0.36517
1958	0.025	0.07	0.164	0.205	0.226	0.228	0.297	0.318	0.393	0.4215
1959	0.025	0.07	0.159	0.198	0.239	0.271	0.292	0.276	0.303	0.42579
1960	0.025	0.07	0.163	0.207	0.234	0.24	0.268	0.242	0.36	0.43132
1961	0.025	0.07	0.148	0.206	0.235	0.232	0.259	0.274	0.281	0.39639
1962	0.025	0.07	0.148	0.192	0.24	0.301	0.293	0.282	0.273	0.44136
1963	0.025	0.07	0.148	0.193	0.243	0.275	0.311	0.363	0.329	0.46536
1964	0.025	0.07	0.159	0.214	0.24	0.291	0.305	0.306	0.365	0.47387
1965	0.025	0.14	0.198	0.223	0.251	0.297	0.337	0.358	0.526	0.46044
1966	0.025	0.07	0.16	0.149	0.389	0.31	0.406	0.377	0.385	0.50451
1967	0.025	0.177	0.164	0.235	0.242	0.399	0.362	0.283	0.381	0.45912
1968	0.025	0.122	0.171	0.248	0.312	0.28	0.629	0.416	0.41	0.48561
1969	0.025	0.137	0.174	0.252	0.324	0.364	0.579	0.415	0.469	0.52107
1970	0.025	0.137	0.201	0.275	0.341	0.367	0.423	0.458	0.39	0.55442
1971	0.034	0.148	0.213	0.313	0.361	0.41	0.432	0.474	0.483	0.53254
1972	0.038	0.155	0.218	0.313	0.419	0.443	0.443	0.443	0.508	0.60178
1973	0.039	0.149	0.226	0.322	0.371	0.433	0.452	0.472	0.446	0.53554
1974	0.035	0.146	0.218	0.329	0.408	0.429	0.499	0.565	0.542	0.61804
1975	0.035	0.148	0.206	0.311	0.403	0.446	0.508	0.582	0.58	0.6501
1976	0.035	0.142	0.201	0.301	0.379	0.458	0.508	0.517	0.644	0.66481
1977	0.035	0.147	0.202	0.291	0.365	0.409	0.478	0.487	0.531	0.64434
1978	0.035	0.139	0.211	0.29	0.365	0.429	0.427	0.385	0.542	0.64441
1979	0.045	0.148	0.211	0.3	0.352	0.429	0.521	0.562	0.567	0.74343
1980	0.039	0.157	0.2	0.304	0.345	0.394	0.489	0.537	0.579	0.64513
1981	0.05	0.137	0.2	0.305	0.364	0.402	0.454	0.522	0.561	0.62226
1982	0.05	0.13	0.193	0.27	0.359	0.411	0.429	0.476	0.583	0.64223
1983	0.05	0.14	0.2	0.285	0.329	0.435	0.464	0.483	0.51	0.63619
1984	0.05	0.133	0.203	0.268	0.348	0.386	0.488	0.591	0.567	0.66346
1985	0.05	0.127	0.185	0.267	0.324	0.381	0.38	0.626	0.554	0.64227
1986	0.05	0.133	0.191	0.278	0.345	0.423	0.495	0.487	0.587	0.68625
1987	0.05	0.154	0.191	0.262	0.357	0.381	0.406	0.454	0.332	0.61971
1988	0.05	0.133	0.193	0.26	0.335	0.409	0.417	0.474	0.486	0.65433
1989	0.05	0.133	0.195	0.29	0.35	0.34	0.411	0.475	0.419	0.59444
1990	0.05	0.148	0.203	0.294	0.357	0.447	0.399	0.494	0.481	0.65279
1991	0.05	0.139	0.184	0.254	0.301	0.413	0.447	0.522	0.548	0.57344
1992	0.05	0.156	0.194	0.257	0.307	0.398	0.406	0.472	0.5	0.54009
1993	0.05	0.128	0.184	0.229	0.265	0.293	0.344	0.482	0.437	0.58327
1994	0.05	0.143	0.174	0.209	0.257	0.326	0.349	0.402	0.494	0.45895
1995	0.05	0.151	0.179	0.24	0.253	0.321	0.365	0.357	0.545	0.54526
1996	0.05	0.147	0.178	0.208	0.274	0.268	0.321	0.375	0.402	0.54643
1997	0.05	0.15	0.19	0.225	0.252	0.303	0.319	0.325	0.36	0.42402
1998	0.05	0.14	0.173	0.234	0.267	0.281	0.328	0.273	0.336	0.4546
1999	0.05	0.131	0.187	0.216	0.259	0.296	0.34	0.322	0.369	0.46388

	1	2	3	4	5	6	7	8	9	10
2000	0.05	0.139	0.185	0.226	0.264	0.275	0.287	0.337	0.391	0.3763
2001	0.05	0.144	0.185	0.223	0.263	0.319	0.327	0.421	0.41	0.53023
2002	0.05	0.145	0.197	0.245	0.267	0.267	0.299	0.308	0.435	0.43536
2003	0.05	0.146	0.194	0.24	0.256	0.288	0.33	0.312	0.509	0.46973
2004	0.05	0.137	0.195	0.24	0.245	0.305	0.316	0.448	0.356	0.60138
2005	0.05	0.15	0.189	0.234	0.237	0.258	0.276	0.396	0.369	0.42863
2006	0.05	0.148	0.197	0.25	0.27	0.319	0.286	0.341	0.409	0.45521
2007	0.05	0.152	0.179	0.216	0.242	0.245	0.275	0.252	0.257	0.36401
2008	0.05	0.154	0.198	0.212	0.239	0.302	0.282	0.231	0.274	0.40044
2009	0.05	0.142	0.185	0.232	0.255	0.279	0.283	0.333	0.302	0.39017
2010	0.05	0.149	0.2	0.23	0.272	0.307	0.336	0.336	0.361	0.41003
2011	0.05	0.141	0.179	0.223	0.261	0.276	0.32	0.36	0.444	0.39082
2012	0.025	0.058	0.144	0.205	0.23	0.209	0.251	0.235	0.334	0.223
2013	0.034	0.068	0.117	0.186	0.254	0.258	0.309	0.241	0.325	0.562
2014	0.022	0.079	0.136	0.188	0.212	0.227	0.228	0.29	0.343	0.603
2015	0.07	0.075	0.142	0.148	0.227	0.244	0.263	0.288	0.37	0.38939
2016	0.010	0.067	0.151	0.186	0.248	0.236	0.261	0.221	0.359	0.227

Table 18.2.7. North Sea sole: Natural mortality at age and maturity ate age.

	1	2	3	4	5	6	7	8	9	10
Natural mortality	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Maturity	0	0	1	1	1	1	1	1	1	1

Table 18.2.8. North Sea sole: Survey tuning indices.

BTS-ISIS	1	2	3	4	5	6	7	8	9
1985	7.031	7.121	3.695	1.654	0.688	0.276	0	0	0
1986	7.168	5.183	1.596	0.987	0.623	0.171	0.158	0	0.018
1987	6.973	12.548	1.834	0.563	0.583	0.222	0.228	0.058	0
1988	83.111	12.512	2.684	1.032	0.123	0.149	0.132	0.103	0.014
1989	9.015	68.084	4.191	4.096	0.677	0.128	0.242	0	0.051
1990	37.839	24.487	21.789	0.778	1.081	0.77	0.12	0.115	0.025
1991	4.035	28.841	6.872	6.453	0.136	0.135	0.063	0.045	0.013
1992	81.625	22.284	10.449	2.529	3.018	0.09	0.162	0.078	0.02
1993	6.35	42.345	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	7.66	7.121	19.743	0.124	1.636	0.088	0.983	0.009	0
1995	28.125	8.458	6.268	5.129	0.363	0.805	0.316	0.734	0.039
1996	3.975	7.634	1.955	1.785	2.586	0.326	0.393	0.052	0.264
1997	169.343	4.919	2.985	0.739	0.71	0.38	0.096	0.035	0.042
1998	17.108	27.422	1.862	1.242	0.073	0.015	0.391	0	0
1999	11.96	18.363	15.783	0.584	1.92	0.31	0.218	0.604	0.003
2000	14.594	6.144	4.045	1.483	0.263	0.141	0.06	0.007	0.15
2001	7.998	9.963	2.156	1.564	0.684	0.074	0.037	0.028	0
2002	20.989	4.182	3.428	0.886	0.363	0.361	0.032	0.069	0
2003	10.507	9.947	2.459	1.67	0.36	0.187	0.319	0	0.02
2004	4.192	4.354	3.553	0.644	0.626	0.118	0.07	0.073	0
2005	5.534	3.395	2.377	1.303	0.167	0.171	0.077	0.047	0
2006	17.089	2.332	0.278	0.709	0.479	0.151	0.088	0	0.007
2007	7.498	19.504	1.464	0.565	0.315	0.537	0.031	0.009	0
2008	15.247	9.062	12.298	1.313	0.222	0.279	0.202	0.028	0.047
2009	15.95	4.999	2.858	4.791	0.252	0.124	0.272	0.079	0
2010	54.811	10.707	2.027	0.774	1.252	0.143	0.122	0.005	0.027
2011	26.166	17.387	4.006	1.094	0.778	0.828	0.013	0	0.141
2012	5.149	18.212	8.863	1.692	0.764	0.257	0.229	0.046	0
2013	6.844	3.558	12.566	5.385	0.871	0.197	0.105	0.078	0.019
2014	18.926	15.576	3.373	6.763	3.208	0.377	0.101	0.02	0
2015	21.099	25.601	9.66	1.294	4.576	1.502	0.419	0.122	0.15
2016	6.454	11.832	8.417	2.912	0.415	1.498	0.471	0.042	0.000

SNS	1	2	3	4	5	6
1970	5410	734	238	35	4	0
1971	903	1831	113	3	28.9	0
1972	1455	272	149	NA	28.3	0
1973	5587	935	84	37	13	0
1974	2348	361	65	NA	0	4.4
1975	525	865	177	18	0	17.1
1976	1399	74	229	27	5.7	0
1977	3743	776	104	43	31.7	3.9
1978	1548	1355	294	28	99.4	13.3
1979	94	408	301	78	0	16.7
1980	4313	89	109	61	3.3	0
1981	3737	1413	50	20	0	0
1982	5857	1146	228	7	10	0
1983	2621	1123	121	40	0	19.7
1984	2493	1100	318	74	8	0
1985	3619	716	167	49	4.4	0
1986	3705	458	69	31	16.7	0
1987	1948	944	65	21	0	0
1988	11227	594	282	82	10.2	15.5
1989	2831	5005	208	53	18.2	18.6
1990	2856	1120	914	100	49.6	12.5
1991	1254	2529	514	624	27.2	35.8
1992	11114	144	360	195	284.8	20
1993	1291	3420	154	213	0	191.7
1994	652	498	934	10	59.3	0
1995	1362	224	143	411	7.1	31.1
1996	218	349	30	36	90	10
1997	10279	154	190	27	58.1	230
1998	4095	3126	142	99	0	10
1999	1649	972	456	10	20.7	0
2000	1639	126	166	118	0	2
2001	970	655	107	36	56.2	0
2002	7548	379	195	NA	30.8	19.2
2003	NA	NA	NA	NA	NA	NA
2004	1370	624	393	69	53.1	7.5
2005	568	163	124	NA	21.3	6.7
2006	2726	117	25	30	0	0
2007	849	911	33	40	14.4	0
2008	1259	259	325	NA	10	0
2009	1932	344	62	103	0	0
2010	2637	237	67	42	23.2	0
2011	1248	884	211	112	0	38
2012	NA	NA	NA	NA	NA	NA
2013	967	427	491	179	50.8	7.6
2014	2849	448	45	60	34	0

2015	3192	2334	138	160	162	151
2016	733.8	623.3	494.6	109.8	16.7	42.9

DFS0	NL	BE	DE	COMBINED
1970	21.56			
1971	20.35			
1972	0.76			
1973	6.52			
1974	1.06		0.21	
1975	9.65		3.79	
1976	4.23		0.55	
1977	1.12		2.80	
1978	5.80		3.10	
1979	12.76		1.33	
1980	26.17		3.56	
1981	15.61		2.10	
1982	12.75		1.11	
1983	4.31	2.67	2.14	
1984	7.27	5.40	1.14	
1985	12.03	16.98	0.03	
1986	4.41	2.56	0.31	
1987	30.82	2.29	1.27	
1988	1.67	0.70	3.17	
1989	3.02	1.00	0.43	
1990	0.44	0.36	0.23	6.38
1991	14.52	2.17	0.87	167.56
1992	0.76	0.16	0.19	9.27
1993	1.26	0.45	0.12	15.32
1994	1.82	0.69	0.15	22.06
1995	0.28	1.57	0.09	7.06
1996	2.45	4.95	0.55	40.27
1997	2.14	1.40	0.03	26.94
1998	1.26	3.48	0.18	
1999	1.34	2.31	0.10	
2000	0.72	0.53	0.12	9.50
2001	2.65	9.45	0.05	51.42
2002	2.43	13.39	0.18	58.58
2003	0.62	1.50	0.10	10.61
2004	0.59	10.52	0.05	31.25
2005	2.24	5.66	0.99	40.99
2006	1.04	0.34	0.12	12.57
2007	0.86	1.74	0.05	13.73
2008	0.97	0.43	0.02	11.77
2009	1.22	5.52	0.31	27.33
2010	2.24	7.72	0.024	42.86
2011	0.98	0.48	0.07	12.13
2012	0.92	0.43	0.05	11.23
2013	3.46	1.94	0.72	44.82
2014	1.98	0.69	0.07	23.62

2015	0.56	0.46	0.05	7.45
2016	0.88	1.11	0.00460	12.28

Table 18.3.1. North Sea sole: Assessment summary: Values in intermediate year are assumed.

YEAR	RECRUITMENT	HIGH	LOW	SSB	HIGH
	Age 1				
	thousands			tonnes	
1957	133277	157330	112859	62951	71130
1958	119237	142089	100087	65521	73570
1959	445212	528931	374515	68339	75969
1960	41864	50175	34917	69232	76648
1961	68533	82118	57187	103212	114205
1962	11002	13109	9233	86875	95959
1963	12732	15346	10564	70529	77938
1964	606577	742576	495895	51794	58345
1965	149746	186924	120035	41119	47516
1966	55012	71824	42109	108951	125152
1967	86645	115522	65041	104919	116658
1968	123437	164049	92789	91218	100712
1969	88165	119475	65065	70097	77685
1970	202370	272998	150058	64109	71649
1971	56296	73765	42931	55916	62603
1972	110810	145318	84569	64570	72612
1973	148539	189624	116448	47820	53446
1974	124012	156198	98432	46689	52231
1975	59216	75430	46492	47513	52848
1976	136518	173265	107519	45657	50424
1977	168197	215647	131216	36705	39942
1978	63044	81336	48906	42569	46975
1979	18291	23135	14462	52281	58659
1980	187369	242191	145004	39679	43325
1981	221990	294779	167045	26090	28240
1982	200654	265338	151636	38600	44239
1983	197456	262073	148690	49211	55814
1984	94911	122514	73572	50710	56982
1985	115068	144128	91816	47706	53694
1986	167104	209831	132978	38487	41934
1987	82858	101873	67408	34879	38436
1988	667131	820279	542856	42374	47412
1989	133529	164266	108528	38162	41582
1990	253242	308603	207771	122584	142153
1991	91031	111886	74070	91883	102544
1992	448133	559881	358800	90099	98379
1993	87272	108989	69913	59420	64350
1994	63189	79110	50483	84580	94924
1995	110762	139291	88052	62927	69484
1996	75318	94750	59814	38775	42087
1997	336195	435435	259341	32537	35715
1998	156889	203756	120731	24627	27055
1999	118445	148961	94142	49838	58603

Year	Recruitment	High	Low	SSB	High
2000	138196	170399	111983	40152	44795
2001	71605	87062	58902	33565	36894
2002	220969	267923	182325	34391	37962
2003	99003	121431	80733	27656	30096
2004	53342	64132	44325	41024	46122
2005	49858	59091	42073	31855	35038
2006	181664	215585	153106	24799	26734
2007	68707	81323	58094	17880	19315
2008	78724	94532	65599	35279	39309
2009	103983	126263	85637	32163	35379
2010	221683	267768	183528	31358	34548
2011	219556	267830	179852	30070	33758
2012	56463	70921	44922	36744	42240
2013	127683	168299	96809	44948	52373
2014	245184	338284	177790	42397	50759
2015	158732	235226	107119	45650	55408
2016	53947	97229	29947	62636	76805
2017	86425			67961	

Table 18.4.1. North Sea sole: Input table for RCT3 analysis.

YEAR–CLASS	N_AGE_1	N_AGE_2	DFS0	SNS0	SNS1	BTS1
1975	136518	120973	NA	577.5	1399.4	NA
1976	168197	149389	NA	464.6	3742.9	NA
1977	63044.3	56504.9	NA	1585	1547.7	NA
1978	18291.3	16465.7	NA	10370.5	93.8	NA
1979	187369	168599	NA	3922.7	4312.9	NA
1980	221990	198541	NA	5145.8	3737.2	NA
1981	200654	177122	NA	3240.7	5856.5	NA
1982	197456	173556	NA	2147	2621.1	NA
1983	94911.2	84288.8	NA	769.1	2493.1	NA
1984	115068	103152	NA	3334	3619.4	7.031
1985	167104	150464	NA	2713.4	3705.1	7.168
1986	82857.6	74742.7	NA	742	1947.9	6.973
1987	667131	602167	NA	13610.1	11226.7	83.111
1988	133529	120510	NA	522.7	2830.7	9.015
1989	253242	228340	NA	1743.4	2856.2	37.839
1990	91031.4	81887.4	6.38	50.8	1253.6	4.035
1991	448133	401062	167.56	3639.7	11114	81.625
1992	87271.7	77465.2	9.27	302.9	1290.8	6.35
1993	63189.1	55705.8	15.32	231.3	651.8	7.66
1994	110762	97551.7	22.06	4692.7	1362.1	28.125
1995	75317.6	66452.6	7.06	1374.9	218.4	3.975
1996	336195	296696	40.27	2322.3	10279.3	169.343
1997	156889	138214	26.94	803	4094.6	17.108
1998	118445	104134	NA	327.9	1648.9	11.96
1999	138196	121424	NA	2187.9	1639.2	14.594
2000	71605	62879	9.5	70	970.3	7.998
2001	220969	193382	51.42	8340	7547.5	20.989
2002	99002.7	85892.4	58.58	1127.7	NA	10.507
2003	53342.1	45847.2	10.61	NA	1369.5	4.192
2004	49858.3	42906.9	31.25	162	568.1	5.534
2005	181664	158395	40.99	305	2726.4	17.089
2006	68706.6	60556.6	12.57	16	848.6	7.498
2007	78724.3	69598.2	13.73	466.9	1259.1	15.247
2008	103983	91599.9	11.77	754.7	1931.6	15.95
2009	221683	194161	27.33	2291	2636.9	54.811
2010	219556	192086	42.86	333.9	1248	26.166
2011	56462.5	49541.1	12.13	136.3	226.6	5.149
2012	127683	111999	11.23	144.7	967.4	6.844
2013	NA	NA	44.82	237.3	2849	18.926
2014	NA	NA	23.62	126	3192	21.099
2015	NA	NA	7.45	109.7	733.8	6.454
2016	NA	NA	12.28	373.2	NA	NA

Table 18.4.2. North Sea sole. RCT3 results for age 1

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years : 1975 - 2016

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Year–class: 2016

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0302	8.534	0.6022	0.5284	21	2.508	11.12	0.6537	0.47204
SNS0	1.0501	4.623	1.4964	0.1697	37	5.922	10.84	1.5659	0.08227
SNS1	0.7572	6.032	0.4131	0.7365	37	NA	NA	NA	NA
BTS1	0.7646	9.757	0.3939	0.7327	29	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	38	NA	11.73	0.6728	0.44569

	WAP	logWAP	int.se
Year-class: 2016	86425	11.37	0.4492

Table 18.4.3. North Sea sole. RCT3 results for age 2.

Analysis by RCT3 ver4.0

Sole

Data for 4 surveys over 42 years: 1975 - 2016

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Year–class: 2015

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	1.0444	8.362	0.6161	0.5197	21	2.008	10.459	0.6859	0.13790
SNS0	1.0398	4.571	1.4779	0.1740	37	4.698	9.456	1.5778	0.02606
SNS1	0.7591	5.896	0.4128	0.7383	37	6.598	10.905	0.4347	0.34343
BTS1	0.7749	9.606	0.4043	0.7259	29	1.865	11.051	0.4303	0.35043
VPA Mean	NA	NA	NA	NA	38	NA	11.606	0.6755	0.14218

	WAP	logWAP	int.se
Year–class: 2015	57339	10.96	0.2547

Table 18.5.1. North Sea sole. Input and assumptions for the intermediate year to the short–term forecast (F values presented are assuming F = Fsq).

2017_SSB	2017_F2-6	2017_F_DIS1-3	2017_F_HC2-6	2017_RECRUITS	2017_LANDINGS	2017_DISCARDS	2017_CATCH	2017_TAC			
67961.0429928025	0.2152114	0.0511476903757308	0.183912523042924	86425	15562.7449669611	1133.47760044678	16696.2226050996	16123			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2017	0.081	0.05	0.03	86425	0.07	0.15	0.04	0.03	0	0.1
2	2017	0.115	0.05	0.06	42068	0.13	0.18	0.08	0.07	0	0.1
3	2017	0.192	0.05	0.14	104563	0.18	0.21	0.09	0.14	1	0.1
4	2017	0.267	0.03	0.23	129900	0.22	0.23	0.09	0.17	1	0.1
5	2017	0.258	0.01	0.24	47952	0.25	0.26	0.11	0.22	1	0.1
6	2017	0.245	0.01	0.24	13164	0.27	0.27	0.11	0.24	1	0.1
7	2017	0.222	0	0.22	29998	0.27	0.28	0.12	0.24	1	0.1
8	2017	0.179	0	0.18	17653	0.29	0.29	0.15	0.28	1	0.1
9	2017	0.179	0	0.18	5060	0.32	0.32	0.17	0.31	1	0.1
10	2017	0.179	0	0.18	6465	0.32	0.32	0.14	0.42	1	0.1
1	2018	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1
2	2018	0.115	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2018	0.192	0.05	0.14	NA	0.18	0.21	0.09	0.14	1	0.1
4	2018	0.267	0.03	0.23	NA	0.22	0.23	0.09	0.17	1	0.1
5	2018	0.258	0.01	0.24	NA	0.25	0.26	0.11	0.22	1	0.1
6	2018	0.245	0.01	0.24	NA	0.27	0.27	0.11	0.24	1	0.1
7	2018	0.222	0	0.22	NA	0.27	0.28	0.12	0.24	1	0.1
8	2018	0.179	0	0.18	NA	0.29	0.29	0.15	0.28	1	0.1
9	2018	0.179	0	0.18	NA	0.32	0.32	0.17	0.31	1	0.1
10	2018	0.179	0	0.18	NA	0.32	0.32	0.14	0.42	1	0.1
1	2019	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1

2	2019	0.115	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2019	0.192	0.05	0.14	NA	0.18	0.21	0.09	0.14	1	0.1
4	2019	0.267	0.03	0.23	NA	0.22	0.23	0.09	0.17	1	0.1
5	2019	0.258	0.01	0.24	NA	0.25	0.26	0.11	0.22	1	0.1
6	2019	0.245	0.01	0.24	NA	0.27	0.27	0.11	0.24	1	0.1
7	2019	0.222	0	0.22	NA	0.27	0.28	0.12	0.24	1	0.1
8	2019	0.179	0	0.18	NA	0.29	0.29	0.15	0.28	1	0.1
9	2019	0.179	0	0.18	NA	0.32	0.32	0.17	0.31	1	0.1
10	2019	0.179	0	0.18	NA	0.32	0.32	0.14	0.42	1	0.1

Table 18.5.2. North Sea sole. Results from the short term forecast assuming F = Fsq.

BASIS	CATCH	LANDINGS	DISCARDS	F2-6	F_HC2-6	F_DIS1-3	SSB2019	SSB_CHANGE	TAC_CHANGE	SSB2018
Fmp	14782	13904	878	0.2	0.17	0.05	60699	-3.37323697	-8.317310674	62818
Fmsy	14782	13904	878	0.2	0.17	0.05	60699	-3.37323697	-8.317310674	62818
Fmsy_low_Btrig	8508	8008	500	0.11	0.09	0.03	66469	5.8120284	-47.23066427	62818
Fmsy_high_Btrig	27351	25686	1664	0.41	0.35	0.1	49204	-21.67213219	69.63964523	62818
Fmsy_low_wo_Btrig	8508	8008	500	0.11	0.09	0.03	66469	5.8120284	-47.23066427	62818
Fmsy_high_wo_Btrig	25160	23636	1524	0.37	0.32	0.09	51201	-18.49310707	56.05036284	62818
Fpa	28936	27170	1767	0.44	0.38	0.1	47761	-23.96924448	79.4703219	62818
Fpasig	30977	29077	1900	0.48	0.41	0.11	45906	-26.92221975	92.12925634	62818
Flim	37506	35170	2336	0.62	0.53	0.15	39995	-36.33194307	132.6242015	62818
SSB>Bpa	40831	38267	2565	0.7	0.6	0.17	37000	-41.0996848	153.2469143	62818
SSB>Blim	52838	49398	3441	1.054	0.9	0.25	26300	-58.1330192	227.7181666	62818
SSB>MSYBtrig	40831	38267	2565	0.7	0.6	0.17	37000	-41.0996848	153.2469143	62818
TACsq	16123	15163	960	0.22	0.19	0.05	59469	-5.331274475	0	62818
15%_TAC_inc	18541	17433	1109	0.258	0.22	0.06	57251	-8.862109586	14.99720896	62818
15%_TAC_dec	13705	12892	812	0.184	0.16	0.04	61689	-1.797255564	-14.99720896	62818
Fsq*0	0	0	0	0	NA	NA	74319	18.30844662	-100	62818
Fsq*0.25	4283	4033	250	0.054	0.05	0.01	70364	12.0124805	-73.43546486	62818
Fsq*0.5	8333	7843	490	0.108	0.09	0.03	66630	6.068324366	-48.31607021	62818
Fsq*0.9	14361	13508	852	0.194	0.17	0.05	61086	-2.757171511	-10.92848725	62818
Fsq*1	15786	14847	939	0.215	0.18	0.05	59778	-4.839377249	-2.090181728	62818
Fsq*1.1	17180	16155	1025	0.237	0.2	0.06	58499	-6.875417874	6.555851889	62818
Fsq*1.25	19214	18063	1150	0.269	0.23	0.06	56635	-9.842720239	19.17137009	62818
Fsq*1.5	22458	21105	1353	0.323	0.28	0.08	53668	-14.56588876	39.29169509	62818
Fsq*1.75	25528	23981	1548	0.377	0.32	0.09	50864	-19.02957751	58.33281647	62818

Table 18.5.3. North Sea sole. Detailed STF table by age, assuming F = Fsq, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	2017	0.081	0.05	0.03	86425	0.07	0.15	0.04	0.03	0	0.1	6435	466	2111	312	4324	154	0	2938
2	2017	0.115	0.05	0.06	42068	0.13	0.18	0.08	0.07	0	0.1	4345	571	2353	420	1992	151	0	3099
3	2017	0.192	0.05	0.14	104563	0.18	0.21	0.09	0.14	1	0.1	17372	3053	12867	2646	4505	407	14953	14953
4	2017	0.267	0.03	0.23	129900	0.22	0.23	0.09	0.17	1	0.1	28992	6284	25326	5943	3666	341	22603	22603
5	2017	0.258	0.01	0.24	47952	0.25	0.26	0.11	0.22	1	0.1	10398	2651	9811	2587	587	64	10725	10725
6	2017	0.245	0.01	0.24	13164	0.27	0.27	0.11	0.24	1	0.1	2730	737	2664	730	66	7	3155	3155
7	2017	0.222	0	0.22	29998	0.27	0.28	0.12	0.24	1	0.1	5686	1557	5629	1550	58	7	7269	7269
8	2017	0.179	0	0.18	17653	0.29	0.29	0.15	0.28	1	0.1	2755	794	2744	792	12	2	4937	4937
9	2017	0.179	0	0.18	5060	0.32	0.32	0.17	0.31	1	0.1	790	256	788	256	1	0	1575	1575
10	2017	0.179	0	0.18	6465	0.32	0.32	0.14	0.42	1	0.1	1009	328	1008	327	1	0	2744	2744
1	2018	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1	8345	604	2738	404	5607	200	0	3811
2	2018	0.115	0.05	0.06	72086	0.13	0.18	0.08	0.07	0	0.1	7446	979	4032	719	3414	259	0	5310
3	2018	0.192	0.05	0.14	33937	0.18	0.21	0.09	0.14	1	0.1	5638	991	4176	859	1462	132	4853	4853
4	2018	0.267	0.03	0.23	78122	0.22	0.23	0.09	0.17	1	0.1	17436	3779	15231	3574	2205	205	13593	13593
5	2018	0.258	0.01	0.24	90033	0.25	0.26	0.11	0.22	1	0.1	19524	4976	18421	4857	1103	119	20137	20137
6	2018	0.245	0.01	0.24	33523	0.27	0.27	0.11	0.24	1	0.1	6951	1877	6783	1859	168	18	8034	8034
7	2018	0.222	0	0.22	9322	0.27	0.28	0.12	0.24	1	0.1	1767	484	1749	482	18	2	2259	2259
8	2018	0.179	0	0.18	21746	0.29	0.29	0.15	0.28	1	0.1	3394	978	3380	976	14	2	6082	6082
9	2018	0.179	0	0.18	13357	0.32	0.32	0.17	0.31	1	0.1	2085	676	2081	676	4	1	4159	4159
10	2018	0.179	0	0.18	8720	0.32	0.32	0.14	0.42	1	0.1	1361	442	1360	442	1	0	3701	3701

Table 18.5.4. North Sea sole. Input and assumptions for the intermediate year to the short term forecast (F values presented are for TAC=landings).

2017_SSB	2017_F2-6	2017_F_DIS1-3	2017_F_HC2-6	2017_RECRUITS	2017_LANDINGS	2017_DISCARDS	2017_CATCH	2017_TAC			
67961.0429928025	0.206963987103605	0.049187589185805	0.176864557580347	86425	15029.1283416805	1093.87162193734	16123	16123			
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2017	0.078	0.05	0.03	86425	0.07	0.15	0.04	0.03	0	0.1
2	2017	0.11	0.05	0.06	42068	0.13	0.18	0.08	0.07	0	0.1
3	2017	0.184	0.05	0.14	104563	0.18	0.21	0.09	0.14	1	0.1
4	2017	0.256	0.03	0.22	129900	0.22	0.23	0.09	0.17	1	0.1
5	2017	0.248	0.01	0.23	47952	0.25	0.26	0.11	0.22	1	0.1
6	2017	0.236	0.01	0.23	13164	0.27	0.27	0.11	0.24	1	0.1
7	2017	0.213	0	0.21	29998	0.27	0.28	0.12	0.24	1	0.1
8	2017	0.172	0	0.17	17653	0.29	0.29	0.15	0.28	1	0.1
9	2017	0.172	0	0.17	5060	0.32	0.32	0.17	0.31	1	0.1
10	2017	0.172	0	0.17	6465	0.32	0.32	0.14	0.42	1	0.1
1	2018	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1
2	2018	0.115	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2018	0.192	0.05	0.14	NA	0.18	0.21	0.09	0.14	1	0.1
4	2018	0.267	0.03	0.23	NA	0.22	0.23	0.09	0.17	1	0.1
5	2018	0.258	0.01	0.24	NA	0.25	0.26	0.11	0.22	1	0.1
6	2018	0.245	0.01	0.24	NA	0.27	0.27	0.11	0.24	1	0.1
7	2018	0.222	0	0.22	NA	0.27	0.28	0.12	0.24	1	0.1
8	2018	0.179	0	0.18	NA	0.29	0.29	0.15	0.28	1	0.1
9	2018	0.179	0	0.18	NA	0.32	0.32	0.17	0.31	1	0.1
10	2018	0.179	0	0.18	NA	0.32	0.32	0.14	0.42	1	0.1

1	2019	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1
2	2019	0.115	0.05	0.06	NA	0.13	0.18	0.08	0.07	0	0.1
3	2019	0.192	0.05	0.14	NA	0.18	0.21	0.09	0.14	1	0.1
4	2019	0.267	0.03	0.23	NA	0.22	0.23	0.09	0.17	1	0.1
5	2019	0.258	0.01	0.24	NA	0.25	0.26	0.11	0.22	1	0.1
6	2019	0.245	0.01	0.24	NA	0.27	0.27	0.11	0.24	1	0.1
7	2019	0.222	0	0.22	NA	0.27	0.28	0.12	0.24	1	0.1
8	2019	0.179	0	0.18	NA	0.29	0.29	0.15	0.28	1	0.1
9	2019	0.179	0	0.18	NA	0.32	0.32	0.17	0.31	1	0.1
10	2019	0.179	0	0.18	NA	0.32	0.32	0.14	0.42	1	0.1

Table 18.5.5. North Sea sole. Results from the short term forecast assuming landings = TAC.

BASIS	CATCH	LANDINGS	DISCARDS	F2-6	F_HC2-6	F_DIS1-3	SSB2019	SSB_CHANGE	TAC_CHANGE	SSB2018
Fmp	14900	14017	882	0.2	0.17	0.05	61164	-3.455242846	-7.585436953	63353
Fmsy	14900	14017	882	0.2	0.17	0.05	61164	-3.455242846	-7.585436953	63353
Fmsy_low_Btrig	8576	8073	502	0.11	0.09	0.03	66981	5.726642779	-46.80890653	63353
Fmsy_high_Btrig	27567	25895	1672	0.41	0.35	0.1	49575	-21.74798352	70.97934628	63353
Fmsy_low_wo_Btrig	8576	8073	502	0.11	0.09	0.03	66981	5.726642779	-46.80890653	63353
Fmsy_high_wo_Btrig	25359	23828	1531	0.37	0.32	0.09	51588	-18.57054915	57.28462445	63353
Fpa	29165	27390	1775	0.44	0.38	0.1	48120	-24.04463877	80.8906531	63353
Fpasig	31222	29313	1908	0.48	0.41	0.11	46251	-26.99477531	93.64882466	63353
Flim	37801	35454	2346	0.62	0.53	0.15	40293	-36.3992234	134.4538858	63353
SSB>Bpa	41456	38859	2597	0.707	0.6	0.17	37000	-41.59708301	157.1233641	63353
SSB>Blim	53464	49992	3472	1.062	0.91	0.25	26300	-58.48657522	231.6008187	63353
SSB>MSYBtrig	41456	38859	2597	0.707	0.6	0.17	37000	-41.59708301	157.1233641	63353
TACsq	16123	15166	957	0.218	0.19	0.05	60041	-5.227850299	0	63353
15%_TAC_inc	18541	17437	1105	0.256	0.22	0.06	57823	-8.728868404	14.99720896	63353
15%_TAC_dec	13705	12895	810	0.182	0.16	0.04	62262	-1.722096823	-14.99720896	63353
Fsq*0	0	0	0	0	NA	NA	74895	18.21855319	-100	63353
Fsq*0.25	4156	3914	242	0.052	0.04	0.01	71056	12.15885593	-74.22315946	63353
Fsq*0.5	8094	7621	474	0.103	0.09	0.02	67424	6.425899326	-49.79842461	63353
Fsq*0.9	13972	13146	826	0.186	0.16	0.04	62016	-2.110397298	-13.3411896	63353
Fsq*1	15365	14454	910	0.207	0.18	0.05	60737	-4.129244077	-4.701358308	63353
Fsq*1.1	16728	15735	994	0.228	0.19	0.05	59486	-6.103894054	3.752403399	63353
Fsq*1.25	18719	17603	1116	0.259	0.22	0.06	57660	-8.98615693	16.10122186	63353

Table 18.5.6. North Sea sole: Detailed STF table by age, assuming catches=TAC, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	2017	0.078	0.05	0.03	86425	0.07	0.15	0.04	0.03	0	0.1	6198	449	2033	300	4164	149	0	2938
2	2017	0.11	0.05	0.06	42068	0.13	0.18	0.08	0.07	0	0.1	4188	550	2268	404	1920	146	0	3099
3	2017	0.184	0.05	0.14	104563	0.18	0.21	0.09	0.14	1	0.1	16764	2947	12417	2554	4347	393	14953	14953
4	2017	0.256	0.03	0.22	129900	0.22	0.23	0.09	0.17	1	0.1	28015	6072	24472	5743	3543	329	22603	22603
5	2017	0.248	0.01	0.23	47952	0.25	0.26	0.11	0.22	1	0.1	10047	2561	9479	2499	567	61	10725	10725
6	2017	0.236	0.01	0.23	13164	0.27	0.27	0.11	0.24	1	0.1	2637	712	2573	705	64	7	3155	3155
7	2017	0.213	0	0.21	29998	0.27	0.28	0.12	0.24	1	0.1	5490	1503	5435	1496	56	7	7269	7269
8	2017	0.172	0	0.17	17653	0.29	0.29	0.15	0.28	1	0.1	2659	766	2647	764	11	2	4937	4937
9	2017	0.172	0	0.17	5060	0.32	0.32	0.17	0.31	1	0.1	762	247	761	247	1	0	1575	1575
10	2017	0.172	0	0.17	6465	0.32	0.32	0.14	0.42	1	0.1	974	316	973	316	1	0	2744	2744
1	2018	0.081	0.05	0.03	112078	0.07	0.15	0.04	0.03	0	0.1	8345	604	2738	404	5607	200	0	3811
2	2018	0.115	0.05	0.06	72311	0.13	0.18	0.08	0.07	0	0.1	7469	982	4045	721	3425	260	0	5327
3	2018	0.192	0.05	0.14	34087	0.18	0.21	0.09	0.14	1	0.1	5663	995	4195	863	1469	133	4874	4874
4	2018	0.267	0.03	0.23	78697	0.22	0.23	0.09	0.17	1	0.1	17564	3807	15343	3601	2221	207	13693	13693
5	2018	0.258	0.01	0.24	90957	0.25	0.26	0.11	0.22	1	0.1	19724	5028	18610	4907	1114	121	20344	20344
6	2018	0.245	0.01	0.24	33856	0.27	0.27	0.11	0.24	1	0.1	7020	1895	6850	1877	170	18	8114	8114
7	2018	0.222	0	0.22	9409	0.27	0.28	0.12	0.24	1	0.1	1784	488	1766	486	18	2	2280	2280
8	2018	0.179	0	0.18	21932	0.29	0.29	0.15	0.28	1	0.1	3423	986	3409	984	14	2	6134	6134
9	2018	0.179	0	0.18	13449	0.32	0.32	0.17	0.31	1	0.1	2099	681	2096	680	4	1	4187	4187

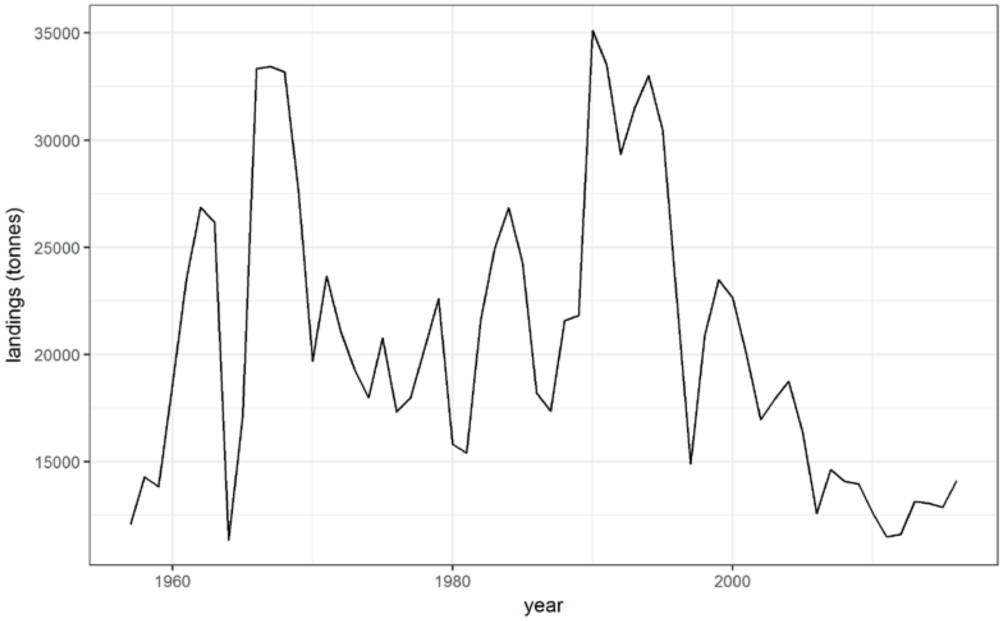


Figure 18.2.1. North Sea sole: Time series of landings (reported to ICES) (1957–present).

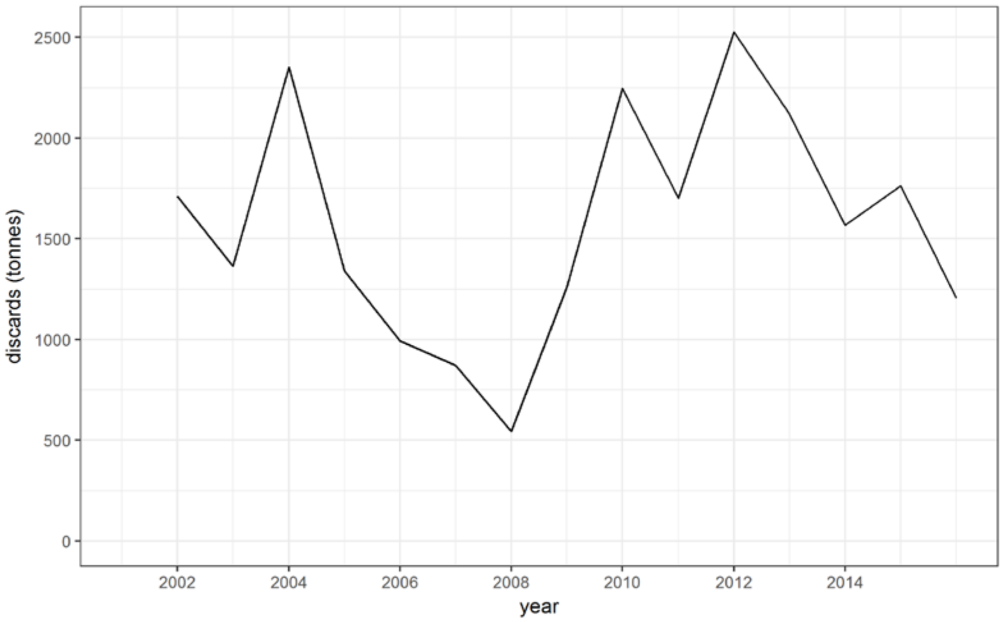
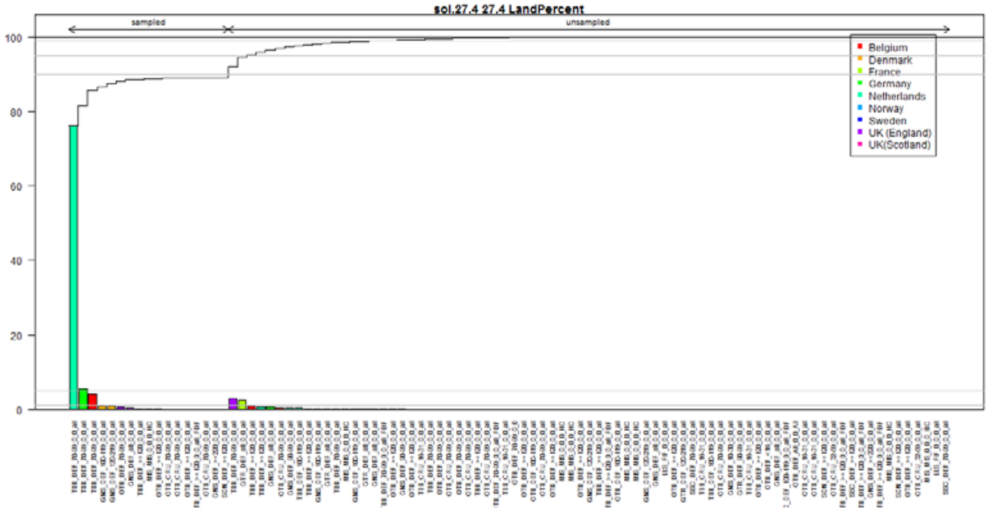


Figure 18.2.2. North Sea sole: Time series of discards (reported to ICES) (2002–present).



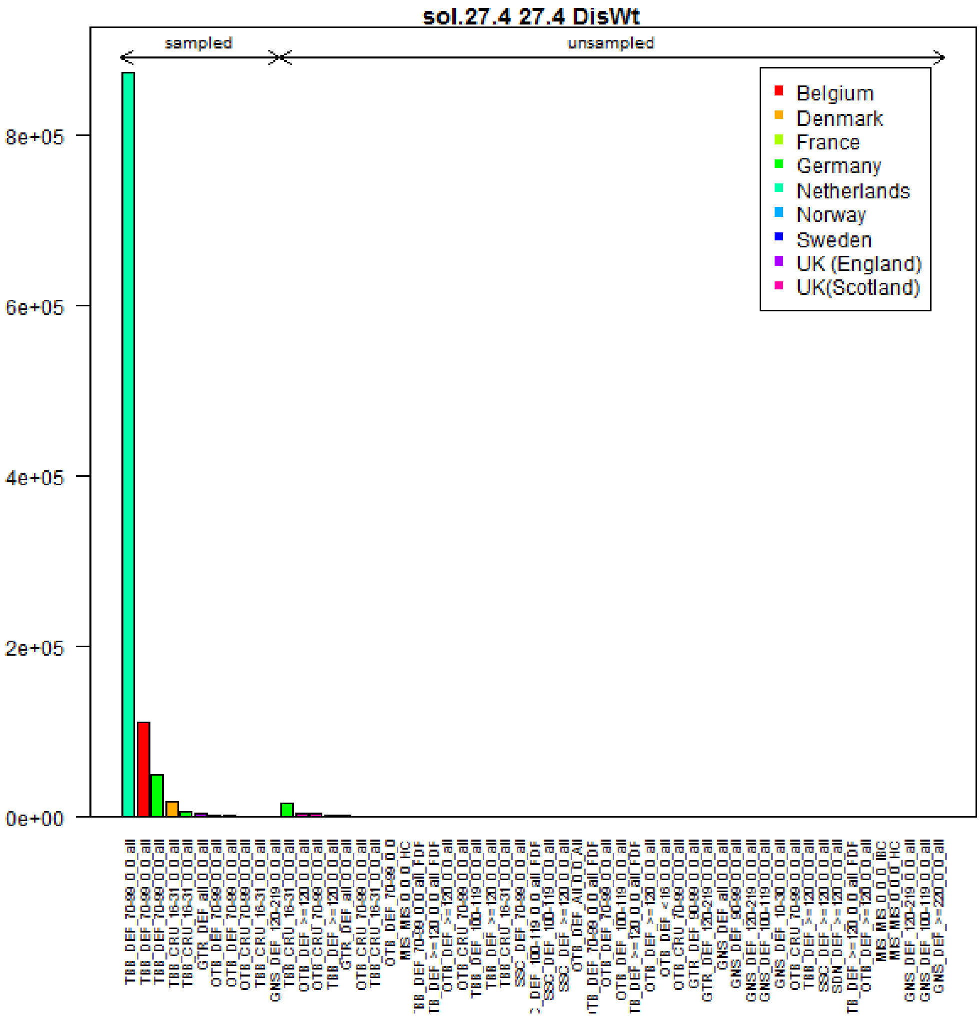


Figure 18.2.3. North Sea sole. Data upload in InterCatch: landings % by country by métier (top); discards in weight (kg) by country by métier (bottom). Sampled and unsampled refers to availability of age-composition information.

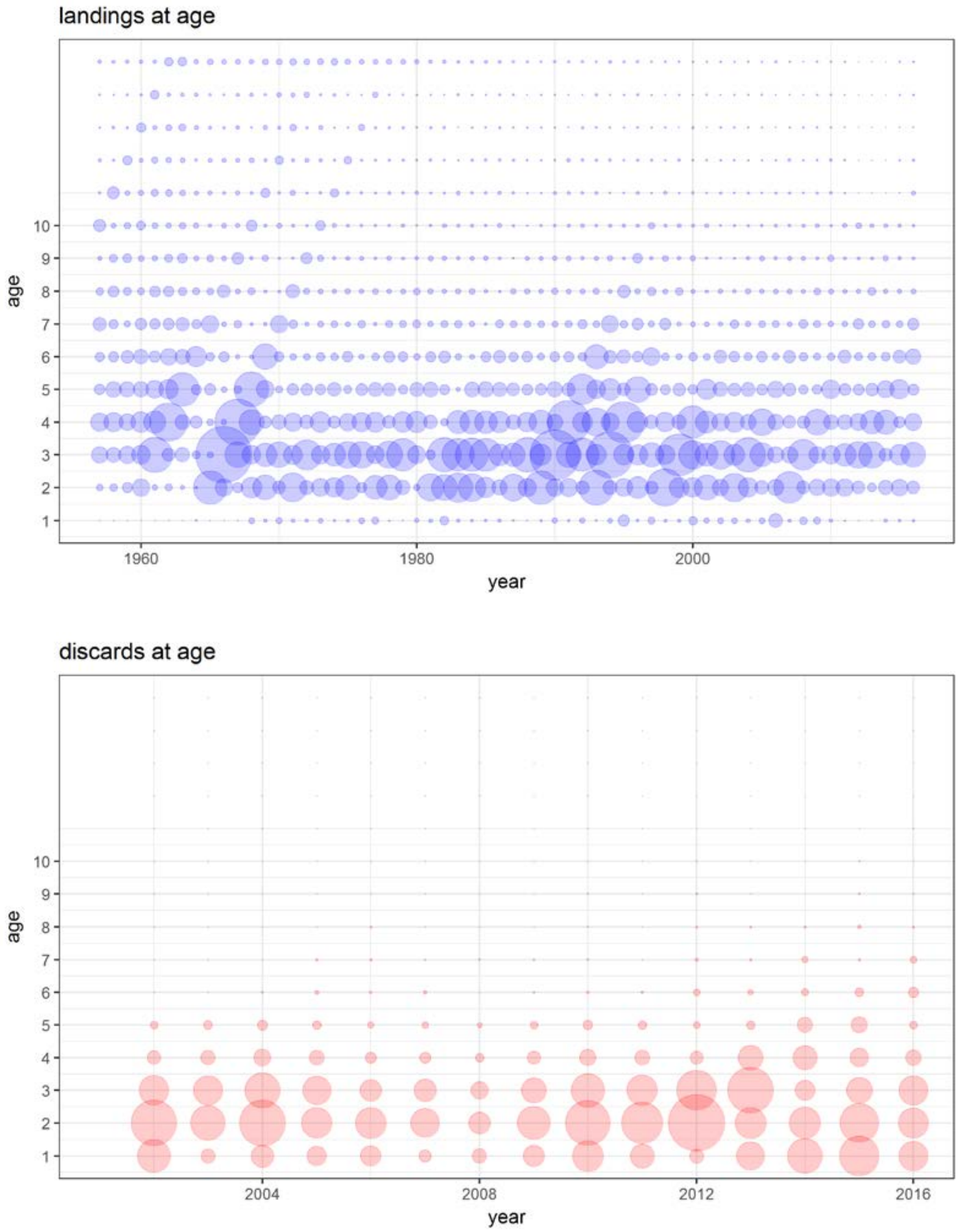
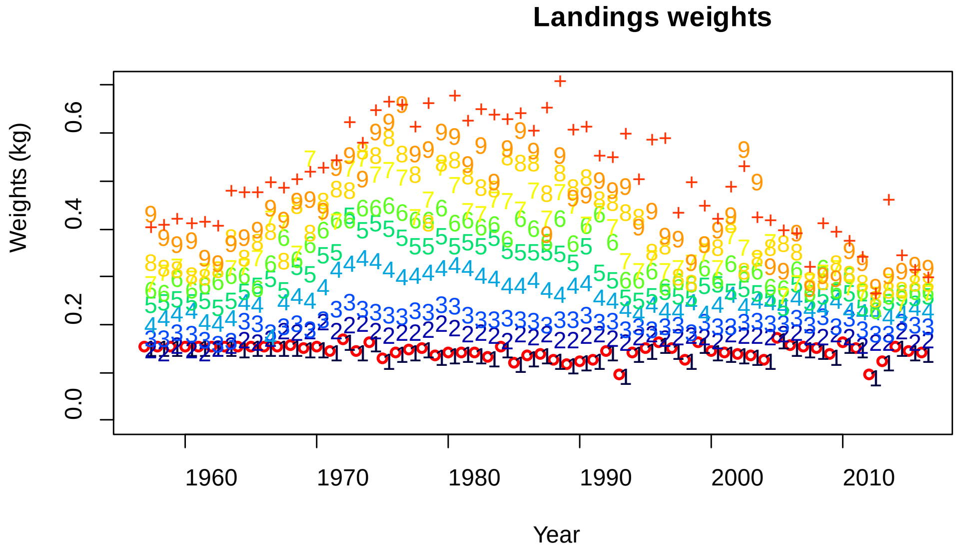
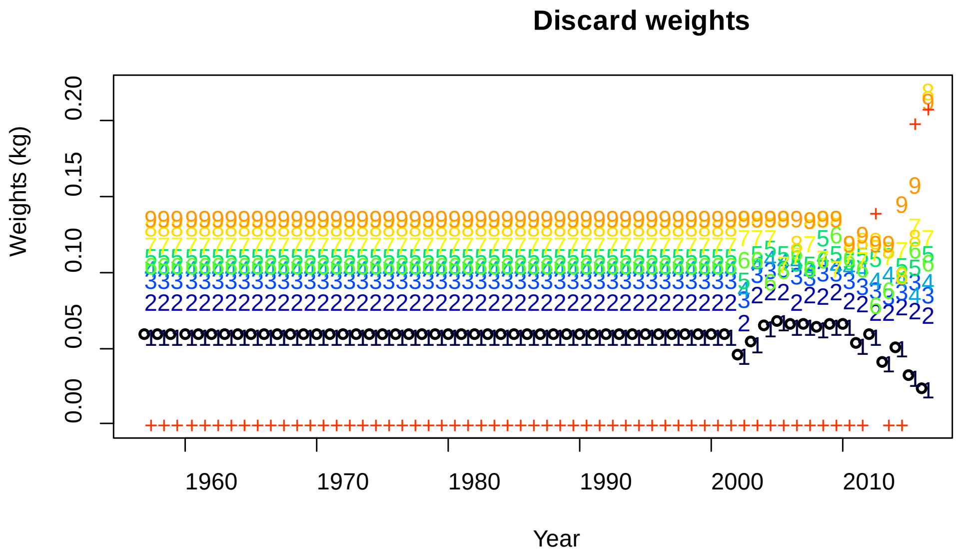


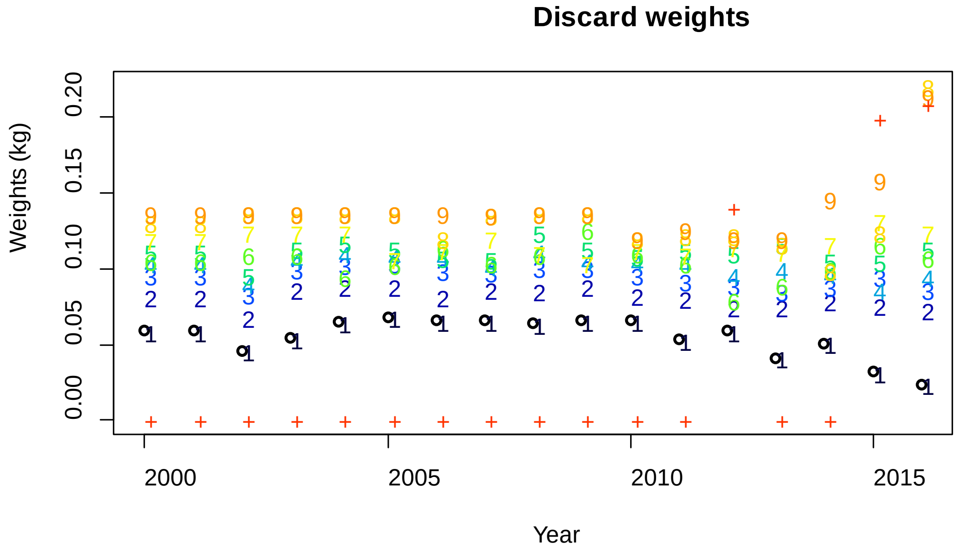
Figure 18.2.4. North Sea sole: Landings and discards numbers-at-age.

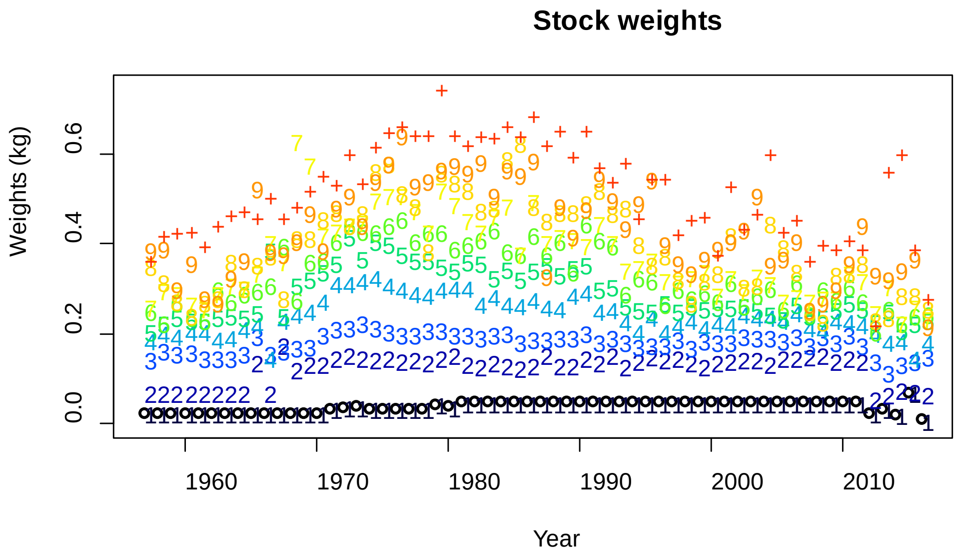


Landings weights
Weights (kg)
0.0
0.2
0.4
0.6
1960
1970
1980
1990
2000
2010
Year



Discard weights
Weights (kg)
0.00
0.05
0.10
0.15
0.20
1960
1970
1980
1990
2000
2010
Year


Discard weights
Weights (kg)
0.00
0.05
0.10
0.15
0.20
2000
2005
2010
2015
Year


Stock weights
Weights (kg)
0.0
0.2
0.4
0.6
1960
1970
1980
1990
2000
2010
Year

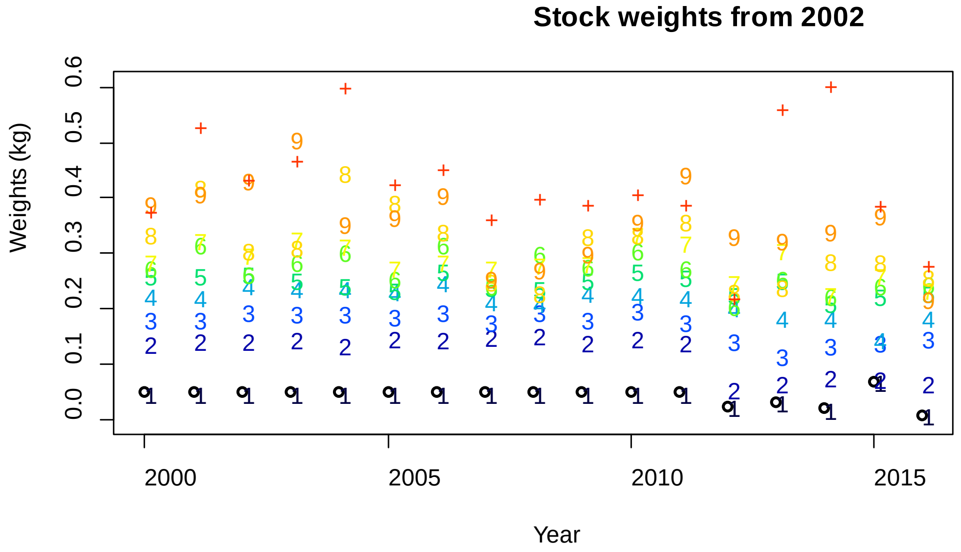
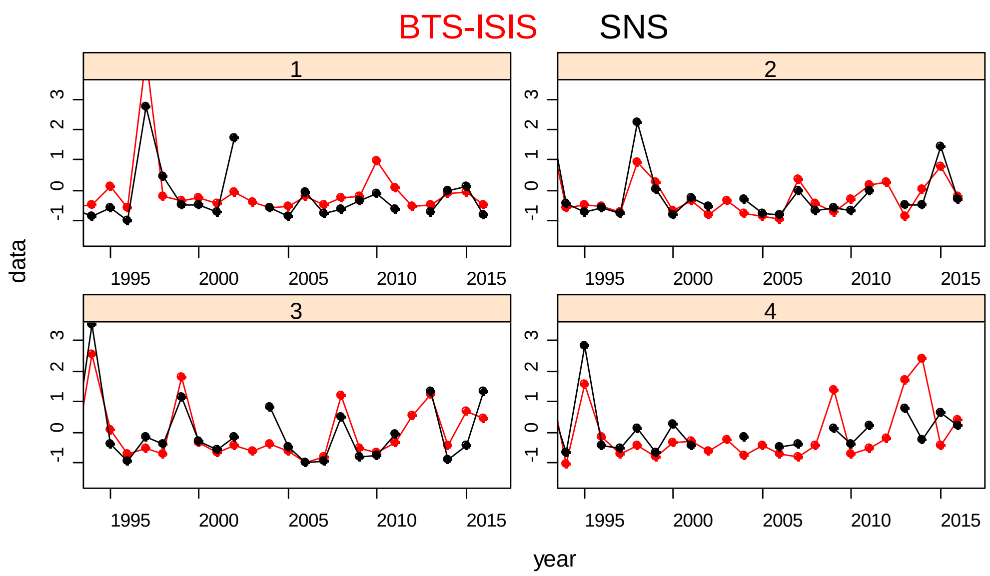


Figure 18.2.5. North Sea sole: Landing, discard, and mean stock weights at age for the whole time series, and for the most recent years (only discard and mean stock weights, 2002–present).



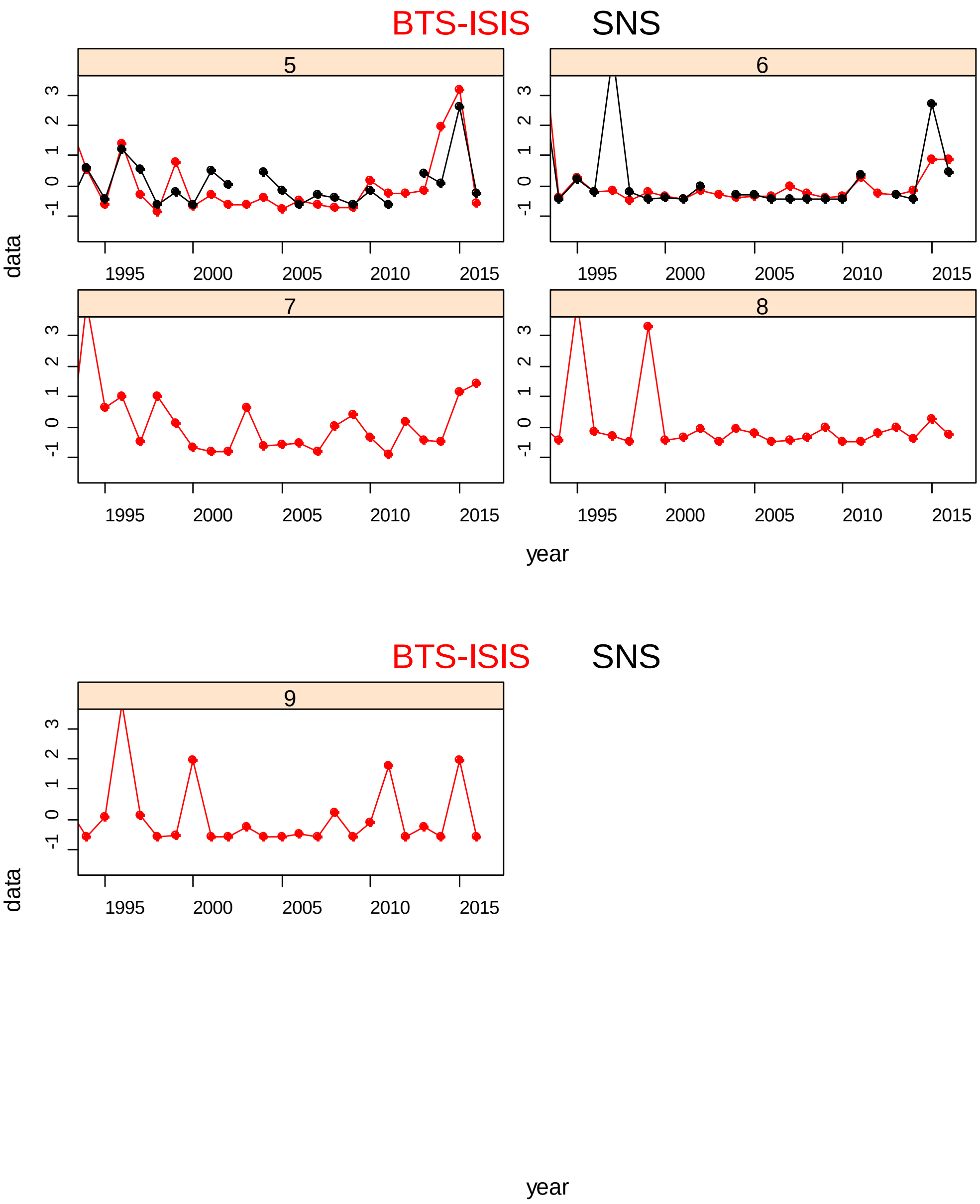


Figure 18.2.7.1. North Sea sole: Standardized survey tuning indices. BTS–Isis (red), SNS (black).

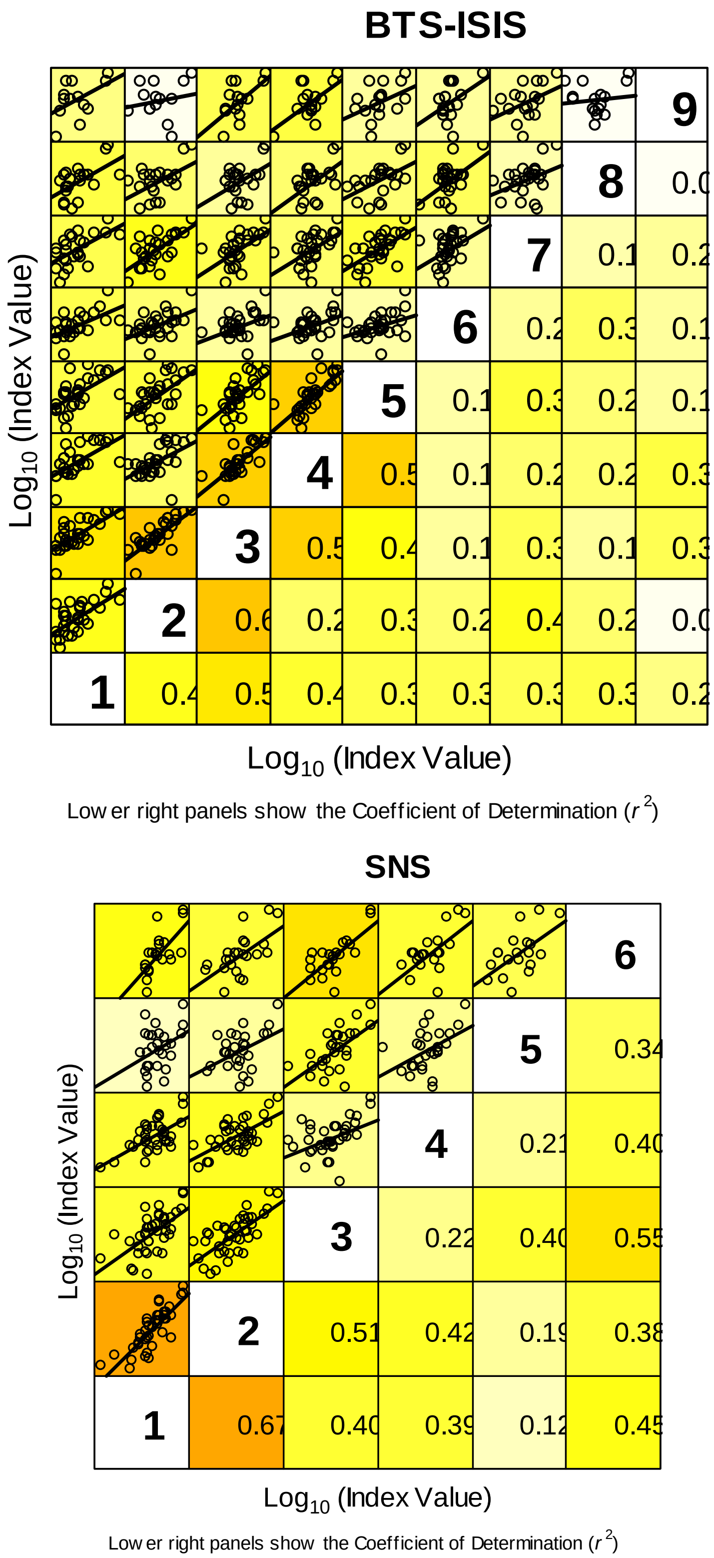


Figure 18.2.7.2 North Sea sole: Correlation plots for both tuning indice.

Figure 18.3.1. North Sea sole: Assessment summary.

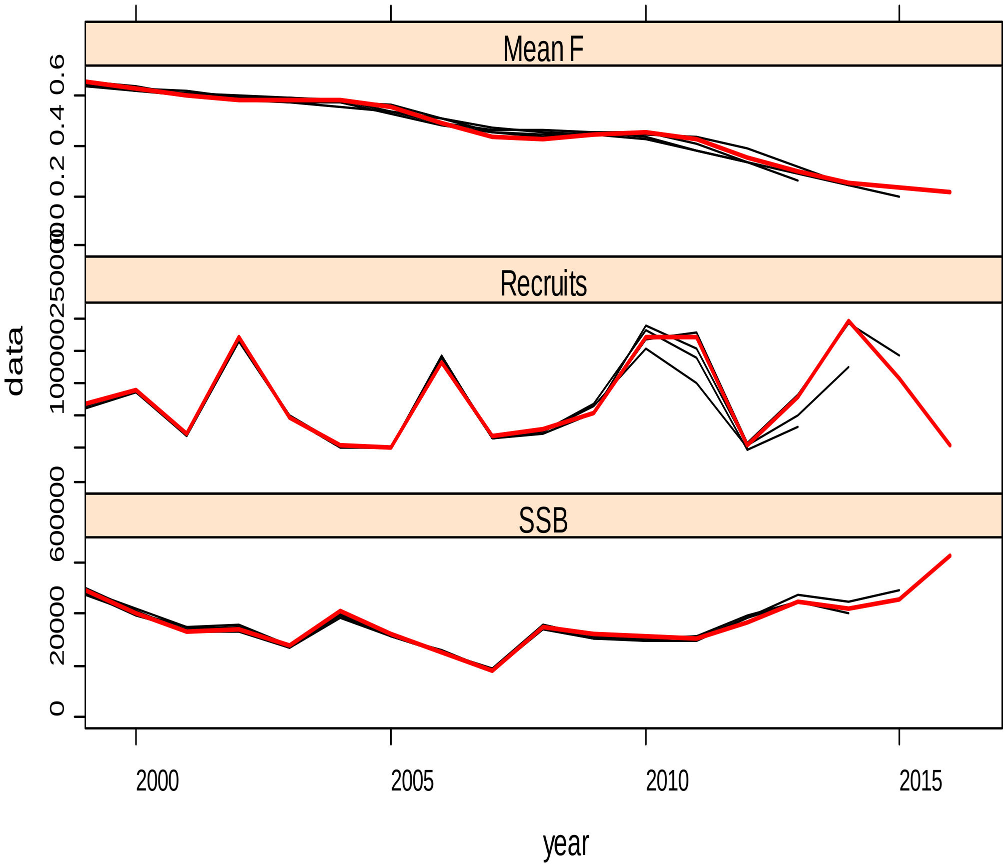


Figure 18.3.2. North Sea sole: Retrospective performance of assessment summary, Y axis: Mean F, no units, Recruits: thousands, SSB: thousand tons.

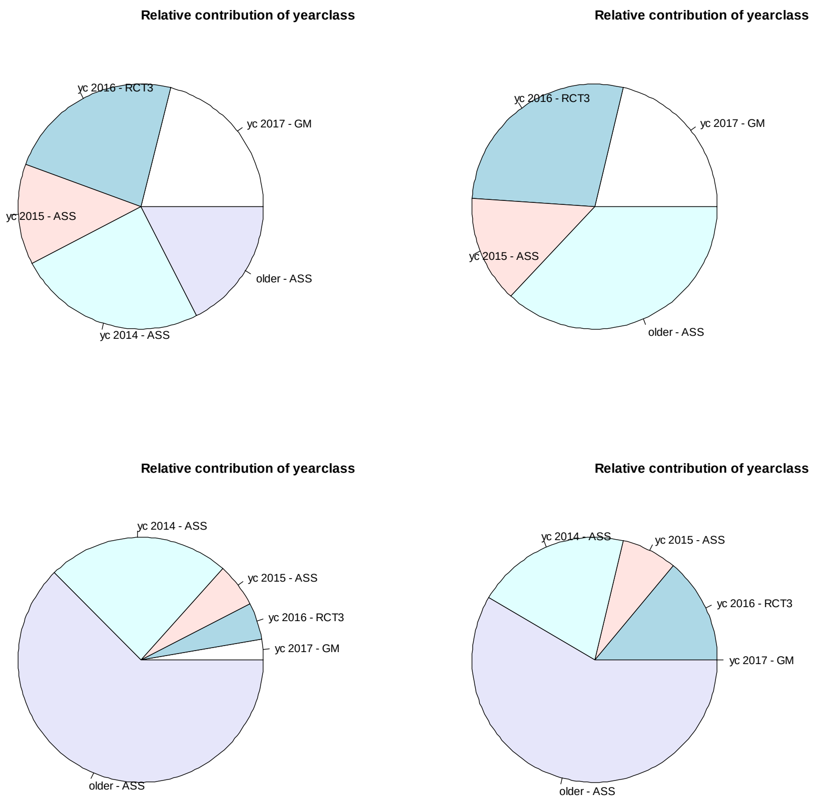


Figure 18.5.1. North Sea sole: Pieplots showing relative contribution of intermediate year assumptions for both F = Fsq scenario.

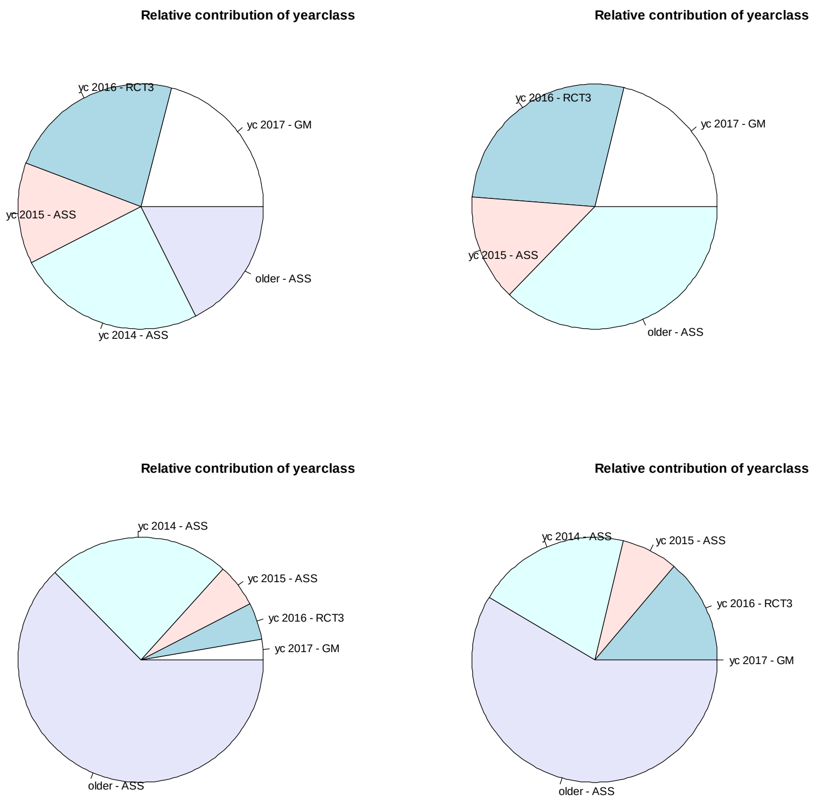


Figure 18.5.2. North Sea sole: Pieplots showing relative contribution of intermediate year assumptions for both F = Ftac=catch scenario.

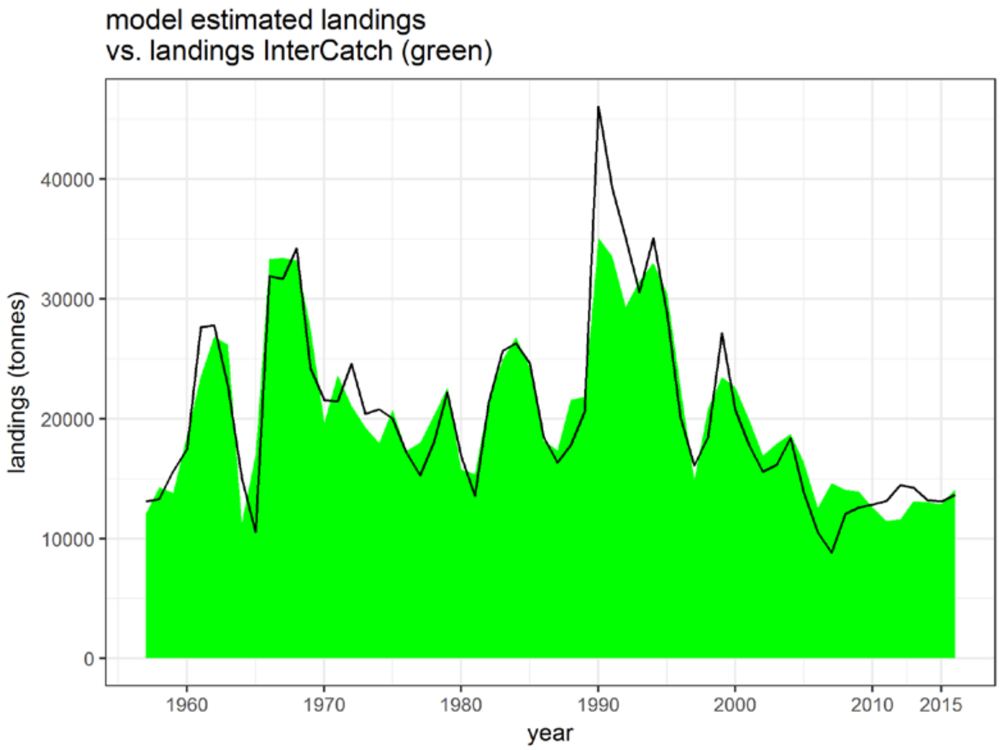


Figure 18.8.1. North Sea sole: Modelled landings (black line) versus observed landings (green area).

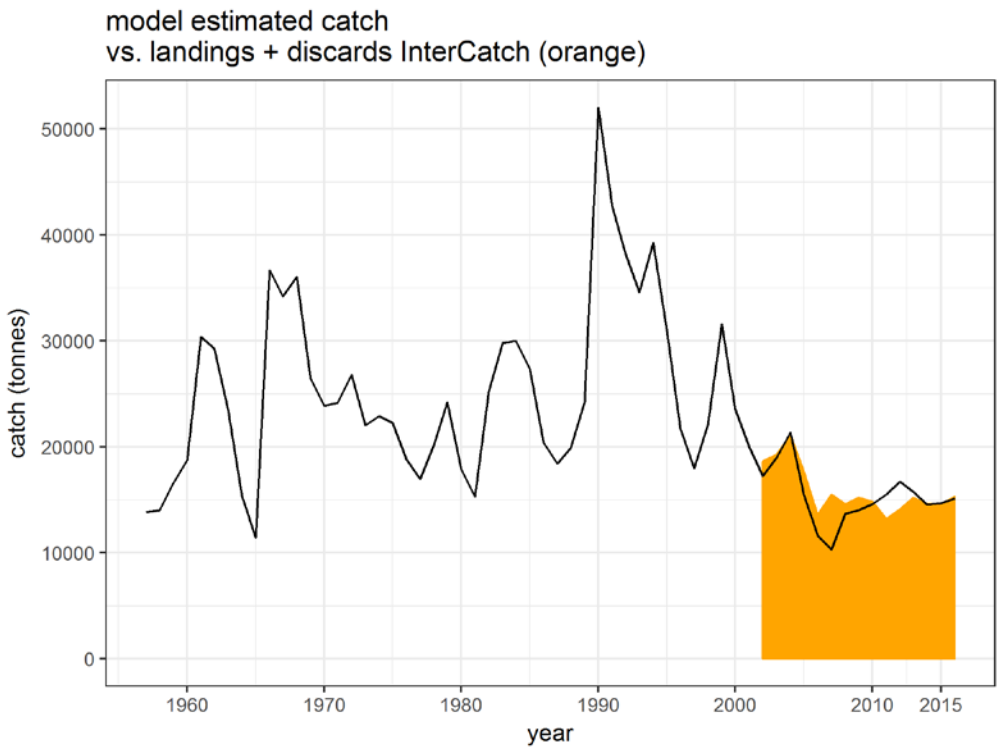


Figure 18.8.2. North Sea sole: Modelled catch (black line) versus observed catches (orange area).

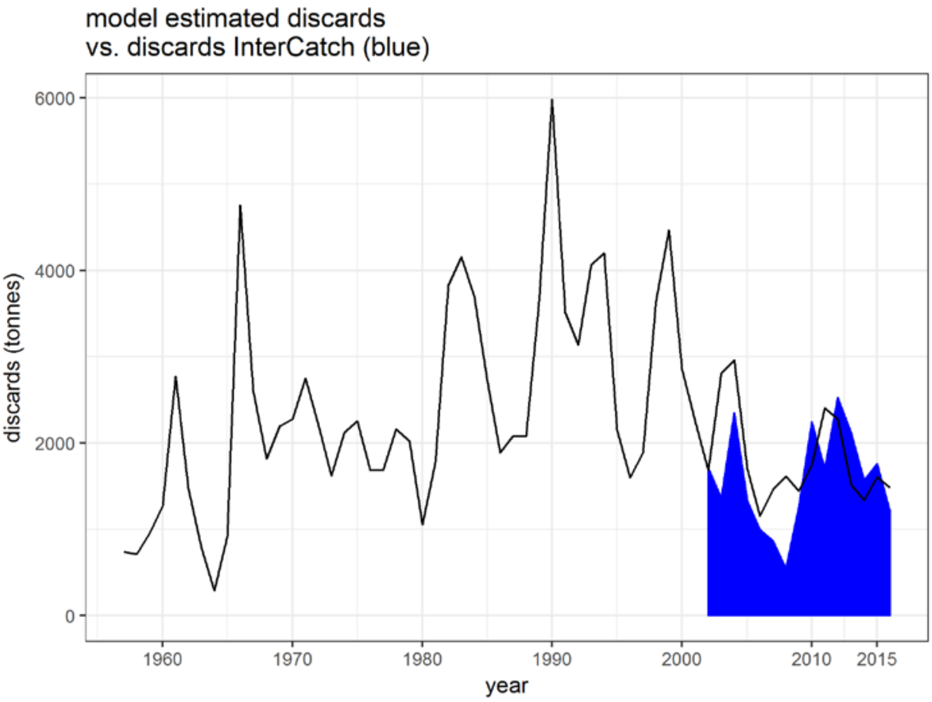


Figure 18.8.3. North Sea sole: Modelled discards (black line) versus observed discards (blue area).

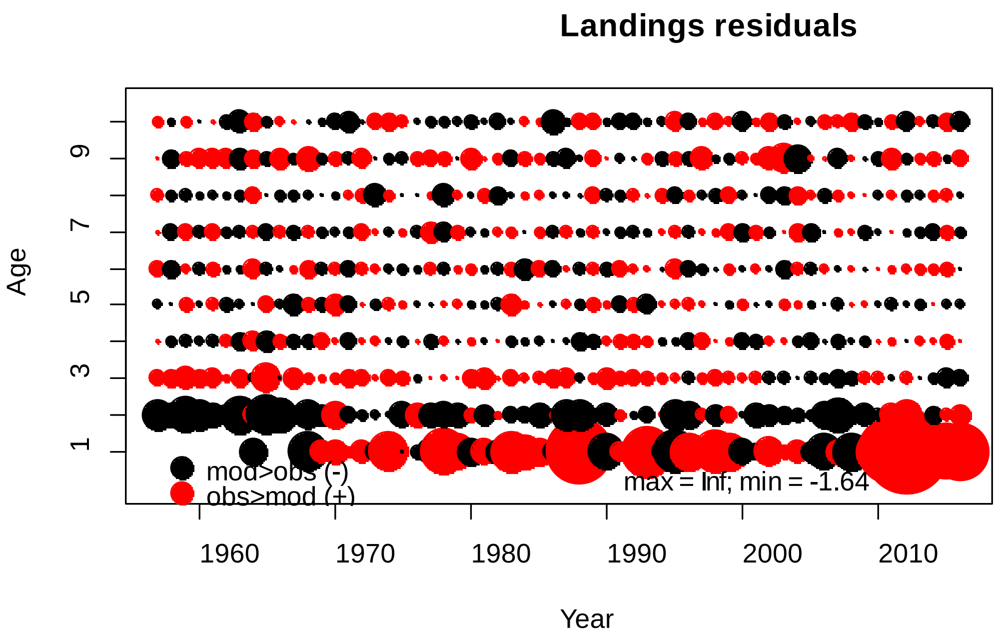


Figure 18.8.4. North Sea sole: Landings residuals.

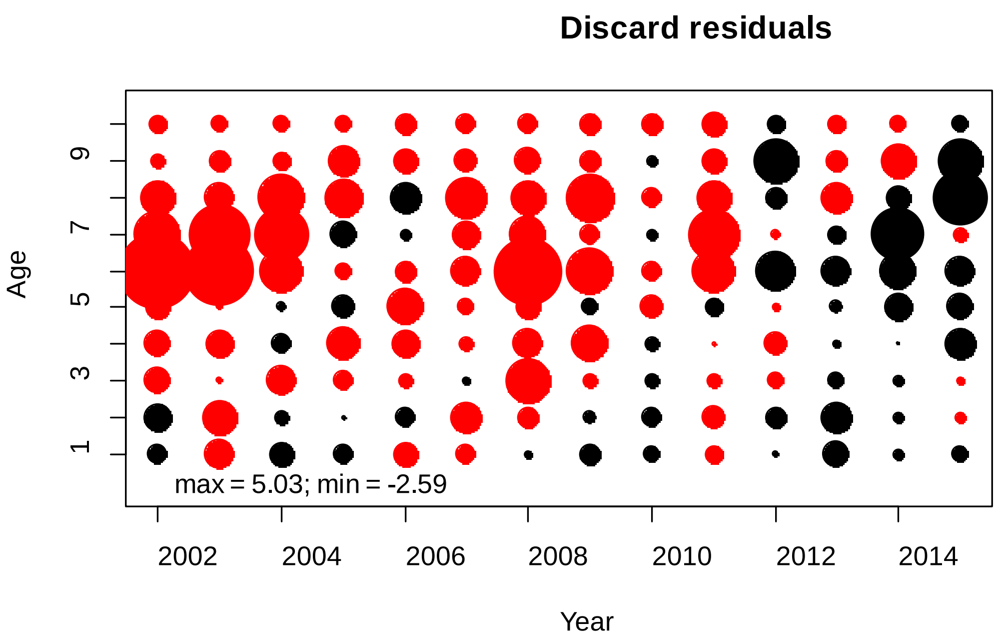


Figure 18.8.5. North Sea sole: Discard residuals.

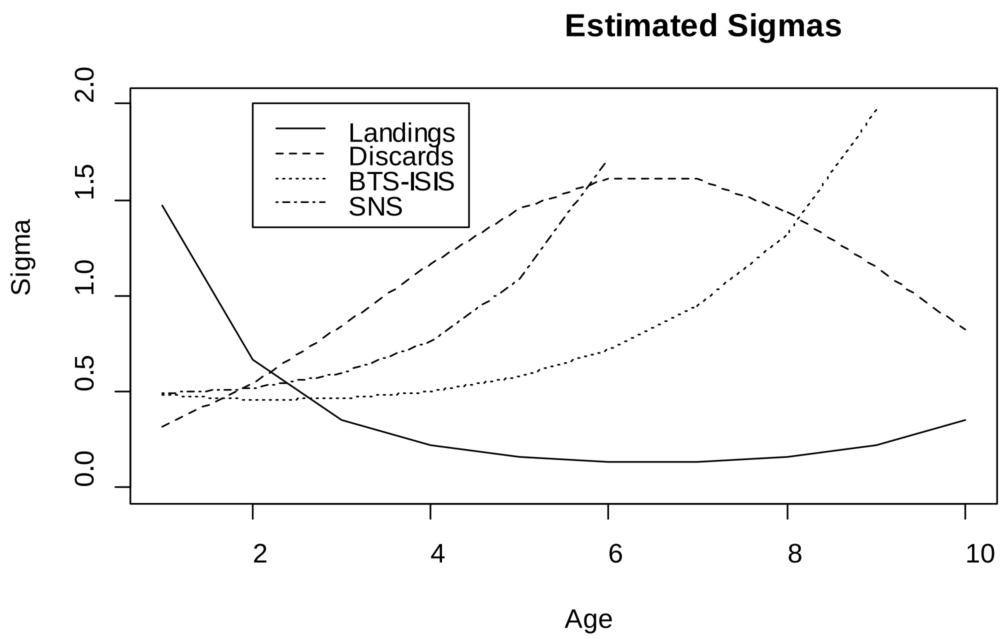


Figure 18.8.6. North Sea sole: Sigmas of different input time series.

19 Sole (*Solea solea*) in Division 7.d (Eastern English Channel)

The assessment of sole in division 7.d (category 1) presented at WGNSKK 2017 is the first assessment after the stock got benchmarked (ICES 2017) in February 2017 (ICES WKNSEA 2017). The Stock Annex was updated with respect to the outcomes of the benchmark. Changes include the use of discards in the assessment, one adjusted and one new commercial tuning series and a new maturity ogive.

This section of the report provides a comprehensive description of the methods and data used for the 2017 assessment. Additional background information can be found in the Stock Annex.

19.1 General

19.1.1 Stock definition

During the WKNSEA 2017 benchmark, the available information on stock identity was investigated, including genetic, tagging and otolith information. Sole in the eastern English Channel (7.d) is still considered to be a stock separated from the larger North Sea stock (27.4) to the east and the smaller geographically separated stock to the west in 27.7.e (western English Channel). Considering the substock structure, three regions with low connectivity were identified within division 7.d for both larvae and juveniles, and adults. More information is provided in the Stock Annex, the report of the benchmark and the associated working document (ICES WKNSEA 2017).

19.1.2 Ecosystem aspects

A general description of the available information on ecological aspects can be found in the Stock Annex.

19.1.3 Fisheries

A general description of the fishery is presented in the Stock Annex.

19.1.3.1 Management regulations

Management of sole in 7.d is by TAC and technical measures.

The minimum landing size for sole is 24 cm. Mesh size restrictions in place are 80 mm for beam trawling and 80 mm for otter trawlers. Fixed nets for the sole fisheries are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

A historical overview of the TAC for sole 7.d since 2000 is presented in the table below.

Historical overview of the TACs for sole in Division 7.d (2000–2017); Note: TAC represents catch from 2016 onwards (landing obligation)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
TAC	4100	4600	5200	5400	5900	5700	5720	6220	6590
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
TAC	5274	4219	4852	5580	5900	4838	3483	3258*	2769*

* Catch TAC

Except for 2010, the TAC has not been restrictive for France, Belgium and the UK since 2003. In 2014, it became restrictive for Belgium, and in 2015 this was the case for Belgium and France (see 19.2.1 Landings).

In response to the drop in SSB and the poor recruitment in 2012–2016 (exception 2015), the two main countries participating in the fishery (France and Belgium) have also implemented additional conservation measures. For Belgian beam trawlers in division 7.d (and 27.7.fg, 7.a) it is mandatory since 1 April 2015 to incorporate a 3 m long section (tunnel) with a 120 mm mesh size before the cod end, in order to reduce the catches of small sole (reduction of undersized sole with 40% and marketable sole with 16%). France engaged in 2016 to i) strengthen the protection of the nursery areas, ii) increase the area closed to fishing within the nursery areas, and iii) increase the minimum conservation reference size to 25 cm for French vessels in accordance with EU legislation, where appropriate. From 11 March until 31 December 2017, the minimum conservation reference size for Belgian vessels has also increased to 25 cm. Finally, also UK beam trawlers usually fish using mesh sizes greater than statutory in order to avoid discarding and to avoid wasting quota.

19.1.3.2 Additional information provided by the fishing industry

For the occasion of the benchmark, the UK fishing industry provided data showing that smaller sole (both in size and weight) are caught over the last three years. The industry suggests this might indicate good recruitment. However, a thorough analysis of the complete sole 7.d dataset showed that sole seems to have decreased in size and weight at age over the past 10 years, and thus not necessarily reflecting recruitment. More information on this is provided in the benchmark report (ICES WKNSEA 2017), the associated working document on biological parameters and below in the section 19.2.2 Discards.

19.1.4 ICES advice

19.1.4.1 ICES advice for 2016

The ICES advice for 2016 was:

ICES advises that when the MSY approach is applied, catches in 2016 should be no more than 2 685 tons. If this stock is not under the EU landing obligation in 2016 and discard rates do not change from 2014, this implies landings of no more than 2376 tonnes.

In 2015 the stock status was presented as follows:

	Fishing pressure					Stock size				
		2012	2013	2014			2013	2014	2015	
Maximum Sustainable Yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✓	At trigger
Precautionary approach	F_{pa}, F_{lim}	O	O	✗	Harvested unsustainably	B_{pa}, B_{lim}	✓	✓	✓	Full reproductive capacity
Management Plan	F_{MGT}	-	-	-	Not applicable	SSB_{MGT}	-	-	-	Not applicable

19.1.4.2 ICES advice for 2017

The ICES advice for 2017 was:

ICES advises that when the MSY approach is applied, catches in 2017 should be no more than 2 487 tons.

In 2016 the stock status was presented as follows:

		Fishing pressure					Stock size			
		2013	2014	2015			2014	2015	2016	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✓	✓	✗	Below trigger
Precautionary approach	F_{pa}, F_{lim}	O	O	O	Increased risk	B_{pa}, B_{lim}	✓	✓	O	Increased risk
Management plan	F_{MGT}	-	-	-	Not applicable	SSB_{MGT}	-	-		Not applicable

19.2 Data

As a result of the data call for the 2017 WKNSEA benchmark, new landings and discard data were uploaded in InterCatch from 2003–2015. These new data were used in the current assessment.

19.2.1 Landings

Table 19.1 and Figure 19.1 summarise the official sole landings by country for division 7.d. The landings have steadily increased over the 1970s and 1990s, fluctuated around an average of 4 815 tons (range: 3 832 tons–6 247 tons) in 2000–2014, and dropped to 3 372 tons in 2015 and even further to 2 527 tons in 2016. Over the last *ca.* 30 years, the contribution to the landings of the three main countries involved in this fishery has remained rather stable over time (~30% Belgium, ~20% UK, and ~50% France) (Figure 19.2).

Since 2010, full uptake of the sole 7.d TAC has not been realised and also the national quota have not been restrictive. In 2014 however, the national Belgian quotum was overshot by 15%. In 2015, Belgium overshot its national quotum again by 12% and France faced a break-even. The total uptake in this year (2015) was 97% (for comparison: 72% in 2012, 75% in 2013, 96% in 2014). For 2016, official landings should no longer be compared to the TAC, as the latter represents catch data instead of only landings. When comparing ICES catch estimates (InterCatch) with the TAC (catch), a total uptake of 88% was realized (Figure 19.3). Figure 19.4 presents a historic overview of TAC levels compared to official landings and ICES estimates (both landings and discards).

ICES estimates were uploaded to InterCatch from 2003 onwards as a result of the benchmark data call. Figure 19.5 summarises the proportion of landings for which samples (age) have been provided in InterCatch by country (91%; see also Table 19.2). Figure 19.6 provides this overview by fleet and country. For some fleets, landings had not been sampled. However, the overall contribution of these fleets to total landings is small (9%). Age compositions for the remaining landings were allocated using the 'mean weight weighted by numbers at age' weighting factor and according to the following scenarios.

- By métier for métiers representing 75% of the total landings
- By gear group when the proportion of landings covered by age was ≥75%. The following gear groups were distinguished: TBB, OTB/SSC/SDN and GTR/GNS. GNS/GTR, TBB and OTB/SSC/SDN contribute respectively 43%, 40% and 16% to the landings of sole in 27.7.d (Table 19.3).
- Overall: When the proportion of landings covered by age was <75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

19.2.2 Discards

For the benchmark (ICES 2017), a data call for all countries involved in this fishery was launched to acquire discard data from 2003 onwards. Discards are from this year (2017) onwards included in the assessment.

Figure 19.7 shows that for the major part of the landings, discard weights are available (shown by fleet and country). When discards were not available, these were raised in InterCatch. Discards on a country-quarter-métier basis were automatically matched by InterCatch to the corresponding landings. The matched discards-landings provided a landing-discard ratio estimate, which was then used for further raising (creating discard amounts) of the unmatched discards (discard ratios larger than 0.5 were excluded as they were not assumed to be representative for the available strata). The weighting factor for raising the discards was 'Landings CATON'. Discard raising was performed on a gear level regardless of season or country.

- The following groups were distinguished based on the gear:
  - i) TBB
  - ii) OTB, SSC and SDN
  - iii) GTR and GNS
- The remaining gears were combined in a REST group (including for example MIS, FPO, LLS and DRB)
- Raising within a gear group was performed when the proportion of landings for which discard weights are available, was equal or larger than 75% compared to the total landings of that group.

More information on how discard raising was performed is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

Similar to the landings, a large proportion of the discards was sampled (age; Table 19.2). For some fleets, discards had not been sampled. Age compositions for the remaining discards were allocated using the 'mean weight weighted by numbers at age' weighting factor and according to the following scenarios.

- By gear group when the proportion of discards covered by age was ≥75%. The following gear groups were distinguished: TBB, OTB/SSC/SDN and GTR/GNS.
- Overall: When the proportion of landings covered by age was <75%, unsampled data were pooled in a rest group and ages were allocated using all sampled data.

More information on the age allocations is provided in the Stock Annex and the WKNSEA 2017 benchmark report and associated working document (ICES WKNSEA 2017).

19.2.3 Weight-at-age

Weights-at-age for discards and landings are shown in Figure 19.8 and 19.9 respectively and weights-at-age in the catch are given in Table 19.4.

During the benchmark, the landings mean weight- and number-at-age data for the years 2003–2010 and discard mean weight- and number-at-age data for the years 2003–2015 were processed through InterCatch for the first time. Because in 2003 the percentage of landings with associated discards is only 4%, it was decided to exclude the estimated discard mean weight- and number-at-age for that year. To estimate discards mean weights and numbers-at-age prior to 2004, a constant ratio of discards to landings by age was applied using data from 2004–2008 (Figure 19.10). Only data from 2004–2008 were used as a notably larger proportion of age 2 and age 3 sole are discarded in more recent years (2009–2016). Analysing data from 2004–2015 indicated that weights and lengths-at-age seem to be decreasing (Figure 19.11). More information is available in the WKNSEA 2017 report (ICES WKNSEA 2017).

Stock weights-at-age were calculated from the quarter 2 mean catch weights (Figure 19.12; Table 19.5). Note that in the current assessment, the Belgian yearly data for the TBB_DEF_70–99 métier were not taken into account for the calculation of the quarter 2 catch weights in InterCatch. Belgium stated that it was not possible to provide a qualitative age distribution for TBB_DEF_70–99 for all quarters, because sampling in division 7.d is limited in some quarters. For the years 2006–2007 and 2012–2015, weights from this Belgian stratum were available and included.

19.2.4 Maturity and natural mortality

During the benchmark, the knife-edged maturity ogive with full maturation from age 3 onwards was investigated. Using data from the French IBTS survey and commercial data from Belgium, France and the UK (15 191 records), a new maturity ogive was constructed (see table below). More information on how this was achieved is provided in the WKNSEA 2017 report and the associated working document (ICES WKNSEA 2017).

Age	0	1	2	3	4	5	6	7	8	9	10 (+)
Maturity	0.00	0.00	0.53	0.92	0.96	0.97	1.00	1.00	1.00	1.00	1.00

Natural mortality is assumed to be a fixed value (0.1) for all ages across all years. This biological parameter was not further investigated during the benchmark.

19.2.5 Tuning series

During the benchmark, the tuning series used for the calibration of the assessment of sole in division 7.d were modified. More specifically, the Belgian commercial beam trawl tuning series was shortened (starting in 2004, instead of 1986) and focused only on the large fleet segment (horsepower of > 221 kW). A French commercial otter trawl series was added (from 2002 onwards) and the UK commercial beam trawl series (from 1986 onwards) remained in the assessment as prior to the benchmark. However, all commercial tuning series were trimmed to age 3–8. The three survey data series (FRA YFS from 1987, UK YFS from 1987–2006 and the UK BTS from 1989) remained in the assessment as prior to the benchmark. The full series are presented in Tables 19.6–19.11.

19.3 Analyses of stock trends/Assessment

19.3.1 Review of last year's assessment

No major deficiencies for the sole assessment in the Eastern English Channel were reported. However, note that this stock was benchmarked in February 2017 largely affecting the stock trends and involving the following changes: include the use of discards in the assessment, one adjusted and one new commercial tuning series and a new maturity ogive (ICES WKNSEA 2017).

19.3.2 Exploratory catch-at-age analysis

Catch numbers-at-age are shown in Figure 19.13. Catch proportions at age and standardized catch proportions at age are shown in Figures 19.14 and 19.15 respectively. Proportionally, older fish are present in the catch in more recent years than before.

The time series of the standardized indices for ages 1 to 8 from the six tuning fleets (BE–CBT, UK(E&W)–CBT, FRA–COT, UK(E&W)–BTS, UK(E&W)–YFS and the FRA–YFS) are plotted in Figure 19.16. All tuning fleets appear to track the year classes reasonably well. Internal consistency plots for the 3 commercial fleets and the UK beam trawl survey are presented in Figures 19.17-19.20. The internal consistency of these three fleets is reasonable for the entire age-range. The catchability residuals for the proposed final XSA (see below) are shown in Figure 19.21. Some concern rises around the UK(E&W)–BTS–Q3, that shows an age effect for Age 1 (that is more effectively estimated by the UK(E&W)–YFS and the FRA–YFS) and a year effect in the most recent years. The latter was also observed in the UK(E&W)–CBT series.

19.3.3 Survivors estimates

In this year's assessment, the estimates for the recruiting year class 2015 were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of 44.5% and 44.0% respectively in the final survivor estimates (Table 19.12). Shrinkage takes 11.6% of the weighting. However, it should be noted that the internal standard errors of both surveys are around 1.0, indicating a high variability and therefore an uncertain estimate providing for this year class strength. Nevertheless, the Expert group decided to use this estimate in the forecast.

The 2014 year class is predominantly estimated by the UK beam trawl survey and the French component of the Young Fish Survey, with weightings of 82.9% and 13.5% respectively (Table 19.12). Shrinkage takes 3.6% of the weighting.

F shrinkage gets low weights for year classes 2013 and older. The weighting of the UK(E&W)–BTS survey decreases for the older ages as the commercial fleets are given more weight.

19.3.4 Final assessment

The final settings used in this year's assessment (using the XSA model) are specified in the new Stock Annex and detailed below:

	2017 ASSESSMENT		
Fleets	Years	Ages	α-β
BE_CBT_2004–2015 commercial	04–15	3–8	0–1
FR_COT commercial	02–15	3–8	0–1
UK(E&W)_CBT commercial	86–15	3–8	0–1
UK(E&W)_BTS survey	89–15	1–6	0.5–0.75
UK_YFS survey	87–06	1–1	0.5–0.75
FR_YFS survey	87–15	1–1	0.5–0.75

-First data year	1982
-Last data year	2015
-First age	1
-Last age	11+

Time series weights	None
-Model	No Power model
-Q plateau set at age	7
-Survivors estimates shrunk towards mean F	5 years / 5 ages
-s.e. of the means	2.0
-Min s.e. for pop. Estimates	0.3
-Prior weighting	None

The diagnostics of this run (including fishing mortalities and stock numbers by age and year) are presented in Table 19.12. A summary of the XSA results is given in Table 19.13 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 19.22. Retrospective patterns for the final run are shown in Figure 19.23. There appears to be no apparent retrospective bias.

19.3.5 Historical stock trends

Trends in catch, SSB, Fbar and recruitment are presented in Table 19.13 and Figure 19.22.

Catches have remained stable around 4 000 tons up to 2003. Higher catches from 2003 onwards are a result of the benchmark data call (ICES WKNSEA 2017) and fluctuate around 5 000 tons. In more recent years, catches have decreased to approximately 3 000 tonnes (2 882 tons in 2016).

For most of the time series, the spawning-stock biomass (SSB) has been fluctuating between B_{lim} (13 751 tons) and MSY Btrigger (19 251 tons; $=B_{pa}$). From 2012–2014, SSB exceeded MSY $B_{trigger}$, probably as a result of the decreased F. The incoming weak year classes of 2012–2014 have reversed the increasing trend in SSB. Consequently, since 2015, SSB is below MSY $B_{trigger}$, but remains above B_{lim}.

For most of the time series, fishing mortality (F) has been fluctuating between 0.2 and 0.5, generally staying above F_{MSY} (0.256; = F_{pa}) and exceeding F_{lim} (0.359). In 1993, F dropped to F_{MSY}, but steadily increased in 1997 to the highest level in the time series (0.5), being far above F_{lim}. After 1997, F fluctuated around F_{lim} until 2009. In 2011, F had dropped well below F_{lim}, almost reaching F_{MSY}. During the last 6 years, F fluctuated around F_{MSY}, with the highest value (0.31) reached in 2014 and the lowest value (0.23) in 2016.

Recruitment has been fluctuating around 20 million recruits with occasional strong year classes and was in 2012–2016 among the lowest of the time series, with the exception of 2015.

Comparing the current stock trends with those prior to the benchmark show that the inclusion of the new commercial tuning series (BE_CBT_2004–2015 and FRA_COT) resulted in a significant increase of the SSB for the whole time series and a substantial decrease of the Fbar, especially in the most recent years. Additionally, the number of recruits are estimated to be higher over the whole time series. Those trends were further enhanced by trimming the age range of the commercial tuning series and excluding the BE_CBT_1986–2003 series (more information is provided in the WKNSEA report and associated working document; ICES–WKNSEA 2017).

19.4 Recruitment estimates and short-term forecast

19.4.1 Recruitment estimates

To estimate the number of recruits in 2017 (age 1; *i.e.* year class 2016), two methods were explored, as is defined in the Stock Annex.

The first method uses the long-term geometric mean excluding the last 3 data years, *i.e.* 1982–2013. This resulted in 29 196 thousand recruits in 2017.

The second method is an RCT3-analysis. This analysis compares the information on the younger yea–classes between the assessment and the available surveys using a regression. For this comparison, data from the French YFS age 0 and 1 and the UK BTS age 1 were used (Table 19.14 and 19.15 present the input for ages 1 and 2 respectively). This resulted in 27 430 thousand recruits in 2017. The RCT3 diagnostics (Table 19.16) showed that the VPA mean contributed most to this number (WAP weight = 92%). Therefore, the working group decided to move forward with the geometric mean to predict recruits in 2017 (age 1).

To estimate age 2 numbers in 2017, the assessment output was used (XSA; this has been the chosen option since 2004).

The table below summarizes the recruitment estimates from the XSA (blue), RCT3-analysis (orange) and the long-term geometric mean (GM 1982–2013; green).

Age	2016	2017	
0			
1	17198	29196	27430
2		14957	14957

An overview of the accepted estimates as input for the short-term forecast is provided in the table below.

Year class	**Age in 2017**	**XSA survivors**	**GM 1982–2013**	**RCT3**	**Accepted estimate**
2015	2	14957	-	24210	XSA
2016	1	-	29196	27430	GM 1982–2013
2017	0	-	29196	-	GM 1982–2013
2018	0	-	29196	-	GM 1982–2013

19.4.2 Short-term forecast

For the short-term forecast, three different Fbar's for the intermediate year (2017) were tested: 1) F_{sq} scaled to the last data year (*i.e.* 2016), 2) F_{sq} being the mean of the 3 last data years (2014–2016) and 3) $F_{TAC\ constraint}$ (TAC 2017 = 2 769 tons). The results of testing these three scenarios are listed below:

1) F_{sq} scaled to the last data year:

The Fbar of 0.231 resulted in a catch of 3 596 tons in 2017.

SSB 2017	F3–7	Fdis1–3	Fhc3–7	recruits
17784	0.231	0.053	0.209	29196

landings	discards	catch	TAC
3117	479	3596	2769

The output of the forecast, giving several options, is shown in the table below. The F_{MSY} was rescaled to F_{tar} (0.243), because the SSB in 2018 would be below MSY $B_{trigger}$.

basis	landings	f3–7	f_hc3–7	f_dis1–3	discards	catch	ssb2018	ssb2019	ssb_change	tac_change
Fmsy	3593	0.256	0.23	0.07	459	4052	18260	18508	1	46
Ftar	3429	0.243	0.22	0.07	437	3866	18260	18697	2	40
Fmsy_low	2817	0.195	0.18	0.06	357	3174	18260	19405	6	15
Fmsy_high	4679	0.348	0.31	0.1	604	5283	18260	17251	-6	91
Fpa	3593	0.256	0.23	0.07	459	4052	18260	18508	1	46
Flim	4803	0.359	0.32	0.1	621	5424	18260	17108	-6	96
SSB>Bpa	2950	0.205	0.19	0.06	375	3325	18260	19251	5	20
TACsq	2458	0.168	0.15	0.05	311	2769	18260	19820	9	0

2) F_{sq} mean 2014-2016 (not scaled):

The Fbar of 0.275 resulted in a catch of 4 198 tons in 2017.

SSB 2017	F3–7	Fdis1–3	Fhc3–7	recruits
17784	0.275	0.063	0.248	29196

landings	discards	catch	TAC
3638	560	4198	2769

The output of the forecast, giving several options, is shown in the table below. The F_{MSY} was rescaled to F_{tar} (0.235), because the SSB in 2018 would be below MSY $B_{trigger}$.

basis	landings	f3–7	f_hc3–7	f_dis1–3	discards	catch	ssb2018	ssb2019	ssb_change	tac_change
Fmsy	3457	0.256	0.23	0.07	450	3907	17638	17990	2	41
Ftar	3199	0.235	0.21	0.07	416	3615	17638	18288	4	31
Fmsy_low	2710	0.195	0.18	0.06	351	3061	17638	18855	7	11
Fmsy_high	4503	0.348	0.31	0.1	593	5096	17638	16777	-5	84
Fpa	3457	0.256	0.23	0.07	450	3907	17638	17990	2	41
Flim	4622	0.359	0.32	0.1	609	5231	17638	16639	-6	89
SSB>Bpa	2368	0.168	0.15	0.05	306	2674	17638	19251	9	-3
TACsq	2452	0.175	0.16	0.05	317	2769	17638	19154	9	0

3) $F_{TAC\ constraint}$

The Fbar of 0.173 resulted in a catch of 2 763 tons in 2017, which is close to the TAC of 2017, being 2 769.

SSB 2017	F3–7	Fdis1–3	Fhc3–7	recruits
17784	0.173	0.039	0.156	29196

landings	discards	catch	TAC
2396	367	2763	2769

The output of the forecast, giving several options, is shown in the table below. The F_{MSY} was rescaled to F_{tar} (0.254), because the SSB in 2018 would be below MSY $B_{trigger}$.

basis	landings	f3–7	f_hc3–7	f_dis1–3	discards	catch	ssb2018	ssb2019	ssb_change	tac_change
Fmsy	3781	0.256	0.23	0.07	471	4252	19122	19226	1	54
Ftar	3759	0.254	0.23	0.07	468	4227	19122	19251	1	53
Fmsy_low	2965	0.195	0.18	0.06	367	3332	19122	20166	5	20
Fmsy_high	4924	0.348	0.31	0.1	620	5544	19122	17908	-6	100
Fpa	3781	0.256	0.23	0.07	471	4252	19122	19226	1	54
Flim	5054	0.359	0.32	0.1	637	5691	19122	17758	-7	106
SSB>Bpa	3759	0.254	0.23	0.07	469	4228	19122	19251	1	53
TACsq	2465	0.159	0.14	0.05	304	2769	19122	20743	8	0

The working group decided to go forward with the first option (using the scaled F_{sq} scaled to the last data year) for the following reasons:

- The last three years (2014–2016), a downward trend in F is observed.
- The TAC was not restrictive in 2016, but undershot by 12% (comparing the ICES catch estimates with the TAC).
- The analyses during the benchmark using new data resulted in a higher SSB and lower F and a re-calculation of the reference points. Using the TAC of 2017 was not perceived to be realistic.
- Using the Fsq mean 2014–2016 resulted in a catch that was far higher than the TAC set for 2017 (4 198 tons compared to 2 769 tons respectively). When using the Fsq scaled, a catch of 3 596 tons was predicted, which lies somewhat closer to the TAC set for 2017.

The results for different management options under this scenario are presented in Table 19.17 and 19.18 and the accompanying relative contributions of year classes to the catch in 2018 and to the SSB in 2019 are shown in Figures 19.24 and 19.25 respectively.

The ICES advice for 2018 will officially be formulated by the ADG North Sea group. The suggested advice at the end of the WGNSSK, assuming an Fsq scaled to the last data year, is the following: ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 3 866 tons.

19.5 Biological reference points

The table below summarizes all known reference points for sole in division 7.d and their technical basis. Reference points have been redefined as a result of the benchmark (more information is provided in the WKNSEA 2017 report; ICES WKNSEA 2017).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	19251	B_{pa}	ICES WKNSEA 2017, ICES WKMSYREF4 2016
	F_{MSY}	0.256	Estimated by application of EqSIM evaluation.	ICES WKNSEA 2017, ICES WKMSYREF4

				2016
Precautionary approach	B_{lim}	13751	Estimated by application of EqSIM evaluation, set as inflection point of the segmented regression curve.	ICES WKNSEA 2017, ICES WKMSYREF4 2016
	B_{pa}	19251	$B_{pa} = B_{lim} \times \exp(1.645\ \sigma_B)$; $\sigma_B = 0.2045$	ICES WKNSEA 2017, ICES WKMSYREF4 2016
	F_{lim}	0.359	Estimated by application of EqSIM evaluation; stochastic projection.	ICES WKNSEA 2017, ICES WKMSYREF4 2016
	F_{pa}	0.256	$F_{pa} = F_{lim} \times \exp(-1.645\ \sigma_F)$; $\sigma_F = 0.2045$	ICES WKNSEA 2017, ICES WKMSYREF4 2016
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

19.6 Quality of the assessment

This stock was benchmarked in 2017 (ICES WKNSEA 2017), which resulted in an increase in SSB and decrease in F_{bar}, especially in more recent years. Changes that triggered these changes were the inclusion of discards (from 2004–2016), additional information concerning the stock weights, modifications to an existing commercial tuning index and the inclusion a new commercial index, and a new maturity ogive in the assessment. Reference points were also re-calculated.

19.7 Management considerations

- Since 1 January 2016, sole fisheries in 7.d fall under the landing obligation (EU regulation nr. 2015/2438 (12/10/2015)).
- The observed decreasing trend in weight- and length-at-age from 2004 onwards evokes concern. Although the advice for this stock (post-benchmark) appears to be positive, this decreasing trend does not fully support the healthy status of the stock. More research should be conducted to further investigate this trend.
- The sole stock in division 7.d is harvested in a mixed fishery with plaice in 7.d. Due to the minimum mesh size in the mixed beam and otter trawl fisheries (80 mm), a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

Table 19.1. Sol in Division 7.d: Official landings (tons) by country over the period 1974–2016, as officially reported (Rec 12); ICES estimates (as reported in InterCatch) for both landings and discards (tons) and TAC (tons). Unallocated landings represent the difference between the total official landings and the ICES landings estimate (in tons). ICES estimates were used by the working group; *TAC represents catch, not landings.

Year	Official Landings					Unallocated landings	ICES estimate		TAC
	Belgium	France	UK (E&W)	Other	Total official		Landings	Discards	
1974	159	383	309	3	854	30	884		
1975	132	464	244	1	841	41	882		
1976	203	599	404	.	1206	99	1305		
1977	225	737	315	.	1277	58	1335		
1978	241	782	366	.	1389	200	1589		
1979	311	1129	402	.	1842	373	2215		
1980	302	1075	159	.	1536	387	1923		
1981	464	1513	160	.	2137	340	2477		
1982	525	1828	317	4	2674	516	3190		
1983	502	1120	419	.	2041	1417	3458		
1984	592	1309	505	.	2406	1169	3575		
1985	568	2545	520	.	3633	204	3837		
1986	858	1528	551	.	2937	995	3932		
1987	1100	2086	655	.	3841	950	4791		3850
1988	667	2057	578	.	3302	551	3853		3850
1989	646	1610	689	.	2945	860	3805		3850
1990	996	1255	785	.	3036	611	3647		3850
1991	904	2054	826	.	3784	567	4351		3850
1992	891	2187	706	10	3794	278	4072		3500
1993	917	2322	610	13	3862	437	4299		3200
1994	940	2382	701	14	4037	346	4383		3800
1995	817	2248	669	9	3743	677	4420		3800
1996	899	2322	877	.	4098	699	4797		3500
1997	1306	1702	933	.	3941	823	4764		5230
1998	541	1703	803	.	3047	316	3363		5230
1999	880	2251	769	.	3900	235	4135		4700
2000	1021	2190	621	.	3832	-356	3476		4100
2001	1313	2482	822	.	4617	-592	4025		4600
2002	1643	2780	976	.	5399	-666	4733		5200
2003	1657	3475	1114	1	6247	730	6977	2	5400
2004	1485	3070	1112	.	5667	616	6283	132	5900
2005	1221	2832	567	.	4620	436	5056	108	5700
2006	1547	2627	678	.	4852	188	5040	76	5720
2007	1530	2981	801	1	5313	275	5588	178	6220
2008	1368	2880	724	.	4972	284	5256	83	6593
2009	1475	2886	754	6	5121	130	5251	262	5274
2010	1294	2407	674	.	4375	-106	4269	318	4219
2011	1181	2283	686	.	4150	75	4225	342	4852
2012	920	2475	623	0	4018	113	4131	464	5580

2013	954	2865	605	.	4424	-17	4407	405	5900
2014	1493	2481	649	0	4623	32	4655	490	4838
2015	1048	1856	468	.	3372	71	3443	246	3483
2016	799	1337	391	0	2527	11	2538	331	3258 *
2017									2724 *

Table 19.2. Sol in Division 7.d: Summary of the InterCatch data in 2016 (imported vs. raised data; sampled vs. estimated data).

Catch Category	Raised or Imported	Sampled or Estimated	CATON	perc
Landings	Imported_Data	Sampled_Distribution	2212	91
Landings	Imported_Data	Estimated_Distribution	211.4	9
Discards	Imported_Data	Sampled_Distribution	355.7	90
Discards	Imported_Data	Estimated_Distribution	26.43	7
Discards	Raised_Discards	Estimated_Distribution	13.43	3

Table 19.3. Sol in Division 7.d: Landings percentages by gear type for 2014–2016 (GNS/GTR = gill and trammel nets; TBB = beam trawls; OTB = otter trawls).

Landings by gear	2014	2015	2016
GNS/GTR	47%	46%	43%
TBB	35%	34%	40%
OTB/SSC/SDN	13%	15%	16%
Other	5%	5%	1%

Table 19.4. Sol in Division 7.d: Catch weights-at-age.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.078	NA	0.076	0.069	0.103	0.072	0.078	0.081	0.091	0.087	0.078	0.065	0.075
2	0.155	0.157	0.162	0.166	0.164	0.159	0.139	0.140	0.162	0.147	0.139	0.134	0.137
3	0.213	0.218	0.222	0.218	0.201	0.224	0.215	0.182	0.226	0.198	0.193	0.187	0.177
4	0.309	0.299	0.311	0.278	0.303	0.292	0.275	0.268	0.286	0.263	0.264	0.244	0.233
5	0.385	0.403	0.379	0.367	0.362	0.352	0.359	0.292	0.348	0.353	0.289	0.334	0.287
6	0.426	0.434	0.434	0.392	0.385	0.405	0.407	0.357	0.338	0.392	0.401	0.382	0.353
7	0.439	0.434	0.417	0.516	0.436	0.411	0.459	0.388	0.470	0.420	0.391	0.537	0.381
8	0.509	0.523	0.537	0.543	0.520	0.482	0.514	0.472	0.464	0.430	0.462	0.553	0.505
9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459	0.515	0.484
10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463	0.766	0.496
11	0.673	0.628	0.714	0.800	0.602	0.618	0.665	0.701	0.562	0.566	0.566	0.667	0.616

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.098	0.108	0.106	0.101	0.099	0.111	0.082	0.091	0.102	0.131	0.120	0.157	0.079
2	0.160	0.150	0.139	0.145	0.138	0.129	0.139	0.148	0.149	0.178	0.156	0.158	0.154
3	0.170	0.169	0.179	0.163	0.179	0.167	0.200	0.194	0.217	0.194	0.202	0.198	0.188
4	0.228	0.227	0.231	0.233	0.213	0.221	0.280	0.250	0.286	0.262	0.268	0.260	0.215
5	0.254	0.268	0.291	0.285	0.259	0.331	0.287	0.315	0.365	0.306	0.330	0.299	0.272
6	0.332	0.323	0.342	0.342	0.279	0.375	0.333	0.373	0.406	0.341	0.384	0.344	0.291
7	0.357	0.361	0.390	0.383	0.290	0.423	0.366	0.375	0.165	0.380	0.448	0.386	0.389
8	0.385	0.404	0.404	0.417	0.341	0.427	0.374	0.393	0.474	0.434	0.462	0.416	0.400
9	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.424	0.483	0.554	0.503	0.466
10	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.504	0.442	0.544	0.530	0.406
11	0.654	0.585	0.651	0.616	0.535	0.680	0.544	0.531	0.565	0.635	0.557	0.560	0.550

age	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.115	0.149	0.081	0.081	0.039	0.039	0.048	0.067	0.110
2	0.151	0.130	0.142	0.120	0.097	0.105	0.128	0.122	0.135
3	0.207	0.206	0.192	0.199	0.179	0.180	0.174	0.174	0.184
4	0.243	0.257	0.235	0.245	0.231	0.237	0.224	0.227	0.238
5	0.159	0.301	0.275	0.295	0.259	0.295	0.262	0.268	0.262
6	0.299	0.313	0.316	0.329	0.299	0.305	0.322	0.282	0.276
7	0.377	0.354	0.337	0.334	0.342	0.378	0.335	0.321	0.324
8	0.392	0.388	0.354	0.382	0.322	0.432	0.393	0.340	0.376
9	0.420	0.385	0.417	0.378	0.381	0.392	0.408	0.405	0.351
10	0.449	0.384	0.462	0.430	0.443	0.462	0.475	0.355	0.407
11	0.492	0.376	0.433	0.470	0.373	0.481	0.450	0.461	0.546

Table 19.5. Sol in Division 7.d: Stock weights at age.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.059	0.070	0.067	0.065	0.070	0.072	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.114	0.135	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138	0.144	0.130	0.116	0.126	0.155
3	0.167	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225	0.199	0.189	0.161	0.129	0.176
4	0.217	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279	0.277	0.246	0.215	0.220	0.258
5	0.263	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.400	0.380	0.305	0.366	0.273	0.234	0.286
6	0.306	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384	0.454	0.377	0.316	0.333	0.308
7	0.347	0.406	0.403	0.436	0.403	0.417	0.477	0.480	0.476	0.410	0.405	0.545	0.368	0.357	0.366
8	0.384	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449	0.459	0.560	0.530	0.330	0.391
9	0.418	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474	0.430	0.559	0.461	0.614	0.438
10	0.450	0.522	0.529	0.611	0.512	0.536	0.636	0.536	0.507	0.451	0.528	0.813	0.470	0.382	0.466
11	0.530	0.601	0.627	0.780	0.576	0.616	0.750	0.714	0.577	0.620	0.527	0.566	0.612	0.629	0.630

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.050	0.050	0.050	0.050	0.050	0.050	0.118	0.092	0.102	0.101	0.071	0.107	0.130	0.081	0.081
2	0.139	0.140	0.128	0.122	0.127	0.136	0.155	0.110	0.132	0.128	0.119	0.146	0.111	0.124	0.081
3	0.165	0.158	0.180	0.148	0.157	0.179	0.212	0.171	0.186	0.169	0.157	0.190	0.180	0.175	0.186
4	0.220	0.233	0.205	0.208	0.216	0.209	0.280	0.241	0.249	0.268	0.181	0.239	0.244	0.212	0.232
5	0.264	0.299	0.253	0.402	0.226	0.258	0.345	0.271	0.292	0.297	0.240	0.266	0.290	0.251	0.267
6	0.317	0.374	0.277	0.440	0.223	0.254	0.432	0.318	0.318	0.363	0.251	0.329	0.321	0.263	0.309
7	0.376	0.363	0.298	0.395	0.231	0.301	0.298	0.303	0.487	0.393	0.302	0.370	0.416	0.292	0.339
8	0.404	0.357	0.324	0.554	0.253	0.234	0.531	0.371	0.498	0.444	0.341	0.406	0.412	0.312	0.329
9	0.563	0.450	0.336	0.443	0.256	0.326	0.332	0.475	0.584	0.507	0.388	0.445	0.372	0.289	0.458
10	0.494	0.372	0.323	0.420	0.301	0.404	0.529	0.312	0.586	0.585	0.377	0.516	0.439	0.405	0.505
11	0.654	0.577	0.512	0.682	0.420	0.417	0.507	0.602	0.525	0.609	0.535	0.530	0.447	0.362	0.441

age	2012	2013	2014	2015	2016
1	0.044	0.044	0.052	0.068	0.127
2	0.057	0.082	0.117	0.070	0.120
3	0.151	0.160	0.160	0.164	0.156
4	0.223	0.239	0.210	0.213	0.222
5	0.240	0.301	0.259	0.254	0.259
6	0.275	0.315	0.310	0.279	0.259
7	0.381	0.393	0.288	0.301	0.303
8	0.342	0.472	0.360	0.341	0.348
9	0.381	0.433	0.336	0.460	0.295
10	0.519	0.456	0.425	0.384	0.384
11	0.345	0.526	0.487	0.472	0.502

Table 19.6. Sol in Division 7.d: Tuning series 1: Belgian commercial beam trawl (2004–2016).

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2004	35.06	1021.34	435.15	646.2	230.74	51.87	49.96
2005	30.34	575.7	591.07	157.21	114.76	85.07	44.09
2006	48.98	611.06	558.75	520.6	219.64	211.17	107.21
2007	57.07	918.74	477.17	195.7	379.63	151.44	187.8
2008	43.34	1116.78	1093.8	255.84	174.78	150.35	82.45
2009	32.63	714.84	771.79	522.56	130.14	75.39	79.5
2010	26.15	768.87	254.8	425.27	226.87	79.22	42.8
2011	26.46	1186.39	368.05	215.91	159.56	112.53	34.85
2012	21.24	1115.28	810.6	230.51	71.1	85.07	83.46
2013	25.9	193.67	724.32	676.31	197.93	96.57	114.82
2014	36.91	501.54	831.85	1059.8	630.7	165.61	80.06
2015	35.62	231.05	368.09	335.41	546.88	441.19	157.85
2016	35.05	257.28	167.1	272.41	219.97	259.49	245.13

Table 19.7. Sol in Division 7.d: Tuning series 2: UK (E&W) commercial beam trawl (1986–2016).

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
1986	2.79	144.8	100.5	28	28.8	39.4	1.2
1987	5.64	106	143.5	99.2	18.6	14.6	37.6
1988	5.09	281.3	56.4	62.9	39.6	9	11.5
1989	5.65	78.1	144.2	18.2	31.7	23.1	5.1
1990	7.27	327.4	47.7	66.1	14.1	15.1	15.1
1991	7.67	139.2	195.2	8.4	30.7	5.1	7.4
1992	8.78	516.6	81.3	167.5	11.1	20.3	6.4
1993	6.4	222.5	218.9	34.6	52.7	5.2	10.7
1994	5.43	260.9	144.1	113.3	27.5	45.5	4.4
1995	6.89	106.9	220.4	107.6	94.6	18.3	37.5
1996	10.31	251.3	79.5	169	84.6	67.4	17.5
1997	10.25	331.1	158.5	42.4	125.2	50.8	48.7
1998	7.31	169.4	97.5	65.2	22.1	51.7	28.8
1999	5.86	300	105.6	43.6	31.8	12.3	26.3
2000	5.65	178.8	171.4	54.7	25.8	18.2	6.9
2001	7.64	268	101	111.9	44	19	19.6
2002	7.9	449	222.2	71.7	54.9	22.9	18.6
2003	6.69	220.8	149.5	64.8	27.2	32	15
2004	4.87	440.41	103.2	62.24	32.62	9.61	18.18
2005	6	178.27	376.44	69.41	72.25	35.36	17.41
2006	5.94	350.51	113.46	188.96	31.71	28.12	13.55
2007	5	303.67	114.86	34.62	102.76	23.99	23.55
2008	6.21	612.94	184.74	40.66	24.66	34.21	12.57
2009	6.21	113.51	272.97	98.85	15.33	12.47	26.55
2010	4.35	151.85	50.86	101.02	33.93	11.9	7.8
2011	3	121.43	59.61	16.54	37.19	10.8	2.5
2012	3.31	323.85	59.64	34.35	5.88	15.99	8.54
2013	2.88	109.6	200.66	36.49	21.35	6.73	9.04
2014	3.02	72.96	164.94	95.63	14.27	8.56	1.03
2015	4.19	54.11	28.85	55.41	41.61	5.8	3.73
2016	7.04	110.1	65.69	22.75	44.63	31.66	9.25

Table 19.8. Sol in Division 7.d: Tuning series 3: French commercial otter trawl (2002–2016).

	Effort	Age3	Age4	Age5	Age6	Age7	Age8
2002	1	2.42	1.09	0.47	0.38	0.14	0.04
2003	1	2.04	0.73	0.59	0.18	0.23	0.08
2004	1	3.42	1	0.69	0.42	0.24	0.17
2005	1	1.13	1.24	0.54	0.41	0.16	0.15
2006	1	0.92	0.96	1.18	0.39	0.27	0.18
2007	1	3.15	1.28	0.67	0.86	0.23	0.11
2008	1	3.44	2.01	0.49	0.47	0.61	0.32
2009	1	2.23	2.54	0.58	0.3	0.18	0.22
2010	1	1.57	2.13	1.71	0.61	0.16	0.32
2011	1	3.98	1.18	0.94	1	0.44	0.1
2012	1	7.82	5.6	1.36	1.3	0.77	0.29
2013	1	5.03	4.04	1.69	0.76	0.73	0.73
2014	1	2.42	4.86	2.81	1.37	0.51	0.36
2015	1	1.02	1.54	2.03	1.41	0.74	0.33
2016	1	1.96	1.09	1.2	1.18	0.76	0.49

Table 19.9. Sol in Division 7.d: Tuning series 4: UK (E&W) beam trawl survey (Q3) (1989–2016).

	Effort	Age1	Age2	Age3	Age4	Age5	Age6
1989	1	3.01	22.09	4.62	2.45	0.56	0.35
1990	1	17.96	5.55	5.55	1.24	1.01	0.33
1991	1	12.14	31.17	3.19	2.82	0.48	0.67
1992	1	1.33	15.29	13.47	1.07	1.61	0.34
1993	1	0.82	22.96	11.42	9.97	1.14	1.52
1994	1	8.33	4.26	11.07	4.65	4.3	0.28
1995	1	5.89	16.09	2.22	3.51	1.67	2.12
1996	1	5.3	10.79	5.97	1.07	1.86	1.15
1997	1	24.75	10.85	4.42	1.94	0.26	0.82
1998	1	3.27	24.11	3.67	1.47	0.83	0.19
1999	1	35.99	8.22	11.33	1.59	0.73	1.02
2000	1	14.98	27.45	5.52	4.85	1.48	0.68
2001	1	10.19	27.88	11.55	1.67	2.33	0.75
2002	1	53.56	16.11	8.6	5.11	0.45	1.04
2003	1	11.03	45.65	5.87	3.2	2.05	0.42
2004	1	12.67	11.81	10.97	2.08	2.02	1.34
2005	1	43.27	6.91	3.5	5.18	1.9	1.15
2006	1	10.84	42.62	4.51	2.68	2.59	0.55
2007	1	2.57	28.97	15.45	1.47	1.04	1.56
2008	1	3.77	7.35	9.14	5.82	0.4	0.68
2009	1	51.25	19.16	7.1	5.81	5.02	0.44
2010	1	16.59	30.76	5.14	1.66	2.7	2.73
2011	1	13.66	28.6	14.7	1.66	0.54	2.62
2012	1	1.75	9.72	7.51	3.53	0.92	0.39
2013	1	0.72	8.91	15.09	9.72	3.23	1.12
2014	1	25.39	16.35	12.38	11.92	5.09	2.73
2015	1	25.24	21.36	6.04	2.29	4.51	2.08
2016	1	10.17	33.14	11.17	3.16	3.17	3.02

Table 19.10. Sol in Division 7.d: Tuning series 5: UK (E&W) young fish survey (1987–2006).

	Effort	Age1
1987	1	1.38
1988	1	1.87
1989	1	0.62
1990	1	1.9
1991	1	3.69
1992	1	1.5
1993	1	1.33
1994	1	2.68
1995	1	2.91
1996	1	0.57
1997	1	1.12
1998	1	1.12
1999	1	1.47
2000	1	2.47
2001	1	0.38
2002	1	4.15
2003	1	1.44
2004	1	2.72
2005	1	4.07
2006	1	2.21

Table 19.11. Sol in Division 7.d: Tuning series 6: UK (E&W) young fish survey (1987–2006).

	Effort	Age1
1987	1	0.07
1988	1	0.17
1989	1	0.14
1990	1	0.54
1991	1	0.38
1992	1	0.22
1993	1	0.03
1994	1	0.7
1995	1	0.28
1996	1	0.15
1997	1	0.03
1998	1	0.1
1999	1	0.35
2000	1	0.31
2001	1	1.21
2002	1	0.11
2003	1	0.32
2004	1	0.15
2005	1	0.82
2006	1	0.83
2007	1	0.08
2008	1	0.06
2009	1	2.78
2010	1	0.1
2011	1	0.32
2012	1	0.35
2013	1	0.052
2014	1	0.04
2015	1	0.09
2016	1	0.04

Table 19.12. Sol in Division 7.d: XSA diagnostics of the 2017 assessment.

FLR XSA Diagnostics 2017/04/26 11:59:16

Cpue data from indices

Catch data for 35 years. 1982 to 2016. Ages 1 to 11.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE-CBT-new	3	8	2004	2016	0	1
2	UK(E&W)-CBT	3	8	1986	2016	0	1
3	FR-COTB	3	8	2002	2016	0	1
4	UK(E&W)-BTS-Q3	1	6	1989	2016	0.5	0.75
5	UK(E&W)-YFS	1	1	1987	2006	0.5	0.75
6	FR-YFS	1	1	1987	2016	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 7

Terminal population estimation :

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population estimates derived from each fleet = 0.3 prior weighting not applied

Regression weights

year

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

year

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.016	0.047	0.059	0.020	0.005	0.015	0.022	0.047	0.009	0.040
2	0.199	0.183	0.256	0.221	0.198	0.140	0.197	0.181	0.162	0.045
3	0.396	0.373	0.425	0.329	0.300	0.289	0.263	0.376	0.297	0.193
4	0.499	0.471	0.454	0.401	0.311	0.329	0.314	0.456	0.317	0.284
5	0.375	0.413	0.210	0.313	0.328	0.243	0.223	0.297	0.340	0.284
6	0.468	0.400	0.363	0.287	0.235	0.347	0.180	0.223	0.261	0.236
7	0.437	0.227	0.391	0.210	0.131	0.130	0.281	0.194	0.208	0.158
8	0.354	0.329	0.188	0.250	0.165	0.137	0.121	0.298	0.183	0.154
9	0.333	0.116	0.381	0.157	0.160	0.125	0.082	0.111	0.121	0.237
10	0.436	0.177	0.163	0.139	0.062	0.067	0.092	0.064	0.090	0.144
11	0.436	0.177	0.163	0.139	0.062	0.067	0.092	0.064	0.090	0.144

XSA population number (Thousand)

year	1	2	3	4	5	6	7	8	9	10	11
2007	24696	44169	27678	8645	6029	7644	2847	2467	1609	517	1390
2008	28972	21996	32744	16863	4749	3750	4331	1665	1567	1043	1920
2009	48721	25022	16582	20397	9531	2843	2274	3123	1084	1262	2847
2010	59315	41559	17531	9805	11717	6990	1789	1391	2341	670	2778
2011	44252	52593	30156	11415	5940	7749	4746	1312	981	1811	3076
2012	21980	39844	39034	20204	7566	3871	5546	3766	1007	756	4446
2013	13660	19586	31345	26461	13150	5368	2475	4406	2973	804	2173
2014	22367	12087	14549	21813	17485	9517	4056	1690	3531	2478	4969
2015	47912	19300	9126	9037	12509	11750	6890	3024	1136	2861	3173
2016	17198	42953	14855	6133	5955	8054	8194	5064	2280	911	1778

Estimated population abundance at 1st Jan 2017

year	1	2	3	4	5	6	7	8	9	10	11
2017	0	14957	37164	11084	4178	4055	5758	6328	3928	1628	714

Fleet: BE-CBT-new

Log catchability residuals.

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
3	0.088	0.320	0.077	-0.373	-0.081	0.461	0.655	0.521	0.416	-1.326	0.091	-0.218	-0.631
4	0.008	-0.112	0.043	-0.106	0.318	0.055	-0.123	0.039	0.486	-0.102	-0.060	-0.022	-0.423
5	0.447	-0.448	-0.295	-0.735	0.064	0.271	0.128	0.125	0.128	0.444	0.289	-0.471	0.053
6	0.250	-0.423	-0.034	-0.146	0.035	0.284	0.126	-0.365	-0.207	0.213	0.465	0.165	-0.363
7	-0.299	-0.162	0.146	-0.027	-0.276	0.039	0.465	-0.209	-0.426	0.381	0.031	0.524	-0.188
8	-0.203	0.152	-0.086	0.293	0.127	-0.320	0.119	-0.079	-0.055	-0.098	0.229	0.307	0.234

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8
Mean_Logq	-6.8389	-6.5504	-6.5086	-6.6306	-6.6949	-6.6949
S.E_Logq	0.3298	0.3298	0.3298	0.3298	0.3298	0.3298

Fleet: UK(E&W)-CBT

Log catchability residuals.

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0.616	0.097	0.451	0.116	0.042	-0.126	-0.095	-0.392	-0.028	-0.469	-0.462	0.207	-0.193	0.131
4	0.417	0.520	0.183	0.344	0.062	-0.066	-0.225	-0.190	-0.167	0.021	-0.562	-0.245	-0.018	0.194
5	0.456	0.356	0.556	-0.178	0.125	-0.970	0.303	-0.064	-0.040	0.056	0.066	-0.218	0.035	0.172

6 0.454 -0.065 0.020 0.312 0.037 -0.115 -0.257 -0.121 0.404 0.040 0.010 0.355 0.308
0.088
7 0.295 -0.320 0.027 -0.125 -0.077 -0.418 -0.057 -0.116 0.334 0.353 -0.145 0.152 0.370
0.704
8 -0.310 -0.235 -0.093 -0.299 -0.581 -0.541 0.058 -0.124 0.194 0.098 0.261 -0.171 0.250
0.199
year
age 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
2013
3 0.323 -0.084 0.115 -0.129 0.445 -0.007 0.856 0.179 0.486 -0.496 0.051 -0.357 0.262 -
0.475
4 0.177 -0.004 0.220 -0.360 0.069 0.583 0.084 0.430 0.008 0.200 -0.416 -0.079 -0.739
0.336
5 0.331 0.187 0.293 -0.124 -0.106 0.168 0.614 -0.220 -0.019 0.078 0.298 -0.454 -0.103 -
0.466
6 0.226 0.328 -0.059 0.054 0.095 0.563 -0.033 0.810 -0.153 -0.368 -0.153 0.183 -1.013
0.010
7 0.109 0.145 0.193 0.311 -0.017 0.575 0.234 0.560 0.181 -0.107 0.357 -0.382 -0.244 -
0.092
8 0.619 0.086 0.323 0.191 0.754 0.837 -0.050 0.646 0.183 0.236 0.205 -0.543 -0.481 -
0.449
year
age 2014 2015 2016
3 -0.109 -0.305 -0.650
4 0.351 -0.902 -0.226
5 0.200 -0.318 -1.011
6 -0.993 -0.443 -0.526
7 -0.434 -1.674 -0.692
8 -1.627 -1.304 -1.443

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
3 4 5 6 7 8
Mean_Logq -6.0632 -6.076 -6.3216 -6.4581 -6.6891 -6.6891
S.E_Logq 0.4230 0.423 0.4230 0.4230 0.4230 0.4230

Fleet: FR-COTB
Log catchability residuals.
year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
2015
3 -0.235 -0.107 -0.025 -0.471 -0.500 0.025 -0.065 0.206 -0.245 0.130 0.542 0.307 0.396 -
0.038
4 -0.356 -1.107 -0.310 -0.666 -0.232 0.217 -0.012 0.024 0.556 -0.228 0.767 0.164 0.607
0.275
5 -0.124 -0.378 -0.481 -0.353 -0.136 -0.011 -0.068 -0.690 0.233 0.321 0.408 0.063 0.322
0.352

6 -0.515 -0.613 -0.224 -0.367 -0.199 0.087 0.164 -0.025 -0.251 0.116 1.125 0.183 0.220
0.055
7 -0.465 -0.352 0.248 -0.659 -0.258 -0.106 0.353 -0.147 -0.110 -0.111 0.292 1.117 0.223
0.072
8 -1.380 -0.769 0.037 0.247 -0.218 -0.739 0.711 -0.359 0.854 -0.291 -0.294 0.465 0.799
0.076
year
age 2016
3 0.079
4 0.301
5 0.542
6 0.243
7 -0.098
8 -0.058

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
3 4 5 6 7 8
Mean_Logq -8.8689 -8.7507 -8.8656 -8.9086 -9.0613 -9.0613
S.E_Logq 0.4369 0.4369 0.4369 0.4369 0.4369 0.4369

Fleet: UK(E&W)-BTS-Q3
Log catchability residuals.
year
age 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
2002
1 -0.584 0.152 0.074 -2.136 -1.840 -0.084 -0.093 -0.171 0.957 -0.619 1.397 0.206 -0.083
1.209
2 0.212 -0.546 0.123 -0.325 0.104 -0.894 -0.074 -0.115 -0.130 0.228 -0.276 0.506 0.237 -
0.166
3 0.675 -0.457 -0.239 0.028 0.088 0.097 -0.799 -0.243 -0.142 -0.411 0.243 0.208 0.414 -
0.170
4 0.023 0.396 -0.280 -0.393 0.556 0.091 -0.203 -0.522 -0.293 -0.219 -0.220 0.338 -0.099
0.507
5 0.093 -0.110 0.174 -0.220 0.338 0.334 -0.213 -0.142 -0.953 -0.376 -0.180 0.407 0.316 -
0.743
6 -0.568 0.149 -0.003 0.317 0.050 -0.604 0.053 -0.056 -0.454 -0.546 0.304 0.200 0.177 -
0.092
year
age 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
2016
1 0.396 0.707 1.228 -0.252 -0.996 -0.753 1.345 -0.004 0.085 -1.264 -1.672 1.414 0.622
0.757
2 0.546 -0.132 -0.445 0.644 0.117 -0.568 0.307 0.251 -0.071 -0.909 -0.250 0.829 0.616
0.183
3 -0.205 -0.062 -0.529 -0.124 0.413 -0.293 0.167 -0.272 0.219 -0.718 0.183 0.823 0.523
0.585

4 -0.328 -0.266 0.080 0.106 -0.309 0.381 0.179 -0.375 -0.583 -0.388 0.346 0.831 -0.024
0.665
5 0.289 0.071 0.327 0.068 -0.147 -0.840 0.866 0.104 -0.817 -0.579 0.112 0.328 0.569
0.923
6 -0.330 0.384 0.099 -0.413 0.150 -0.011 -0.192 0.686 0.509 -0.631 -0.007 0.338 -0.122
0.613

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
1 2 3 4 5 6
Mean_Logq -8.1026 -7.2593 -7.5952 -7.9967 -8.2218 -8.2926
S.E_Logq 0.5451 0.5451 0.5451 0.5451 0.5451 0.5451

Fleet: UK(E&W)-YFS
Log catchability residuals.
year
age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
2001
1 0.702 0.034 -0.507 -0.437 0.54 -0.359 0.3 0.439 0.859 -0.743 -0.482 -0.034 -0.144 0.061 -
1.715
year
age 2002 2003 2004 2005 2006
1 0.308 0.017 0.826 0.521 -0.185

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
1
Mean_Logq -9.7595
S.E_Logq 0.6163

Fleet: FR-YFS
Log catchability residuals.
year
age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
2000 2001
1 -0.103 -0.188 0.181 0.481 0.443 -0.102 -1.315 1.272 0.694 0.098 -1.925 -0.274 0.596
0.161 1.619
year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
2016
1 -1.146 0.689 0.104 1.095 1.011 -0.632 -1.06 2.263 -1.282 0.164 0.96 -0.467 -1.207 -1.181 -
0.949

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
1
Mean_Logq -11.9356

S.E_Logq 0.9891

Terminal year survivor and F summaries:
Age = 1 . Catchability constand w.r.t. time and dependant on age
Year class = 2015
Fleet = FR-YFS
1
Survivors 5793.000
Raw weights 0.951
Fleet = fshk
1
Survivors 30096.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
1
Survivors 31879.000
Raw weights 0.961

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"FR-YFS"	"5793"	"1.005"	"Inf"	"Inf"	"1"	"0.44"	"0.099"
[2,]	"fshk"	"30096"	"1.961"	"Inf"	"Inf"	"1"	"0.116"	"0.02"
[3,]	"UK(E&W)-BTS-Q3"	"31879"	"1"	"Inf"	"Inf"	"1"	"0.445"	"0.019"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"14957"	""	""	""	"0.04"

Age = 2 . Catchability constand w.r.t. time and dependant on age
Year class = 2014
Fleet = FR-YFS
1
Survivors 11406.000
Raw weights 0.937
Fleet = fshk
2
Survivors 8848.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
2 1
Survivors 44611.000 69237.000
Raw weights 4.799 0.947

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"FR-YFS"	"11406"	"1.005"	"Inf"	"Inf"	"1"	"0.135"	"0.139"
[2,]	"fshk"	"8848"	"1.956"	"Inf"	"Inf"	"1"	"0.036"	"0.176"
[3,]	"UK(E&W)-BTS-Q3"	"47964"	"0.408"	"0.163"	"0.4"	"2"	"0.829"	"0.035"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"37164"	""	""	""	"0.045"

Age = 3 . Catchability constand w.r.t. time and dependant on age
Year class = 2013
Fleet = BE-CBT-new
3
Survivors 5898.00
Raw weights 2.58
Fleet = FR-COTB
3
Survivors 11990.000
Raw weights 8.908
Fleet = FR-YFS
1
Survivors 3317.000
Raw weights 0.662
Fleet = fshk
3
Survivors 6590.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
3 2 1
Survivors 19898.000 20530.00 45570.000
Raw weights 4.758 3.52 0.669
Fleet = UK(E&W)-CBT
3
Survivors 5785.000
Raw weights 6.217

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"5898"	"0.565"	"Inf"	"Inf"	"1"	"0.094"	"0.336"
[2,]	"FR-COTB"	"11990"	"0.304"	"Inf"	"Inf"	"1"	"0.323"	"0.18"
[3,]	"FR-YFS"	"3317"	"1.005"	"Inf"	"Inf"	"1"	"0.024"	"0.537"
[4,]	"fshk"	"6590"	"1.816"	"Inf"	"Inf"	"1"	"0.009"	"0.306"
[5,]	"UK(E&W)-BTS-Q3"	"21432"	"0.292"	"0.152"	"0.521"	"3"	"0.325"	"0.104"
[6,]	"UK(E&W)-CBT"	"5785"	"0.364"	"Inf"	"Inf"	"1"	"0.226"	"0.342"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"11084"	""	""	""	"0.193"

Age = 4 . Catchability constand w.r.t. time and dependant on age
Year class = 2012
Fleet = BE-CBT-new
4 3
Survivors 2735.000 3359.000
Raw weights 8.364 1.749
Fleet = FR-COTB
4 3

Survivors 5646.00 4022.00
Raw weights 2.82 6.04
Fleet = FR-YFS
1
Survivors 2620.000
Raw weights 0.451
Fleet = fshk
4
Survivors 3312.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
4 3 2 1
Survivors 8126.000 7046.000 9572.000 785.000
Raw weights 4.984 3.226 2.341 0.456
Fleet = UK(E&W)-CBT
4 3
Survivors 3332.00 3079.000
Raw weights 5.84 4.215

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"2834"	"0.267"	"0.078"	"0.292"	"2"	"0.248"	"0.395"
[2,]	"FR-COTB"	"4480"	"0.265"	"0.158"	"0.596"	"2"	"0.217"	"0.267"
[3,]	"FR-YFS"	"2620"	"1.005"	"Inf"	"Inf"	"1"	"0.011"	"0.421"
[4,]	"fshk"	"3312"	"1.735"	"Inf"	"Inf"	"1"	"0.006"	"0.347"
[5,]	"UK(E&W)-BTS-Q3"	"7325"	"0.238"	"0.275"	"1.155"	"4"	"0.27"	"0.172"
[6,]	"UK(E&W)-CBT"	"3223"	"0.258"	"0.039"	"0.151"	"2"	"0.247"	"0.355"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"4178"	""	""	""	"0.284"

Age = 5 . Catchability constand w.r.t. time and dependant on age
Year class = 2011
Fleet = BE-CBT-new
5 4 3
Survivors 4276.00 3967.000 4443.000
Raw weights 5.05 6.089 1.177
Fleet = FR-COTB
5 4 3
Survivors 6972.000 5337.000 6025.000
Raw weights 5.304 2.053 4.064
Fleet = FR-YFS
1
Survivors 10589.000
Raw weights 0.301
Fleet = fshk
5
Survivors 4008.00

Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
5 4 3 2 1
Survivors 10209.000 3960.000 9234.000 3156.00 1146.000
Raw weights 3.125 3.629 2.171 1.55 0.304
Fleet = UK(E&W)-CBT
5 4 3
Survivors 1475.000 1645.000 3637.000
Raw weights 5.183 4.252 2.836

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"4135"	"0.224"	"0.03"	"0.134"	"3"	"0.26"	"0.279"
[2,]	"FR-COTB"	"6309"	"0.226"	"0.072"	"0.319"	"3"	"0.241"	"0.192"
[3,]	"FR-YFS"	"10589"	"1.005"	"Inf"	"Inf"	"1"	"0.006"	"0.119"
[4,]	"fshk"	"4008"	"1.735"	"Inf"	"Inf"	"1"	"0.005"	"0.287"
[5,]	"UK(E&W)-BTS-Q3"	"5776"	"0.222"	"0.28"	"1.261"	"5"	"0.228"	"0.208"
[6,]	"UK(E&W)-CBT"	"1887"	"0.22"	"0.257"	"1.168"	"3"	"0.259"	"0.534"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"4055"	""	""	""	"0.284"

Age = 6 . Catchability constand w.r.t. time and dependant on age
Year class = 2010
Fleet = BE-CBT-new
6 5 4 3
Survivors 4003.000 3594.000 5425.000 1528.000
Raw weights 8.778 3.773 3.959 0.857
Fleet = FR-COTB
6 5 4 3
Survivors 7344.000 8183.000 10560.000 7829.00
Raw weights 4.346 3.962 1.335 2.96
Fleet = FR-YFS
1
Survivors 6784.000
Raw weights 0.235
Fleet = fshk
6
Survivors 5397.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 10632.00 10166.000 13222.000 6911.000 2319.000 6268.000
Raw weights 5.68 2.335 2.359 1.581 1.196 0.237
Fleet = UK(E&W)-CBT
6 5 4 3
Survivors 3403.000 4187.000 8181.000 3581.000

Raw weights 4.942 3.872 2.764 2.066
Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BE-CBT-new" "3996" "0.188" "0.152" "0.809" "4" "0.302" "0.324"
[2,] "FR-COTB" "8015" "0.209" "0.06" "0.287" "4" "0.219" "0.175"
[3,] "FR-YFS" "6784" "1.005" "Inf" "Inf" "1" "0.004" "0.203"
[4,] "fshk" "5397" "1.778" "Inf" "Inf" "1" "0.004" "0.25"
[5,] "UK(E&W)-BTS-Q3" "9009" "0.203" "0.207" "1.02" "6" "0.233" "0.157"
[6,] "UK(E&W)-CBT" "4345" "0.202" "0.19" "0.941" "4" "0.237" "0.302"
Weighted prediction:
Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "5758" "" "" "" "0.236"

Age = 7 . Catchability constand w.r.t. time and dependant on age
Year class = 2009
Fleet = BE-CBT-new
7 6 5 4 3
Survivors 5244.000 7463.000 8447.000 5713.000 9589.000
Raw weights 8.548 7.308 3.278 3.964 0.836
Fleet = FR-COTB
7 6 5 4 3
Survivors 5738.000 6688.000 8730.000 7451.000 10874.000
Raw weights 4.513 3.618 3.442 1.336 2.887
Fleet = FR-YFS
1
Survivors 1755.000
Raw weights 0.212
Fleet = fshk
7
Survivors 5218.00
Raw weights 0.25
Fleet = UK(E&W)-BTS-Q3
6 5 4 3 2 1
Survivors 5602.000 8783.000 8942.000 3085.000 5891.0 6302.000
Raw weights 4.728 2.028 2.362 1.542 1.1 0.215
Fleet = UK(E&W)-CBT
7 6 5 4 3
Survivors 3167.00 4063.000 7728.000 8858.000 8226.000
Raw weights 4.11 4.115 3.364 2.767 2.015
Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BE-CBT-new" "6459" "0.164" "0.1" "0.61" "5" "0.349" "0.156"
[2,] "FR-COTB" "7482" "0.192" "0.116" "0.604" "5" "0.23" "0.136"
[3,] "FR-YFS" "1755" "1.005" "Inf" "Inf" "1" "0.003" "0.482"
[4,] "fshk" "5218" "1.848" "Inf" "Inf" "1" "0.004" "0.189"
[5,] "UK(E&W)-BTS-Q3" "6181" "0.198" "0.151" "0.763" "6" "0.175" "0.162"
[6,] "UK(E&W)-CBT" "5420" "0.187" "0.213" "1.139" "5" "0.239" "0.183"
Weighted prediction:

```
   Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "6328"   ""       ""       ""        "0.158"

Age =  8 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2008
Fleet =  BE-CBT-new
               8       7      6       5       4       3
Survivors   4966.000 6631.000 6255.00 6124.000 6384.000 6616.000
Raw weights    9.526    6.974    6.19    2.991    3.562    0.743
Fleet =  FR-COTB
               8       7       6       5       4       3
Survivors   3708.000 4223.000 4893.000 4185.000 8457.000 4472.000
Raw weights    2.027    3.682    3.065    3.141    1.201    2.564
Fleet =  FR-YFS
                1
Survivors   37773.000
Raw weights     0.177
Fleet =  fshk
               8
Survivors   3297.00
Raw weights    0.25
Fleet =  UK(E&W)-BTS-Q3
               6       5       4       3       2       1
Survivors   5505.000 4393.000 2666.000 4889.000 5048.000 15073.000
Raw weights    4.005    1.851    2.122    1.369    0.955    0.179
Fleet =  UK(E&W)-CBT
               8      7       6       5       4       3
Survivors   927.000 737.000 1456.000 2465.000 1876.000 2750.000
Raw weights   2.338   3.353    3.485    3.069    2.487    1.789
    Fleet           Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-new"     "5902"       "0.146"   "0.054"   "0.37"     "6" "0.41"      "0.105"
[2,] "FR-COTB"        "4542"       "0.185"   "0.088"   "0.476"    "6" "0.215"     "0.134"
[3,] "FR-YFS"         "37773"      "1.005"   "Inf"     "Inf"      "1" "0.002"     "0.017"
[4,] "fshk"           "3297"       "1.852"   "Inf"     "Inf"      "1" "0.003"     "0.181"
[5,] "UK(E&W)-BTS-Q3" "4540"       "0.197"   "0.14"    "0.711"    "6" "0.143"     "0.135"
[6,] "UK(E&W)-CBT"    "1460"       "0.18"    "0.213"   "1.183"    "6" "0.226"     "0.37"
 Weighted prediction:
   Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "3928"   ""       ""       ""        "0.154"

Age =  9 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2007
Fleet =  BE-CBT-new
               8       7       6      5       4       3
Survivors   2213.000 1679.000 2014.000 1850.00 1692.000 3134.000
Raw weights    7.304    5.425    5.025    2.38    2.887    0.585
```

Fleet = FR-COTB

	8	7	6	5	4	3
Survivors	1757.000	2035.000	1954.000	2448.0	1296.000	1274.00
Raw weights	1.554	2.864	2.488	2.5	0.973	2.02

Fleet = FR-YFS

	1
Survivors	564.000
Raw weights	0.137

Fleet = fshk

	9
Survivors	3418.00
Raw weights	0.25

Fleet = UK(E&W)-BTS-Q3

	6	5	4	3	2	1
Survivors	1616.000	912.000	909.00	1240.000	2212.000	767.000
Raw weights	3.252	1.473	1.72	1.079	0.726	0.138

Fleet = UK(E&W)-CBT

	8	7	6	5	4	3
Survivors	442.000	1055.000	1644.00	1468.000	1504.000	1713.00
Raw weights	1.793	2.609	2.83	2.443	2.016	1.41

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BE-CBT-new"	"1951"	"0.145"	"0.061"	"0.421"	"6"	"0.408"	"0.201"
[2,]	"FR-COTB"	"1839"	"0.184"	"0.101"	"0.549"	"6"	"0.214"	"0.212"
[3,]	"FR-YFS"	"564"	"1.005"	"Inf"	"Inf"	"1"	"0.002"	"0.572"
[4,]	"fshk"	"3418"	"1.777"	"Inf"	"Inf"	"1"	"0.004"	"0.12"
[5,]	"UK(E&W)-BTS-Q3"	"1274"	"0.198"	"0.138"	"0.697"	"6"	"0.145"	"0.294"
[6,]	"UK(E&W)-CBT"	"1220"	"0.179"	"0.195"	"1.089"	"6"	"0.226"	"0.305"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"1628"	""	""	""	"0.237"

Age = 10 . Catchability constand w.r.t. time and dependant on age

Year class = 2006

Fleet = BE-CBT-new

	8	7	6	5	4	3
Survivors	897.000	1045.000	580.000	809.000	631.000	1131.0
Raw weights	6.331	4.307	3.377	1.469	1.628	0.3

Fleet = FR-COTB

	8	7	6	5	4	3
Survivors	1587.000	2181.000	2198.000	983.000	1245.000	877.000
Raw weights	1.348	2.274	1.672	1.543	0.549	1.035

Fleet = FR-YFS

	1
Survivors	379.000
Raw weights	0.078

Fleet = fshk

```
            10
Survivors   463.00
Raw weights   0.25
Fleet =  UK(E&W)-BTS-Q3
              6       5      4       3     2       1
Survivors   380.000 315.000 491.00 843.000 404.0 264.000
Raw weights   2.185   0.909   0.97   0.553   0.4   0.079
Fleet =  UK(E&W)-CBT
              8       7       6       5       4       3
Survivors   140.000 651.000 259.000 453.000 471.000 435.000
Raw weights   1.554   2.071   1.902   1.508   1.137   0.722
    Fleet            Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BE-CBT-new"     "824"        "0.153"   "0.099"   "0.647"   "6" "0.434"     "0.126"
[2,] "FR-COTB"        "1546"       "0.198"   "0.165"   "0.833"   "6" "0.21"      "0.069"
[3,] "FR-YFS"         "379"        "1.005"   "Inf"     "Inf"     "1" "0.002"     "0.256"
[4,] "fshk"           "463"        "1.861"   "Inf"     "Inf"     "1" "0.006"     "0.214"
[5,] "UK(E&W)-BTS-Q3" "420"        "0.205"   "0.126"   "0.615"   "6" "0.127"     "0.234"
[6,] "UK(E&W)-CBT"    "357"        "0.192"   "0.237"   "1.234"   "6" "0.222"     "0.27"
 Weighted prediction:
    Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "714"    ""       ""       ""        "0.144"
```

Table 19.13. Sol in Division 7.d: XSA summary.

Year	Recruitment	SSB	Landings	Discards	F
	Age 1				Ages 3–7
	thousands	tons	tons	tons	Year–1
1982	14824	10550	3190	183	0.29
1983	27535	13127	3458	100	0.31
1984	25152	13824	3575	131	0.37
1985	14322	15891	3837	219	0.25
1986	29797	16048	3932	139	0.28
1987	12621	16285	4791	179	0.45
1988	33481	16558	3853	188	0.34
1989	19215	19080	3805	171	0.48
1990	56111	17005	3647	300	0.32
1991	40224	16345	4351	317	0.39
1992	39749	19783	4072	251	0.29
1993	18284	19651	4299	247	0.25
1994	31910	16798	4383	123	0.29
1995	24008	17113	4420	249	0.34
1996	22115	17660	4797	166	0.4
1997	33458	18259	4764	143	0.5
1998	21407	13752	3363	120	0.38
1999	31564	15690	4135	227	0.42
2000	43058	14444	3476	180	0.32
2001	39174	14010	4025	280	0.31
2002	57268	14290	4733	390	0.29
2003	26138	21905	6977	473	0.46
2004	22550	16730	6283	308	0.43
2005	44955	17407	5056	319	0.34
2006	49428	16253	5040	229	0.32
2007	24696	14873	5588	379	0.43
2008	28972	18285	5256	256	0.38
2009	48721	17053	5251	360	0.37
2010	59315	15151	4269	438	0.31
2011	44252	18653	4225	477	0.26
2012	21980	19489	4131	533	0.27
2013	13660	22917	4372	466	0.25
2014	22367	21068	4655	528	0.31
2015	47912	16525	3443	294	0.28
2016	17198	15912	2538	344	0.23

Table 19.14. Sol in Division 7.d: RCT3-input for Age 1.

Sole	VIId	Age1		
3	36	2		
1981	14824	3.33	0.07	-11
1982	27535	1.04	0.02	-11
1983	25152	0.79	-11	-11
1984	14322	-11	-11	-11
1985	29797	-11	-11	-11
1986	12621	-11	0.07	-11
1987	33481	0.75	0.17	8.2
1988	19215	0.04	0.14	3.01
1989	56111	17.43	0.54	17.96
1990	40224	0.57	0.38	12.14
1991	39749	1.04	0.22	1.33
1992	18284	0.48	0.03	0.82
1993	31910	0.27	0.7	8.33
1994	24008	4.04	0.28	5.89
1995	22115	3.5	0.15	5.3
1996	33458	0.28	0.03	24.75
1997	21407	0.07	0.1	3.27
1998	31564	10.52	0.35	35.99
1999	43058	2.84	0.31	14.98
2000	39174	2.41	1.21	10.19
2001	57268	4.32	0.11	53.56
2002	26138	0.94	0.32	11.03
2003	22550	0.21	0.15	12.67
2004	44955	7.29	0.82	43.27
2005	49428	0.05	0.83	10.84
2006	24696	1.04	0.08	2.57
2007	28972	0.03	0.06	3.77
2008	48721	6.58	2.78	51.25
2009	59315	2.47	0.1	16.59
2010	44252	0.2	0.32	13.66
2011	21980	2.78	0.35	1.75
2012	13660	0.44	0.052	0.72
2013	-11	0.72	0.04	25.39
2014	-11	1.08	0.09	25.24
2015	-11	0.26	0.04	10.17
2016	-11	0.34	-11	-11
FRYF0				
FRYF1				
BTS1				

Table 19.15. Sol in Division 7.d: RCT3–input for Age 2.

Sole	VIId	Age2			
4	36	2			
1981	13081	3.33	0.07	-11	-11
1982	24914	1.04	0.02	-11	-11
1983	22706	0.79	-11	-11	-11
1984	12852	-11	-11	-11	-11
1985	26855	-11	-11	-11	-11
1986	11400	-11	0.07	-11	14.2
1987	30088	0.75	0.17	8.2	22.09
1988	17032	0.04	0.14	3.01	5.55
1989	48063	17.43	0.54	17.96	31.17
1990	35563	0.57	0.38	12.14	15.29
1991	35738	1.04	0.22	1.33	22.96
1992	16359	0.48	0.03	0.82	4.26
1993	28806	0.27	0.7	8.33	16.09
1994	19901	4.04	0.28	5.89	10.79
1995	19990	3.5	0.15	5.3	10.85
1996	30222	0.28	0.03	24.75	24.11
1997	19299	0.07	0.1	3.27	8.22
1998	28196	10.52	0.35	35.99	27.45
1999	38660	2.84	0.31	14.98	27.88
2000	35080	2.41	1.21	10.19	16.11
2001	50280	4.32	0.11	53.56	45.65
2002	23603	0.94	0.32	11.03	11.81
2003	19553	0.21	0.15	12.67	6.91
2004	40107	7.29	0.82	43.27	42.62
2005	44169	0.05	0.83	10.84	28.97
2006	21996	1.04	0.08	2.57	7.35
2007	25022	0.03	0.06	3.77	19.16
2008	41559	6.58	2.78	51.25	30.76
2009	52593	2.47	0.1	16.59	28.6
2010	39844	0.2	0.32	13.66	9.72
2011	19586	2.78	0.35	1.75	8.91
2012	12087	0.44	0.052	0.72	16.35
2013	-11	0.72	0.04	25.39	21.36
2014	-11	1.08	0.09	25.24	33.14
2015	-11	0.26	0.04	10.17	-11
2016	-11	0.34	-11	-11	-11
FRYF0					
FRYF1					
BTS1					
BTS2					

Table 19.16. Sol in Division 7.d: Diagnostics of the RCT3 analysis for Age 1.

RCT3 - age1

yearclass: 2016

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
FRYF0	0.8373	10.406	1.3869	0.08043	29	-1.079	9.503	1.4706	0.08006
FRYF1	0.6989	11.476	0.7126	0.27803	29	NA	NA	NA	NA
BTS1	0.4458	9.446	0.3714	0.54182	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	32	NA	10.282	0.4338	0.91994

	WAP	logWAP	int.se
Year class:2016	**27430**	10.22	0.4161

Table 19.17. Sol in Division 7.d: Output of the short-term forecast showing different management options under the scenario of scaling F for the intermediate year (2017) to the last data year (2016).

basis	catch	landings	discards	f3-7	f_hc3-7	f_dis1-3	ssb2018	ssb2019	ssb_change	tac_change
Fmsy	4052	3593	459	0.256	0.23	0.07	18260	18508	1	46
Ftar	3866	3429	437	0.243	0.22	0.07	18260	18697	2	40
Fmsy_low	3174	2817	357	0.195	0.18	0.06	18260	19405	6	15
Fmsy_high	5283	4679	604	0.348	0.31	0.1	18260	17251	-6	91
Fmsy_high_wo_Btrig	4465	3958	507	0.286	0.26	0.08	18260	18086	-1	61
Fpa	4052	3593	459	0.256	0.23	0.07	18260	18508	1	46
Flim	5424	4803	621	0.359	0.32	0.1	18260	17108	-6	96
SSB>Bpa	3325	2950	375	0.205	0.19	0.06	18260	19251	5	20
SSB>Blim	8731	7704	1027	0.657	0.59	0.19	18260	13751	-25	215
TACsq	2769	2458	311	0.168	0.15	0.05	18260	19820	9	0
15%_TAC_inc	3184	2825	359	0.196	0.18	0.06	18260	19395	6	15
15%_TAC_dec	2354	2090	264	0.141	0.13	0.04	18260	20245	11	-15
Fsq*0	0	0	0	0	NA	NA	18260	22660	24	-100
Fsq*0.25	1007	895	112	0.058	0.05	0.02	18260	21625	18	-64
Fsq*0.5	1960	1740	220	0.116	0.1	0.03	18260	20649	13	-29
Fsq*0.9	3366	2986	380	0.208	0.19	0.06	18260	19209	5	22
Fsq*1	3698	3280	418	0.231	0.21	0.07	18260	18869	3	34
Fsq*1.1	4024	3568	456	0.254	0.23	0.07	18260	18537	2	45
Fsq*1.25	4506	3994	512	0.289	0.26	0.08	18260	18044	-1	63
Fsq*1.5	5271	4668	603	0.347	0.31	0.1	18260	17265	-5	90
Fsq*1.75	5983	5295	688	0.404	0.37	0.12	18260	16539	-9	116
Fsq*2	6670	5900	770	0.462	0.42	0.13	18260	15840	-13	141

Table 19.18. Sol in Division 7.d: Output of the short-term forecast providing a list of F changing in 0.01 intervals, using a scaled F for the intermediate year (2017).

basis	catch	landings	discards	f3-7	f_hc3-7	f_dis1-3	ssb2018	ssb2019	ssb_change	tac_change
F=0	0	0	0	0	NA	NA	18260	22660	24.09639	-100
F=0.01	178	158	20	0.01	0.01	0	18260	22477	23.09419	-93.5717
F=0.02	354	315	39	0.02	0.02	0.01	18260	22296	22.10296	-87.2156
F=0.03	528	469	59	0.03	0.03	0.01	18260	22117	21.12267	-80.9317
F=0.04	701	623	78	0.04	0.04	0.01	18260	21940	20.15334	-74.684
F=0.05	872	775	97	0.05	0.05	0.01	18260	21764	19.18949	-68.5085
F=0.06	1041	925	116	0.06	0.05	0.02	18260	21591	18.24206	-62.4052
F=0.07	1209	1074	135	0.07	0.06	0.02	18260	21419	17.30011	-56.338
F=0.08	1375	1221	154	0.08	0.07	0.02	18260	21248	16.36364	-50.3431
F=0.09	1539	1367	172	0.09	0.08	0.03	18260	21080	15.44359	-44.4204
F=0.1	1702	1512	190	0.1	0.09	0.03	18260	20913	14.52903	-38.5338
F=0.11	1863	1655	208	0.11	0.1	0.03	18260	20747	13.61993	-32.7194
F=0.12	2023	1797	226	0.12	0.11	0.03	18260	20583	12.7218	-26.9411
F=0.13	2182	1937	245	0.13	0.12	0.04	18260	20421	11.83461	-21.199
F=0.14	2338	2076	262	0.14	0.13	0.04	18260	20261	10.95838	-15.5652
F=0.15	2494	2214	280	0.15	0.14	0.04	18260	20102	10.08762	-9.93138
F=0.16	2647	2350	297	0.16	0.14	0.05	18260	19944	9.222344	-4.40592
F=0.17	2800	2485	315	0.17	0.15	0.05	18260	19788	8.368018	1.119538
F=0.18	2951	2619	332	0.18	0.16	0.05	18260	19634	7.524644	6.57277
F=0.19	3100	2751	349	0.19	0.17	0.05	18260	19481	6.686747	11.95377
F=0.2	3248	2882	366	0.2	0.18	0.06	18260	19330	5.859803	17.29866
F=0.21	3395	3012	383	0.21	0.19	0.06	18260	19180	5.038335	22.60744
F=0.22	3540	3140	400	0.22	0.2	0.06	18260	19031	4.222344	27.84399
F=0.23	3684	3267	417	0.23	0.21	0.07	18260	18884	3.417306	33.04442
F=0.24	3827	3393	434	0.24	0.22	0.07	18260	18738	2.617744	38.20874
F=0.25	3968	3518	450	0.25	0.23	0.07	18260	18594	1.829135	43.30083
F=0.26	4108	3642	466	0.26	0.23	0.07	18260	18451	1.046002	48.35681
F=0.27	4246	3764	482	0.27	0.24	0.08	18260	18310	0.273823	53.34056
F=0.28	4383	3885	498	0.28	0.25	0.08	18260	18169	-0.49836	58.28819
F=0.29	4519	4005	514	0.29	0.26	0.08	18260	18031	-1.25411	63.19971
F=0.3	4654	4124	530	0.3	0.27	0.09	18260	17893	-2.00986	68.07512
F=0.31	4788	4242	546	0.31	0.28	0.09	18260	17757	-2.75465	72.91441
F=0.32	4920	4359	561	0.32	0.29	0.09	18260	17622	-3.49398	77.68147
F=0.33	5051	4474	577	0.33	0.3	0.09	18260	17489	-4.22234	82.41242
F=0.34	5181	4589	592	0.34	0.31	0.1	18260	17356	-4.95071	87.10726
F=0.35	5309	4702	607	0.35	0.32	0.1	18260	17225	-5.66813	91.72987
F=0.36	5436	4814	622	0.36	0.33	0.1	18260	17096	-6.37459	96.31636
F=0.37	5563	4925	638	0.37	0.33	0.11	18260	16967	-7.08105	100.9029
F=0.38	5688	5035	653	0.38	0.34	0.11	18260	16840	-7.77656	105.4171
F=0.39	5812	5144	668	0.39	0.35	0.11	18260	16714	-8.46659	109.8953
F=0.4	5934	5252	682	0.4	0.36	0.11	18260	16589	-9.15115	114.3012
F=0.41	6056	5359	697	0.41	0.37	0.12	18260	16465	-9.83023	118.7071
F=0.42	6176	5465	711	0.42	0.38	0.12	18260	16342	-10.5038	123.0408
F=0.43	6296	5570	726	0.43	0.39	0.12	18260	16221	-11.1665	127.3745

F=0.44	6414	5674	740	0.44	0.4	0.13	18260	16101	-11.8237	131.636
F=0.45	6531	5777	754	0.45	0.41	0.13	18260	15981	-12.4808	135.8613
F=0.46	6647	5879	768	0.46	0.42	0.13	18260	15863	-13.1271	140.0506
F=0.47	6762	5980	782	0.47	0.42	0.13	18260	15747	-13.7623	144.2037
F=0.48	6876	6080	796	0.48	0.43	0.14	18260	15631	-14.3976	148.3207
F=0.49	6989	6180	809	0.49	0.44	0.14	18260	15516	-15.0274	152.4016
F=0.5	7101	6278	823	0.5	0.45	0.14	18260	15402	-15.6517	156.4464

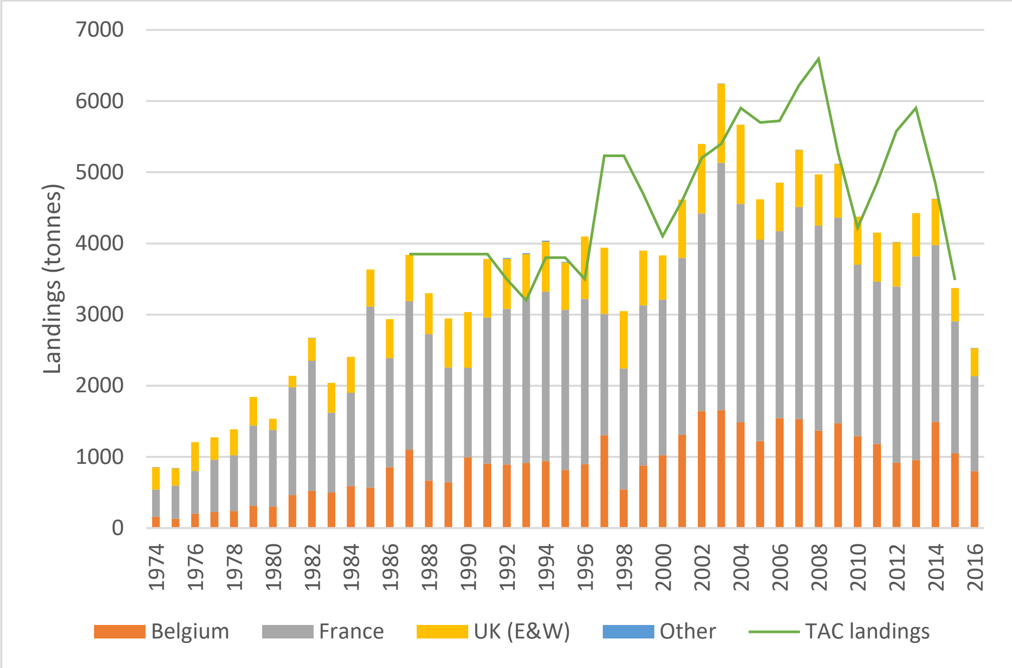


Figure 19.1. Sol in Division 7.d: Official landings (tons) for sole in Division 7.d by country over the period 1974–2016, as officially reported (Rec 12) (stacked barplot); green line represents the official TAC (landings; 2016 TAC is not shown as this represents catch).

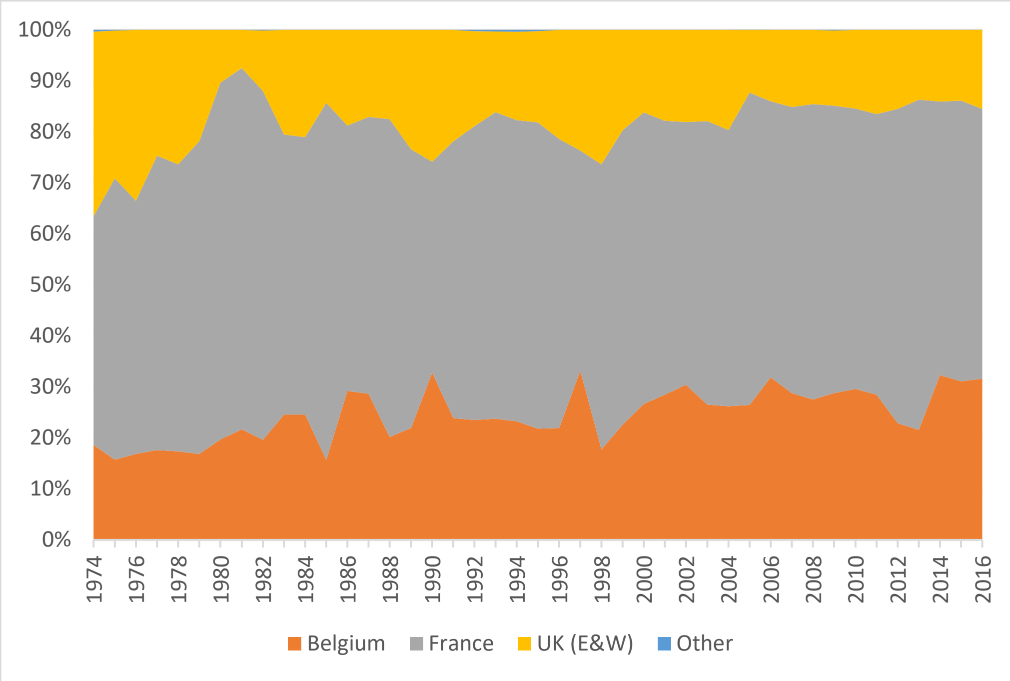


Figure 19.2. Sol in Division 7.d: Relative contribution to the official landings of sole in Division 7.d for the main countries involved over the period 1974–2016.

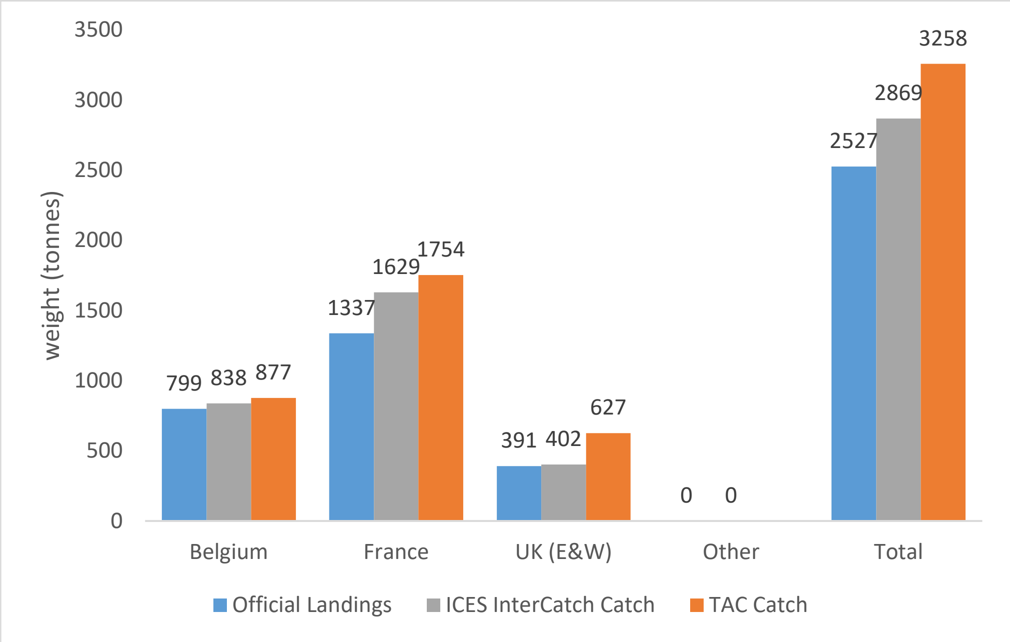


Figure 19.3. Sol in Division 7.d: Uptake of the national quota and the total TAC of sole in Division 7.d in 2016; note that TAC represents catch.

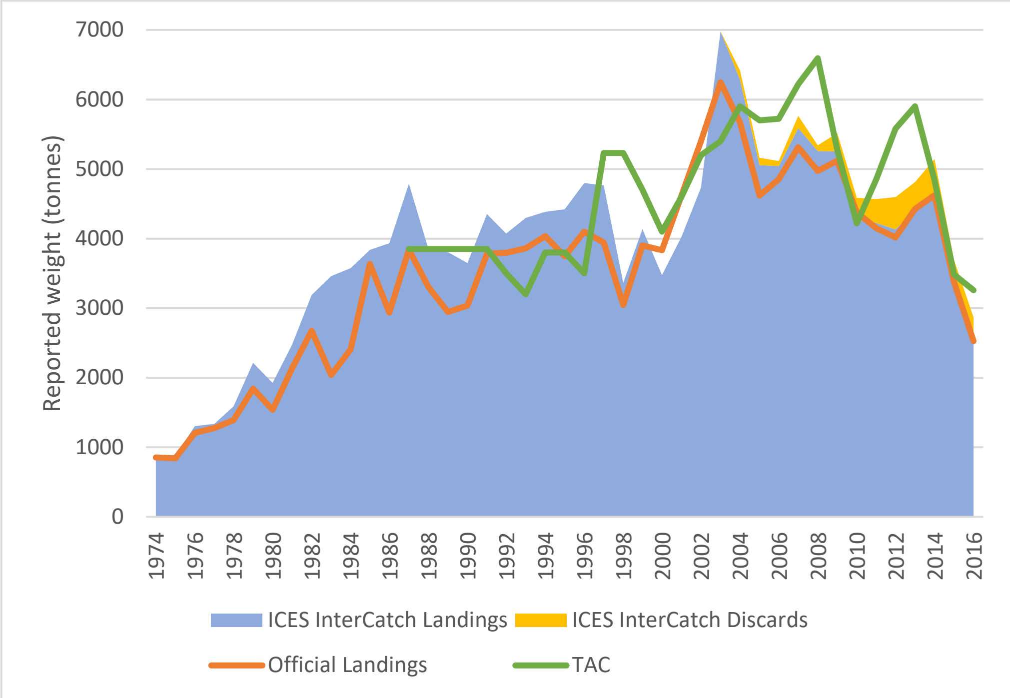


Figure 19.4. Sol in Division 7.d: Historic overview (1974–2016) of the official landings, TAC and ICES estimates (InterCatch; including discards from 2003 onwards); Note that the TAC value represents catch from 2016 onwards.

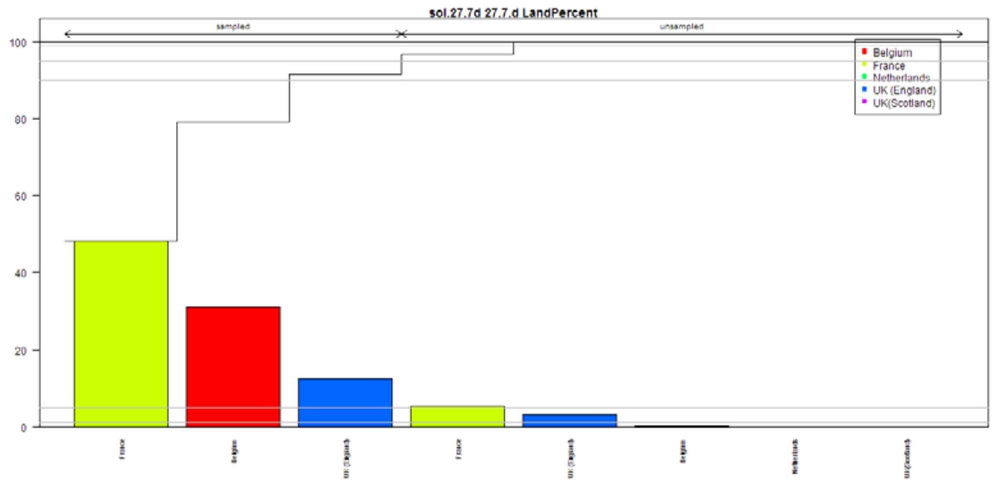


Figure 19.5. Sol in Division 7.d: Overview of the proportion of 2016 landings of sole in Division 7.d for which samples have been provided in InterCatch by country.

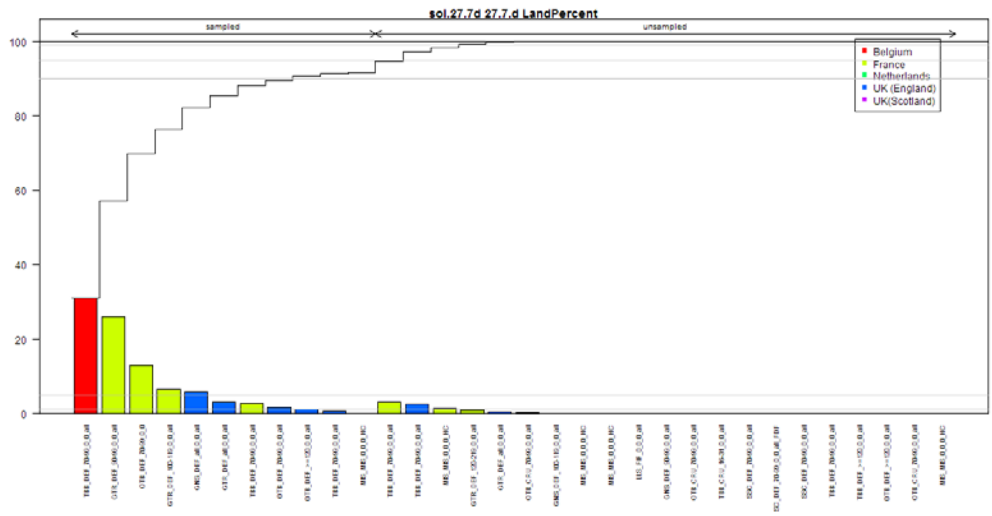


Figure 19.6. Sol in Division 7.d: Overview of the proportion of 2016 landings of sole in Division 7.d for which samples have been provided in InterCatch by fleet and country.

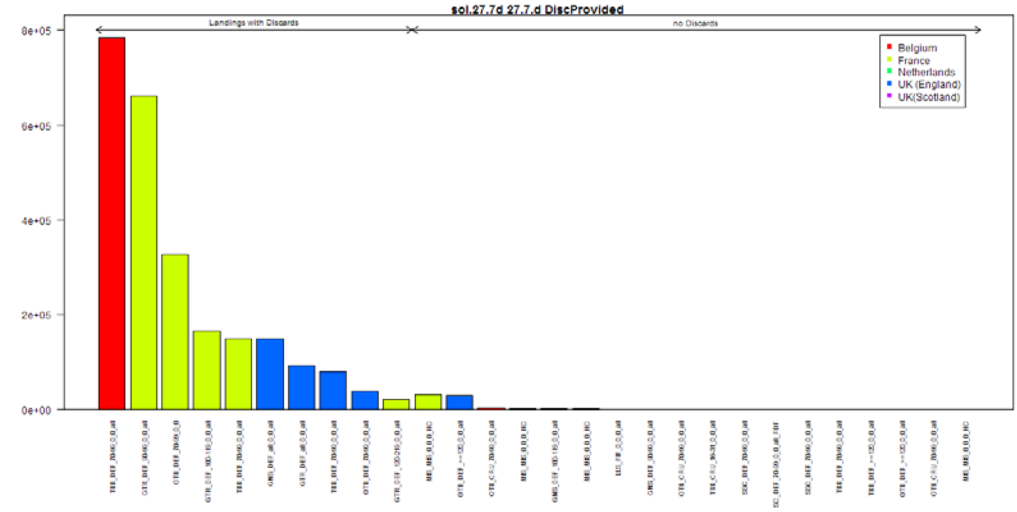


Figure 19.7. Sol in Division 7.d: Overview of the landings with and without discards by fleet and country.

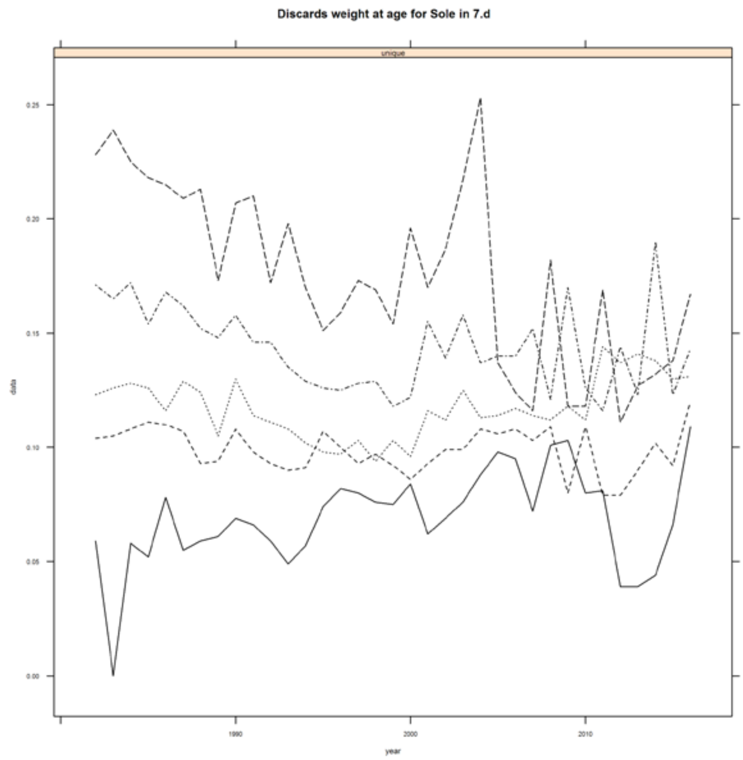


Figure 19.8. Sol in Division 7.d: Discard weights-at-age (ages 1–5 are shown).

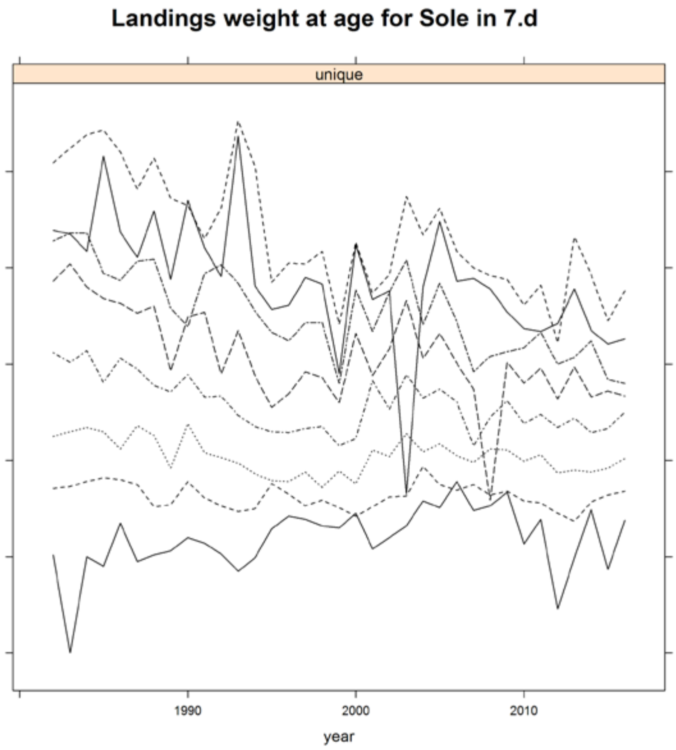


Figure 19.9. Sol in Division 7.d: Landings weights-at-age (ages 1–8 are shown).

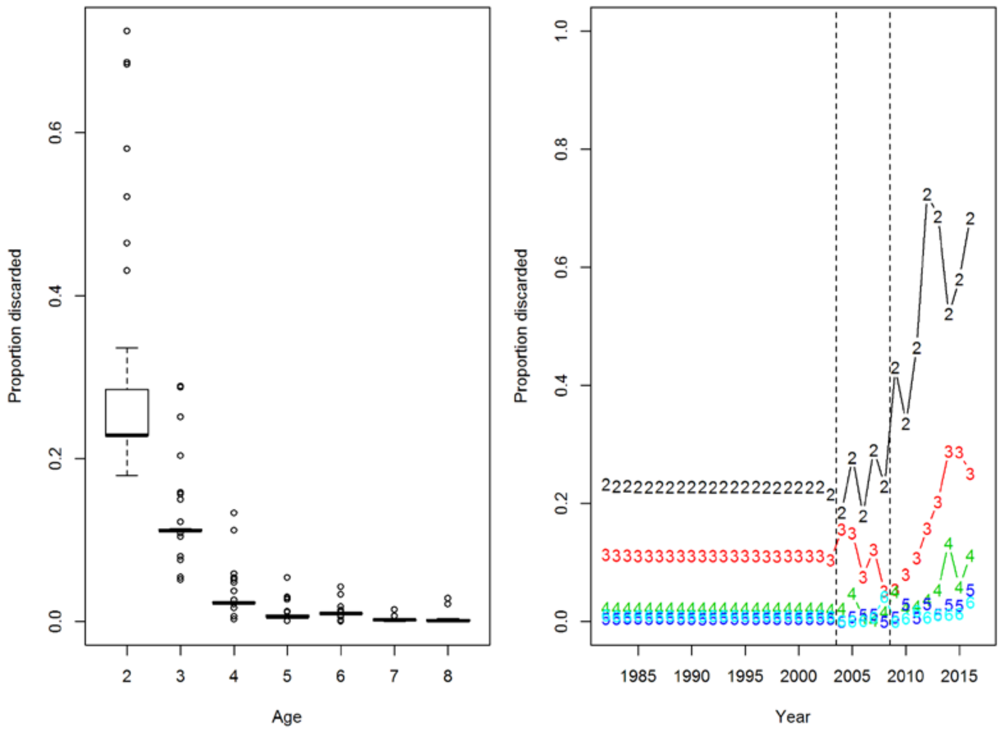


Figure 19.10. Sol in Division 7.d: Proportion discarded (discard numbers/catch numbers) (data before 2004 are estimated based on an average ratio from 2004–2008 (indicated by dotted lines)) at age.

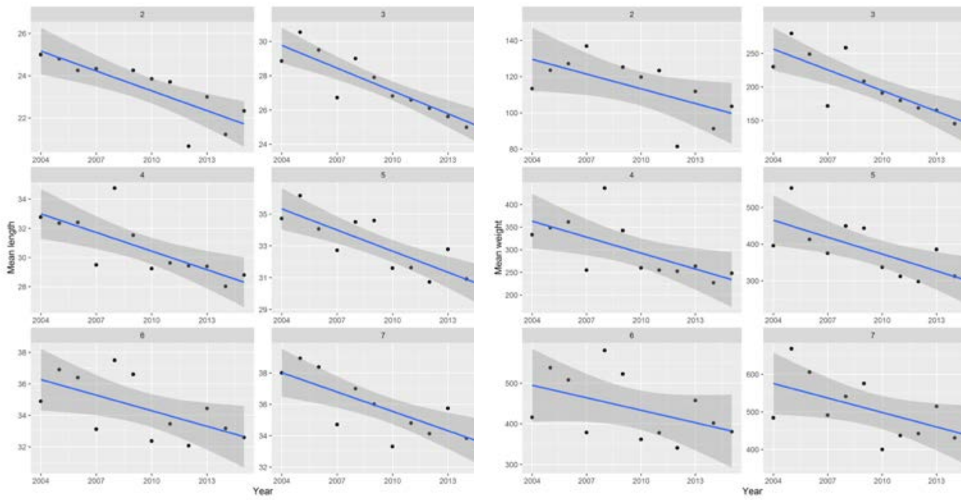


Figure 19.11. Sol in Division 7.d: Left: Mean length-at-age from 2004–2015 for ages 2–7; Right: Mean weight-at-age from 2004–2015 for ages 2–7.

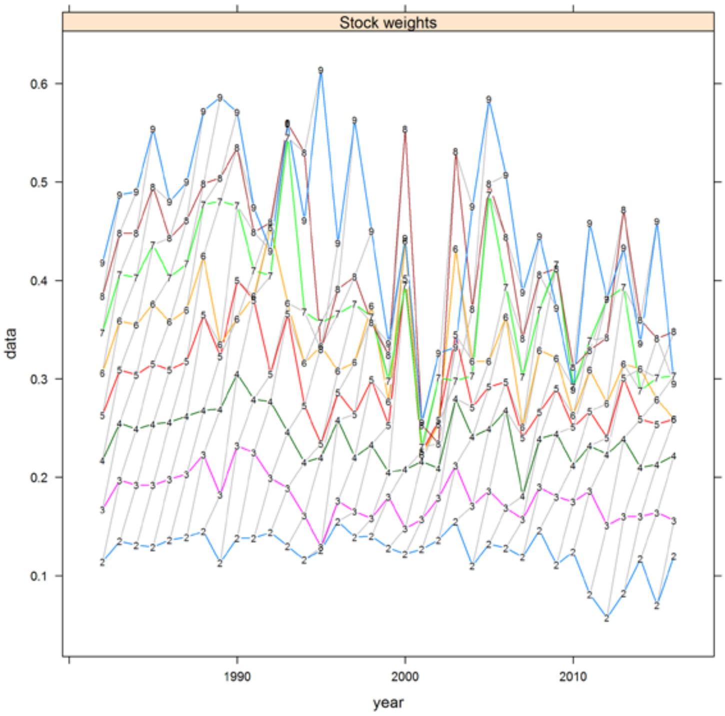


Figure 19.12. Sol in Division 7.d: Stock weights at age with indication of year classes (grey lines).

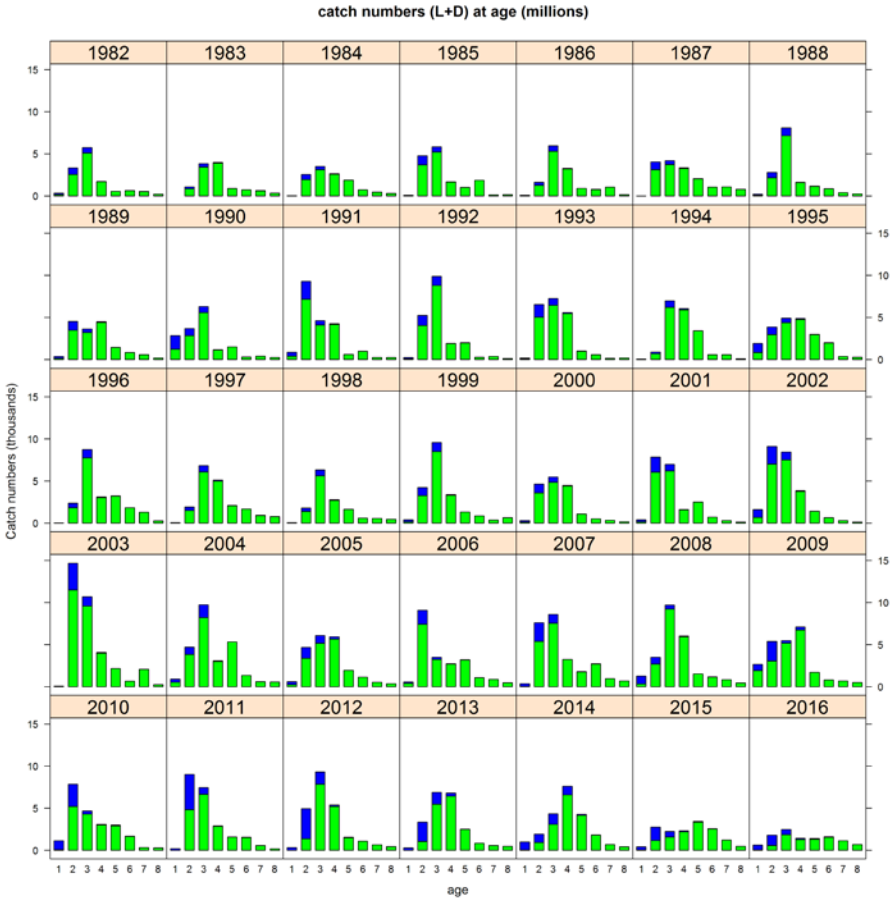


Figure 19.13. Sol in Division 7.d: Catch numbers at age.

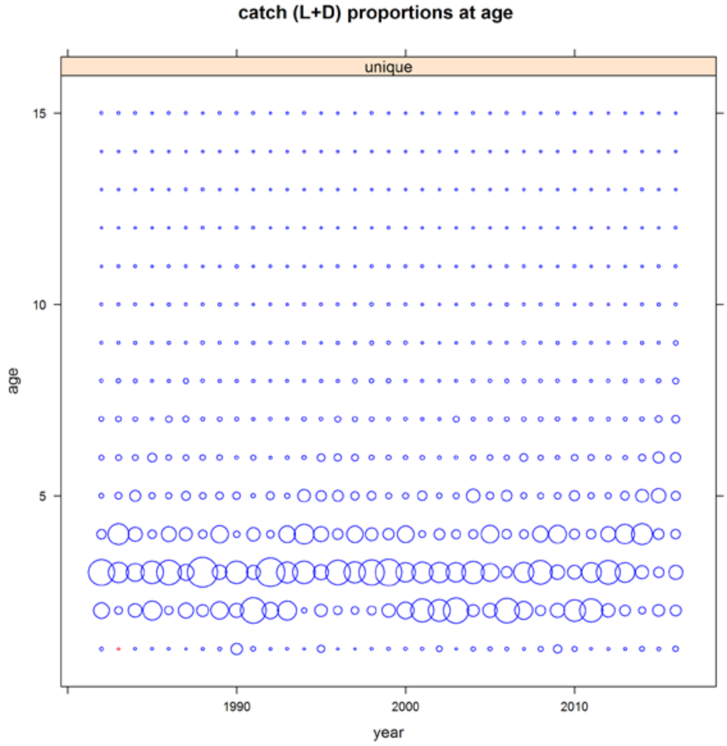


Figure 19.14. Sol in Division 7.d: Catch proportion at age.

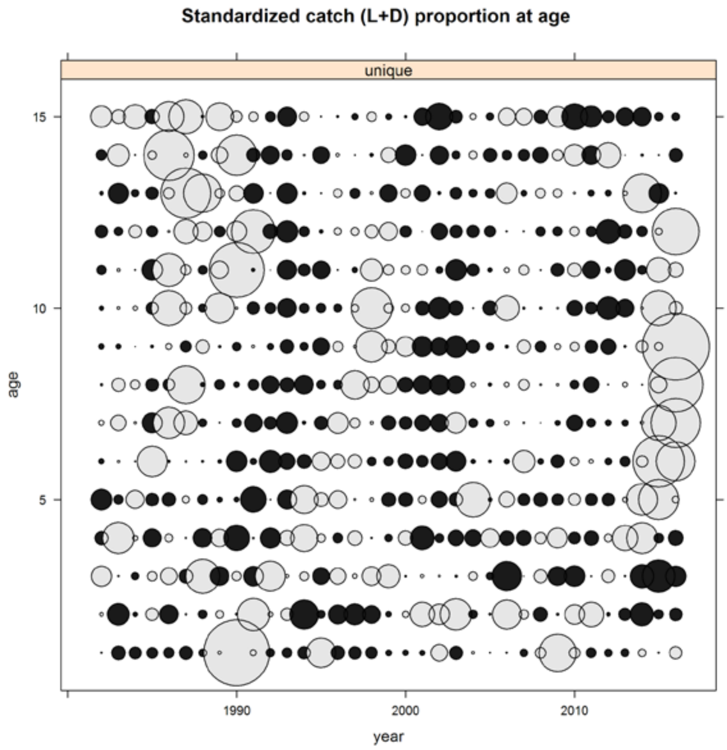


Figure 19.15. Sol in Division 7.d: Standardised catch proportion at age.

Figure 19.16. Sol in Division 7.d: Standardised tuning indices at age.

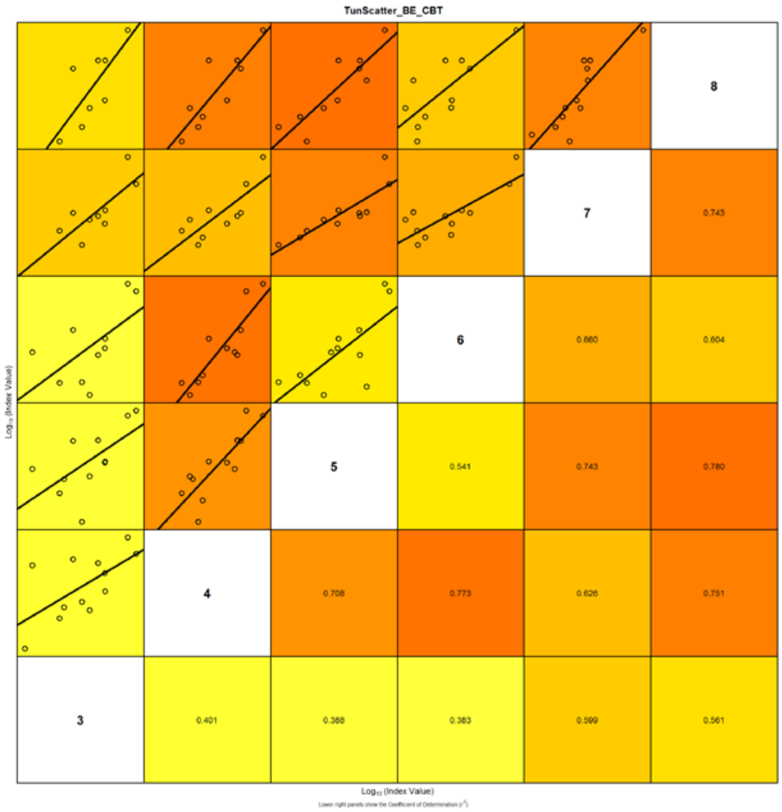


Figure 19.17. Sol in Division 7.d: Internal consistency plot of the BEL–CBT tuning series.

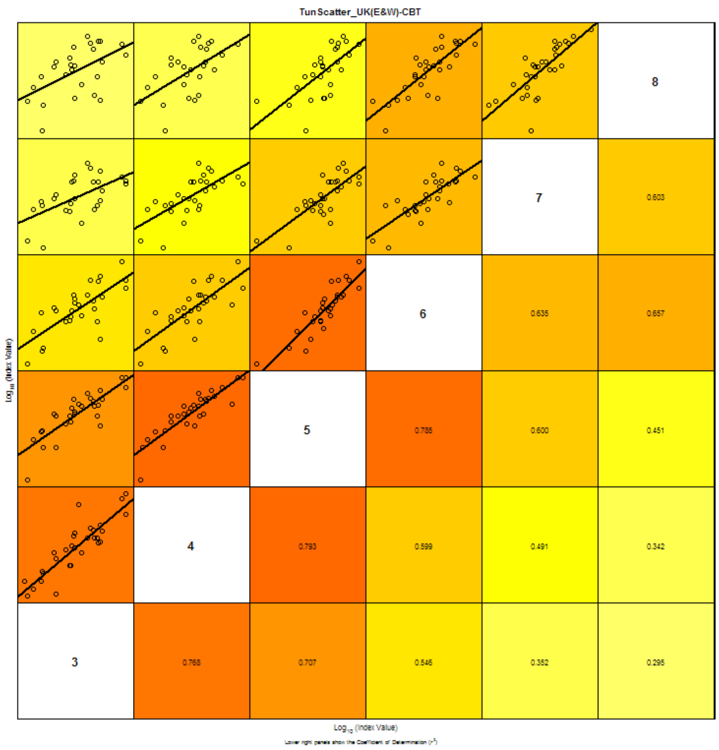


Figure 19.18. Sol in Division 7.d: Internal consistency plot of the UK–CBT tuning series.

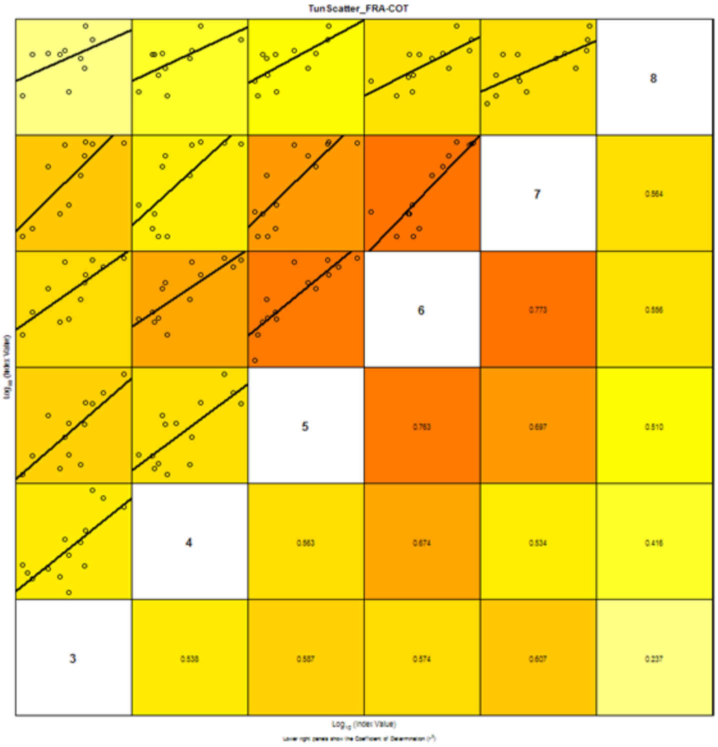


Figure 19.19. Sol in Division 7.d: Internal consistency plot of the FRA–COT tuning series.

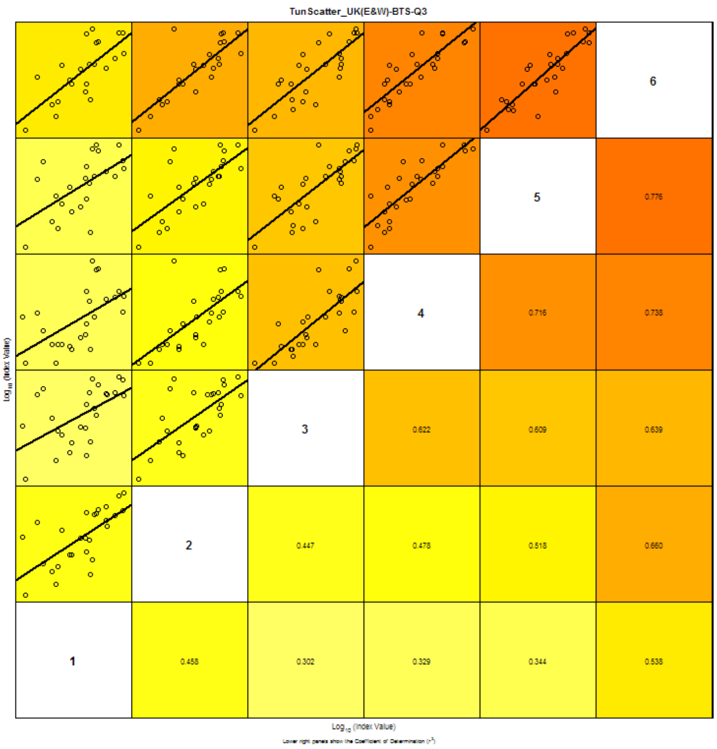


Figure 19.20. Sol in Division 7.d: Internal consistency plot of the UK–BTS tuning series.

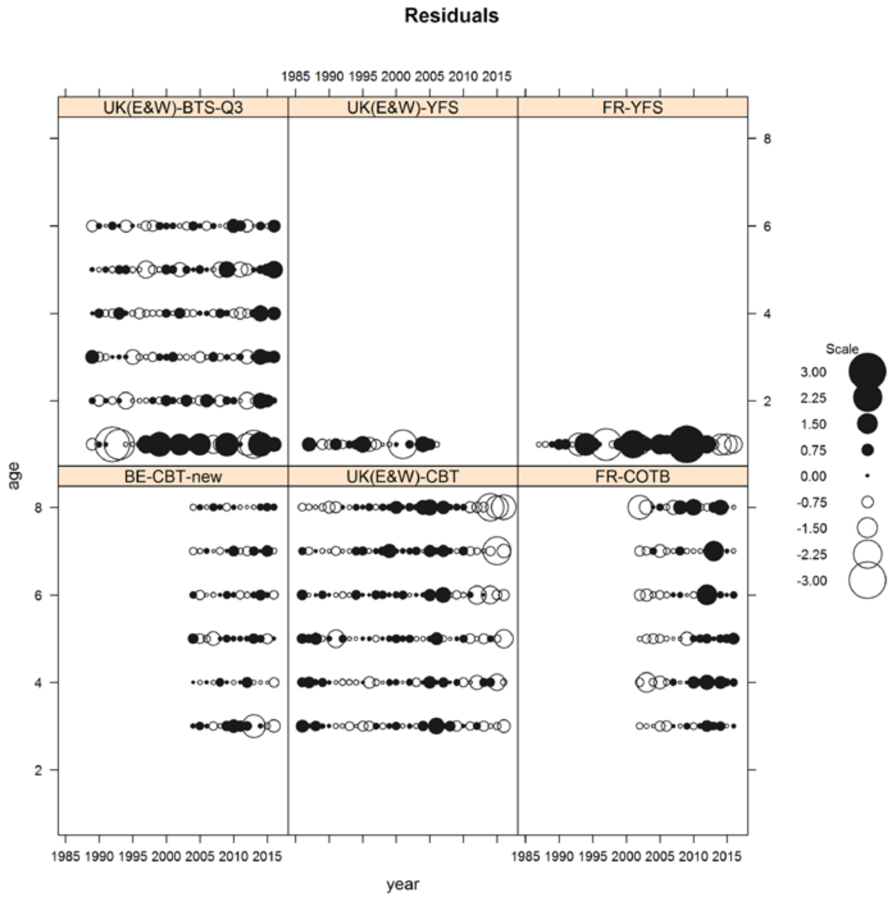


Figure 19.21. Sol in Division 7.d: Catchability residuals for all tuning fleets used in the 2017 assessment.

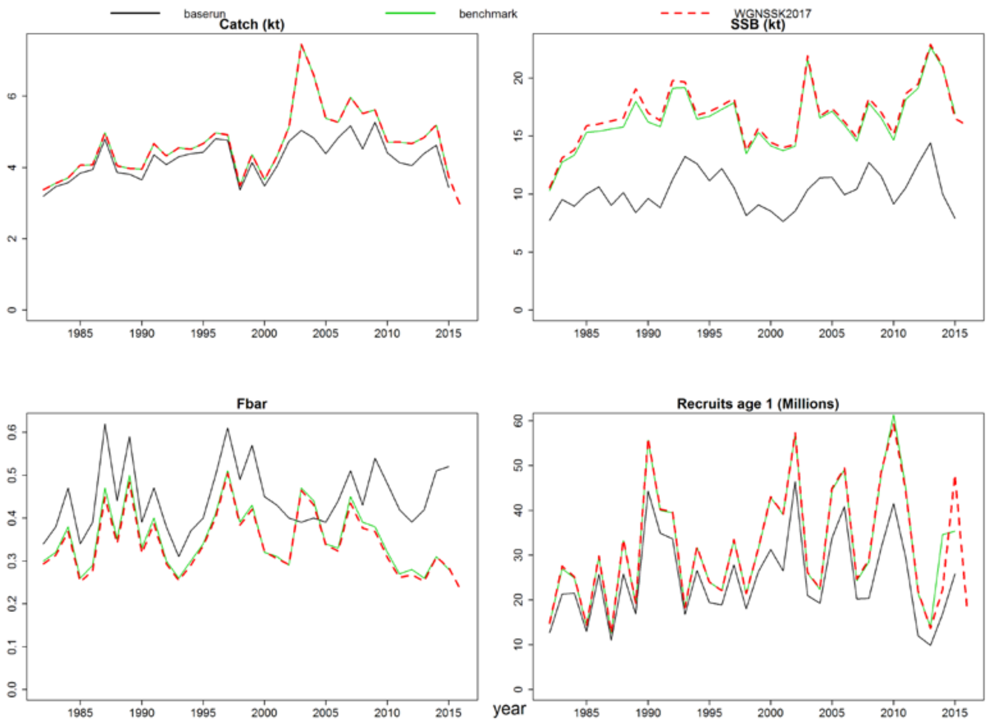


Figure 19.22. Sol in Division 7.d: XSA summary: trends in catch, spawning stock biomass (SSB), Fbar and recruitment with indication of 2016 assessment prior to the benchmark (baserun, black line); benchmark output (including data up to 2015; green line); and 2017 assessment (including data up to 2016; dashed red line).

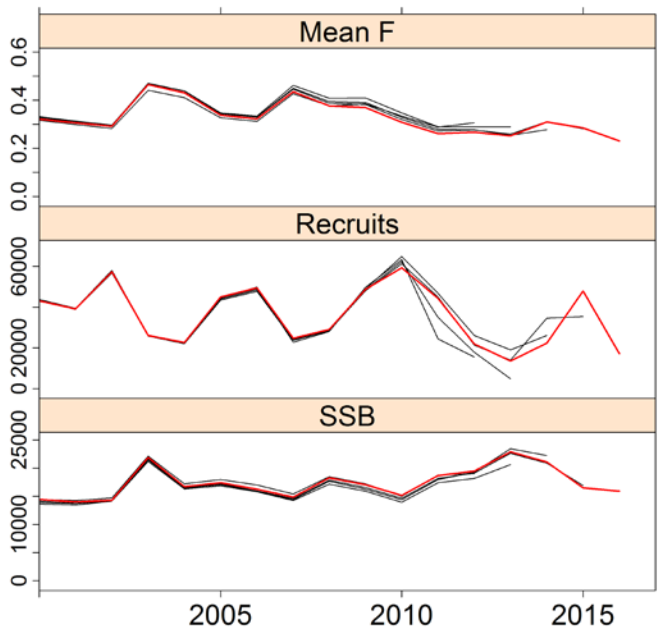


Figure 19.23. Sol in Division 7.d: Retrospective pattern in F, recruitment and SSB.

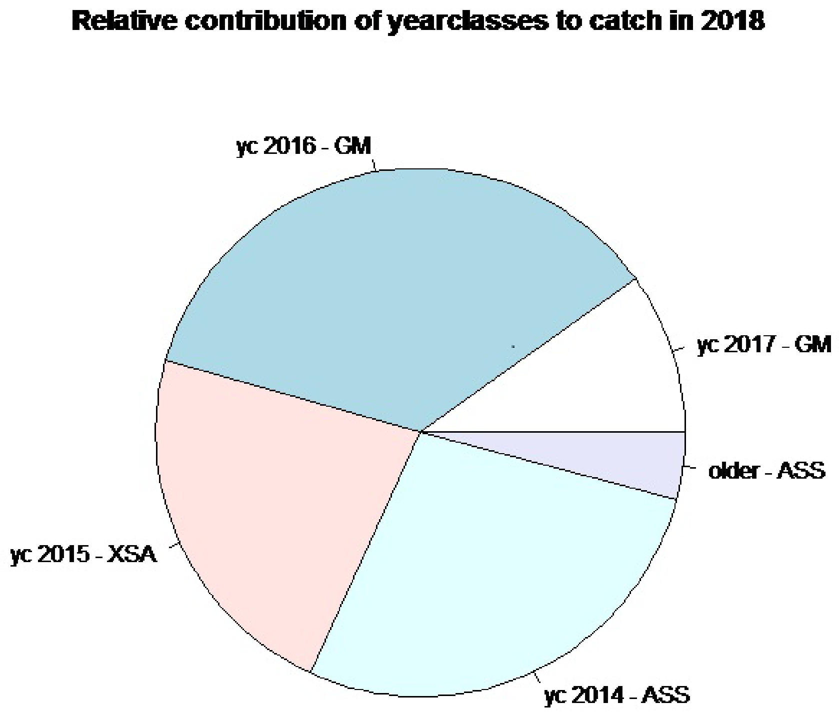


Figure 19.24. Sol in Division 7.d: Relative contribution of year classes to catch in 2018.

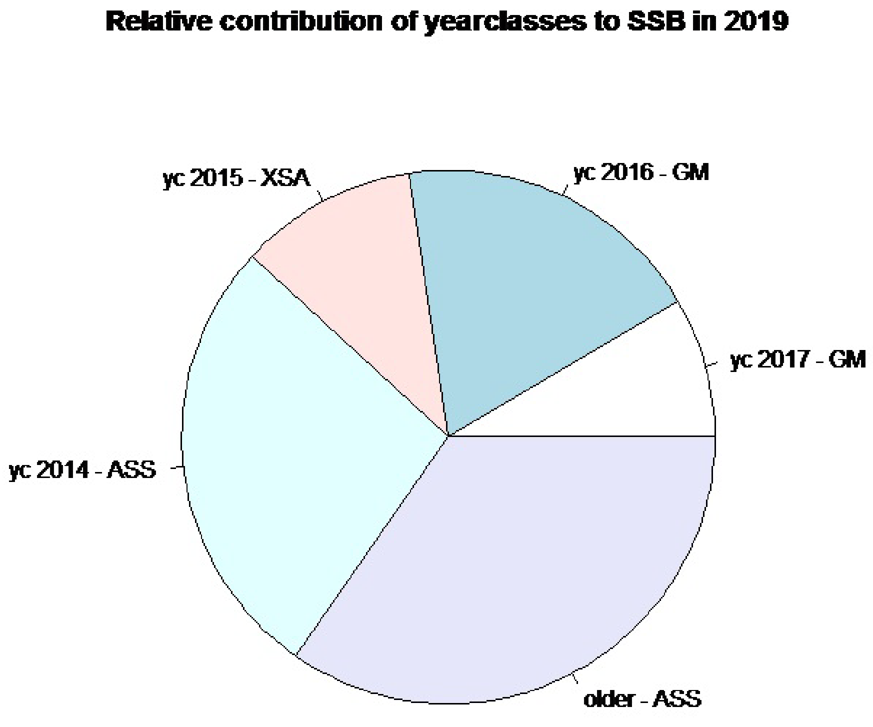


Figure 19.25. Sol in Division 7.d: Relative contribution of year classes to SSB in 2019.

20 Striped red mullet in Subarea 4 (North Sea), divisions 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

20.1 General

Striped red mullet has been benchmarked in 2015 (ICES, 2015).

The main issues addressed during the benchmark were the quantity and representativeness of the observational data. Analyses suggested the extrapolation of the assessment results from the eastern English Channel to the southern North Sea had merit. It was less clear whether the assessment was valid for the other areas within the stock region, because the fishery catches were small and data were sparse.

The conclusion of the benchmark were, that the agreed stock assessment seemed reasonable given the available information and that it could be used for providing fisheries advice under the ICES Stock Category 3 framework.

Ecosystem aspects

Striped red mullet (*Mullus surmuletus*) is a benthic species. Young fish are distributed in coastal areas, while adults have a more offshore distribution. Benzinou *et al.* (2013) conducted stock identification studies based on otolith and fish shape in European waters and showed that striped red mullet can be geographically divided into two units: Western Unit (Subareas 6 and 8, and divisions 7a–c, 7e–k, and 9a) and Northern Unit (Subarea 4 (North Sea) and divisions 7d (Eastern English Channel) and 3a (Skagerrak, Kattegat).

In the English Channel, this species matures at approximately 16 cm.

Juveniles are found in waters of low salinity, while adults are found at high salinity. Striped red mullet prefers sandy sediments.

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud.

20.2 Fisheries

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (>90% of landings in the beginning of the 2000's). This French fishery targeting striped red mullet is conducted by bottom trawlers using a mesh size of 70–99 mm in the eastern English Channel and in the southern North Sea.

The eastern English Channel and southern North Sea areas are also fished by trawlers of various types targeting a variety of species. Striped red mullet might be a bycatch in these fisheries.

From 2000 a Dutch targeted fishery, using fly shooters, and a UK fisheries have also developed. Landings are shared by these three fleets in the latter years. The Netherlands landed more than half of the total landings in 2016.

20.3 ICES advice

Advice for 2018 and 2019 ICES advices that the fishery for striped red mullet should be managed through technical measures that would reduce the catches of small fish and would contribute to more stable yields.

In additional to technical measures, ICES advises that when the precautionary approach is applied catches in 2018 should not be more than 530 tonnes. All catches are assumed to be landed

Advice for 2016 and 2017

ICES advises that when precautionary approach is applied, catches should be no more than 552 tonnes in each of the years 2016 and 2017.

All catch are assumed to be landed. Selectivity in the fishery should be improved to avoid fishing on juvenile recruits and to protect the strong 2014 year class.

20.4 Management

No specific management objectives are known to ICES. There is no TAC for this species.

There is no minimum landing size for this species.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

20.5 Data available

20.5.1 Catch

Official landings data are shown by country in Table 20.5.1.1 and by area in Table 20.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 20.5.1.3 presents total official landings and ICES estimates over the period 2006–2016 as well as the predicted catch corresponding to advice. In 2016 54% of the catches were made using demersal seines and 14% using demersal trawls.

Total landings were provided under the ICES InterCatch format for the period 2003–2013 during the benchmark. However, only France provided age composition for the period 2006–2013. 2014 to 2016 landings were provided under the ICES InterCatch format. Figure 20.5.1.1 shows that only landings from France in the Eastern Channel (representing around 30% of the total landings) were provided in 2014 to 2016 with an age structure. Figure 20.5.1.2 shows that IC data and official landings are consistent over years and countries.

Prior to 2009, no landings of age 0 were observed. Most of the landings are made on age 1. There is no age reading problem reported. This change in the landings might reflect a change in the reporting or a change in the fishing behaviour.

20.5.2 Weight-at-age

Mean weight at age were computed as described in the Stock Annex and are presented in Figures 20.5.2.1 and 20.5.2.2 and Table 20.5.2.1.

Weights at age in the landings show a slight decrease for the oldest ages. However sampling intensity for these ages is very low due to the low number of fishes in the catches. Stock weight do not show this slight decrease of age 3 and 4+ but as for landings weight, the sampling is very low due to the low number of fishes in the landings.

20.5.3 Maturity and natural mortality

Information about maturity per age class is given with the table included in this section. At an age of one year more than 50 percent of the striped red mullet are mature.

Age	0	1	2	3	4	5	6
Maturity	0	0.54	0.65	1	1	1	1

As defined during WKNSEA (ICES, 2015), natural mortality was derived from Gislason first estimator (Gislason *et al*., 2010) leading, as expected for this species, to high natural mortality for the youngest ages (see table below).

age	**M_Gislason**
0	1.426
1	0.6641
2	0.4888
3	0.4164
4	0.3616
5	0.3275
6	0.3421

20.5.4 Survey data

The Channel Ground Fish Survey (CGFS) and the IBTS–Q3 surveys were estimated to be good indicators of the population trends as they cover the spatial distribution of this stock. However none of them have an exhaustive coverage of the spatial distribution.

In 2015, a change in the research vessel used for the CGFS was realised. The consequences of these changes were assessed via an inter-calibration in 2014 and some analysis of the catch data (ICES, 2015). It appeared that for red mullet indices seem to be used without correcting factor.

Only CGFS survey allowed deriving age structured indices. Internal consistencies of the survey (Figure 20.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 20.5.4.2.

20.6 Trend based assessment

As agreed during WKNSEA (ICES, 2015), the assessment model was used for trend as the SSB estimated by the model was considered to be a more reliable indicator of stock status than the direct use of survey indices.

The settings used are described on the following table.

Setting/Data	Values/source
Catch at age	Landings (since 2004, ages 0–4+) InterCatch Discards are assumed neglictible
Tuning indices	FR CGFS (since 2004 ages 0–4+)
Plus group	4
First tuning year	2004
Fishing mortality	~ s(year, k=5) + factor(age)
Survey catchability	~ factor(age)
Recruitment	~ factor(year)

Results from the assessment are presented in Figure 20.6.1. Log residuals of the model are presented in Figure 20.6.2 and observed and predicted catches in Figure 20.6.3 and indices in Figure 20.6.4.

As observed during WKNSEA, there is still a relatively high uncertainty in this assessment but the SSB is still at a very low level and the recruitment seems to be the highest observed during this limited time series. The slight increase in SSB in mostly due to the few age 1 fishes left in the population. Trends show a very low level of biomass and a very high fishing mortality. Most of the catches rely only on the recruitment (age 0) and age 1 fishes.

20.7 Length-based indicators screening

The ICES LBI were computed for three years of data (2014–2016), using the length distributions from InterCatch (Tables 20.7.1-2).

Most of the indicators appeared outside the established references:

- Length at first catch Lc and Length of 25% of catches are above Lmaturity (16 cm) in 2015 and 2016. These indicators are below Lmat in 2014. This is directly linked with the good recruitment observed in 2014. The good recruitment observed in 2014 decreased Lc and L25, but the two next years no good recruitment was observed and Lc and L25 increased to be above Lmat.
- ratio of the 5% largest catches to Linf (40 cm) around 0.6/0.7 clearly show the lack of big/old fish in the population
- Lmean/Lopt around 0.8 give the same picture as Lmax5
- Lmean/$L_{F=M}$ below 1 tend to show that this stock is not exploited optimally

This indicates that the stock may be considered not to be exploited sustainably. The main concerns are for the big/old fish that are missing from the population. Length-based indicators based on samples from commercial catches (2014–2016) show that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized it's growth potential (Table 20.7.2).

20.8 Mean length Z

The Mean length Z was computed for three years of data (2014–2016), using the length distributions from InterCatch (Table 20.8.1 and Figure 20.8.1).

Based on the Mean length Z method using the length distributions from InterCatch, Z is estimated around **0.9**. Considering natural mortality around 0.4 and given that YPR methods on the same data estimate F0.1 at 0.41. Mean length based methods tend to assess this stock as fished beyond the reference limits.

20.9 Conclusions drawn from analyses

The very good recruitment observed in 2014 was confirmed by the catches in 2015 and the remaining age 1 seen in 2015 during CGFS. Since, no good recruitment was observed in 2015 or 2016. There is no TAC on that species so the advice was not followed and the catches overshot the advice for 2015 and 2016 (4487 and 2579 tonnes against 460 and 552 tonnes respectively in the advice).

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016) show that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized its growth potential. The SSB is dependent on recruitment and based on the CGFS there is no evidence of a strong incoming recruitment in 2016. Therefore, the SSB is expected to decline further. Furthermore, the mean length of the catch is lower than would be expected when fishing at MSY. The precautionary buffer was last applied in 2013 but not in 2015. For these reasons, the precautionary buffer was applied.

Striped red mullet in Subarea 4 and divisions 7.d and 3.a. For stocks in ICES data categories 3–6, one catch option is possible. This is highlighted in bold.

Index A (2015–2016)		5130
Index B (2012–2014)		1578
Index ratio (A/B)		3.25
Uncertainty cap	Applied	1.2
Advised catch for 2016–2017		552 tonnes
Discard rate	Negligible	
Precautionary buffer	Applied	0.8
Catch advice*		**530** tonnes

The SPiCT assessment (Figure 20.9.1) was not considered sufficiently robust to be used for this stock.

Table 20.5.1.1. Striped red mullet in Subarea IV and divisions VIId and IIIa: Official and ICES landings by country (tonnes).

Year	Belgium	Denmark	France	Netherlands	UK	total
1975	0	0	140	0	0	140
1976	0	0	156	3	1	160
1977	0	0	279	12	1	292
1978	0	0	207	25	3	235
1979	0	0	212	32	11	255
1980	0	0	86	25	4	115
1981	0	0	44	19	1	64
1982	0	0	32	18	2	54
1983	0	0	232	15	1	248
1984	0	0	204	0	3	207
1985	0	0	135	0	4	140
1986	0	0	84	0	3	88
1987	0	1	40	0	3	46
1988	0	1	35	0	4	41
1989	0	0	37	0	5	42
1990	0	0	524	0	13	537
1991	0	0	208	0	11	219
1992	0	0	458	0	17	475
1993	0	0	576	0	21	597
1994	0	0	362	0	18	380
1995	0	0	2537	0	69	2606
1996	0	2	2039	2	44	2087
1997	0	2	856	0	61	919
1998	0	2	2966	0	117	3085
1999[1)]	0	4	NA	0	103	107
2000	0	4	3201	464	133	3802
2001	0	10	1789	915	183	2897
2002	0	24	1658	560	141	2383
2003	28	0	3256	626	177	4087
2004	31	0	4137	1148	129	5445
2005	29	0	1918	914	136	2997
2006	16	0	1145	466	97	1724
2007	16	0	3982	1147	183	5328
2008	19	0	3723	1270	353	5365
2009	17	0	827	889	293	2026
2010	80	0	947	802	337	2166
2011	97	0	705	771	244	1817
2012	52	0	170	525	146	893
2013	40	0	121	260	40	461
2014	79		765	912	242	2002
2015	211		1598	1996	356	4161
2016	147		556	1421	485	2609

[1)] No data reported by France in 1999.

[2)] ICES estimates.

Table 20.5.1.2. Striped red mullet in Subarea IV and divisions VIId and IIIa: Official landings by area (tonnes). Note: Most of the Subarea IV catches are made in Division IVc.

Year	IV	IIIa	VIId	total
1975	0	0	140	140
1976	4	0	156	160
1977	19	0	273	292
1978	30	0	205	235
1979	49	0	206	255
1980	29	0	86	115
1981	20	0	44	64
1982	21	0	33	54
1983	41	0	207	248
1984	22	0	185	207
1985	10	0	130	140
1986	6	0	82	88
1987	7	0	38	46
1988	7	0	33	41
1989	5	0	37	42
1990	33	0	504	537
1991	26	0	193	219
1992	60	0	415	475
1993	126	0	471	597
1994	116	0	264	380
1995	1054	0	1552	2606
1996	528	0	1559	2087
1997	278	0	641	919
1998	778	0	2307	3085
1999[1)]	70	0	37	107
2000	1764	0	2038	3802
2001	1600	0	1297	2897
2002	1234	0	1149	2383
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	641	0	1083	1724
2007	1546	0	3782	5328
2008	1824	0	3536	5365
2009	910	0	1113	2026
2010	698	0	1468	2166
2011	611	0	1206	1817
2012	388	0	505	893
2013	195	0	266	461
2014	526	0	1476	2002
2015	769		3392	4161
2016	824		1785	2609

[1)] No data reported by France in 1999.

Table 20.5.1.3. Striped red mullet in Subarea IV and divisions VIId and IIIa: History of ICES advice, the agreed TAC, and ICES estimates of landings.

Year	ICES Advice	Predicted catch corresp. to advice	Official landings	ICES Estimates
2006		-	1451	1483
2007		-	4686	4610
2008		-	4744	2066
2009		-	1740	1518
2010		-	1974	1920
2011		-	1611	1512
2012	No increase in catch	-	748	725
2013	No increase in catches (average 2009–2010)	< 1700	367	409
2014	Reduce catches by 36% compared to 2012	< 460	1732	1717
2015	No new advice, same as for 2014	< 460	4162	4487
2016	Precautionary approach	<552	2609	2579
2017	Precautionary approach	<552		

Weights in tonnes.

Table 20.5.1.4. Striped red mullet landing numbers at age (thousands).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	55	14734	0	6	1384	10124	1832	45
1	43375	16606	3912	37013	1323	16259	15203	9317	1335	2771	10790	37485	4113
2	1839	2455	2332	1124	10518	1319	674	1454	1244	467	1329	6310	11381
3	947	263	1679	553	1255	662	142	639	1477	289	14	19	2503
4	187	256	188	127	537	102	102	80	183	0	29	36	234

Table 20.5.2.1. Striped red mullet stock weights (kg).

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0.046	0.042	0	0.02	0.02	0.029	0.038	0.038
1	0.09	0.105	0.15	0.107	0.096	0.07	0.077	0.05	0.09	0.06	0.093	0.1	0.1135
2	0.222	0.172	0.19	0.313	0.139	0.16	0.112	0.15	0.17	0.12	0.144	0.114	0.1379
3	0.27	0.3	0.24	0.422	0.226	0.177	0.24	0	0.25	0.12	0.259	0.37	0.37
4	0.569	0.411	0.37	0.506	0.361	0.423	0.209	0.02	0.23	0	0.309	0.2	0.2

Table 20.7.1. Striped red mullet 27.3a47d length based indicators.

Data Type	Value/Year	Source
Length at maturit	162 162 162	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
von Bertalanffy growth parameter	400 400 400	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
Catch at length by year	2014 2016	Length data from IC
Length-weight relationship parameters for landings and discards	2014 2016	Mean weight at length from IC

Table 20.7.2. Striped red mullet in Subarea 4 and divisions 7.d and 3.a.: Traffic light table for length-based indicators. Conservation criteria for small fish: L_c (length at first catch) and 25% percentile relative to L_{mat} (length at 50% maturity); and for large fish: mean length of the largest 5% in the catch ($L_{max5\%}$) relative to asymptotic length L_{inf} and the proportion of mega spawners (P_{mega}). Optimising yield criterion: the mean length L_{mean} is compared to the theoretical length of optimal biomass (L_{opt}). MSY criterion: L_{mean} is compared to $L_{F=M}$, the MSY proxy. "Ref" indicates the reference criterion: green colour for meeting the criterion, and red flagging issues (e.g. dome-shaped vs. overexploitation). "Ref" indicates the criterion required for a green light. Each year is evaluated separately.

	Conservation				Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2014	0.87	0.93	0.66	0.01	0.72	0.96
2015	1.2	1.17	0.64	0	0.82	0.89
2016	1.2	1.23	0.68	0.01	0.84	0.91

Table 20.8.1. Striped red mullet 27.3a47d Mean Length based input.

Data Type	Value/Year	Source
Linf	360	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
K	0.218	K. Mahé, F. Coppin, S. Vaz, A. Carpentier, 2013. Striped red mullet (Mullus surmuletus, Linnaeus, 1758) in the eastern English Channel and southern North Sea: growth and reproductive biology. J. Appl. Ichthyol. 29(5):1067-1072.
max age	11	
Data (year range)	2014 2016	Mean length from IC

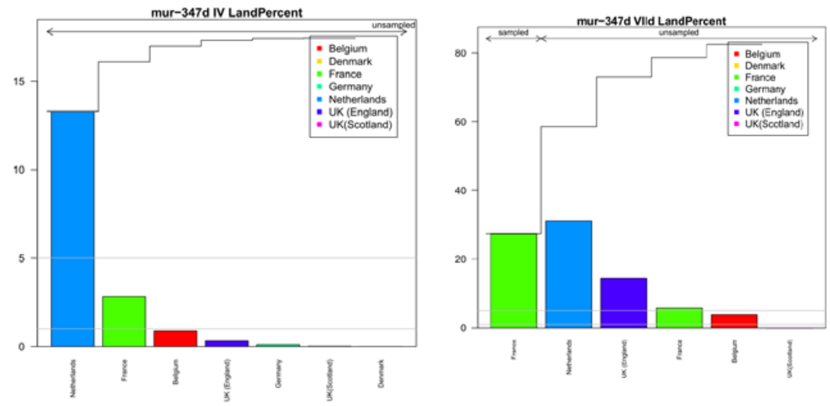


Figure 20.5.1.1. Striped red mullet in Subarea IV and Division VIId ICES landings by country (percentage over the total area).

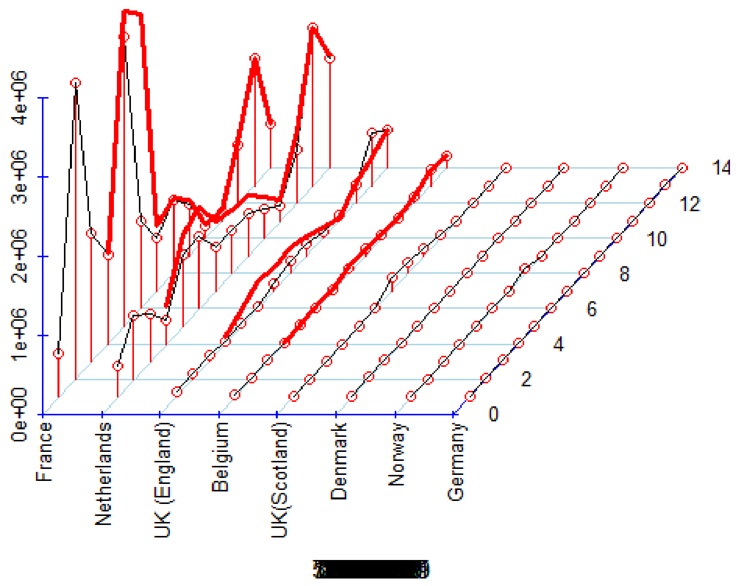


Figure 20.5.1.2. Striped red mullet in Subarea IV landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

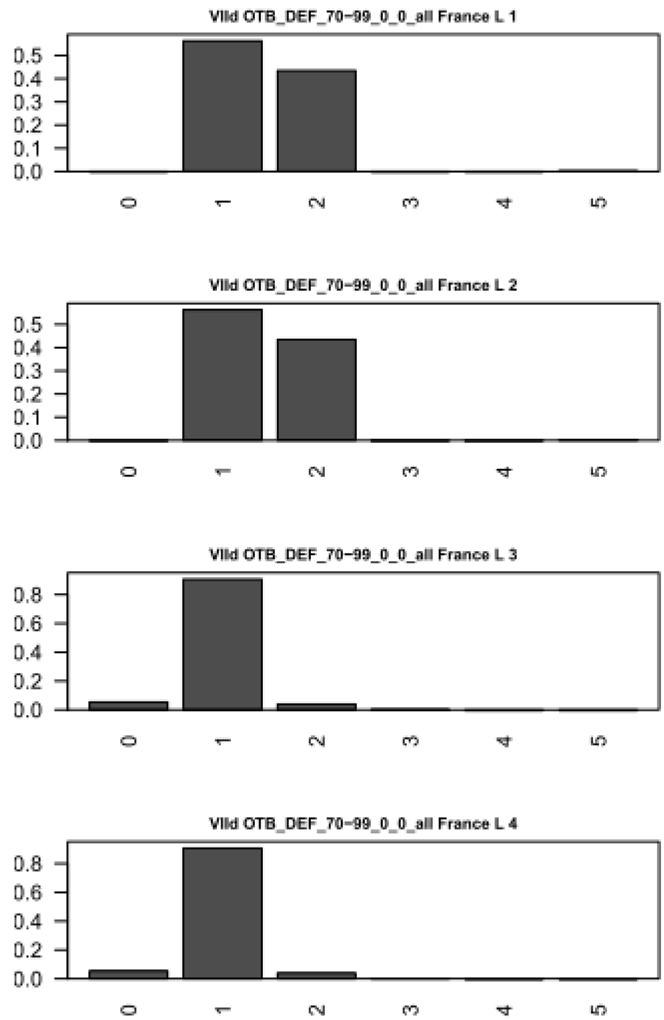


Figure 20.5.1.3. Striped red mullet age structure as provided in 2014 for the French.

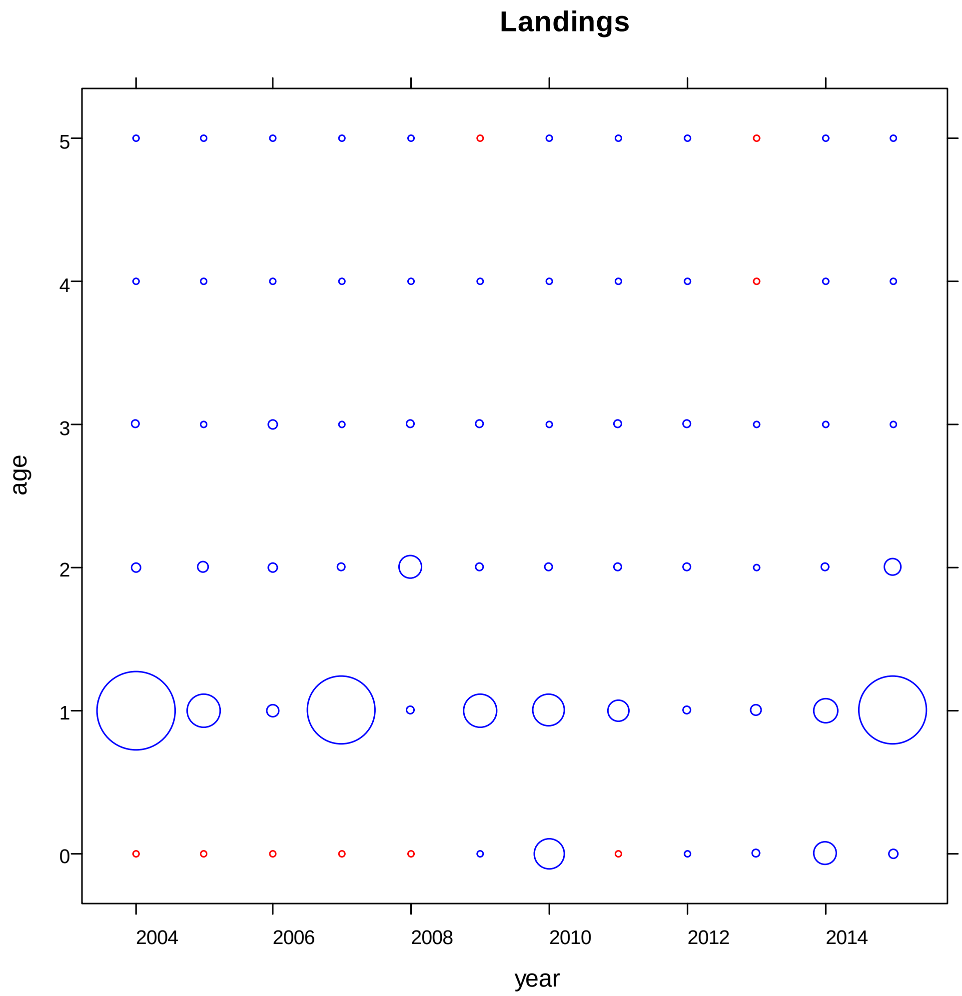


Figure 20.5.1.4. Striped red mullet age structure (in numbers) as provided in the landings.

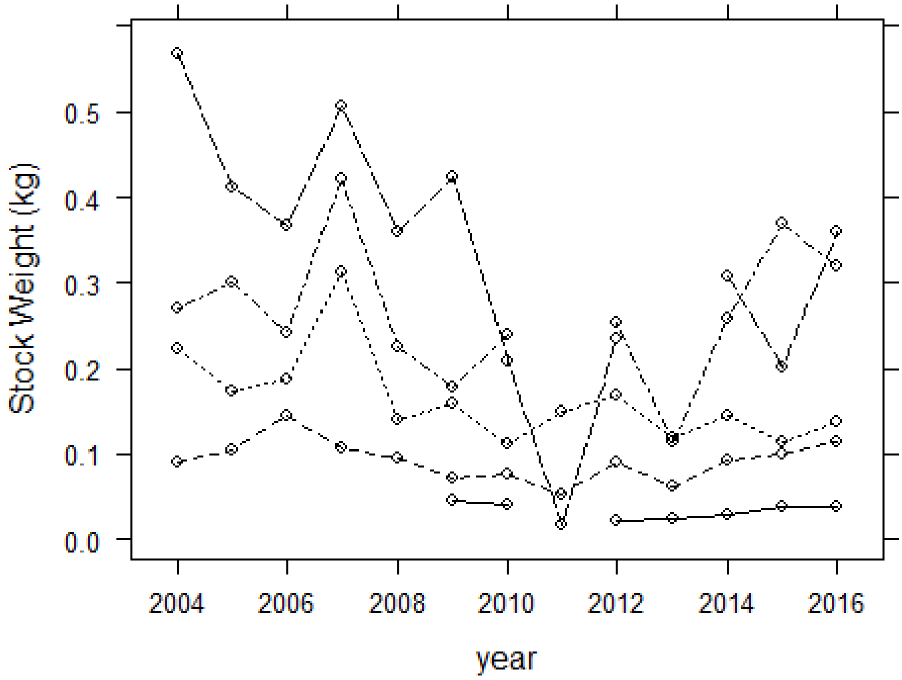


Figure 20.5.2.1. Weight at age in the stock.

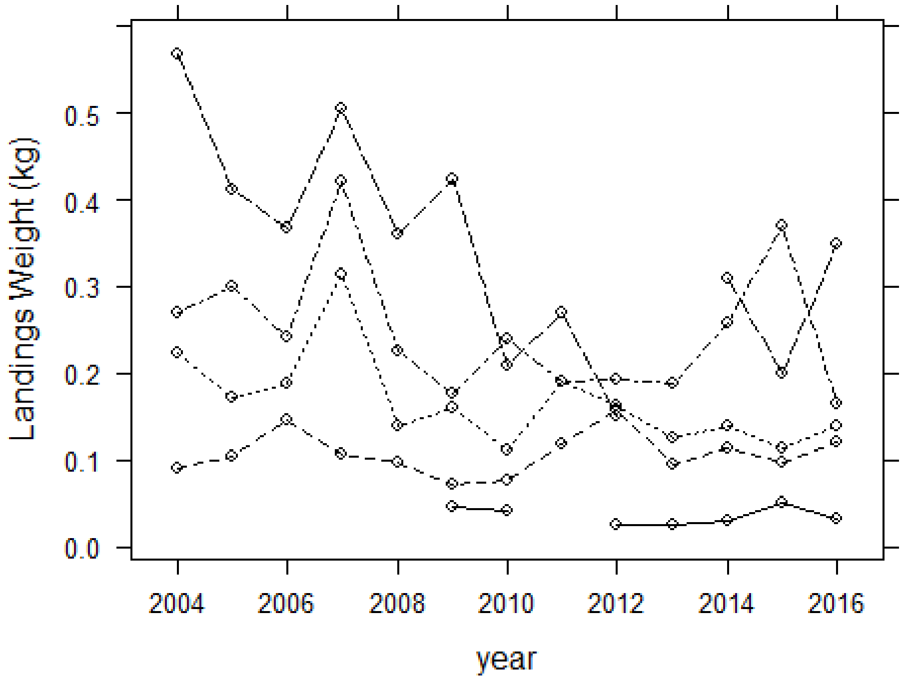


Figure 20.5.2.2. Weight at age in the landings.

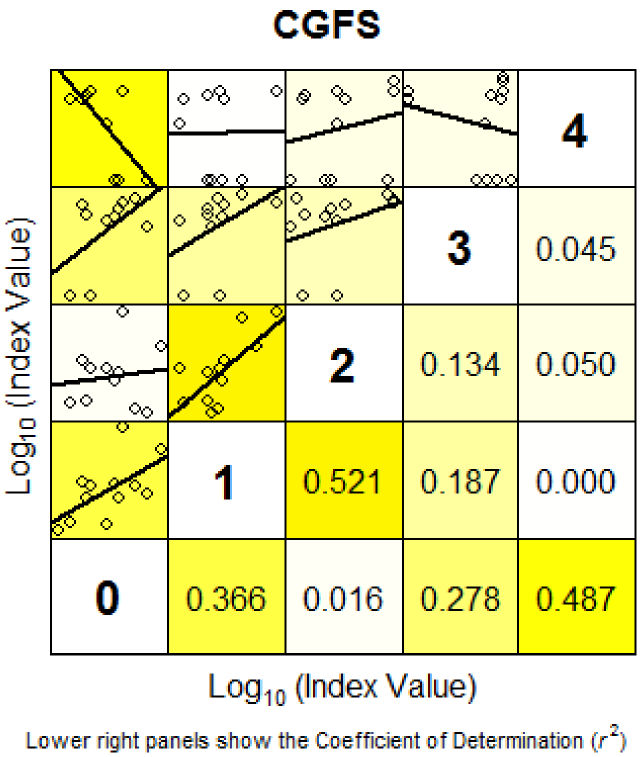


Figure 20.5.4.1. CGFS internal consistencies.

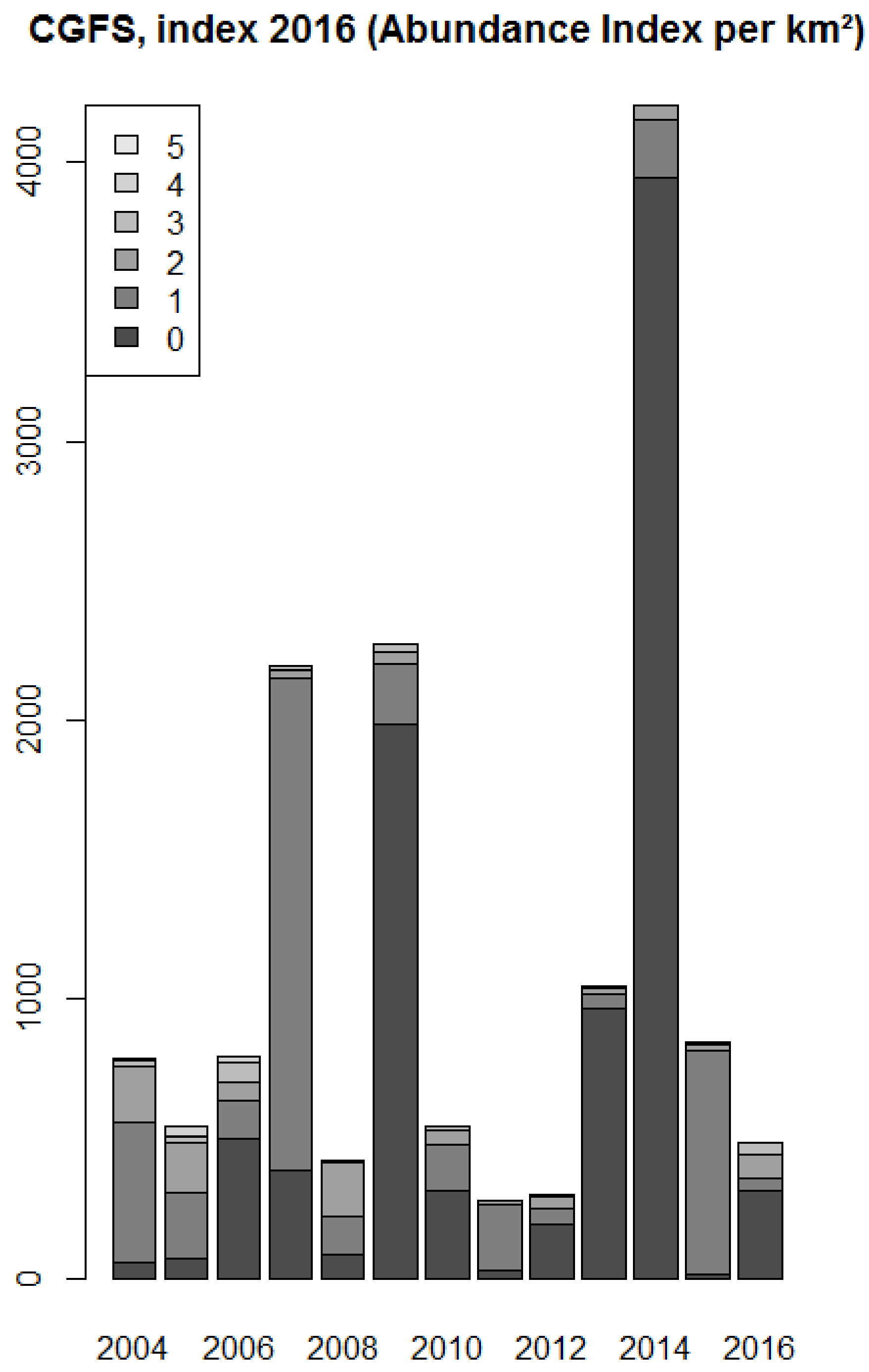


Figure 20.5.4.2. CGFS catch age composition.

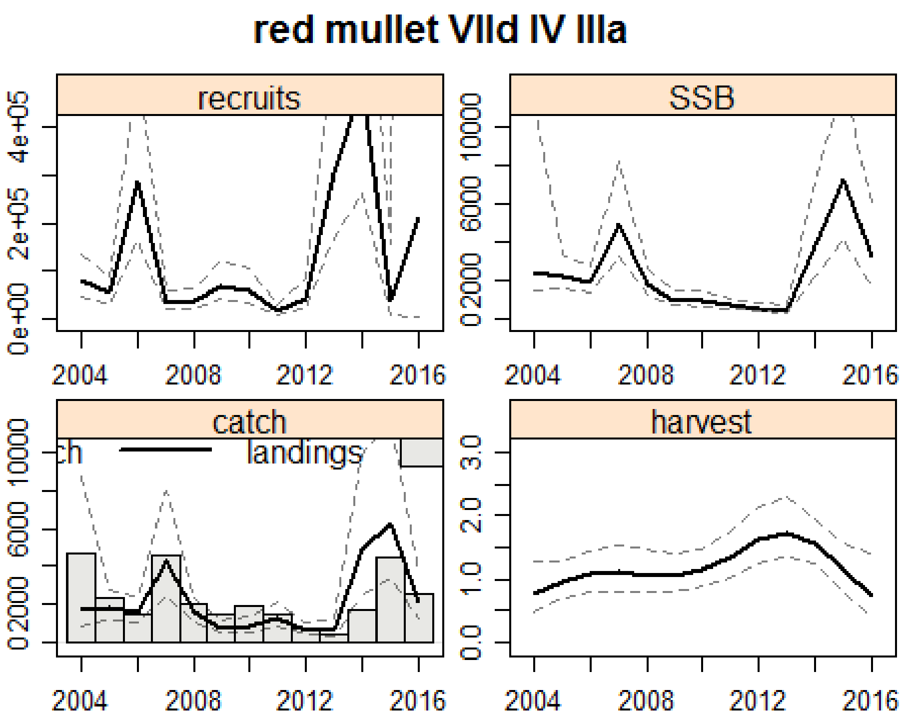


Figure 20.6.1. CGFS internal consistencies

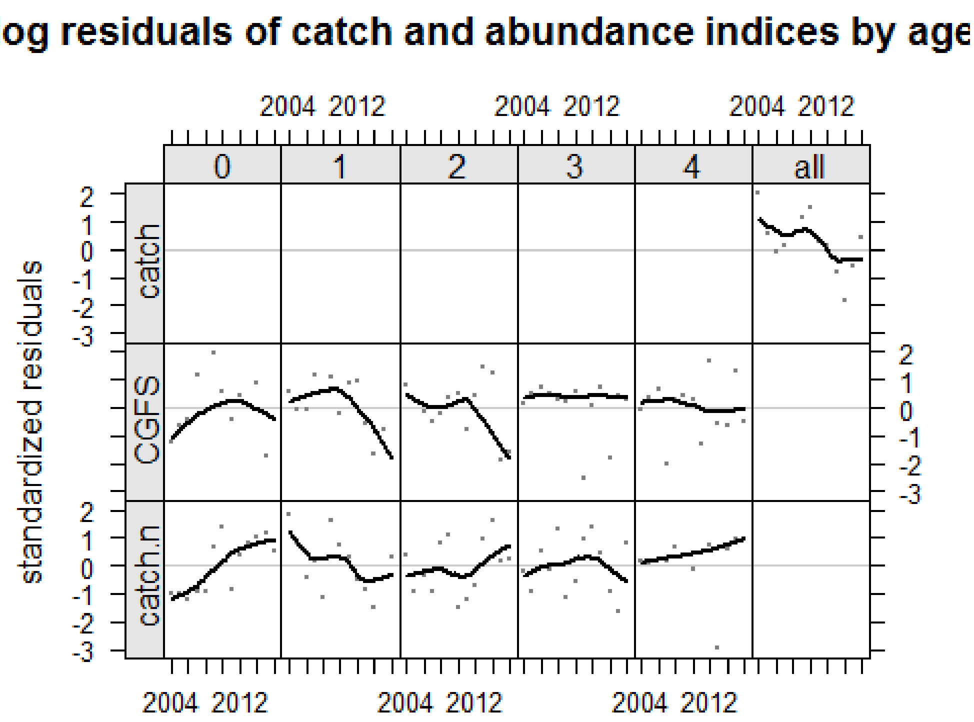


Figure 20.6.2. Log residuals of the assessment.

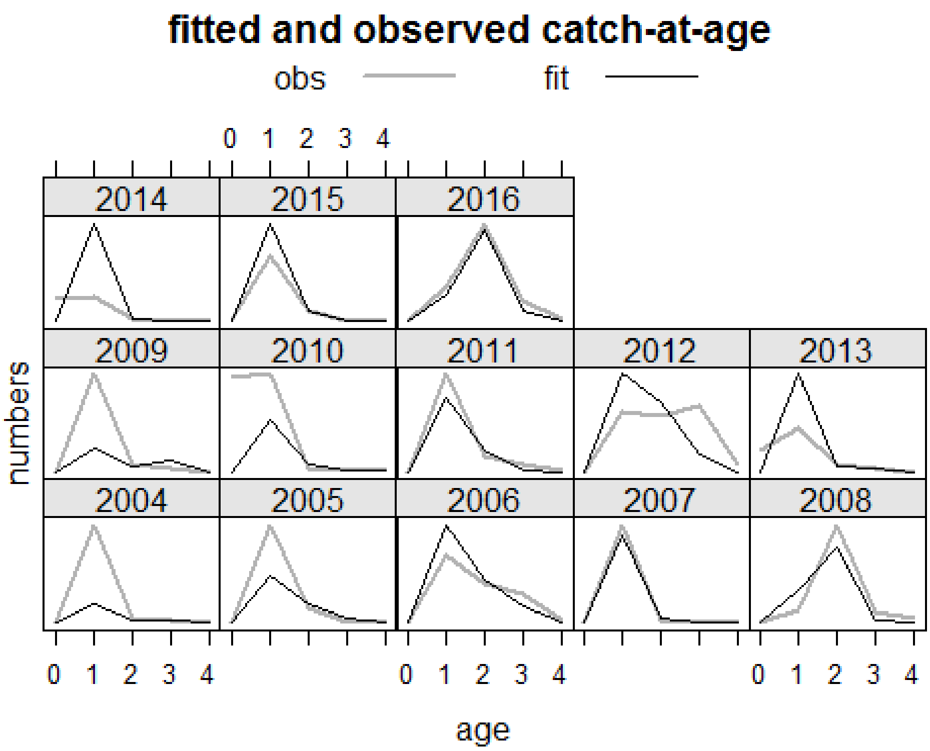


Figure 20.6.3. Observed (pink) and estimated (blue) catch number-at-age.

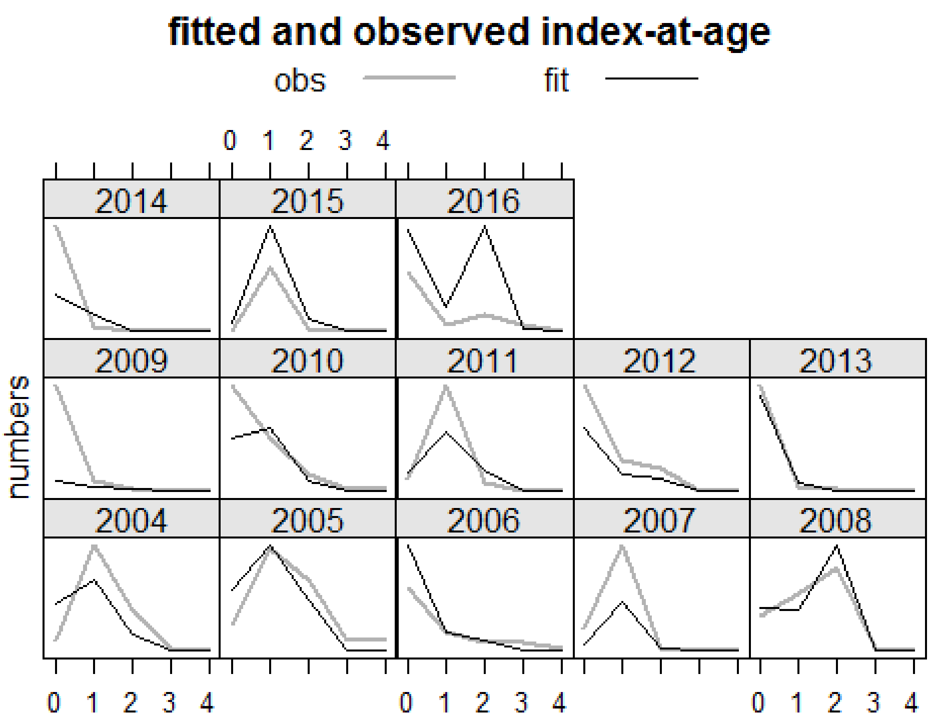


Figure 20.6.4. Observed (pink) and estimated (blue) indices at age.

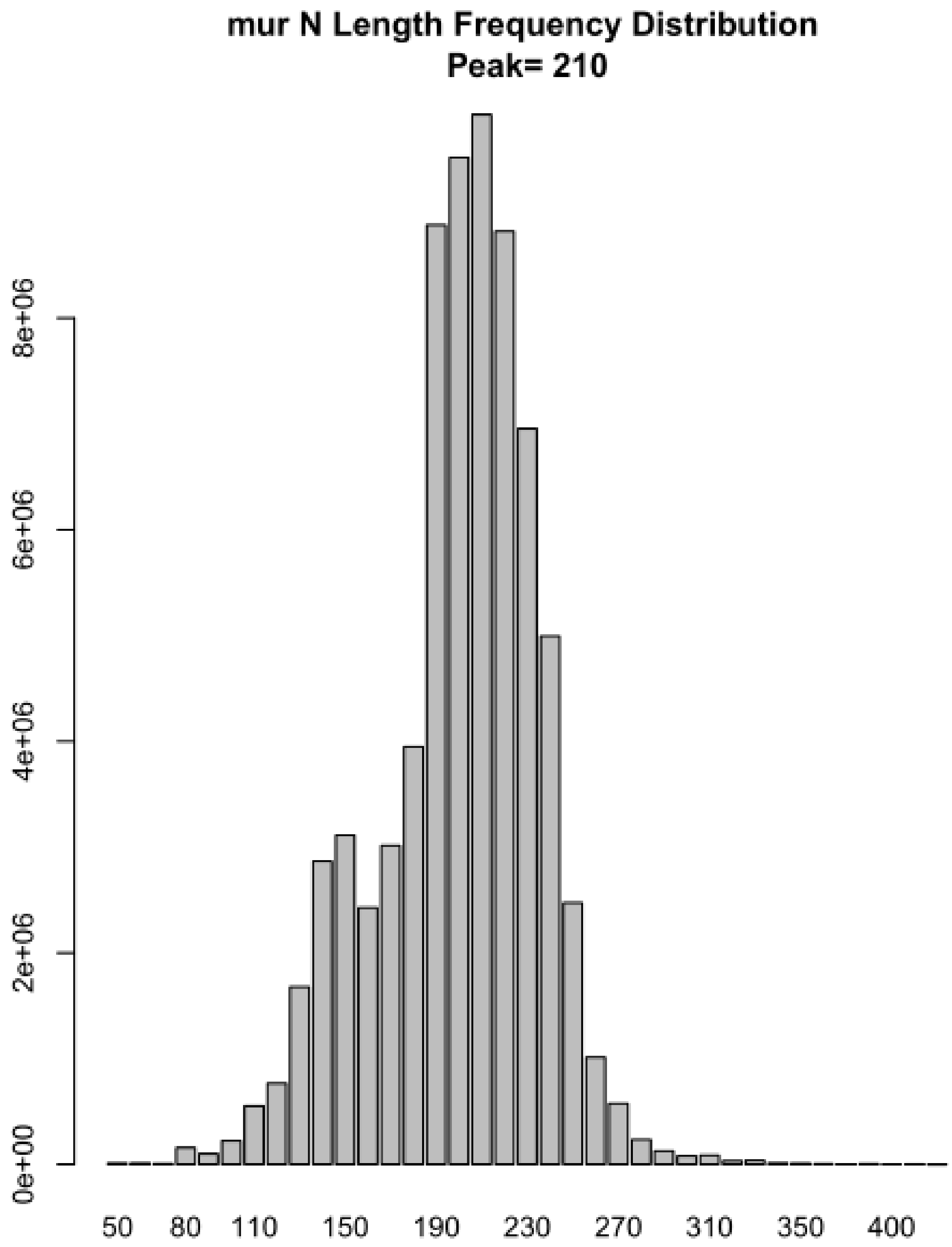


Figure 20.8.1. Length distribution of the catches from InterCatch (2014–2016) aggregated.

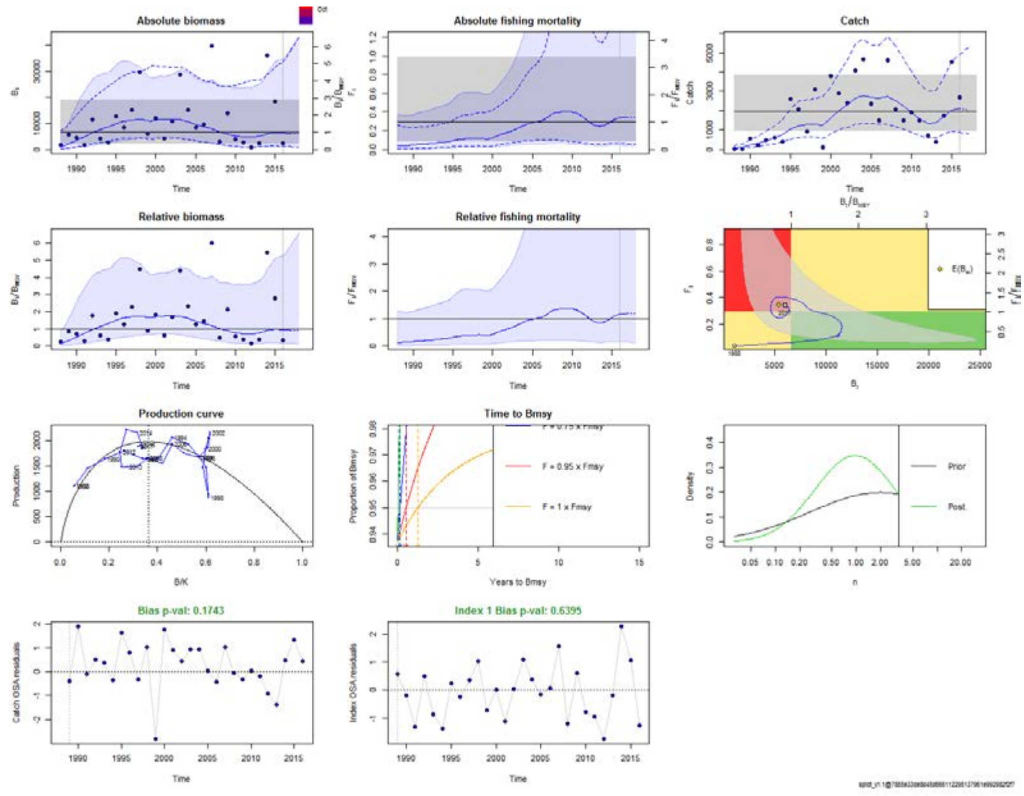


Figure 20.9.1. Outputs from SPiCT model.

21 Turbot in 3.a (Kattegat, Skagerrak)

This stock is under a biennial advice, so no advice was scheduled for this stock in 2016. The last advice issued in 2015 was based on the 3:2 rule applied to the BITS–Q1 abundance index, following the procedures defined earlier by ICES WGNEW. In 2017, the new information available for 2016 was compiled, but substantial changes were also performed. This includes changes in the compilation and analyses of the survey indices, as well as some exploratory length-based indicators and SPiCT runs to estimate the status of the stock with regards to MSY proxies.

The general perception is that landings fluctuating without trends over a long period. The survey indices are of poor quality, with low catch rates and large annual fluctuations, and they are either showing no trends or slightly increasing trends. The length-based indicators and exploratory SPiCT runs usually point out that the stock may be exploited sustainably.

21.1 Management regulations

There are no TACs in place for turbot in area 3.a.

There is no official EC minimum landing size, but Denmark has a minimum size at 30 cm. In the Netherlands, quotas restrictions for North Sea turbot led Dutch POs to increase their own MLS during the course of 2016 (see section 14), which would also affect the Dutch discarding of turbot caught in Skagerrak.

21.2 Fisheries data

In 3.a, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale *et al*., 2009), while today turbot is only caught as by-catch in the trawl and gillnet fisheries. Table 21.1 and Figure 21.1 summarize turbot landings in ICES area 3.a. Over the period 1950–2016, total landings (3.a) ranged from 64 tons to 736 tons per year, with the lowest landings during the end of 1960´s and the beginning of the 1970s, and the highest peaks in 1977 and in the early nineties. Over the last fifteen years, the total landings of turbot in 3.a had declined to around 100 tons per year, but have increased again since 2015 (around 175 tons in 2015 and 2016), at the level observed in the 50s–60s. The fishery catches mainly turbot during third and fourth quarter.

2016 catch data for turbot.27.3a were uploaded into InterCatch, according to the specification of the data call. This allowed compiling information by area and metier. Length-based information was provided, but no age information. There is a difference of around 10 tonnes between official and ICES landing estimates from the Netherlands in 2015 and 2016, leading to up to 5% higher total landings in the ICES estimates.

Discard ratios were provided for strata summing up to 62% of the reported landings (Figure 21.2). For those strata where information exist, discards ratios were estimated at 8.6% in the Kattegat and 7% in the Skagerrak. This represents a significant change compared to last year, where discards ratio were estimated at 31% of catches in the Kattegat, but only 4% in the Skagerrak

The raising of discards was performed by groups of métiers: all passive gears together (discards ratio close to zero), all trawled gears together (medium discards ratio), without distinction of area or mesh size. After raising, the discard ratio for the entire stock area was estimated at 8%, Overall, the discard ratio for the combined area has remained around 6–9% since 2013 (Table 21.2), but can be substantially higher in some trawl fisheries.

This year, length distributions were also estimated for the years 2014–2016 (Figure 21.4). The allocation was made with InterCatch, all discards together and all landings together. 65% of the landings and 63% of the discards had sampled length distribution (Table 21.3). It is noted some high SOP discrepancies in 2014 and 2015, which should be investigated further in a coming benchmark.

Turbot is fully discarded until 30 cm (Figure 21.3)

21.3 Survey data, recruit series and analysis of stock trends

Two survey series catching turbot are available: the International Bottom Trawl Survey (IBTS), with two research vessels (Argos and Dana), and the Baltic International Trawl Survey (BITS) with the Danish vessel Havfisken (KASU survey). Since the initial investigations of ICES WGNEW (2013), and until last year, only the Havfisken trawl survey (BITS) had been used to derive an index of abundance of turbot in 3.a.

In 2017, this basis was reconsidered, and a number of observations were made. First, the actual catch rates do not widely differ between IBTS and BITS, and remain low and variable in both surveys. Second, the IBTS only covers the Kattegat part of area 3a, where only a limited part of the stock catches occur. Third, BITS gave a poor convergence and fit in SPiCT model (see later) compared to IBTS. Consequently, the advice was given using a biomass index for both IBTS–Q1 and Q3, computed from the file "cpue per length per haul" from the ICES DATRAS database. Cpue per length were translated to weight using a fixed length-weight relationship from www.fishbase.org (a=0.00802, b=3.260), then summed over length classes within a haul and finally averaged across all hauls.

Indices are noisy (Table 21.4 and Figure 21.5), but in all four surveys the ratio of the average of the last two years over the average of the last three preceding years (2:3 rule) was above 1.

21.4 Length-based indicators screening

The ICES LBI were computed for three years of data (2014–2016), using the length distributions from InterCatch (Table 21.5). Most of the indicators appeared closed to the established references: length at first catch Lc and Length of 25% of catches around $L_{maturity}$ (30 cm); ratio of the 5% largest catches to L_{inf} (62 cm) around 0.8; L_{mean}/L_{opt} above 0.9; Lmean/$L_{F=M}$ slightly below 1. L_{opt} (=2/3 L_{inf}) is estimated at 41 cm.

Only the indicator Pmega (Proportion of individuals above L_{opt} + 10%) returned an outcome far from the desired reference.

This indicates that the stock may be considered to be exploited somehow sustainably and in the vicinity of MSY.

21.5 MSY proxy reference points

A number of exploratory SPiCT assessments were performed in 2017, expanding on the exploratory work performed by M. Pedersen (DTU Aqua) in 2015–2016. Exploratory runs explored the effects of i) the length of the time series of landings using ICES official statistics starting in either 1950 (full time series) or 1991 (start of the surveys times series); ii) the various IBTS and BITS indices, one by one or in combination; iii) the removal of priors default settings.

The final run used in the advice sheet uses the following settings:

- Landings data from 1991 only, due to unceratinties in the coverage of historical Dutch data
- Both IBTS–Q1 and Q3
- No priors

The results of the run are presented in Figures 21.6, 21.7 and Table 21.6. Although the Shapiro test for IBTS–Q1 returned negative results, it is considered necessary to keep IBTS–Q1, not least due to uncertainty regarding a possible summer inflow of North Sea turbot in Skagerrak (as hypothesised for plaice) that could influence IBTS–Q3.

The base run indicates a high level of uncertainty in the estimation of Fmsy and Bmsy, but some confidence that fishing mortality might be below Fmsy and biomass might be above Bmsy.

In comparison, the run with default priors settings is given Figure 21.8.

The retrospective analysis (Figures 21.9 and 21.10) shows however a poor stability in the model outcomes beyond the last two years. Model runs up until 2014 show poor convergence and different estimates; nevertheless, the trends are similar and the estimated status with regards to reference points is consistent.

21.6 Summary

More information regarding of the stock of Turbot in area 3a has been collected in 2017, and the perception of the stock has been revised accordingly. The combination of survey trends, length-based indicators and surplus production model seem to indicate that the stock is not experiencing a downwards trend and might be exploited sustainably. This contrasts with the advice previously given, and with the conclusions drawn by Cardinale *et al*. (2009).

A benchmark is scheduled for 2019, which should investigate further these trends and other information available.

Table 21.1. Turbot in 27.3a: Official landings by country from 1950 to 2016.

Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total
1950	0	13	212	0	0	1	73	299
1951	0	6	191	0	0	6	62	265
1952	0	6	114	0	0	3	58	181
1953	0	4	80	0	0	4	51	139
1954	0	0	78	0	0	1	61	140
1955	0	4	77	0	0	0	49	130
1956	0	7	75	0	0	0	41	123
1957	0	3	108	0	0	0	30	141
1958	0	7	112	0	0	0	41	160
1959	0	6	132	0	0	3	43	184
1960	0	11	115	0	0	2	46	174
1961	0	4	130	0	0	0	45	179
1962	0	5	157	0	0	0	0	162
1963	0	4	124	0	0	0	0	128
1964	0	5	89	0	0	0	0	94
1965	0	6	79	1	0	0	0	86
1966	0	2	104	0	0	0	0	106
1967	0	4	68	1	0	0	0	73
1968	0	0	64	0	0	0	0	64
1969	0	1	75	0	0	0	0	76
1970	0	1	76	0	0	0	0	77
1971	0	1	100	0	0	0	0	101
1972	0	2	130	0	0	0	0	132
1973	0	2	98	0	0	0	0	100
1974	0	1	116	0	0	0	0	117
1975	0	2	167	0	7	0	7	183
1976	7	2	178	0	190	0	6	383
1977	7	4	331	0	389	0	5	736
1978	2	4	327	0	186	0	6	525
1979	8	0	307	0	87	0	4	406
1980	7	0	205	1	14	0	6	233
1981	2	0	183	2	12	0	8	207
1982	1	0	164	1	9	0	7	182
1983	4	0	171	0	24	0	10	209
1984	0	0	176	0	0	0	12	188
1985	1	0	224	0	0	0	16	241
1986	2	0	180	0	0	0	11	193
1987	5	0	147	0	0	0	9	161
1988	2	0	115	0	11	0	10	138
1989	2	0	173	0	0	0	9	184
1990	5	0	363	0	0	0	18	386
1991	4	0	244	0	0	7	21	276
Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total
1992	4	0	278	0	0	8	19	309

1993	3	0	336	0	0	10	0	349
1994	2	0	313	0	0	15	22	352
1995	4	0	268	0	0	17	11	300
1996	0	0	185	0	0	13	11	209
1997	0	0	200	0	0	9	11	220
1998	0	0	148	0	0	7	8	163
1999	0	0	139	0	0	10	6	155
2000	0	0	180	0	0	6	6	192
2001	0	0	227	0	0	8	3	238
2002	0	0	205	0	0	11	5	221
2003	0	0	128	0	13	14	4	159
2004	0	0	119	0	14	7	7	147
2005	0	0	108	0	7	6	6	127
2006	0	1	95	0	8	8	9	121
2007	0	1	138	0	15	7	12	173
2008	0	1	121	0	4	6	11	143
2009	0	1	94	0	2	6	17	120
2010	0	0	72	0	6	4	13	95
2011	0	1	78	0	0	7	13	99
2012	0	0	168	0	0	8	14	189
2013	0	0	91			5	15	111
2014	0	1	94	0	2	6	17	120
2015	0	0	135	0	20	8	11	175
2016	0	0	137	0	25	6	10	179

Table 21.2. Turbot in 27.3a: Landings and discards (in kg) after raising in InterCatch (using CATON estimate).

	Discards	Landings	Grand Total	Discard Ratio
2013	**7365**	**112960**	**120326**	6.1%
3.aN	1905	78830	80735	2.4%
3.aS	5461	34130	39591	13.8%
2014	**10508**	**120240**	**130748**	8.0%
3.aN	2712	80969	83681	3.2%
3.aS	7796	39272	47068	16.6%
2015	**18274**	**183502**	**201776**	9.1%
3.aN	4639	145084	149723	3.1%
3.aS	13635	38417	52052	26.2%
2016	16349	188027	204376	8%
3.aN	12543	145240	157783	8%
3.aS	3806	42787	46593	8.2%

Table 21.3: Turbot in 27.3a. Summary of the Imported/Raised data for 2016 (based on SOP CANUM* WECA; small differences arise with the previous table).

Catch category	Raised or Imported	Sampled or Estimated	CATON	perc
Landings	Imported_Data	Estimated_Distribution	124.8	65
Landings	Imported_Data	Sampled_Distribution	66.62	35
Discards	Imported_Data	Sampled_Distribution	10.25	63
Discards	Raised_Discards	Estimated_Distribution	5.48	34
Discards	Imported_Data	Estimated_Distribution	0.588	4

Table 21.4. Turbot in 27.3a: Average cpue (kg/hr) estimated from IBTS and BITS surveys, and DLS calculations using 2:3 rule.

Year	*IBTS–Q1*	*IBTS–Q3*	*BITS–Q1*	*BITS–Q4*
1991	1.061	0.218		
1992	0.378	0.225		
1993	0.595	0.066		
1994	0.437	0.427		
1995	0.540	0.087		
1996	0.591	0.225	0.280	
1997	0.426	0.095	0.523	
1998	0.381	0.029		
1999	0.109	0.109	0.590	0.579
2000	0.232	0.000	0.194	0.161
2001	0.397	0.121	0.094	0.411
2002	0.155	0.337	0.207	0.271
2003	0.297	0.117	0.130	0.187
2004	0.350	0.095	0.366	2.076
2005	0.304	0.133	0.340	0.434
2006	0.700	0.316	0.598	0.104
2007	0.461	0.253	0.424	0.407
2008	0.099	0.599	0.507	0.315
2009	0.316	0.418	0.467	0.110
2010	0.294	0.312	0.138	0.510
2011	0.271	0.201	0.540	0.611
2012	0.466	0.386	0.471	0.348
2013	0.418	0.167	1.002	0.239
2014	0.088	0.382	0.067	0.303
2015	0.922	0.379	0.364	0.919
2016	0.661	0.355	1.550	0.800
2017	0.529		0.452	
last 2	0.595	0.367	1.001	0.860
previous 3	0.476	0.312	0.477	0.296
rule	1.250	1.178	2.097	2.899

Table 21.5. Turbot in 27.3a: Length-Based Indicators

Input Parameters

Data Type	Value	Source
Length at maturity	30 cm	Fishbase
von Bertalanffy growth parameter	62 cm	Fishbase
Catch at length by year	2014–2016	Length data from IC
Length-weight relationship parameters for landings and discards	2014–2016	Mean weight at length from IC

Outputs

	Conservation				Optimizing	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2014	1.08	0.97	0.8	0.02	0.95	0.98
2015	0.92	1	0.81	0.04	0.86	0.98
2016	1.08	1.03	0.79	0.05	0.9	0.94

Table 21.6. Turbot in 27.3a: Summary of SPiCT run 1 –Landings 1991–2016, IBTS–Q1+Q3 1991–2016, no priors.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 72.0354227
Euler time step (years):  1/16 or 0.0625
Nobs C: 26,  Nobs I1: 26,  Nobs I2: 25
Catch/biomass unit: t

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.4418 0.6769 0.7621 0.9750       -    -   -    -
 I1  0.0126 0.9155 0.3469 0.6224       *    -   -    -
 I2  0.5529 0.7850 0.3127 0.6064       -    -   -    -

Model parameter estimates w 95% CI
           estimate       cilow         ciupp    log.est
 alpha1   1.8183841   0.4484062     7.3739406  0.5979482
 alpha2   1.8257897   0.4751987     7.0149763  0.6020126
 beta     0.3399537   0.0097856    11.8100674 -1.0789459
 r        1.0903808   0.1415392     8.4000050  0.0865270
 rc       1.5966740   0.3117380     8.1779179  0.4679227
 rold     2.9806879   0.0091963   966.0971625  1.0921541
 m      246.6423510 160.5197217   378.9718091  5.5079393
 K      724.4219680 175.0561421  2997.8221923  6.5853741
 q1       0.0009035   0.0002066     0.0039509 -7.0091898
 q2       0.0004948   0.0001129     0.0021682 -7.6114337
 n        1.3658151   0.2151970     8.6685739  0.3117514
 sdb      0.3283071   0.0918263     1.1737978 -1.1138059
 sdf      0.1936985   0.0842292     0.4454404 -1.6414524
 sdi1     0.5969883   0.4263142     0.8359916 -0.5158577
 sdi2     0.5994197   0.4278381     0.8398129 -0.5117933
 sdc      0.0658485   0.0023787     1.8228311 -2.7203983

Deterministic reference points (Drp)
         estimate      cilow       ciupp    log.est
 Bmsyd 308.945156  65.106865 1466.006848  5.7331638
 Fmsyd   0.798337   0.155869    4.088959 -0.2252245
 MSYd  246.642351 160.519722  378.971809  5.5079393
Stochastic reference points (Srp)
          estimate       cilow       ciupp    log.est rel.diff.Drp
 Bmsys 287.3714102  53.8776748 1532.774524  5.6607755 -0.075072695
 Fmsys   0.7928304   0.1484933    4.233054 -0.2321459 -0.006945502
 MSYs  227.7179958 161.2151632  321.653898  5.4281080 -0.083104347

States w 95% CI (inp$msytype: s)
                   estimate       cilow        ciupp    log.est
 B_2016.50      620.4282073 143.8098466 2676.6676246  6.4304099
 F_2016.50        0.2870989   0.0651731    1.2647207 -1.2479286
 B_2016.50/Bmsy   2.1589768   0.9907485    4.7047064  0.7696344
 F_2016.50/Fmsy   0.3621189   0.1473469    0.8899411 -1.0157827

Predictions w 95% CI (inp$msytype: s)
                 prediction       cilow        ciupp    log.est
 B_2017.00      583.3678255 125.1321040 2719.6699250  6.3688179
 F_2017.00        0.2885663   0.0640992    1.2990882 -1.2428302
 B_2017.00/Bmsy   2.0300134   0.9508655    4.3338983  0.7080424
 F_2017.00/Fmsy   0.3639698   0.1438524    0.9209024 -1.0106843
 Catch_2017.00  161.5990584 100.4506250  259.9710621  5.0851183
 E(B_inf)       506.0743030          NA           NA  6.2266835
```

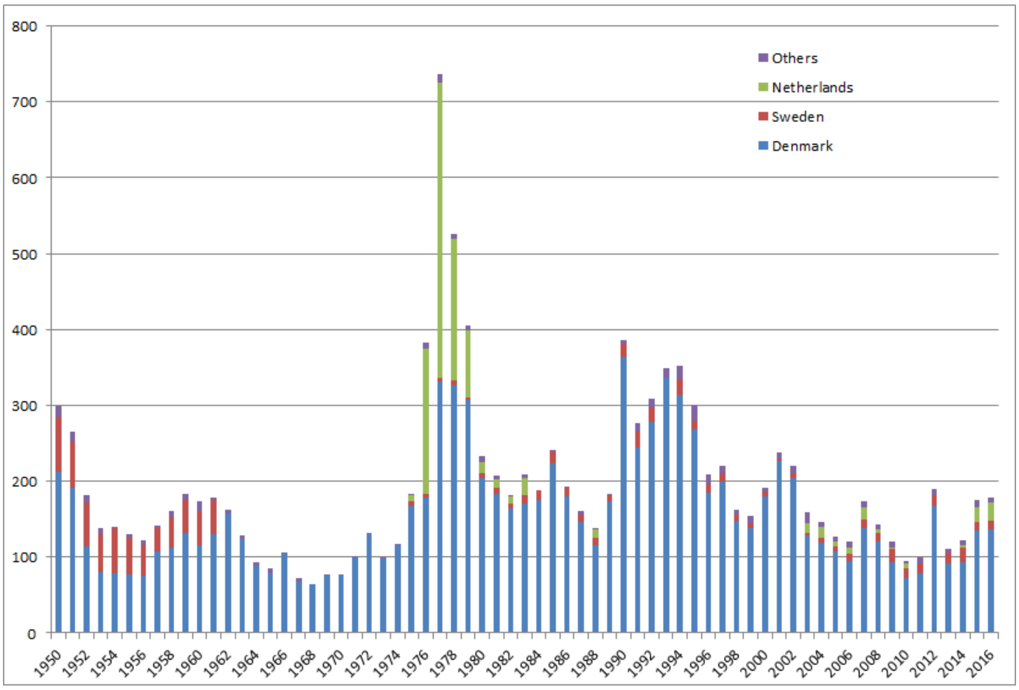


Figure 21.1. Turbot in 27.3a: Official landings by country from 1950 to 2016.

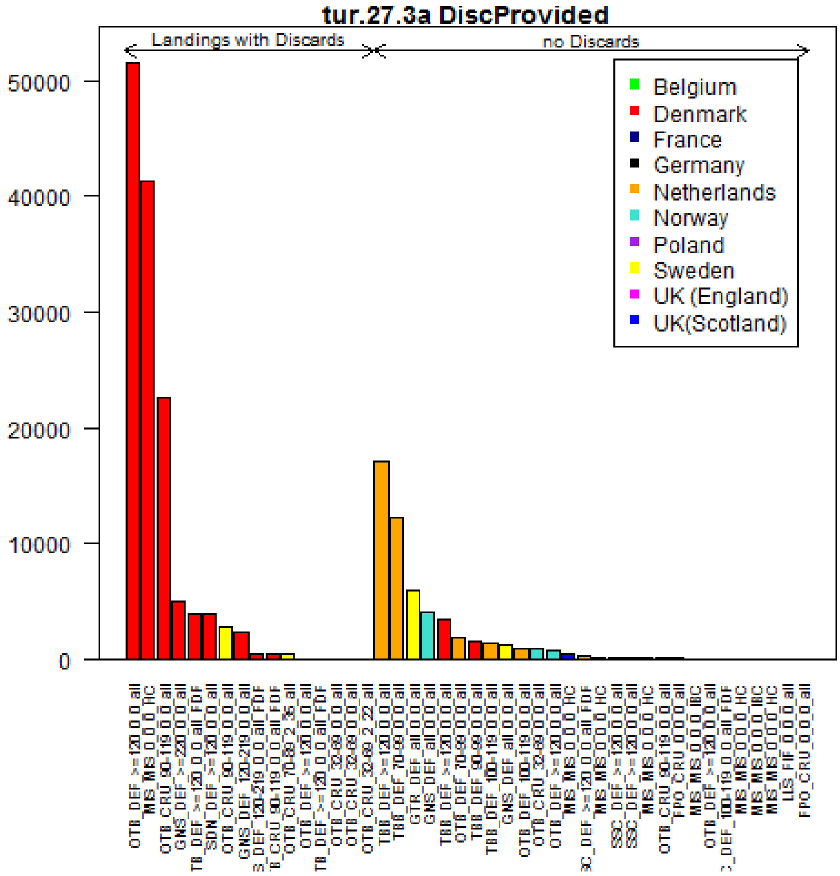


Figure 21.2. Turbot in 27.3a: Summary of the information provided to InterCatch for 2016, landings by métier and country, distinguishing between strata with and without discard information provided.

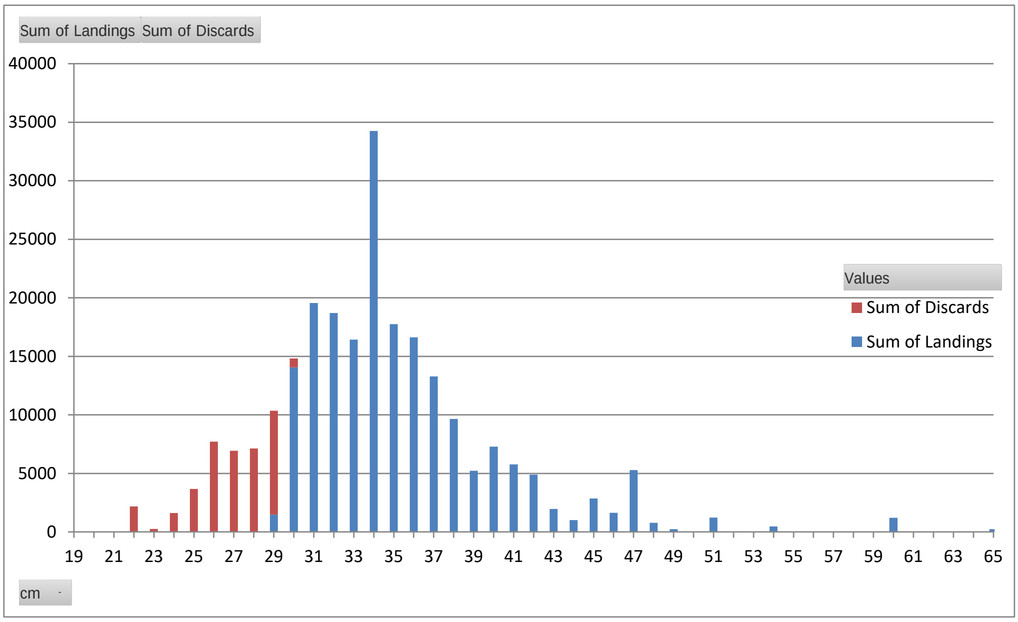


Figure 21.3. Turbot in 27.3a: Length distribution in landings and discards in 2016, after raising in InterCatch.

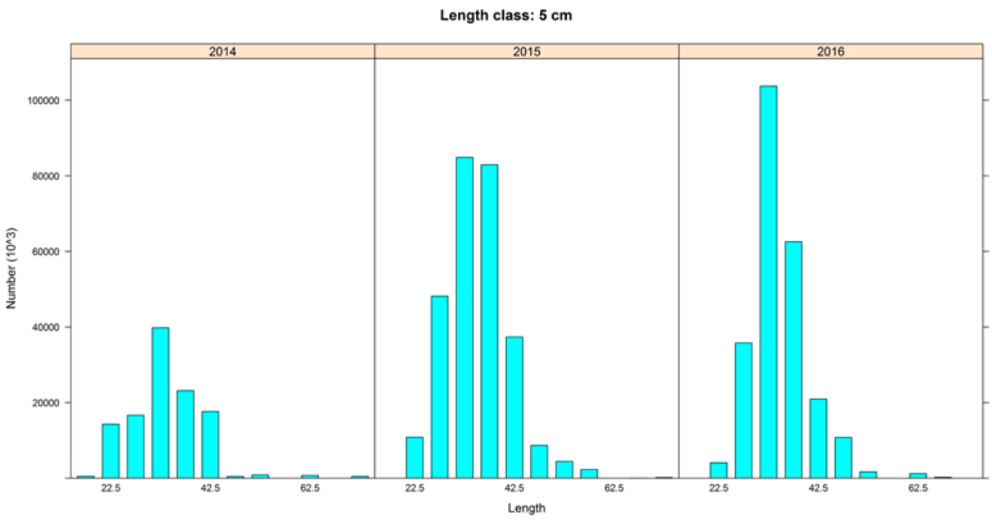


Figure 21.4. Turbot in 27.3a: Length distribution in 2014–2016, after raising in InterCatch. Disclaimer: Some SOP discrepancies have been observed in 2014 and 2015 and should be investigated further.

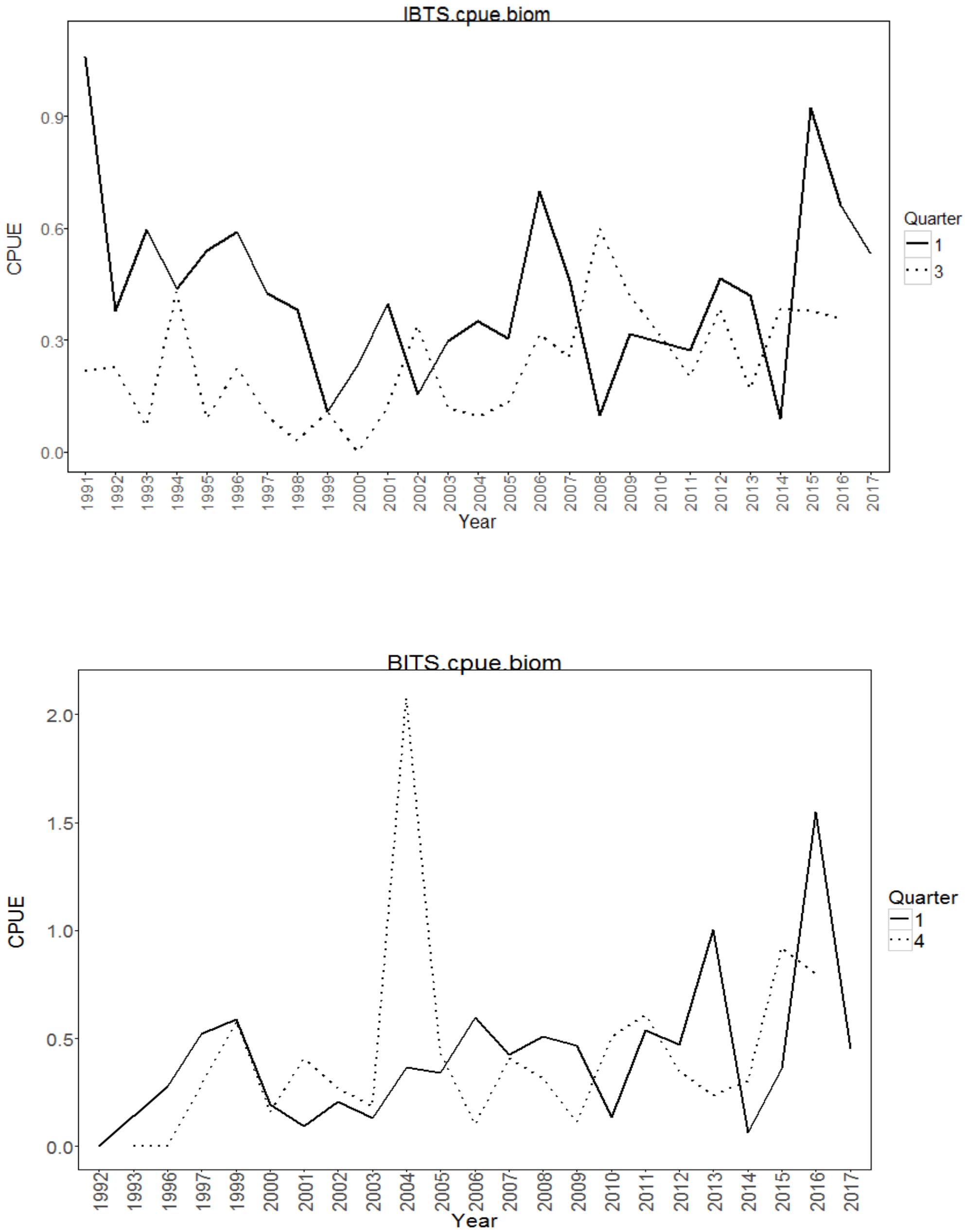


Figure 21.5. Turbot in 27.3a: IBTS and BITS biomass survey indices by quarter.

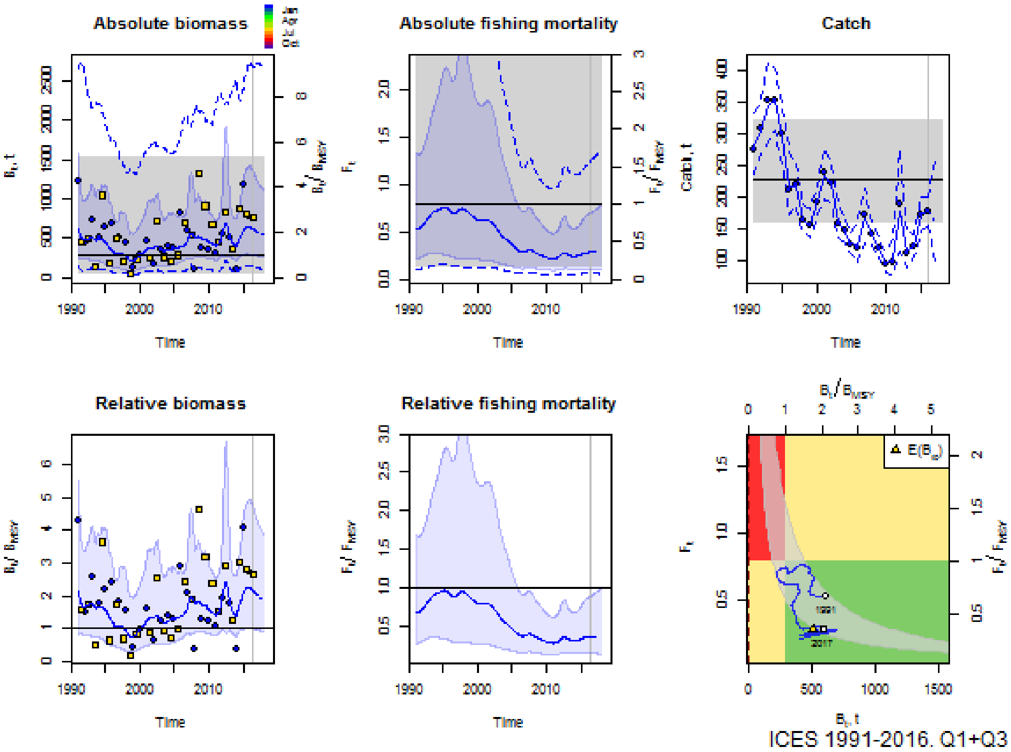


Figure 21.6. Turbot in 27.3a: SPiCT base run, stock status.

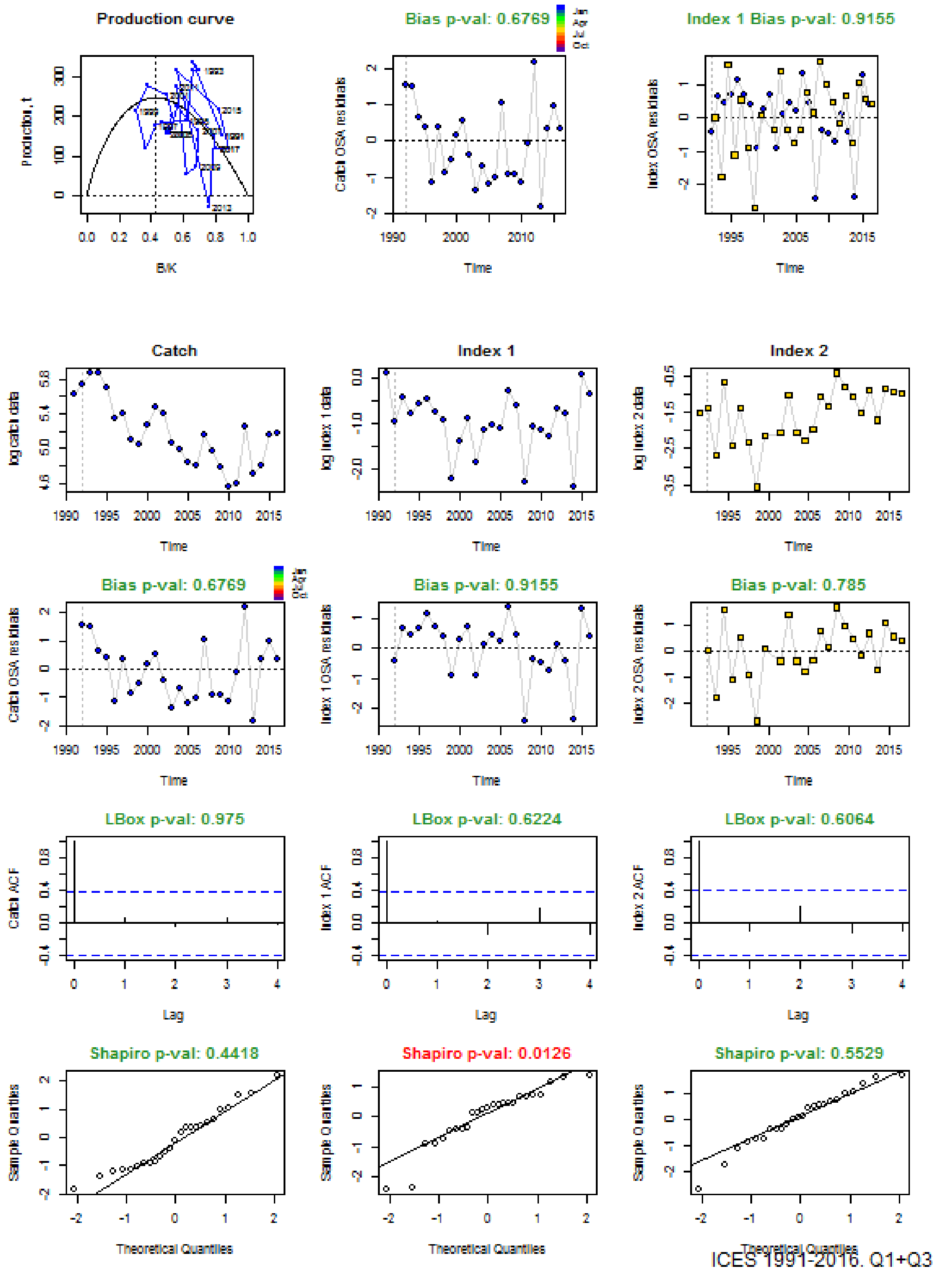


Figure 21.7. Turbot in 27.3a: SpiCT base run, diagnostics.

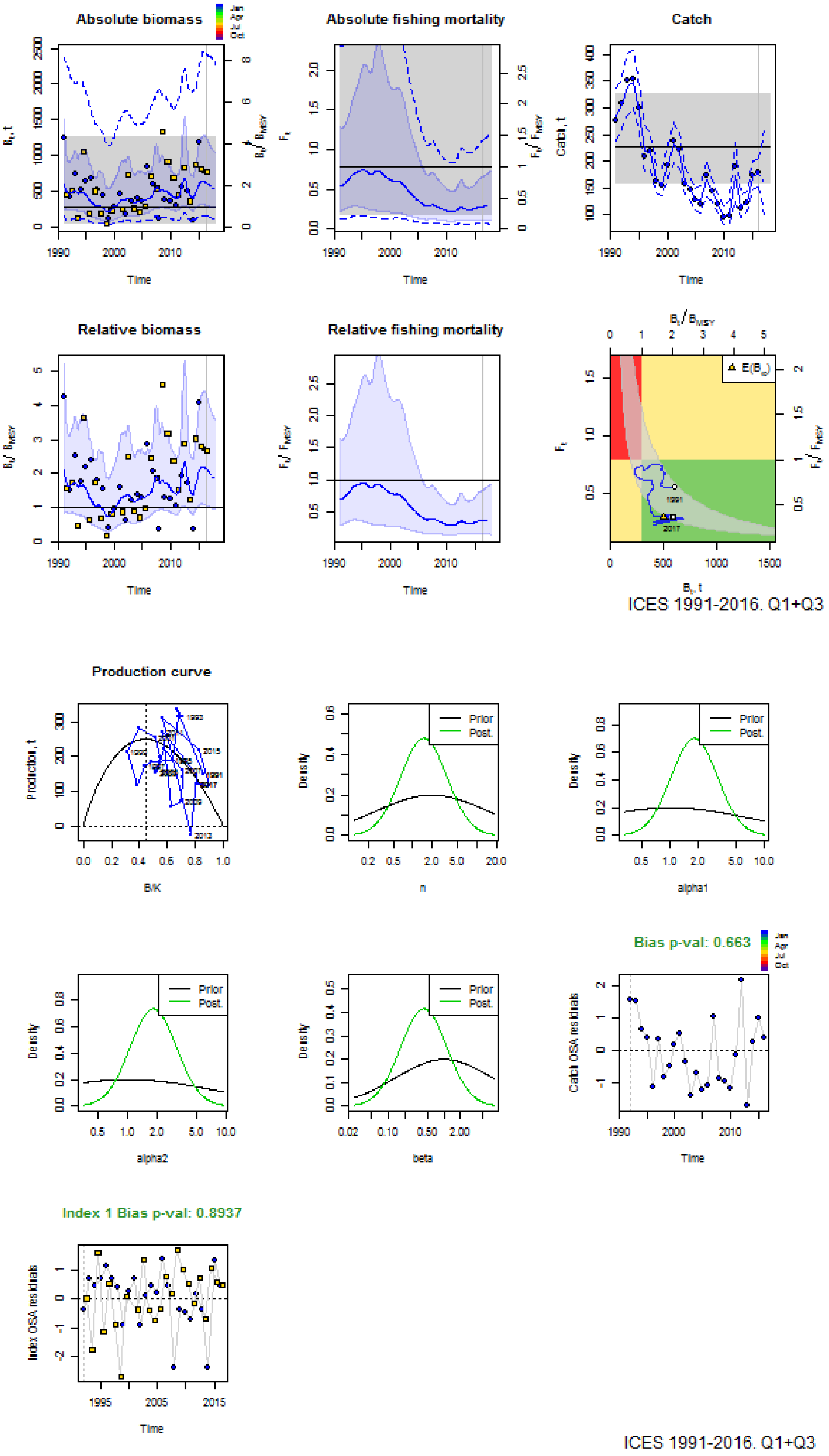


Figure 21.8 Turbot in 27.3a: SPiCT run 2 with default prior settings.

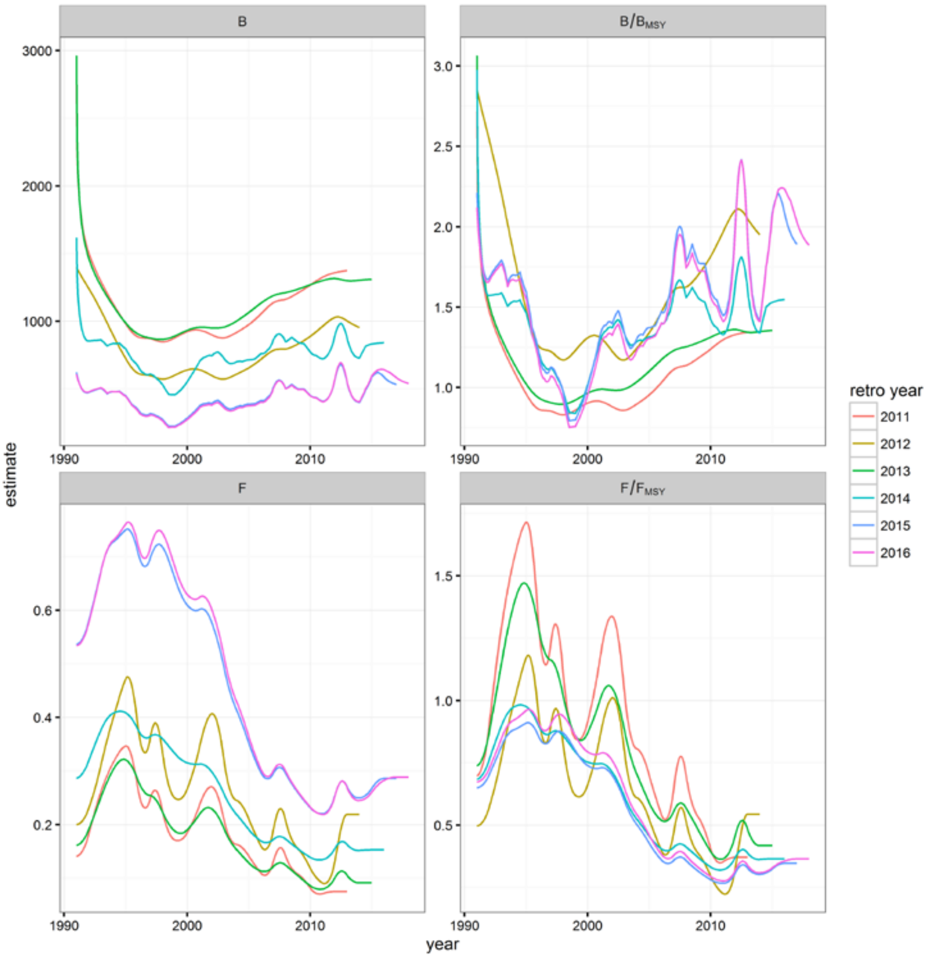


Figure 21.9. Turbot in 27.3a: SPiCT base run, retrospective analysis, time series.

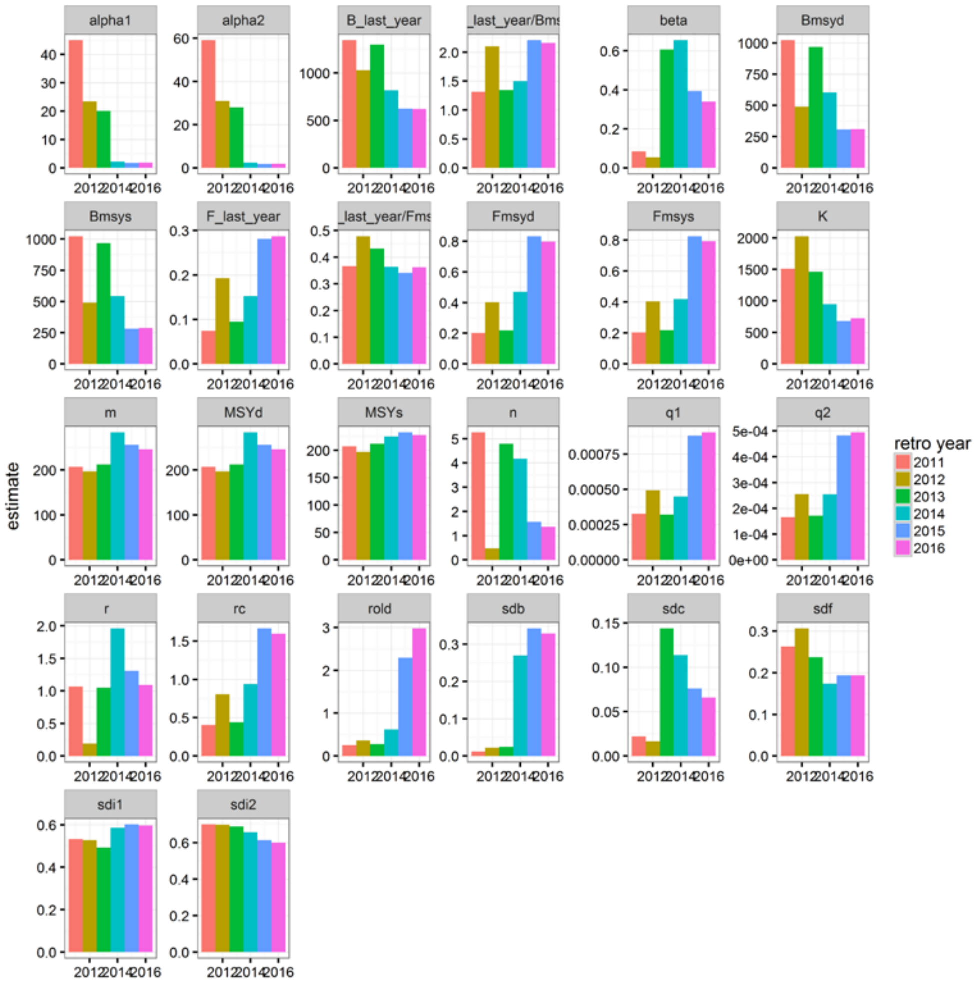


Figure 21.10. Turbot in 27.3a: SPiCT retrospective analysis: value of estimated parameters.

22 Turbot in Subarea 4

This report presents the stock assessment carried out for turbot (*Scophthalmus maxima*) in Subarea 4 in 2017. Following an inter-benchmark procedure for this stock in 2015 and another one in 2017, a new assessment model (SAM) was used since 2015. More details on the data used, assumptions made and the assessment model settings can be found in the Stock Annex and inter-benchmark report. The assessment output (SSB) was used as the basis for deriving advice under category 3 of the ICES DLS approach in 2017, as the assessment showed extreme recurring retrospective bias in F and SSB estimates.

At WGNSSK 2017, some serious issues were found in the settings of the assessment that were causing the retrospective patterns. The assessment for this stock was therefore delayed, pending further work to be carried out during the inter-benchmark process that took place during the summer of 2017.

During the inter-benchmark an evaluation was made of current input data, new catch-at-age data was supplied, new catch and survey data was evaluated in terms of its performance in and suitability for the assessment, the SAM model settings were parameterised, a decision was made on the category of the assessment, and finally new reference points were estimated.

22.1 General

22.1.1 Biology and ecosystem aspects

Turbot is broadly distributed from Iceland in the North, along the European coastline, to the Mediterranean and Adriatic Sea in the south. In general, turbot is a rather sedentary species, but there are some indications of migratory patterns. For example in the North Sea, migrations from the nursery grounds in the south-eastern part to more northerly areas have been recorded. IBPNEW (ICES, 2012) concluded that Turbot in the North Sea (Subarea 4) can be considered as a distinct stock for management purposes.

Turbot is typically found at a depth range of 10 to 70 m, on sandy, rocky or mixed bottoms and is one of the few marine fish species that inhabits brackish waters. It is a typical visual feeder and could be regarded as a top predator. Turbot feeds mainly on bottom living fishes (e.g. common gadoids, sandeels, gobies, sole, dab, dragonets, sea breams etc.) and small pelagic fish (e.g. herring, sprat, boarfish, sardine) but also, to a lesser extent, on larger crustaceans and bivalves. Despite its role as a top predator in the North Sea ecosystem, at present turbot is not included as a species in the WGSAM multispecies assessment (ICES, 2014a).

22.1.2 Fisheries

In the 1950s the UK was the biggest contributor to the landings (~50% of the landings). In recent years most of the landings stem from the Netherlands (~50-60%). In most countries turbot is caught in mixed fisheries trawls, with most of the landings in the Netherlands coming from the 80 mm beam trawl fleet (BT2) fishing for sole and plaice. In Denmark, the second largest contributor to the landings in recent times, there is a directed fishery for turbot using gillnets (~10% of the total landings).

See the Stock Annex for more details.

22.1.3 Management

A combined EU TAC for turbot and brill is set for EU waters in areas 2a and 4. This TAC only applies to the EU fisheries. This management area (particularly the inclusion of Area IIa) does not correspond to either of the stock areas defined by ICES for turbot and brill.

No specific management objectives or plans are known to ICES.

As a primarily bycatch species, regulations relating to effort restrictions for the primary métiers catching turbot (e.g. beam trawlers) are likely to impact on the stock. Fishing effort has been restricted for demersal fleets in a number of EC regulations (e.g. EC Council Regulation Nos. 2056/2001, 51/2006, 41/2007, and 40/2008).

The Dutch Producer Organisations have introduced a minimum landings size of 27 cm in 2013. In 2016 this size was increased to 30 cm first, and then to 32 cm. In the summer of 2016, the POs decided to prohibit landing the smallest market category and in October the weekly landings were capped to 375 kg wk^{-1}. These measures were taken in order to try and keep the landings within the national quota. In 2017, these measures were continued.

See the Stock Annex for more details.

22.2 Data used

Following the inter-benchmark conducted in the summer of 2017, the assessment of North Sea turbot requires three main types of data:

Catch data: estimates of removals of turbot by the fishery.

Survey data and commercial LPUE (landings per unit effort): indices of trends in population abundance over time from fisheries independent and fisheries dependent sources, respectively.

Biological data: estimates and/or assumptions on growth, maturation and natural mortality.

Since the assessment is age-based, data for the above is required for each age. See the Stock Annex for more details on the data used in the assessment, sources and historical values.

22.2.1 Catch data

InterCatch was used for the first time for the North Sea turbot stock at WGNSSK 2014, and has been used since.

Dutch samples (for data from 2004 – present) and Danish samples (from 2014 – present) accounting for auctions, quarters and market categories, are used for estimating the age structure of the landings. Prior to that, the landings-at-age information is from an old Dutch monitoring scheme from the 1980s.

Figure 22.2.1 shows the métiers with numbers at age samples for the landings in 2016. The only usable samples were those from the Dutch TBB_DEF_70-99 (beamtrawl) métier, and these samples were used to raise all the unsampled métiers.

Raising was done by quarter. The TBB_DEF_70-99 samples were evenly spread over the seasons. All beam trawl fleets were raised using the age distributions calculated from the TBB samples. There are a wide variety of métiers that land turbot, including a significant amount from the Danish > 220mm gillnet fleet.

Figure 22.2.2 shows the trend in total landings over time. Landing of turbot decreased during the 1990s and for the last ten years have been stable in the region of 3000t. Over this time effort by the Dutch beam trawl fleet, which contributes the most of the landings, has decreased notably. Since turbot is primarily a bycatch species, this indicates that abundance of turbot has likely increased over this period.

Landings at age are presented in Table 22.2.1 and Figure 22.2.3, with weights-at-age in the catch presented in Table 22.2.2. The 2005 year class shows up clearly in the landings data. In 2016, there appear to be large landings of age 3, suggesting a strong 2013 year class. Following a decrease in minimum market size for turbot in the Netherlands in 2002, there has been a notable increase in the amount of age 1 and 2 turbot landed, accounting for half of the catch in some years but this proportion has been decreasing in recent years due to some poor year classes in 2012 and 2013. Since turbot are only fully mature at age 4, a high proportion of immature fish are the landings. However, the last 5 years have also seen an increase in the proportion of age 5+ fish in the landings compared to the five years prior to that, these are now in the same order of magnitude as the estimates in the 1980s. This could reflect a reduction in F recently leading to an increasing proportion of older fish in the landings. However, since the catch data is raised using only the Dutch 80mm TBB fleet, signals in catch at age data may not be accurate reflections of true removals from the population over time.

22.2.1.1 Discard data

The assessment of this stock assumes that discarding of catches for this stock is negligible. However, there was a sudden increase in the landing of age two turbot following the decrease in minimum market size in the Netherlands in 2002. Given that there was no known change in the fishing behaviour of the main fleets at this time, this could indicates that previously more age 1 fish must have been caught than were actually landed. These were either discarded or, as a much sought after fish, kept by the fishermen for personal use. This would mean that the discards could be underestimated in the period up to 2002 relative to the period following this, potentially causing a bias in the assessment outputs. Alternatively, subsequent to the change in MLS, more targeting of small turbot may have occurred. Without a useable time series of discards before and after this change it is difficult to determine which of these explanations holds.

However, the impact on the final year estimates is likely to be small because with the reduction in minimum market size in 2002, the assumption of negligible discards probably holds for the last 10 years. Discard data were submitted to InterCatch by various nations. However, there is very limited age sampling of the discards. Very few fish were sampled in the discards of some of the Danish métiers (<10 per métier, fewer than the number of ages in the assessment model), not enough to be used in the raising of international landings.

In 2017, most countries provided estimates of discards in 2015 to InterCatch. Out of the 665 tonnes of estimated discards, 566 (85%) was reported data and 99,5 tonnes is raised in InterCatch. The proportion of landings with discards associated (same strata) is 22 percent.

The discard rate (discards: 665 562 / (discards + landings: 3 487 133) was 16% in 2016. This is a substantial increase compared to the most recent period (2013 – 2015), when discard ratios were approximately 5%. No useable age structure information was submitted for the discard estimates.

22.2.2 Survey data and commercial LPUE

Two survey abundance indices, the Sole Net Survey (SNS) and the Beam Trawl Survey (BTS ISIS), and one standardised commercial LPUE abundance index, the Dutch 80 mm beam trawl fleet (BT2), are used to tune the assessment (Table 22.3.1 and Figure 22.2.4).

All abundance indices indicate an increase in the number of fish aged 4 and older in late 2000s compared to the past. An increase in the amount of older fish would indicate either strong recruitment or a decrease in mortality (e.g. fishing pressure) exerted on the stock. After a decrease in some of the older ages and no clear indications of strong year classes since 2010, year classes 2013 and 2014 (ages 2 and 3 in 2016) appear strong.

There is fairly close agreement between the three indices on the general trends in abundance at age, but the data are noisy from year to year. This can be seen in the low R^2 values in the internal consistency correlations in the BTS_ISIS and SNS surveys (Figure 22.2.5). The SNS survey is particularly poor at picking up cohort signals, with low R^2 values on the correlations between numbers at consecutive ages. Though all correlations between successive ages are positive, estimated numbers at age, particularly for the younger ages, fluctuate a lot from year to year. The BTS-ISIS is more internally consistent for ages 3 and up. The almost non-existent relationship between the numbers estimated at age 1 and the numbers estimated at age 2 in the following year suggest that in future removing age 1 from this index may be appropriate. The internal consistency of the NL_BT2 LPUE index is significantly better, though the removal of age 1 from this index could also be considered. However, this index is no longer used as an age-structured index.

Noisy indices that are more indicative of general trends are best used in an assessment model that is able to smooth over the noise in the data. The SAM model used for this stock is able do this, but nevertheless inputting noisy data into the assessment will increase uncertainty in the outputs. By removing the age-structure from the NL BT2 LPUE index, the clearest cohort signals in the assessment of this stock are coming from the catch at age matrix.

22.2.3 Biological data

All biological data used in the assessment are presented in Table 22.2.3-7.

Weight at age

Constant annual catch and stock weights at age (long term means of all available data) were previously used in the assessment because of large gaps in the time series of weight at age data for turbot in the North Sea (Figure 22.2.6). What data is available is also very noisy, due to low sample sizes for most ages. The data that are available, and trends in other flatfish species in the same areas suggest that there have been potentially significant changes in weight at age over time. At IBPturbot a method was developed to model the growth parameters over time, allowing smooth changes over the time series (see Stock Annex for full details). The results indicate an increase in weight at age from the start of the time series, peaking in the early 1990s. Since then weights at age have decreased again to slightly lower than the 1970s.

Maturity

At IBPNEW (ICES, 2012) turbot maturity data from the Netherlands was used to study some reproductive characteristics of turbot from the North Sea. A female maturity ogive constructed from derived from a General Linear Model fit using the maturity data from the recent time period was chosen for the stock.

Natural mortality

There are currently no accepted estimates of turbot natural mortality over time. A number of alternative methods, using different estimates of growth parameters, were used to estimate the level of natural mortality by age for turbot in the North Sea at IBPNEW (ICES, 2012). Since turbot grows relatively fast compared to other flatfish species in the same areas, results indicate that natural mortality is higher. However, due to high variability for recorded values of K (an estimated growth parameter) for turbot, it proved difficult to find agreement on natural mortality values. Hence, after performing assessment test runs, a constant value of M = 0.2 for all ages and years was chosen for this stock. This is twice the level used in the sole and plaice assessments in the North Sea.

22.3 Stock assessment model

After the inter-benchmark protocol for this stock in the summer of 2017, a new assessment model (SAM) is used. More details on the data used, assumptions made and the assessment model settings can be found in the Stock Annex and in the inter-benchmark protocol report.

In summary, three abundance indices are used (Table 22.3.1):

- The SNS survey, from age 1 – 6 without plus group over the period 2004 – 2016,
- The BTS-ISIS survey, from age 1 - 7 with plus group over the period 1991 – 2016, and,
- A standardised age-aggregated commercial LPUE of Dutch BT2 over the period 1995 – 2016.

As mentioned above, Danish age information for the period 2014 - 2016 was supplied before the inter-benchmark protocol. This was evaluated and added to the catch-at-age matrix. The previous age data sources were revaluated and finally only the Dutch data sources were accepted. This means that the start of the catch-at-age matrix is now reduced to 1981. Catches are fitted to catch-at-age data from the Netherlands (1981–1990, 1998, 2004–2016) and Denmark (2014–2016).

Finally, different SAM model configuration were tested and a final set was used. Natural mortality is fixed at 0.2 and the surveys present a maximal age plus group at age 7 (BTS-ISIS, no plus group on SNS) and catch at age 8.

While the diagnostics of the new base assessment looked satisfactory, the retrospective pattern in F is still large so the inter-benchmark protocol agreed to keep considering the assessment as a category 3. The external reviewers agree that results generated by the assessment model can be used for providing fisheries advice as an ICES Category 3 stock although the stock has a quantitative assessment that could qualify as category 1.

The assessment output (SSB) is used as the basis for deriving advice in 2017 under category 3 of the ICES DLS approach (2 over 3 rule).

22.3.1 Model settings

The assessment model was conducted using the settings and configuration given below. Details of the assessment model can be found in the Stock Annex and Inter-benchmark report (see also tables 22.3.2-4).

Assessment settings used in the final assessment

Year	2017 (IBPTurbot proposal)
Model	SAM
First tuning year	1981
Last data year	2016
Ages	1-8+
Plus group	Yes
Stock weights at age	Von Bertalanffy growth curve with time varying Linf
Catch weights at age	Von Bertalanffy growth curve with time varying Linf
Total Landings	Not used
Landings at age	1981–1990, 1998, 2000–present
Discards	Not used (assumed 0)
Abundance indices	BTS-Isis 1991–2016 SNS 2004–2016
	Standardized NL-BT2 LPUE age-aggregated catchable biomass 1995–2016
Catchability in catch at age matrix independent of age for ages >=	7
coupling of fishing mortality STATES (Row represent Catch, olumns represent ages)	1 2 3 4 5 6 7 7
Use correlated random walks for the fishing mortalities (0 = independent, 1= correlation estimated)	2
Coupling of catchability PARAMETERS (Surveys)) Row represent fleets (SNS and BTS-only, lpue age-aggregated), Columns represent ages)	1 1 2 3 3 3 0 0 4 4 5 5 6 6 6 0 7 0 0 0 0 0 0 0
Coupling of fishing mortality RW VARIANCES	1 1 2 2 3 3 3 3
Coupling of log N RW VARIANCES	1 2 2 2 2 2 2 2
Coupling of OBSERVATION VARIANCES (Row represent fleets (Catch, SNS, BTS, lpue age-aggregated), Columns represent ages)	1 1 2 2 2 3 3 3 4 4 5 5 5 5 0 0 6 6 6 7 8 8 8 0 9 0 0 0 0 0 0 0
Stock-recruitment model code (0=RW, 1=Ricker, 2=BH)	0
Fbar ranges	2-6

22.4 Assessment model results

The stock summary is given in Table 22.4.1, while fishing mortality at age and abundance at age estimated by the assessment model are presented in tables 22.4.2 and

22.4.3, respectively. Other key model outputs are given in tables 22.4.4-9 and plotted in Figure 22.4.1-12.

22.4.1 Status of the stock

Fishing mortality was estimated at 0.36 in 2016, an increase from 2015 (0.30). This is well below the long term geometric mean (0.45). The SSB in 2016 was estimated to be 11789t, a small increase from 2015 which was estimated at 10868t. Both years are higher than the long term geometric mean (8078 t). The estimated recruitment (age 1) for 2016 is just below the geometric mean of the time series (4950). However, this estimate is based on very little data and is unlikely to be a reliable estimate.

22.4.2 Historic stock trends

SSB was at its highest in the early 1980s (possibly higher before that time for which no reliable data is available). From the mid–1980s up until the early 2000s SSB declined gradually and F increased gradually (Figure 22.4.6). The lowest observed SSB was in 1999, SSB subsequently increased and has continued to increase since. Recruitment has been variable over the time-series without a clear trend. Recent recruitment (2014 and 2015) have been well above long term mean and do now contribute to the increase in SSB.

Mean F peaked in 1994 at 0.80, but then declined gradually to ~0.3 in 2006. before gradually increasing again. These trends correspond well with the trends in fishing effort of the beam trawl fleet.

There are no clear patterns in recruitment, though values are estimated at a slightly higher level, but with more uncertainty, during the years of missing landings at age data (1990s). Recent recruitment has been at or above average.

22.4.3 Retrospective assessments

The results of five retrospective assessments, run using the same model settings but removing one year of data from the end of the time series, are plotted in figures 22.4.10-12. In most years F has been severely overestimated. There is a smaller retrospective pattern in SSB or recruitment. For F, all retrospective peels are well outside the confidence bounds of the latest assessment.

The disagreement between retrospective assessments is large. This is likely due to the quality of the data used by the assessment and the model itself. No clear reason for the retrospective pattern could be found in the inter-benchmark.

22.5 Model diagnostics

Model diagnostics are provided in tables 22.4.4-9 and figures 22.4.1-2, 22.4.4, and 22.4.7-12. Please refer to the Turbot Inter-benchmark 2017 report for more detailed specifications.

22.6 Management considerations

There are a number of EC regulations that affect the flatfish fisheries in the North Sea, e.g. as a basis for setting the TAC, limiting effort, and minimum mesh size.

22.6.1 Effort regulations

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. In 2008, 25 vessels were decommissioned.

22.6.2 Technical measures

Turbot is mainly taken by beam trawlers in a mixed fishery directed at sole and plaice in the southern and central part of the North Sea. Technical measures (EC Council Regulation 1543/2000) applicable to the mixed flatfish fishery affect the catching of turbot. The minimum mesh size of 80 mm in the beam trawl fishery selects sole at the minimum landing size (24 cm). However, this mesh size is likely to catch immature turbot (age 1 and 2 fish). Mesh enlargement would reduce the catch of smaller turbot at the same time potential increasing the yield per recruit, but would also result in loss of marketable sole catches.

A closed area has been in operation since 1989 (the plaice box) and since 1995 this area has been closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation. An additional technical measure concerning the fishing gear is the restriction of the aggregated beam length of beam trawlers to 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9 m.

22.6.3 Combined TAC

At present the EU provides a combined TAC for turbot and brill in the North Sea. This TAC seems largely ineffective in reducing F: increases in the stock at similar TACs lead to increased discarding. In addition, it is unclear how the quantitative single species advice for turbot and the qualitative single species advice for brill can/will be used to formulate a combined TAC for these two stocks. In this situation, improving the brill assessment may be necessary in order to ensure efficient management of both of these stocks. Ideally, a combined TAC is on that is not used.

22.7 Proxy reference points

In order to get reference point proxies a SPiCT analysis was done (Table 22.7.1 and figures 22.7.1–3). Additionally, since the quality of the turbot assessment is of category 1 level, an EQsim analysis is run too. See the Stock Annex and the inter-benchmark protocol report for more details.

In summary, the SPiCT run estimates a proxy of fishing mortality at maximum sustainable yield (Fmsy) of 0.279 (95% CI 0.124 - 0.623) (Table 22.7.1) with some retrospective patterns (Figure 22.7.2).

Both methods and runs indicate that the stock is not overfished in relation to F_{MSY} proxies. The SPiCT run is appropriate for management, and allows for using a single consistent model. Due to the retrospective issues, the SPiCT model without the prior on LPUE sdi should be used (Figures 22.7.1-3). Both the SPiCT and Eqsim models could still be run in the future to check for consistency in status determination and management advice.

22.8 References

ICES, 2012. Report of the Inter-Benchmark Protocol on New Species (Turbot and Sea bass; IBPNew 2012), 1–5 October 2012, Copenhagen, Denmark. ICES CM 2012/ACOM: 45. 239pp.

ICES. 2013a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:13. 1435 pp.

ICES, 2013b. (DRAFT) ICES Implementation of Advice for Data-limited Stocks in 2013. ICES CM 2012/ACOM: 68. 42pp.

ICES, 2014a. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 20-24 October 2014, London, UK. ICES CM 2014/SSGSUE: 11. 103 pp.

ICES. 2014b. Report of the Working Group on Mixed-Fisheries Advice for the North Sea (WGMIXFISH), 26–30 May 2014. ICES CM 2014/ACOM:22.

ICES. 2014c. Report of the Joint ICES–MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3), 17–21 November 2014, Charlottenlund, Denmark. ICES CM 2014/ACOM:64. 147 pp.

ICES. 2015. Report of the Inter-Benchmark Protocol for Turbot in Subarea 4 (IBP Turbot), May 2015, By correspondence. ICES CM 2015/ACOM:XXX. Xxx pp.

Table 22.2.1. Turbot in Area 4. Catch in numbers (units: thousands).

age	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	12.58987	32.07306	0.00000	43.95691
2	284.62711	150.53287	359.13063	1194.02495	621.16802	320.89279	627.55660	965.75553	663.01888	978.29686
3	718.70725	931.70048	601.23113	1126.76892	1886.94436	1271.46199	528.77454	799.15379	1157.49255	1054.96590
4	506.42683	237.82412	427.91934	286.52914	510.99860	602.86327	654.67324	158.58347	351.60092	311.78740
5	435.98400	148.75142	98.26958	144.64654	139.86047	158.28404	153.01534	156.80164	155.15088	163.56060
6	166.58777	260.09229	100.94966	55.27893	85.16643	57.95099	50.35948	80.18265	81.48212	74.62453
7	63.77932	87.29125	160.80476	52.51499	20.31493	25.08326	18.40058	24.94571	31.25342	100.18087
8	101.85652	138.06269	181.35204	179.65653	125.01495	107.25258	67.79161	68.60072	68.08780	112.44792

age	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
1	-1	-1	-1	-1	-1	-1	-1	0.000000	-1	-1	-1	-1	212.80776	442.912175	350.838557
2	-1	-1	-1	-1	-1	-1	-1	401.903199	-1	-1	-1	-1	1935.99269	2016.026483	2022.353482
3	-1	-1	-1	-1	-1	-1	-1	861.859082	-1	-1	-1	-1	467.06123	806.771565	736.387352
4	-1	-1	-1	-1	-1	-1	-1	354.270227	-1	-1	-1	-1	301.27840	140.778931	235.017240
5	-1	-1	-1	-1	-1	-1	-1	72.193723	-1	-1	-1	-1	71.73295	83.925901	25.309549
6	-1	-1	-1	-1	-1	-1	-1	29.249622	-1	-1	-1	-1	33.39567	9.836477	22.296507
7	-1	-1	-1	-1	-1	-1	-1	8.410197	-1	-1	-1	-1	20.96196	7.670647	2.651477
8	-3	-3	-3	-3	-3	-3	-3	14.148481	-3	-3	-3	-3	20.52359	5.865789	19.162944

age	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	907.299517	81.091976	183.12213	123.78383	283.13150	216.03065	0.00000	173.29164	64.29735
2	1686.803127	2871.204009	1393.51471	1139.36187	1426.41839	1988.74401	1933.52705	1589.94784	367.15641
3	827.973486	636.353805	847.62219	1064.18093	392.17538	617.23042	786.70444	1087.87148	609.85146
4	122.138946	294.326321	227.28979	459.55674	314.45770	113.38897	269.84061	327.04460	641.08213
5	35.998847	41.611652	201.48396	97.41756	174.56587	140.99672	42.65863	91.16259	128.69619
6	8.099741	30.041583	48.63406	27.42516	89.55468	78.87929	64.38476	25.76871	114.04499
7	16.585183	8.525314	13.29993	12.07131	31.08707	33.03070	73.61093	41.89161	35.34555
8	18.140848	15.721085	10.20323	19.91765	19.45333	23.82154	23.99796	24.92014	97.62236

age	**2015**	**2016**
1	38.00685	0.00000
2	1184.23815	993.90877
3	452.70448	950.07642
4	317.78108	318.57339
5	308.00335	342.24945
6	106.63814	178.84046
7	41.75888	42.85270
8	76.73417	66.59811

Table 22.2.2. Turbot in Area 4. Weights at age in the catch (units: kg).

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.350135	0.362959	0.375714	0.388240	0.400360	0.411882	0.422601	0.432304	0.440770	0.447778	0.453114
2	0.745421	0.772721	0.799876	0.826544	0.852347	0.876876	0.899697	0.920353	0.938376	0.953298	0.964658
3	1.283690	1.330710	1.377470	1.423390	1.467830	1.510070	1.549370	1.584940	1.615980	1.641680	1.661240
4	1.940110	2.011170	2.081850	2.151250	2.218410	2.282260	2.341650	2.395410	2.442320	2.481160	2.510730
5	2.685250	2.783600	2.881420	2.977490	3.070440	3.158800	3.241010	3.315420	3.380340	3.434090	3.475020
6	3.489840	3.617660	3.744790	3.869640	3.990440	4.105280	4.212120	4.308820	4.393210	4.463060	4.516250
7	4.327380	4.485870	4.643510	4.798320	4.948120	5.090520	5.223000	5.342910	5.447540	5.534160	5.600110
8	5.985123	6.315863	6.400858	6.642016	7.082561	7.646902	8.033960	7.189092	7.680484	7.497206	7.774917

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.456573	0.457967	0.457135	0.453947	0.448320	0.440415	0.430611	0.419303	0.406872	0.393680	0.380062
2	0.972021	0.974988	0.973217	0.966429	0.954451	0.937621	0.916750	0.892674	0.866209	0.838125	0.809133
3	1.673920	1.679030	1.675980	1.664290	1.643660	1.614680	1.578740	1.537280	1.491700	1.443340	1.393410
4	2.529890	2.537610	2.533000	2.515340	2.484160	2.440360	2.386030	2.323370	2.254490	2.181400	2.105940
5	3.501540	3.512230	3.505850	3.481400	3.438250	3.377620	3.302440	3.215710	3.120370	3.019200	2.914760
6	4.550720	4.564610	4.556320	4.524540	4.468470	4.389670	4.291960	4.179240	4.055340	3.923860	3.788120
7	5.642860	5.660090	5.649800	5.610400	5.540860	5.443160	5.321990	5.182230	5.028590	4.865550	4.697240
8	7.834260	7.858180	7.843900	7.789197	7.692657	7.557007	7.272287	7.194743	6.981440	6.755090	6.521420

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.366319	0.352717	0.339488	0.326831	0.314913	0.303876	0.293838	0.284901	0.277156	0.270686	0.265577
2	0.779874	0.750917	0.722754	0.695807	0.670435	0.646936	0.625565	0.606539	0.590050	0.576277	0.565399
3	1.343020	1.293160	1.244660	1.198250	1.154560	1.114090	1.077290	1.044520	1.016130	0.992409	0.973676
4	2.029790	1.954420	1.881120	1.810990	1.744950	1.683790	1.628170	1.578650	1.535730	1.499880	1.471570
5	2.809370	2.705050	2.603600	2.506530	2.415130	2.330480	2.253490	2.184960	2.125560	2.075940	2.036760
6	3.651140	3.515570	3.383720	3.257570	3.138780	3.028770	2.928720	2.839640	2.762440	2.697960	2.647040
7	4.527390	4.359290	4.195790	4.039360	3.892060	3.755650	3.631580	3.521130	3.425410	3.345450	3.282300
8	6.287884	5.700812	5.381053	6.000499	5.231290	5.292194	5.097322	4.879336	4.433223	4.407282	4.218735

age	2014	2015	2016
1	0.261917	0.259810	0.259380
2	0.557608	0.553123	0.552207
3	0.960259	0.952535	0.950958
4	1.451290	1.439620	1.437240
5	2.008690	1.992530	1.989230
6	2.610560	2.589560	2.585270
7	3.237070	3.211040	3.205720
8	4.361404	4.488926	4.538716

Table 22.2.3. Turbot in Area 4. Weights at age in the stock (units: kg)

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.338587	0.350987	0.363322	0.375435	0.387155	0.398297	0.408662	0.418045	0.426232	0.433009	0.438169
2	0.720834	0.747234	0.773494	0.799282	0.824233	0.847954	0.870022	0.889996	0.907425	0.921855	0.932840
3	1.241350	1.286810	1.332040	1.376450	1.419420	1.460260	1.498270	1.532670	1.562680	1.587530	1.606450
4	1.876120	1.944830	2.013180	2.080300	2.145240	2.206980	2.264410	2.316400	2.361770	2.399320	2.427910
5	2.596680	2.691790	2.786380	2.879280	2.969160	3.054610	3.134110	3.206060	3.268850	3.320830	3.360400
6	3.374740	3.498330	3.621270	3.742010	3.858820	3.969870	4.073190	4.166710	4.248300	4.315860	4.367290
7	4.184650	4.337910	4.490350	4.640060	4.784910	4.922610	5.050720	5.166680	5.267860	5.351630	5.415400
8	5.787711	6.107547	6.189735	6.422943	6.848954	7.394679	7.768970	6.951970	7.427159	7.249921	7.518470

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.441514	0.442862	0.442057	0.438974	0.433533	0.425888	0.416408	0.405473	0.393452	0.380695	0.367526
2	0.939960	0.942830	0.941117	0.934553	0.922970	0.906695	0.886512	0.863231	0.837638	0.810481	0.782445
3	1.618710	1.623650	1.620700	1.609400	1.589450	1.561420	1.526670	1.486570	1.442500	1.395730	1.347450
4	2.446440	2.453910	2.449460	2.432370	2.402230	2.359870	2.307330	2.246740	2.180130	2.109450	2.036480
5	3.386050	3.396390	3.390220	3.366570	3.324850	3.266220	3.193510	3.109640	3.017450	2.919620	2.818630
6	4.400620	4.414060	4.406040	4.375310	4.321080	4.244880	4.150390	4.041400	3.921580	3.794440	3.663180
7	5.456740	5.473400	5.463450	5.425350	5.358110	5.263620	5.146460	5.011300	4.862730	4.705070	4.542310
8	7.575860	7.598990	7.585183	7.532283	7.438927	7.307747	7.032425	6.957437	6.751170	6.532287	6.306320

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.354236	0.341083	0.328291	0.316051	0.304526	0.293853	0.284146	0.275504	0.268014	0.261758	0.256817
2	0.754151	0.726149	0.698915	0.672857	0.648321	0.625598	0.604932	0.586533	0.570588	0.557270	0.546750
3	1.298730	1.250500	1.203600	1.158730	1.116480	1.077340	1.041760	1.010070	0.982612	0.959676	0.941561
4	1.962840	1.889960	1.819070	1.751250	1.687390	1.628250	1.574460	1.526580	1.485080	1.450410	1.423030
5	2.716700	2.615830	2.517720	2.423860	2.335470	2.253610	2.179170	2.112890	2.055450	2.007470	1.969580
6	3.530720	3.399620	3.272120	3.150120	3.035250	2.928870	2.832120	2.745980	2.671330	2.608970	2.559730
7	4.378060	4.215500	4.057400	3.906130	3.763690	3.631770	3.511800	3.404990	3.312430	3.235110	3.174040
8	6.080492	5.512778	5.203566	5.802582	5.058746	5.117639	4.929198	4.718397	4.287001	4.261911	4.079590

age	2014	2015	2016
1	0.253278	0.251241	0.250825
2	0.539216	0.534879	0.533993
3	0.928586	0.921117	0.919592
4	1.403420	1.392140	1.389830
5	1.942440	1.926810	1.923620
6	2.524450	2.504150	2.500000
7	3.130300	3.105130	3.099980
8	4.217550	4.340867	4.389016

Table 22.2.4. Turbot in Area 4. Natural mortality.

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 22.2.5. Turbot in Area 4. Proportion mature

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
3	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
4	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
3	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
4	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 22.2.6. Turbot in Area 4. Fraction of harvest before spawning

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 22.2.7. Turbot in Area 4. Fraction of natural mortality before spawning.

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 22.3.1. Turbot in Area 4. Survey indices

SNS – Configuration

Turbot in IV - 22/04/2015. Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	6.00	NA	2004.00	2016.00	0.66	0.75

Index type : number

SNS - Index Values

Units : NA

year

```
age   2004   2005   2006  2007  2008  2009  2010   2011  2012   2013   2014  2015
 1 186.5150 75.3905 196.1540 89.7415 52.0905 26.2675 96.0185 116.6900 39.8585 110.1600 102.7140 273.794
 2 27.0285 155.5480 97.4725 55.6055 99.7425 20.3115 35.8115 36.8895 33.5115 16.1155 18.3059 45.873
 3 18.7565 23.6635 14.8685 33.7815 40.8285 5.6455 9.2565  0.0000 9.4645 15.6395  9.4471  2.000
 4  4.0895  0.0000  3.6135 11.8455 11.8675 14.4675 5.3675  0.0000 1.2325  0.4405  6.1647  2.000
 5  2.9985  0.0000  1.0895 1.3245 10.9225 5.0895 3.7005  0.0000 0.0000  0.0000  4.7412  0.000
 6  3.4225  0.0000  0.0000 0.0000 1.2005 0.0000 6.7565  1.6895 0.0000  0.0000  1.2000  0.000
  year
age   2016
 1 52.8330
 2 115.6860
 3 26.7100
 4  2.0000
 5  1.3095
 6  0.5000
```

BTS-ISIS - Configuration
Turbot in IV - 22/04/2015. Imported from VPA file.

```
   min    max plusgroup  minyear  maxyear  startf   endf
   1.00   7.00   7.00  1991.00  2016.00   0.66   0.75
```

Index type : number

BTS-ISIS - Index Values
Units : NA

```
  year
age  1991  1992  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003
 1 1.22675 1.36115 1.67955 1.83025 1.83265 0.61465 0.66885 1.91495 1.24255 4.21375 1.04385 2.81445 1.54345
 2 1.66485 1.17845 1.40555 1.58005 0.60705 1.90125 1.30755 0.91595 1.18095 0.84715 1.40955 0.49315 0.87475
 3 0.21705 0.31985 0.18545 0.10225 0.10125 0.11255 0.37765 0.23285 0.19545 0.38565 0.12875 0.14595 0.10115
 4 0.02365 0.03375 0.05225 0.03125 0.01185 0.07465 0.02625 0.15245 0.09545 0.16375 0.15225 0.04625 0.05435
 5 0.01415 0.01545 0.04505 0.00625 0.00895 0.04045 0.03805 0.00475 0.01665 0.05395 0.00000 0.03195 0.00000
 6 0.00000 0.01055 0.00175 0.00325 0.00345 0.00000 0.01335 0.00000 0.00265 0.05465 0.00000 0.02175 0.01215
 7 0.01215 0.00335 0.00075 0.00325 0.00000 0.00915 0.01155 0.00135 0.00115 0.00000 0.04025 0.00095 0.01145
  year
age  2004  2005  2006  2007  2008  2009  2010  2011  2012  2013  2014  2015  2016
 1 2.16585 1.14255 1.70525 1.34235 1.19555 0.97165 1.69095 1.84005 0.97725 0.66795 2.26954 4.27908 0.77369
 2 0.63995 1.53825 0.79935 0.90235 1.12475 0.41985 0.34825 0.89155 0.93035 0.58505 0.17582 1.16285 1.90925
 3 0.35895 0.52595 0.27315 0.56285 0.43125 0.34585 0.09925 0.16335 0.24015 0.45565 0.22454 0.19162 0.45058
 4 0.00000 0.11575 0.11375 0.27955 0.14325 0.28145 0.07015 0.06325 0.23555 0.15835 0.32127 0.08827 0.05635
 5 0.06855 0.03595 0.00475 0.09035 0.07615 0.15225 0.08895 0.06535 0.02135 0.01775 0.12045 0.09938 0.03461
 6 0.01715 0.00625 0.00000 0.06005 0.01735 0.04955 0.01465 0.01665 0.04495 0.03735 0.04955 0.00000 0.03657
 7 0.00000 0.01215 0.00000 0.00000 0.07975 0.00505 0.01465 0.00000 0.08375 0.04055 0.01422 0.01235 0.02381
```

Dutch_BT2_LPUE_ModelD - Configuration
Turbot in IV - 22/04/2015. Imported from VPA file.

```
   min    max plusgroup  minyear  maxyear  startf   endf
    -1    -1    -1  1995   2016     0     1
```

Index type : biomass

Dutch_BT2_LPUE_ModelD - Index Values
Units : NA

```
  year
age   1995   1996   1997   1998   1999  2000   2001   2002   2003   2004   2005
 -1 0.042271 0.036913 0.037283 0.034519 0.034486 0.04409 0.045691 0.045351 0.046866 0.047674 0.047145
  year
age   2006   2007   2008   2009   2010   2011   2012   2013   2014   2015   2016
 -1 0.048433 0.064184 0.066611 0.065974 0.058335 0.059202 0.073476 0.075294 0.074674 0.087463 0.097216
```

Table 22.3.2. Turbot in Area 4. Stock object configuration

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	8	8	1981	2016	2	6

Table 22.3.3. Turbot in Area 4. SAM configuration settings

```
name      : Turbot in IV
desc      : Imported from a VPA file. ( D:/Repository/Turbot/assessment runs/Lowestoft files/index_raw.txt ).
Wed Sep 20 16:45:39 2017
range    :   min   max plusgroup  minyear  maxyear  minfbar  maxfbar
range    :    1     8     8  1981  2016     2     6
fleets    :  catch   SNS BTS-ISIS NL_LPUE
fleets    :    0   2   2   3
plus.group   : TRUE
states    :      age
states    : fleet    1 2 3 4 5 6 7 8
states    :  catch   0 1 2 3 4 5 6 6
states    :  SNS   NA NA NA NA NA NA NA NA
states    :  BTS-ISIS NA NA NA NA NA NA NA NA
states    :  NL_LPUE NA NA NA NA NA NA NA NA
logN.vars   : 0 1 1 1 1 1 1 1
catchabilities :      age
catchabilities : fleet    1 2 3 4 5 6 7 8
catchabilities :  catch  NA NA NA NA NA NA NA NA
catchabilities :  SNS    0 0 1 2 2 2 NA NA
catchabilities :  BTS-ISIS 3 3 4 4 5 5 5 NA
catchabilities :  NL_LPUE  6 NA NA NA NA NA NA NA
power.law.exps :      age
power.law.exps : fleet    1 2 3 4 5 6 7 8
power.law.exps :  catch  NA NA NA NA NA NA NA NA
power.law.exps :  SNS   NA NA NA NA NA NA NA NA
power.law.exps :  BTS-ISIS NA NA NA NA NA NA NA NA
power.law.exps :  NL_LPUE NA NA NA NA NA NA NA NA
f.vars    :      age
f.vars    : fleet    1 2 3 4 5 6 7 8
f.vars    :  catch   0 0 1 1 2 2 2 2
f.vars    :  SNS   NA NA NA NA NA NA NA NA
f.vars    :  BTS-ISIS NA NA NA NA NA NA NA NA
f.vars    :  NL_LPUE NA NA NA NA NA NA NA NA
obs.vars    :      age
obs.vars    : fleet   1 2 3 4 5 6 7 8
obs.vars    :  catch  0 0 1 1 1 2 2 2
obs.vars    :  SNS   3 3 4 4 4 4 NA NA
obs.vars    :  BTS-ISIS 5 5 5 6 7 7 7 NA
obs.vars    :  NL_LPUE 8 NA NA NA NA NA NA NA
obs.weight    : NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
NA NA NA NA NA NA NA
srr     : 0
scaleNoYears  : 0
scaleYears    : NA
scalePars    :
cor.F     : 2
cor.obs    : NA 0 NA NA NA 1 NA NA NA 1 NA NA NA 1 NA NA NA 1 NA NA NA NA NA NA NA NA
NA NA
cor.obs.Flag  : ID AR ID ID
biomassTreat  : -1 -1 -1 2
nohess     : FALSE
timeout    : 3600
likFlag    : LN LN LN LN
fixVarToWeight : FALSE
simulate    : FALSE
residuals   : TRUE
sam.binary   :
```

Table 22.3.4. Turbot in Area 4. FLR, R SOFTWARE VERSIONS

FLSAM.version	2.01
FLCore.version	2.6.2
R.version	R version 3.3.3 (2017-03-06)
platform	x86_64-w64-mingw32
run.date	2017-09-20 17:10:59

Table 22.4.1. Turbot in Area 4. Stock Summary

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
	Age 1		(Ages 2-6)			SOP								
	thousands	thousands	thousands				f	f	f	tonnes				
1981	3058	1911	4895	21202	15253	29470	16702	11255	24784	0.3535	0.2591	0.4823	4755	1.0000
1982	4240	2852	6304	20179	14225	28626	15393	9970	23766	0.3421	0.2515	0.4654	4453	1.0000
1983	5523	3560	8569	20061	14225	28292	14220	9034	22382	0.3798	0.2799	0.5154	4575	1.0000
1984	4649	3113	6943	20803	15166	28534	13087	8349	20513	0.4114	0.3039	0.5568	5297	1.0000
1985	3123	2045	4769	20709	15453	27754	13262	8836	19905	0.4656	0.3442	0.6299	6188	1.0000
1986	3454	2351	5073	18237	13435	24754	12639	8413	18986	0.4380	0.3218	0.5962	5263	1.0000
1987	3715	2560	5391	16571	12053	22783	11518	7491	17712	0.4106	0.3065	0.5500	4271	1.0000
1988	4068	2766	5983	15791	11765	21196	9788	6337	15120	0.3979	0.2982	0.5310	4041	1.0000
1989	4841	3084	7599	16852	12743	22286	10257	6806	15457	0.5485	0.4241	0.7095	4927	1.0000
1990	5746	3597	9180	16659	12396	22386	9106	5893	14071	0.6673	0.4991	0.8922	5750	1.0000
1991	5437	3520	8398	16907	11941	23938	7886	4752	13087	0.7160	0.5283	0.9704	6340	-0.0067
1992	5429	3480	8468	16534	11660	23446	7401	4548	12043	0.7529	0.5542	1.0228	5933	-0.0072
1993	5939	3727	9464	15438	11032	21605	6647	4212	10488	0.7832	0.5820	1.0540	5546	-0.0077
1994	5213	3294	8249	14446	10444	19981	5665	3719	8630	0.7974	0.5994	1.0608	5244	-0.0082
1995	5815	3681	9185	13356	9859	18095	5301	3723	7549	0.7953	0.6141	1.0298	4671	-0.0091
1996	4070	2721	6086	12562	9342	16891	4670	3302	6604	0.7244	0.5582	0.9400	3644	-0.0115
1997	3820	2566	5687	11691	9031	15134	4818	3486	6657	0.6692	0.5032	0.8899	3382	-0.0122
1998	5270	3439	8075	10760	8537	13562	4560	3405	6108	0.5900	0.4313	0.8073	3086	1.0000
1999	4961	3204	7684	11786	8960	15504	4555	3283	6319	0.5041	0.3694	0.6880	3187	-0.0123
2000	6551	3998	10733	13279	9980	17667	5660	4054	7902	0.5072	0.3713	0.6928	4025	-0.0095
2001	4717	3014	7383	13097	9819	17468	5873	4198	8215	0.5240	0.3820	0.7188	4100	-0.0090
2002	6208	4221	9132	12191	9453	15723	5895	4232	8212	0.5237	0.3727	0.7360	3749	-0.0095
2003	5794	4106	8175	12270	9568	15734	5832	4062	8373	0.4661	0.3461	0.6278	3374	1.0000
2004	7587	5376	10708	12761	9978	16320	5847	4039	8463	0.3991	0.2939	0.5419	3317	1.0000
2005	6298	4543	8732	13544	10604	17300	6064	4289	8574	0.3476	0.2578	0.4687	3195	1.0000
2006	7235	5131	10201	13488	10622	17128	6430	4612	8966	0.2844	0.2085	0.3878	2976	1.0000
2007	5308	3836	7344	14243	10983	18470	7797	5439	11178	0.2666	0.1915	0.3713	3509	1.0000
2008	3893	2770	5472	14167	10955	18319	8465	6020	11901	0.3155	0.2338	0.4257	3005	1.0000
2009	3926	2806	5493	12883	9995	16604	8667	6316	11895	0.3608	0.2752	0.4730	3089	1.0000
2010	5670	4065	7909	11922	9303	15279	7900	5759	10838	0.3675	0.2838	0.4758	2692	1.0000
2011	6137	4323	8711	12835	9987	16495	7740	5540	10813	0.3290	0.2531	0.4276	2771	1.0000
2012	4122	2908	5844	14148	10729	18658	8891	6109	12940	0.2991	0.2284	0.3917	2914	1.0000
2013	3715	2585	5339	13952	10653	18273	9427	6686	13292	0.2954	0.2252	0.3875	2982	1.0000
2014	5842	4116	8292	14018	10843	18124	10226	7504	13936	0.2993	0.2275	0.3937	2834	1.0000
2015	7121	4593	11042	16052	12056	21372	10868	7586	15569	0.2993	0.2209	0.4054	2922	1.0000
2016	4524	2640	7752	17729	12966	24242	11789	7954	17472	0.3603	0.2493	0.5207	3493	1.0000

Table 22.4.2. Turbot in Area 4. Estimated fishing mortality (units: na)

age	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.003997882	0.003850043	0.004307046	0.0050590	0.005780275	0.005790076	0.005999697	0.006914063	0.009035375
2	0.120036101	0.114062490	0.133134163	0.1659864	0.199117097	0.199680049	0.209760345	0.226761052	0.308898145
3	0.587951464	0.554960461	0.583954562	0.6335307	0.703903616	0.669657286	0.668024135	0.673709309	0.874586364
4	0.499893095	0.479811507	0.520656766	0.5493282	0.615262094	0.585339574	0.546553317	0.494905430	0.651315562
5	0.292582995	0.289111012	0.345708671	0.3780767	0.452683923	0.413489259	0.355272364	0.333690060	0.550775074
6	0.266982354	0.272513051	0.315552364	0.3299079	0.357260870	0.322078615	0.273171527	0.260605483	0.357095134
7	0.200997350	0.210489434	0.237509086	0.2340786	0.231767030	0.212180358	0.186912165	0.185692822	0.237395154
8	0.200997350	0.210489434	0.237509086	0.2340786	0.231767030	0.212180358	0.186912165	0.185692822	0.237395154

age	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.01040317	0.01192223	0.01400104	0.01661019	0.01910639	0.02176006	0.02134101	0.02129047	0.0207356
2	0.35361883	0.38171368	0.42611389	0.48259034	0.52281329	0.56029373	0.48646226	0.43321154	0.3744910
3	0.99605777	1.04946624	1.10274043	1.16025788	1.19381511	1.19206528	1.07644915	0.95254616	0.8228175
4	0.75693745	0.80549544	0.83562597	0.86042088	0.86720197	0.85806797	0.79378608	0.73477094	0.6508672
5	0.73948004	0.81361254	0.84894397	0.86215134	0.86369599	0.84513037	0.78136458	0.75628122	0.6756188
6	0.49053078	0.52968997	0.55089112	0.55082745	0.53960529	0.52083772	0.48379225	0.46894823	0.4264051
7	0.32853346	0.34220479	0.35039516	0.34918794	0.33985319	0.33086319	0.31165267	0.30089703	0.2754592
8	0.32853346	0.34220479	0.35039516	0.34918794	0.33985319	0.33086319	0.31165267	0.30089703	0.2754592

age	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.02355517	0.03098823	0.03977513	0.04805244	0.04895199	0.05341126	0.05379890	0.04911474	0.03791102
2	0.39842481	0.52058630	0.65270379	0.76197120	0.69928477	0.68187916	0.62191616	0.51934876	0.44638853
3	0.73938278	0.75377471	0.77399756	0.75689806	0.67610665	0.60469606	0.54338857	0.44136348	0.40386483
4	0.56378465	0.54612256	0.54209114	0.52115302	0.46978878	0.39565379	0.33455214	0.26179365	0.25229671
5	0.50287320	0.45032925	0.41679989	0.37680270	0.31774322	0.20824966	0.15011815	0.11691513	0.13338189
6	0.31613953	0.26524257	0.23452594	0.20175936	0.16771736	0.10479988	0.08813416	0.08244174	0.09719425
7	0.21098885	0.17555114	0.15184854	0.12993581	0.10856374	0.06319364	0.05704035	0.05989036	0.06429518
8	0.21098885	0.17555114	0.15184854	0.12993581	0.10856374	0.06319364	0.05704035	0.05989036	0.06429518

age	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.04048713	0.04536014	0.04303217	0.03592528	0.02966324	0.02608579	0.01738545	0.01286938	0.01333984
2	0.48994620	0.61902790	0.58846378	0.49934773	0.42392132	0.39371397	0.29978012	0.24102709	0.25263074
3	0.44624672	0.52003292	0.51851474	0.47195327	0.43700312	0.42046925	0.39956542	0.37584208	0.40552366
4	0.29975935	0.33279286	0.34627983	0.32732431	0.32134306	0.33231801	0.35391905	0.35638376	0.42375940
5	0.20650482	0.20169582	0.22601583	0.20045964	0.17664978	0.18531920	0.23806094	0.29212094	0.42871724
6	0.13485515	0.13051949	0.15809189	0.14596691	0.13638067	0.14524967	0.20513150	0.23089064	0.29085029
7	0.07509535	0.07778274	0.09276188	0.08899243	0.08490419	0.08594778	0.12043365	0.12237929	0.13309096
8	0.07509535	0.07778274	0.09276188	0.08899243	0.08490419	0.08594778	0.12043365	0.12237929	0.13309096

Table 22.4.3. Turbot in Area 4. Estimated population abundance (units: na)

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	3058.0986	4239.8976	5523.0911	4649.1851	3122.5210	3453.6913	3714.8899	4068.0604	4840.5349	5746.3707
2	3199.6293	2243.7708	3528.4054	5185.1496	4074.0450	2163.1809	2836.7891	3225.5872	3109.3906	3930.3894
3	1702.2277	2374.0640	1560.7727	2621.8219	3838.9119	2973.1823	1253.8681	1829.8478	2088.6036	1790.9820
4	1386.7553	712.1951	1121.5602	758.5080	1181.3881	1453.5938	1499.4909	517.3870	790.7917	656.3920
5	1899.9212	664.9356	364.6478	515.0138	401.9193	509.4095	589.0500	645.0857	356.9553	338.7702
6	799.4906	1178.6910	413.4617	208.0874	286.6113	211.7288	265.5375	334.8838	394.5465	179.7628
7	402.6022	503.9956	743.2550	250.9676	119.5905	159.7338	124.4993	164.5622	202.5980	252.0665
8	661.5214	732.6766	830.0471	980.8618	772.0144	580.6968	483.2675	417.5866	393.8525	397.1208

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	5437.01553	5428.77211	5939.20569	5212.61185	5814.93197	4069.72709	3820.29942	5269.55297	4961.37875
2	5166.32822	4560.69696	4388.09877	5159.50994	3715.33985	5312.72188	3404.82208	3007.00207	4549.97821
3	2290.89305	2963.02134	2434.58143	2024.56521	2472.69027	1594.88000	2700.30238	1672.06585	1759.07019
4	503.03582	642.87730	769.70161	620.48486	495.65196	634.41289	405.12251	809.04398	558.88273
5	245.64888	184.43089	237.66491	263.15876	225.96980	186.96459	228.11823	154.66789	352.46282
6	130.83532	86.60550	63.41517	80.79011	92.84955	82.53360	70.46312	82.40402	61.68105
7	92.59398	62.32402	38.61021	30.51198	38.74066	46.55761	42.84899	34.91212	41.33591
8	386.39610	281.87641	201.43655	141.04774	102.13610	81.61012	73.12578	66.12821	60.86779

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	6550.92561	4717.14931	6208.32375	5793.6704	7587.0175	6298.32655	7234.5517	5307.8262	3893.3489	3925.6780
2	3663.15177	5320.67696	3221.90548	4894.4569	4202.2335	6234.65643	4852.3322	5407.9376	4781.9036	2652.0397
3	2631.81270	1600.46508	2151.02403	1097.3226	2042.6899	1807.91790	2573.5709	2252.3319	2804.0431	2587.9017
4	764.95717	990.64505	569.99196	881.9696	458.6350	840.96342	645.4141	1549.0847	1044.5269	1661.4099
5	252.93562	380.62367	453.22968	280.2697	477.8383	213.57325	386.1189	383.0804	1029.5373	616.9979
6	196.07388	122.49628	217.29770	253.9426	151.2300	292.73782	143.9317	309.6251	263.4588	493.3022
7	36.82332	131.35603	73.86474	155.9621	174.3133	95.56824	217.5445	113.0699	220.9273	166.2817
8	67.75128	72.08704	145.94406	169.2186	217.9932	294.05593	273.2243	342.3196	276.5223	309.4676

age	2010	2011	2012	2013	2014	2015	2016
1	5670.1871	6136.7904	4122.2257	3714.9345	5841.6782	7121.2076	4523.9494
2	3213.5127	4587.1541	5383.3436	3276.3874	2287.4200	4981.0338	6157.6989
3	1046.1501	1731.9302	2404.4947	3535.3191	1989.9396	1536.9155	3247.9872
4	1188.0335	472.9785	1043.0705	1231.4354	2124.8895	1247.3973	953.7757
5	924.5945	816.9479	301.6518	610.4727	708.5030	1326.3343	967.3724
6	441.2355	651.6832	619.6441	236.6567	444.5970	515.3059	806.0878
7	312.4968	316.5041	564.1994	464.1700	189.0050	318.7744	354.9883
8	291.5959	396.5256	516.5400	697.2502	802.5777	831.6600	915.3175

Table 22.4.4a. Turbot in Area 4. Predicted catch numbers at age (units: na)

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	11.05953	14.76751	21.51553	21.26543	16.31305	18.07370	20.14237	25.40764	39.46740	53.91029
2	328.67632	219.63773	399.51694	720.74580	668.87646	356.06142	488.20945	595.38507	752.76779	1067.29937
3	692.52438	924.87322	631.75692	1126.86611	1778.79808	1329.93677	559.89266	822.03579	1119.47250	1040.49517
4	498.56909	247.95980	416.14341	293.21818	497.02955	589.41398	577.43537	184.56284	346.76001	319.79596
5	438.93830	152.03918	97.15392	147.87723	133.62476	157.43569	160.58421	166.80661	138.26481	162.43586
6	170.54187	255.98531	101.94244	53.28929	78.50116	53.12452	57.79062	69.93439	108.02197	63.68157
7	66.66485	87.00921	142.97905	47.65678	22.50917	27.77590	19.29715	25.35488	38.95688	64.32332
8	109.53795	126.48845	159.67514	186.25795	145.30757	100.97661	74.90551	64.33957	75.73258	101.33883

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	58.41336	68.42591	88.69834	89.438401	113.485333	77.91171	72.96521	98.048187	104.724476
2	1495.23140	1444.33782	1534.72719	1920.487767	1457.903558	1869.80714	1092.76245	856.607643	1364.176063
3	1372.60855	1826.45607	1543.77247	1303.791787	1591.122595	969.70006	1526.87373	861.436659	843.374757
4	255.54345	334.57543	408.25065	330.772034	262.430580	319.15684	193.39878	354.587697	220.336139
5	125.62158	96.97689	126.22100	139.921579	118.472039	93.06838	111.07418	69.622586	127.305770
6	49.19140	33.55157	24.56532	30.809525	34.460100	28.92240	24.09318	26.111151	15.232189
7	24.45893	16.79441	10.37411	8.013001	9.945525	11.35755	10.14193	7.653708	7.151451
8	102.06749	75.95704	54.12364	37.041700	26.220439	19.90847	17.30815	14.497142	10.530627

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	181.261688	166.826317	264.203629	251.06480	357.96271	299.262189	314.52222	179.078827	140.10875
2	1359.033116	2336.680397	1576.812874	2257.45004	1904.02666	2643.771206	1796.92014	1777.942566	1692.42471
3	1278.572316	791.622239	1047.947597	494.20501	848.51009	693.136686	838.45631	682.840876	921.63776
4	294.398951	379.111747	211.644981	301.99609	136.72232	217.932943	135.32325	314.389009	246.42296
5	83.743150	118.399434	129.773212	69.51297	81.70087	27.050096	38.68926	43.451343	174.69762
6	41.585948	23.300701	36.104786	35.63763	13.66130	22.415934	10.33749	26.033885	30.19218
7	5.389220	16.814950	8.175031	14.56873	9.68512	4.807011	11.47340	6.388486	14.50424
8	9.915633	9.227898	16.152460	15.80705	12.11204	14.790794	14.40998	19.341158	18.15413

age	2009	2010	2011	2012	2013	2014	2015	2016
1	157.90598	216.61331	196.38922	109.25306	86.73329	91.27957	82.54808	54.34573
2	1120.75868	1308.21430	1647.78109	1697.75911	972.77571	539.67640	970.80392	1251.17525
3	959.32743	386.93130	595.19134	777.14657	1107.57704	598.02512	439.13371	988.00121
4	428.62842	316.97095	120.31863	261.20510	317.31434	577.42605	340.95169	300.70167
5	102.48716	170.16147	134.94620	44.40120	93.88561	136.57559	306.00367	307.87182
6	54.82669	58.63262	80.41350	71.76234	29.06823	74.98799	96.66278	185.27474
7	11.29284	25.13000	24.46182	41.68343	34.69745	19.47584	33.34775	40.18265
8	21.01716	23.44922	30.64648	38.16232	52.12056	82.70087	87.00195	103.60874

Table 22.4.4b. Turbot in Area 4. Catch at age residuals (units: na)

age	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.00000000	0.000000000	0.00000000	0.0000000	0.0000000	0.00000000	0.3309887	1.20304148	0.0000000
2	0.04374955	-2.120045728	1.09682795	2.0446403	0.0305713	-0.90755424	0.4935080	0.88286685	-0.2679269
3	-3.55289715	0.002894272	-0.09259620	0.4553059	0.5644825	-0.25594164	-1.8213677	-0.54841303	0.4563584
4	1.99909566	-1.654368651	0.75128126	0.3792106	0.4154605	-0.58567070	1.0586554	-1.30585385	0.5312791
5	0.51593822	-1.402874436	0.43948247	-0.2817548	0.9106259	-0.29569703	-1.0472644	-0.18169713	2.9811073
6	1.87113393	-2.054560451	-0.08792520	-0.1668192	-0.2122292	-0.07017426	-0.6929809	0.29769094	-0.5659385
7	0.16513517	-1.023094723	0.06919896	-0.1546216	-0.7683362	-0.51316168	-0.1887388	0.04321231	-0.3828237
8	1.14034211	0.012650520	-0.07571357	-0.8138738	-0.8999697	-0.17757998	-0.5388380	-0.05368932	-0.4339008

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.71434731	0	0	0	0	0	0	0	0.00000000	0	0	0	0	1.58557427	1.4148289
2	0.09577495	0	0	0	0	0	0	0	-0.36803326	0	0	0	0	-0.07167284	-0.2060452
3	-0.21996847	0	0	0	0	0	0	0	-0.99434740	0	0	0	0	-2.22741559	-0.7015181
4	-0.93021481	0	0	0	0	0	0	0	0.08464074	0	0	0	0	0.06915722	-0.2308778
5	0.25098967	0	0	0	0	0	0	0	0.94970517	0	0	0	0	-0.55581650	-0.4334341
6	0.85499835	0	0	0	0	0	0	0	0.05562634	0	0	0	0	-0.92437575	-1.6258090
7	1.78384193	0	0	0	0	0	0	0	-0.18619938	0	0	0	0	0.05103255	-1.6668240
8	0.09988640	0	0	0	0	0	0	0	-0.34569241	0	0	0	0	-0.15045705	-2.4700296

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.2363639	1.80921066	-2.4751680	0.04665691	-0.449070838	0.9963093	-0.2124384	0.00000000	0.006606296
2	-0.4901555	-0.27187750	0.7884886	0.09387749	0.005534742	0.4310452	0.1787552	-0.05509211	0.366782163
3	0.1369908	-1.25990353	-0.9435583	0.08978061	1.152778786	-0.6039085	1.2247125	0.16380041	1.212539518
4	-0.6158839	-2.58149405	0.6665754	-0.43349556	1.188556449	-0.1190901	-0.5225276	1.26497089	0.388422957
5	-1.5262587	-1.05836394	0.4321044	2.26316520	-0.543208680	0.1763780	0.4047616	-0.66205496	-0.432077448
6	0.1532540	-0.01552558	1.1338534	1.06807574	-2.183263721	1.7448913	0.1683364	0.21559460	0.486475630
7	-1.6893056	1.32058744	0.5757596	-0.55243252	0.207732408	0.3025896	0.7064365	1.79597635	0.607276216
8	1.0964191	0.57975538	-1.0068425	-1.81908808	-0.131401753	-0.8248043	-1.2978333	-1.83928992	-2.242621044

age	2014	2015	2016
1	-1.311329727	-1.6521357	0.0000000
2	-1.647397798	0.3732681	-0.6446977
3	0.856275802	0.9823942	0.0517744
4	1.545041686	0.7662223	1.4569051
5	0.323617502	1.0226371	2.6725442
6	1.766401431	0.3658857	-0.4233574
7	2.052133393	0.1794648	-0.1844594
8	-0.001647798	-0.4465169	-1.0718416

Table 22.4.5a. Turbot in Area 4. Predicted index at age SNS (units: na).

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	115.6510258	95.980916	110.6128359	81.797669	59.890619	60.180826	87.067012	94.705131	63.897121	57.729263
2	41.1278293	63.654258	53.2560926	62.486936	53.582380	27.131842	33.592113	51.060607	63.195859	39.289869
3	11.6403865	10.757582	16.4554542	14.787248	17.867479	15.654337	6.334987	10.837727	15.421713	22.940333
4	1.5443094	2.956325	2.3883092	5.770787	3.763115	5.847774	4.142028	1.671204	3.701119	4.335815
5	1.8362297	0.855050	1.5824563	1.551883	3.961160	2.381971	3.508794	3.156644	1.185297	2.384148
6	0.6251123	1.224339	0.6043969	1.286723	1.066180	2.002435	1.756603	2.616690	2.504915	0.950723

age	2014	2015	2016
1	91.336914	111.697915	70.935741
2	29.308372	66.520289	81.564336
3	13.104223	10.291648	21.299108
4	7.368545	4.318128	3.148532
5	2.666001	4.804184	3.182274
6	1.712251	1.948853	2.922389

Table 22.4.5b. Turbot in Area 4. Index at age residuals SNS

age	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.6406214	-0.8227174	0.6424782	0.1500086	-0.5948697	-1.4757955	0.82584879	0.764627906	-1.235189099
2	-1.0578024	1.5585476	0.8872064	-0.3765265	1.4258555	-1.0223714	0.51626347	-0.006780442	-0.338209679
3	1.3534750	0.1128069	-0.5236515	1.4714906	0.2310289	-0.9405161	0.18072078	0.000000000	0.009042746
4	0.9649828	0.0000000	0.5765803	0.5398330	0.7012099	1.8676025	0.05327686	0.000000000	-0.946312703
5	0.1291654	0.0000000	-0.9638592	-0.8794097	0.2264855	0.4082947	-0.15073065	0.000000000	0.000000000
6	1.7077426	0.0000000	0.0000000	0.0000000	-0.6666473	0.0000000	1.60759648	-0.200250703	0.000000000

age	2013	2014	2015	2016
1	0.8032300	1.38957325	2.68628480	-1.19166968
2	-1.3724792	-0.79475076	-0.05267627	0.87287097
3	0.7320474	0.27514972	-1.62854061	-0.06677688
4	-2.7942514	-0.05012638	0.30776417	-0.79869905
5	0.0000000	0.84125613	0.00000000	-0.76712365
6	0.0000000	-0.91685517	0.00000000	-1.63903097

Table 22.4.6a. Turbot in Area 4. Predicted index at age BTS-ISIS

age	1991	1992	1993	1994	1995	1996	1997	1998
1	1.576466498	1.571771101	1.716394799	1.503764857	1.674390253	1.172210595	1.100406709	1.518446488
2	1.154208596	0.987504714	0.913045733	1.043540297	0.731852637	1.102421616	0.733549191	0.675223345
3	0.184156520	0.229406489	0.181002540	0.147000111	0.179759301	0.125790758	0.232417829	0.157699547
4	0.048026351	0.060087409	0.070694583	0.056717713	0.045599594	0.061071392	0.040655688	0.086138345
5	0.013222186	0.009682877	0.012362093	0.013673253	0.011895667	0.010294883	0.012785038	0.009175700
6	0.008602887	0.005610136	0.004108095	0.005275232	0.006143408	0.005605351	0.004835917	0.005827618
7	0.006948734	0.004650190	0.002883281	0.002293577	0.002930640	0.003569998	0.003310633	0.002746219

age	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	1.426805616	1.874084891	1.341145394	1.754834917	1.63659145	2.13644761	1.773077207	2.04337599	1.51106687
2	1.004604348	0.742057463	0.981969729	0.550539858	0.87412525	0.75976371	1.175899525	0.98381187	1.15433534
3	0.175956804	0.260598187	0.156232301	0.212522722	0.11477068	0.22467947	0.207639817	0.31761855	0.28541931
4	0.063271452	0.087686345	0.113879946	0.066498017	0.10668912	0.05845641	0.111905151	0.09040416	0.21844038
5	0.023618004	0.017588454	0.027100631	0.033193129	0.02139877	0.03941104	0.018351960	0.03396430	0.03330810
6	0.004714714	0.015534841	0.009917785	0.018004428	0.02155176	0.01341680	0.026278013	0.01297219	0.02761696
7	0.003402717	0.003107932	0.011273423	0.006438017	0.01379996	0.01592504	0.008768949	0.01992092	0.01032190

age	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	1.10637299	1.11173405	1.60840864	1.74950935	1.18038599	1.06644576	1.68728751	2.06342090	1.31041203
2	0.98983945	0.50121266	0.62055471	0.94325416	1.16743142	0.72581065	0.54142019	1.22884437	1.50675647
3	0.34487307	0.30215562	0.12227615	0.20918676	0.29766557	0.44278786	0.25293403	0.19864650	0.41110939
4	0.14244440	0.22135453	0.15678731	0.06325973	0.14009769	0.16412270	0.27891997	0.16345319	0.11918071
5	0.08501848	0.05112430	0.07530932	0.06775112	0.02544006	0.05117102	0.05722044	0.10311231	0.06830122
6	0.02288345	0.04297831	0.03770202	0.05616207	0.05376306	0.02040539	0.03675008	0.04182827	0.06272330
7	0.02001499	0.01503583	0.02796034	0.02839424	0.05076159	0.04173114	0.01658432	0.02793264	0.03087187

Table 22.4.6b. Turbot in Area 4. Index at age residuals BTS-ISIS

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-0.5215564	-0.1074630	0.2678711	0.2110707	0.04041288	-1.74663501	-0.8059635	1.4956152	-0.08908703
2	0.8558361	0.4949594	0.7481750	0.7582673	-1.10543369	1.82859222	1.5257068	0.6772442	0.52087508
3	-0.7221896	0.3296298	-0.4773509	-1.5832235	-0.94648786	-0.05889062	1.1678742	0.8663920	0.17275563
4	-2.2313975	-1.3650144	-0.9896868	-0.9419736	-1.43012946	1.13203399	-0.8168602	0.8247327	0.74943921
5	-0.2827285	0.1933645	1.2648636	-0.7065430	0.54158173	2.07188606	1.2060280	-1.1213423	-0.12711821
6	0.0000000	0.1623497	-1.3023477	-0.2493694	-0.03226716	0.00000000	0.9996802	0.0000000	-0.53191471
7	0.3872762	-0.7477778	-1.6260824	0.7863827	0.00000000	1.17621069	1.2415592	-0.9986123	-1.04169039

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	2.0336852	-1.3443468	1.1479077	-0.57006312	-0.1424828	-1.3445449	-1.08388711	-0.1902009	-0.2704859
2	-0.6873813	0.0377492	-1.7301720	0.03328485	-0.2527912	0.3494854	-0.79367085	-0.4478155	0.4032392
3	0.8282355	-1.4807909	-1.3927040	0.33687312	1.3751033	1.9353709	-0.06141474	1.9225622	0.3541490
4	1.3352405	0.3279192	-0.6403477	-0.69559148	0.0000000	-0.1616283	0.43628666	0.6368473	-0.3870267
5	1.3794614	0.0000000	0.1214888	0.00000000	0.7378023	0.6999795	-2.34483690	1.0381816	-0.5229345
6	1.9449711	0.0000000	0.7016469	-0.27215649	0.1081154	-1.7543557	0.00000000	0.8458339	-0.5875451
7	0.0000000	1.8848427	-1.8673629	0.32819405	0.0000000	0.2772791	0.00000000	0.0000000	1.4833441

age	2009	2010	2011	2012	2013	2014	2015	2016
1	0.15029423	0.6060344	0.3760846	-0.4750175	-1.3441389	1.7462077	2.07104086	-1.5916825
2	-0.89875593	-0.8916108	0.4847604	0.5587157	0.3501864	-2.3433833	0.19225247	0.7886219
3	0.09077904	-0.4376153	0.2360235	0.2403094	0.9343077	0.3510070	0.60103246	0.3789511
4	0.22847780	-1.3448100	0.3650959	1.3624620	0.2001999	0.4000244	-0.60325000	-1.2611998
5	1.18733055	0.2244503	0.3186039	0.1793405	-1.0390612	0.8152461	0.02957099	-0.6183442
6	-0.16014377	-1.2071420	-1.0921988	0.1457262	0.9495664	0.2815267	0.00000000	-0.3957789
7	-1.57332934	-1.0419613	0.0000000	0.6983731	-0.0719940	-0.1998339	-0.76362139	-0.1183270

Table 22.4.7a. Turbot in Area 4. Predicted index at age NL_LPUE

age	1995	1996	1997	1998	1999	2000	2001	2002	2003
all	0.04140952	0.03648132	0.03763195	0.03562398	0.03558118	0.04421284	0.0458741	0.04605038	0.04555527

age	2004	2005	2006	2007	2008	2009	2010	2011	2012
all	0.04567166	0.04736739	0.05023114	0.06090703	0.06612061	0.06770485	0.06171158	0.06046262	0.06944947

age	2013	2014	2015	2016
all	0.07363787	0.0798802	0.08489252	0.09208609

Table 22.4.7b. Turbot in Area 4. Index at age residuals NL_LPUE

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
all	1.088666	-0.3210536	-1.53392	-1.297889	-0.7321676	-0.4677361	-0.7637251	-0.06159445	1.812658	0.4218898

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
all	-1.330611	-1.02308	0.2268083	-1.678767	-1.988996	-1.280124	0.6370704	1.759722	0.6819395	-0.9788853

age	2015	2016
all	1.69099	1.815503

Table 22.4.8. Turbot in Area 4. Fit parameters

	name	value	std.dev
1	logFpar	-4.00496165	0.13496907
2	logFpar	-4.60023142	0.26038394
3	logFpar	-5.27374189	0.27789459
4	logFpar	-7.99639445	0.10283347
5	logFpar	-8.54779253	0.13701815
6	logFpar	-9.11516550	0.25027886
7	logFpar	-11.75991253	0.16732413
8	logSdLogFsta	-1.22878929	0.24891175
9	logSdLogFsta	-1.85180385	0.21910113
10	logSdLogFsta	-1.31587047	0.18175328
11	logSdLogN	-1.13613316	0.29156789
12	logSdLogN	-1.70071705	0.19488654
13	logSdLogObs	-0.75262924	0.18201747
14	logSdLogObs	-2.10552710	0.41264746
15	logSdLogObs	-0.98225103	0.14930797
16	logSdLogObs	-0.62311627	0.15925576
17	logSdLogObs	-0.09859845	0.14013529
18	logSdLogObs	-0.92882819	0.11112510
19	logSdLogObs	-0.58399015	0.17326256
20	logSdLogObs	-0.14323540	0.09521469
21	logSdLogObs	-2.88863887	0.49539753
22	transfIRARdist	3.28605698	372.38520318
23	transfIRARdist	-0.09504957	0.42145202
24	itrans_rho	0.92483623	0.19824036

Table 22.4.9. Turbot in Area 4. Negative Log-Likelihood

352.912609753862

Table 22.7.1. Summary of SPiCT analyses (with priors on logn, logalpha, and logbeta).

```
> summary(fit)
Convergence: 0 MSG: both X-convergence and relative convergence (5)
Objective function at optimum: 7.9313578
Euler time step (years): 1/16 or 0.0625
Nobs C: 36, Nobs I1: 26, Nobs I2: 22, Nobs I3: 13

Priors
inp$priors$logn <- c(log(2), 1, 0)
inp$priors$logalpha <- c(log(2), 3, 0)
inp$priors$logbeta <- c(log(2), 1, 0)

Residual diagnostics (p-values)
shapiro bias acf LBox shapiro bias acf LBox
C 0.2538 0.7754 0.0480 0.0972 - - * .
I1 0.7237 0.6519 0.0021 0.0002 - - ** ***
I2 0.4744 0.9918 0.0875 0.3141 - - .
I3 0.3685 0.9891 0.0220 0.0176 - - * *

Model parameter estimates w 95% CI
estimate cilow ciupp log.est
alpha1 4.960137e+00 3.1489514 7.813065e+00 1.6014334
alpha2 1.196369e-01 0.0000816 1.754187e+02 -2.1232941
alpha3 7.687052e+00 4.5233648 1.306345e+01 2.0395373
beta 3.577090e-02 0.0000302 4.242571e+01 -3.3306200
r 2.402434e-01 0.0087836 6.570982e+00 -1.4261029
rc 5.570380e-01 0.2489503 1.246399e+00 -0.5851218
rold 1.748170e+00 0.0000000 2.419633e+09 0.5585694
```

```
m 4.287111e+03 3586.5805255 5.124470e+03 8.3633684
K 4.513327e+04 6317.1339573 3.224582e+05 10.7173749
q1 1.146000e-04 0.0000589 2.230000e-04 -9.0739089
q2 4.300000e-06 0.0000022 8.300000e-06 -12.3509722
q3 3.710700e-03 0.0017199 8.005900e-03 -5.5965431
n 8.625744e-01 0.0505801 1.471002e+01 -0.1478339
sdb 9.581800e-02 0.0665961 1.378623e-01 -2.3453046
sdf 1.215013e-01 0.0857153 1.722278e-01 -2.1078306
sdi1 4.752705e-01 0.3607752 6.261020e-01 -0.7438712
sdi2 1.146340e-02 0.0000093 1.411794e+01 -4.4685987
sdi3 7.365580e-01 0.5010226 1.082821e+00 -0.3057672
sdc 4.346200e-03 0.0000038 5.014694e+00 -5.4384507

Deterministic reference points (Drp)
estimate cilow ciupp log.est
Bmsyd 15392.526454 6566.9207764 3.607929e+04 9.641637
Fmsyd 0.278519 0.1244752 6.231994e-01 -1.278269
MSYd 4287.111230 3586.5805255 5.124470e+03 8.363368

Stochastic reference points (Srp)
estimate cilow ciupp log.est rel.diff.Drp
Bmsys 1.524843e+04 6530.2398757 3.560583e+04 9.632232 -0.009449893
Fmsys 2.788262e-01 0.1258981 6.175155e-01 -1.277167 0.001101726
MSYs 4.251706e+03 3600.0872308 5.021268e+03 8.355076 -0.008327321

States w 95% CI (inp$msytype: s)
estimate cilow ciupp log.est
B_2016.75 2.337392e+04 1.207222e+04 4.525598e+04 10.0593764
F_2016.75 1.545035e-01 7.960620e-02 2.998679e-01 -1.8675382
B_2016.75/Bmsy 1.532874e+00 7.565896e-01 3.105651e+00 0.4271445
F_2016.75/Fmsy 5.541214e-01 2.687584e-01 1.142478e+00 -0.5903715

Predictions w 95% CI (inp$msytype: s)
prediction cilow ciupp log.est
B_2017.00 2.346066e+04 1.208349e+04 4.554998e+04 10.0630802
F_2017.00 1.550850e-01 7.921400e-02 3.036253e-01 -1.8637817
B_2017.00/Bmsy 1.538562e+00 7.732731e-01 3.061239e+00 0.4308484
F_2017.00/Fmsy 5.562068e-01 2.679242e-01 1.154678e+00 -0.5866150
Catch_2017.00 3.645997e+03 2.888802e+03 4.601665e+03 8.201385
E(B_inf) 2.396382e+04 NA NA 10.0843006
```

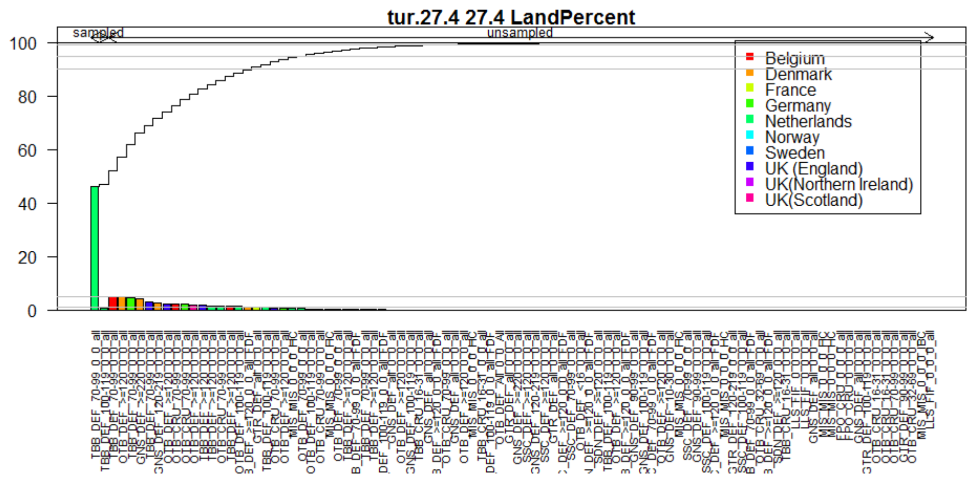


Figure 22.2.1. Turbot in 27.4.20: Total landings by métier in 2016 sorted by sampled/unsampled for numbers at age in InterCatch.

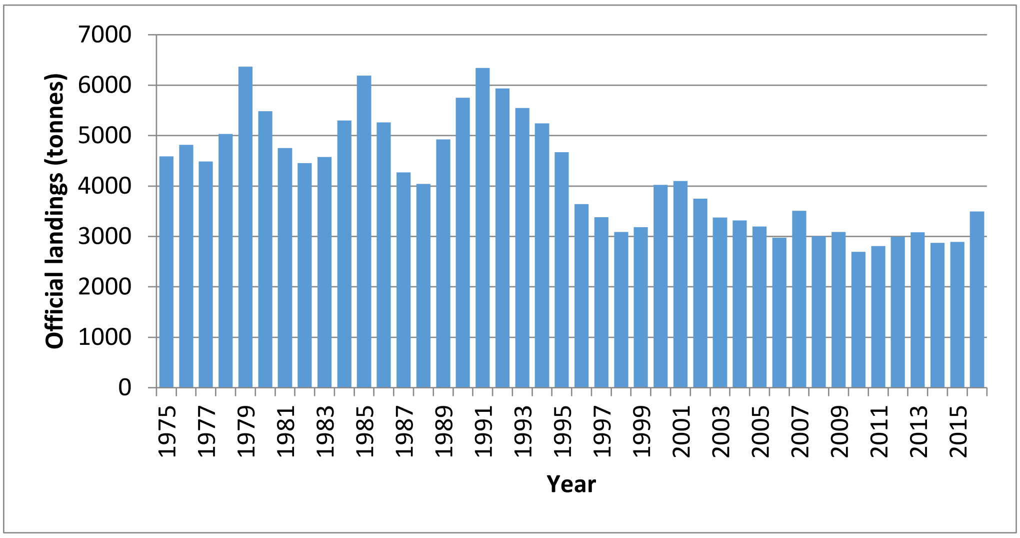


Figure 22.2.2. Turbot in 27.4.20. Total landings 1975 - 2016 (from the ICES database of official landings).

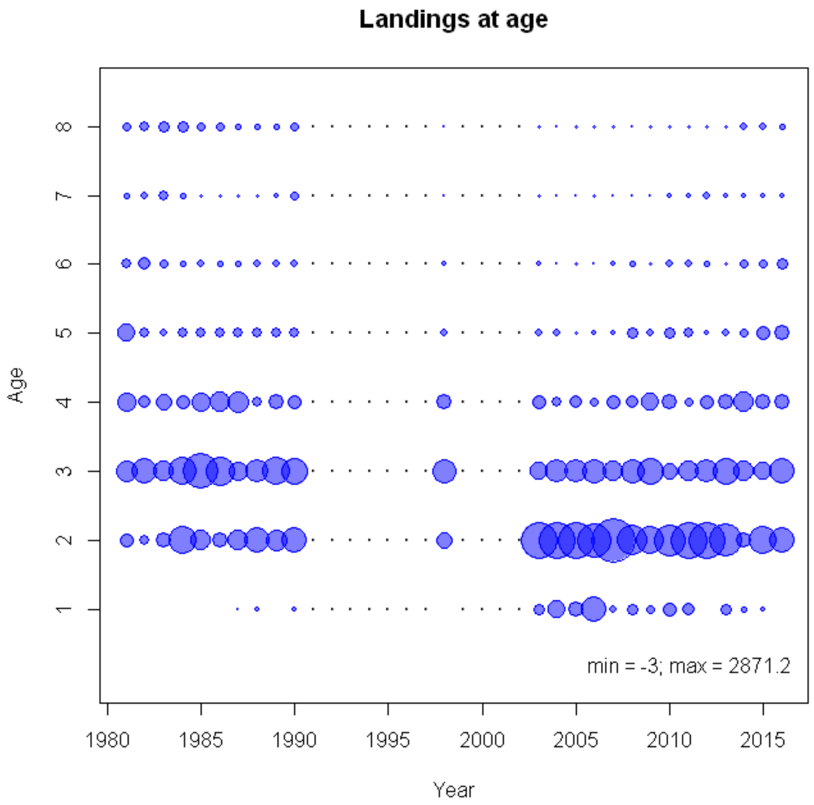


Figure 22.2.3. Turbot in 27.4.20. Landings at age for the years with available data between 1975 – 2016.

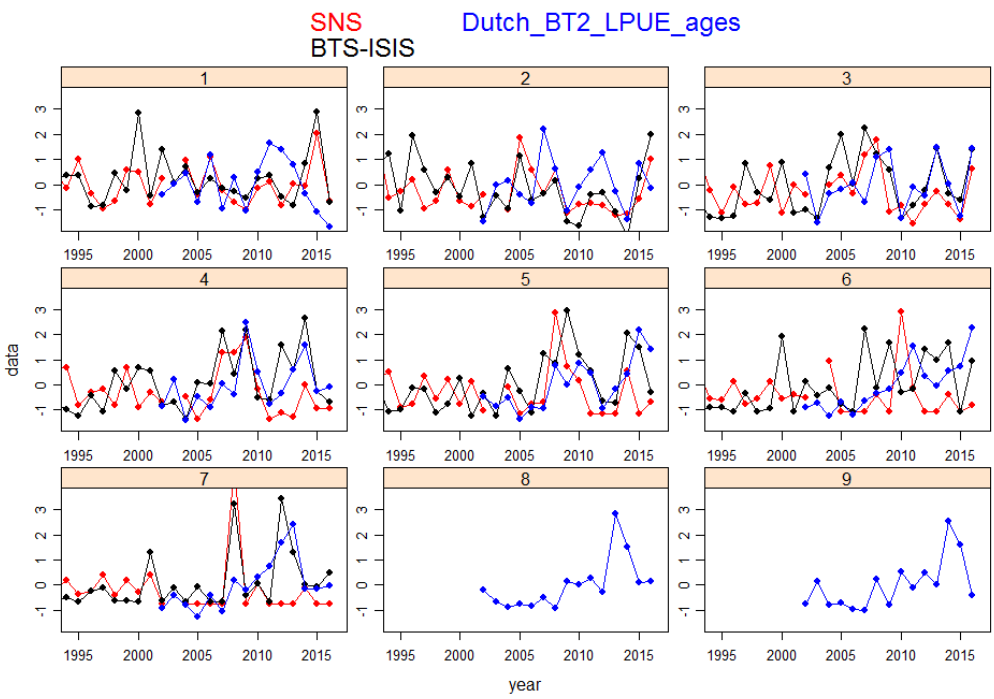


Figure 22.2.4. Turbot in 27.4.20. Time series of the standardized indices for ages 1 to 9 from the three tuning fleets available for the assessment: BTS-ISIS (black), SNS (red) and NL beam trawl LPUE (blue; not used in the final assessment).

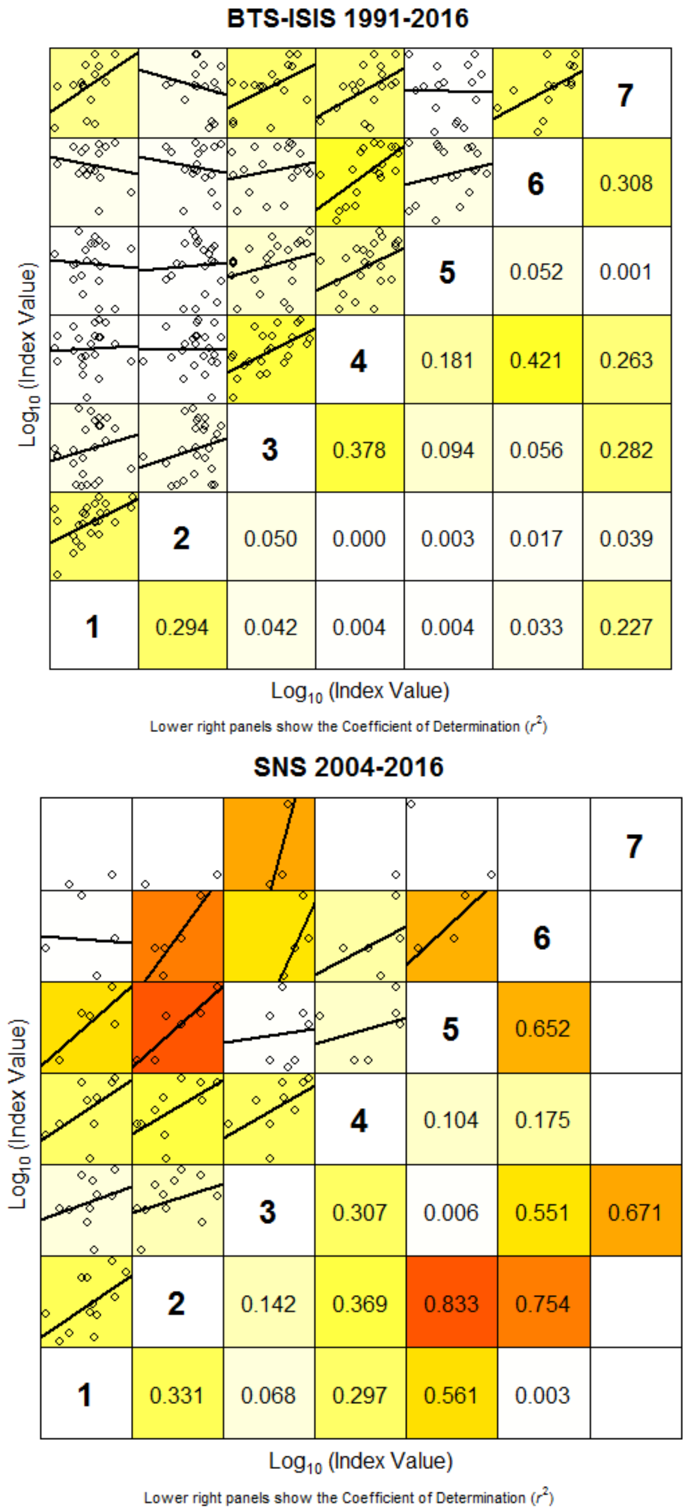


Figure 22.2.5. Turbot in 27.4.20. Internal consistency of the two tuning indices available for the assessment : BTS-ISIS (top), and SNS (bottom)

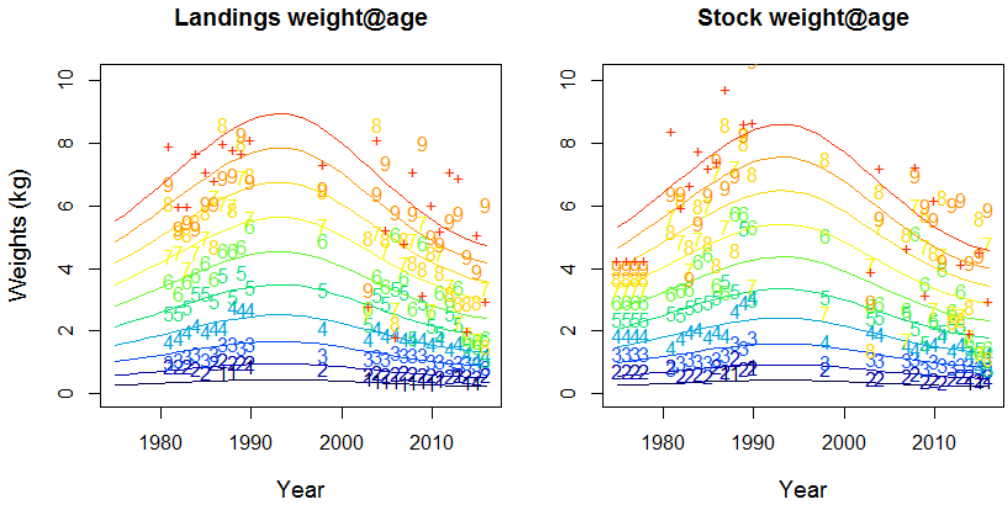


Figure 22.2.6. Landings (left) and stock (right) weight at age from observations (points) and modelled values (lines).

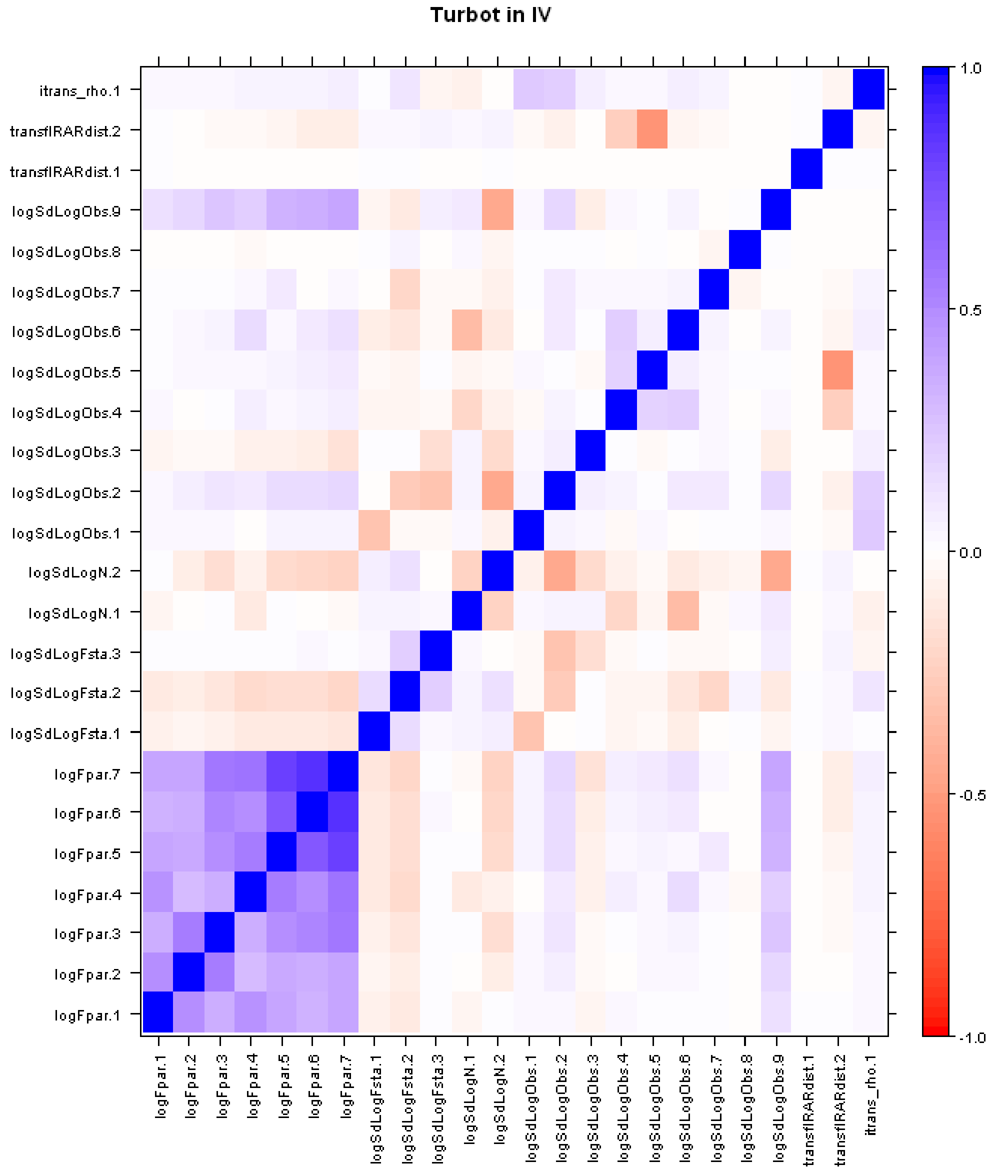


Figure 22.4.1. parameter-correlation plot. It shows the correlation among all parameters that are estimated in the model. Fpar parameters refer to catchabilities, Fstates to the random walk in F, logN to the random walk in N, logObs to the observation variances, fRARdist to the auto-correlation in the surveys and trans_rho to the correlation in the F-random walks

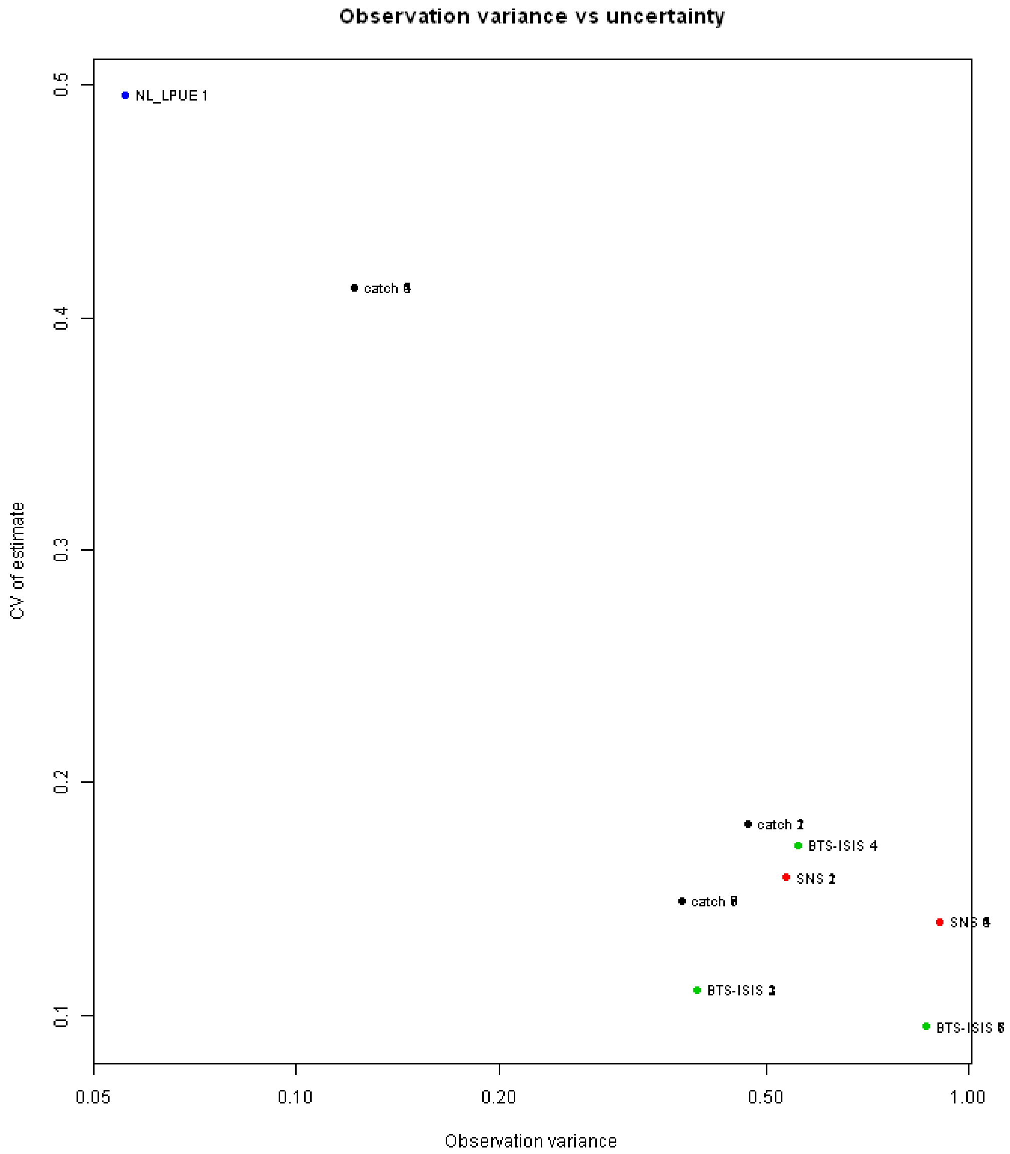


Figure 22.4.2. plot showing the observation variance vs the CV of that estimate

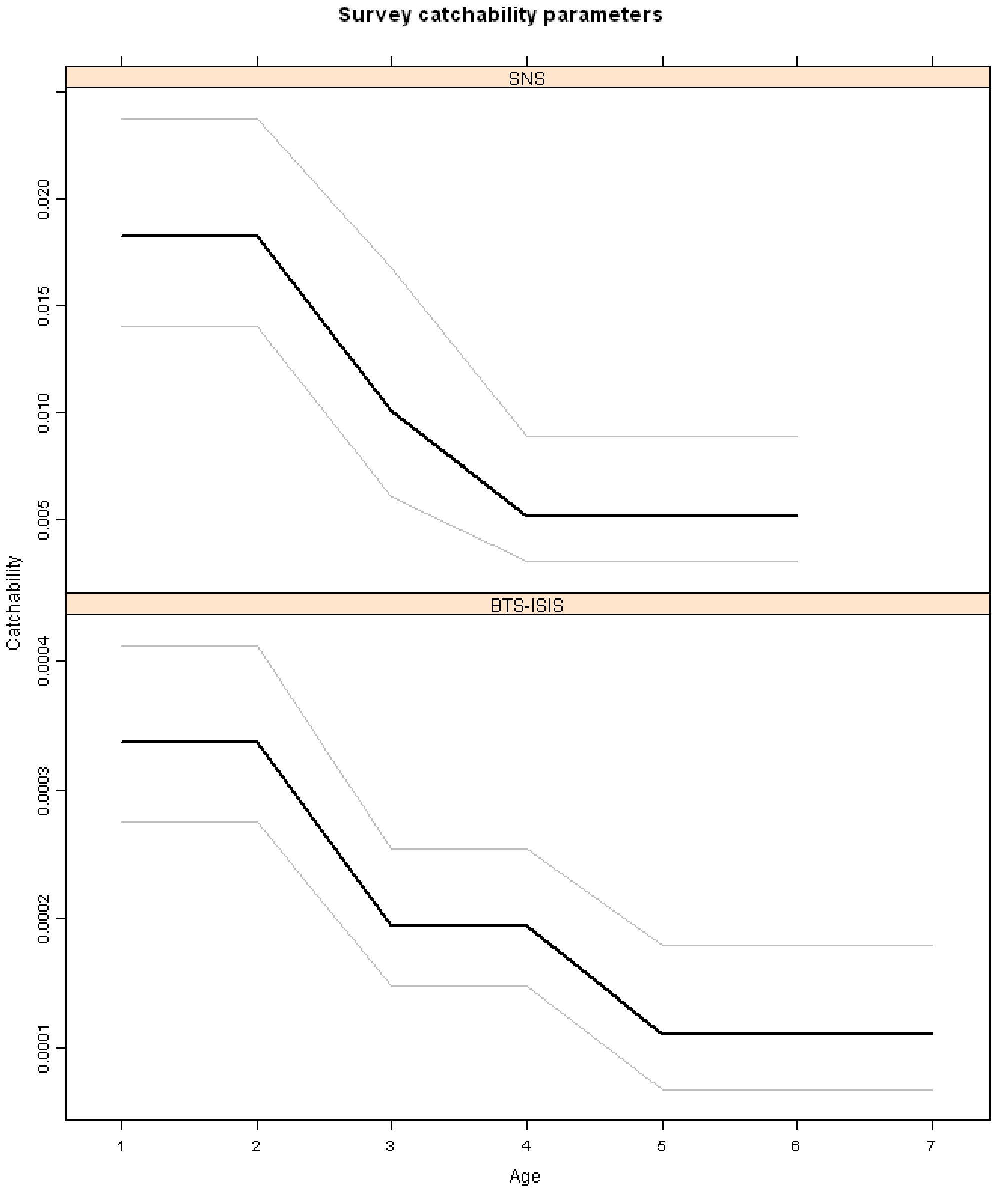


Figure 22.4.3. catchabilities of the surveys for all surveys with more than 1 age-group

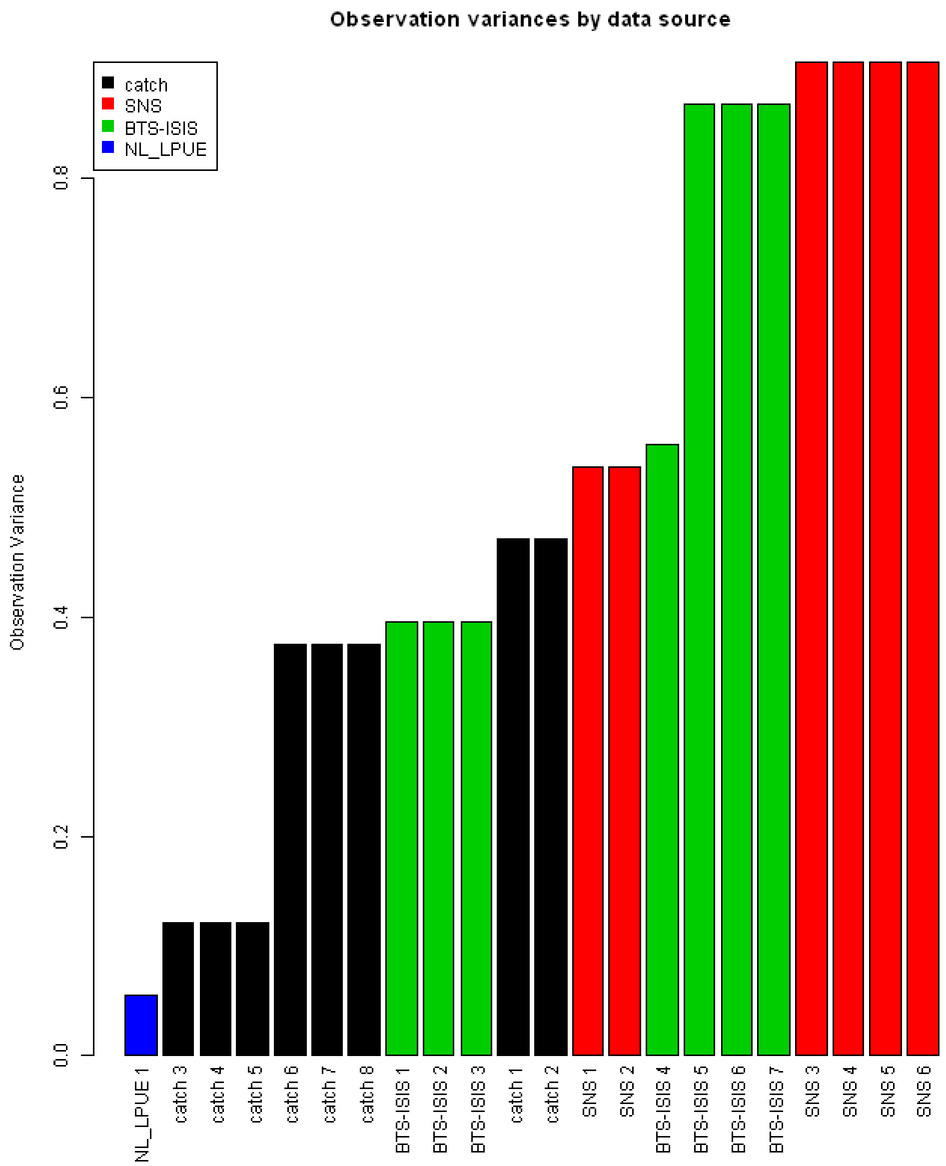


Figure 22.4.4. Estimated observation variances (scaling factor for each of the surveys), ordered from the best to the worst survey fit and has colour coding to show which bars belong to one dataset

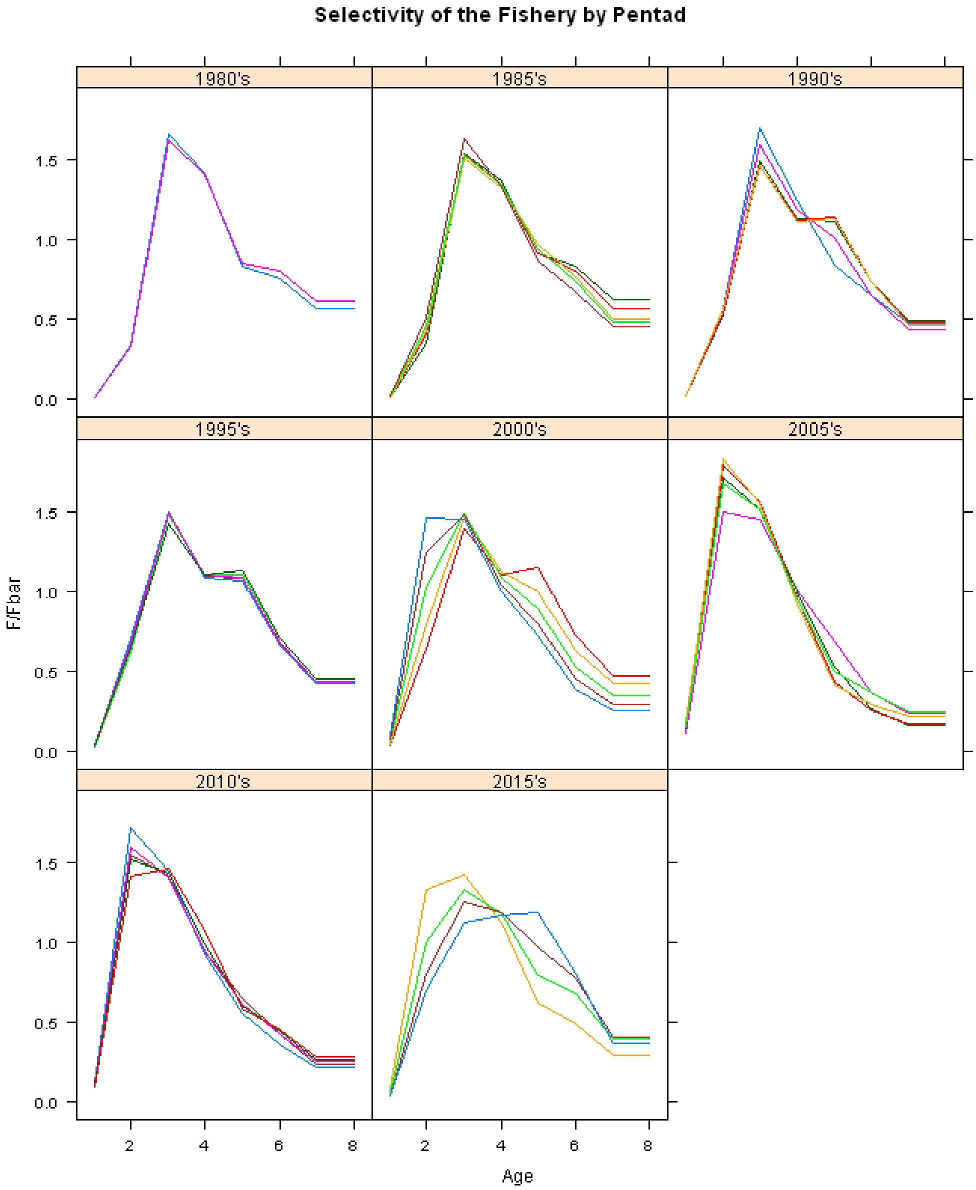


Figure 22.4.5. estimated selectivity, grouped by a 5-year period. Values represent actual F-at-age

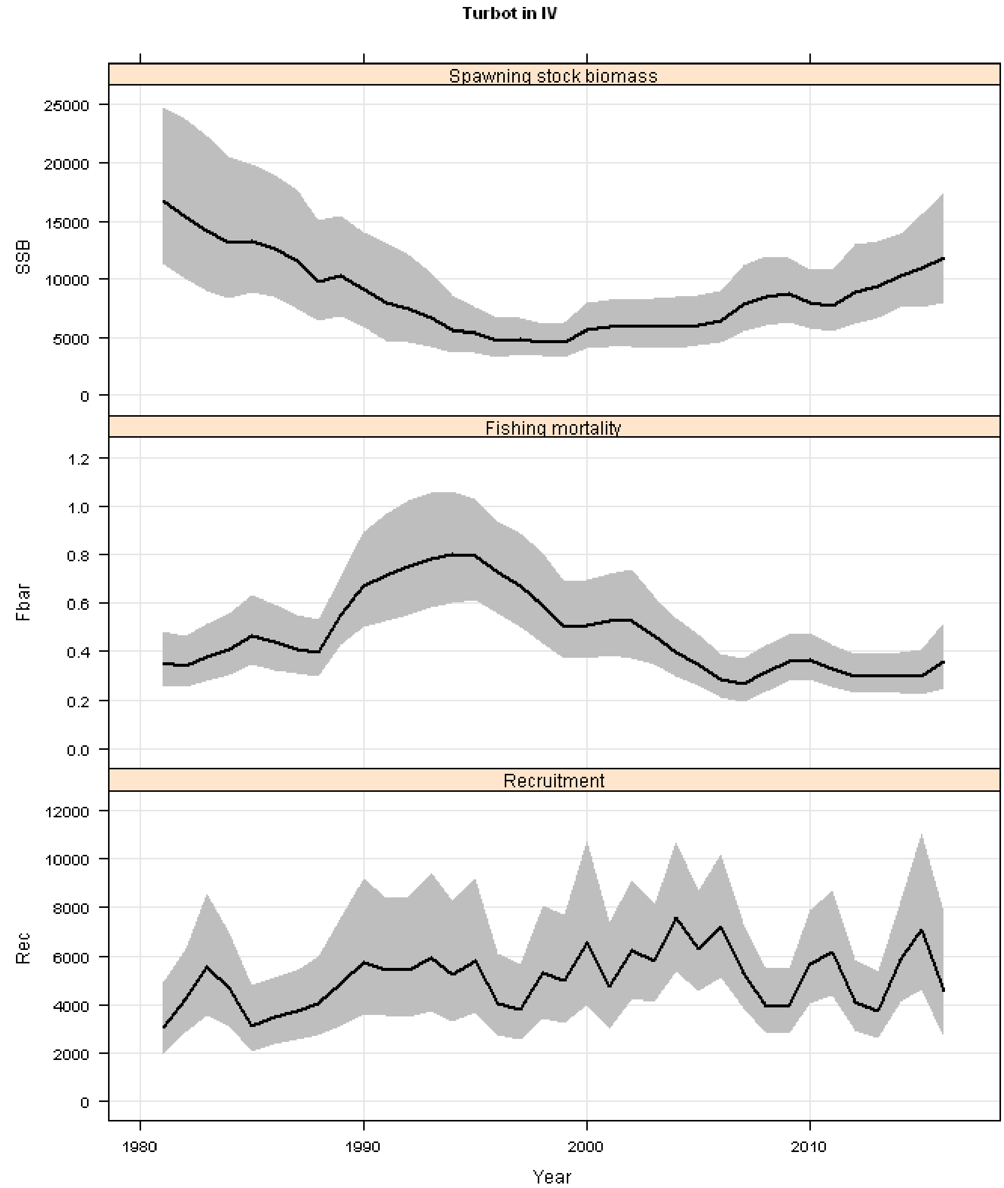


Figure 22.4.6. summary plot of SSB, F and Recruitment, including the uncertainty bounds

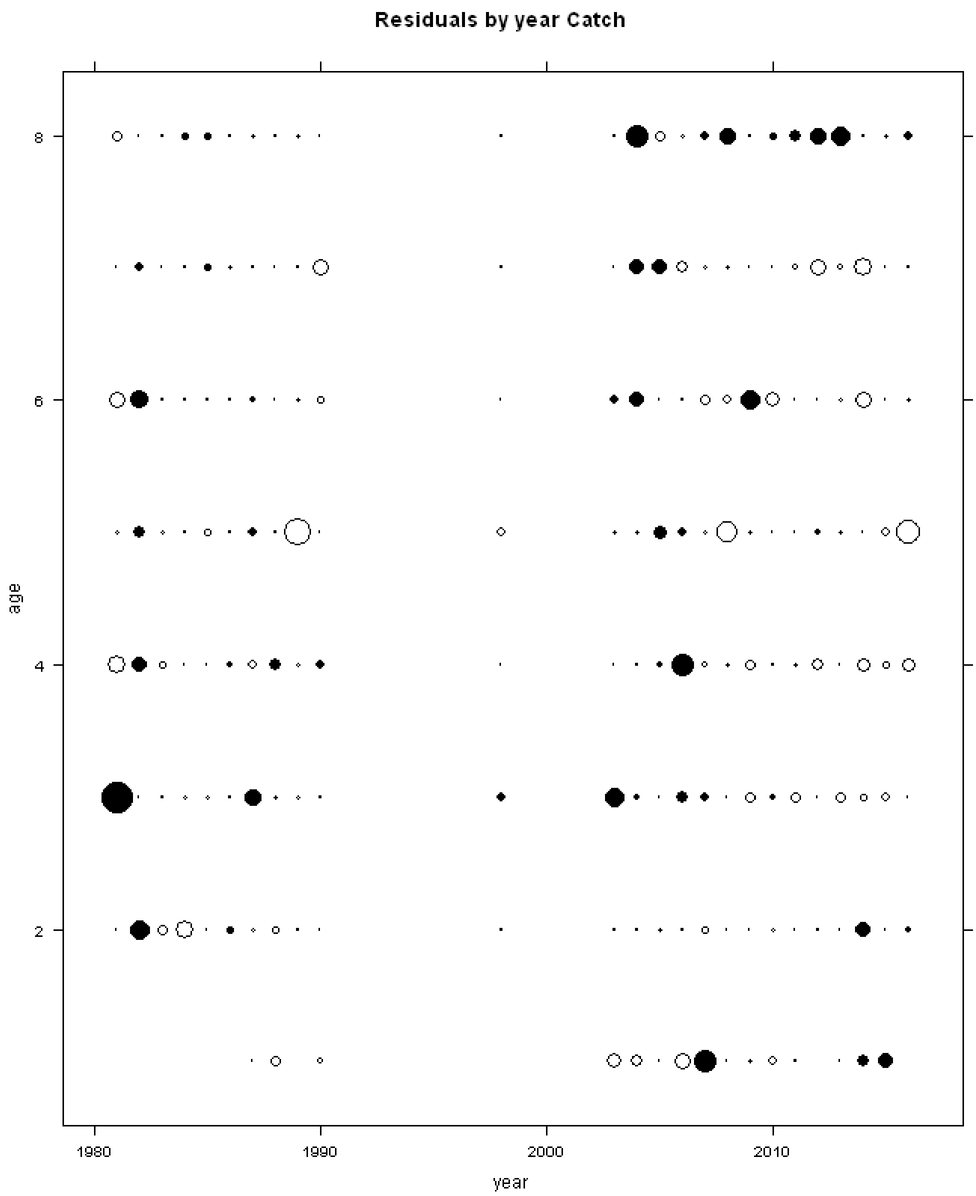


Figure 22.4.7. residual bubble plot of catches

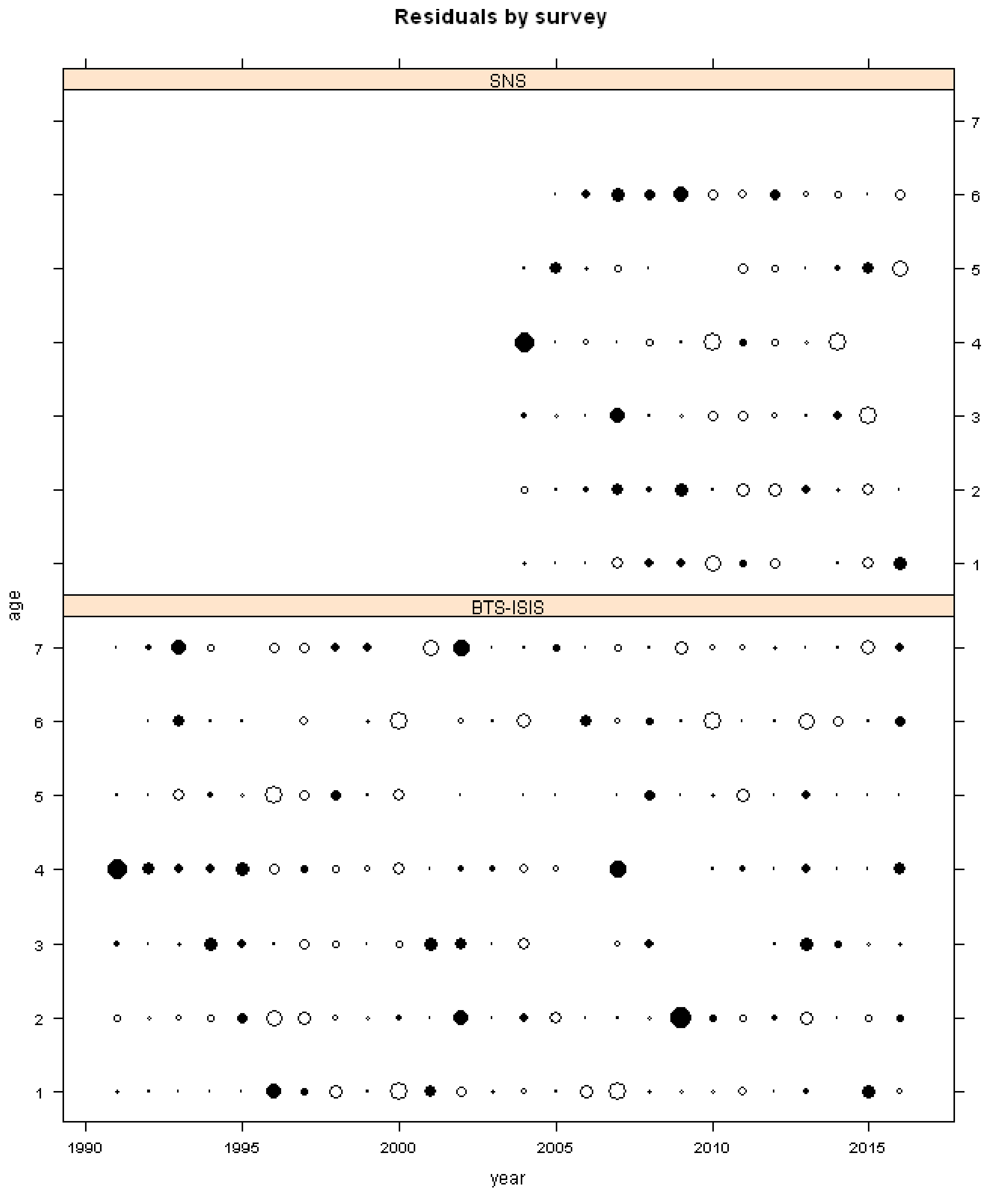


Figure 22.4.8. residual bubble plot of SNS and BTS-ISIS survey

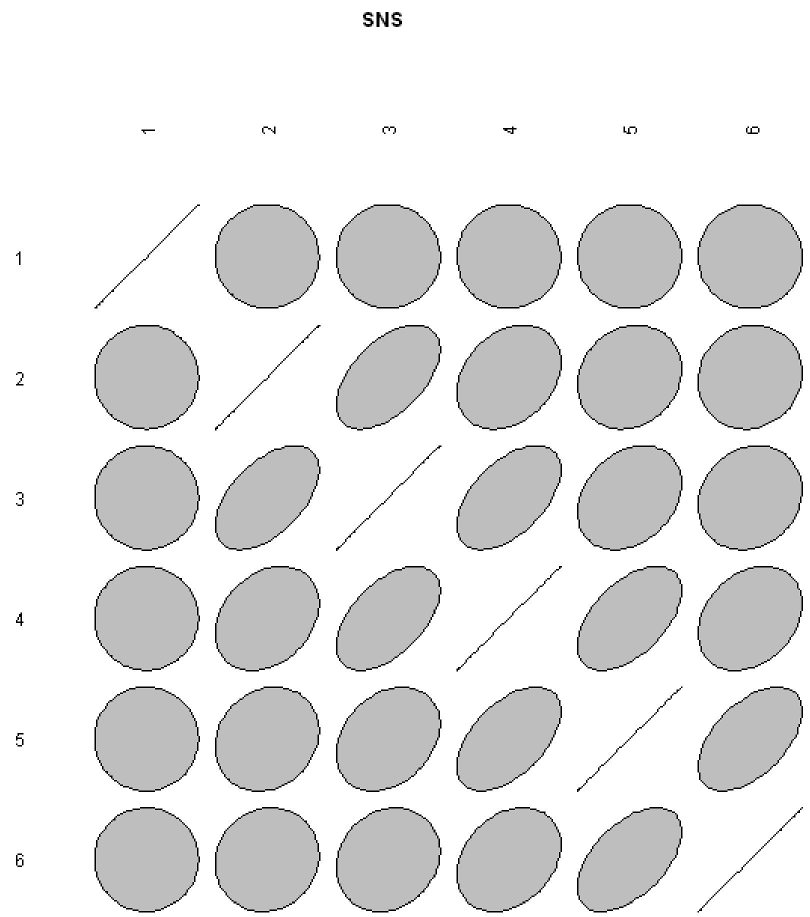


Figure 22.4.9. estimated correlation between age-groups, the rounder the circle, the less correlation there is, flat lines indicate a 100% correlation

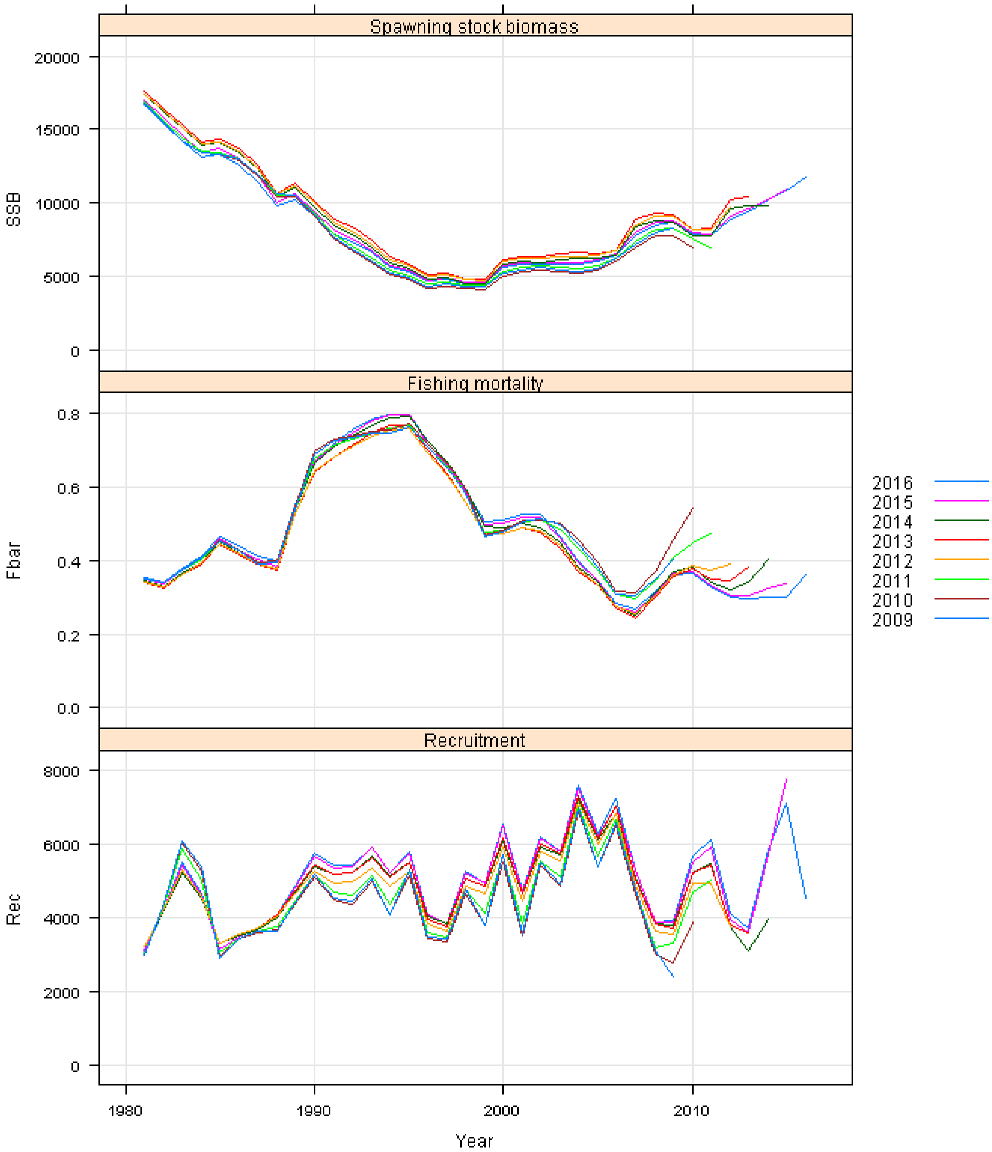


Figure 22.4.10. retrospective analysis plot on SSB, F and R

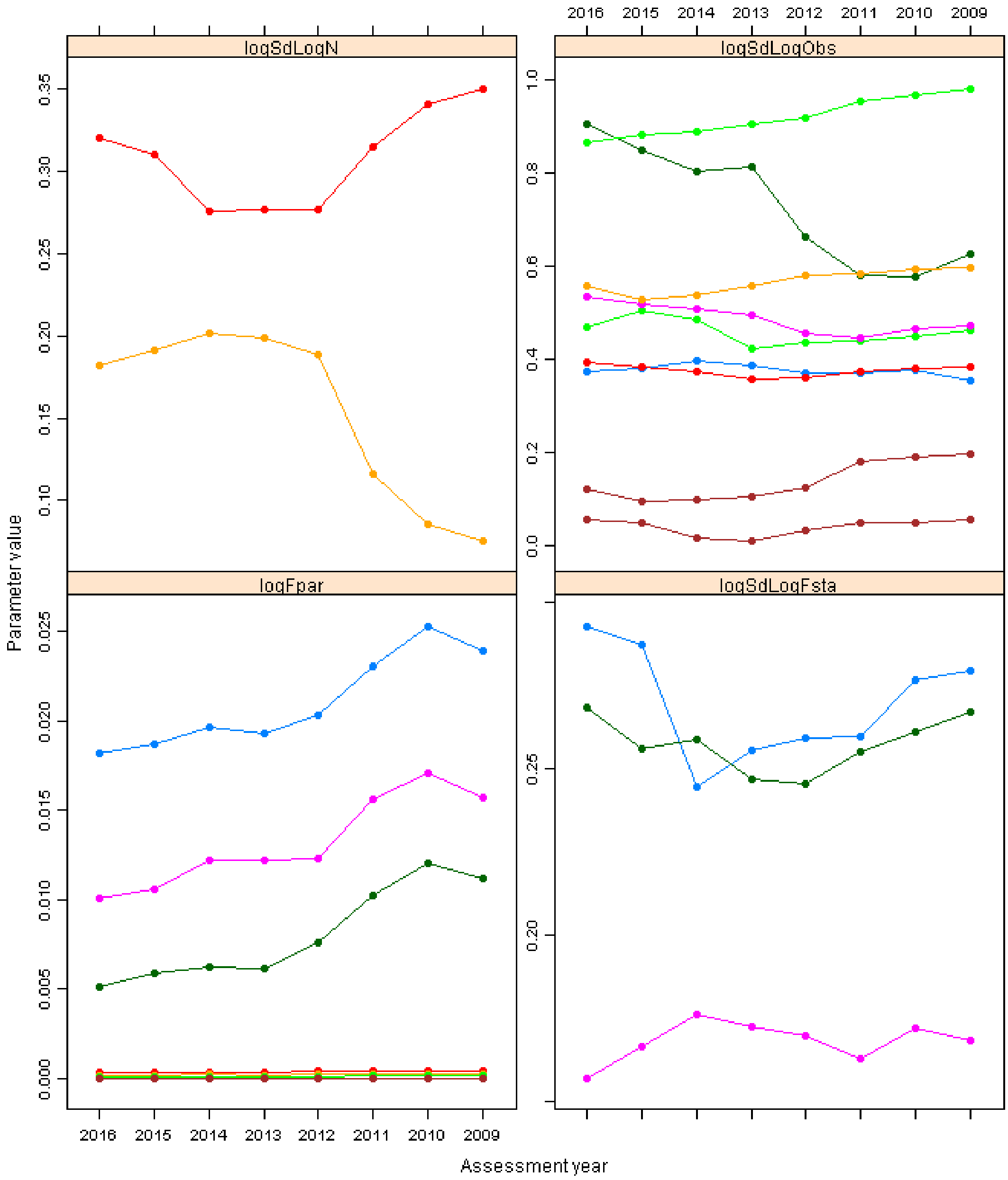


Figure 22.4.11. Retrospective analysis plot on the value of the estimated parameters, ideally, all show a flat line indicating that with reducing the model with a year's worth of data does not affect the parameters to be estimated: logSdLogN = the random walk in N, logSdLogObs is the observation variance in the surveys and catch, logFpar are the catchability parameters and logSdLogFsta are the sd's of the random walks in F

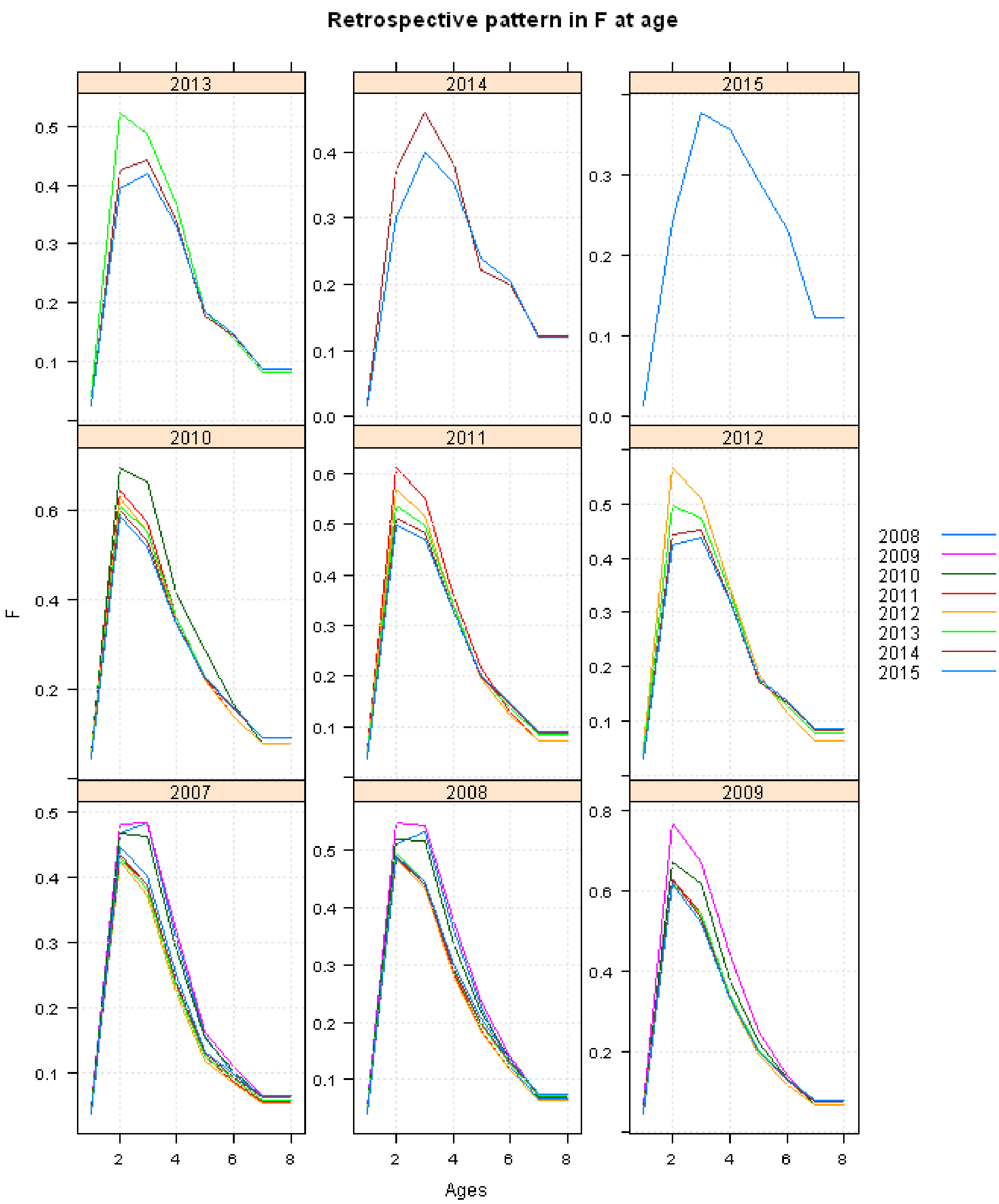


Figure 22.4.12. retrospective analysis plot of selectivity pattern

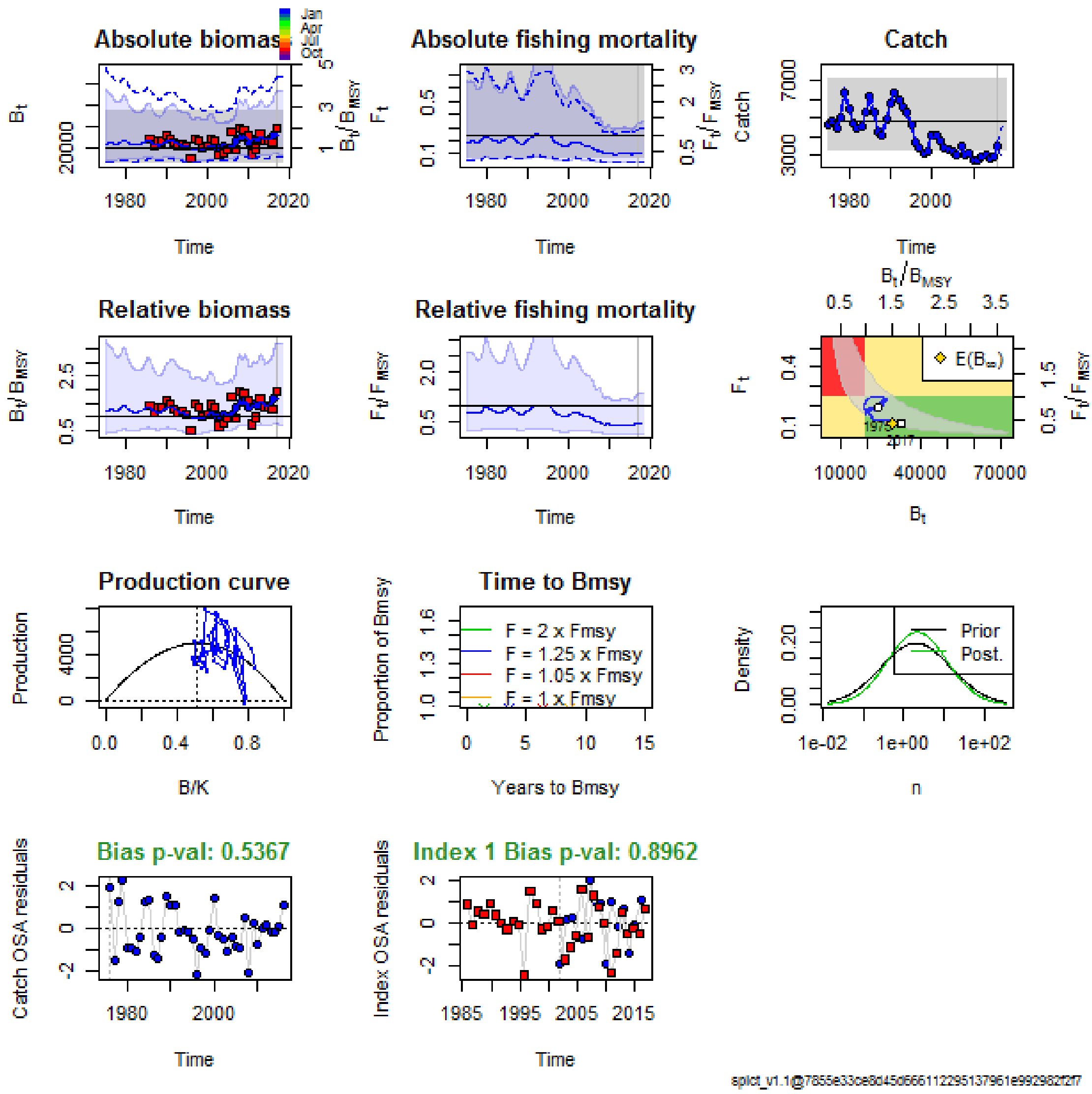


Figure 22.7.1. Turbot in 27.4.20. Summary plot of SPiCT analysis base run

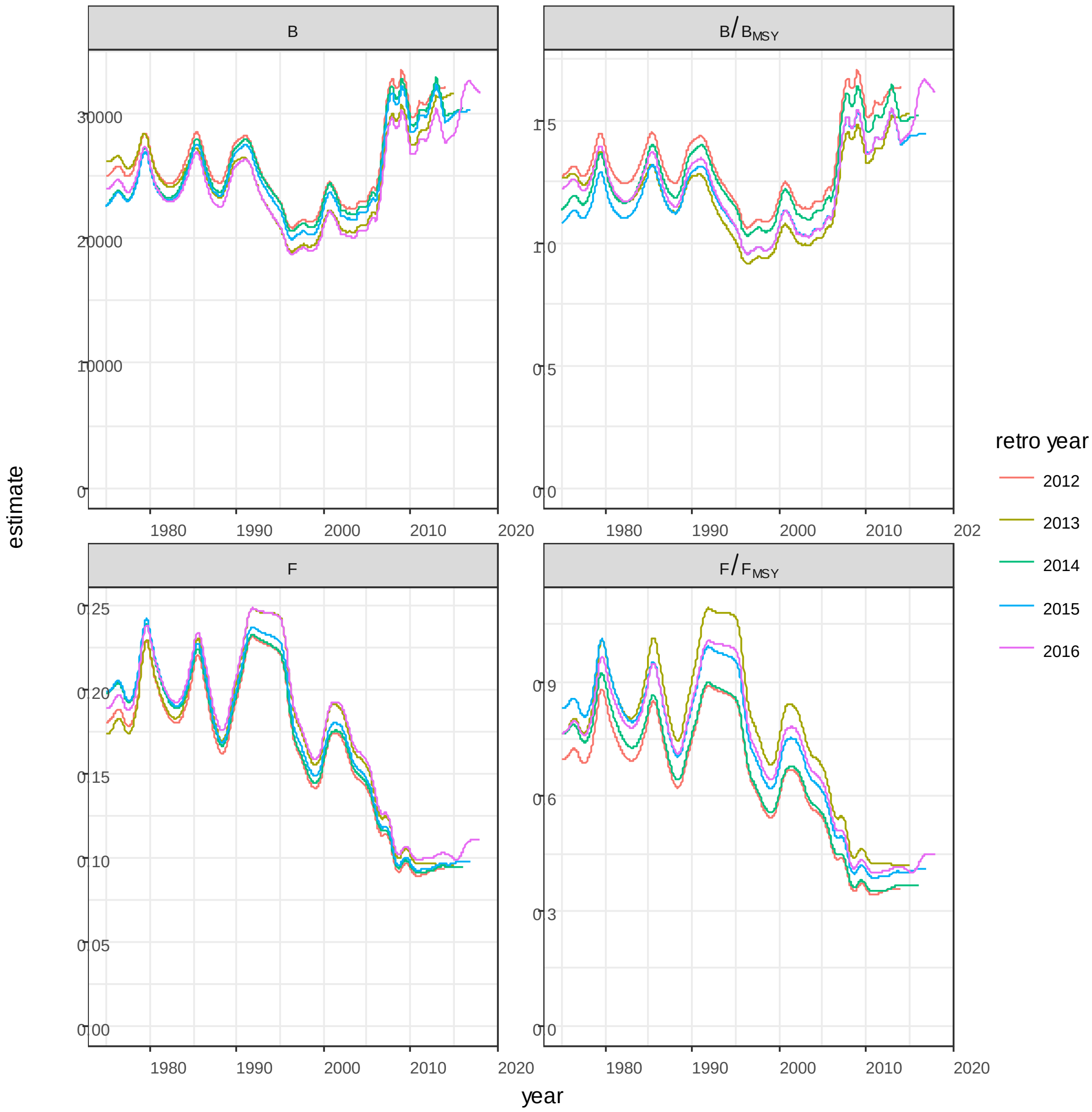


Figure 22.7.2. Turbot in 27.4.20. Retrospective plot of SPiCT analysis base run

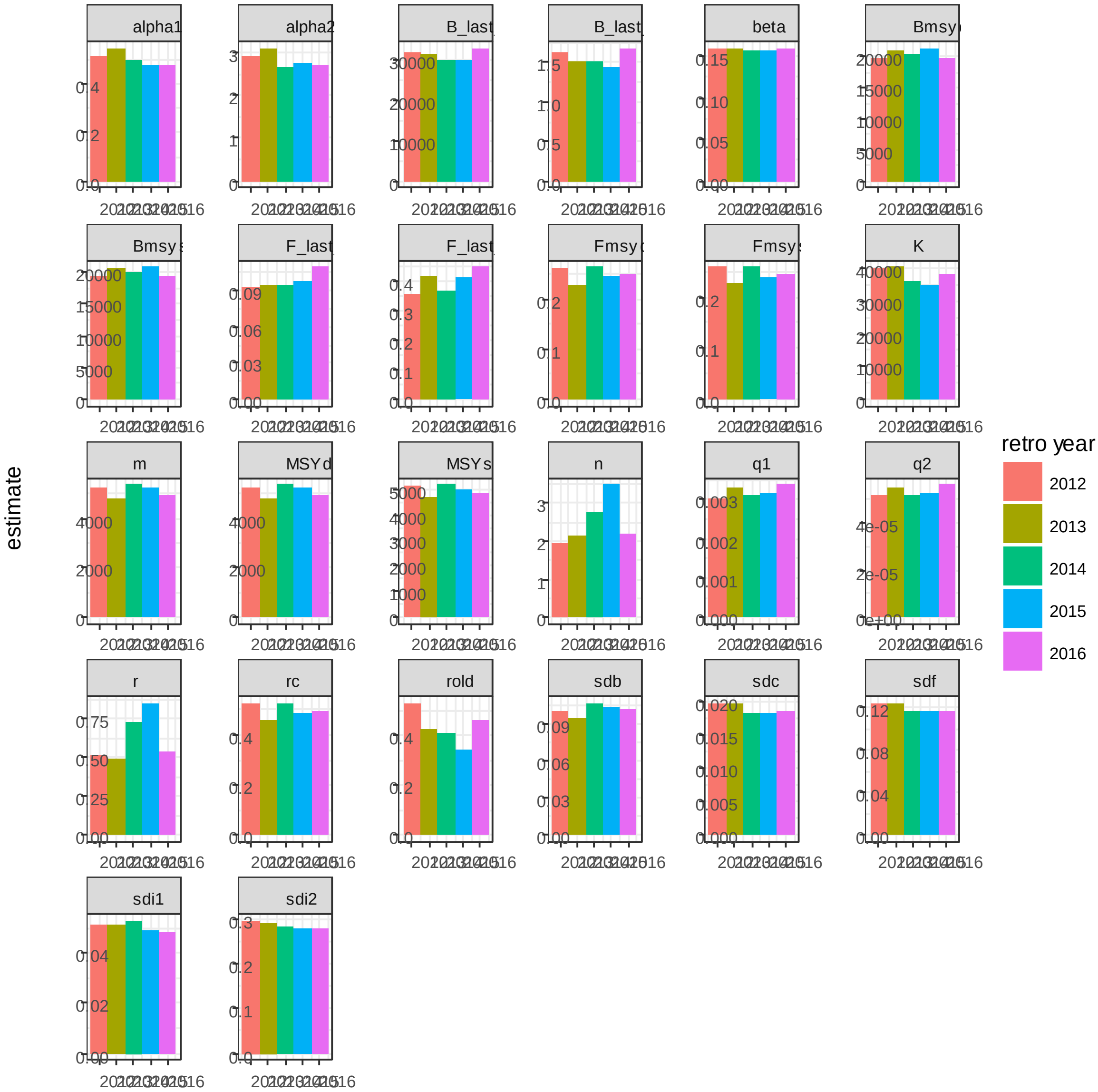


Figure 22.7.3. Turbot in 27.4.20. Parameter estimates of SPiCT retrospective analysis base run

23 Whiting (*Merlangius merlangus*) in Subarea 4 (North Sea), Division 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

23.1 Whiting in Subarea 4 and Divisions 7.d

This Section contains the assessment relating to whiting in the North Sea (ICES Subarea 4) and eastern Channel (ICES Division 7.d). The current assessment is formally classified as an update assessment. The most recent benchmark for this stock was conducted in January 2013 (ICES 2013). An inter-benchmark was conducted in March 2016 (ICES 2016) to test new natural mortalities from the 2014/2015 key run from of the SMS multispecies model (ICES 2014).

Available information on whiting in Division 3.a (Skagerrak and Kattegat) is presented in Section 23.2.

23.1.1 General

23.1.1.1 Stock definition

No new information was presented at the WG. A summary of available information on stock definition can be found in the Stock Annex prepared by ICES WKROUND (2013).

23.1.1.2 Ecosystem aspects

No new information was presented at the WG. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared by ICES WKROUND (2013).

23.1.2 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES WKROUND (2013).

23.1.3 ICES advice

ICES advice for 2015

In November 2014, ICES concluded as follows:

ICES advised on the basis of the EU–Norway management plan that total catches should be no more than 30 579 tons. If rates of discards and industrial bycatch do not change from the average of the last three years (2011–2013), this implies human consumption of no more than 17 190 tons (13 678 tons in the North Sea and 3 512 tons in Division 7.d). Management for Division 7.d should be separated from the rest of Subarea 7.

ICES advice for 2016

In November 2015, ICES concluded as follows:

ICES advised on the basis of the EU–Norway management plan that total catches should be no more than 30 510 tons. If rates of discards and industrial bycatch do not change from the average of the last three years (2012–2014), this implies human consumption of no more than 14 853 tons (12 373 tons in the North Sea and 2 480 tons in Division 7.d). Management for Division 7.d should be separated from the rest of Subarea 7.

ICES advice for 2017

In November 2016, ICES concluded as follows:

ICES advised that when the MSY approach is applied, total catches in 2017 should be no more than 23 527 tons. If discard and industrial bycatch rates do not change from the average (2013–2015), this implies human consumption landings of no more than 12 679 tons.

ICES advice for 2018

In November 2017, ICES concluded as follows:

ICES advises that when the MSY approach is applied, catches in 2018 should be no more than 26 804 tons. If unwanted catch and industrial bycatch rates do not change from the average of the last 3 years (2014–2016), this implies wanted catch of no more than 13 445 tons.

23.1.4 Management

Management of whiting is by TAC and technical measures. The TACs for this stock are split between two areas: (i) Subarea 4 and Division 2.a (EU waters), and (ii) Divisions 7b–k. Since 1996 the North Sea and eastern Channel whiting assessments have been combined into one.

The agreed TACs for whiting in Subarea 4 and Division 2.a (EU waters) were 16 092 tons in 2014 and 13 678 tons in 2015. The TAC for 2016 was set as a Roll-over TAC at 13 678 tons, for 2017 the TAC was increased to 16 003 tons. There is no separate TAC for Division 7.d; landings from this Division are counted against the TAC for Divisions 7b–k combined (17 742 tons in 2015, 22 778 tons in 2016, and 27 500 tons in 2017). There are no means to control how much of the Division 7b–k TAC is taken from Division 7.d. By comparison, a specific TAC for Division 7.d was established for cod in 2009, and the same procedure for whiting may be appropriate.

In previous years, the human consumption landings in Subarea 4 and Division 7.d were calculated as 70% and 30% of the combined area totals. Since 2006, the landings data have been collated separately for each area. In 2016, 80% of the total landings originated in Subarea 4.

The minimum landing size for whiting in Subarea 4 and Division 7.d is 27 cm. The minimum mesh size for whiting in Division 7.d is 80 mm.

Whiting are a by-catch in some *Nephrops* fisheries that use a smaller mesh size, although landings are restricted through bycatch regulations. They are also caught in flatfish fisheries that use a smaller mesh size. Industrial fishing with small-meshed gear is permitted, subject to by-catch limits of protected species. Regulations also apply to the area of the Norway pout box, preventing industrial fishing with small meshes in an area where the by-catch limits are likely to be exceeded. Industrial by-catch occurred mainly in Subarea 4 by Danish industrial fisheries.

Conservation credit scheme

During 2008, 15 real time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), 166 (2013), 94 (2014), 97 (2015) and 114 (2016). The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it undoubtedly has an effect on the mortality of associated species such as whiting. However, the scheme was suspended on 20th November 2016 and there are no plans for its reintroduction.

Studies tracking Scottish vessels during 2009–2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behavior on the whiting stock is still under investigation.

In 2016, 14 Scottish demersal whitefish vessels participated in a trial Fully Documented Fishery (FDF) scheme, following similar schemes during 2010–2015. The uptake of the scheme declined due to concerns about monitoring of discards under the EU Landing Obligation. The cod-specific FDF scheme terminated at the end of 2016, due to the suspension of most aspects of the EU Cod Recovery plan which removed the opportunity for countries to provide additional quota for participants. However, a new Scottish FDF scheme has commenced, which is being run along similar lines and which is intended to monitor discarding of saithe and monkfish: there are currently three vessels participating in this new scheme in 2017.

23.1.5 Data available

23.1.5.1 Catch

Since 2012, international data on landings and discards have been collated through the InterCatch system.

In 2016 data, 61% of the landings (here total landings include industrial bycatch) had associated discard data imported to InterCatch. The landings of métiers for which discard data was provided in 2016 are illustrated in Figure 23.1.1. Discards were raised from discard ratios for all strata from Subarea 4 and Division 7.d combined. The raised discards amounted to 15% of total discards (Table 21.1.3b). Industrial bycatch landings were excluded from the discard raising, as now discards occur in that fleet. Minor whiting landings (originating from a Norwegian OTB fisheries) were imported as BMS landing (below minimum landing size) into InterCatch. Throughout this report minor BMS landings were grouped together with discards as “unwanted catch”, for age allocations as well as mean weights-at-age.

Figure 23.1.2a shows métier specific landings in percent of the total landings in 2016 for whiting in Subarea 4 and Division 7.d, for fleets sampled for age compositions in landings and unsampled fleets. The Figure also shows the cumulative landings when sampled and unsampled fleets are ordered by landings yield. Sampled fleets comprise around 59% of the overall landings, from 11 métiers.

However, although the unsampled fleets provide considerable landings overall (41%), most métiers provide each less than 5% of the overall landings each. A métier summarized as miscellaneous landings of industrial bycatch (MIS_MIS_0_0_0_IBC) provides about 23% of the total landings, occurred in the Danish fishery and were not sampled.

For raising discard rates from sampled to unsampled fleets all samples were used without any splitting of fleets on the basis of area, quarter or gear type. Discard rates for unsampled whiting fleet components were obtained from discards reported by France, UK (England, Scotland), Netherlands, Denmark, Belgium and Germany.

Of the total discards, 84% were imported into InterCatch. 67% of the imported discards were sampled for age distributions. The 15 métiers providing discard samples and unsampled métiers are listed in Figure 23.1.2b.

Official reported landings by country, WG estimates of total catch and catch component yields, as well as TACs covering the respective areas are given in Table 23.1.1 for the North Sea (Subarea 4) and in Table 23.1.2 for the Eastern Channel (Division 7.d).

WG estimates of numbers and weights at age for the defined catch components (total catch, landings, unwanted catch and industrial bycatch) are given in Tables 23.1.4 to 23.1.11. The estimated tonnages of the Subarea 4 landings remained at a low level, but whiting industrial by-catch increased in comparison to last year (14% of the total catches). The main contribution of industrial bycatch in 2016 originated from the Danish industrial sprat fishery in quarter 3. The level of industrial sprat fishery remained similar to last year. The increase is therefore most likely due to an increased abundance of young whiting. Unwanted catch represent 39 % of the total catches. Figure 23.1.3 plots the trends in the commercial catch for each component in both Subarea 4 and Division 7.d combined. Recent years have seen these time series stabilize to a certain extent. There has been an increase in discards and bycatch in recent years. There continued to be high discard of age 1 whiting (Figure 23.1.4).

23.1.5.2 Age compositions

Age compositions in the landings and unwanted catch were based on samples provided by France, UK (England) and UK (Scotland). Age compositions were applied to landings without any splitting of fleets on the basis of area, quarter or gear type. For consistency, unwanted catch age compositions were allocated using all discard samples with splitting of fleets.

Limited sampling of the industrial bycatch component resulted in the 2006 data appearing as an outlier and the 2007 to 2010 data were deemed unreliable. This applies to both the age compositions and the estimates of mean weights at age. Thus the data for 2006 to 2010 were replaced with estimates derived from the years 1990 to 2005 (as described in the Stock Annex). For the industrial bycatch in 2011 and 2012, age compositions were inferred in InterCatch from corresponding age samples taken from small-mesh fisheries of France and the UK. In recent years age compositions for industrial bycatch are estimated from samples for landings and discards. Minor BMS landings (below minimum landing size) were not sampled. BMS was treated the same as discards, and age compositions are inferred from discard samples only. BMS and discards were combined as unwanted catch.

Total international catch numbers at age (Subarea 4 and Division 7.d combined) are presented in Table 23.1.4. Numbers for human consumption landings, unwanted, and industrial bycatch are given in Tables 23.1.5 to 23.1.7.

23.1.5.3 Weight at age

Mean weights at age (Subarea 4 and Division 7.d combined) in the catch are presented in Table 23.1.8. Catch mean weights are also used as stock mean weights at age. Mean weights at age (both areas combined) in human consumption landings are presented in Table 23.1.9, and for the unwanted catch and industrial by-catch in the North Sea in

Tables 23.1.10 and 23.1.11 respectively. Weights-at-age are depicted graphically in Figure 23.1.5, which indicates an increasing trend (with annual fluctuations) in mean weight-at-age in the landings, unwanted catch and total catch for ages >2.

Unrepresentative sampling of industrial bycatch in 2006 to 2010 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values). From 2012 onwards, the weights at ages of total catches were used for weights at ages of industrial bycatches.

23.1.5.4 Maturity and natural mortality

Values for maturity remain unchanged from those used in recent assessments and are given in Table 23.1.12. Their origin is discussed in the Stock Annex.

Estimates of natural mortality (M) are taken from the 2014/2015 update key run from of the SMS multispecies model (ICES–WGSAM 2014) (Table 23.1.13 and Figure 23.1.6). It was decided by WGNSSK 2016 following an inter-benchmark to use the most recent estimates of natural mortality values from the 2014/2015 model key run, because recruitment estimates in the assessment changed significantly with the new estimates, while SSB and F were hardly impacted. The new natural mortality values are constant for ages 5+ (Figure 23.1.6). Natural mortalities and reference points were updated in 2016, accordingly (Table 23.1.19; ICES 2016).

23.1.5.5 Research vessel data

Survey tuning indices are presented in Table 23.1.14. The indices used in the assessment are ages 1 to 5 from the IBTS–Q1 and IBTS–Q3 surveys, from 1990 to 2017 and 1991 to 2016, respectively. The report of the 2001 meeting of WGNSSK (ICES–WGNSSK 2002), and the ICES advice for 2002 (ICES–ACFM 2001) provide arguments for the exclusion of commercial cpue tuning series from calibration of the catch-at-age analysis. Such arguments remain valid and only survey data have been considered for tuning purposes. All available tuning series are presented in the Stock Annex prepared at ICES WKROUND (2013).

In Figure 23.1.7 survey distribution maps, based on the IBTS–Q1 survey in the North Sea, for ages 1–3+ of the first quarter (Q1) 2013–2017 are presented. Figure 23.1.8, the third quarter is represented (Q3) for ages 0–3+ for the years 2013–2016. The figures illustrate the cpue is high throughout the North Sea for age 1 in quarter 1. For ages 1–3+ cpue was higher along the UK east coast. In quarter 3 survey, whiting at age 0 are found in the Northern North Sea and Scottish east coast as well as in the German Bight. Whiting at age 1 are found throughout the North Sea. For age 2 and ages 3+ the cpue is highest along the UK East Coast and the northern North Sea. In 2016/2017 cpue generally remained high as the last year and increased for age 1 in quarter 1, 2017.

23.1.6 Data analyses

The benchmark meeting for whiting in Subarea 4 and Division 7.d was held in Galway and Aberdeen in early 2013 (ICES WKROUND 2013). Analyses focused on a number of key issues: these are listed below, along with relevant recommendations for future work (and steps taken by WGNSSK to address them):

CCTV–based discard-rate estimation

Several participating countries have now installed CCTV cameras on a subset of vessels, and the issue is whether footage from these can be used to improve discard- rate estimation for assessments. The WKROUND meeting concluded that further work is needed to integrate CCTV with existing observer programs, and work is ongoing to improve length measurements accordingly (new camera and annotation systems, automated image analysis, and length-based assessments).

Length of assessment time-series

Considerable effort was put into the evaluation of the pre–1990 catch and survey data which were previously used in the assessment, but which were removed in recent years due to discrepancies between catch and survey information. WKROUND found that pre–1990 catch data would need to be reduced by at least 75% for the FLXSA SSB estimates (catch-based) to resemble those from SURBAR (survey-based). It did not seem possible to resolve this discrepancy, and WKROUND concluded that 1990 should be retained as the starting point for the update assessment.

Stock identity

The issue of how to define stock units for whiting that are biologically relevant remains a difficult one to address. WKROUND evaluated the available evidence, and produced area-specific SURBAR analyses to determine whether estimated time-series of biomass and mortality were correlated between different areas. Although the northern North Sea appeared to be linked with the areas immediately to the south and with no others, the analysis was not sufficiently conclusive. Spatially discrete nursery grounds exist and are visible in surveys (age 0, Q3 survey; Figure 23.1.8). However, the distinction becomes less clear for older ages. There is some evidence for north–south split in the North Sea, and some evidence for links between Divisions 4.a and 6.a (Holmes *et al.* 2014, Barrios *et al.* 2017). But full stock determination is hindered by data availability. It would be very difficult to subdivide historical landings and discards time-series from all participating nations between a northern and southern component. WGNSSK recommends, that the stock identity issue should be reviewed in the future when firm evidence become available and data can be provided at the appropriate spatial scale.

Assessment models

WKROUND concluded that the update assessment model should continue to be FLXSA, with supporting exploratory runs using SURBAR (and, time permitting, SAM). A full investigation of the appropriate SAM run settings was not possible due to lack of time, although WKROUND recommended that this be done in the near future. A benchmark in 2018 is planned to address the issue.

23.1.6.1 Exploratory survey-based analyses

Figure 23.1.9 presents time-series of survey log cpue at age, and suggests that while broad trends are captured in a consistent way by the two surveys, finer-scale details of year-class strength may not be.

Catch-curve analyses for the surveys are shown in Figure 23.1.10. These show consistent tracking of year classes (since catch curves are mostly smooth) and consistent selection with some recent exceptions. The catchability of the IBTS–Q1 seems to have changed since 2007, underestimating the size of the 2006 year class at age 1. The 2007 to 2010 and 2012 year classes also seem to have been underestimated at age 1. The IBTS–Q3 survey shows low mortality for the 2006 year class, and a potential under estimate of the 2007 year class at age 1; however, numbers at age 2 in the 2007 year class may well be an overestimate. There does not appear to be a problem estimating age 1 in the 2008 or subsequent year classes in the IBTS–Q3 survey.

The consistency within surveys is assessed using correlation plots in Figures 23.1.11 and 23.1.12. These indicate that the IBTS–Q1 and Q3 surveys both show good internal consistency across ages. The log cpue plots by survey (Figure 23.1.13) support the conclusion of good internal consistency.

Figures 23.1.14 to 23.1.16 summarize the results of a SURBAR analysis using the available whiting surveys. These show a well-specified analysis in which the data agree broadly with the separability assumptions in the model and uncertainty bounds are fairly tight.

23.1.6.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 23.1.17 and show numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 2 for some cohorts. Also evident is the persistence of the 1999 to 2001 year classes in past catches and the recent low catches of the 2002–2010 year classes.

The negative gradients of log catches per cohort, averaged over ages 2–6 are given in Figure 23.1.18. The gradients (since the 2002 year class) appear to be fluctuating around a mean level that is lower than the mean level before the 1998 year class, which suggests that recent fishing mortality is likely to be lower than in the past. For the 2010 cohort the negative gradient of commercial catch data was lowest in the series (similar to 2010 cohort). Slopes for the catch curves were less steep for this cohort, indicating relatively higher cpue at higher ages.

Within cohort correlations between ages are presented in Figure 23.1.19. In general, catch numbers correlate well between cohorts with the relationship breaking down as cohorts are compared across increasing age gaps.

Single fleet XSA runs were conducted to compare trends in the catch data with using survey data for quarter 1 and 3 separately. These used the same procedure as this year's final assessment. Summary plots of these runs are presented in Figure 23.1.20. The population trends from each survey are consistent; however, the mean F estimates differ considerably throughout the time-series. In recent years estimates in SSB, fishing mortality have been diverging. Residual patterns (Figure 23.1.21) show that the 2006 year class has a large negative residual at age 1 for both surveys (and particularly IBTS–Q1). In quarter 1, residuals for age 1 have been larger in some years (2006, 2013).

23.1.6.3 Conclusions drawn from exploratory analyses

Catch curve analysis and correlation plots show that in general both surveys and catch data track cohorts well and are internally consistent (Figure 23.1.10-12, 23.1.17-19). However, beginning with the 2006 year class, the IBTS Q1 appears to be underestimating the abundance of age 1 and 2 whiting (Figure 23.1.10). In previous assessments, this had implications for the estimation of recruitment at age 1 in 2007 and resulted in a considerable retrospective bias in recruitment.

23.1.6.4 Final assessment

The final assessment used an FLXSA model fitted to the combined landings, unwanted catch and industrial bycatch data for the period 1990–2016. This is the same procedure as last year and that agreed at WKROUND (ICES WKROUND 2013). The settings are provided in the table below.

Catch-at-age data	1990–2016
	Ages 1–8+
Calibration period	1990–2016
Survey: IBTS Q1	1990–2017
Ages 1–5	
Survey: IBTS Q3	1991–2016
Ages 1–5	
Catchability independent of stock size from	Age 1
Catchability plateau	Age 4
Weighting	No taper weighting
Shrinkage	Last 3 years and 4 ages
Shrinkage SE	2.0
Minimum SE for survivors' estimates	0.3

Diagnostics for the final XSA run are given in Table 23.1.15. Residual plots are presented in Figure 23.1.23. These show that the IBTS–Q3 survey fits more closely to the model and the catch data, than the IBTS–Q1 survey which demonstrated considerable year effects towards the end of the time series. This indicates that the model is effectively paying less attention to the Q1 survey than to the Q3 survey, and this is borne out by Figure 23.1.24 which shows the contribution of each tuning fleet to the estimation of survivors in the most recent year.

Finally, Figure 23.1.22 compares the SURBAR results with the final XSA assessment. The mean Z (total mortality) estimates show year-to-year variation, but the trends in all outputs are very similar.

Fishing mortality estimates are presented in Table 23.1.16, estimated stock numbers in Table 23.1.17 and the assessment summary in Table 23.1.18 and Figure 23.1.25.

A retrospective analysis is shown in Figure 23.1.26. There is a consistent bias in recruitment from 2006 to 2012. The largest revision in recruitment is for recruitment in 2008 and 2011 (the 2007 and 2010 year class, respectively) which coincides with large negative residuals and the flat catch curve in the IBTS–Q1 survey and commercial catch curves (Figure 23.1.10, 23.1.17). This translates directly to a large revision of SSB. However, the last four retrospective runs are very consistent for fishing mortality. This may indicate that previous data problems have been corrected, although it may be too early to say whether the retrospective bias has actually been eliminated.

23.1.7 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 23.1.25. These show that mean F has been declining and has reached the minimum of the post–1990 time-series in 2012, but is increasing in the recent years. The SSB has decreased after recent increases; and recruitment is fluctuating around a recent low average. In the most recent year, landings, unwanted catch and industrial bycatch have also all remained at or around a recent average. The stock–recruitment plot in Figure

23.1.27 does not show a clear relationship between SSB and subsequent recruitment, although such evidence is not compelling.

23.1.8 Biological reference points

Due to the shape of the yield per recruit (YPR) curve, a maximum is often not reached, and F_{max} has therefore not been defined for several years. The WG considers that YPR F reference points are not applicable to this stock since F_{max} is undefined in most years, and the estimate of $F_{0.1}$ is very variable in recent years (see ICES WGNSSK, 2009). A long-term average selection pattern could be used to stabilize $F_{0.1}$ or a long term average of $F_{0.1}$ could be interpreted as a sensible reference point. The 2013 benchmark meeting (ICES WKROUND 2013) attempted to calculate F_{msy} for North Sea whiting, but concluded that this value was inestimable using standard equilibrium considerations and would need to be determined as part of a management strategy evaluation.

After the considerable revisions in the 2012 assessment, caused by new estimates of natural mortality, the target F of 0.3 was no longer considered applicable. The management plan was re-evaluated in October 2013 (ICES 2013) and ICES advised that updating the target F from 0.3 to 0.15 within the management plan.

New revisions of natural mortalities were presented at WGSAM 2014. The new natural mortality values from the 2014/2015 key run are used in the current assessment. Due to the new natural mortalities, the recruitment estimates and SSB decreased in the assessment, an interbenchmark was performed for whiting in the North Sea and Division 7.d in early 2016 (ICES 2016). This included a comparison of assessment results, Eqsim runs and MSE. On the basis of the 2015 assessment using the new natural mortalities the target F of 0.15 leads to maximum probabilities above 5% of SSB falling below B_{lim}, which is considered precautionary. This is under the assumption that recruitment stays within a medium-low range. Therefore, a target F of 0.15 together with a TAC constraint of 15% according to the EU–Norway Management Plan may not be sufficient to keep SSB above B_{lim}. It was concluded to use an MSY approach with F_{MSY} of 0.15 and an additional check of SSB relative to B_{lim}. The target fishing mortality can then be adapted at very low biomass levels. Until additional information becomes available, it is considered that the lowest observed SSB (SSB in 2007, 172 741 tons in the 2015 assessment) can be used as a B_{lim} reference point. As a result new reference points are listed in Table 23.1.19.

23.1.9 Recruitment estimates

RCT3 input data are presented in Table 23.1.20, and RCT3 output is presented in Table 23.1.21. The RCT3 estimate of recruitment at age 1 in 2017 (that is, the 2016 year class) was 3340 million. Following the approach taken last year, and subsequently formalized in the benchmark report (ICES WKROUND 2013), the WG agreed to use the RCT3 estimates for recruitment in the intermediate year 2017, and the long-term geometric mean for recruitment in 2018 and beyond in the short-term forecast. The long-term geometric mean of all recruitments excluding the most recent year is 2 444 million (Table 23.1.22).

23.1.10 Short-term forecasts

A short-term forecast was carried out based on the final FLXSA assessment. FLXSA survivors from 2016 were used as input population numbers for ages 2 and older in 2017. Recruitment assumptions are detailed in the preceding section.

The exploitation pattern was chosen as the mean exploitation pattern over the most recent three years 2014–2016. A simple mean F would have led to bias in forecast F, given the recent changes in F_{2-6}, so this exploitation pattern was scaled to the mean F_{2-6} in 2016 for forecasts. Partial F at age for each catch component was estimated by splitting the forecast F at age using the mean proportion in the catch of each catch component over the years 2014–2016. The F at age used in the forecast is compared with the F at age estimates for 2014–2016 in Figure 23.1.28.

Mean weights at age are generally consistent over the recent period but there are trends at several ages (Figure 23.1.5). To avoid introducing bias, therefore, the 2016 estimates were used for the purposes of forecasting.

The inputs to the short-term forecast are given in Tables 23.1.22 to 23.1.23, and results are presented in Table 23.1.24. The MFDP program was used to carry out the forecasts, since there is no available function currently within FLR to account for industrial by-catch in forecasts and WGNSSK could not complete the coding required to address this in the time available.

No TAC constraint was applied in the intermediate year since it is not considered that fishing will stop when the TAC is reached.

Assuming mean F_{2017} to equal mean F_{2016}, results in human consumption landings in 2017 of 20 916 t from a total catch of 40 010 tons, giving an SSB in 2018 of 354 119 tons (Table 23.1.24).

Carrying the same fishing mortality forward into 2018 (the status quo F option, F_{sq}) would result in landings of 23 122 tons out of total catches of 43 207 tons, and would result in an SSB of 341 306 t in 2019 (a 4% decrease in SSB relative to 2018).

Applying the F_{msy} of 0.15 in 2018 would generate landings of 13 445 tons out of total catches of 26 804 tons, and result in an SSB of 354 527 tons in 2019 (a 0.1% increase in SSB relative to 2018). In 2019, SSB would be above B_{lim}. F of 0.15 would also cause the TAC (relative to the TAC in 2017) to be changed by -33%.

23.1.11 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting.

23.1.12 Quality of the assessment

Previous meetings of WGNSSK and the benchmark workshop (ICES WKROUND 2009, ICES WKROUND 2013) have concluded that the historical survey data and commercial catch data contain different signals concerning the stock. Analyses by Working Group members and by the ICES Study Group on Stock Identity and Management Units of Whiting (ICES SGSIMUW 2005) indicate that data since the early to mid–1990s are sufficiently consistent to undertake a catch-at-age analysis calibrated against survey data from 1990. This has been taken forward into prediction for catch option purposes. However, due to the lack of concordance in the data pre-dating the early 1990s, WGNSSK considers that it is not possible categorically to classify the current state of the stock with reference to precautionary reference points as the biomass reference points are derived from a consideration of the stock dynamics dating from a time when the commercial catch-at-age data and the survey data conflict. Precautionary reference points must be reconsidered following the ongoing management strategy evaluation.

The IBTS–Q1 survey is showing a step change in catchability of young fish (especially age 1). The reason for this is unclear, but it appears to have happened after the 2006 survey. This represents a model misspecification, as the current model (FLXSA) assumes constant catchability through time.

Due to the likely population structuring in the North Sea and Eastern Channel, it is probable that the overall stock estimates may not reflect trends in more localized areas.

Given the spatial structure of the whiting stock and of the fleets exploiting it, it is important to have data that covers all fleets. Considering that age 1 and age 2 whiting make up a large proportion of the total stock biomass, good information of the discarding practices of the major fleets is important.

The survey information for Division 7.d were not available in a form that could be used by WGNSSK. Due to the recent changes in distribution of the stock, tuning information from this area would be extremely useful, and could improve the estimate of recruitment in the most recent year. However, previous analyses of the survey in Division 7.d showed it did not track cohorts well (ICES WKROUND 2009).

Age distributions and mean weights at age have been estimated for the industrial bycatch from 2006 to 2010. This was due to low sampling levels of the Danish industrial bycatch fisheries. In recent years no samples of industrial bycatch were available. Age distributions and weights at age were inferred from sampling of landings and discards from other fleets.

There have been issues with regard to the age readings of North Sea whiting as compared to other gadoids (Norway as compared to Netherlands and UK (Scotland)). This applies in particular to the age readings used for the IBTS indices. An otholith workshop took place in late 2016, to improve consistency in preparation techniques and readings (ICES WKARWHG2 2016). This exercise showed an improvement in age reading compared to the same read in the 2015 exchange. As a result WKARWHG2 recommended further review of ageing techniques to improve data quality. Reported age readings are used as in previous years.

The historical performance of the assessment is summarized in Figure 23.1.29. The difference in level of recruitment estimates in last year's and the current assessment are caused by the new natural mortality estimates.

23.1.13 Status of the stock

For North Sea whiting, SSB has a generally downwards trend since the start of the assessment time-series. SSB is estimated to be well above B_{lim} since 2008 (Figure 23.1.25, 23.1.30). The stock, at the level of the entire North Sea and Eastern Channel, was at an historical low level during 2005 to 2008 (relative to the period since 1990), and the recent increase in SSB is in large part due to relatively improved perception of recruitment in 2008, 2011 and 2015. All indications are that fishing mortality has been declining over most of the time-series, currently fluctuating around a low level with some increase in recent years. In recent years fishing mortality remained above F_{msy}=0.15, but is below F_{pa} and F_{lim}. While landings have been relatively stable and increase in unwanted catch and industrial bycatch can be observed in recent years. The level of recruitment has been generally low since 2003, with recruitment since 2014 above the average of the recent years. Recruitment is varying around a recent mean, but that mean is low relative to the rest of the time series and whiting biomass is likely to decline in future (even at low fishing mortality rates) without the appearance of the next good year class. The recruitment in 2017 is predicted to be above the lower recent average.

23.1.14 Management considerations

In 1997, 2003 to 2007 and 2012 to 2013, the whiting stock produced the lowest recruitments in the series. Whiting recruitment (estimated largely from the IBTS–Q1 and IBTS–Q3 surveys) was underestimated substantially in 2007 and 2008 resulting in low forecasts of recruitment and recommendations of reduced TACs due to the perception of critically low recruitment. Subsequent recruitment is below the long-term average.

Whiting mature at age 2 and grow quickly at young ages; therefore an increase in SSB is seen the year immediately after a good recruitment. Managers should consider the age structure of the population as well as the SSB since at low stock sizes short term forecasts are highly sensitive to recruitment assumptions.

Catches of whiting have been declining since 1980 (from 243 570 tons in 1979 to 25 078 tons in 2012, including discards and industrial bycatch). Catch rates from localized fleets may not represent trends in the overall North Sea and English Channel population. The localized distribution of the population is known to be resulting in substantial differences in the quota uptake rate. This is likely to result in localized discarding problems that should be monitored carefully.

Whiting are caught in mixed demersal roundfish fisheries, fisheries targeting flatfish, the *Nephrops* fisheries, and the Norway pout fishery. The current minimum mesh-size in the targeted demersal roundfish fishery in the northern North Sea has resulted in reduced discards from that sector compared with the historical discard rates. Mortality may have increased on younger ages due to increased discarding in recent years as a result of recent changes in fleet dynamics of *Nephrops* fleets and small mesh fisheries in the southern North Sea. The industrial bycatch of whiting in the Norway pout, sandeel and sprat fisheries is dependent on activity in that fishery, which has recently declined after strong reductions in the fisheries. Industrial bycatches are considered low in the forecast. A larger catch allocation for bycatch may be required if industrial effort increases.

Catches of whiting in the North Sea are also likely to be affected by the effort reduction seen in the targeted demersal roundfish and flatfish fisheries, although this will in part be offset by increases in the number of vessels switching to small mesh fisheries. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed stocks considerations. WGMIXFISH monitors the consistency of the various single species management plans and TAC advice under current effort schemes, in order to estimate the potential risks of quota over and under shooting for the different stocks, and it was demonstrated that the current basis for whiting advice was not consistent with other single-stock management objectives. It is recommended that the ongoing discussions about the whiting management plan takes into account such mixed-fisheries considerations before implementation.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear in the North Sea and Skagerrak, should be encouraged for whiting. There is a mismatch between quota allocations, derived from relative stability criteria, and the access of the various fisheries to the resource which has changed because of changes in the distribution of whiting.

ICES has developed a generic approach to evaluate whether new survey information that becomes available in September forms a basis to update the advice. ICES will publish new advice in November 2016 if this is the case for this year.

Table 23.1.1. Whiting in Subarea 4 and Division 7.d: Whiting in Subarea 4. Nominal landings (in tons) as officially reported to ICES, WG estimates of catch components, and TACs.

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
belgium.4	1040	913	1030	944	1042	880	843	391	268	529	536
denmark.4	1206	1528	1377	1418	549	368	189	103	46	58	105
france.4	4951	5188	5115	5502	4735	5963	4704	3526	1908	NA	2527
germany.4	692	865	511	441	239	124	187	196	103	176	424
netherlands.4	3273	4028	5390	4799	3864	3640	3388	2539	1941	1795	1884
norway.4	55	103	232	130	79	115	66	75	65	68	33
sweden.4	16	48	22	18	10	1	1	1	0	9	4
england.wales.4	2338	2676	2528	2774	2722	2477	2329	2638	2909	2268	1782
scotland.4	23486	31257	30821	31268	28974	27811	23409	22098	16696	17206	17158
uk.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.4	41057	46606	47026	47295	42214	41379	35116	31567	23936	NA	24453
unallocated.landings.4	-1123	396	1816	685	344	829	-434	627	246	NA	173
wg.landings.4	42180	46210	45210	46610	41870	40550	35550	30940	23690	25700	24280
wg.unwanted.catch.4	52270	30840	28470	41400	31840	28940	27130	16660	12480	22110	21931
wg.ibc.4	51337	39755	25045	20723	17473	27379	5116	6213	3494	5038	9160
wg.catch.4	145787	116805	98725	108733	91183	96869	67796	53813	39664	52848	55371
tac.4.2a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30000

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.4	454	270	248	144	105	93	45	115	162	147	74
denmark.4	105	96	89	62	57	251	78	42	79	156	135
france.4	3455	3314	2675	1721	1261	2711	3336	3076	2305	2644	2794
germany.4	402	354	334	296	149	252	76	76	124	156	111
netherlands.4	2478	2425	1442	977	805	702	618	656	718	614	514
norway.4	44	47	39	23	16	17	11	92	73	118	28
sweden.4	6	7	10	2	0	2	1	2	4	8	6
england.wales.4	1301	1322	680	1209	2560	NA	NA	NA	NA	NA	NA
scotland.4	10589	7756	5734	5057	3441	NA	NA	NA	NA	NA	NA
uk.4	NA	NA	NA	NA	NA	11632	12110	10391	8853	7845	8892
total.landings.4	18834	15591	11251	9491	8394	15660	16275	14451	12318	11690	12554
unallocated.landings.4	-426	721	801	541	-2286	563	609	972	544	-591	-751
wg.landings.4	19260	14870	10450	8950	10680	15097	15666	13479	11774	12281	13305
wg.unwanted.catch.4	16130	17144	26135	18142	10300	14018	5206	8356	5223	7853	8180
wg.ibc.4	940	7270	2730	1210	890	2190	1240	0	1020	1350	1750
wg.catch.4	36330	39284	39315	28302	21870	31305	22112	21835	18017	21484	23235
tac.4.2.a	29700	41000	16000	16000	28500	23800	23800	17850	15173	12897	14832

YEAR	2012	2013	2014	2015	2016	2017
belgium.4	45	33	46	69	65	NA
denmark.4	131	124	160	215	208	NA
france.4	1925	942	1884	1130	1232	NA
germany.4	25	44	31	73	0	NA
netherlands.4	471	495	464	548	644	NA
norway.4	94	560	914	1088	1148	NA
sweden.4	4	1	2	5	6	NA
england.wales.4	NA	NA	NA	NA	NA	NA
scotland.4	NA	NA	NA	NA	NA	NA
uk.4	9893	11162	10290	9970	9406	NA
total.landings.4	12588	13361	13791	13098	12709	NA
unallocated.landings.4	-341	-2023	-1825	-510	25	NA
wg.landings.4	12929	15384	15616	13608	12684	NA
wg.unwanted.catch.4	5929	4198	8326	10468	10474	NA
wg.ibc.4	78	1530	1479	2053	4701	NA
wg.catch.4	18936	21119	25421	24076	27859	NA
tac.4.2.a	17056	18932	16092	13678	13678	16003

Table 23.1.2. Whiting in Subarea 4 and Division 7.d: Whiting in Division 7.d. Nominal landings (in tons) as officially reported to ICES, WG estimates of catch components, and TACs.

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
belgium.7.d	83	83	66	74	61	68	84	98	53	48	65
france.7.d	NA	NA	5414	5032	6734	5202	4771	4532	4495	NA	5875
netherlands.7.d	0	0	0	0	0	0	1	1	32	6	14
england.wales.7.d	239	292	419	321	293	280	199	147	185	135	118
scotland.7.d	0	0	24	2	0	1	1	1	0	0	0
uk.7.d	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.7.d	NA	NA	5923	5429	7088	5551	5056	4779	4765	NA	6072
unallocat.landings.7.d	NA	NA	203	219	468	161	106	159	165	NA	1772
wg.landings.7.d	3480	5720	5740	5210	6620	5390	4950	4620	4600	4430	4300
wg.unwanted.catch.7.d	3330	4220	4090	2970	3850	3240	3370	3000	3210	3570	4129
wg.catch.7.d	6810	9940	9830	8180	10470	8630	8320	7620	7810	8000	8429
tac.7b.k	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22000

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
belgium.7.d	75	58	67	46	45	73	75	69	71	88	78
france.7.d	6338	5172	6654	5006	4638	3487	3135	2875	6248	5512	4833
netherlands.7.d	67	19	175	132	128	117	118	162	112	275	282
england.wales.7.d	134	112	109	99	NA	NA	NA	NA	NA	NA	NA
scotland.7.d	0	0	0	0	NA	NA	NA	NA	NA	NA	NA
uk.7.d	NA	NA	NA	NA	90	72	63	87	138	258	271
total.landings.7.d	6614	5361	7005	5283	4901	3749	3391	3193	6569	6133	5464
unalloc.landings.7.d	814	-439	1295	933	111	306	137	-1278	-77	194	400
wg.landings.7.d	5800	5800	5710	4350	4790	3443	3254	4471	6646	5939	5064
wg.unwanted.catch.7.d	3109	1356	604	907	2219	2291	1763	1943	2477	3727	3538
wg.catch.7.d	8909	7156	6314	5257	7009	5734	5017	6414	9123	9666	8602
tac.7b.k	21000	31700	31700	27000	21600	19940	19940	19940	16949	14407	16568

YEAR	2012	2013	2014	2015	2016	2017
belgium.7.d	66	95	89	121	144	NA
france.7.d	3093	3076	2115	3065	2771	NA
netherlands.7.d	437	650	663	558	557	NA
england.wales.7.d	NA	NA	NA	NA	NA	NA
scotland.7.d	NA	NA	NA	NA	NA	NA
uk.7.d	261	472	345	365	259	NA
total.landings.7.d	3857	4293	3212	4109	3730	NA
unalloc.landings.7.d	-246	343	82	11	560	NA
wg.landings.7.d	4103	3950	3130	4098	3170	NA
wg.unwanted.catch.7.d	2446	1778	2125	2960	2730	NA
wg.catch.7.d	6549	5728	5255	7059	5900	NA
tac.7b.k	19053	24500	20668	17742	22778	27500

Table 23.1.3.a. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of catch and sample data.Tables.txt. SOP.

Catch Category	SOP
Discards	1.057
Landings (incl.IBC)	1.098
BMS landing	1.153

Table 23.1.3.b. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of imported and raised data.

Catch Category	Raised or Imported	CATON kg	percent
Discards	Raised	1769572	15
Discards	Imported	9676641	85
Landings (incl.IBC)	Imported	20478468	100
BMS landing	Imported	548213	100

Table 23.1.3.c. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of the imported/raised/sampled or estimated data.

Catch Category	Raised Or Imported	Sampled or estimated distribution	CATON tonnes	percent
Landings (incl.IBC)	Imported	Sampled	12702	59
Landings (incl.IBC)	Imported	Estimated	8935	41
Discards	Imported	Sampled	84818	67
Discards	Imported	Estimated	2112	17
Discards	Raised	Estimated	2041	16
BMS landing	Imported	Estimated	632.4	100

Table 23.1.3d. Whiting in Subarea 4 and Division 7.d: Description of InterCatch raising procedure using Table 2 of CatchAndSampleData.Tables.txt. Summary of the imported/raised/sampled or estimated data by area.

Catch Category	Raised Imported	Sampled or Estimated distribution	Area	CATON tonnes	percent
Landings	Imported	Sampled	7.d	2340	65
Landings	Imported	Estimated	7.d	1256	35
Discards	Imported	Sampled	7.d	1816	67
Discards	Raised	Estimated	7.d	731.9	27
Discards	Imported	Estimated	7.d	181.6	7
Landings (incl.IBC)	Imported	Sampled	4	10362	57
Landings (incl.IBC)	Imported	Estimated	4	7679	43
Discards	Imported	Sampled	4	6602	67
Discards	Imported	Estimated	4	1931	20
Discards	Raised	Estimated	4	1310	13
BMS landing	Imported	Estimated	4	632.4	100

Table 23.1.4. Whiting in Subarea 4 and Division 7.d: Total catch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	687238	418910	313391	242370	90047	7563	7565	1851	253	11	9	4	0	0	0	0	277
1979	476383	615524	467537	218283	100975	29267	3111	1657	264	35	1	4	0	0	0	0	304
1980	332209	265359	416008	286077	90718	52969	10751	1152	689	58	14	5	1	0	0	0	767
1981	516869	162899	346343	266517	102295	27776	12297	3540	244	45	37	1	0	0	0	0	326
1982	101058	192640	114444	245246	88137	26796	6909	2082	400	53	26	4	1	0	0	0	484
1983	668604	205646	184746	118412	131508	37231	8688	1780	794	101	35	0	0	0	0	0	930
1984	157819	323408	175965	124886	49505	59817	13860	2964	410	182	21	0	0	0	0	0	613
1985	186723	203321	141716	82037	37847	14420	17445	3328	805	89	9	1	0	0	0	0	904
1986	225201	576731	167077	169577	46517	13367	3487	3975	497	71	0	1	0	0	0	0	569
1987	84863	267051	368229	122748	85240	11392	4556	928	929	98	7	0	0	0	0	0	1035
1988	416924	430344	307429	179502	39635	17901	2175	544	59	72	37	0	0	0	0	0	168
1989	87325	331672	173676	191942	78464	14367	5050	516	291	36	6	1	0	0	0	0	334
1990	289174	258102	501372	127966	84147	31102	1934	719	93	16	0	0	0	0	0	0	109
1991	1058000	135797	194921	184960	36290	25554	5339	526	249	17	1	0	0	0	0	0	268
1992	259390	230302	167478	87819	91081	11654	6634	2546	104	7	1	0	0	0	0	0	112
1993	628301	223425	172048	125599	46181	45300	3899	1501	682	56	15	0	0	0	0	0	754
1994	218286	191544	158369	97559	51040	18683	17905	1258	441	73	0	0	0	0	0	0	514
1995	1597900	148170	144023	112416	35649	15062	5117	4472	315	101	54	0	0	0	0	0	470
1996	96515	86318	118910	99644	48303	14088	4638	1281	897	166	24	6	2	0	0	0	1095
1997	19001	60946	80471	84336	41975	18304	3333	1012	304	135	16	0	0	0	0	0	456
1998	72289	92557	50361	43423	36295	17627	6343	1416	306	66	33	0	0	0	0	0	405
1999	76976	189162	95416	45920	33921	18271	7443	2021	565	95	12	0	0	0	0	0	672
2000	1970	82545	129582	63706	23913	16198	8758	4309	969	244	47	3	0	0	0	0	1264
2001	18011	52567	83086	52076	20799	9256	4826	2233	896	246	124	2	0	0	0	0	1268
2002	135848	51338	62462	84600	34659	8098	2048	1461	621	102	13	9	9	0	0	0	755
2003	60744	83680	111144	55866	41840	14218	2358	473	329	50	16	1	0	0	0	0	397
2004	34210	47967	23009	32557	30401	21755	8342	1351	197	93	12	1	4	0	0	0	307
2005	17621	47805	34627	12204	18146	14931	8979	3041	540	83	29	1	0	0	0	0	654
2006	15673	73908	42198	21651	8642	15077	11822	4618	1300	142	14	0	0	0	0	0	1457
2007	2490	39041	34001	24900	9905	4009	7657	5267	2559	476	82	0	0	0	0	0	3117
2008	5631	62164	28301	22741	13571	4305	1848	3954	2134	631	143	43	0	0	0	0	2951
2009	2362	19919	56301	14922	11605	5331	1409	613	1504	942	341	49	1	0	0	0	2837
2010	1224	26266	60426	24826	8016	5394	2867	518	650	567	239	54	1	0	0	0	1510
2011	612	32894	59451	27509	14825	3331	2179	1032	119	47	92	55	0	0	0	0	312
2012	1854	28438	29366	22034	17656	6541	2406	1215	330	86	52	18	55	0	5	0	546
2013	4979	19972	17442	30164	16063	11179	3598	781	366	132	3	0	0	0	0	0	501
2014	4885	39651	18749	19365	20688	9500	3638	1137	218	104	14	0	0	0	0	0	336
2015	5939	32225	50035	12293	8802	12871	4507	1536	473	18	31	4	0	0	0	0	525
2016	8604	25509	38543	35939	9603	7303	6289	2557	988	779	16	1	0	0	0	0	1784

Table 23.1.5. Whiting in Subarea 4 and Division 7.d: Landings numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0	14793	99836	155424	76829	6693	7202	1837	253	11	9	4	0	0	0	0	277
1979	8	8488	108548	144343	89093	26584	3011	1617	250	35	1	4	0	0	0	0	290
1980	0	3656	62405	152570	68422	41430	9911	1135	689	58	14	5	1	0	0	0	767
1981	6	4240	69211	104348	78253	23698	12036	3530	244	45	37	1	0	0	0	0	326
1982	0	10890	46703	124656	59393	21376	5664	2058	400	53	26	4	1	0	0	0	484
1983	1	10568	68640	67312	101342	31266	8330	1730	784	101	35	0	0	0	0	0	921
1984	0	14388	62693	99204	41277	51745	12735	2813	410	182	21	0	0	0	0	0	613
1985	1	2288	51194	57049	32340	12974	16361	3238	805	89	9	1	0	0	0	0	904
1986	29	12879	44500	111527	37287	11285	3379	3912	485	71	0	1	0	0	0	0	557
1987	22	11074	72372	70504	73742	10808	4506	928	899	98	7	0	0	0	0	0	1004
1988	0	7462	61360	94163	29147	16556	2158	544	56	72	37	0	0	0	0	0	164
1989	52	8636	28406	77009	44307	9249	3888	420	208	35	6	1	0	0	0	0	249
1990	23	6910	52533	43850	48537	16845	1341	605	91	16	0	0	0	0	0	0	107
1991	410	11565	42525	88974	25738	21261	4581	396	249	17	1	0	0	0	0	0	268
1992	298	9565	44697	47843	59208	9784	6099	1453	99	7	1	0	0	0	0	0	107
1993	720	5957	28935	63383	32819	33741	2932	1339	682	56	15	0	0	0	0	0	753
1994	77	17124	31351	45492	36289	13920	14407	914	366	73	0	0	0	0	0	0	439
1995	277	8829	28027	58046	27775	13652	4911	4359	308	101	54	0	0	0	0	0	463
1996	1015	12517	26611	47125	35828	11861	4396	1103	897	166	24	6	2	0	0	0	1095
1997	608	6511	23436	47717	31503	15615	2931	1010	289	135	15	0	0	0	0	0	439
1998	1202	17071	19828	24860	24473	14579	5395	1204	219	64	16	0	0	0	0	0	299
1999	68	16661	26669	25504	23465	14483	6554	1854	514	61	12	0	0	0	0	0	587
2000	0	15384	31808	28283	14241	11775	6618	3758	862	244	47	3	0	0	0	0	1157
2001	150	12260	28476	27293	17491	8633	4503	2091	877	246	124	2	0	0	0	0	1249
2002	0	2610	10346	30890	22353	6712	1710	1330	511	99	10	9	9	0	0	0	639
2003	20	403	11613	13990	18974	9513	1861	443	329	50	16	0	0	0	0	0	396
2004	0	3973	2812	9629	13302	11846	4409	747	174	84	12	1	4	0	0	0	274
2005	74	11009	10414	5669	10926	10283	5933	2343	321	78	29	1	0	0	0	0	429
2006	11	11055	11023	8494	5362	12259	10161	4118	1080	105	6	0	0	0	0	0	1192
2007	140	10378	14740	16491	7666	3310	6681	4227	2179	383	77	0	0	0	0	0	2638
2008	0	13234	12334	14120	9106	3564	1519	2505	1481	568	143	43	0	0	0	0	2235
2009	2	2462	31910	9615	9516	4318	1252	548	1156	876	304	49	1	0	0	0	2386
2010	9	3593	27147	15341	4885	4063	1746	363	391	489	230	54	1	0	0	0	1165
2011	0	4679	22858	14952	10821	2333	1484	729	114	42	76	48	0	0	0	0	280
2012	213	4872	13111	13014	11490	4726	1590	860	247	76	28	13	49	0	4	0	417
2013	7	2596	7176	17656	12699	9914	3208	705	328	122	3	0	0	0	0	0	453
2014	0	4089	8459	10697	12414	7312	2675	898	176	90	13	0	0	0	0	0	280
2015	0	2458	21019	7325	6139	8801	3559	1213	360	15	29	4	0	0	0	0	408
2016	0	1269	8061	15588	5803	3762	4131	1651	761	603	10	0	0	0	0	0	1375

Table 23.1.6. Whiting in Subarea 4 and Division 7.d: Unwanted catch numbers at age (thousands). Age 8 is a plus–group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	28587	52684	114965	37682	7154	255	110	0	0	0	0	0	0	0	0	0	0
1979	4577	473830	126724	31601	7322	1263	27	7	0	0	0	0	0	0	0	0	0
1980	3144	103203	250735	88399	14135	10795	786	0	0	0	0	0	0	0	0	0	0
1981	867	50407	96509	57403	7313	1285	149	10	0	0	0	0	0	0	0	0	0
1982	18639	53753	26922	52349	18230	2972	343	22	0	0	0	0	0	0	0	0	0
1983	71016	152488	85318	33325	23442	4309	295	25	9	0	0	0	0	0	0	0	9
1984	16724	200589	82563	16814	4437	4495	1034	151	0	0	0	0	0	0	0	0	0
1985	8497	154232	48791	15117	2985	761	801	65	0	0	0	0	0	0	0	0	0
1986	7966	404604	120492	43479	5242	627	108	63	12	0	0	0	0	0	0	0	12
1987	9978	158531	202154	34824	9776	582	49	0	31	0	0	0	0	0	0	0	31
1988	21321	65021	87197	51135	5877	846	16	0	3	0	0	0	0	0	0	0	3
1989	6898	150598	36712	61442	21267	3276	103	8	12	0	0	0	0	0	0	0	12
1990	147764	83152	241924	33084	23009	11665	246	85	0	0	0	0	0	0	0	0	0
1991	7208	81678	82053	75035	5176	1885	91	60	0	0	0	0	0	0	0	0	0
1992	7587	105838	63830	27659	23115	1231	355	1064	2	0	0	0	0	0	0	0	2
1993	48873	128248	104844	51054	9205	10727	521	131	0	0	0	0	0	0	0	0	0
1994	8352	96890	102020	37751	9867	2885	2338	7	0	0	0	0	0	0	0	0	0
1995	33363	53830	81783	50019	7136	1336	206	113	6	0	0	0	0	0	0	0	6
1996	4575	43126	86878	49817	11506	2205	240	179	0	0	0	0	0	0	0	0	0
1997	11525	26188	34948	32473	9398	2412	400	2	16	0	1	0	0	0	0	0	17
1998	6098	50703	24200	17053	11076	2987	936	213	87	2	18	0	0	0	0	0	106
1999	14762	96413	56365	15228	9016	3104	862	167	51	34	0	0	0	0	0	0	85
2000	1682	48162	81086	24082	3075	2311	1560	478	107	0	0	0	0	0	0	0	107
2001	17352	39826	52156	23055	2795	471	283	142	19	0	0	0	0	0	0	0	19
2002	1158	10597	33371	45125	10136	1182	218	131	110	3	3	0	0	0	0	0	116
2003	3584	65829	94497	39301	21654	4314	449	30	0	0	0	1	0	0	0	0	1
2004	10478	31169	15698	21879	16951	9909	3922	605	24	9	0	0	0	0	0	0	33
2005	5499	25753	23486	6041	7192	4616	2992	688	211	5	0	0	0	0	0	0	216
2006	15662	51961	25906	10935	2474	2595	1598	493	219	37	8	0	0	0	0	0	265
2007	2350	22508	16283	7153	1784	572	940	1037	380	93	5	0	0	0	0	0	478
2008	5631	48929	15967	8621	4465	741	328	1449	653	63	0	0	0	0	0	0	716
2009	2360	12411	21950	4277	1715	910	128	62	347	66	37	0	0	0	0	0	450
2010	1215	15988	30046	8121	2637	1194	1082	151	258	77	9	0	0	0	0	0	344
2011	612	28024	34431	11770	3314	866	641	274	5	3	9	5	0	0	0	0	22
2012	1635	23479	16165	8953	6112	1796	809	352	82	10	23	5	6	0	0	0	128
2013	4972	17154	9653	10997	2277	417	116	15	10	0	0	0	0	0	0	0	10
2014	4596	33213	9161	7496	7019	1607	742	170	28	7	0	0	0	0	0	0	35
2015	5552	27642	25529	4088	2023	3136	616	210	78	1	0	0	0	0	0	0	79
2016	7510	20959	25335	15304	2401	2498	1231	531	79	58	3	0	0	0	0	0	140

Table 23.1.7. Whiting in Subarea 4 and Division 7.d: Industrial bycatch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	658651	351432	98590	49263	6064	616	252	14	0	0	0	0	0	0	0	0	0
1979	471798	133206	232266	42339	4561	1420	73	33	14	0	0	0	0	0	0	0	14
1980	329065	158500	102869	45108	8162	744	55	18	0	0	0	0	0	0	0	0	0
1981	515996	108252	180623	104766	16729	2793	112	0	0	0	0	0	0	0	0	0	0
1982	82418	127998	40818	68242	10514	2448	902	2	0	0	0	0	0	0	0	0	0
1983	597587	42591	30789	17774	6723	1656	63	25	0	0	0	0	0	0	0	0	0
1984	141095	108431	30709	8868	3790	3577	91	0	0	0	0	0	0	0	0	0	0
1985	178224	46801	41731	9871	2522	685	284	26	0	0	0	0	0	0	0	0	0
1986	217207	159249	2086	14572	3987	1456	0	0	0	0	0	0	0	0	0	0	0
1987	74863	97446	93704	17420	1722	1	0	0	0	0	0	0	0	0	0	0	0
1988	395603	357861	158872	34205	4611	500	0	0	0	0	0	0	0	0	0	0	0
1989	80375	172438	108558	53491	12890	1842	1060	89	71	2	0	0	0	0	0	0	72
1990	141387	168040	206916	51033	12601	2592	346	29	2	0	0	0	0	0	0	0	2
1991	1050381	42554	70343	20951	5376	2408	667	70	0	0	0	0	0	0	0	0	0
1992	251505	114899	58952	12318	8758	639	180	29	3	0	0	0	0	0	0	0	3
1993	578708	89219	38270	11162	4157	832	445	31	0	0	0	0	0	0	0	0	0
1994	209858	77530	24998	14316	4885	1878	1160	337	75	0	0	0	0	0	0	0	75
1995	1564260	85510	34213	4351	738	73	0	0	0	0	0	0	0	0	0	0	0
1996	90925	30675	5421	2702	970	21	2	0	0	0	0	0	0	0	0	0	0
1997	6868	28247	22087	4146	1074	276	2	0	0	0	0	0	0	0	0	0	0
1998	64989	24782	6334	1511	746	62	12	0	0	0	0	0	0	0	0	0	0
1999	62145	76088	12381	5188	1440	684	27	0	0	0	0	0	0	0	0	0	0
2000	288	19000	16688	11341	6597	2113	580	73	0	0	0	0	0	0	0	0	0
2001	510	481	2453	1728	514	152	40	0	0	0	0	0	0	0	0	0	0
2002	134690	38131	18745	8585	2170	205	120	0	0	0	0	0	0	0	0	0	0
2003	57140	17448	5034	2575	1213	390	49	0	0	0	0	0	0	0	0	0	0
2004	23732	12824	4499	1049	147	0	11	0	0	0	0	0	0	0	0	0	0
2005	12049	11043	726	494	28	32	54	10	8	0	0	0	0	0	0	0	8
2006	0	10892	5270	2222	806	223	63	7	1	0	0	0	0	0	0	0	1
2007	0	6155	2978	1256	456	126	36	4	1	0	0	0	0	0	0	0	1
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	5046	2441	1030	374	103	29	3	1	0	0	0	0	0	0	0	1
2010	0	6685	3234	1364	495	137	39	4	1	0	0	0	0	0	0	0	1
2011	0	191	2162	787	691	132	54	30	0	1	7	2	0	0	0	0	11
2012	6	87	90	67	54	20	7	4	1	0	0	0	0	0	0	0	2
2013	1	222	614	1511	1087	848	275	60	28	10	0	0	0	0	0	0	39
2014	288	2349	1129	1172	1255	581	222	70	13	6	1	0	0	0	0	0	21
2015	387	2125	3487	880	640	934	332	113	35	1	2	0	0	0	0	0	39
2016	1094	3281	5147	5047	1399	1044	926	376	149	118	2	0	0	0	0	0	269

Table 23.1.8. Whiting in Subarea 4 and Division 7.d: Total catch mean weights at age (kg). Age 8 is a plus-group. These estimates are also used as stock mean weights at age. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.010	0.074	0.182	0.234	0.322	0.427	0.428	0.466	0.615	0.702	1.539	0.589	0	0	0	0	0.649
1979	0.009	0.098	0.166	0.259	0.301	0.411	0.455	0.492	0.578	0.617	0.737	0.515	0	0	0	0	0.582
1980	0.013	0.075	0.176	0.252	0.328	0.337	0.458	0.458	0.568	0.539	0.790	0.688	1.711	0	0	0	0.572
1981	0.011	0.083	0.168	0.242	0.321	0.379	0.411	0.444	0.651	0.833	1.041	0.695	0	0	0	0	0.720
1982	0.029	0.061	0.184	0.253	0.314	0.376	0.478	0.504	0.702	0.772	1.141	0.853	1.081	0	0	0	0.736
1983	0.015	0.107	0.191	0.273	0.325	0.384	0.426	0.452	0.520	0.677	0.516	0	0	0	0	0	0.537
1984	0.020	0.089	0.188	0.271	0.337	0.382	0.391	0.463	0.575	0.514	0.871	0	0	0	0	0	0.567
1985	0.014	0.094	0.192	0.284	0.332	0.402	0.435	0.494	0.426	0.507	0.852	0.976	0	0	0	0	0.438
1986	0.015	0.105	0.183	0.255	0.318	0.378	0.475	0.468	0.540	1.226	0.990	0.535	0	0	0	0	0.626
1987	0.013	0.077	0.148	0.247	0.297	0.375	0.379	0.542	0.555	0.857	0.603	1.193	0	0	0	0	0.584
1988	0.013	0.054	0.146	0.223	0.301	0.346	0.423	0.506	0.854	0.585	0.648	0	0	0	0	0	0.694
1989	0.023	0.070	0.157	0.225	0.267	0.318	0.391	0.431	0.369	0.517	0.857	0.609	0	0	0	0	0.394
1990	0.016	0.084	0.137	0.210	0.252	0.279	0.411	0.498	0.636	0.351	0.918	0	0	0	0	0	0.594
1991	0.018	0.104	0.168	0.217	0.289	0.306	0.339	0.365	0.385	0.589	0.996	2.756	0	0	0	0	0.401
1992	0.013	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.48	0.763	1.728	0	0	0	0	0	0.506
1993	0.012	0.073	0.174	0.250	0.316	0.328	0.346	0.400	0.376	0.417	0.359	0	0	0	0	0	0.379
1994	0.013	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.438	0.392	0.499	0	0	0	0	0	0.431
1995	0.010	0.089	0.180	0.257	0.340	0.384	0.429	0.434	0.445	0.346	0.406	0	0	0	0	0	0.419
1996	0.018	0.094	0.167	0.235	0.302	0.388	0.407	0.431	0.439	0.404	0.376	0.398	0.287	0	0	0	0.432
1997	0.028	0.096	0.178	0.242	0.295	0.334	0.384	0.387	0.394	0.479	0.458	0	0	0	0	0	0.422
1998	0.018	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.335	0.495	0.433	0.600	0	0	0	0	0.369
1999	0.023	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.286	0.316	0.344	0	0	0	0	0	0.292
2000	0.034	0.117	0.182	0.238	0.287	0.286	0.276	0.275	0.268	0.264	0.280	0.321	0	0	0	0	0.268
2001	0.024	0.101	0.192	0.244	0.282	0.267	0.298	0.284	0.286	0.301	0.315	0.505	0	0	0	0	0.292
2002	0.010	0.069	0.155	0.218	0.273	0.303	0.350	0.343	0.327	0.412	0.288	0.231	0.304	0.643	0	0	0.336
2003	0.012	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.342	0.462	0.620	0	0	0	0	0	0.368
2004	0.031	0.111	0.150	0.213	0.253	0.286	0.285	0.286	0.347	0.351	0.352	1.463	0.337	0	0	0	0.350
2005	0.032	0.124	0.199	0.239	0.250	0.282	0.305	0.298	0.271	0.376	0.316	0.337	0.670	0	0	0	0.286
2006	0.093	0.131	0.180	0.231	0.274	0.288	0.360	0.345	0.318	0.299	0.289	0	0	0	0	0	0.316
2007	0.059	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.325	0.288	0.328	0.350	0	0	0	0	0.320
2008	0.027	0.104	0.218	0.282	0.315	0.402	0.407	0.317	0.359	0.337	0.334	0.433	0	0	0	0	0.354
2009	0.042	0.092	0.220	0.289	0.381	0.401	0.465	0.393	0.336	0.310	0.342	0.321	0.436	0	0	0	0.328
2010	0.022	0.088	0.226	0.305	0.376	0.448	0.422	0.458	0.380	0.376	0.351	0.355	0.272	0	0	0	0.373
2011	0.046	0.106	0.185	0.315	0.379	0.443	0.499	0.460	0.568	0.606	0.396	0.437	0.894	0	0	0	0.501
2012	0.021	0.086	0.191	0.275	0.376	0.391	0.403	0.413	0.437	0.583	0.223	0.473	0.616	0.489	0.288	0	0.458
2013	0.045	0.090	0.186	0.244	0.397	0.481	0.497	0.522	0.465	0.567	1.027	0	0	0	0	0	0.496
2014	0.027	0.115	0.215	0.286	0.321	0.468	0.500	0.542	0.603	0.651	0.667	1.754	0	0	0	0	0.621
2015	0.033	0.115	0.207	0.322	0.386	0.400	0.492	0.509	0.519	0.81	0.764	0.778	0	0	0	0	0.546
2016	0.054	0.131	0.209	0.296	0.397	0.405	0.411	0.493	0.409	0.424	0.733	1.297	0	0	0	0	0.419

Table 23.1.9. Whiting in Subarea 4 and Division 7.d: Landings mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0	0.185	0.233	0.250	0.334	0.426	0.434	0.466	0.615	0.702	1.539	0.589	0	0	0	0	0.649
1979	0.113	0.206	0.231	0.277	0.304	0.416	0.456	0.491	0.583	0.617	0.737	0.515	0	0	0	0	0.587
1980	0	0.204	0.239	0.273	0.335	0.358	0.473	0.457	0.568	0.539	0.790	0.688	1.711	0	0	0	0.572
1981	0.144	0.194	0.242	0.292	0.331	0.378	0.411	0.445	0.651	0.833	1.041	0.695	0	0	0	0	0.720
1982	0	0.186	0.230	0.282	0.340	0.396	0.461	0.507	0.702	0.772	1.141	0.853	1.081	0	0	0	0.736
1983	0.132	0.199	0.240	0.282	0.332	0.383	0.429	0.452	0.522	0.677	0.516	0	0	0	0	0	0.538
1984	0	0.194	0.231	0.279	0.346	0.391	0.403	0.472	0.575	0.514	0.871	0	0	0	0	0	0.567
1985	0.137	0.187	0.248	0.307	0.337	0.408	0.443	0.498	0.426	0.507	0.852	0.976	0	0	0	0	0.438
1986	0.131	0.189	0.230	0.279	0.327	0.376	0.484	0.472	0.546	1.226	0.990	0.535	0	0	0	0	0.632
1987	0.135	0.188	0.226	0.286	0.310	0.381	0.381	0.542	0.564	0.857	0.603	1.193	0	0	0	0	0.593
1988	0.117	0.194	0.226	0.256	0.328	0.351	0.425	0.506	0.887	0.585	0.648	0	0	0	0	0	0.702
1989	0.171	0.178	0.226	0.253	0.288	0.345	0.370	0.440	0.373	0.522	0.857	0.609	0	0	0	0	0.405
1990	0.167	0.206	0.222	0.263	0.296	0.337	0.455	0.533	0.640	0.351	0.918	0	0	0	0	0	0.597
1991	0.139	0.202	0.249	0.252	0.308	0.317	0.349	0.387	0.385	0.589	0.996	2.756	0	0	0	0	0.401
1992	0.145	0.194	0.246	0.289	0.306	0.34	0.356	0.383	0.473	0.763	1.728	0	0	0	0	0	0.501
1993	0.153	0.194	0.248	0.284	0.345	0.358	0.385	0.418	0.376	0.417	0.359	0	0	0	0	0	0.379
1994	0.132	0.182	0.248	0.297	0.346	0.392	0.382	0.412	0.414	0.392	0.499	0	0	0	0	0	0.410
1995	0.140	0.171	0.256	0.299	0.367	0.397	0.437	0.437	0.448	0.346	0.406	0	0	0	0	0	0.421
1996	0.143	0.169	0.222	0.274	0.329	0.408	0.415	0.452	0.439	0.404	0.376	0.398	0.287	0	0	0	0.432
1997	0.149	0.171	0.206	0.260	0.315	0.349	0.401	0.386	0.398	0.479	0.437	0	0	0	0	0	0.424
1998	0.138	0.164	0.208	0.259	0.304	0.331	0.361	0.348	0.392	0.504	0.603	0.600	0	0	0	0	0.427
1999	0.135	0.184	0.237	0.271	0.281	0.303	0.316	0.320	0.292	0.368	0.344	0	0	0	0	0	0.301
2000	0	0.166	0.227	0.272	0.299	0.292	0.313	0.276	0.269	0.264	0.280	0.321	0	0	0	0	0.269
2001	0.138	0.160	0.216	0.268	0.285	0.267	0.301	0.288	0.287	0.301	0.315	0.505	0	0	0	0	0.293
2002	0	0.183	0.214	0.260	0.293	0.313	0.364	0.350	0.325	0.390	0.311	0.231	0.304	0.643	0	0	0.333
2003	0.128	0.208	0.228	0.258	0.308	0.311	0.374	0.391	0.342	0.462	0.620	0	0	0	0	0	0.369
2004	0	0.210	0.216	0.242	0.290	0.326	0.330	0.334	0.366	0.351	0.352	1.463	0.337	0	0	0	0.363
2005	0.164	0.205	0.253	0.277	0.270	0.308	0.339	0.313	0.296	0.381	0.316	0.337	0.670	0	0	0	0.313
2006	0.133	0.217	0.254	0.285	0.295	0.298	0.377	0.353	0.334	0.306	0.290	0	0	0	0	0	0.331
2007	0.202	0.199	0.264	0.280	0.351	0.361	0.319	0.332	0.342	0.318	0.334	0	0	0	0	0	0.338
2008	0	0.223	0.265	0.324	0.356	0.431	0.424	0.359	0.389	0.339	0.334	0.433	0	0	0	0	0.374
2009	0.148	0.205	0.246	0.318	0.386	0.404	0.464	0.404	0.347	0.313	0.311	0.321	0.436	0	0	0	0.329
2010	0.359	0.221	0.255	0.331	0.416	0.470	0.479	0.541	0.439	0.374	0.337	0.355	0.272	0	0	0	0.388
2011	0	0.182	0.237	0.374	0.416	0.506	0.569	0.504	0.582	0.634	0.406	0.465	0.894	0	0	0	0.523
2012	0.021	0.135	0.236	0.337	0.468	0.443	0.501	0.478	0.478	0.584	0.256	0.514	0.621	0.489	0.288	0	0.498
2013	0.066	0.181	0.224	0.275	0.421	0.487	0.508	0.526	0.464	0.567	1.027	0	0	0	0	0	0.496
2014	0	0.177	0.259	0.326	0.361	0.508	0.546	0.571	0.642	0.675	0.667	1.754	0	0	0	0	0.654
2015	0	0.179	0.247	0.367	0.423	0.448	0.521	0.527	0.569	0.835	0.764	0.778	0	0	0	0	0.594
2016	0	0.197	0.275	0.352	0.453	0.502	0.453	0.560	0.420	0.434	0.850	1.297	0	0	0	0	0.429

Table 23.1.10. Whiting in Subarea 4 and Division 7.d: Unwanted catch mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.036	0.145	0.158	0.185	0.209	0.222	0.239	0	0	0	0	0	0	0	0	0	0
1979	0.080	0.104	0.158	0.191	0.189	0.234	0.265	0.295	0	0	0	0	0	0	0	0	0
1980	0.030	0.107	0.166	0.202	0.244	0.253	0.264	0	0	0	0	0	0	0	0	0	0
1981	0.071	0.131	0.164	0.197	0.230	0.289	0.252	0.268	0	0	0	0	0	0	0	0	0
1982	0.047	0.091	0.182	0.211	0.225	0.241	0.244	0.261	0	0	0	0	0	0	0	0	0
1983	0.036	0.114	0.167	0.235	0.264	0.290	0.317	0.277	0.365	0	0	0	0	0	0	0	0.365
1984	0.038	0.101	0.162	0.216	0.246	0.265	0.248	0.278	0	0	0	0	0	0	0	0	0
1985	0.022	0.105	0.169	0.213	0.238	0.242	0.253	0.255	0	0	0	0	0	0	0	0	0
1986	0.028	0.123	0.166	0.190	0.208	0.227	0.194	0.217	0.311	0	0	0	0	0	0	0	0.311
1987	0.016	0.090	0.149	0.206	0.205	0.263	0.257	0	0.292	0	0	0	0	0	0	0	0.292
1988	0.030	0.063	0.146	0.181	0.210	0.219	0.235	0	0.284	0	0	0	0	0	0	0	0.284
1989	0.033	0.083	0.164	0.191	0.213	0.227	0.241	0.351	0.221	0	0	0	0	0	0	0	0.221
1990	0.024	0.095	0.130	0.183	0.186	0.196	0.249	0.302	0	0	0	0	0	0	0	0	0
1991	0.041	0.089	0.154	0.177	0.213	0.230	0.253	0.268	0	0	0	0	0	0	0	0	0
1992	0.037	0.093	0.173	0.210	0.215	0.241	0.245	0.220	1.183	0	0	0	0	0	0	0	1.183
1993	0.023	0.087	0.160	0.205	0.237	0.235	0.225	0.213	0	0	0	0	0	0	0	0	0
1994	0.040	0.090	0.151	0.203	0.230	0.244	0.254	0.332	0	0	0	0	0	0	0	0	0
1995	0.032	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.290	0	0	0	0	0	0	0	0.290
1996	0.031	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0	0	0	0	0	0	0	0	0
1997	0.031	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.320	0.601	0.773	0	0	0	0	0	0.352
1998	0.026	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.191	0.180	0.284	0	0	0	0	0	0.206
1999	0.062	0.100	0.166	0.197	0.201	0.225	0.231	0.212	0.231	0.220	0	0	0	0	0	0	0.227
2000	0.033	0.127	0.167	0.195	0.226	0.209	0.219	0.222	0.264	0	0	0	0	0	0	0	0.264
2001	0.023	0.084	0.183	0.217	0.259	0.248	0.240	0.225	0.243	0	0	0	0	0	0	0	0.243
2002	0.039	0.130	0.167	0.196	0.224	0.224	0.225	0.272	0.334	1.120	0.217	0	0	0	0	0	0.352
2003	0.048	0.062	0.105	0.170	0.214	0.262	0.257	0.293	0.237	0	0	0	0	0	0	0	0.055
2004	0.079	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.204	0.351	0	0	0	0	0	0	0.245
2005	0.070	0.124	0.177	0.207	0.221	0.223	0.235	0.245	0.222	0.293	0	0	0	0	0	0	0.224
2006	0.093	0.131	0.161	0.193	0.229	0.233	0.247	0.273	0.239	0.279	0.289	0	0	0	0	0	0.246
2007	0.050	0.065	0.170	0.214	0.225	0.247	0.237	0.215	0.229	0.166	0.241	0.350	0	0	0	0	0.217
2008	0.027	0.072	0.181	0.213	0.230	0.265	0.328	0.244	0.291	0.317	0.057	0	0	0	0	0	0.293
2009	0.042	0.089	0.193	0.243	0.376	0.393	0.484	0.286	0.300	0.268	0.596	0	0	0	0	0	0.319
2010	0.019	0.075	0.211	0.272	0.319	0.384	0.330	0.254	0.290	0.390	0.730	0	0	0	0	0	0.323
2011	0.046	0.093	0.147	0.242	0.271	0.285	0.339	0.344	0.246	0.291	0.304	0.167	0	0	0	0	0.256
2012	0.021	0.076	0.155	0.184	0.204	0.254	0.211	0.252	0.313	0.574	0.183	0.374	0.580	0.489	0.288	0	0.325
2013	0.045	0.076	0.158	0.196	0.262	0.326	0.207	0.335	0.508	0	0	0	0	0	0	0	0.508
2014	0.027	0.107	0.173	0.229	0.250	0.289	0.333	0.385	0.360	0.342	0.469	0	0	0	0	0	0.357
2015	0.033	0.109	0.173	0.240	0.275	0.266	0.320	0.407	0.289	0.413	0	0	0	0	0	0	0.290
2016	0.054	0.126	0.187	0.237	0.265	0.259	0.269	0.283	0.257	0.220	0.297	0	0	0	0	0	0.243

Table 23.1.11. Whiting in Subarea 4 and Division 7.d: Industrial bycatch mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2016 are included in the final assessment.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.009	0.059	0.158	0.220	0.295	0.529	0.351	0.449	0	0	0	0	0	0	0	0	0
1979	0.008	0.069	0.141	0.249	0.428	0.477	0.467	0.605	0.482	0	0	0	0	0	0	0	0.482
1980	0.013	0.051	0.164	0.281	0.412	0.380	0.389	0.561	0	1.000	0	0	0	0	0	0	1.000
1981	0.011	0.056	0.141	0.218	0.318	0.433	0.596	0.600	0.800	0	0	0	0	0	0	0	0.800
1982	0.025	0.038	0.133	0.232	0.320	0.366	0.674	0.284	0.800	1.000	1.200	0	0	0	0	0	0.840
1983	0.012	0.058	0.148	0.311	0.431	0.651	0.565	0.602	0.800	1.000	0	0	0	0	0	0	0.802
1984	0.018	0.053	0.173	0.289	0.343	0.390	0.228	0.600	0.800	1.000	0	0	0	0	0	0	0.896
1985	0.014	0.054	0.150	0.263	0.382	0.454	0.504	0.584	0.800	1.000	0	0	0	0	0	0	0.809
1986	0.014	0.054	0.150	0.262	0.381	0.455	0.500	0.600	0.800	0	0	0	0	0	0	0	0.800
1987	0.012	0.043	0.085	0.173	0.262	0.400	0.500	0.600	0.800	1.000	0	0	0	0	0	0	0.822
1988	0.012	0.050	0.115	0.197	0.245	0.380	0.500	0.600	0.800	0	0	0	0	0	0	0	0.800
1989	0.022	0.053	0.137	0.224	0.285	0.344	0.482	0.396	0.385	0.401	0	0	0	0	0	0	0.385
1990	0.007	0.073	0.123	0.181	0.201	0.280	0.355	0.335	0.472	0	0	0	0	0	0	0	0.472
1991	0.018	0.105	0.136	0.215	0.272	0.265	0.279	0.322	0	0	0	0	0	0	0	0	0
1992	0.012	0.068	0.151	0.235	0.244	0.364	0.219	0.256	0.282	0	0	0	0	0	0	0	0.282
1993	0.011	0.045	0.156	0.260	0.264	0.307	0.235	0.392	0	0	0	0	0	0	0	0	0
1994	0.012	0.055	0.131	0.259	0.388	0.521	0.555	0.44	0.555	0	0	0	0	0	0	0	0.555
1995	0.009	0.072	0.160	0.312	0.373	0.511	0	0	0	0	0	0	0	0	0	0	0
1996	0.016	0.064	0.151	0.239	0.233	0.347	0.250	0	0	0	0	0	0	0	0	0	0
1997	0.012	0.051	0.145	0.252	0.321	0.348	0.588	0	0	0	0	0	0	0	0	0	0
1998	0.015	0.049	0.115	0.220	0.304	0.286	0	0	0	0	0	0	0	0	0	0	0
1999	0.013	0.027	0.077	0.144	0.194	0.286	0	0	0	0	0	0	0	0	0	0	0
2000	0.038	0.051	0.166	0.242	0.289	0.339	0	0.588	0	0	0	0	0	0	0	0	0
2001	0.012	0.055	0.118	0.225	0.320	0.351	0.386	0	0	0	0	0	0	0	0	0	0
2002	0.010	0.044	0.101	0.185	0.294	0.415	0.380	0	0	0	0	0	0	0	0	0	0
2003	0.010	0.035	0.102	0.189	0.302	0.418	0.462	0	0	0	0	0	0	0	0	0	0
2004	0.010	0.032	0.083	0.143	0.264	0	0.380	0	0	0	0	0	0	0	0	0	0
2005	0.014	0.043	0.133	0.196	0.205	0.366	0.438	0.541	0.530	0	0	0	0	0	0	0	0.530
2006	0	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0	0	0	0	0	0	0	0.530
2007	0	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0	0	0	0	0	0	0	0.530
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0	0	0	0	0	0	0	0.530
2010	0	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0	0	0	0	0	0	0	0.530
2011	0	0.188	0.242	0.305	0.321	0.371	0.464	0.436	0.628	0.421	0.393	0.480	0	0	0	0	0.419
2012	0.021	0.086	0.191	0.275	0.376	0.391	0.403	0.413	0.437	0.583	0.223	0.473	0.616	0.489	0.288	0	0.458
2013	0.045	0.090	0.186	0.244	0.397	0.481	0.497	0.522	0.465	0.567	1.027	0	0	0	0	0	0.497
2014	0.028	0.117	0.217	0.288	0.323	0.465	0.499	0.548	0.604	0.660	0.685	1.754	0	0	0	0	0.625
2015	0.034	0.118	0.209	0.321	0.385	0.400	0.491	0.510	0.525	0.825	0.769	0.778	0	0	0	0	0.552
2016	0.058	0.133	0.215	0.299	0.395	0.407	0.415	0.497	0.434	0.474	0.810	1.296	0	0	0	0	0.455

Table 23.1.12. Whiting in Subarea 4 and Division 7.d: Estimated proportion mature at age as used in the assessment.

Age	1	2	3	4	5	6	7	8+
Mat	0.11	0.92	1	1	1	1	1	1

Table 23.1.13. Whiting in Subarea 4 and Division 7.d: Natural mortality at age from ICES WGSAM (2014).

Age	1	2	3	4	5	6	7	8+
1990	1.248	0.608	0.549	0.545	0.478	0.478	0.478	0.478
1991	1.242	0.604	0.547	0.544	0.487	0.487	0.487	0.487
1992	1.237	0.603	0.546	0.543	0.496	0.496	0.496	0.496
1993	1.233	0.603	0.546	0.543	0.506	0.506	0.506	0.506
1994	1.233	0.605	0.547	0.544	0.515	0.515	0.515	0.515
1995	1.238	0.607	0.549	0.545	0.523	0.523	0.523	0.523
1996	1.246	0.609	0.551	0.547	0.531	0.531	0.531	0.531
1997	1.258	0.610	0.553	0.549	0.538	0.538	0.538	0.538
1998	1.274	0.612	0.556	0.551	0.544	0.544	0.544	0.544
1999	1.292	0.614	0.558	0.552	0.549	0.549	0.549	0.549
2000	1.314	0.619	0.562	0.555	0.554	0.554	0.554	0.554
2001	1.338	0.626	0.567	0.559	0.559	0.559	0.559	0.559
2002	1.362	0.637	0.574	0.565	0.566	0.566	0.566	0.566
2003	1.380	0.651	0.583	0.573	0.573	0.573	0.573	0.573
2004	1.386	0.668	0.592	0.582	0.579	0.579	0.579	0.579
2005	1.379	0.686	0.601	0.591	0.584	0.584	0.584	0.584
2006	1.362	0.704	0.608	0.599	0.586	0.586	0.586	0.586
2007	1.338	0.722	0.613	0.605	0.585	0.585	0.585	0.585
2008	1.312	0.739	0.617	0.610	0.580	0.580	0.580	0.580
2009	1.288	0.755	0.620	0.615	0.574	0.574	0.574	0.574
2010	1.271	0.771	0.624	0.620	0.567	0.567	0.567	0.567
2011	1.261	0.790	0.629	0.627	0.561	0.561	0.561	0.561
2012	1.257	0.809	0.636	0.635	0.557	0.557	0.557	0.557
2013	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553
2014	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553
2015	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553
2016	1.255	0.830	0.643	0.644	0.553	0.553	0.553	0.553

Table 23.1.14. Whiting in Subarea 4 and Division 7.d: Tuning series used in the assessment and forecast. Note that only years from 1990 onwards are used in the final assessment.

IBTS–Q1					
Age	1	2	3	4	5
1978	5.472	2.629	0.919	0.220	0.042
1979	4.439	2.307	1.143	0.335	0.050
1980	6.750	4.037	1.250	0.254	0.088
1981	2.297	4.635	2.285	0.460	0.091
1982	1.515	2.173	2.581	0.686	0.101
1983	1.266	1.250	1.100	0.764	0.322
1984	4.345	1.780	0.890	0.303	0.254
1985	3.392	3.623	0.659	0.186	0.071
1986	4.687	2.683	1.946	0.321	0.066
1987	6.849	5.611	0.904	0.455	0.049
1988	4.480	8.657	3.143	0.330	0.126
1989	14.476	5.328	4.055	1.073	0.119
1990	5.189	8.624	1.982	0.916	0.169
1991	10.076	6.864	4.796	0.709	0.376
1992	9.073	6.657	2.402	1.508	0.127
1993	10.756	5.228	2.446	0.655	0.590
1994	7.217	6.274	1.810	0.681	0.119
1995	6.786	4.485	2.394	0.581	0.119
1996	5.024	4.860	2.447	0.697	0.231
1997	2.878	3.422	1.624	0.604	0.180
1998	5.431	1.607	1.254	0.540	0.155
1999	6.763	3.054	0.947	0.575	0.258
2000	7.679	5.449	1.836	0.537	0.202
2001	6.142	5.924	2.995	0.983	0.258
2002	5.585	3.428	2.629	0.632	0.208
2003	1.316	2.984	2.367	1.334	0.484
2004	1.844	0.901	1.727	0.999	0.487
2005	1.127	0.978	0.456	0.601	0.390
2006	1.844	1.251	0.455	0.183	0.270
2007	0.645	1.473	0.673	0.186	0.084
2008	2.686	2.058	0.655	0.221	0.075
2009	2.112	2.958	0.936	0.272	0.119
2010	3.262	2.248	2.441	0.948	0.285
2011	1.849	3.371	1.575	0.926	0.197
2012	2.313	5.883	1.147	0.464	0.324
2013	0.544	1.630	2.413	0.883	0.269
2014	2.652	1.845	0.992	0.659	0.227
2015	3.150	2.126	0.598	0.287	0.240

2016	3.016	3.230	0.908	0.202	0.116
2017	6.132	2.484	1.106	0.252	0.079
IBTS-Q3					
Age	1	2	3	4	5
1991	7.034	1.586	0.790	0.146	0.052
1992	6.009	2.961	0.725	0.575	0.103
1993	6.387	1.774	0.661	0.147	0.159
1994	6.776	2.195	0.747	0.195	0.047
1995	6.198	2.912	1.072	0.215	0.060
1996	5.457	2.782	1.294	0.340	0.069
1997	3.330	1.807	1.090	0.280	0.107
1998	3.306	1.502	0.528	0.310	0.112
1999	12.035	1.906	0.539	0.245	0.095
2000	9.408	3.265	0.644	0.136	0.065
2001	6.689	2.831	0.940	0.191	0.043
2002	8.119	2.572	1.315	0.350	0.055
2003	2.576	2.928	1.287	0.679	0.173
2004	1.506	0.590	0.663	0.457	0.271
2005	1.714	0.683	0.314	0.456	0.340
2006	1.746	0.863	0.326	0.135	0.233
2007	0.955	0.636	0.376	0.115	0.084
2008	3.623	0.689	0.309	0.138	0.041
2009	5.855	3.848	0.410	0.123	0.080
2010	2.243	1.457	0.546	0.128	0.060
2011	4.468	1.444	0.472	0.162	0.069
2012	2.567	1.935	0.570	0.201	0.106
2013	0.675	0.601	0.658	0.175	0.071
2014	2.234	0.980	0.656	0.333	0.103
2015	3.125	2.226	0.431	0.240	0.184
2016	2.972	2.437	0.777	0.122	0.081

Table 23.1.15. Whiting in Subarea 4 and Division 7.d: FLXSA tuning diagnostics.

FLR XSA Diagnostics 2017-04-28 09:46:50

Cpue data from indices

Catch data for 27 years 1990 to 2016. Ages 1 to 8.

fleet	first age	last age	first year	last year	alpha	beta
1 IBTS–Q1	1	5	1990	2016	0	0.25
2 IBTS–Q3	1	5	1991	2016	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 4

Terminal population estimation :

Survivor estimates shrunk towards the mean F

of the final 3 years or the 4 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population

estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.051	0.044	0.017	0.022	0.021	0.034	0.034	0.034	0.023	0.024
2	0.141	0.114	0.122	0.157	0.148	0.054	0.063	0.096	0.132	0.082
3	0.242	0.220	0.134	0.122	0.169	0.129	0.125	0.163	0.148	0.238
4	0.328	0.323	0.264	0.155	0.156	0.252	0.211	0.191	0.166	0.272
5	0.252	0.364	0.315	0.292	0.134	0.144	0.398	0.291	0.272	0.318
6	0.337	0.269	0.296	0.435	0.276	0.201	0.161	0.324	0.327	0.308
7	0.480	0.463	0.201	0.254	0.422	0.371	0.134	0.101	0.330	0.481
8	0.480	0.463	0.201	0.254	0.422	0.371	0.134	0.101	0.330	0.481

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8
2007	1523410	372079	157182	47926	24143	35829	18518	10558
2008	2764813	379796	157085	66800	18844	10462	14251	10261

2009	2259351	712318	161901	68035	26277	7326	4473	20236
2010	2330274	612412	296286	76112	28245	10800	3069	8727
2011	3028641	639713	242073	140562	35051	11955	3965	1162
2012	1579943	840390	250383	108949	64251	17477	5173	2256
2013	1125900	434338	354459	116548	44873	31860	8192	5163
2014	2220038	310400	177848	164440	49561	17327	15592	4522
2015	2668688	611899	122950	79439	71357	21295	7204	2397
2016	1991084	743803	233742	55712	35336	31273	8828	5948

Estimated population abundance at 1st Jan 2017

age

year	1	2	3	4	5	6	7	8
2017	0	554170	298843	96804	22296	14782	13215	3137

Fleet: IBTS–Q1

Log catchability residuals.

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.062	0.728	0.668	0.704	0.368	0.415	0.454	0.167	0.476	0.210	0.161	0.124	0.184	-0.202	0.116
2	-0.130	0.518	0.413	0.269	0.287	0.004	0.182	0.162	-0.321	0.023	0.148	0.011	-0.335	-0.278	-0.302
3	0.064	0.142	0.303	0.193	0.016	0.061	0.125	-0.209	-0.159	-0.186	0.245	0.233	-0.191	-0.095	-0.108
4	0.002	0.294	0.016	0.093	0.126	-0.004	-0.092	-0.230	-0.302	-0.019	0.252	0.647	-0.468	0.026	-0.095
5	-0.477	0.423	-0.373	0.099	-0.440	-0.396	0.079	-0.421	-0.632	-0.118	-0.064	0.502	-0.066	0.069	-0.180

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	-0.646	-0.153	-1.163	-0.337	-0.381	0.021	-0.810	0.066	-1.042	-0.138	-0.151	0.099
2	-0.284	-0.331	-0.154	0.159	-0.104	-0.222	0.141	0.416	-0.204	0.260	-0.272	-0.056
3	-0.309	-0.289	-0.194	-0.222	0.094	0.447	0.218	-0.138	0.259	0.064	-0.075	-0.288
4	-0.328	-0.346	-0.172	-0.332	-0.147	0.977	0.341	-0.082	0.489	-0.151	-0.255	-0.242
5	-0.261	-0.373	-0.295	-0.141	-0.019	0.776	0.172	0.064	0.267	-0.013	-0.324	-0.349

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-13.3431	-12.1797	-12.0622	-12.1750	-12.1750
S.E_Logq	0.3346	0.3346	0.3346	0.3346	0.3346

Fleet: IBTS–Q3

Log catchability residuals.

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.250	0.164	0.078	0.196	0.210	0.418	0.199	-0.124	0.703	0.261	0.115	0.478	0.457	-0.129	-0.283
2	-0.320	0.191	-0.204	-0.192	0.140	0.182	0.076	0.147	0.122	0.192	-0.215	-0.109	0.279	-0.175	-0.054
3	-0.805	-0.016	-0.172	0.036	0.141	0.354	0.241	-0.230	0.095	0.062	-0.156	-0.090	0.072	-0.302	0.098

```
 4 -0.283  0.024 -0.352 -0.038 -0.023  0.174 -0.050  0.069  0.090 -0.159 -0.099 -0.183  0.222 -0.018  0.238
 5 -0.411  0.370 -0.152 -0.204 -0.001 -0.143  0.054  0.011 -0.132 -0.147 -0.322 -0.521 -0.092  0.129  0.468
  year
age   2006   2007   2008   2009   2010   2011   2012   2013   2014   2015   2016
 1 -0.255 -0.853 -0.136  0.514 -0.484 -0.063  0.039 -0.961 -0.442 -0.297 -0.054
 2 -0.112 -0.412 -0.358  0.748 -0.040 -0.086 -0.113 -0.604  0.241  0.406  0.270
 3  0.230  0.056 -0.152  0.049 -0.274 -0.184 -0.051 -0.253  0.456  0.396  0.399
 4  0.239  0.287  0.136 -0.029 -0.162 -0.538 -0.004 -0.229  0.057  0.444  0.187
 5  0.379  0.600  0.193  0.503  0.120 -0.053 -0.226 -0.120  0.090  0.295  0.199
Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time
                  1        2        3        4        5
Mean_Logq -12.5662 -12.3309 -12.4652 -12.6473 -12.6473
S.E_Logq    0.2950   0.2950   0.2950   0.2950   0.2950
Terminal year survivor and F summaries:
 ,Age 1 Year class =2015
source
         scaledWts  survivors yrcls
IBTS–Q1     0.392    611567    2015
IBTS–Q3     0.583    525179    2015
fshk        0.025    414809    2015
,Age 2 Year class =2014
source
         scaledWts survivors yrcls
IBTS-Q1     0.494    282704    2014
IBTS-Q3     0.494    391356    2014
fshk        0.012    241312    2014
,Age 3 Year class =2013
source
         scaledWts survivors yrcls
IBTS–Q1     0.493     72546    2013
IBTS–Q3     0.493    144338    2013
fshk        0.014    162475    2013
,Age 4 Year class =2012
source
         scaledWts survivors yrcls
IBTS–Q1     0.437     17495    2012
IBTS–Q3     0.547     26872    2012
fshk        0.016     32512    2012
,Age 5 Year class =2011
```

source

	scaledWts	survivors	yrcls
IBTS–Q1	0.418	10426	2011
IBTS–Q3	0.565	18035	2011
fshk	0.017	14267	2011

,Age 6 Year class =2010

source

	scaledWts	survivors	yrcls
fshk	1	14944	2010

,Age 7 Year class =2009

source

	scaledWts	survivors	yrcls
fshk	1	5752	2009

Table 23.1.16. Whiting in Subarea 4 and Division 7.d: Final fishing mortality estimates from FLXSA.

AGE	1	2	3	4	5	6	7	8+
1990	0.144	0.378	0.606	0.760	0.983	0.710	0.786	0.786
1991	0.074	0.349	0.359	0.524	0.865	0.625	0.608	0.608
1992	0.133	0.271	0.407	0.458	0.465	0.875	1.130	1.130
1993	0.112	0.311	0.535	0.607	0.669	0.396	0.740	0.740
1994	0.102	0.236	0.458	0.684	0.853	0.986	0.303	0.303
1995	0.088	0.226	0.411	0.457	0.682	0.966	1.224	1.224
1996	0.071	0.204	0.376	0.475	0.497	0.713	1.173	1.173
1997	0.066	0.192	0.339	0.405	0.505	0.301	0.489	0.489
1998	0.073	0.156	0.229	0.359	0.450	0.496	0.296	0.296
1999	0.094	0.225	0.323	0.430	0.473	0.536	0.436	0.436
2000	0.034	0.192	0.361	0.425	0.590	0.698	1.245	1.245
2001	0.026	0.096	0.167	0.285	0.443	0.541	0.597	0.597
2002	0.030	0.088	0.206	0.239	0.256	0.244	0.480	0.480
2003	0.149	0.199	0.164	0.224	0.218	0.162	0.119	0.119
2004	0.082	0.131	0.128	0.191	0.264	0.294	0.198	0.198
2005	0.062	0.190	0.151	0.148	0.205	0.253	0.252	0.252
2006	0.096	0.173	0.288	0.235	0.273	0.390	0.308	0.308
2007	0.051	0.141	0.242	0.328	0.252	0.337	0.480	0.480
2008	0.044	0.114	0.220	0.323	0.364	0.269	0.463	0.463
2009	0.017	0.122	0.134	0.264	0.315	0.296	0.201	0.201
2010	0.022	0.157	0.122	0.155	0.292	0.435	0.254	0.254
2011	0.021	0.148	0.169	0.156	0.134	0.276	0.422	0.422
2012	0.034	0.054	0.129	0.252	0.144	0.201	0.371	0.371
2013	0.034	0.063	0.125	0.211	0.398	0.161	0.134	0.134
2014	0.034	0.096	0.163	0.191	0.291	0.324	0.101	0.101
2015	0.023	0.132	0.148	0.166	0.272	0.327	0.330	0.330
2016	0.024	0.082	0.238	0.272	0.318	0.308	0.481	0.481

Table 23.1.17. Whiting in Subarea 4 and Division 7.d: Final abundance estimates from FLXSA.

AGE	1	2	3	4	5	6	7	8+
1990	3602224	2158488	370671	207691	63128	4829	1677	245
1991	3559519	895377	805584	116792	56321	14654	1471	724
1992	3426549	954691	345269	325302	40150	14578	4820	201
1993	3906041	870862	398562	133090	119577	15350	3699	1782
1994	3661737	1017612	349088	135208	42123	36934	6230	2486
1995	3282168	963578	438686	127739	39596	10730	8230	812
1996	2335674	872378	418874	167916	46897	11869	2419	1945
1997	1782753	625546	386905	165744	60408	16773	3422	1490
1998	2478930	474193	280475	158517	63828	21288	7248	2022
1999	4042873	644745	220052	128005	63845	23621	7525	2422
2000	4799029	1011427	278595	91163	47949	22984	7984	2189
2001	3992721	1247254	449742	110740	34233	15277	6570	3582
2002	3428809	1020432	606295	215886	47612	12571	5084	2537
2003	1208118	852227	494404	277929	96577	20939	5596	4605
2004	1223023	262014	364193	234224	125253	43789	10038	2226
2005	1596036	281806	117897	177203	108097	53888	18288	3829
2006	1598134	377825	117365	55611	84592	49122	23341	7154
2007	1523410	372079	157182	47926	24143	35829	18518	10558
2008	2764813	379796	157085	66800	18844	10462	14251	10261
2009	2259351	712318	161901	68035	26277	7326	4473	20236
2010	2330274	612412	296286	76112	28245	10800	3069	8727
2011	3028641	639713	242073	140562	35051	11955	3965	1162
2012	1579943	840390	250383	108949	64251	17477	5173	2256
2013	1125900	434338	354459	116548	44873	31860	8192	5163
2014	2220038	310400	177848	164440	49561	17327	15592	4522
2015	2668688	611899	122950	79439	71357	21295	7204	2397
2016	1991084	743803	233742	55712	35336	31273	8828	5948

Table 23.1.18. Whiting in Subarea 4 and Division 7.d: Final FLXSA summary table. Units are millions of individuals and tons.

Year	Recruitment	TSB	SSB	Catch	Landings	Unwanted catch	Bycatch	Yield /SSB	Mean F(2–6)
1990	3602224	747068	455279	152602	45662	55603	51337	0.100	0.687
1991	3559519	751420	411050	126742	51929	35058	39755	0.126	0.544
1992	3426549	665285	392805	108555	50946	32564	25045	0.130	0.495
1993	3906041	625217	359044	116911	51818	44370	20723	0.144	0.504
1994	3661737	644799	357259	101650	48486	35692	17473	0.136	0.644
1995	3282168	645318	372021	105494	45938	32176	27379	0.123	0.548
1996	2335674	539777	332282	76123	40503	30505	5116	0.122	0.453
1997	1782753	452940	292302	61435	35563	19660	6213	0.122	0.348
1998	2478930	450588	244159	47475	28288	15693	3494	0.116	0.338
1999	4042873	540425	250651	60845	30130	25677	5038	0.120	0.397
2000	4799029	859257	345801	63806	28583	26063	9160	0.083	0.453
2001	3992721	802688	422950	45242	25061	19237	944	0.059	0.306
2002	3428809	606754	384093	46450	20675	18501	7275	0.054	0.206
2003	1208118	376815	307423	45640	16161	26745	2734	0.053	0.194
2004	1223023	363853	239795	33557	13295	19048	1214	0.055	0.201
2005	1596036	379901	199359	28883	15471	12525	888	0.078	0.189
2006	1598134	372562	180314	36769	18535	16310	1924	0.103	0.272
2007	1523410	310014	171511	26974	18915	6971	1088	0.110	0.260
2008	2764813	455881	192996	28247	17951	10296	0	0.093	0.258
2009	2259351	460493	262076	27015	18418	7705	892	0.07	0.226
2010	2330274	483224	290502	30982	18224	11577	1181	0.063	0.232
2011	3028641	592524	297582	31988	18899	11977	1112	0.064	0.177
2012	1579943	441746	307953	25076	17032	7968	77	0.055	0.156
2013	1125900	359556	262743	26841	19335	5976	1530	0.074	0.192
2014	2220038	469197	236283	27991	16755	9543	1692	0.071	0.213
2015	2668688	547576	264295	30015	17598	10294	2123	0.067	0.209
2016	1991084	540573	296870	33759	15854	13204	4701	0.053	0.244

Table 23.1.19. Whiting in Subarea 4 and Division 7.d: Reference points as determined in the inter-benchmark 2016 (ICES, 2016).

Reference point	Value
Blim	172 741 t (Bloss)
Flim	0.39
Bpa	241 837 t (Btrigger)
Fpa	0.28
Fp.05 (without Btrigger)	0.12
Fp.05 (with Btrigger)	0.15 (final Fmsy , with SSB > Blim)

Table 23.1.20. Whiting in Subarea 4 and Division 7.d: RCT3 input table.

Year class	Recruitment	IBTSQ11	IBTSQ12	IBTSQ30	IBTSQ31	IBTSQ32
1989	3602224	518.936	686.445	NA	NA	158.594
1990	3559519	1007.621	665.714	NA	703.368	296.100
1991	3426549	907.297	522.811	536.990	600.867	177.377
1992	3906041	1075.624	627.406	1379.459	638.722	219.541
1993	3661737	721.709	448.484	919.193	677.645	291.180
1994	3282168	678.590	485.968	610.743	619.786	278.218
1995	2335674	502.361	342.246	729.246	545.708	180.681
1996	1782753	287.779	160.695	316.501	332.968	150.205
1997	2478930	543.117	305.445	2062.670	330.600	190.643
1998	4042873	676.266	544.860	2631.690	1203.501	326.515
1999	4799029	767.887	592.395	2498.550	940.784	283.081
2000	3992721	614.174	342.774	1961.467	668.907	257.157
2001	3428809	558.505	298.408	3548.815	811.915	292.805
2002	1208118	131.588	90.134	269.285	257.637	59.032
2003	1223023	184.399	97.824	356.523	150.623	68.259
2004	1596036	112.663	125.057	714.270	171.386	86.336
2005	1598134	184.411	147.304	169.321	174.625	63.592
2006	1523410	64.530	205.798	198.949	95.495	68.886
2007	2764813	268.598	295.812	822.902	362.299	384.777
2008	2259351	211.202	224.795	764.759	585.529	145.671
2009	2330274	326.192	337.096	593.801	224.321	144.439
2010	3028641	184.867	588.309	510.123	446.812	193.523
2011	1579943	231.255	162.985	247.085	256.718	60.102
2012	1125900	54.431	184.517	306.812	67.451	97.962
2013	2220038	265.226	212.642	334.257	223.400	222.551
2014	NA	315.019	323.000	1401.008	312.453	243.653
2015	NA	301.636	248.367	2091.636	297.165	NA
2016	NA	613.221	NA	971.588	NA	NA

Table 23.1.21. Whiting in Subarea 4 and Division 7.d: RCT3 output, year class 2016.

Analysis by RCT3 ver4.0									
Whiting									
Data for 5 surveys over 28 years : 1989 -2016									
Regression type = C									
Tapered time weighting not applied									
Survey weighting not applied									
Final estimates not shrunk towards mean									
Estimates with S.E.'S greater than that of mean included									
Minimum S.E. for any survey taken as 0									
Minimum of 3 points used for regression									
Forecast/Hindcast variance correction used.									
yearclass:2016									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.6004	11.22	0.2585	0.7443	25	6.419	15.08	0.2777	0.652
IBTSq12	0.7728	10.32	0.2104	0.8145	25	NA	NA	NA	NA
IBTSq30	0.6345	10.55	0.3542	0.6124	23	6.879	14.92	0.3802	0.348
IBTSq31	0.6577	10.81	0.2307	0.7867	24	NA	NA	NA	NA
IBTSq32	0.8446	10.42	0.2583	0.7446	25	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	25	NA	14.71	0.4317	0
	WAP	logWAP	int.se						
yearclass: 2016	3339689	15.02	0.199						

Table 23.1.22. Whiting in Subarea 4 and Division 7.d: Recruitment estimates as used in the short-term forecast (RCT3 estimate year class 2016, geometric mean).

YEAR CLASS	RCT3 ESTIMATE	GEOMETRIC MEAN OF TIME SERIES (1990–2016)
2016	3340	
2017		2444
2018		2444

Table 23.1.23. Whiting in Subarea 4 and Division 7.d: Short-term forecast inputs.

MFDP version 1a						
Run: run2						
Time and date: 20:45 30/04/2017						
Fbar age range (Total) : 2–6						
Fbar age range Fleet 1 : 2–6						
Fbar age range Fleet 2 : 2–6						
2017						
Age	N	M	Mat	PF	PM	SWt
1	3339689	1.255	0.11	0	0	0.131
2	554319	0.83	0.92	0	0	0.209
3	298757	0.643	1	0	0	0.296
4	96837	0.644	1	0	0	0.397
5	22288	0.553	1	0	0	0.405
6	14784	0.553	1	0	0	0.411
7	13216	0.553	1	0	0	0.493
8	5252	0.553	1	0	0	0.419
Catch						
Age	Sel	CWt	DSel	DCWt		
1	0.00228	0.197	0.02508	0.126		
2	0.04149	0.275	0.0636	0.187		
3	0.10492	0.352	0.07597	0.237		
4	0.14452	0.453	0.06225	0.265		
5	0.21169	0.502	0.08117	0.259		
6	0.25688	0.453	0.06315	0.269		
7	0.24248	0.56	0.05382	0.283		
8	0.25943	0.429	0.03628	0.243		
IBC						
Age	Sel	CWt				
1	0.00253	0.133				
2	0.01012	0.215				
3	0.01808	0.299				
4	0.02121	0.395				
5	0.02975	0.407				
6	0.0332	0.415				
7	0.03075	0.497				
8	0.03133	0.455				
2018						
Age	N	M	Mat	PF	PM	SWt
1	2443772	1.255	0.11	0	0	0.131
2	.	0.83	0.92	0	0	0.209
3	.	0.643	1	0	0	0.296
4	.	0.644	1	0	0	0.397
5	.	0.553	1	0	0	0.405
6	.	0.553	1	0	0	0.411

7	.	0.553	1	0	0	0.493
8	.	0.553	1	0	0	0.419
Catch						
Age	Sel	CWt	DSel	DCWt		
1	0.00228	0.197	0.02508	0.126		
2	0.04149	0.275	0.0636	0.187		
3	0.10492	0.352	0.07597	0.237		
4	0.14452	0.453	0.06225	0.265		
5	0.21169	0.502	0.08117	0.259		
6	0.25688	0.453	0.06315	0.269		
7	0.24248	0.56	0.05382	0.283		
8	0.25943	0.429	0.03628	0.243		
IBC						
Age	Sel	CWt				
1	0.00253	0.133				
2	0.01012	0.215				
3	0.01808	0.299				
4	0.02121	0.395				
5	0.02975	0.407				
6	0.0332	0.415				
7	0.03075	0.497				
8	0.03133	0.455				
2019						
Age	N	M	Mat	PF	PM	SWt
1	2443772	1.255	0.11	0	0	0.131
2	.	0.83	0.92	0	0	0.209
3	.	0.643	1	0	0	0.296
4	.	0.644	1	0	0	0.397
5	.	0.553	1	0	0	0.405
6	.	0.553	1	0	0	0.411
7	.	0.553	1	0	0	0.493
8	.	0.553	1	0	0	0.419
Catch						
Age	Sel	CWt	DSel	DCWt		
1	0.00228	0.197	0.02508	0.126		
2	0.04149	0.275	0.0636	0.187		
3	0.10492	0.352	0.07597	0.237		
4	0.14452	0.453	0.06225	0.265		
5	0.21169	0.502	0.08117	0.259		
6	0.25688	0.453	0.06315	0.269		
7	0.24248	0.56	0.05382	0.283		
8	0.25943	0.429	0.03628	0.243		
IBC						
Age	Sel	CWt				
1	0.00253	0.133				
2	0.01012	0.215				

3	0.01808	0.299
4	0.02121	0.395
5	0.02975	0.407
6	0.0332	0.415
7	0.03075	0.497
8	0.03133	0.455
Input units are thousands and kg - output in tonnes		

Table 23.1.24. Whiting in Subarea 4 and Division 7.d: MFDP output table for short-term forecasts.

MFDP version 1a; Run: run2. Time and date: 14:59 28/04/2017, Fbar age range: 2–6; 2016 landings: total 15 854 tons; 4: 12 684 tons (80%); 7.d: 3 170 tons (20%)

2017		**Catch**			**Landings**				**Unwanted catch**		**IBC**				
Biomass	SSB	FMult	FBar	Yield	FBar	4+7.d yield	4 yield	7.d yield	FBar	Yield	FMult	FBar	Yield	0.75*Fbar	1.25*Fbar
704047	305405	1	0.2436	40010	0.1519	20916	16734	4182	0.0692	15550	1	0.0225	3544	0.183	0.3045

2018														**2019**		**2017 TAC 4**	**16003**	
		Catch			**Landings**				**Unwanted catch**		**IBC**	**Landings**						
Biomass	SSB	FMult	FBar	Yield	FBar	4+7.d yield	4 yield	7.d yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	4 TAC change	SSB change	
654489	354119	0	0.023	4088	0.000	0	0	0	0.000	0	1	0.023	4088	669413	372875	-100%	5%	No HC fishery
.	354119	0.1	0.045	8247	0.015	2486	1989	497	0.007	1702	1	0.023	4059	666001	369494	-88%	4%	
.	354119	0.2	0.067	12348	0.030	4932	3946	986	0.014	3386	1	0.023	4030	662641	366166	-75%	3%	
.	354119	0.3	0.089	16393	0.046	7338	5871	1467	0.021	5053	1	0.023	4002	659332	362889	-63%	2%	
.	354119	0.4	0.111	20382	0.061	9704	7764	1940	0.028	6704	1	0.023	3974	656074	359662	-51%	2%	
.	354119	0.5	0.133	24317	0.076	12032	9626	2406	0.035	8338	1	0.023	3947	652865	356485	-40%	1%	
.	354119	0.6	0.155	28198	0.091	14322	11458	2864	0.042	9956	1	0.023	3920	649705	353356	-28%	0%	
.	354119	0.7	0.177	32027	0.106	16576	13262	3314	0.049	11558	1	0.023	3893	646592	350274	-17%	-1%	
.	354119	0.8	0.199	35803	0.122	18793	15035	3758	0.055	13144	1	0.023	3866	643526	347239	-6%	-2%	
.	354119	0.9	0.222	39530	0.137	20975	16781	4194	0.062	14715	1	0.023	3840	640506	344250	5%	-3%	
.	354119	1	0.244	43207	0.152	23122	18499	4623	0.069	16271	1	0.023	3814	637530	341306	16%	-4%	Fsq
.	354119	1.1	0.266	46835	0.167	25235	20189	5046	0.076	17811	1	0.023	3789	634599	338405	26%	-4%	
.	354119	1.2	0.288	50415	0.182	27315	21853	5462	0.083	19337	1	0.023	3763	631711	335548	37%	-5%	
.	354119	1.3	0.310	53949	0.198	29362	23491	5871	0.090	20848	1	0.023	3739	628865	332733	47%	-6%	
.	354119	1.4	0.332	57436	0.213	31377	25103	6274	0.097	22345	1	0.023	3714	626062	329960	57%	-7%	
.	354119	1.5	0.354	60877	0.228	33360	26690	6670	0.104	23827	1	0.023	3690	623299	327228	67%	-8%	

.	354119	1.6	0.376	64275	0.243	35313	28252	7061	0.111	25296	1	0.023		3666	620576	324535	77%	-8%	
.	354119	1.7	0.398	67628	0.258	37235	29790	7445	0.118	26751	1	0.023		3642	617892	321882	86%	-9%	
.	354119	1.8	0.421	70938	0.273	39128	31304	7824	0.125	28192	1	0.023		3618	615248	319268	96%	-10%	
.	354119	1.9	0.443	74206	0.289	40991	32795	8196	0.132	29620	1	0.023		3595	612641	316691	105%	-11%	
.	354119	2	0.465	77432	0.304	42826	34263	8563	0.139	31034	1	0.023		3572	610071	314152	114%	-11%	
.	354119	0.75	0.188	33156	0.114	17153	13723	3430	0.052	12119	1	0.023		3884	645746	349443	-14%	-1%	0.75 * Fsq
.	354119	0.58	0.150	26804	0.088	13445	10757	2688	0.040	9429	1	0.023		3929	650884	354527	-33%	0.1%	Fmsy
.	354119	1.25	0.299	51466	0.190	27840	22273	5567	0.087	19871	1	0.023		3756	630935	334786	39%	-5%	1.25 * Fsq
.	354119	0.74	0.187	32901	0.113	17002	13603	3400	0.051	12012	1	0.023		3886	645954	349648	-15%	-1%	15% TAC decrease (27.4)
.	354119	1.02	0.249	43179	0.155	23003	18403	4599	0.071	16362	1	0.023		3814	637638	341420	15%	-4%	15% TAC increase (27.4)
.	354119	0.88	0.218	38040	0.134	20002	16003	3999	0.061	14187	1	0.023		3850	641796	345534	0%	-2%	Rollover TAC
.	354119	1.00	0.244	42372	0.152	22532	18027	4505	0.069	16020	1	0.023		3820	638291	342066	13%	-3%	Fsq
.	354119	1.16	0.280	48334	0.177	26012	20811	5201	0.081	18545	1	0.023		3778	633469	337293	30%	-5%	Fpa
.	354119	1.66	0.390	66551	0.252	36644	29317	7327	0.115	26257	1	0.023		3650	618732	322711	83%	-9%	Flim
.	354119	4.42	0.999	167379	0.671	95493	76400	19094	0.306	68945	1	0.023		2941	537172	241837	377%	-32%	Bpa, MSY Btrigger
.	354119	6.77	1.519	253557	1.028	145792	116641	29151	0.469	105430	1	0.023		2335	467462	172741	629%	-51%	Blim

Output units in tons

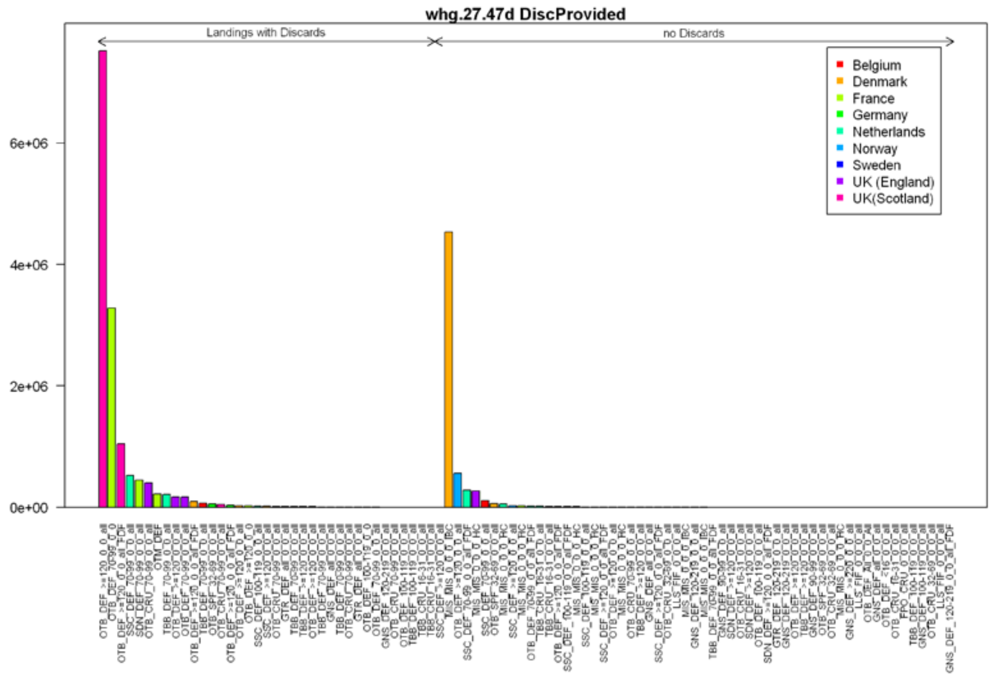


Figure 23.1.1. Whiting in Subarea 4 and Division 7.d: Landings with discards. Métier with industrial bycatch landings (MIS_MIS_0_0_0_IBC, Denmark, orange) generally does not have discards.

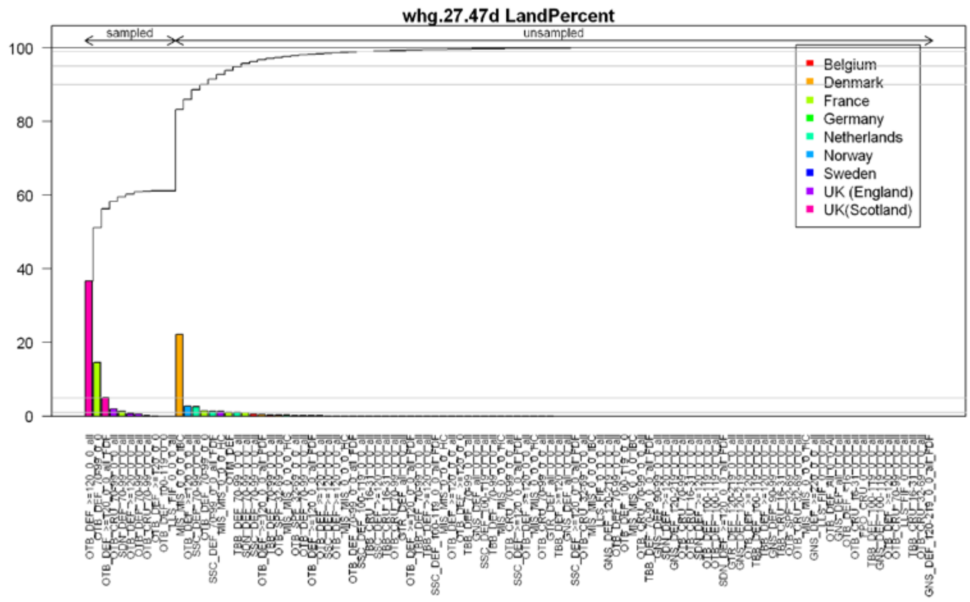


Figure 23.1.2a. Whiting in Subarea 4 and Division 7.d: Reported landings (in percent, colored bars) for each sampled and unsampled fleet, along with cumulative landings (in percent, black line) for fleets in descending order of yield.

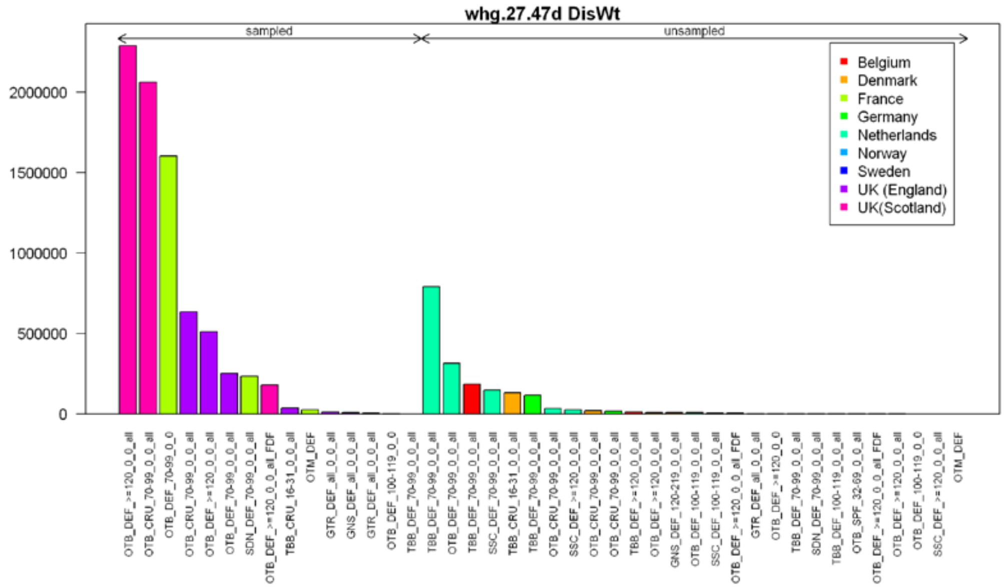


Figure 23.1.2b. Whiting in Subarea 4 and Division 7.d: Reported discards (in tons, colored bars) for each sampled and unsampled fleet, along with cumulative discards (black line) for fleets in descending order of yield.

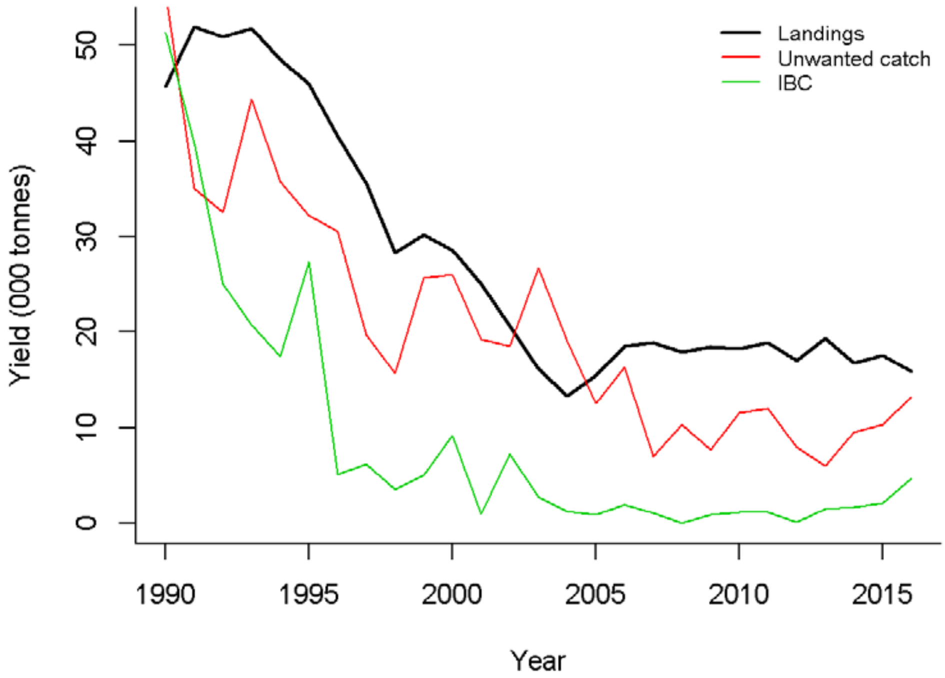


Figure 23.1.3. Whiting in Subarea 4 and Division 7.d: Yield by catch component. Unwanted catch includes discards and BMS landings.

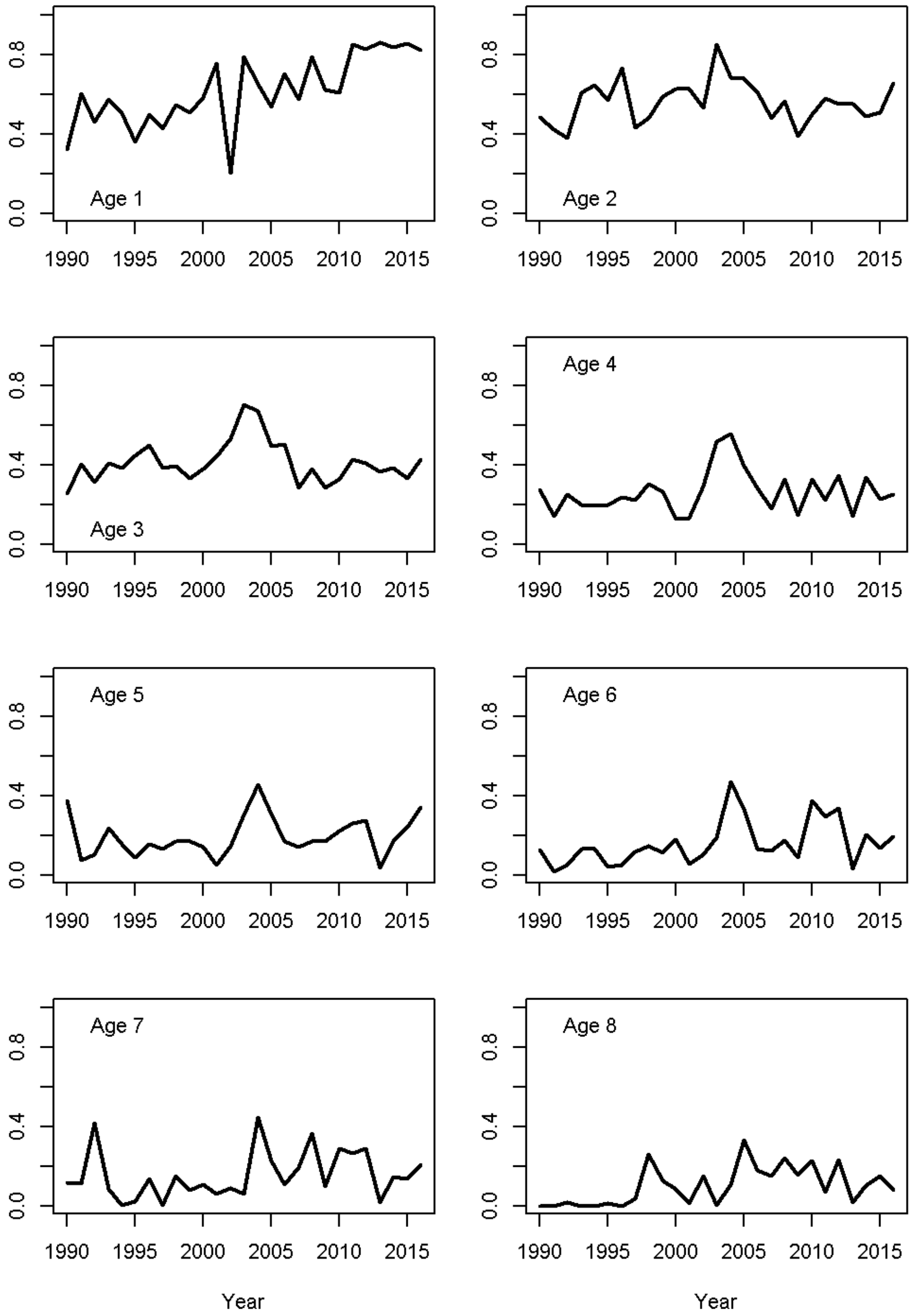


Figure 23.1.4. Whiting in Subarea 4 and Division 7.d: Proportion of unwanted catch in total catch, by age and year.

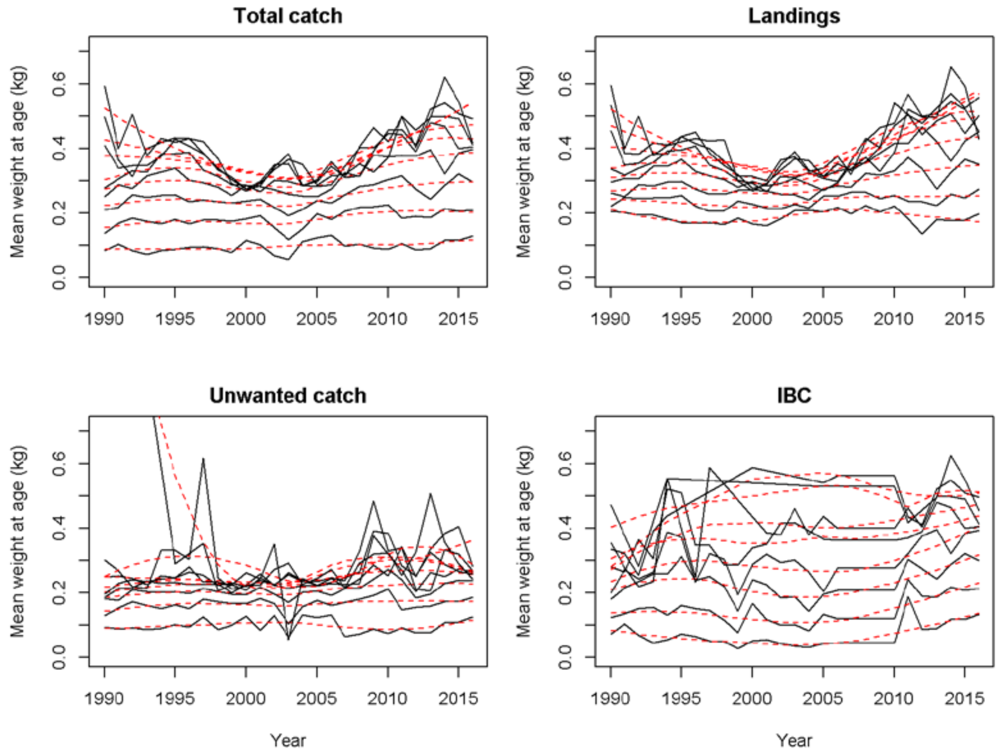


Figure 23.1.5. Whiting in Subarea 4 and Division 7.d: Mean weights-at-age (kg) by catch component (black lines) and LOESS smoothers through each time-series of mean weights-at-age (red dashed lines). Catch mean weights are used as stock mean weights.

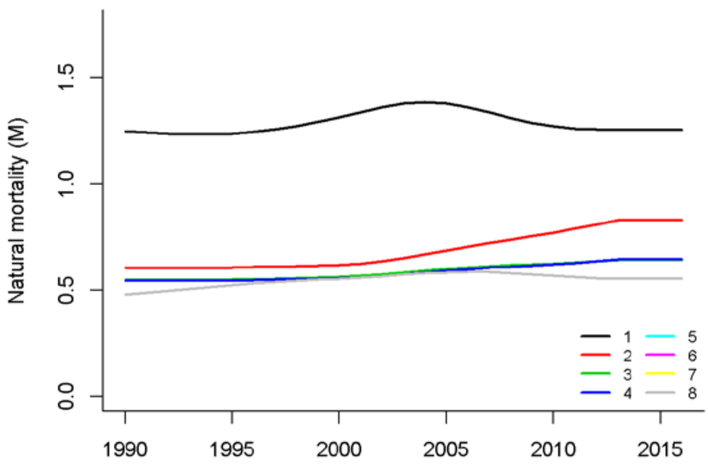


Figure 23.1.6. Whiting in Subarea 4 and Division 7.d: Natural mortality estimates from the 2015 update of SMS key run (WGSAM 2014) used in assessment.

Figure 23.1.7. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for Ages 1–3+ Q1 2013–2017. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q1 survey in the North Sea.

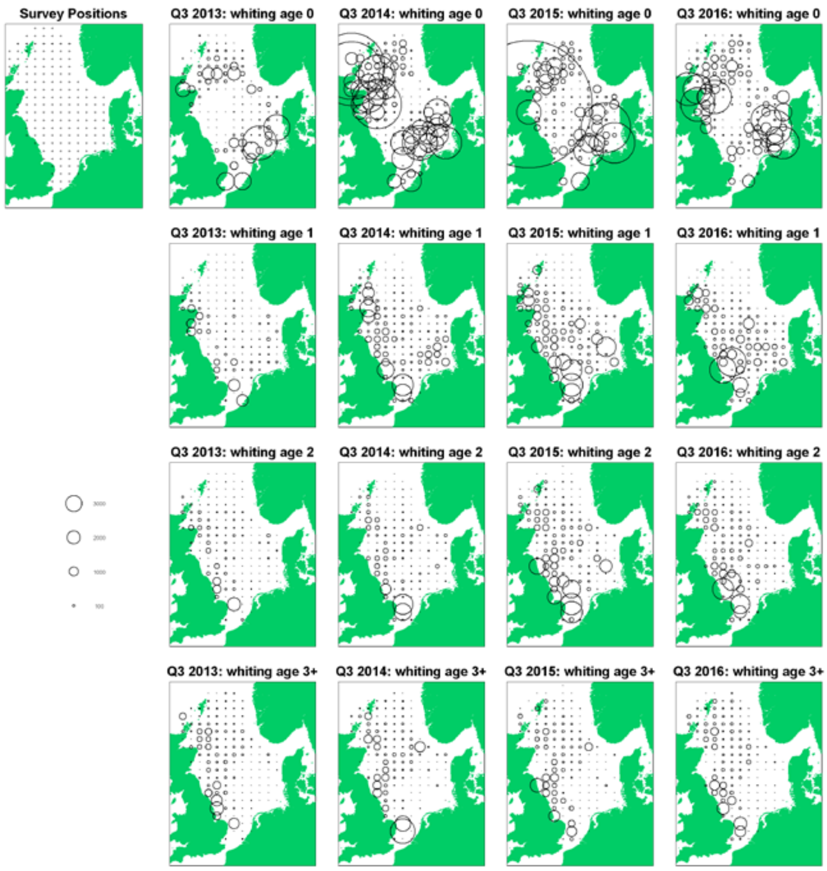


Figure 23.1.8. Whiting in Subarea 4 and Division 7.d: Survey distribution maps for ages 0–3+ Q3 2012–2016. Size of the bubbles indicates numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS–Q3 survey in the North Sea.

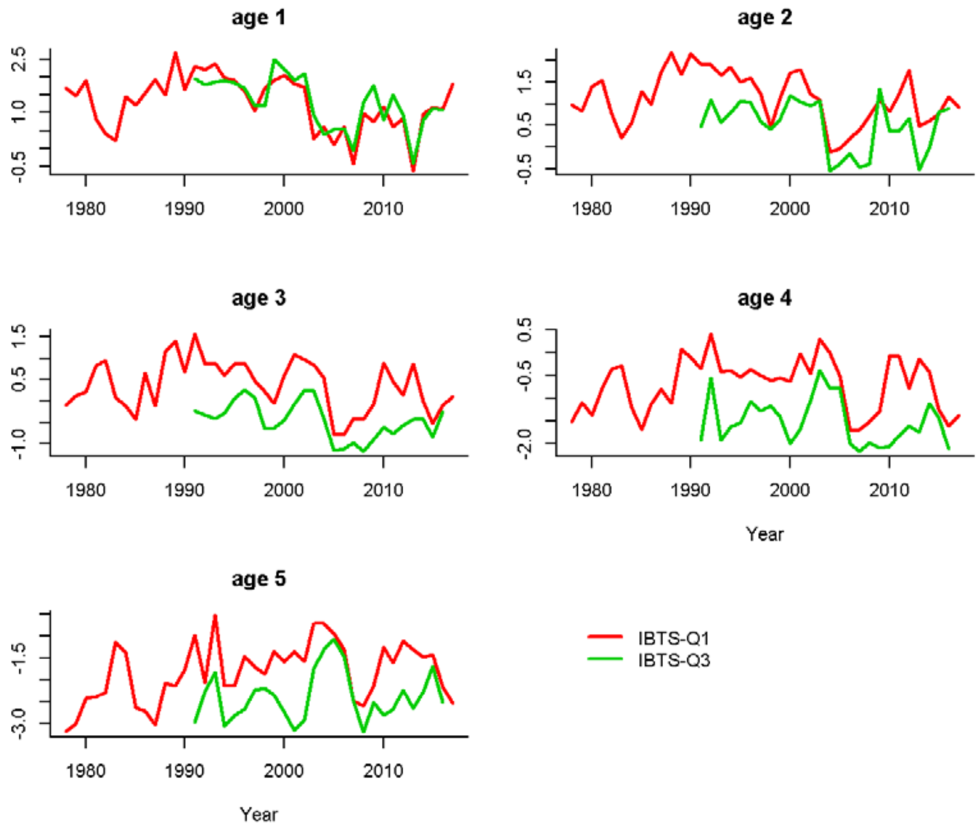


Figure 23.1.9. Whiting in Subarea 4 and Division 7.d: Survey log cpue (catch per unit effort) at age.

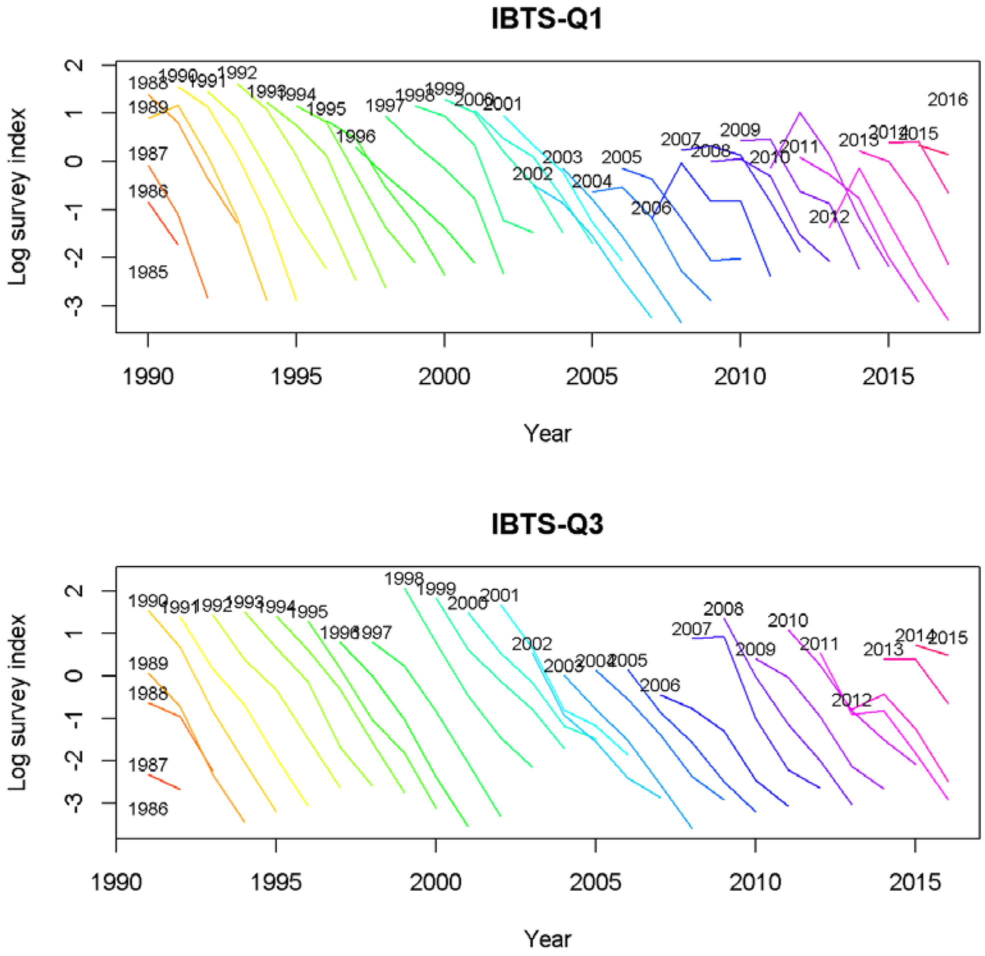


Figure 23.1.10. Whiting in Subarea 4 and Division 7.d: Log survey indices by cohort for each of the two surveys. The spawning year for each cohort is indicated at the start of each line.

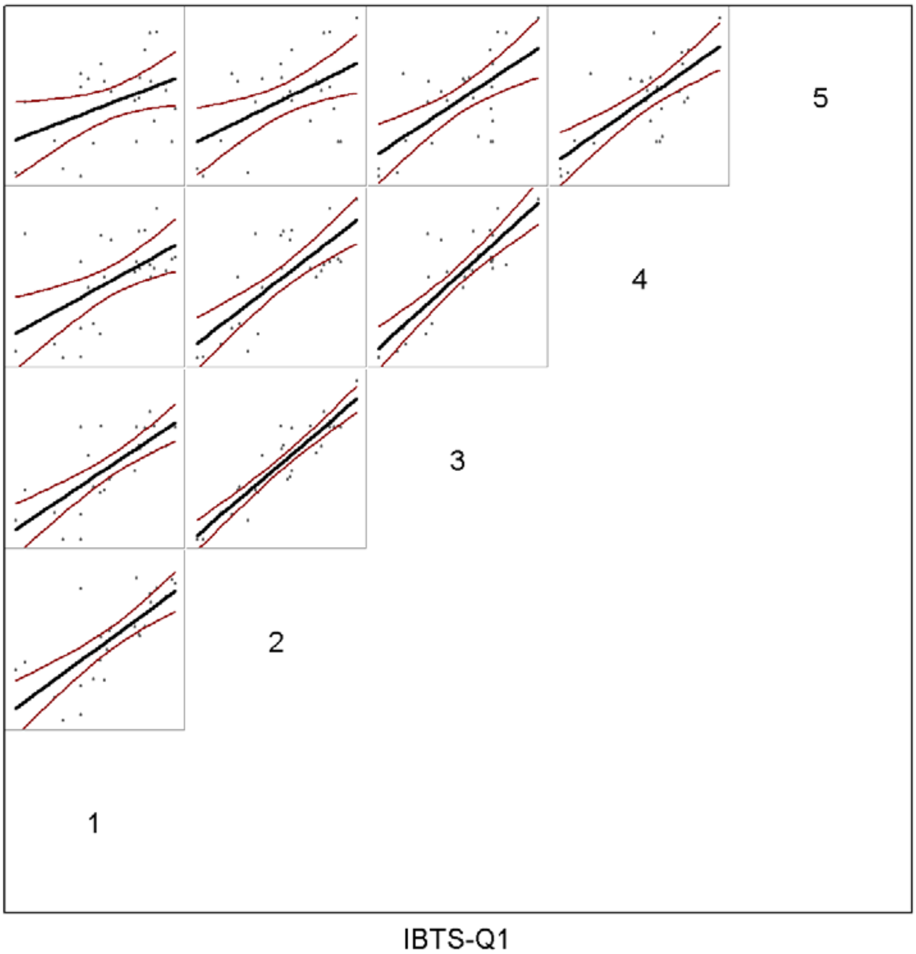


Figure 23.1.11. Within-survey correlations for the IBTS–Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximatee 95% confidence intervals for each fit are also shown.

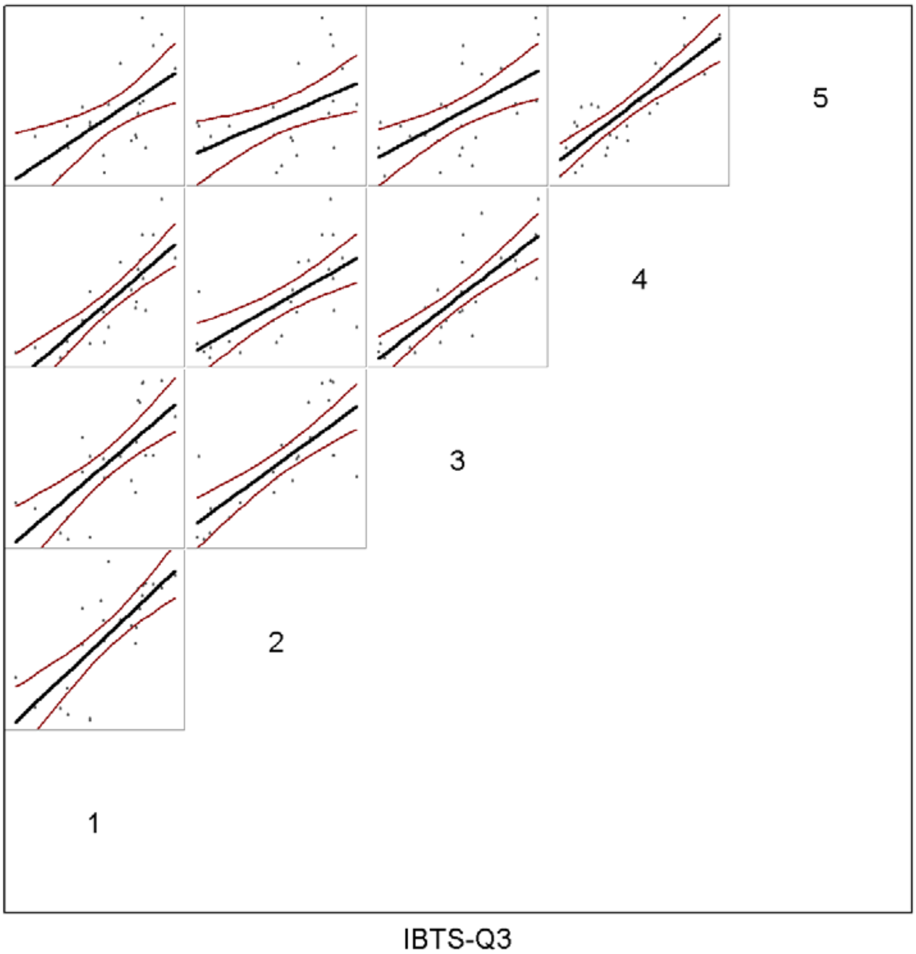
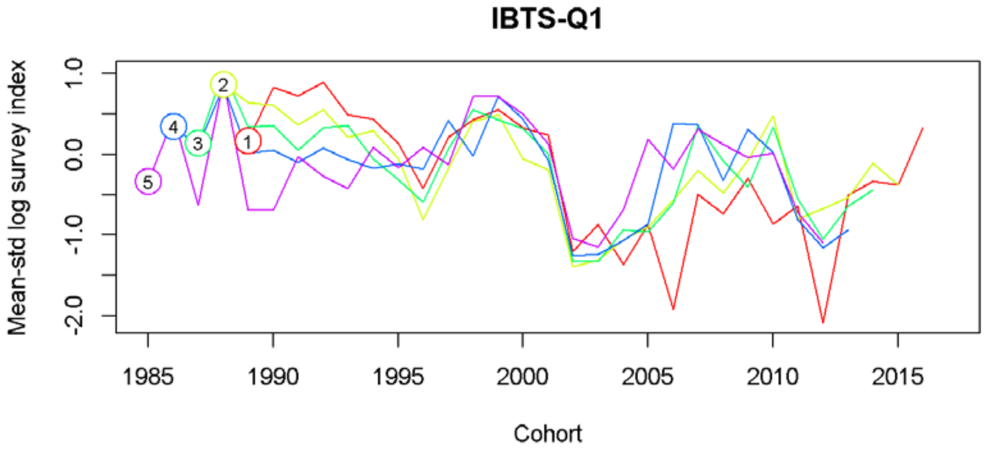


Figure 23.1.12. Within-survey correlations for the IBTS–Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.



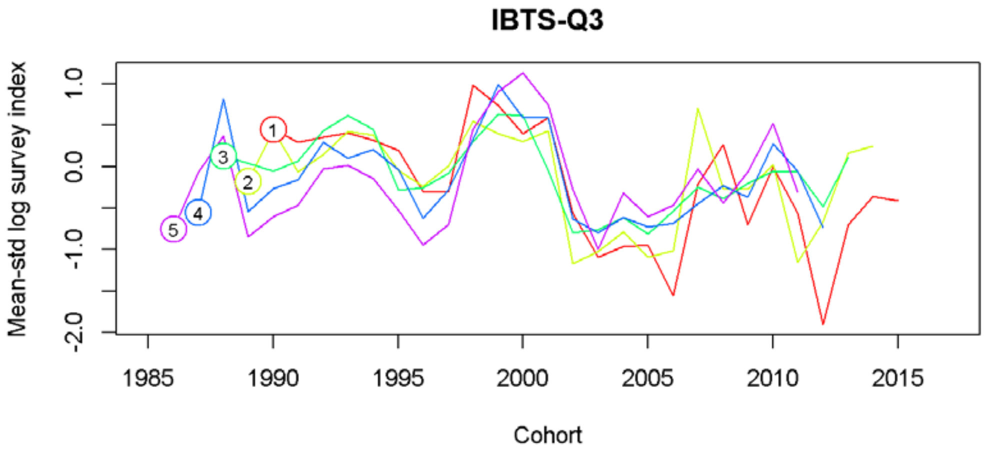


Figure 23.1.13. Whiting in Subarea 4 and Division 7.d: Survey log cpue (catch per unit effort) for the IBTS–Q1 and Q3 surveys, by cohort. Each line shows the log cpue for the age indicated at the start of the line.

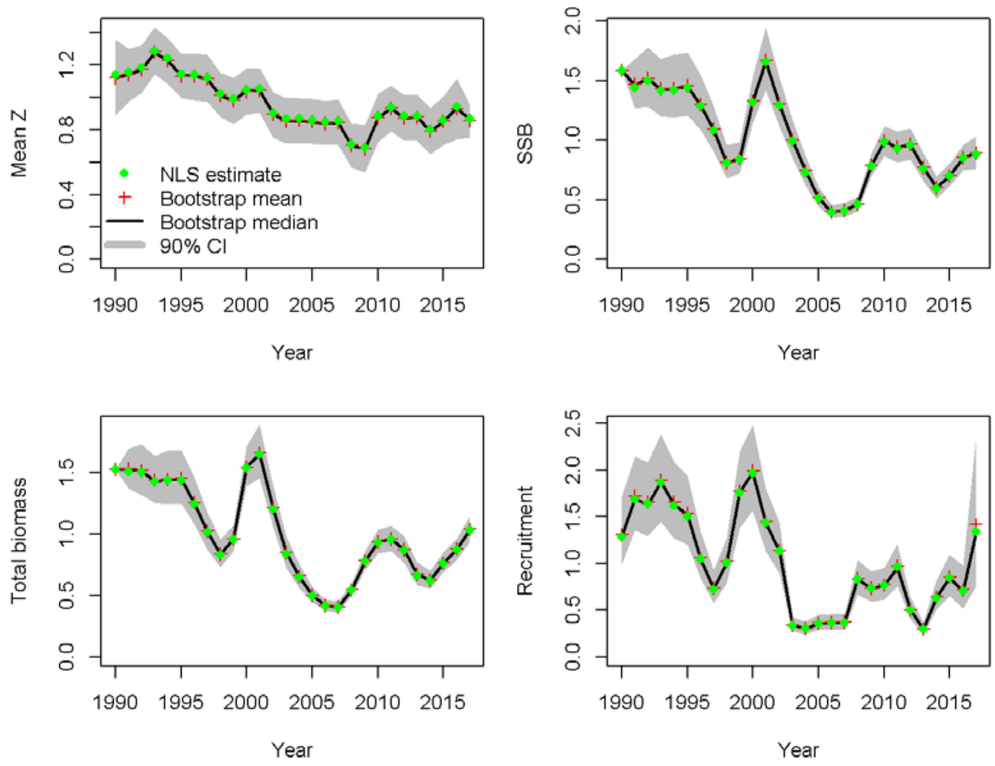


Figure 23.1.14. Whiting in Subarea 4 and Division 7.d: Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS–Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

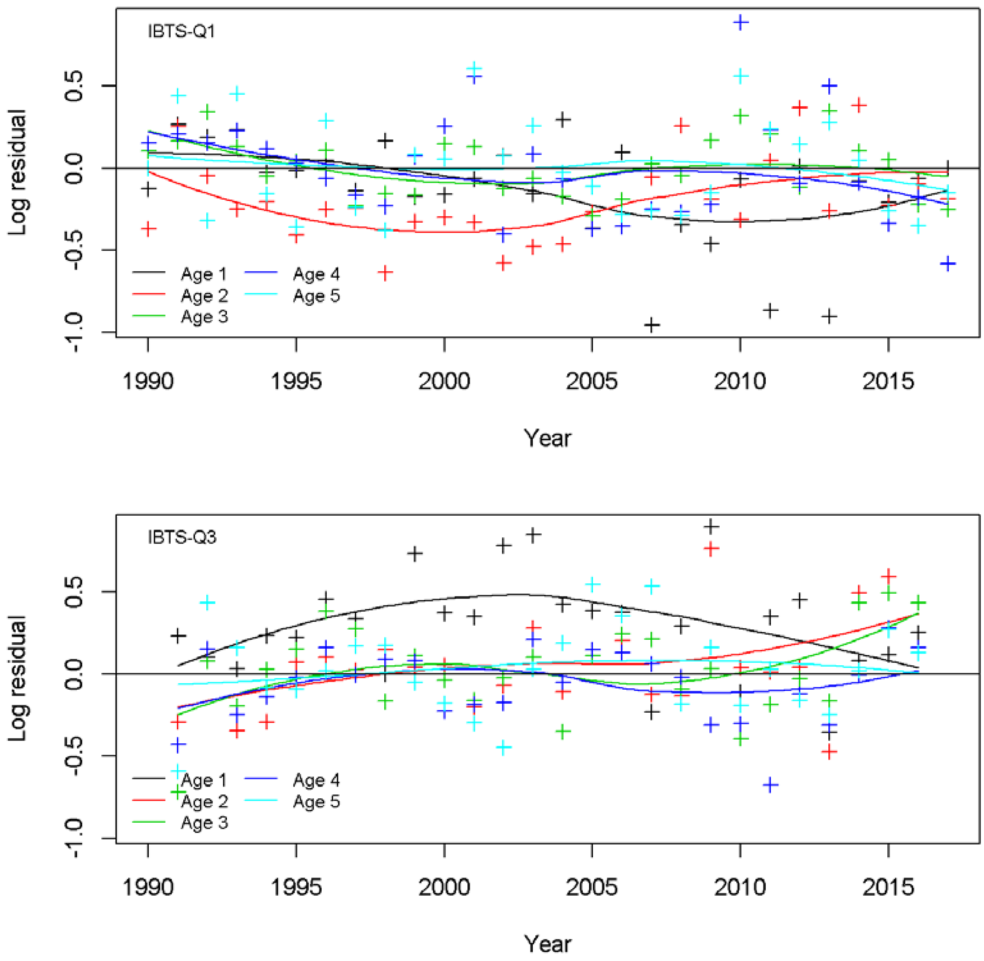


Figure 23.1.15. Whiting in Subarea 4 and Division 7.d: Log survey residuals from the SURBAR analysis. Ages are color-coded, and a LOESS smoother (span = 2) has been fitted through each age time-series.

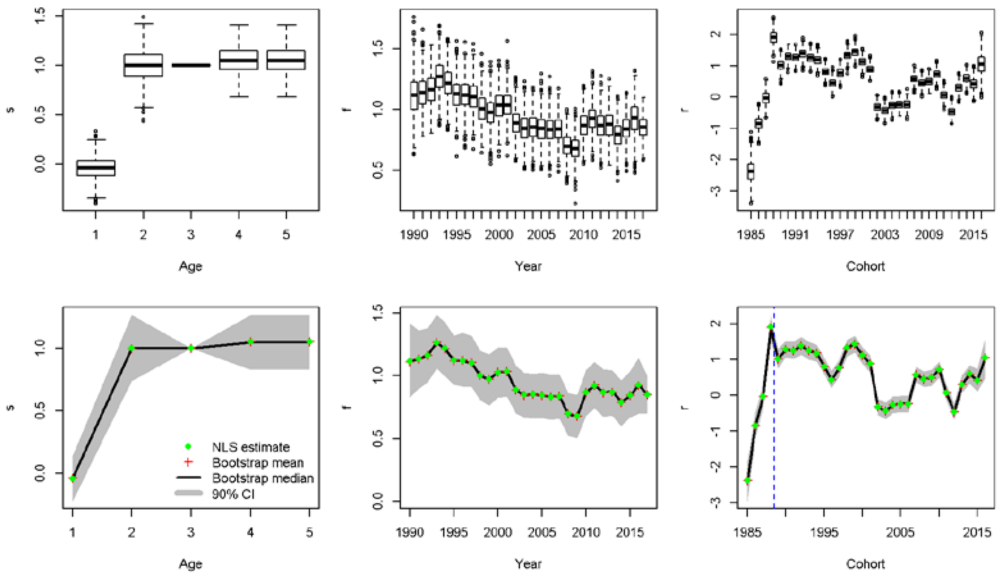


Figure 23.1.16. Whiting in Subarea 4 and Division 7.d: Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

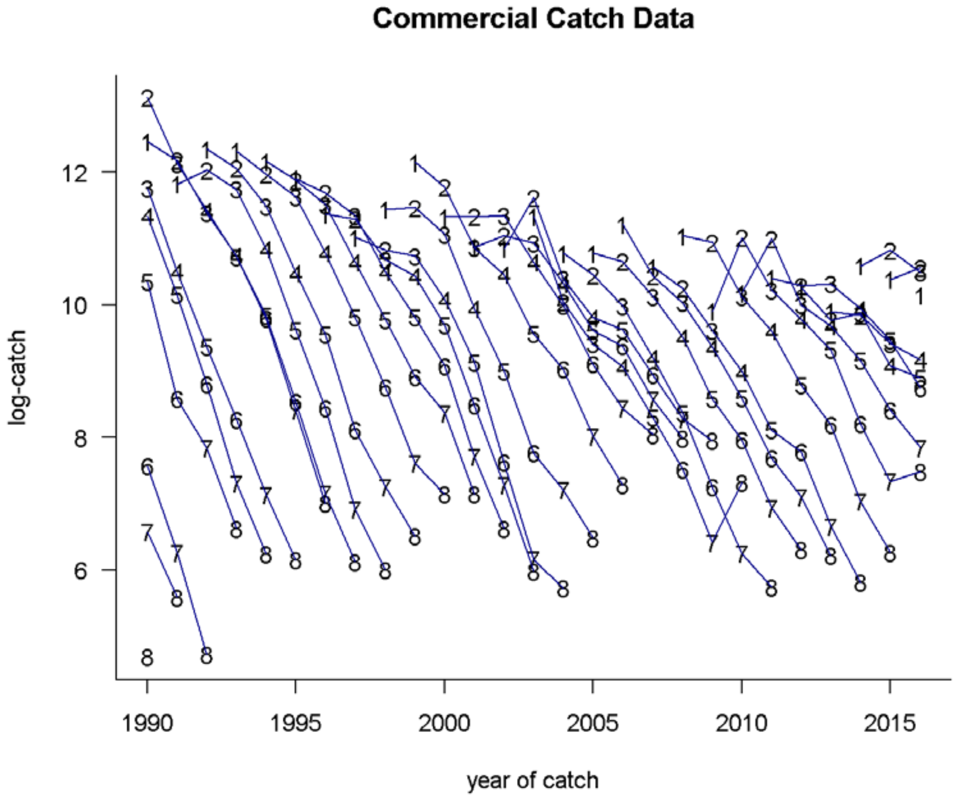


Figure 23.1.17. Whiting in Subarea 4 and Division 7.d: Log-catch curves by cohort for total catches.

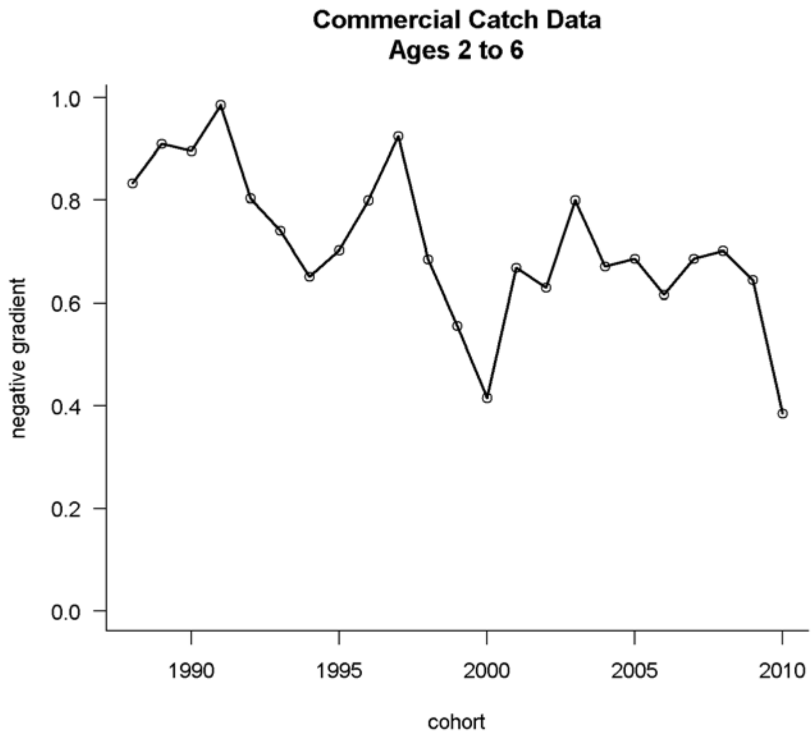


Figure 23.1.18. Whiting in Subarea 4 and Division 7.d: Negative gradients of log catches per cohort, averaged over ages 2–6. The x-axis represents the spawning year of each cohort.

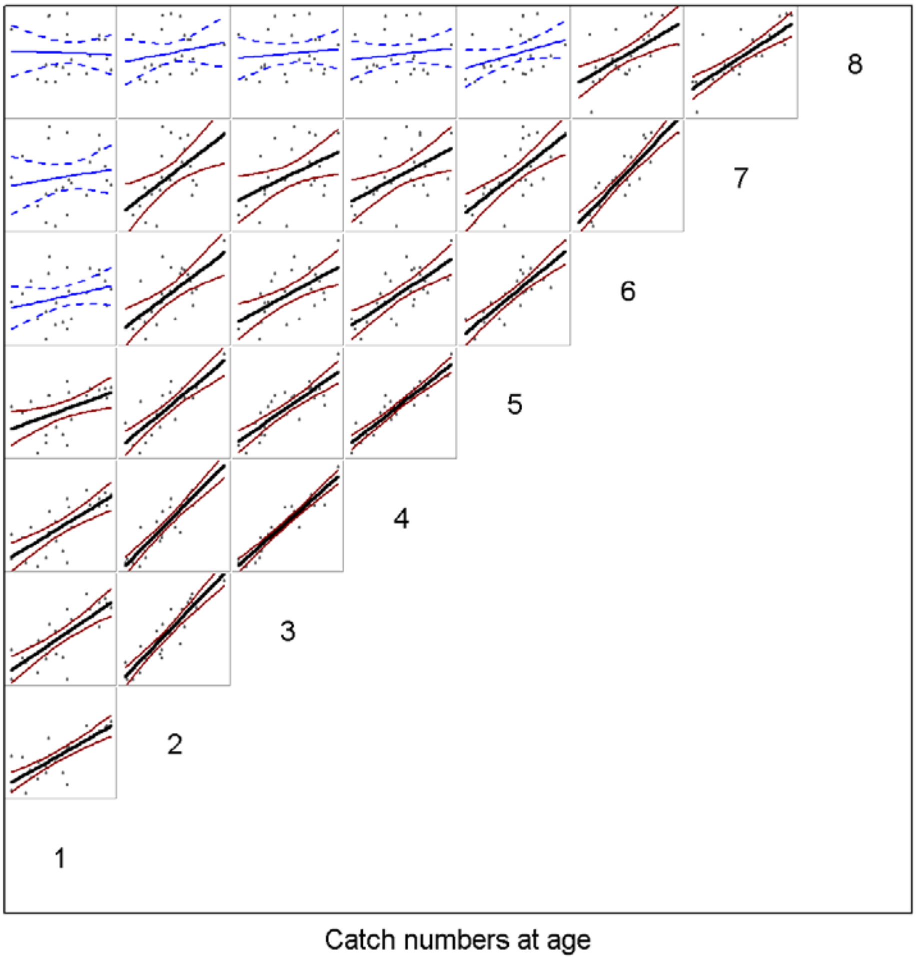


Figure 23.1.19. Whiting in Subarea 4 and Division 7.d: Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

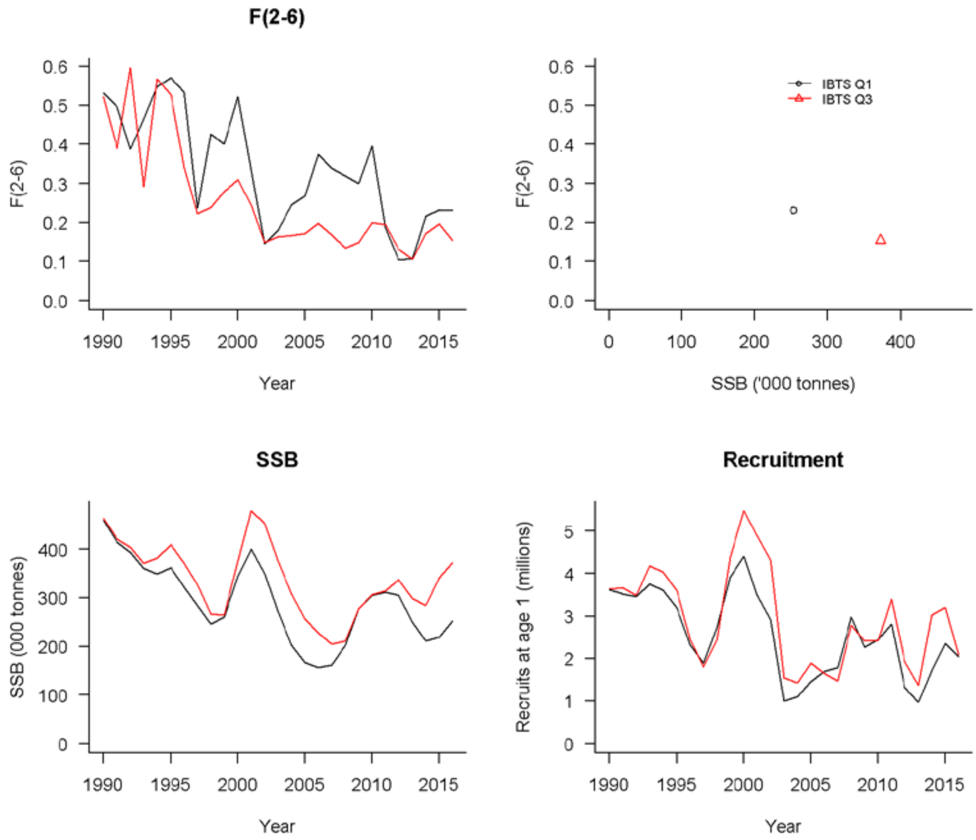


Figure 23.1.20. Whiting in Subarea 4 and Division 7.d: Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2016) values of SSB and mean F(2–6) are plotted against each other in the upper right plot.

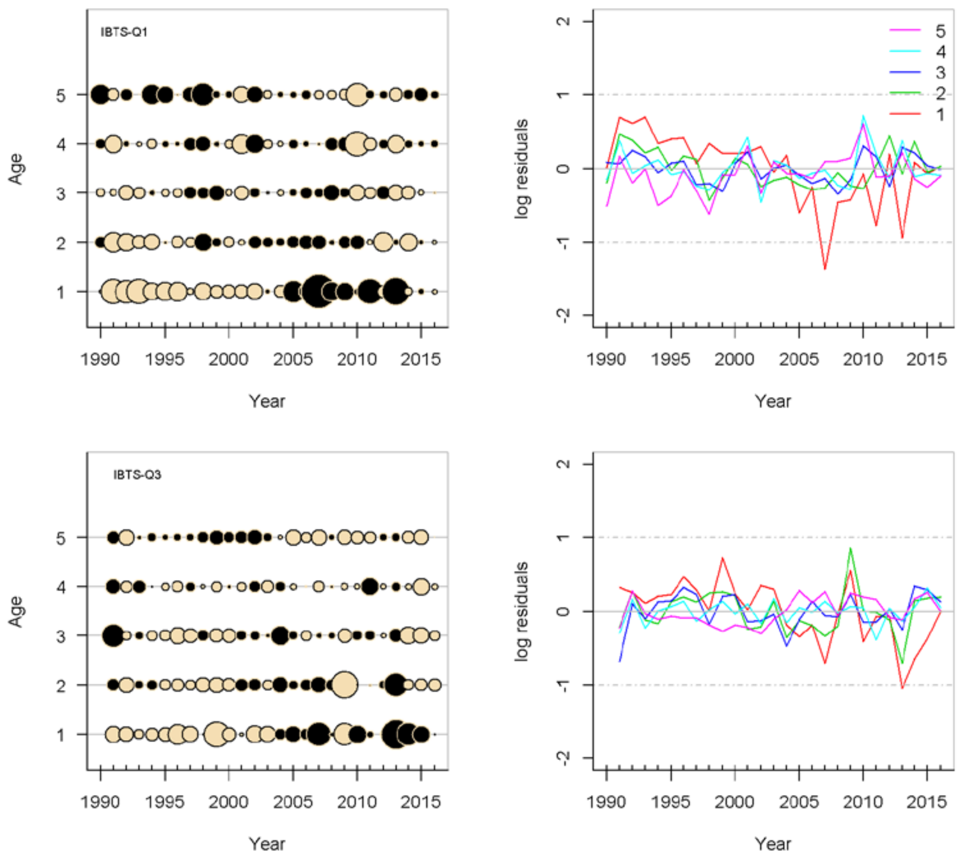


Figure 23.1.21. Whiting in Subarea 4 and Division 7.d: Log-catchability residuals for single-fleet FLXSA assessments (negative values as black bubbles, positive values as yellow bubbles).

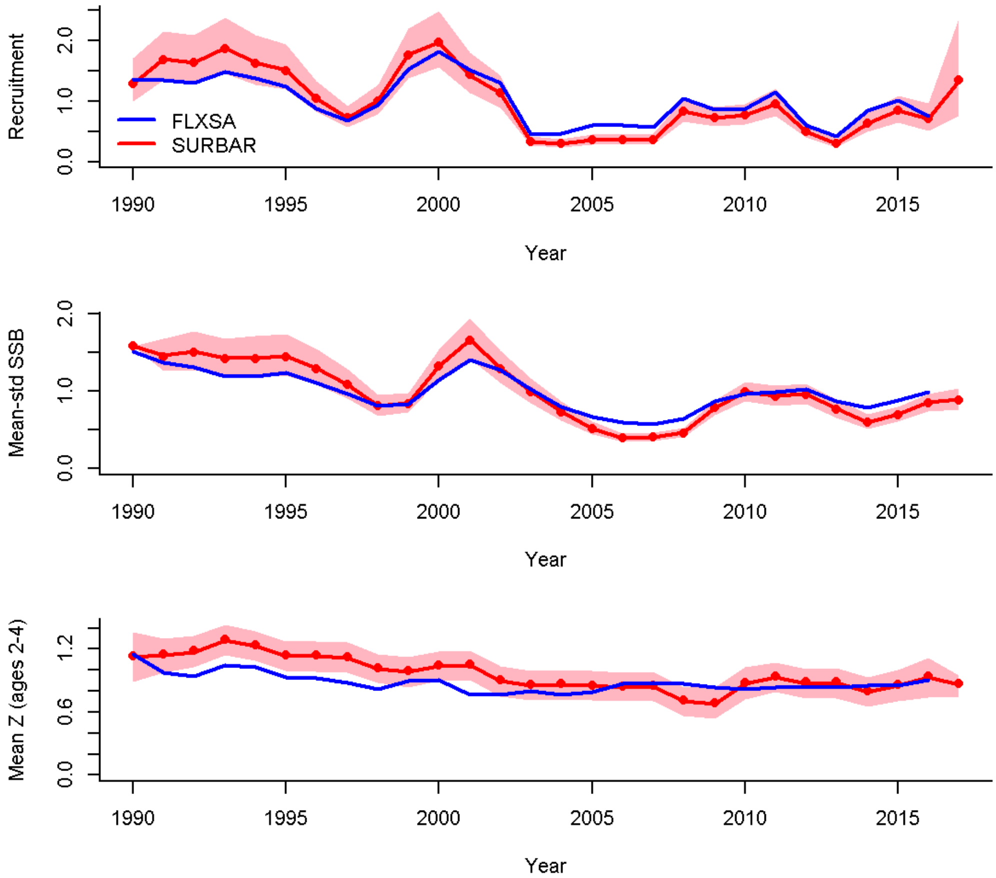


Figure 23.1.22. Whiting in Subarea 4 and Division 7.d: Comparisons of stock summary estimates from the final XSA (blue) and SURBAR (red) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models. The SURBAR estimates are plotted along with their 90% confidence bounds (shaded pink regions).

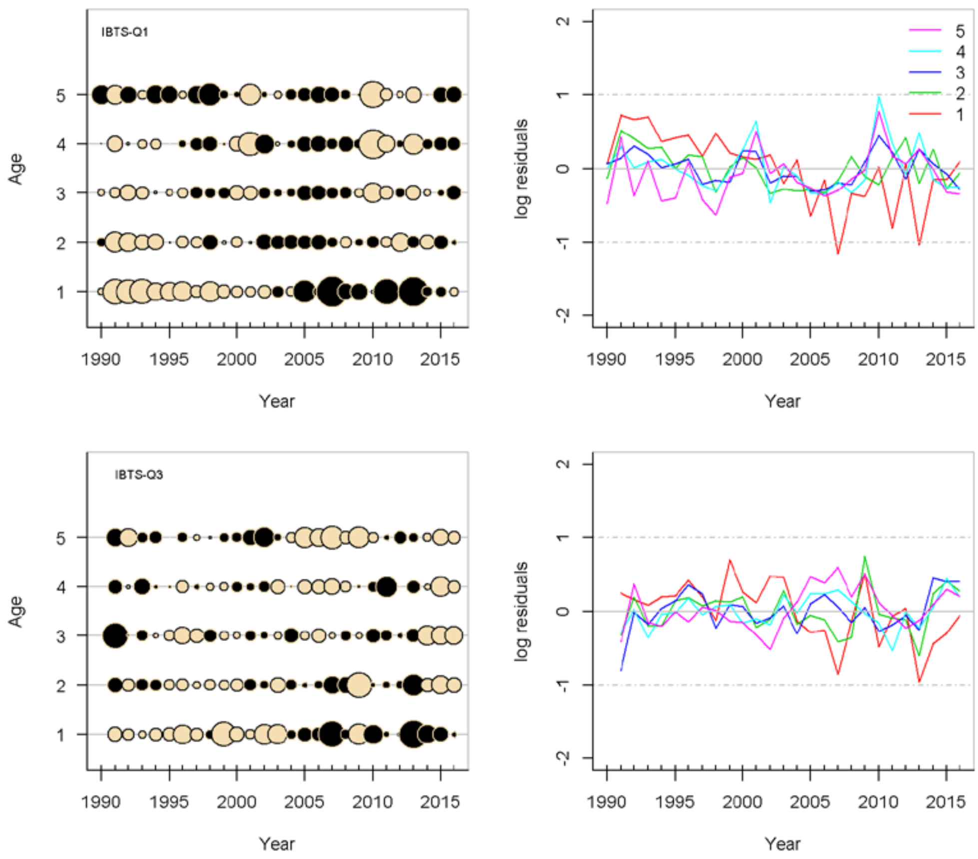


Figure 23.1.23. Whiting in Subarea 4 and Division 7.d: Log-catchability residuals for final FLXSA assessment (negative values as black bubbles, positive values as yellow bubbles).

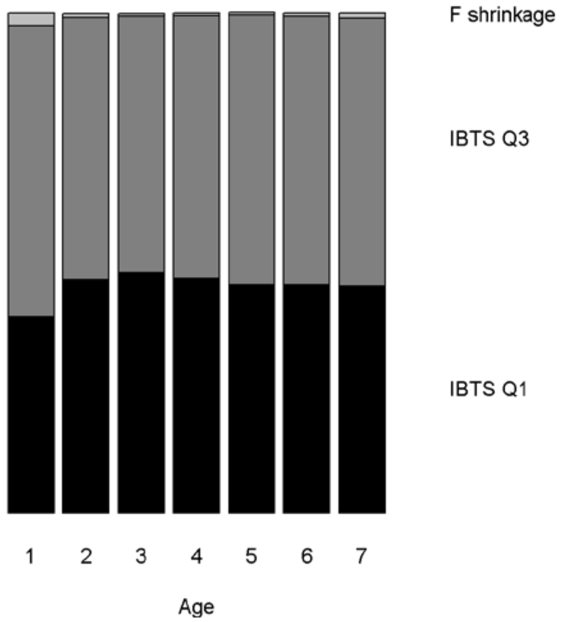


Figure 23.1.24. Whiting in Subarea 4 and Division 7.d: Contribution to survivors' estimates in final FLXSA assessment.

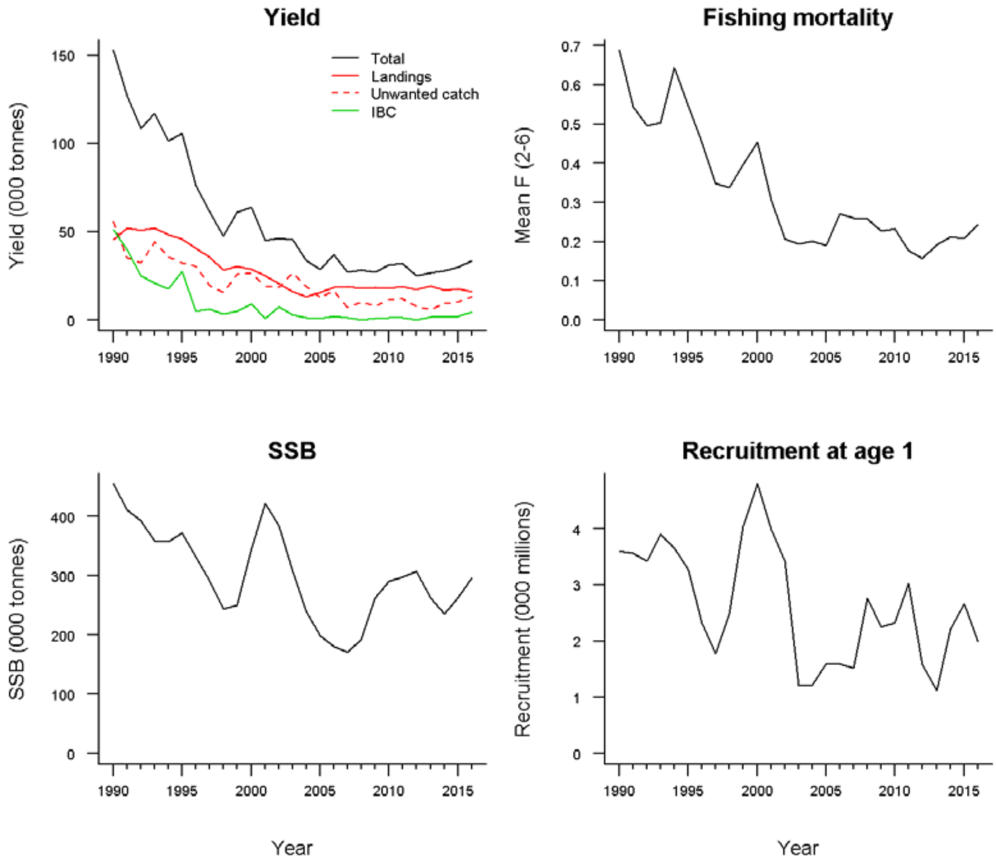


Figure 23.1.25. Whiting in Subarea 4 and Division 7.d: Summary plots for final FLXSA assessment.

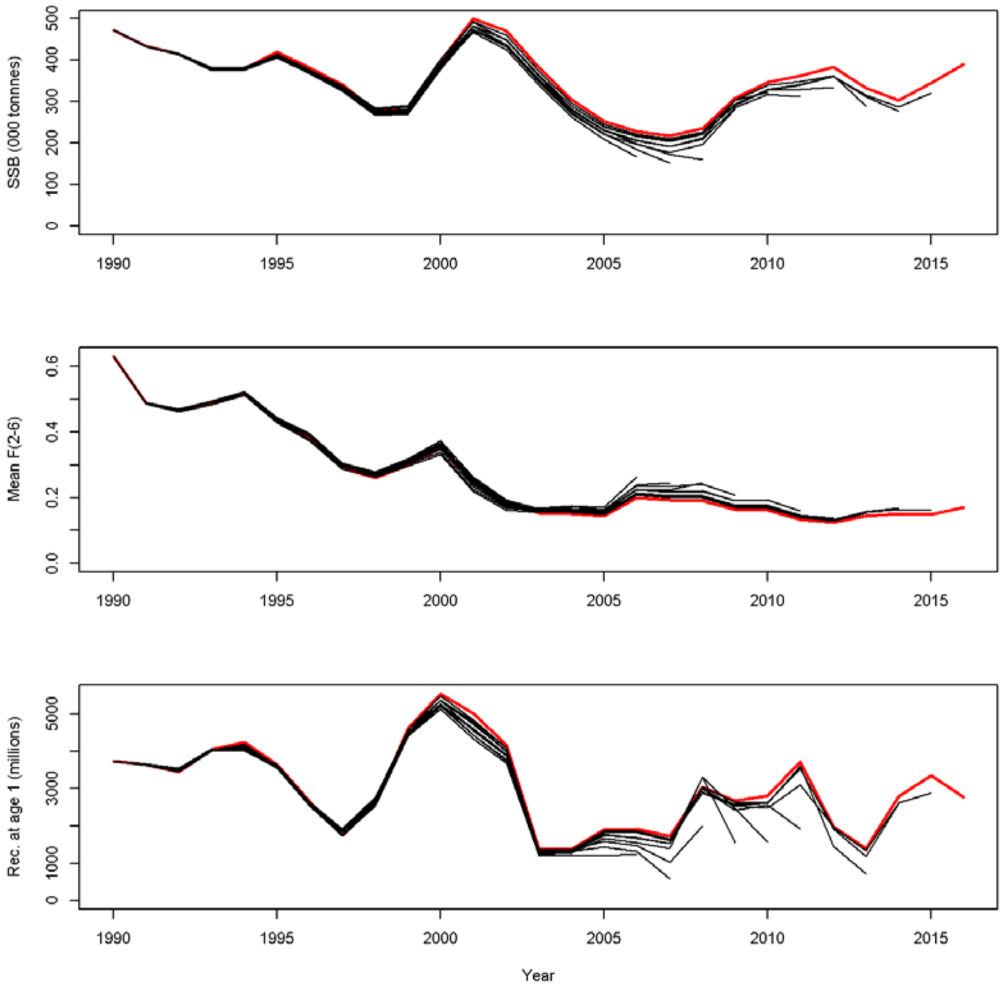


Figure 23.1.26. Whiting in Subarea 4 and Division 7.d: Retrospective plots for final FLXSA assessment.

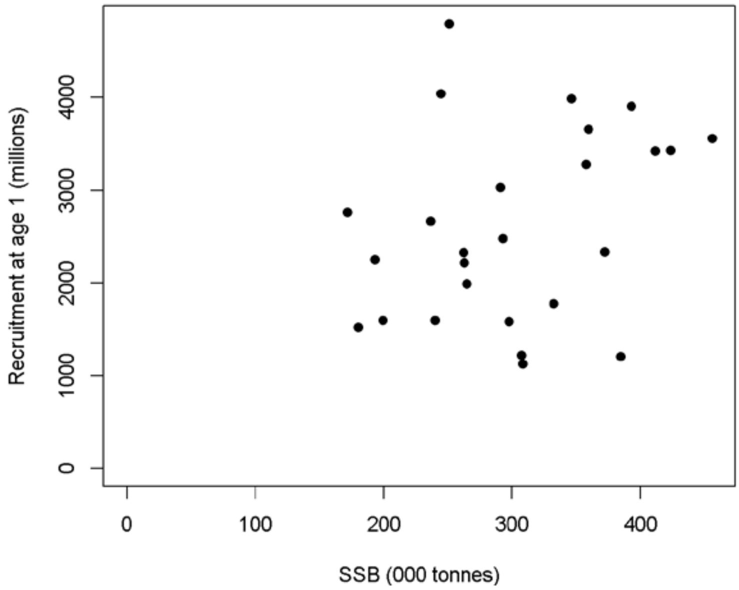


Figure 23.1.27. Whiting in Subarea 4 and Division 7.d: Stock-recruitment plot from final FLXSA assessment.

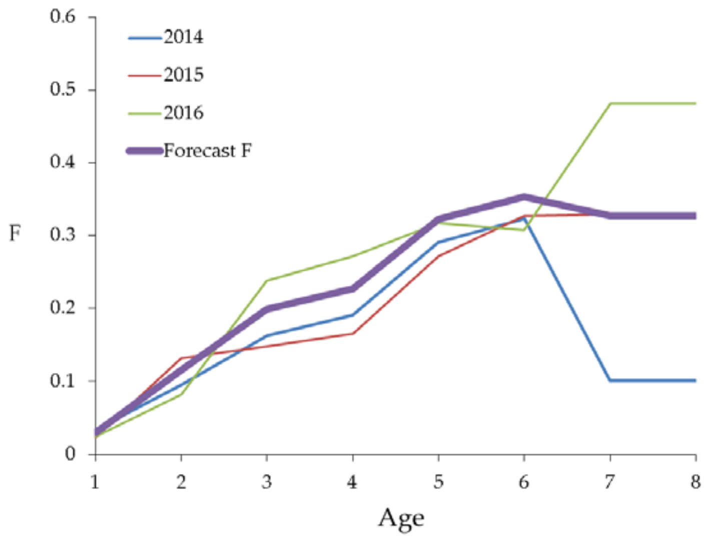


Figure 23.1.28. Whiting in Subarea 4 and Division 7.d: FLXSA F at age estimates for 2014–2016, along with scaled mean exploitation used for the forecast.

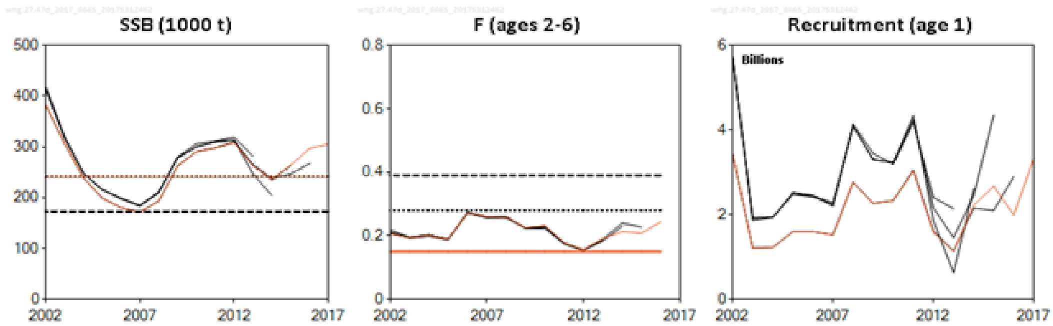


Figure 23.1.29. Whiting in Subarea 4 and Division 7.d: Standard graphs. Historical assessment comparison plot.

23.2 Whiting in Division 3.a

23.2.1 General

23.2.1.1 Stock definition

There is a paucity of information on the population structure of whiting in Division 3.a (the Skagerrak-Kattegat area). No genetic or otolith-based surveys have been conducted. Tagging of whiting has previously been undertaken, but these data need to be re-examined. Results from previously modelled survey data (SURBAR) were inconclusive regarding independent population dynamics in Division 3.a in comparison with the North Sea (ICES 2016), presumably due to the need of age readings in 3.a (age information used in SURBAR was borrowed from Subarea 4). The drop in landings in the beginning of the 1990s gives, however, an indication of local stock structure as this reduction was not paralleled by any similar event in the North Sea. There are also findings of locally spawned whiting eggs in Kattegat 3.aS (Börjesson *et al*., 2013).

23.2.1.2 Ecosystem aspect

No new information was presented at the Working Group. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared at ICES WKROUND (2009).

23.2.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the landings and discard information from InterCatch. A summary of available information on fisheries is presented in the Stock Annex prepared at ICES WKROUND (2009). Discards estimates are available since 2003. Information on derivation of discards is presented in the Stock Annex.

23.2.1.4 Data available

According to the WKLIFE categorisation of various levels of available data for assessment, whiting in Division 3.a can be considered to be a stock for which survey based indices are available, indicating trends. This survey data have been used for an exploratory assessment.

Total landings are shown in Table 23.2.1.

The WGNSSK in 2017 used IBTS indices per area (Skagerrak and Kattegat) and BITS indices (Kattegat) for plotting cpue per quarter of fish of total length > 21 cm, which corresponds to the 50% point of the maturity ogive of whiting in the North Sea. ALK was borrowed from Subarea 4 and no ALK exists for Division 3a, however in 2018 years and individuals will be sufficient to generate an ALK for Division 3a. Plots of the IBTS–Q1 and IBTS–Q3 per area are shown in Figure 23.2.1 and BITS–Q1 and Q4 in Figure 23.2.2. IBTS–Q3 indicate high inter-annual variability in recruitment. IBTS–Q1 in Kattegat shows a marked increase in cpue in 2015 which has since come down. The 2015 index was assigned to one single haul dominating the data series. Survey abundance indices are plotted in log-mean standardized form by year and cohort in Figure 23.2.3 for the IBTS–Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS–Q3 survey in Figure 23.2.4. Year effects occur (top left) and the importance of cohorts fluctuate through the time-series (top right) indicating migratory behavior. No clear pattern of total mortality (bottom right).

23.2.2 Data analyses

23.2.2.1 Exploratory survey-based analysis

Previously exploratory SURBAR analysis has been performed and showed that internal consistency was virtually absent, impeding cohort analysis for the stock (ICES 2016).

23.2.2.2 Conclusions drawn from exploratory analysis

The lack of internal consistency in the available survey indices (Figure 12.1.6 in ICES 2016) prevents analytical assessment. This internal inconsistency could be related to a) age reading problems, and/or b) a mixture of several stock components leading to unaccounted migrations. As the survey-based assessment cannot be used as a basis for advice, the stock is thus classified, according to the ICES rules for data limited stocks, as belonging to category 5.2. No new data were presented at the WGNSSK 2017 to change the perception of the stock.

23.2.2.3 Advice

DLS-category 5.2, which is based on catch information only. Multi-annual advice was given (2015). There are no new data that change the perception of the stock status.

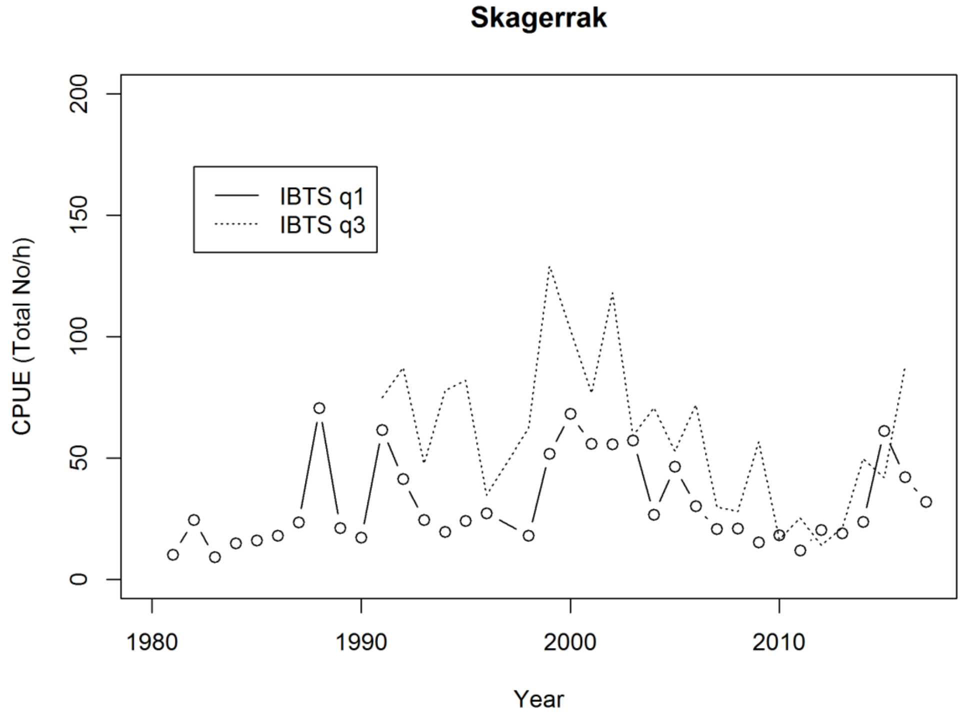
Table 23.2.1. Whiting in Division 3.a (Skagerrak and Kattegat): Nominal landings (t) as supplied by the Study Group on Division 3.a Demersal Stocks (ICES 1992b) and updated by the Working Group, and WG estimate of Discards.

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
1975	19,018			57	611	4	19,690	
1976	17,870			48	1,002	48	18,968	
1977	18,116			46	975	41	19,178	
1978	48,102			58	899	32	49,091	
1979	16,971			63	1,033	16	18,083	
1980	21,070			65	1,516	3	22,654	
	Total consumption	Total industrial	Total					
1981	1,027	23,915	24,942	70	1,054	7	26,073	
1982	1,183	39,758	40,941	40	670	13	41,664	
1983	1,311	23,505	24,816	48	1,061	8	25,933	
1984	1,036	12,102	13,138	51	1,168	60	14,417	
1985	557	11,967	12,524	45	654	2	13,225	
1986	484	11,979	12,463	64	477	1	13,005	
1987	443	15,880	16,323	29	262	43	16,657	
1988	391	10,872	11,263	42	435	24	11,764	
1989	917	11,662	12,579	29	675	-	13,283	
1990	1,016	17,829	18,845	49	456	73	19,423	
1991	871	12,463	13,334	56	527	97	14,041	
1992	555	3,340	3,895	66	959	1	4,921	
1993	261	1,987	2,248	42	756	1	3,047	
1994	174	1,900	2,074	21	440	1	2,536	
1995	85	2,549	2,634	24	431	1	3,090	
1996	55	1,235	1,290	21	182	-	1,493	
1997	38	264	302	18	94	-	414	
1998	35	354	389	16	81	-	486	
1999	37	695	732	15	111	-	858	
2000	59	777	836	17	138	1	992	
2001	61	970	1,031	27	126	+	1,184	
2002	101	975	1,076	23	127	1	1,227	
2003	93	654	747	20	71.9	2	840.9	429
2004	93	1,120	1,213	17	74	1	1,305	909
2005	49	907	956	13	73	0	1,042	299
2006	591	290	349	n/a	85.92	n/a	434.9	331
2007	532	278	331	14	82	1	428	561
2008	522	288	340	14	52	n/a	406	241
2009	712	173	244	10.3	33.82	-	288.1	128
2010	41	165	206	9.7	29.7	-	245.4	291
2011	40	44	84	8.3	20.4	0.2	112.9	794
2012	30	6.8	37	15.5	9.6	0.8	62.9	277
2013	29	102	131	8.4	14.5	1.0	155	591

2014	49	346	395	4.8	37.6	1.3	439	579
2015	74	572	646	5.9	55.681	5.1	713.4	604
2016	129	335	464	13	62	6	545	1115

[1] **Values from 1992 updated by WGNSSK (2007).**

[2] **Values updated by WGNSSK (2011).**



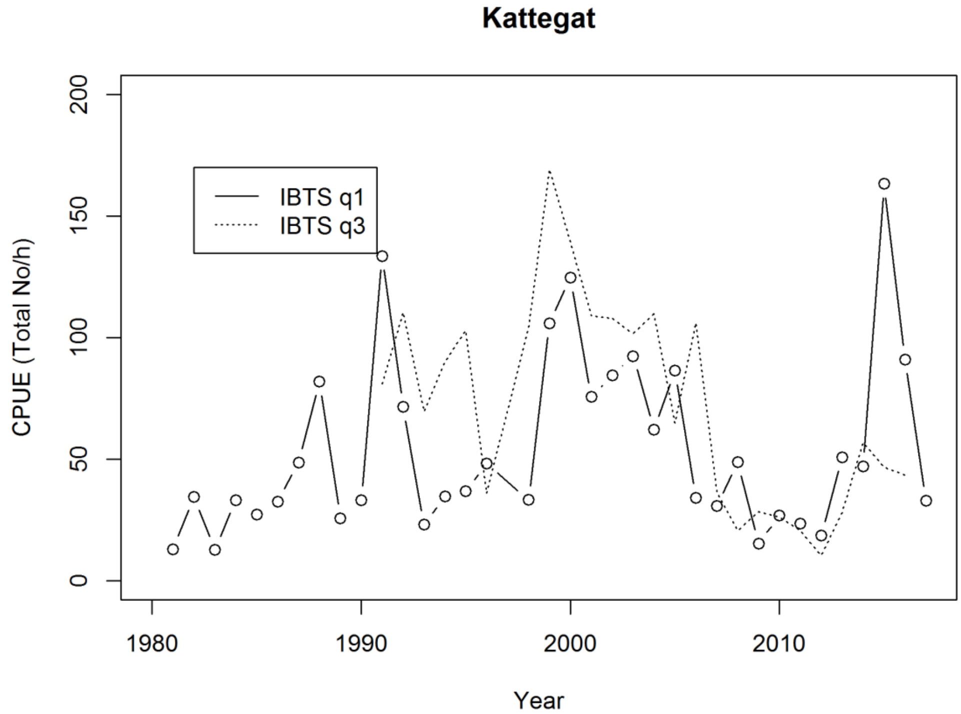


Figure 23.2.1. Whiting in Division 3.a (Skagerrak and Kattegat): IBTS cpue for fish >21 cm per area Q1 covering the years 1981–2017 and Q3 covering the years 1991–2016.

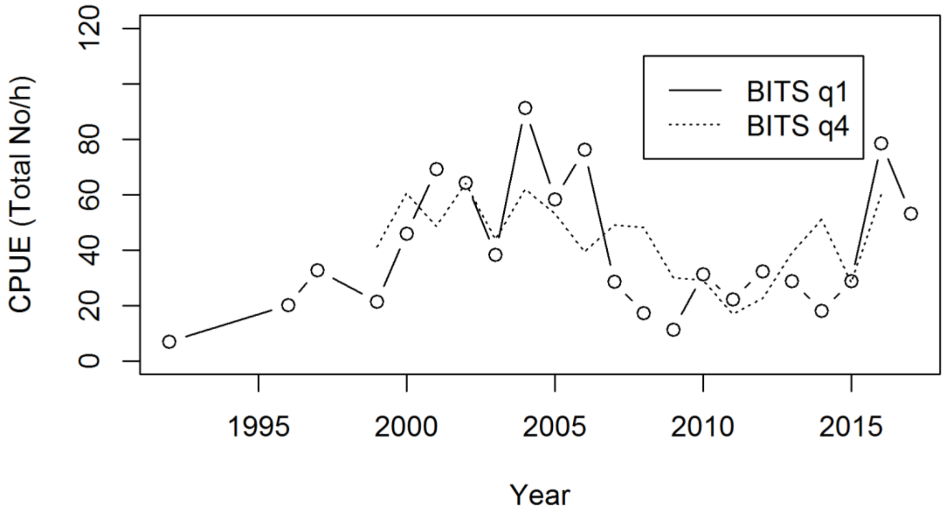


Figure 23.2.2. Whiting in Division 3.a S (Kattegat): BITS cpue for fish >21 cm per Q1 and Q4 covering the years 1992–2017 and 1999–2016, respectively.

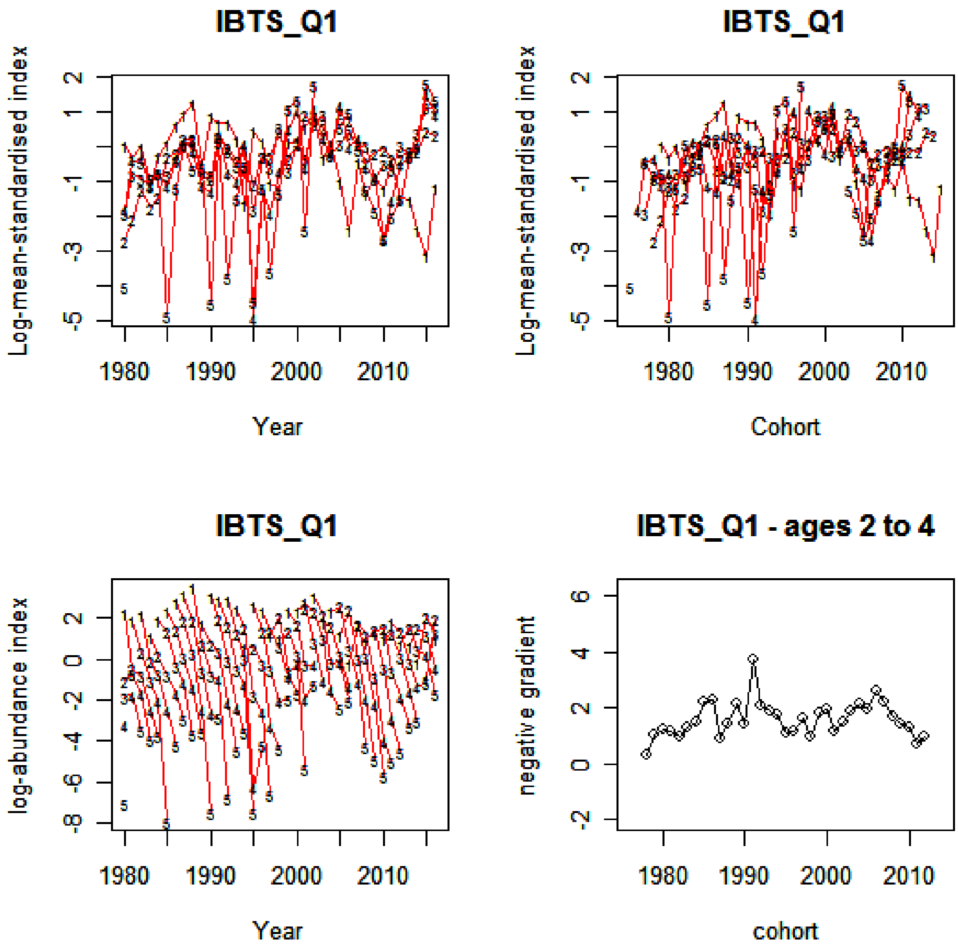


Figure 23.2.3. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta-GAM index).

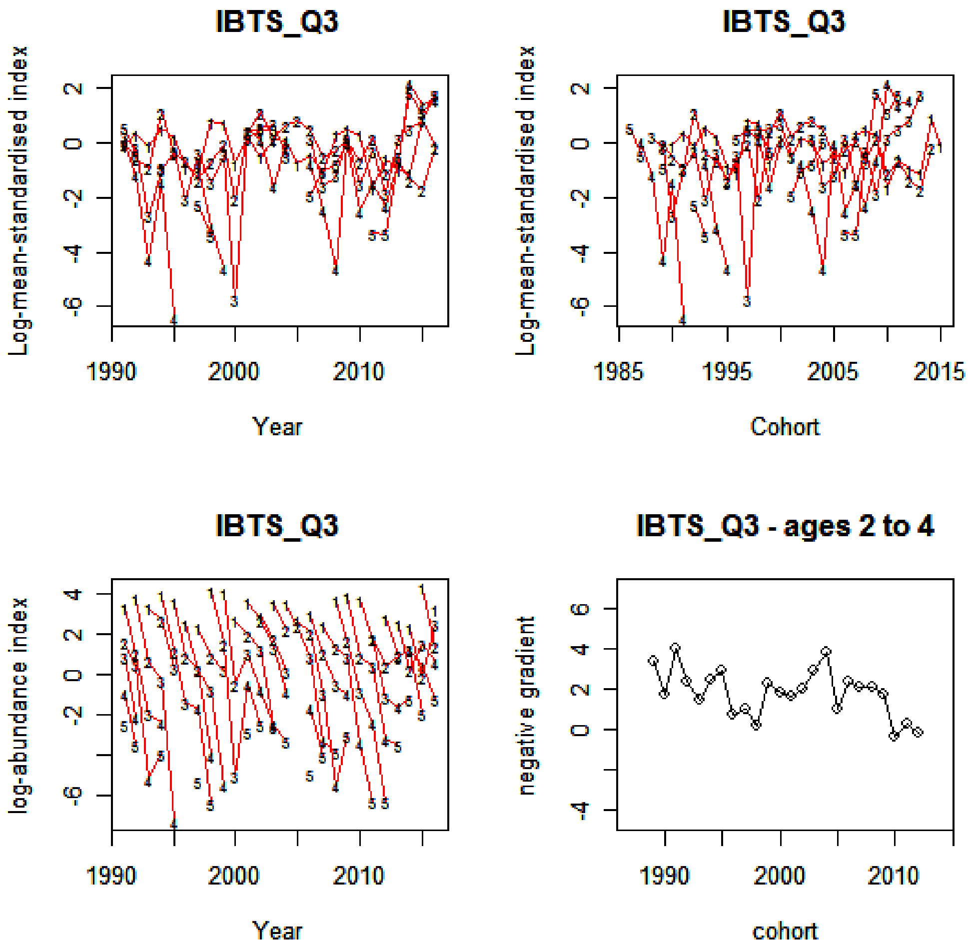


Figure 23.2.4. Whiting in Division 3.a. Log mean standardized indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

24 Witch in Subarea 4 (North Sea) and Division 3.a (Skagerrak, Kattegat) and 7.d (Eastern Channel)

24.1 General

Witch flounder (*Glyptocephalus cynoglossus*) was assessed, between 2010 and 2013, by the Working Group on Assessment of New MoU Species (WGNEW ICES 2013a). Since 2014 WGNEW was dissolved thus this species was included in the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).

Following the ICES guidelines for data limited stocks (ICES 2012) witch was defined as a category 3 species as only official landings and survey data were available. The biennial advice, drafted in 2013 (ICES 2013b), was based on stock size indicators (DATRAS standardized cpue in number per hour) derived from IBTS (both Q1 and Q3) and exploratory estimates (merely indicative of trends and not used for catch forecast) suggesting that fishing mortality was above potential F_{MSY} proxies. In 2015, witch flounder was included into the official data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated by this group. The new data call for the WGNSSK 2016 included landing and discard data for the years 2012–2015 for attempting to give catch advice for this species. The same was done in 2017, with landing and discard data updated up to 2016.

24.1.1 Biology and ecosystem aspects

The existing knowledge of witch biology is summarized in the Stock Annex.

In 2009, witch flounder has been included as a mandatory species in the EU Data Collection Framework (DCF). Accordingly, Denmark and Sweden started the regular sampling of biological data, i.e. length, weight, maturity status and age, in 3.a and 4 both in discards and landings. Scotland has also been collecting biological samples since 2009 but only from the landings.

Age readings techniques are now well established while the macroscopic evaluation of maturity status is still uncertain and a histological analysis of the gonads is under development and it is planned to be ready before the benchmark scheduled in 2018.

24.1.2 Management regulations

According to EU–Regulations a precautionary TAC is given in EU waters of 3.a and 4 together with lemon sole (*Microstomus kitt*). The TACs have been stable, varying around 6 000 tons since 2006. There is no official Minimum Landing Size (MLS) specified in EU waters. However, in most of the countries reporting catches the landing of witch below 28 cm is prohibited. Currently, lemon sole and witch flounder are managed under a combined species TAC, which prevents the effective control of the single species exploitation rates and could potentially lead to the overexploitation of either species. Furthermore, witch flounder is mainly a bycatch species in a mixed fisheries (although some limited seasonal target fisheries occurs) thus a TAC alone may not be appropriate as a management tool.

24.2 Fisheries data

24.2.1 Historical landings

North Sea witch flounder's landings have declined from a peak in 2000 up to 2010, but from 2011 a general increasing trend is observed. This species is nowadays mainly landed by Denmark, Norway, Sweden and Germany in both areas (3.a and 4) and UK mainly in Subarea 4. The Netherlands reports only a small fraction of the total landings in Subarea 4 as this species it is mostly discarded. In division 3.a, Denmark is landing the largest amount of witch flounder, while in Subarea 4 it is Scotland having the largest portion of the landings.

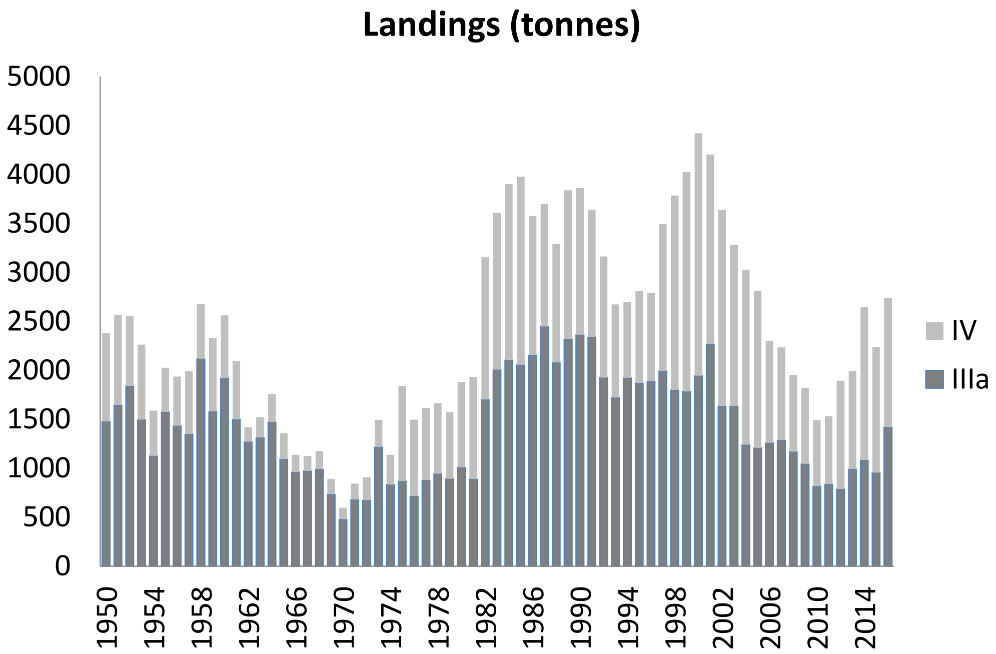


Figure 24.2.1.1. Witch flounder in Subarea 4 and Division 3.a: Total official landings (in tons).

24.2.2 InterCatch

In 2014, witch flounder was included for the first time into the data call for WGNSSK 2014 and since 2015 the data call was extended to obtain landing and discard data for the years 2012–2016. From all countries data were uploaded to the InterCatch data portal. Norway did not report any discards.

Discards could thus be raised for the period 2012–2016 and catches estimated. In general, the discard rate is moderately low and it has been decreasing from 23% in 2012 to 11 and 10% respectively in 2013 and 2014 and increased again in 2015 (18%). In 2016, discard rate has been estimate to be around 16%, which is around the average of the times series. However, it should be noted that not all métiers were sampled in every quarter and that raising procedure may not be adequate in all cases. Thus for some metiers the applied raising procedure might introduce some bias to the total discard estimates. An overview of the reported landings and discards and the resulting discard rates for all fleets is given in table 24.4.1. Landings showed a slight decrease from 2014 to 2015, around 2 300 tons and an increase in 2016.

For 2016, the largest amount of landings and discards was reported by Scotland in Subarea IV using the OTB_DEF_>=120_0_0_all métier and the OTB_CRU_70-

99_0_0_all métier and Denmark in Division 3.a using the OTB_CRU_90-119_0_0_all métier (Figures 26.2.2.1–3). The total catch estimated with InterCatch in 2016 was 3 187 tons, of which only 448 tons were discards (16% of the total catch).

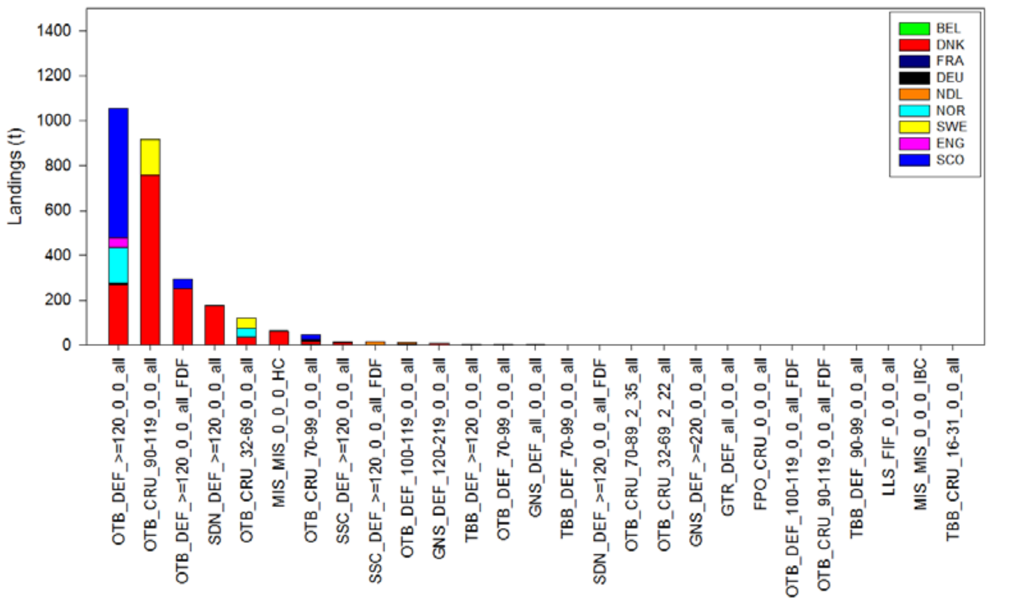


Figure 24.2.2.1. Witch flounder in Subarea 4 and Division 3.a: Landings by métier and country in 2016.

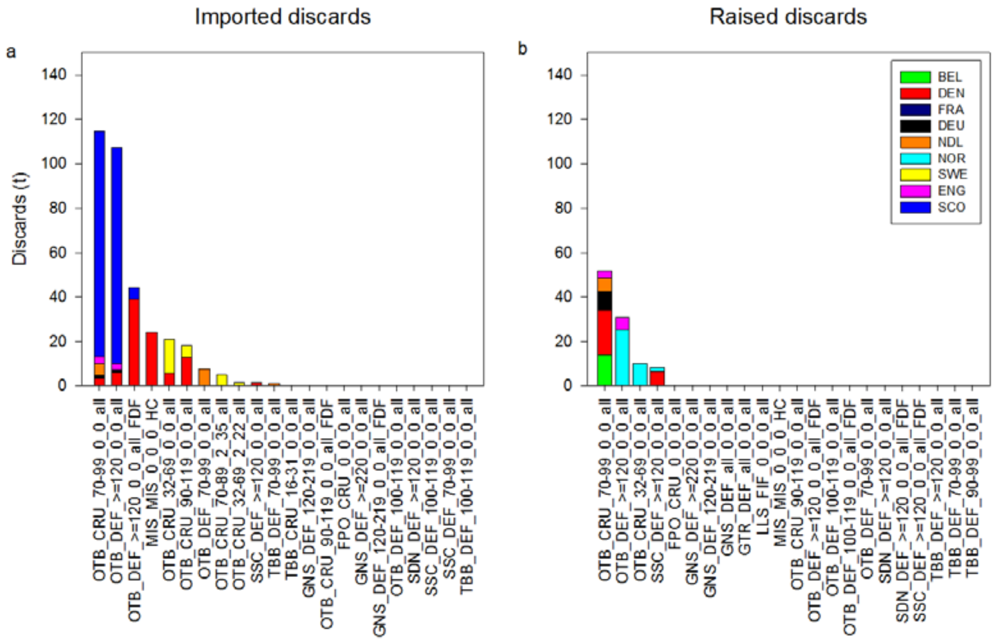


Figure 24.2.2.2. Witch flounder in Subarea 4 and Division 3.a: Discards by métier and country in 2016. Reported discards panel (a), raised discards panel (b).

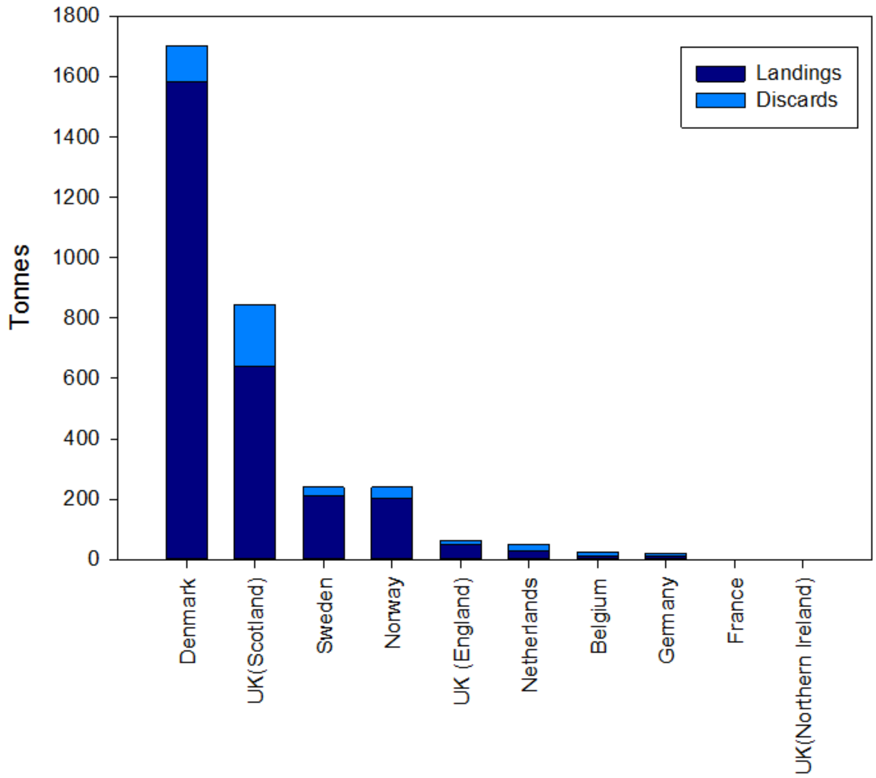
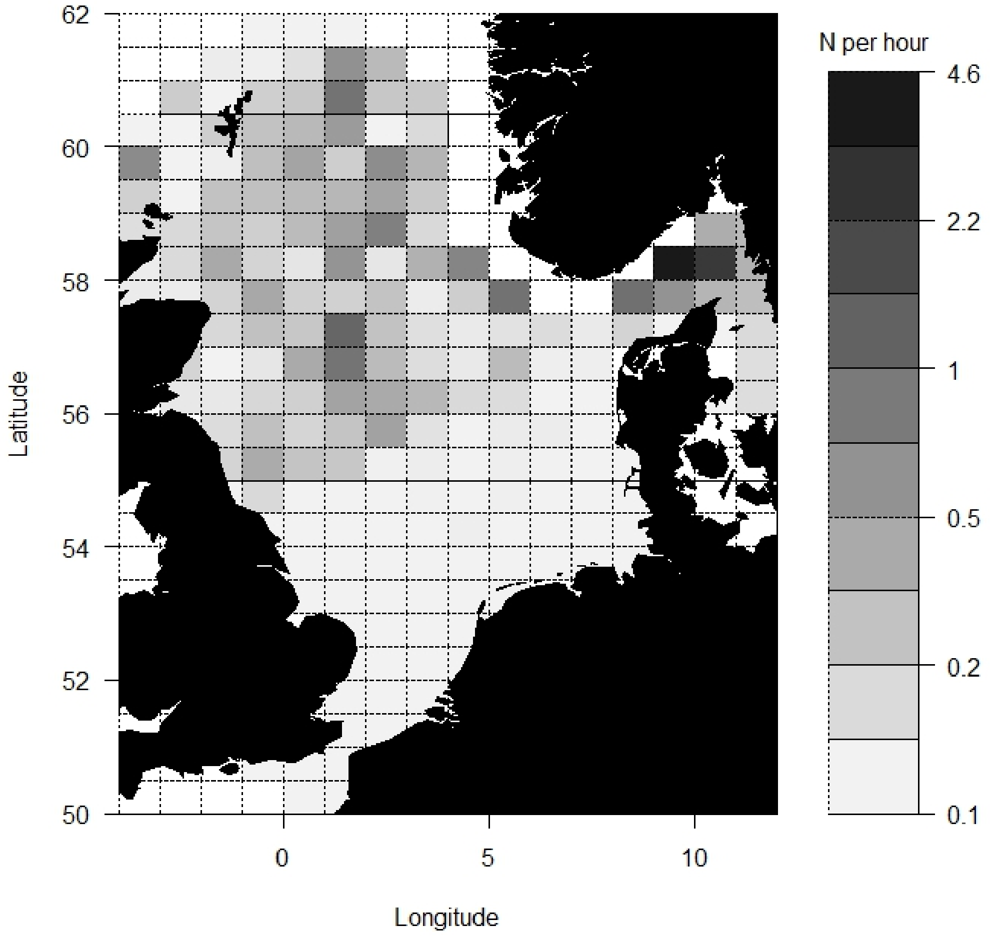


Figure 24.2.2.3. Witch flounder in Subarea 4 and Division 3.a: Estimated landings and discards by countries in 2016.

24.3 Survey data/recruit series

The International Bottom Trawl Survey (IBTS) performed every year during the first and third quarter since 1975 provides indices for the North Sea and 3.a. Furthermore a time series of Dutch Beam Trawl Survey (BTS) data (1985–2008) in 4 is also available but it was not explored during the current assessment. The IBTS seem to be the most valuable and promising data source to be used as tuning fleet for the assessment, particularly during Q1 when more stations are usually fished and the time series is longer (Figure 24.3.1).



N per hour
4.6
2.2
1
0.5
0.2
0.1
62
60
58
56
54
52
50
Latitude
0
5
10
Longitude

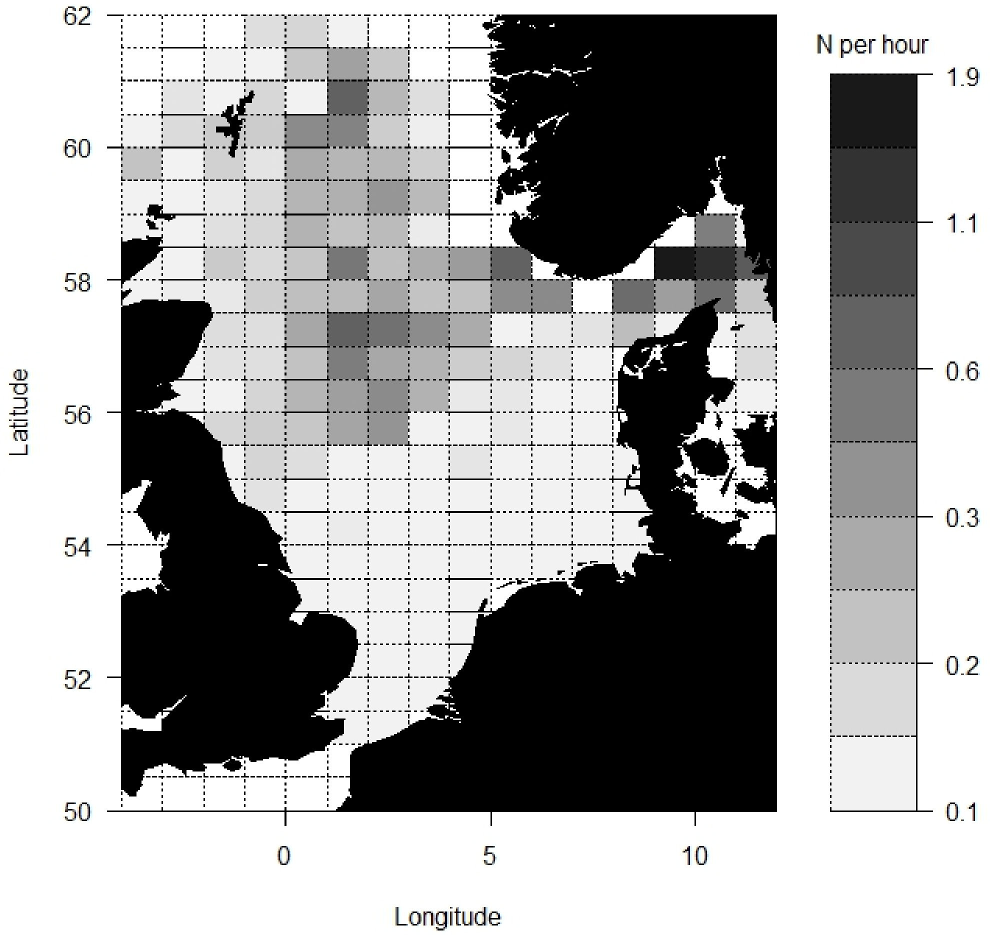


Figure 24.3.1. Witch flounder in Subarea 4 and Division 3.a: Aggregated distribution over the entire time series in the North Sea derived from IBTS–Q1 (upper) and Q3 (lower) using data collected between 1968 and 2016.

24.4 Analysis of stock trends/assessment

Witch flounder has been classified as category 3 stocks following the guidelines of the ICES Data Limited Stocks (DLS) methodological document (ICES 2012). This category includes stocks for which survey indices (or other indicators of stock size) are available and provide reliable indications of trends in stock metrics.

Consequently, the basis of the biennial advice in 2013 was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. A mature biomass index in kg per hour was estimated from the IBTS–Q1 and Q3 survey. The choice to compare three versus five rather than two versus three years index values applied for the advice 2013 was made for accounting the inter-annual variability of surveys. Recent more detailed analysis of the gonads (i.e. ongoing work at the Swedish

Institute for Marine Research) revealed that this species becomes reproductively mature at age 5 and therefore considering a three versus five years average will include at least one generation. However, since 2015 the ICES DLS guidelines two versus three years average was used to provide advice for this stock.

A logistic regression applied in 2014 on the DATRAS CA records showed that L_{50}, i.e. the length at which 50% of the stock is mature, corresponds to 34 cm (ICES 2015). Thus, as in 2016, the mature biomass indices were estimated including all specimens larger than 34 cm and the same LW relationship as in 2016 was used (ICES 2015).

For IBTS–Q1 survey the three most recent year indices of the mature biomass (in kg per hour) (2015–2017) were more than 64% higher than five previous year index, while for IBTS Q3, the three most recent year indices (2014–2016) were around 19% higher than five previous year index.

During WGNSSK 2017, a mature biomass index in kg per hour as derived from both surveys (IBTS–Q1 and Q3) was estimated in accordance with the DLS guidelines and thus the mean of the two most recent year (2015–2016) index was compared to the mean of the three previous years (2012–2014) indices. The combined mature biomass index (i.e. average of IBTS–Q1 and IBTS–Q3) corresponds to an increase of 8% between 2012–2014 and 2015–2016 and therefore the uncertainty cap was not applied in estimating the catch advice. The precautionary buffer was not applied because current F is estimated to be below FMSY (i.e. based on the results of the latest SPiCT assessment; ICES 2017).

Based on this information, WGNSSK 2017 consider that a biannual advice is issued by ICES in 2017 and valid for 2018 and 2019. According to this advice, total catches in 2018 should be no more than 3 165 tons.

Table 24.4.1. Witch flounder in Subarea 4 and Division 3.a. Summary of the assessment. Landings, discards and catches are in tons. The IBTS indices indicate mature biomass in kg/hour.

Year	Official landings	ICES Landings	ICES catches	ICES discards	IBTS–Q1 index	IBTS–Q3 index	Discard rate
1968	1174				0.08		
1969	891				0.04		
1970	597				0.15		
1971	843				0.01		
1972	908				0.01		
1973	1494				0.06		
1974	1138				0.04		
1975	1841				0.03		
1976	1496				0.13		
1977	1618				0.04		
1978	1664				0.05		
1979	1572				0.07		
1980	1883				0.03		
1981	1933				0.38		
1982	3155				0.06		
1983	3606				0.15		

1984	3903				0.11		
1985	3979				0.16		
1986	3579				0.17		
1987	3700				0.21		
1988	3290				0.07		
1989	3841				0.30		
1990	3862				0.12		
1991	3641				0.10	0.11	
1992	3164				0.39	0.12	
1993	2673				0.28	0.06	
1994	2696				0.09	0.08	
1995	2810				0.25	0.13	
1996	2790				0.09	0.10	
1997	3494				0.25	0.17	
1998	3786				0.25	0.08	
1999	4024				0.19	0.12	
2000	4422				0.24	0.04	
2001	4206				0.13	0.11	
2002	3640				0.16	0.09	
2003	3281				0.12	0.05	
2004	3029				0.12	0.08	
2005	2813				0.14	0.05	
2006	2303				0.06	0.08	
2007	2236				0.08	0.12	
2008	1953				0.11	0.06	
2009	1818				0.06	0.05	
2010	1490				0.04	0.06	
2011	1530				0.05	0.09	
2012	1895	1953	2544	592	0.09	0.13	0.233
2013	1993	2020	2272	252	0.08	0.13	0.111
2014	2646	2669	2950	281	0.29	0.08	0.095
2015	2359	2238	2649	410	0.19	0.12	0.155
2016	2658	2739	3187	448	0.13	0.13	0.141
2017					0.23		

24.5 MSY proxy reference points

The SPiCT methodology was used to derive reference points for witch flounder. SPiCT is a stochastic surplus production model in continuous time and the methodology is described in details in Pedersen and Berg (2017). Further, the method and its application on several ICES stocks is also described in ICES WKCat34 2017, ICES WKLIFE VI 2016, ICES WKLIFE V 2015 and ICES WKPROXY 2015. The data used are catches from 1992 to 2016 from Subarea 4, Divisions 3.a and 7.d. From 1992 to 2011, official landings were raised to catch using the average yearly discard rate from 2012–2016. From 2012–2016, official reported landings and observed discards were used instead. The IBTS–Q1 and Q3 surveys from 1992 to 2016 for Subarea 4, Divisions 3.a and 7.d were used as indicators of the mature biomass of the stock (see section 24.4 for details). Landings, discards and IBTS indices are presented in Table 24.4.1.

In Figures 24.5.1-4 the main output of the SPiCT assessment is presented. According to the baseline SPiCT model, fishing mortality is below F_{MSY} and the current biomass is above B_{MSY} in 2016 (Figure 24.5.1) thus the stocks is estimated to be sustainable exploited. However, the model could not converge if the IBTS–Q1 1992 estimate was not excluded or the StdDev of the IBTS–Q1 1992 estimate was not increased. Model residuals (Figure 24.5.3) are generally normally distributed, although retrospective analysis showed a rather severe retrospective pattern especially for the estimate of fishing mortality (Figure 24.5.4).

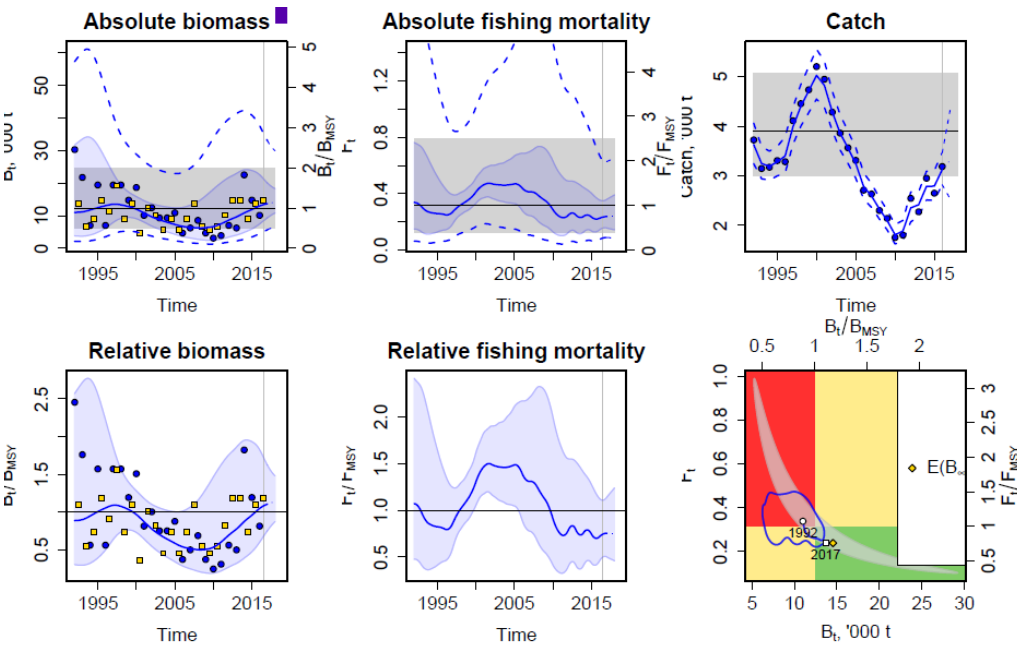


Figure 24.5.1. Witch flounder in Subarea 4 and Division 3.a: Results of the baseline SPiCT model.

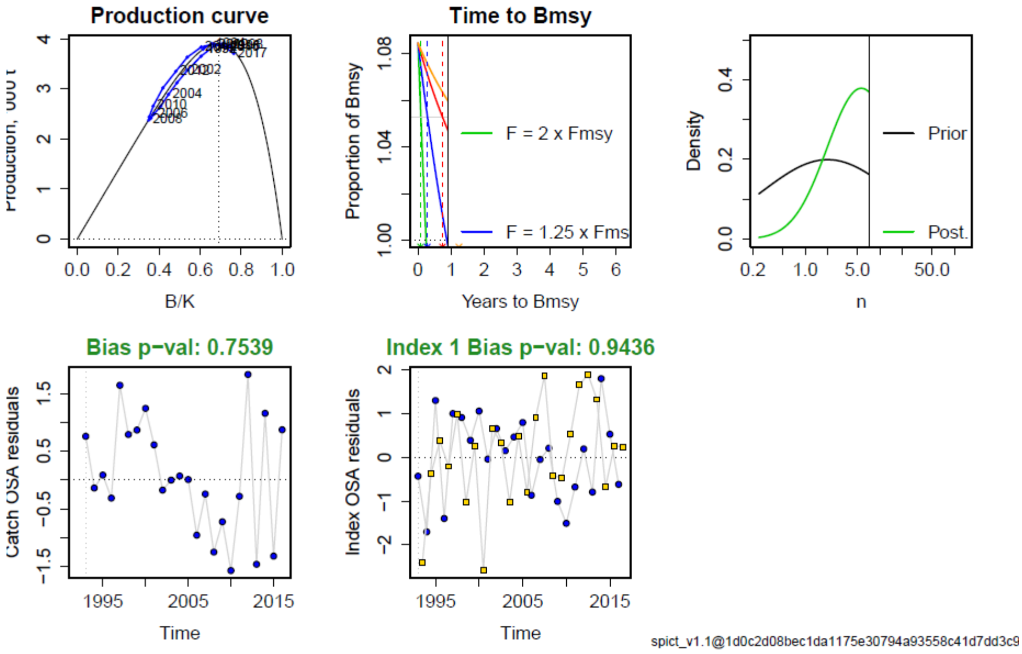


Figure 24.5.2. Witch flounder in Subarea 4 and Division 3.a: Results of the baseline SPiCT model.

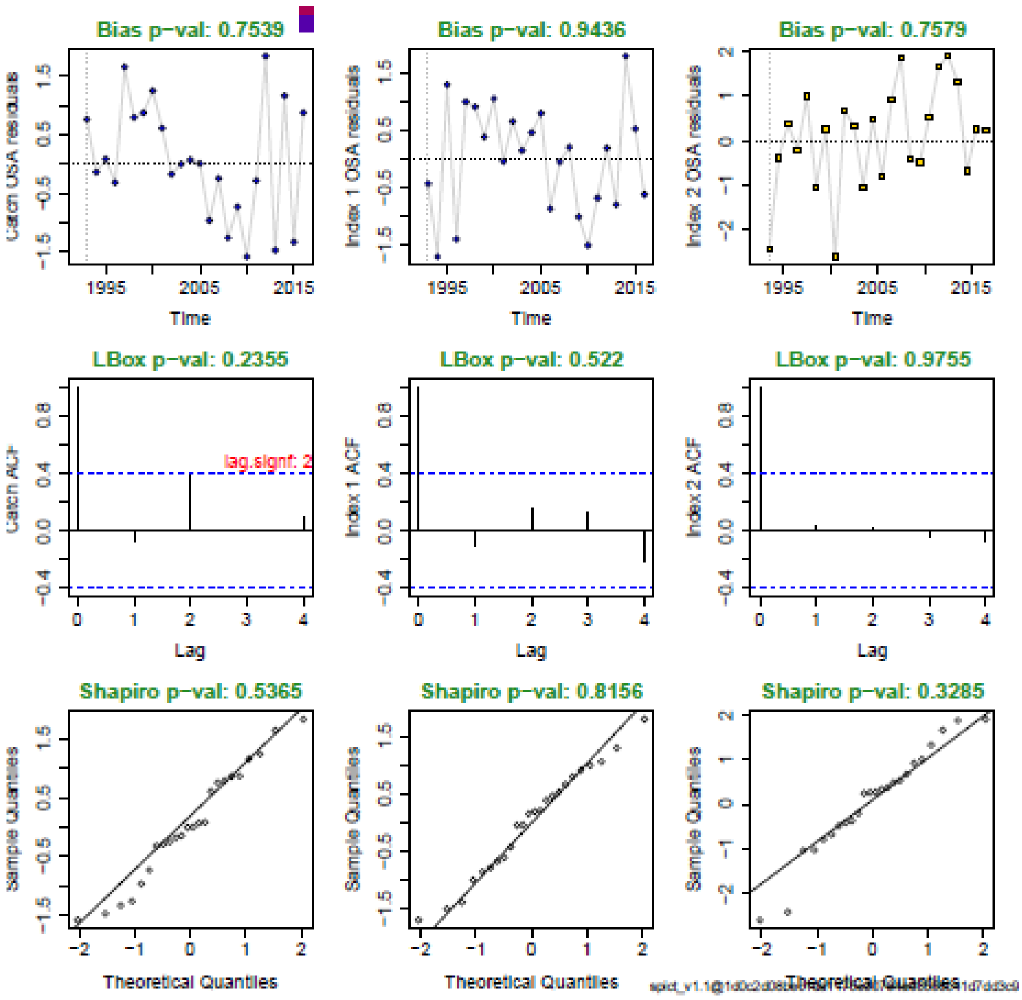


Figure 24.5.3. Witch flounder in Subarea 4 and Division 3.a: Results of the baseline SPiCT model. Residuals plots for catches and survey observations.

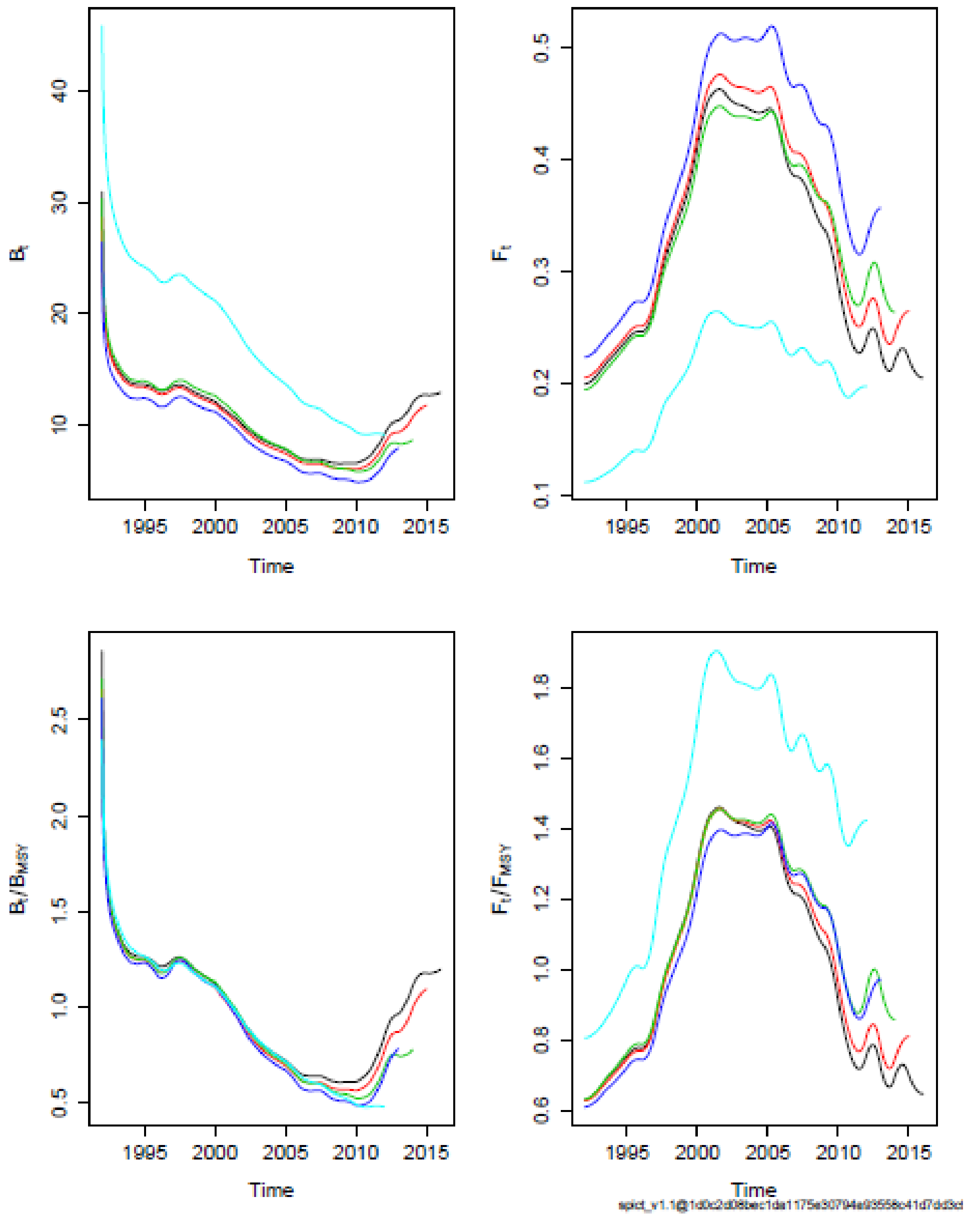


Figure 24.5.4. Witch flounder in Subarea 4 and Division 3.a: Results of the baseline SPiCT model. Retrospective analysis.

Table 24.6.1. Witch flounder in Subarea 4 and Division 3.a: Official ICES landings by Subarea 4 and Division 3.a.

Year	3.a	4	Tot
1950	902	1477	2379
1951	923	1645	2568
1952	713	1841	2554
1953	767	1496	2263
1954	463	1127	1590
1955	450	1577	2027
1956	502	1434	1936
1957	643	1348	1991
1958	559	2119	2678
1959	752	1581	2333
1960	640	1923	2563
1961	594	1499	2093
1962	148	1271	1419
1963	209	1314	1523
1964	288	1472	1760
1965	260	1096	1356
1966	175	962	1137
1967	152	973	1125
1968	185	989	1174
1969	156	735	891
1970	118	479	597
1971	162	681	843
1972	235	673	908
1973	277	1217	1494
1974	304	834	1138
1975	972	869	1841
1976	778	718	1496
1977	738	880	1618
1978	719	945	1664
1979	678	894	1572
1980	874	1009	1883
1981	1044	889	1933
1982	1453	1702	3155
1983	1598	2008	3606
1984	1796	2107	3903
1985	1921	2058	3979
1986	1426	2153	3579
1987	1252	2448	3700
1988	1210	2080	3290
1989	1520	2321	3841
1990	1498	2364	3862

1991	1301	2340	3641
1992	1237	1927	3164
1993	950	1723	2673
1994	771	1925	2696
1995	939	1871	2810
1996	902	1888	2790
1997	1502	1992	3494
1998	1986	1800	3786
1999	2239	1785	4024
2000	2477	1945	4422
2001	1939	2267	4206
2002	2006	1634	3640
2003	1646	1635	3281
2004	1788	1241	3029
2005	1605	1208	2813
2006	1043	1260	2303
2007	949	1287	2236
2008	783	1170	1953
2009	773	1045	1818
2010	675	815	1490
2011	693	837	1530
2012	1107	788	1895
2013	1000	993	1993
2014	1562	1085	2646
2015	1282	956	2238
2016	1317	1421	2739

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Annex 1: List of Participants

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Max Cardinale (by correspondence)	SLU	Sweden

Annex 2: Recommendations

The following table summarises the main recommendations arising from the WGNSSK and identifies suggested responsibilities for action.

RECOMMENDATION	FOR FOLLOW UP BY:
Currently it is not easy to perform sensitivity analyses in InterCatch to check the effect of alternative assumptions made when raising data, because of the way Intercatch has been designed (menu- and choice-driven through a series of clicks, instead of script-based). Given that ICES has indicated that it will be focussing its resources on a succssor to Intercatch instead of developing Intercatch much further (apart from handing relatively minor issues), WGNSSK strongly recommends that any successor to Intercatch facilitate the ability to easily and quickly perform sensitivity analysis to input data and raising assumptions.	Regional Coordination Group, ICES Data Centre, PGCatch
ICES currently has procedures for developing DATRAS data products, such as survey indices-at-age and corresponding covariance matrix, for Category 1 stocks, but does not have similar procedure for deriving indices (e.g. age-aggregated survey indices) for Category 3 stocks which could be used in methods such as SPiCT. WGNSSK recommends that a consistent methodology be developed for deriving indices (both in numbers and weight) for Category 3 stocks that would form part of the ICES DATRAS data products available.	WGISDA, Survey Groups, ACOM
Current methods in DATRAS for producing survey indices make use of ALK substituation procedures, which creates a bottle-neck for producing such indices, particularly if calculations need to be repeated, e.g. due to new data uploads. WGNSSK recommends that ICES develops automated ALK substitution procedures for Datras data products, following advise from appropriate survey groups (e.g. WGISDA) on appropriate methodology.	ICES Data Centre, WGISDA, Survey Groups
Once methods are developed for producing products such as survey indices, it is not clear which group should be responsible for producing such indices - currently it is a mix of EGs running scripts directly on exchange data, and more formal algorithms embedded in Datras data products. WGNSSK recommends that ACOM provide guidance on which group (EGs, Survey Groups, Datras data centre) is ultimately responsible for producing indices that are subsequently used for producing advice.	ACOM
Changes that will affect indices such as the NS	Survey Groups

IBTS are currently being planned. Although WGNSSK recognises the need for such changes, WGNSSK recommends that any change be conducted in such a way that it is possible to determine the effects of such changes through statistical procedures (e.g. there should be sufficient overlap between vessels when changing gear so that the effect of this change is estimable).	
Current guidelines for a transition from MSY–Btrigger=Bpa to an estimated MSY–Btrigger can lead to large changes in MSY–Btrigger. This has occurred for ple.27.420, which is one of he first stocks to test the guidelines for calculating MSY–Btrigger. The recent benchmark for this stock (WKNSEA 2017) chose to deviate from these guidelines because they argued that, for a stock with an Fmsy=0.21 (so that total Z at MSY ~0.3), it will likely take longer than 5 years of fishing at Fmsy for the SSB to stabalise at some Bmsy level. WGNSSK recommends that ACOM develop the guidelines for MSY–Btrigger further so that there is a more gradual shift from MSY-Btrigger=Bpa to an estimated MSY–Btrigger to avoid sudden changes that may not immediately lead to an appropriate MSY–Btrigger.	ACOM
There was confusion in 2016 about how to treat BMS when raising discards. WGNSSK recommends that a cooridnation meeting be held to involving experts from WGCatch, the ICES data centre (for InterCatch), ACOM and selected EG groups. Guidance is also need on how to report BMS in an unambiguous and unbiased manner.	WGCatch, the ICES data centre (for Intercatch), ACOM and selected EG groups
WGNSSK notes the difficulties that WKNEP experienced with the methodology for setting MSY proxy harvest rates and supports the proposal to hold a specific workshop to address the issues. WGNSSK proposes that the workshop should also define buffer/limit setting guidelines and explore the appropriateness of lags in TV surveys in the reporting of observed harvest rates. This group should meet before the next round of assessment working groups (suggest November 2017 or January 2018).	ACOM

Annex 3: ToRs for next meeting

WGNSSK (Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak).

2017/2/ACOM:21 The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), chaired by José De Oliveira, UK, in meet in Ostend, Belgium, 24 April–3 May 2018 and by correspondence in September 2018 to:

Address generic ToRs for Regional and Species Working Groups. The Norway pout assessments shall be developed by correspondence.

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date. WGNSSK will report by 18 May 2018, and by 24 September 2018 (Norway pout) for the attention of ACOM.

Annex 4: List of Stock Annexes

The table below provides an overview of the WGNSSK Stock Annexes. Stocks Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the year, ecoregion, species, and acronym of the relevant ICES expert group.

Stock ID	Stock Name	Modified	Link
bll-nsea_SA	Brill in Subarea 4, Divisions 3.a and 7.d–e	07-12-2015 13:46	bll-nsea_SA.docx
cod.27.47d20_SA	Cod in Subarea 4, Division 7.d and Subdivision 20	31-07-2017 11:30	cod.27.47d20_SA.doc
dab-nsea_SA	Dab in Subarea 4 and Division 3.a	04-07-2016 13:59	dab-nsea_SA.docx
fle-nsea_SA	Flounder in Subarea 4 and Division 3.a	29-06-2015 16:29	fle-nsea_SA.docx
gug-347d_SA	Grey gurnard in Subarea 4, Divisions 7.d and 3.a	28-10-2014 13:28	gug-347d_SA.docx
had-346a_SA	Haddock in Subarea 4, Divisions 6.a and 3.a West	28-10-2014 13:26	had-346a_SA.docx
lem-nsea_SA	Lemon sole in Subarea 4, Divisions 3.a and 7.d	29-06-2015 16:30	lem-nsea_SA.docx
mur-347d_SA	Striped red mullet in Subarea 4, Divisions 7.d and 3.a	14-04-2015 14:57	mur-347d_SA.docx
nep-10_SA	Norway lobster in Division 4.a, FU 10	04-11-2014 12:04	nep-10_SA.docx
nep-32_SA	Norway lobster in Division 4.a, FU 32	04-11-2014 12:03	nep-32_SA.docx
nep-33_SA	Norway lobster in Division 4.b, FU 33	05-07-2016 12:11	nep-33_SA.docx
nep-34_SA	Norway lobster in Division 4.b, FU 34	04-11-2014 12:03	nep-34_SA.docx
nep-3-4_SA	Norway lobster in Division 3.a	29-06-2015 16:32	nep-3-4_SA.docx
nep-5_SA	Norway lobster in Divisions 4.b and 4.c, FU 5	06-07-2016 09:23	nep-5_SA.docx
nep-6_SA	Norway lobster in Division 4.b, FU 6	04-11-2014 12:02	nep-6_SA.docx
nep-7_SA	Norway lobster in Division 4.a, FU 7	29-06-2015 16:38	nep-7_SA.docx
nep-8_SA	Norway lobster in Division 4.b, FU 8	04-11-2014 12:02	nep-8_SA.docx
nep-9_SA	Norway lobster in Division 4.b, FU 9	04-11-2014 12:01	nep-9_SA.docx
nop-34_SA	Norway pout in Subarea 4 and Division 3.a	04-11-2014 14:26	nop-34_SA.docx
ple.27.7d_SA	Plaice in Division 7.d	03-07-2017 11:25	ple.27.7d_SA.docx
ple-kask_SA	Plaice in Subdivisions 21–23	04-11-2014 15:03	ple-kask_SA.docx
ple.27.420_SA	Plaice in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	03-07-2017 11:58	ple.27.420_SA.docx
pol-nsea_SA	Pollack in Subarea 4 and Division 3.a	04-11-2014 15:02	pol-nsea_SA.docx
sai-3a46_SA	Saithe in Subareas 4–5 and Division 3.a	06-07-2016 15:52	sai-3a46_SA.docx
sol.27.7d _SA	Sole in Division 7.d	04-11-2014 12:47	sol.27.7d_SA.docx
sol-nsea_SA	Sole in Subarea 4	14-04-2015 14:58	sol-nsea_SA.docx

Annex 5: Audit Reports

No information provided for 2017.

Annex 6: Benchmark Planning and Data Problems by Stock

1 Benchmark Planning

1.1 Summaries of recent benchmarks and inter-benchmarks

1.1.1 Haddock in 4, 6.a. and 3.a.20 (IBP Haddock 2016)

The Inter-benchmark Protocol on Haddock in Subarea 4, Division 6.a and Subdivision 3.a.20 (IBP Haddock 2016), chaired by José De Oliveira (UK) took place by correspondence during four meetings spread over several weeks (29 June–29 September 2016). There were eight participants, including two external reviewers (both from the USA) and scientists from the UK and Germany. The main focus of the IBP was to investigate the cause of the apparent failure of the TSA model, to remedy this failure, if possible, or to consider alternative models, if not, and to re-estimate reference points based on the newly selected model. The IBP identified the problem as a retrospective pattern caused by the way in which the larger post–1999 recruitment events were treated, and was able to find a TSA model configuration that remedied this problem; this was achieved by not treating any of the post–1999 year classes as "outstanding". The post-1999 period was then used as a basis for estimating reference points, apart from Blim which was taken as the lowest SSB that produced an outstanding year class (1979).

1.1.2 Norway Pout in 3.a and 4 (WKPOUT 2016)

The Benchmark Workshop on Norway Pout (WKPOUT), chaired by External Chair Jerry Ault, USA, and ICES Chair José De Oliveira, UK, met at ICES HQ, Copenhagen on 23–25 August 2016. There were 13 participants, including three external reviewers (two from USA, one from France), Danish, Norwegian and UK scientists, and Danish Industry representatives. The benchmark followed a data evaluation workshop in May 2016 during which input data for the assessment were agreed. The main focus of the benchmark was to agree a new assessment methodology, seasonal SAM (SESAM), for Norway Pout. In addition, reference points and forecasting methodology were discussed. A number of variants of the SESAM model were investigated and compared to the previous assessment model, SXSA. These variants included the use (or not) of commercial cpue data, omission of the earliest years of data from the assessment, alternative settings for the detection threshold used to handle zero-valued data, and omitting the years of fishery closure when estimating the random walk variance on fishing mortality. The final SESAM model excludes commercial cpue data, omits 1983 data from the assessment and omits the years of fishery closure from the random walk variance calculation. Blim is set equal to Bloss based on quarter 4 SSB values to align with the new fishing season (1st November to 31st October). The short-term forecast is stochastic, which allows the probability of SSB being below Blim to be evaluated immediately following the fishing season.

1.1.3 Plaice in 4 and 3.a.20 (WKNSEA 2017)

No new information on stock id or sub stock structure was presented during the benchmark. During a plaice benchmark in 2015, the decision was made to assess western Skagerrak plaice with North Sea plaice (area 4). Plaice migrate into 7d during quarter 1, therefore 50% of the mature individuals were assigned to North Sea plaice stock in addition to 50% of the mature discards; this as different to previous years, when 50% of the catches were assigned to the North Sea stock.

Alternate survey indices were explored. In addition to the beam trawl and sole net surveys used in the assessment prior to the benchmark, the IBTS quarters 1 and 3 were investigated. Alternative ways of calculating standardized age-based survey indices based on GAMs and Delta distributions were explored.

A new maturity ogive was estimated using Dutch commercial landings 1957–2015, but assessment model runs showed the new ogives had limited effect on the reconstructed SSB. Therefore, the previously-used, time-invariant maturity ogive was chosen.

Several methods for estimating natural mortality were investigated. The rates based on Hoenig's Tmax-based estimator (Hoenig 1983) were thought to be the best for this stock, but did not deviate greatly from the previous estimate, based on Beverton (1963). Therefore, natural mortality was not changed from 0.1 year–1 for all ages and years.

The assessment model was changed from XSA to a smoother-based age structured stock assessment, based on Aarts and Poos (2009), but the F-at-age matrix is generated using a tensor spline. Rather than using the discards and landings-at-age as separate data sources as in Aarts and Poos (2009), the final assessment uses the catches (the sum of landings and discards) as data and the basis for the likelihood fitting.

New reference points were estimated. FMSY analyses were conducted with Eqsim.

1.1.4 Sole in 7.d (WKNSEA 2017)

Existing research showed that sole in 7d are genetically distinct from sole in 7e, but some exchange between stocks occurred with North Sea sole and sole 7d. Within the 7d stock, limited exchange of larvae and juveniles occurs between three regions: along the English coast, the Bay of Seine, and along the coast of northern France.

InterCatch was used for estimation of landings age composition, as well as the estimation of both discards numbers and age composition. Data from each nation were input for 2003–2015. Stock weights at age were generated from quarter 2 catch weights.

Research tuning indices were investigated to determine whether there was sufficient information on age 1 fish in the French YFS and UK YFS surveys. There was no evidence to revise the tuning indices and they were retained in their current form in the assessment.

The suggestions made during WKFLAT 2009 were implemented for the Belgian commercial series, which was to investigate a more realistic conversion factor for horse power for converting nominal fishing effort to effective effort. This was successfully done for 2004–2015, but resulted in truncating the tuning series in the assessment model. A new French commercial tuning series was constructed from the French otter trawl fleet targeting sole along the French coast.

A new maturity ogive was constructed using data from the UK commercial fisheries.

Three assessment models were trialled at the benchmark: XSA, SAM, and the Aarts and Poos model. The final model was an XSA and included catch data (2003–2015), discards, new stock weights, new maturity ogive, three research surveys (the UK BTS survey, and the UK and French YFS surveys), and three commercial surveys (the newly constructed Belgium commercial survey 2004–2015, the new French otter trawl series 2002–2015, and the UK CBT commercial series). The new model resulted in an increase in SSB and decrease in Fbar, especially in more recent years.

New reference points were estimated. F_{MSY} analyses were conducted with Eqsim.

Future Research and data requirements were identified, also by the external reviewers.

1.1.5 *Nephrops* in FU 32 (WKNEP 2016)

Data needed

1) Danish data from at-sea-observers (discard, lfd, sex ratio)

2) Danish log book data

3) Norwegian shrimp survey data

4) Norwegian electronic log book data

5) Norwegian data from recreational *Nephrops* fishery

6) Norwegian Coast Guard data from vessel inspections

Assessment issues

- Investigate possibilities for obtaining biological data (maturity, weight, length) from the Danish at-sea-observer programme
- Analyze discard data (strange values in recent years), document old and new sampling procedures, agree on standard sampling procedure
- Analyze spatial distribution of Danish fishery
- Explore possibilities for obtaining a *Nephrops* biomass index from the survey data
- Analyze biological data from recent studies on recreational fishery along Norwegian coast (sex ratio, length)
- Analyze so far unused total length data (TL) from Coast Guard inspections
- Investigate possibilities for obtaining discard data from Coast Guard inspections
- Explore the area calculations used for estimating harvest rates. Is the current estimated area too large?
- Explore electronic logbook data from 2011 onwards and establish new lpue time-series from respectively shrimp and *Nephrops* trawls.

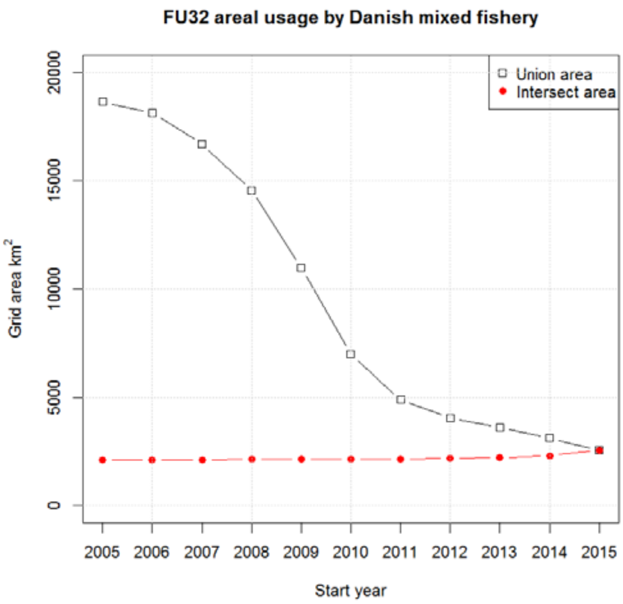
The following data sources were made available to the benchmark: 2, 3, 4, 6. The following assessment issues were followed up: 3, 4, 8, 9. Due to time constraints the remaining issues were not dealt with.

There has never been any fishery-independent stock size index available for *Nephrops* in FU 32. The annual Norwegian shrimp survey covers Skagerrak and the Norwegian Deep at depths >100 m. Analyses of the 2006–2016 survey data were carried out and a working document produced. Separate biomass indices were estimated for Skagerrak and the Norwegian Deep using GLMs within a mixed generalized gamma-binomial model and Bayesian inference. The biomass index for the Norwegian Deep had high values in 2006 and 2007 and then declined to a lower level in 2008. Thereafter, the index has fluctuated without trend. The survey index is based on few observations. However, in lack of better data, the benchmark considers that the index should be presented and updated as part of the annual assessment procedure of the FU 32 stock.

Norwegian electronic logbooks were introduced for vessels ≥15 m in 2011. There are, however, few large Norwegian vessels landing *Nephrops* from FU 32. One vessel dominated the large mesh trawl fishery for several years. In 2015–2016, trawl landings were only 7–8 tons (divided approximately equal between shrimp and large mesh trawls) and comprised <10% of the total Norwegian *Nephrops* landings from FU 32. The Norwegian fishery is now mainly a coastal trap fishery, which is carried out by small vessels, not obliged to fill out logbooks. An lpue index based on the Norwegian electronic logbooks is thus not representative of the present Norwegian *Nephrops* fishery in FU 32 and will not be included in future assessments.

Danish *Nephrops* fishing grounds were identified using Danish VMS and logbook data, and annual maps of total *Nephrops* landings and nominal effort were produced. The data were further filtered for daily *Nephrops* ratios >0.05 in the landings. This filtering of the data revealed a further decline in the spatial distribution of the Danish fishery, from 2012 to 2013 which was not evident before the filtering.

The area of *Nephrops* grounds in FU 32 (used for calculating total abundance in the harvest rate table) has previously been estimated using information on the spatial distribution of the Norwegian and Danish fisheries, as well as suitable sediment (55 500 km^2). With the fishery being contracted in the southern part of FU 32, the value of 55 500 km^2 gives unrealistically low harvest rates. The benchmark therefore decided to use the present distribution of the Danish fishery to provide a new area estimate. For each year, fishing ground, defined as the smallest number of grid cells containing 95% of the landings, was estimated. Both the union and the intersection of the areas for each year was calculated representing the maximum and minimum estimate of the fishing grounds (Figure below). The 2005 values are the set of all grid cells common to the years 2005–2015 (union and intersection). The 2004 values are the set of all grid cells common to the years 2004–2015, etc. By shifting the starting year to use in the calculations, from 2005 towards present time, the spatial contraction of the utilized fishing ground was visualized. The benchmark decided to use the union of the fishing areas for 2013–2015 as the area estimate in the harvest rate table (3 613 km^2), as there has not been any great changes in the spatial distribution from 2013 to 2015.



1.1.6 *Nephrops* in FU 3-4 (WKNEP 2016)

A summary was not supplied, but the text below was largely drawn from the WKNEP 2016 report.

For each of the stocks with UWTV surveys (including FU 3–4) the group considered in detail:

- The technology of the survey, including correction for edge effects, discovery rate, species identification, etc.;
- The distribution area and coverage;
- The derivation of a recommended harvest rate.

For all these stocks the WGNEP considered, and the reviewers endorsed, that with regard to the first two bullet points, the UWTV survey based assessment as described could be standard for the future. When attempting to derive reference points, with what is deemed to be an accepted method for such stocks, unexpected problems were uncovered that could not be solved at the meeting (see below).

For FUs 3–4, UWTV surveys have been used for several years to assess the stock, and the present benchmark was mostly to endorse improvements and refinements. The WKNEP agreed that the proposed changes were acceptable and appropriate for providing scientific advice on the abundance of this stocks. However, the reviewers agreed that for deriving reference points, and hence translating the stock abundance estimate to recommended removals, the common length-based yield per recruit method was not appropriate. The reviewers agreed that deriving harvest rates from historical experience and from experience with similar stocks, as suggested by WKNEP was acceptable as an interim solution, until a firmer basis for generating advice from UWTV survey abundance estimates can be developed.

In relation to the issues surrounding the analytical approach to reference point setting, WKNEP proposed an interim solution, but recommended that ICES establishes a study group to examine methods to derive recommended removals in stocks where the abundance estimate comes from other sources than an analytic assessment. Although *Nephrops* monitored with UWTV surveys perhaps is the most obvious example at present, a study group can have a broader scope.

One of the major drawbacks of the current analytical approach is the equilibrium assumption is made and whilst the use of 3 year averaged length distributions may go some way to removing the effects of strong year classes, these models are unsuitable for the determination of stock status where there are systematic changes in fishing mortality. It was noted at the 2009 *Nephrops* Benchmark that there was some discrepancy between the size of population the cohort models generated compared to the estimates of abundance coming from the TV surveys, but at the time the discrepancies were not considered to be of concern because the LCA was being used to essentially parameterise the selection parameters for a yield-per-recruit analysis and not be an assessment of absolute stock or mortality.

At WKNEP 2016 two new TV surveys were presented, for FU 23–24 and FU 30 and initial runs of the cohort based models resulted in radically different population estimates compared to the TV abundance (differences of ~5–10 fold), coupled to high estimates of fishing mortality even at times where the fisheries were very small. Reconstructing the total mortality from the length distribution of catches by a Jones cohort analysis indicated fishing mortality at length being very different from the assumed logistic function, however this deviation from model assumption is unlikely to be the sole cause of the difference between population abundance estimates. Although the estimates of population size and fishing mortality from the LCA are not used as measures of stock status, the group felt that these discrepancies were so great that there was a significant risk of the LCA derived estimates of fishery parameters and their associated MSY proxy points being biased.

For many stocks, including *Nephrops*, the stock abundance is monitored by methods that measure the abundance in absolute terms, or have the potential to do so. That includes UWTV surveys for *Nephrops* but also acoustics, egg surveys, tagging and even swept area measures in trawl surveys. Combining such absolute measures with a catch-dependent analytic assessments can lead to conflicts as survey and catches are two competing absolute measures, both with errors and with an uncertain link (natural mortality) between them. Most often, the conflict is avoided by treating survey information as relative. However, that may not be the only way, and there is considerable interest in making more direct use of survey measurements. In all such cases methods will be needed for translating the measured abundance into advice.

At present, solutions have been somewhat *ad hoc*, and the result not always satisfactory. It is suggested that ICES may benefit from establishing firmer standards in this field. Such methods may go beyond length based yield per recruit and include approaches that do not require analytic assessments or models of population dynamics. The suggestion by WKNEP 2016 to consider what harvest rate the stock seems to have tolerated in recent years may be one way forward.

In conclusion, WKNEP 2016 recommends that ICES establishes a study group to examine and propose methods for deriving catch advice from absolute abundance measurements for stocks where there is no analytic assessment. *Nephrops* monitored by UWTV surveys represents the most prominent problem at present, and may be taken as a working example. The group should consider length-based yield per recruit as one approach, but also alternative approaches.

1.2 Benchmarks and inter-benchmarks for 2017/2018

1.2.1 Turbot in 4

1) Evaluate the suitability of input data for the assessment:
   - a. The catch-at-age matrix currently used
   - b. The fishery-independent tuning indices currently used
   - c. The incorporation of fishery-dependent tuning indices that may improve the assessment

2) Evaluate the assessment model settings:
   - a. Find model settings that reduce the large retrospective biases in F (and to a lesser extent in SSB)
   - a. Determine whether the model in 2(a) can be used to provide category 1 advice (with forecast) for North Sea turbot, or whether it should continue to be used to provide category 3 advice.
   - b. If the model in 2(a) is not adequate for either category 1 or category 3 advice, propose an alternative (e.g. index of abundance) that can be used for category 3 advice.

3) Estimate reference points for the stock
   - a. If a category 1 assessment is found acceptable, estimate the reference points.

b. If a category 3 assessment is found acceptable, estimate proxy reference points. (Here, I note that SPicT was run in WGNSSK, so would only need to be re-run if any of the data were updated)

More details can be found in the issue list below

Table 1. Issue list for Turbot (*Scophthalmus maximus*) in Subarea 4 (North Sea)

Stock	Turbot (*Scophthalmus maximus*) in Subarea IV (North Sea)	
Stock coordinator	Name: Ruben Verkempynck	Email: ruben.verkempynck@wur.nl
Stock assessor	Name: Jan Jaap Poos	Email: janjaap.poos@wur.nl
Data contact	Name:	Email:

Issue	**Problem/Aim**	**Work needed/ possible direction of solution**	**Data needed to be able to do this: are these available/ where should these come from?**	**Responsible expert from WG**	**External expertise needed at benchmark type of expertise/ proposed names**
Catch at age matrix	Landings at age and age-composition only from NL data in recent years	Age data for landings from other countries	Other countries, e.g. Denmark and UK, to deliver age data for landings (and discards)	Ruben Verkempynck José De Oliveira Clara Ulrich Lies Vansteenbrugge Bart Vanelslander	/
Tuning series	BTS–ISIS and SNS have very bad internal consistencies (low R2)	Reevaluate age-structured lpue	Age-based lpue	Jan Jaap Poos, Ruben Verkempynck, Lies Vansteenbrugge/Bart Vanelslander	
Method	Consistent and large retrospective pattern	Evaluate assessment model to see if retrospective pattern can be reduced	/	Jan Jaap Poos, Ruben Verkempynck	SAM expertise (Anders Nielsen, Casper Berg)
Other	PO imposed catch restrictions have biased the lpue in Dutch fisheries	Recalculate and standardise lpue	English flagship turbot catches 2016, discard data from Dutch landing obligation project collecting all turbot discards during trips	Ruben Verkempynck, Jan Jaap Poos	/

Working papers:

Turbot catch data–age

- Get data from DK, nothing from DE, UK
- Also compare age-length key from (Dutch) surveys

Surveys

- Combine indices using Kasper's surveys

i) What surveys? First check with previous benchmark reports

ii) Otherwise, use cpue's and start from there

iii) At the moment we have BTS–ISIS and SNS

iv) Check IBTS + other BTS surveys (e.g., BTS–Tridens, Belgium and German BTS)

Commercial lpue

- English lpue compare with non-recent years of Dutch lpue

i) In terms of catch and in terms ICES rectangles

ii) Estimate gear effect of pulse trawl gear from both lpue's? (GAM/GLM)

Runs:

- Working papers on run's, there is already preparation by Jan Jaap in the report, update with latest information.
- SAM. Also settings and configuration
- Do a run with this new input data in AAP
- (SPICT run with new data if assessment still not acceptable)

1.2.2 Whiting in 4 and 7.d

Data needed

Historical catch (landings, discards, IBC) data (BEL, DNK, FR, GER, NDL, NOR, SWE, UK ENG, UK SCO). Numbers and weights at age back to per catch components from 1990 onwards for the combined areas 27.4 and 27.7d.

Biological data available from commercial sampling and IBTS surveys (including (maturity, length distributions, age distributions, individual weights, sex ratios).

Natural mortality estimates from the most recent key run from SMS multispecies model (WGSAM).

IBTS survey data (from 1990 onwards).

Current assessment and forecast

Currently, assessment is done using a FLXSA, assuming catches to be exact. For comparison a SURBAR analysis is run using IBTS survey indices quarter 1 and 3. Alternative assessment model should be explored, i.e. SAM, taking into account uncertainty and variability in catches.

According to the stock annex, the maturity ogive is based on North Sea IBTS quarter 1 data, averaged over the period 1981–1985. The calculation was carried out at some point during the mid-to-late 1980s. There was no information available to WKROUND to allow a determination of whether the estimates are based on combined sex or females only, and exactly how the calculation was done. Recent biological data should be used to check whether used values for the maturity ogive are still appropriate.

The short term forecast inputs should be checked whether they are still appropriate. The weight at age are taken from the final historical year while exploitation rates are taken as an average of the recent three years. The settings will be checked.

Proposed analysis

An update of the assessment model is suggested. Available models include SAM. This would address issues with variability in catches, and catchability changes. An exploratory run has been set up. The exploratory run showed a generally similar fit to XSA results. In more recent years, estimates of fishing mortality diverge somewhat. Further, sensitivity analysis for settings and correlation between ages, will be considered to improve the fit (led by Anders Nielsen).

Maturity values at age used in the XSA originate from analysis from the 1980ies. A check is suggested whether an update of the used values is necessary. National catch sampling and survey data can provide these information. An analysis of probabilistic maturation reaction norms by Marty *et al.* 2014 analysing whiting maturity data for 1975–2005 indicate a reduction A50 over time. Further analysis including recent data will be done and compared to previous study and data currently used in the assessment (led by Peter Wright).

Within the framework of a benchmark the choice of input data into a short term forecast will be reviewed (individual weights at age, recruitment estimates, and fishing mortality at age estimates). In particular, the assumption of using only the final historical year's data of mean weights at age for the short term forecast will be reviewed. While there has been an increase in mean weights at age over the last decade, taking an average of the most recent three years may be required due to variability in mean weights for older ages in recent years (led by Tanja Miethe).

Workplan

Data compilation workshop in autumn

- Compilation of historical time series catch data by catch components (Landings, Discards and IBC, BMS).
- Compilation of IBTS survey data including biological information, maturity data (autumn 2017) (WG to be involved: IBTS WG, WGBIOP)
- New natural mortality estimates from WGSAM recent SMS key run (autumn 2017)

Exploratory assessment runs, refine settings of SAM model (autumn 2017)

Analysis of maturity data for an update maturity ogive for assessment input (winter 2017).

Evaluation of new natural mortality estimates

Exploration of short term forecast settings (winter 2017)

Table 2.

Stock	**Whg47d**	
Stock coordinator	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk
Stock assessor	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk
Data contact	Name: Tanja Miethe	Email: tanja.miethe@marlab.ac.uk

Issue	**Problem/Aim**	**Work needed/ possible direction of solution**	**Data needed to be able to do this: are these available/ where should these come from?**	**External expertise needed at benchmark type of expertise/ proposed names**
(New) data to be Considered and/or quantified	Additional M– predator relations			
	Prey relations			
	Ecosystem drivers			
	Natural mortality M	Evaluate new estlimated natural mortality	Recent SMS key run	WGSAM
	Other ecosystem parameters that may need to be explored?			
Tuning series				
Discards				
Biological Parameters	Maturity	Compile and evaluate available data on maturity	IBTS Survey data (DATRAS), commercial sampling data	Peter Wright (Scotland)
Assessment method	XSA treats catch data as exact	Develop and test new assessment model (e.g. SAM)	Catch data, survey data	Anders Nielsen (DTUAqua)
Biological Reference Points				
Short term forecast update	Check choice of input data to STF		Catch data(landings, discards, ibc), survey outputs	

Literature review and discussion of stock identity

Advice for North Sea whiting is given on ICES Subdivision 4 and Division 7.d combined. The TAC is given for Subdivision 4 separately, and for Division 7.d in combination with 7b–k. Literature suggests that the current management units may not adequately reflect the underlying population structure. A more detailed structure for whiting in the North Sea has been proposed repeatedly based on studies about parasite infection, tag-recapture, genetic data, biomass trends and growth differences (Pilcher *et al.*, 1989, Charrier *et al.*, 2007, Tobin *et al.*, 2010, de Castro *et al.*, 2013, Holmes *et al.*, 2014, Barrios *et al.*, 2017).

Parasite infestation was found to differ in the southern and northern North Sea (Pilcher *et al.* 1989). Charrier *et al.* (2007) identified significant genetic structure in the North Sea by analysing microsatellite data from four different sampling locations within the North Sea (45–50 individuals each). Samples were taken from mature adults during the spawning period. Larval retention and homing behaviour of adults was suggested. Similarly, Rico *et al.* (1997) analysed genetic samples of two locations in the North Sea (50–87 individuals each) in November 1992 and identified genetic structuring which may be important to consider in the fisheries management. The Dogger Bank may be acting as a natural barrier between the northern and southern components (Hislop *et al.*, 1976, Holmes *et al.*, 2014).

Subpopulations are expected to differ in SSB and recruitment trends over time when exchange is limited. De Castro *et al.* (2013) found significant differences in SSB as well as recruitment trends in the southern and northern North Sea, based on IBTS–Q1 survey data from 1986-2011. Testing the assessment boundaries, they also concluded that the exact location of the boundary was not crucially affecting the assessment outcome. Holmes *et al.* (2014) confirmed the results in SSB trends using similar data. Analysis of individual growth trajectories support the stock split into northern and southern North Sea stocks (Barrios *et al*., 2017). The data used in the growth analysis originated again from the quarter 1 NS–IBTS survey.

While the studies all confirm to some degree a split of northern and southern subpopulations, it remains difficult to evaluate whether the split is continuous throughout the year. Many of the studies relied samples taken during spawning time or explicitly use only the quarter 1 NS–IBTS survey data. Even when spatially distinct nursery and spawning aggregations for the two subpopulations can be defined, it remains to be determined whether the split continues during the rest of the year. It would be helpful to use spatial data for growth, SSB, genetic testing collected outside the spawning season.

Failure to take into account of population structure can lead to overfishing of some components and reduction of genetic diversity. In the current management and assessment set up biomass trends are dominated by whiting in the northern part of the North Sea. It is not clear whether a split into two North Sea stocks will improve the fit of assessment and improve management (Barrios *et al*., 2017).

In recent years, scientific advice given by ICES WGNSSK was repeatedly ignored and instead the TAC chosen for area 4 was higher than recommended. In the current situation, a split in stock units will not improve stock management.

A split stock assessment would require considerable effort to provide a historical series of national catch data with age samples for the northern and southern North Sea separately. Previously, such data could not be provided for an earlier attempt to revise management units to account for stock structures (SGSIMUW 2005). The sampled Scottish trips in recent years were mainly in the northern part of area 27.4. It can be suggested that the French samples originated mainly in the southern part of the North Sea. The provision of data at the appropriate scale may be more difficult for England (UK) which submits samples for both northern and southern part of the North Sea.

Considering the evidence from literature, current management and the workload connected to a split assessment, the issue of stock identity will not be included in the 2018 benchmark. It is recommended that the stock identity issue should be revisited in the future when further evidence for a continuous split of subpopulations in the North Sea are provided and management structures are in place to support a stock specific quota following a stock-specific assessment and advice.

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Marty, L., Rochet, M. J., and Ernande, B. 2014. Temporal trends in age and size at maturation of four North Sea gadid species: cod, haddock, whiting and Norway pout. Marine Ecology Progress Series, 497: 179–197.

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Rico, C., Ibrahim, K. M., Rico, I., and Hewitt, G. M., 1997. Stock composition in North Atlantic populations of whiting using microsatellite markers. Journal of Fish Biology, 51: 462–475.

Tobin, D., Wright, P. J., Gibb, F. M., and Gibb, I. M., 2010. The importance of life stage to population connectivity in whiting (*Merlangius merlangus*) from the northern European shelf. Marine Biology, 157: 1063–1073.

1.2.3 Lemon Sole in 3.a, 4 and 7.d

Data needed

- Catch (landings and discards) data, for as many years and countries as possible. Yield, ages and lengths should all be sought. We note here that historical catch data to this level of detail may be difficult to find.
- Effort data by single métiers as potential additional source of information to estimate the amount of discards where no sufficient information from sampling programs is available.
- Available IBTS and BTS survey data on lemon sole.
- Available biological data from scientific surveys and sampling programs of the commercial fleets (length distributions, age distributions, spatial distributions, weight, maturity, sex ratios).

Current assessment issues

Currently lemon sole is treated as a data limited species and the stock perception is derived from simple survey trends and catch data, along with the application of a surplus production model to evaluate stock status against proxy reference points. For the current assessment method the IBTS–Q1 index (mature biomass in kg per hour) is used as basis for the trend based analysis (DLS 3.2. method). The IBTS surveys appear to cover the stock distribution well, but may not provide representative indices as the GOV gear is not optimized for flatfish sampling. The available beam-trawl surveys could provide a more representative index in terms of catchability, but may not cover the full stock distribution. Survey data needs to be analysed to see if these issues can be circumvented. Further, it was often argued within the WGNSSK that the indices used for the DLS 3.2. method do not come with uncertainty estimates and that these estimates should be calculated. The generation of appropriate survey time-series (biomass, length-based, and potentially age-based) should be a key task for the benchmark.

For commercial catches to be used in assessments, discards need to be quantified for lemon sole. Data are available to do this for 2013–2016, but more discard data sampled under the DCF should be available and should be uploaded into the InterCatch data portal by all relevant institutes. In general, additional data from commercial catches should be sought, covering more years and countries, and including yield, lengths and ages (it is recognized, however, that such historical data may be difficult to find and collate).

Although lemon sole is treated as a data-limited stock, much data exist which are not utilized today. The available surveys can provide biological data for a number of years (including lengths, ages, maturity, weights and spatial location), and national catch-sampling programmes may be able to provide further valuable information. Age-based stock abundance indices can be generated from survey data, and could be used as the basis for survey-based assessment methods such as SURBAR. The distribution of age samples would need to be evaluated first, to ensure that they cover the likely stock distribution. If age-length keys can be generated for commercial data, then further work could explore the possibility of an age-based assessment model such as SAM. Concurrent developments in spatial length-based assessment methods (in Denmark and Scotland) could also be used to indicate stock trends in the absence of age estimates, and a variety of data-limited assessment methods could be explored as exploratory analyses.

WGNSSK (2017) proposed exploratory MSY proxy reference points. The benchmark should explore if these are appropriate, or if the use of alternative indicators would be preferred.

The key first task of the benchmark will be to determine whether or not sufficient historical data exist to warrant a move towards a full analytic assessment, and to evaluate whether management of the stock on this basis would improve the efficacy of decision-making over the existing data-limited approach.

Workplan

Compilation of catch data in InterCatch format (years to be confirmed): all national institutes; prior to the benchmark.

Compilation of survey data (IBTS and BTS): probably via DATRAS, although would also need to check that biological information for lemon sole has been uploaded. Scotland in collaboration with contributing institutes; prior to the benchmark.

Evaluation of survey indices: Scotland; prior to the benchmark.

Compilation of input data for age- and length-based (and potentially spatial) assessment models: relevant counties; prior to the benchmark.

Exploratory assessment runs: Scotland; during the benchmark.

Other working groups to be involved:

WGBEAM, IBTS–WG (age based indices, index uncertainty estimate, combination of IBTS and BTS indices).

Stock	Lem–nsea	
Stock coordinator	Name: Coby Needle	Email: needlec@marlab.ac.uk
Stock assessor	Name: Coby Needle	Email: needlec@marlab.ac.uk
Data contact	Name: Coby Needle	Email: needlec@marlab.ac.uk

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
New) data to be considered and/or quantified	Lemon sole have never been the subject of a full analytic assessment. A key role of the benchmark is therefore to determine whether data exist to enable an assessment of this kind.	See below.	See below.	See below.
Tuning series	Tuning series do not yet exist for lemon sole.	Age- or lengthbased tuning series should be generated on the basis of DATRAS data.	Data should be available in DATRAS, but national institutes should also be approached to determine if all relevant data have been uploaded.	Coby Needle (Sco), Liz Clarke (Sco), ICES DATRAS staff.
Discards	Discard estimates from 2013-2015 indicate average	Check availability of	Discard information from national sampling	Coby Needle (Sco), Liz Clarke (Sco).

	rates of around 30%. Therefore, any catch-based assessment will need to account for discards.	discard data from commercial sampling programmes and upload data to InterCatch for years prior to 2013.	programmes. All relevant institutes (BEL, DNK, NDL, GER, ENG, SCO, FRA, SWE, NOR).	
Biological Parameters	To collate and compile available data on weight, length, maturity, age, sex and spatial distribution.	Standard approaches currently applied to stocks such as haddock and plaice could be applied to collate these data.	Much of the required information can be obtained from DATRAS, but national institutes also need to be approached about the availability of relevant (and unsubmitted) data from survey and catch-sampling programmes.	Coby Needle (Sco), Liz Clarke (Sco), Rasmus Nielsen (Den).
Assessment method	Lemon sole are not currently assessed using an analytic method.	The applicability and utility of a range of candidate models to lemon sole needs to be evaluated.	The models to use depends on the data available (see previous row).	Coby Needle (Sco), Anders Nielsen (Den), Tanja Buch (Den), Colin Millar (ICES)
Biological Reference Points	No biological reference points exist for lemon sole.	The approach used to determine reference points will depend on the data available and the assessment methods used.	See above.	Coby Needle (Sco), Tanja Miethe (Sco), Alex Kempf (Ger).

1.2.4 Witch in 3.a, 4 and 7.d

Stock	**wit.27.3a47d**	
Stock coordinator	Name: Francesca Vitale	Email: francesca.vitale@slu.se
Stock assessor	Name: Rasmus Nielsen	Email: rn@aqua.dtu.dk
Data contact	Name:	Email:

Issue	**Problem/Aim**	**Work needed/ possible direction of solution**	**Data needed to be able to do this: are these available/where should these come from?**	**External expertise needed at benchmark type of expertise/proposed names**
(New) data to be Considered and/or quantified	Additional M - predator relations	None		
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			
Tuning series by age	IBTS–Q1 and Q3, BTS–Q1 and Q3	The series are available	DATRAS	
Discards by age	Partially available on Intercatch only for Sweden, Netherland and Denmark in 2013	MS to submit discards information for the rest of the time series	Estimation of discards by country and by area via INTERCATH	
Biological Parameters survey by age	MO, WAA, NM	The series are available and need to be updated. Ongoing maturity studies.	SLU AQUA will collate and update the biological data	Barbara Bland, SLU AQUA
Biological Parameters catches by age		MS to submit landings information (number at age and weight at age) for the entire time series	SLU AQUA will collate and compile the biological data	Barbara Bland, SLU AQUA
Assessment method	SPiCT, SAM	The work will conducted during the benchmark	The work will conducted during the benchmark.	

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/where should these come from?	External expertise needed at benchmark type of expertise/proposed names
Biological Reference Points	MSY library	It will be fitted after the assessment is ready	Final assessment model	To be conducted after the benchmark

Expected WDs:

Maturity estimation and ageing of witch flounder. SLU AQUA.

1.2.5 Flounder in 3.a and 4

Data needed

- Catch (landings and discards) data back to 2002 (BEL, NDL, GER, DNK, SWE, NOR, UK ENG, UK, SCO, FRA).
- Effort data by single métiers as potential additional source of information to estimate the amount of discards where no sufficient information from sampling programs is available.
- Available IBTS, BTS and DYFS/DFS survey data on flounder.
- Available biological data from scientific surveys and sampling programs of the commercial fleets (length distributions, age distributions, spatial distributions, weight, maturity, sex ratios).

Current assessment issues

Currently flounder is treated as a data limited species and the stock perception is derived from simple survey trends and catch data. For the current assessment method the IBTS–Q1 index (excluding round fish area 1 and 2; mature biomass index in kg) is used as basis for the trend based analysis (DLS 3.2. method). The IBTS surveys appear to cover most of the stock distribution, but may not provide representative indices as the GOV gear is not optimized for flatfish sampling. The available beam trawl surveys should provide a more representative index. Flounder is more distributed near coastal areas, therefore also the inshore surveys (DYFS/DFS) should be evaluated as a possible data source for a representative survey index. Survey data needs to be evaluated to estimate a reasonable survey index for flounder. Further, it was often argued within the WGNSSK that the indices used for the DLS 3.2. method do not come along with uncertainty estimates and that these estimates should be calculated.

For commercial catches to be used in assessments, discards need to be quantified for flounder. Data are available to do this for 2012–2015, but more discard data sampled under the DCF should be available and should be uploaded into the InterCatch data portal by all relevant institutes.

Although flounder is treated as a data-limited stock, much data may exist which are not utilized today. The compilation of such data can possibly provide biological data for a number of years (including lengths, ages, maturity, weights and spatial location), and national catch-sampling programmes may be able to provide further valuable information. The compilation of these data will be one of the major tasks during the proposed benchmark.

No biological reference points are defined yet. The benchmark should explore if reference points can be defined or if the use of alternative indicators such as SSB proxies is possible.

Work plan

Compilation of catch data in InterCatch format (years to be confirmed): all national institutes; prior to the benchmark.

Compilation of survey data (IBTS, BTS, DYFS/DFS): probably via DATRAS, although would also need to check that biological information for flounder has been uploaded: all national institutes.

Evaluation of survey indices; prior to the benchmark.

Compilation of input data for age and/or length-based assessment models: relevant countries; prior to the benchmark.

Exploratory assessment runs: during the benchmark.

Other working groups to be involved:

WGBEAM, IBTS–WG (indices, index uncertainty estimate, combination of IBTS and BTS indices).

Stock	fle-nsea	
Stock coordinator	Name: Holger Haslob	Email: holger.haslob@thuenen.de
Stock assessor	Name: Holger Haslob	Email: holger.haslob@thuenen.de
Data contact	Name: Holger Haslob	Email: holger.haslob@thuenen.de

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
New) data to be considered and/or quantified	Flounder has never been the subject of a full analytic assessment. A key role of the benchmark is therefore to determine whether data exist to enable an assessment of this kind.	See below.	See below.	See below.
Tuning series	Tuning series do not yet exist for flounder.	Age- or length-based tuning series should be generated on the basis of DATRAS data.	Data should be available in DATRAS, but national institutes should also be approached to determine if all	GER, NDL, DNK, ICES DATRAS staff.

			relevant data have been uploaded.	
Discards	Discard estimates from 2012-2014 indicate average rates of around 45%. Therefore, any catch-based assessment will need to account for discards.	Check availability of discard data from commercial sampling programmes and upload data to InterCatch for years prior to 2013.	Discard information from national sampling programmes. All relevant institutes (BEL, DNK, NDL, GER, ENG, SCO, FRA, SWE, NOR).	GER, NDL, DNK, InterCatch staff.
Biological Parameters	To collate and compile available data on weight, length, maturity, age, sex and spatial distribution.	Standard approaches currently applied to stocks such as haddock and plaice could be applied to collate these data.	Much of the required information can be obtained from DATRAS, but national institutes also need to be approached about the availability of relevant (and unsubmitted) data from survey and catch-sampling programmes.	GER, NDL, DNK.
Assessment method	Flounder are not currently assessed using an analytic method.	The applicability and utility of a range of candidate models to flounder needs to be evaluated.	The models to use depends on the data available (see previous row).	GER, NDL, DNK.
Biological Reference Points	No biological reference points exist for flounder.	The approach used to determine reference points will depend on the data available and the assessment methods used.	See above.	GER, DNK, NDL.

1.3 Benchmarks planned for 2019

1.3.1 Brill in 3.a, 4, 7.d-e

Stock	**BLL 27.3a47de**	
Stock coordinator	Name: Lies Vansteenbrugge	Email: lies.vansteenbrugge@ilvo.vlaanderen.be
Stock assessor	Name: Bart Vanelslander	Email: bart.vanelslander@ilvo.vlaanderen.be
Data contact	Name: Lies Vansteenbrugge, Bart Vanelslander	Email: lies.vansteenbrugge@ilvo.vlaanderen.be; bart.vanelslander@ilvo.vlaanderen.be

Issue	**Problem/Aim**	**Work needed/ possible direction of solution**	**Data needed to be able to do this: are these available/ where should these come from?**	**External expertise needed at benchmark type of expertise/ proposed names**
(New) data to be Considered and/or quantified	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	Check whether BITS and BTS ISI still give an adequate estimation of the stock trends (cfr earlier analysis by WGNEW in 2012). Check whether there is survey information available in the 7.d,e part of the stock area.	Analyse DATRAS data; Investigate whether a survey should be designed focussing mainly on fast flatfish species such as brill and turbot.	Data available in DATRAS. Consult with survey experts concerning the suitability of existing surveys in catching brill.	Survey experts
Discards	Discards are not included in the 'assessment' (lpue biomass index)	Considering that discarding of larger length classes occurs when the TAC is restrictive, it should be verified whether the NL lpue could be revised to a cpue index.	Discard data from the Netherlands	Dutch experts to revise the lpue index
Biological Parameters	When using length based indicators, correct information on length at maturity (Lmat), and length von Bertalanfy growth curve (L inifinity) are needed. Determine the sex ratio in the stock area.	van der Hammen et al (2013) suggested values for Linf and Lmat based on Dutch market samples; check whether these are representative for the entire fleet fishing on brill	Data from surveys and commercial sampling on maturity (at age/length per sex) and on individual weights (at age/length per sex)	

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
Assessment method	Currently a biomass index is calculated Check whether the index series can be elongated Investigate how this series should be corrected for technological creep (Dutch fleet has an increasing amount of pulse trawlers compared to the beginning of the series) Check whether age 0 and 1 should be included in the index Should the index be age structured or not? Explore whether other assessment methods can be used.	Verify whether aim 1–4 are feasible. Investigate all available data and use them in SPiCT, SAM or length based indicator analyses	A longer time-series of age and/or length data is needed from all countries involved in the fisheries.	Experts on length based indicators, SPiCT and SAM; experts on the Dutch biomass index currently used
Biological Reference Points	Determine MSY (proxy) reference points	Depending on the assessment method and available data	See issue 'assessment method'	Experts in computation of reference points

1.3.2 Turbot in 3.a

Stock	Tur.27.3a	
Stock coordinator	Name: Clara Ulrich	Email: clu@aqua.dtu.dk
Stock assessor	Name: Clara Ulrich	Email:
Data contact	Name: Clara Ulrich	Email:

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
(New) data to be Considered and/or quantified	Additional M - predator relations			
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			

Issue	Problem/Aim	Work needed/ possible direction of solution	Data needed to be able to do this: are these available/ where should these come from?	External expertise needed at benchmark type of expertise/ proposed names
	Stock ID. Is Turbot 3a a real stock? What is the li	Review of available knowledge and data - update since 2013.	No new data sources will likely be available	experts in flatfish/turbot ecology/genetics (DTU Aqua, SLU, IMARES)
Tuning series	Stock perception different from the work by Cardinale *et al.*, 2009	To check and validate further. Consider extensions and linkages with the time series by Cardinale *et al.*, 2009	Historical survey data	SLU
Discards	Short time series	Length data to be provided back in time	Standard intercatch data	DTU Aqua, SLU, IMARES
Biological Parameters				
Assessment method	Validate SPiCT assessment	Additional runs and analyses of outcomes		DTU Aqua
Biological Reference Points				

2 Stock Data Problems Relevant to Data Collection

Stock	Data Problem	How to be addressed in	By who
Stock name	Data problem identification	Description of data problem and recommend solution	Who should take care of the recommended solution and who should be notified on this data issue.
Ple-nsea, sol-nsea	An increasing number of beam trawlers (in the Dutch fleet) are using 'Pulse trawl' gear. There is no recognised gear code for this gear and catches etc. are still registered as TBB, grouping them with the traditional twin beam trawl fleet.	It is felt that this gear is likely to have different selectivity (for discards and landings) as well as different catch per unit effort as the traditional beam trawl gears. This has implication for the assessment of sole and plaice. In the first case, for the raising of discards and landings data. In the second case for the determination of the cpue index used in the sole assessment. It is necessary to create a separate gear code/gear type category for pulse trawls. This would allow for improved raising of data and prevent a discontinuity in the cpue index for sole.	RCM-NS&EA, RBD–SG
Saithe in Subarea 4, 6 and Division 3.a	No accoustic survey index for older year-classes, assessment heavily dependent on commercial cpue	The NORACU can no longer be used in the assessment because of errors in sampling design and inconsistencies in the time series. Establish an acoustic survey in Q1 or Q3 to get fishery independent information on older age groups .	ACOM (Norway); ACOM (Germany); ACOM (France), ACOM (Denmark); ACOM (Scotland)
Saithe in Subarea 4, 6 and Division 3.a	No recruitment index time series	The number of recruits is difficult to determine before they have been targeted by the fishery. Establish a recruitment survey .	ACOM (Norway)
Saithe in Subarea 4, 6 and Division 3.a	Age sampling from commercial fleets	Possible cluster sampling due to few vessels in the reference fleet (Norway), needs review/redesign	ACOM (Norway); PGDATA
Turbot in 3.a	Small turbot stocks cannot be easily assessed because of potentially large migrations in and out the	Most knowledge about stocks connectivity is based on old and limited tagging experiments. New tagging studies would be necessary to improve the understanding of migratory patterns	SIMWG; ACOM (Denmark, Sweden)

Stock	Data Problem	How to be addressed in	By who
	large areas IV and the Baltic.		
Nep 32	Deficient Norwegian catch sampling	The coast guard sampling of Norwegian and Danish commercial catches is satisfactory in some years, but not in others. The main problems with these data are that catches are often measured by total length (whole cm) and sample weight is missing. As total length data have lower resolution compared with carapace length data, the two cannot be combined without losing accuracy. The coast guard is aware of these problems and strives to improve the data	ACOM (Norway)
Nep 32 and 3.a	Scarce Norwegian log book data	The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks compulsory for all vessels ≥15 m. In 2013 compulsory electronic logbooks for vessels ≥ 12 m were introduced in FU 3. As a large portion of the Norwegian fleet landing Nephrops in FU 3 and 32 consists of vessels <12 m / <15 m, the logbook data will continue to be limited. A growing part of the Norwegian Nephrops landings come from the trap fishery, but this part of the fleet is not required to fill in logbooks, probably because of the small size of the vessels. Logbooks from traps would provide data from the eastern (less exploited) part of FU 32. Log books should be introduced for vessels <15 m, including trap fishers.	ACOM (Norway)
Pollack in Subarea 4 and Division 3.a	General lack of biological data needed for better understanding of growth and maturity.	In routine surveys, such as the quarter 1 and quarter 3 IBTS in Subarea 4 and Division 3.a, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity WGNEW recommended that otoliths and maturity information should be collected during these surveys for a few years. WGNSSK also recommends that biological data from commercial catches should be processed.	IBTSWG; RCM-NS&EA
Whiting in Division 4 and 3.a	General lack of stock identity and area specific age readings	Studies on whiting stock identity and connectivity in western Baltic, Division IIIa and Division 4 should be encouraged In the routine surveys, IBTS quarter 1 and quarter 3 in Division 3.a, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity it is recommendable that otoliths and maturity (also in area 4) information should be collected during surveys.	National research services and IBTSWG
Cod in subdivision 3.aW, subarea 4,	Perceived catchability problems in	Appropriate standardisation of IBTS–Q1 and Q3 surveys was carried out during WKNSEA 2015. Inconsistencies were found between q1 and q3 in the Skagerrak area.	IBTS–WG, ACOM (Danmark, Sweden,

Stock	Data Problem	How to be addressed in	By who
and Division 7.d	IBTS–Q1 and Q3 indices,	However, so far only one vessel is fishing in the Skagerrak making it impossible to differentiate vessel, gear and crew effects from real changes in abundance. It is recommended that also in the Skagerrak two vessels fish in each ICES rectangle. This is the standard in all other areas covered by the IBTS.	Germany, Norway).
Nephrops FU 33	Not enough discard information available to give catch advice	The sampling in this FU is insufficient. Samples are needed from the main fleets fishing in this FU.	ACOM (Denmark, Netherlands, Belgium, Germany)
Turbot in 4	Biological information is only available from the Netherlands. This is a serious concern leading to a potentially biased assessment	Age information is needed also from other countries. So far age distributions are mainly available from the Dutch BT2 fishery. However, these samples may not be representative for other fisheries and countries (e.g., gill net fishery, otter trawl fisheries). All available information needs to be uploaded to Intercatch as far back in time as possible. Future sampling effort needs to ensure a proper sampling coverage over the main fleets and countries.	ACOM (Denmark, UK, Germany, Belgium)
Sole-eche	The UK YFS stopped in 2006 and the French Young Fish survey as conducted now is probably not providing the correct recruitment estimates as it only covers part of 7.d	The UK component of the YFS index is not available since 2007, resulting in the unavailability of the combined YFS-index. This combined index has been estimating the incoming year class strength very consistently, hereby providing reliable estimates to the forecasts. Although results of using the YFS indices separately (FR–YFS for 1987–present and UK-YFS for 1987–2006) did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. In RCT3 analysis the FR–YFS gets hardly any weight and the gemoetric mean has to be used instead. Possible solutions could be that either the UK YFS is conducted again in future years or the French Young Fish survey can be extended to include at least some of the sampling points from the former UK Young Fish survey.	ACOM (UK, France)
Nep 5	Incomplete catch sampling	Only Dutch catches are sampled, and discard data were only available for 2015. Length distributions and sex ratios are poorly defined due to limited sampling. Acknowledging that this is a difficult fishery to effectively sample, electronic capture of at-sea data could be developed.	ACOM (UK, Netherlands, Germany, Belgium)

Annex 7: Update Forecasts and Assessments

7.1 Summary

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chair: José De Oliveira, UK) communicated by correspondence at the beginning of October 2017 to evaluate new information from the fisheries independent surveys carried out during 2017 subsequent to the meeting of the group in April/May. The 15-minute tow duration experiment that was carried out during the IBTS Q3 survey in 2016 was discontinued during 2017, mainly because it was felt that changing the tow duration affected biodiversity indices/analyses, so 30-minute hauls were reinstated throughout, and instead a preference was expressed for investigating options for improving the efficiency of the survey design in other ways (e.g. redesign IBTS to cover all relevant habitats).

The WGNSSK followed the protocol defined by the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES CM 2008/ACOM: 60) in its evaluation of the survey information - fitting the RCT3 regression model to data that included the 2017 survey information to estimate the recent recruitment abundance and then comparing the prediction and its associated uncertainty with the assumptions made in forecasts used as the basis for the ACOM spring advice.

As in the past, the indices used in the current update must be considered as provisional and may be revised for the assessment in May next year.

An update is also presented for the *Nephrops* stocks, given that UWTV surveys usually take place over summer. This allows for a considerably smaller time lag between the last abundance observations and their use for next year's advice.

Following the re-opening protocol, the following stocks could be considered for reopening:

- Cod in Subarea 4, Division 7.d and Subdivision 20 [potential decrease in advised catch from 59 888 t to 53 058 t]
- Haddock in Subarea 4 and Division 6.a and Subdivision 20 [potential decrease in advised catch from 51 037 t to 48 990 t]
- Whiting in Subarea 4 and Division 7.d [potential decrease from 26 804 t to 26 191 t]
- Plaice in Subarea 4 and Subdivision 20 [potential increase from 134 238 t to 142 481 t]
- Sole in Subarea 4 [potential increase from 14 900 t to 15 726 t]
- *Nephrops* in FU 6 (Farn Deeps) [potential increase from 1178 t to 1876 t]
- *Nephrops* in FU 7 (Fladen) [potential increase from 13 264 t to 16 577 t]
- *Nephrops* in FU 8 (Firth of Forth) [potential decrease from 2826 t to 2376 t]

Details are provided in the sub-sections below.

7.2 Cod in Subarea 4, Division 7.d and Subdivision 20

7.2.1 New survey information

New survey information, in the form of the IBTS Q3 2017 data, has come to light, subjecting this assessment to the AGCREFA protocol for re-opening advice in the autumn. The Delta-GAM model was re-applied to the full IBTS Q3 time series of North Sea cod data from DATRAS to provide a Q3 index for this stock. The new Delta-GAM Q3 index time series is given in Table 7.2.1.

7.2.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA, 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2016) year-class at age 1. The RCT3 input and output files are given in tables 7.2.2 and 7.2.3, respectively

7.2.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2016 year-class at age 1	
Log WAP from RCT3 (R)	13.16
Log of recruitment assumed in spring (A)	13.45
Int SE of log WAP (S)	0.146
Distance D $\left(D = \frac{R-A}{S}\right)$	**-1.975**

7.2.4 Conclusions from Protocol

As the distance D < -1.0, the protocol concludes that **the advisory process for North Sea cod should be reopened**. The autumn indices suggest that the size of the incoming year-class is significantly lower than what had been assumed in the forecast produced by WGNSSK in May 2017.

7.2.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea cod. The assessment and forecast were re-run with the new Q3 time-series of survey data. Otherwise the settings and assumptions were unchanged from those used by WGNSSK in May 2017.

Outputs from the assessment re-run with the new Q3 data included are given in Table 7.2.4 and Figure 7.2.1, and the updated catch options Table 7.2.5.

Following the ICES MSY approach, the new short-term forecasts lead to a **decrease in advised catch from 59 888 tonnes to 53 058 tonnes** (a decrease of 6830 tonnes).

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

Table 7.2.1. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. Survey tuning indices for Q3 (NS-IBTS Delta-GAM indices). Data used in the assessment are highlighted in bold font. (The equivalent Q1 index can be found in Section 4, Table 4.6 of this report).

North Sea Cod Survey Index Q3 (DG) calculated 2017-10-04 14:19:44

1992	2017						
1	1	0.5	0.75				
1	4						
1	**16739.68**	**1702.648**	**391.9486**	**336.8442**	119.16	41.6924	1992
1	**4417.619**	**4565.987**	**601.8199**	**126.8324**	93.9733	7.5406	1993
1	**17389.56**	**2350.218**	**952.1674**	**162.768**	45.5189	34.7659	1994
1	**9338.805**	**6977.455**	**719.4347**	**306.6364**	35.1705	19.6021	1995
1	**4904.34**	**2997.337**	**1092.76**	**178.7832**	146.244	14.2789	1996
1	**29061.91**	**2067.335**	**743.3968**	**271.4676**	53.2668	37.3731	1997
1	**866.8532**	**9350.591**	**709.9723**	**195.0502**	121.1173	40.7716	1998
1	**3376.088**	**490.8132**	**2500.058**	**155.9722**	42.9377	17.9496	1999
1	**6283.204**	**995.9097**	**118.0642**	**345.6277**	38.6179	33.4473	2000
1	**1399.22**	**2241.239**	**383.6506**	**78.2424**	60.4427	37.1098	2001
1	**3928.595**	**931.2217**	**775.4173**	**195.9262**	53.2177	24.1319	2002
1	**953.4988**	**1312.158**	**252.4438**	**181.5719**	88.1413	60.659	2003
1	**3137.62**	**792.5245**	**493.9611**	**95.6476**	71.6715	25.5373	2004
1	**1054.857**	**758.6407**	**291.8791**	**120.2418**	26.992	47.7117	2005
1	**5386.224**	**724.6387**	**612.1492**	**120.2914**	30.1543	19.451	2006
1	**1805.859**	**2345.121**	**440.1032**	**175.8672**	101.5217	46.6275	2007
1	**2393.322**	**1209.917**	**1131.519**	**229.5687**	125.1901	32.0314	2008
1	**1889.572**	**967.673**	**299.7611**	**242.4845**	53.5605	25.975	2009
1	**4506.044**	**1662.886**	**546.9409**	**182.3023**	112.5708	22.4904	2010
1	**1210.748**	**2840.769**	**885.7927**	**373.2841**	105.0443	99.5514	2011
1	**2083.853**	**1025.708**	**1244.683**	**373.7028**	104.9019	18.6279	2012
1	**3059.927**	**1065.571**	**486.5423**	**515.2075**	139.1448	64.0962	2013
1	**3290.576**	**1466.27**	**606.6339**	**297.0415**	198.0628	96.1828	2014
1	**1826.453**	**2950.976**	**1047.482**	**459.8805**	140.3295	137.7539	2015
1	**1366.139**	**1120.925**	**1661.033**	**827.4612**	202.2397	130.9238	2016
1	**6769.824**	**603.7144**	**466.7102**	**410.0955**	212.8819	46.1296	2017

Table 7.2.2. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. RCT3 Inputs.

YEARCLASS	RECRUITMENT	DELTAGAMQ11	DELTAGAMQ31
1982	946002	4220.4018	NA
1983	1744537	12660.5081	NA
1984	416649	587.2731	NA
1985	1901208	12460.1144	NA
1986	714258	5117.0718	NA
1987	485046	2668.2031	NA
1988	853414	9911.6827	NA
1989	328733	2003.3753	NA
1990	377755	1688.7826	NA
1991	883812	9397.0472	16739.6803
1992	430198	3256.9126	4417.6188
1993	1056001	6977.64	17389.5578
1994	604405	7097.3864	9338.8051
1995	382697	1821.619	4904.3396
1996	1218340	15374.1003	29061.9124
1997	121176	653.102	866.8532
1998	248699	1409.3719	3376.0875
1999	456343	3521.0097	6283.2044
2000	162592	848.1939	1399.2197
2001	248699	2856.2116	3928.5953
2002	119253	357.559	953.4988
2003	202197	2782.3546	3137.6195
2004	153430	1091.4329	1054.8565
2005	360411	3880.0716	5386.2235
2006	168721	1440.0839	1805.8588
2007	195243	2272.9368	2393.3223
2008	190042	1067.7997	1889.5724
2009	294490	2855.3644	4506.0439
2010	143631	763.521	1210.7481
2011	201189	1545.3286	2083.8525
2012	265136	1623.4061	3059.9269
2013	380408	2664.2048	3290.576
2014	184979	1672.3367	1826.453
2015	134592	945.5566	1366.1387
2016	NA	8423.6427	6769.8241

Table 7.2.3. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. RCT3 Outputs.

```
Analysis by RCT3 ver4.0

Cod

Data for 2 surveys over 35 years : 1982 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
      index slope intercept se rsquare n indices prediction se.pred WAP.weights
 DeltaGAMq 11 0.9259   5.552 0.4194  0.7786 34   9.039    13.92  0.4493 0.1089
 DeltaGAMq 31 0.7294   6.630 0.1459  0.9556 25   8.820    13.06  0.1571 0.8911
    VPA Mean   NA        NA     NA     NA 34     NA     12.78  0.7745 0.0000

                  WAP logWAP int.se
yearclass:2016 517410  13.16 0.1456
```

Table 7.2.4. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. Assessment summary. Weights are in tonnes.

Year	Recruits age 1 ('000)	Low	High	TSB (tons)	Low	High	SSB (tons)	Low	High	Fbar 2-4	Low	High	Landings	Discards	Catch	Unaccounted	Total Removals	Low	High
1963	483110	349298	668185	512471	437374	600463	152055	116749	198039	0.476	0.411	0.552	107689	10969	118658		118658	105230	133800
1964	787800	570678	1087530	656711	555826	775909	163571	128130	208814	0.516	0.451	0.589	134996	9633	144495		144495	131053	159316
1965	1053891	766370	1449284	836515	715280	978298	199786	161629	246950	0.565	0.495	0.645	181498	17118	198590		198590	177331	222398
1966	1278247	930577	1755809	1000490	856581	1168575	221682	180430	272365	0.572	0.504	0.650	215346	26397	241591		241591	216249	269902
1967	1073033	780961	1474339	1053891	913393	1216001	251450	204909	308563	0.607	0.537	0.687	260928	26582	287506		287506	256932	321719
1968	537132	390155	739478	880284	781837	991127	262761	221076	312305	0.642	0.568	0.727	276509	16963	293314		293314	266378	322974
1969	469771	339069	650854	730877	644061	829395	258849	215555	310839	0.613	0.544	0.691	216642	9529	226160		226160	209058	244662
1970	1572221	1142741	2163115	1195410	983072	1453612	269952	226122	322278	0.651	0.581	0.730	232582	20022	252458		252458	221968	287136
1971	2051332	1485824	2832074	1338420	1124299	1593319	274306	230097	327009	0.735	0.658	0.820	292728	58337	351161		351161	301897	408464
1972	504842	365288	697711	924492	815671	1047832	244019	204522	291142	0.793	0.710	0.886	329062	34269	363306		363306	318152	414868
1973	741922	537122	1024812	738961	651634	837990	214915	186467	247704	0.780	0.699	0.871	234451	24909	259367		259367	236294	284694
1974	725778	524542	1004218	709276	624522	805532	230268	199693	265525	0.749	0.671	0.836	209819	26239	236097		236097	211047	264121
1975	1246687	893963	1738581	808552	684262	955418	207731	178568	241657	0.804	0.723	0.894	208981	36425	245487		245487	214132	281433
1976	862853	614547	1211488	640497	560167	732347	177194	150164	209090	0.858	0.770	0.956	201793	44445	246225		246225	213820	283540
1977	2118036	1517356	2956510	995500	804262	1232210	149941	127473	176370	0.821	0.738	0.913	182590	79142	261450		261450	214977	317970
1978	1301464	928941	1823375	1115708	926012	1344265	149492	131505	169940	0.902	0.812	1.001	305285	48050	353628		353628	291794	428564
1979	1642943	1176671	2293983	1037163	877182	1226322	147561	130974	166250	0.851	0.767	0.944	276786	62505	339422		339422	290533	396538
1980	2660434	1896802	3731497	1261737	1038174	1533443	161135	143899	180436	0.923	0.835	1.020	290396	102232	392385		392385	325071	473639
1981	1043405	746134	1459114	1034057	891523	1199378	168890	152106	187525	0.940	0.852	1.036	342833	53637	396726		396726	338489	464981
1982	1718565	1244544	2373129	1128049	938415	1356003	168384	150933	187852	1.044	0.948	1.150	321579	63007	384616		384616	326320	453326
1983	943168	693953	1281882	882929	756065	1031081	137861	123084	154411	1.041	0.947	1.146	287219	37123	324162		324162	276520	380013
1984	1742794	1284577	2364459	916209	762322	1101161	119970	106759	134817	0.981	0.892	1.079	210660	69773	280408		280408	237713	330770
1985	416233	302156	573378	588893	518995	668205	118658	105482	133480	0.947	0.860	1.043	215561	28368	244019		244019	211251	281869
1986	1897409	1401201	2569341	828192	673902	1017806	109426	98220	121910	0.997	0.907	1.095	169566	60476	230038		230038	192082	275494
1987	712831	527994	962376	753889	645519	880451	113210	101403	126391	0.981	0.893	1.078	227521	33090	260667		260667	220003	308848
1988	484077	358011	654535	547436	476524	628899	111413	101365	122457	1.000	0.911	1.099	191568	14659	206282		206282	183066	232443
1989	850858	626535	1155496	562418	471569	670769	103363	93493	114274	1.016	0.924	1.117	138829	41274	180052		180052	154845	209362
1990	328404	243697	442555	373249	327278	425677	92411	83182	102663	0.948	0.859	1.045	116076	23459	139525		139525	121941	159645
1991	377377	281627	505680	342833	297492	395085	90219	80616	100967	0.937	0.850	1.032	102539	15829	118421		118421	105175	133335
1992	884697	665398	1176271	546342	452523	659611	86422	77703	96120	0.926	0.842	1.019	109316	32241	141634		141634	119421	167978
1993	431922	329226	566652	416233	365438	474088	89322	81005	98492	0.940	0.854	1.035	130591	28306	158868	-9525	149343	129001	172892
1994	1058115	797295	1404259	541447	454785	644622	95320	87008	104427	0.960	0.875	1.054	105961	42567	148573	5935	154508	133188	179240
1995	605010	458731	797933	574353	494354	667298	107904	98956	117661	1.001	0.912	1.098	130586	31723	162396	29748	192144	164930	223848
1996	381933	290942	501380	428909	377993	486683	107581	98704	117257	1.004	0.915	1.101	131283	21047	152377	5252	157629	140135	177307
1997	1217122	905570	1635861	669978	542628	827215	96955	88709	105967	0.981	0.895	1.075	133602	46566	180163	-22691	157472	131807	188133
1998	120813	90702	160920	331705	291332	377672	92874	84291	102331	1.010	0.922	1.105	146668	41812	188514	-48149	140365	120580	163396
1999	249447	190476	326675	226613	202711	253333	83952	76523	92102	1.067	0.974	1.168	94762	13055	107809	-11819	95990	87954	104760
2000	456800	348537	598690	287219	243847	338305	65382	59191	72220	1.067	0.974	1.170	73169	16503	89637	-5853	83784	72689	96572
2001	163898	124677	215458	196811	173975	222645	61636	55754	68138	0.999	0.908	1.099	44642	11512	56186	15425	71611	63201	81140
2002	249197	190019	326805	169397	148377	193395	56613	51303	62473	0.953	0.865	1.049	53446	11440	64889	-8049	56840	51464	62779
2003	118895	90127	156846	140927	126294	157257	58865	53437	64844	0.940	0.848	1.042	31054	4652	35720	18186	53906	48435	59996
2004	201995	154338	264369	122394	106894	140142	46677	41909	51987	0.898	0.808	0.997	27287	7557	34863	4203	39066	35570	42905
2005	152818	115144	202817	136489	118627	157041	49217	43313	55927	0.835	0.750	0.930	29867	11348	41213	-1557	39656	35125	44772
2006	358613	274361	468738	145365	121890	173359	43915	38201	50482	0.751	0.669	0.843	22675	9223	31888		31888	28333	35890
2007	167711	128754	218456	192144	168938	218538	76267	67280	86455	0.696	0.617	0.785	24053	29261	53316		53316	46716	60849
2008	193881	148607	252948	201592	176078	230803	82702	73083	93587	0.661	0.582	0.752	27065	25336	52365		52365	47653	57543
2009	188151	144224	245458	213203	186485	243749	91035	79619	104088	0.650	0.568	0.744	33190	21545	54776		54776	49581	60515
2010	291851	222544	382743	228205	195779	266001	91126	77984	106483	0.569	0.491	0.660	36243	12599	48825		48825	44404	53686
2011	143057	109360	187138	212777	183359	246915	100408	83550	120667	0.471	0.401	0.552	34441	10497	44936		44936	40621	49709
2012	199786	153258	260438	188151	161410	219323	98913	81254	120411	0.432	0.367	0.510	32696	7675	40376		40376	37368	43626
2013	260407	199466	339966	246718	210224	289547	107152	88120	130293	0.422	0.360	0.494	30884	10937	41815		41815	38458	45464
2014	365127	279071	477720	307122	260026	362748	114462	94559	138555	0.420	0.361	0.488	34857	11097	45936		45936	41814	50464
2015	175431	132431	232392	272665	234284	317335	130744	107173	159501	0.402	0.345	0.467	38177	13324	51483		51483	46762	56680
2016	122516	88362	169872	240867	205896	281777	133386	109316	162755	0.377	0.319	0.445	38369	12362	50716		50716	46980	54749
2017	619706	356960	1075848				152207	121523	190640										

Table 7.2.5. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. Catch options. Units are '000t (SSB landings, discards, unaccounted) or millions (recruitment).

Intermediate year F assumption: F(2017) = F(2016) =	**0.38**
SAM estimate of recruitment =	**629**
SSB(2018) =	**180990**
HC landings (2017) =	**39254**
Discards (2017) =	**12671**

Rationale	Catch (2018)	Landings (2018)	Discards (2018)	Basis	Ftotal (2018)	F land (2018)	F disc (2018)	SSB (2019)	SSB 5% (2019)	%SSB change	%TAC change	Ftotal (2019)	Ftotal (2020)	Catch (2019)	Catch (2020)	Landings (2019)	Landings (2020)	Discards (2019)	Discards (2020)	SSB (2020)	SSB (2021)	%change SSB 20:18	%change SSB 21:18
Management Plan	66224	44527	21697	EU MP	0.40	0.26	0.14	180686	139485	-0.168	-5.307	0.40	0.40	68434	65567	50331	52641	18103	12926	190716	182649	5	1
Management Plan	66224	44527	21697	EU-Norway	0.40	0.26	0.14	180686	139485	-0.168	-5.307	0.40	0.40	68434	65567	50331	52641	18103	12926	190716	182649	5	1
MSY approach	53058	35725	17333	FMSY *SSB2017/Btrigger	0.31	0.20	0.11	193248	149843	6.773	-24.027	0.31	0.31	58701	60074	43615	48924	15086	11150	218002	220938	20	22
Zero Catch	0	0	0	F=0	0.00	0.00	0.00	244926	192448	35.326	-100	0.00	0.00	0	0	0	0	0	0	357294	452544	97	150
MSY	53058	35725	17333	FMSY	0.31	0.20	0.11	193248	149843	6.773	-24.027	0.31	0.31	58701	60074	43615	48924	15086	11150	218002	220938	20	22
Fpa	64805	43575	21230	Flim/1.4	0.39	0.25	0.14	182038	140536	0.579	-7.333	0.39	0.39	67453	65059	49672	52342	17781	12717	193578	186702	7	3
Flim	85121	56970	28151	Flim	0.54	0.35	0.19	162901	125256	-9.994	21.153	0.54	0.54	79354	69388	57379	53700	21975	15688	154653	138107	-15	-24
SSB(2019)=Blim	148238	97786	50452	SSB(2019)=Blim	1.15	0.75	0.40	107000	78442	-40.88	107.954	1.15	1.15	90408	60902	60619	38782	29789	22120	71101	53120	-61	-71
SSB(2019)=Bpa	99187	66220	32967	SSB(2019)=Bpa	0.66	0.43	0.23	150000	114115	-17.122	40.824	0.66	0.66	85311	69661	60482	52186	24829	17475	131481	111026	-27	-39
SSB(2019)=Btrigger	99187	66220	32967	SSB(2019)=Btrigger	0.66	0.43	0.23	150000	114115	-17.122	40.824	0.66	0.66	85311	69661	60482	52186	24829	17475	131481	111026	-27	-39
TAC constraint	55919	37618	18301	TAC2017 - 20%	0.33	0.21	0.12	190195	142011	5.086	-20.001	0.27	0.22	50845	45744	37618	37618	13227	8126	223339	242094	23	34
TAC constraint	59454	39970	19484	TAC2017 - 15%	0.35	0.23	0.12	186777	138798	3.198	-14.998	0.29	0.25	54126	48846	39970	39970	14156	8876	215241	229271	19	27
TAC constraint	62998	42321	20677	TAC2017 - 10%	0.38	0.25	0.13	183393	135820	1.328	-9.999	0.32	0.28	57461	51973	42321	42321	15140	9652	207067	215462	14	19
TAC constraint	66545	44672	21873	TAC2017 - 5%	0.40	0.26	0.14	179881	133050	-0.613	-4.999	0.35	0.31	60794	55192	44672	44672	16122	10520	198369	202308	10	12
TAC constraint	70094	47023	23071	TAC2017	0.43	0.28	0.15	176460	129948	-2.503	0	0.38	0.35	64145	58446	47023	47023	17122	11423	190346	189273	5	5
TAC constraint	73650	49374	24276	TAC2017 + 5%	0.45	0.30	0.16	173105	126744	-4.356	5	0.41	0.39	67497	61807	49374	49374	18123	12433	182060	175589	1	-3
TAC constraint	77207	51725	25482	TAC2017 + 10%	0.48	0.31	0.17	169665	123554	-6.257	9.999	0.45	0.44	70875	65207	51725	51725	19150	13482	173953	162995	-4	-10
TAC constraint	80783	54076	26707	TAC2017 + 15%	0.51	0.33	0.18	166176	120373	-8.185	14.999	0.49	0.50	74326	68760	54076	54076	20250	14684	165580	149657	-9	-17
TAC constraint	84378	56428	27950	TAC2017 + 20%	0.53	0.35	0.19	162761	117247	-10.072	20.001	0.53	0.56	77789	72473	56428	56428	21361	16045	156931	136738	-13	-24
Status quo	62830	42277	20553	Fsq	0.38	0.25	0.13	183927	142122	1.623	-10.093	0.38	0.38	66054	64341	48769	51933	17285	12408	197546	192044	9	6
FMSY lower	35631	24076	11555	FMSY lower	0.20	0.13	0.07	210118	163596	16	-49	0.20	0.20	43105	47656	32340	39846	10765	7810	258341	281560	43	56
FMSY upper with AF	74528	50058	24470	FMSY upper with AR	0.46	0.30	0.16	172838	133319	-5	6	0.46	0.46	73811	67957	53885	53464	19926	14493	174464	161520	-4	-11

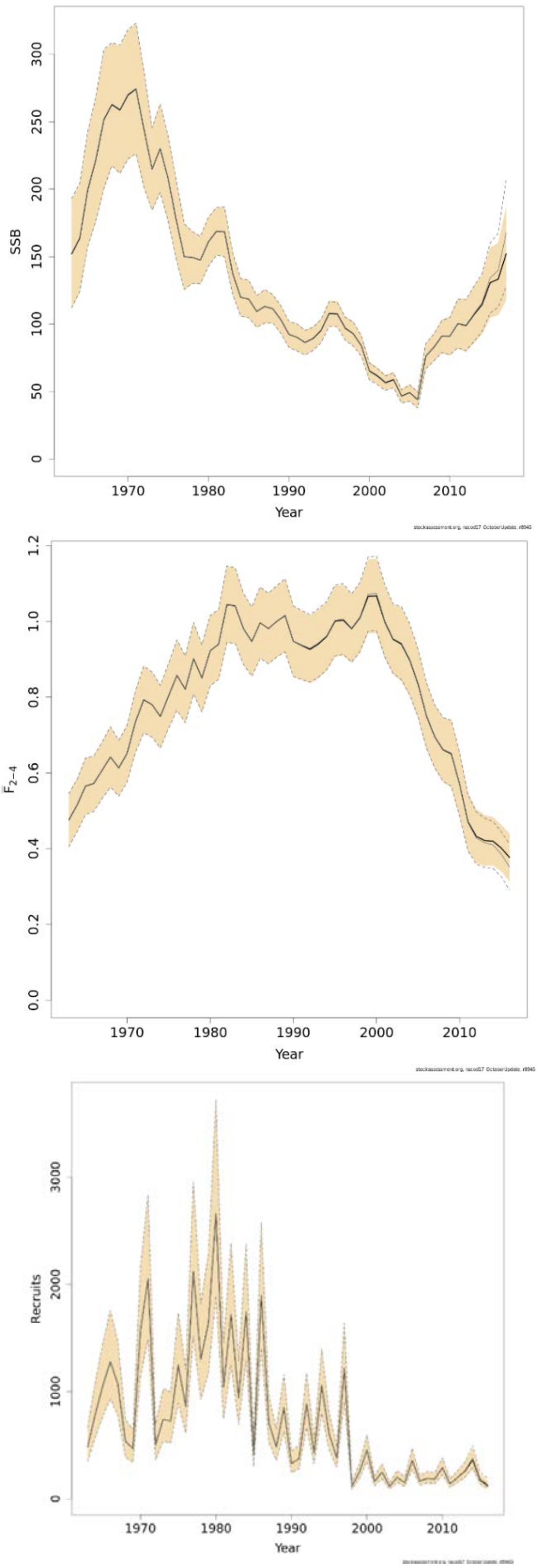

Figure 7.2.1. Cod in Subarea 4 and divisions 3.a (Skagerrak) and 7.d. Summary of stock assessment with point-wise 95% confidence intervals. The SAM assessment produced by WGNSSK in May 2017 is plotted in grey for comparison.

7.3 Haddock in Subarea 4 and Division 6.a and Subdivision 20

7.3.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 7.3.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK, 2017), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA, 2008).

7.3.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA, 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2017) year-class at age 0. The RCT3 input and output files are given in tables 7.3.2 and 7.3.3.

7.3.3 Update protocol calculation

The outcome of the application of the protocol was as follows:

Calculations for 2017 year-class at age 0	
Log WAP from RCT3 (R)	7.392
Log of recruitment assumed in spring (A)	8.351
Int SE of log WAP (S)	0.5303
Distance D $\left(D = \frac{R-A}{S}\right)$	**-1.809**

7.3.4 Conclusions from protocol

As the distance D < -1.0, the protocol concludes that **the advisory process for Northern Shelf haddock should be reopened.** The autumn indices suggest that the size of the incoming year-class is significantly lower than had been assumed in the forecast produced by WGNSSK in May 2017.

7.3.5 Updated forecast

The forecast from May 2017 was re-run with the same parameters and settings, apart from the assumed recruitment at age 0 in 2017 which was reduced from 4236 million to 1623 million, following the new RCT3 analysis reported above. Recruitment in 2018 and 2019 was assumed to be 4236 million, as before. The updated catch-option table is given in Table 7.3.4, while the original catch-option table from May 2017 in given in Table 7.3.5. The new wanted catch forecast at F(msy) in 2018 is **43 437 tonnes** (an increase of **10%** over the 2017 TAC), compared to the original wanted catch forecast of **43 555 tonnes** (an increase of **11%** over the 2017 TAC). The difference of **118 tonnes** is caused by the updated recruitment assumption for 2017: the forecast settings are otherwise unchanged.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2017). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2017/ACOM:21.

Table 7.3.1. Haddock in Subarea 4 and divisions 3a and 6a. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2017 are shaded grey.

YEAR	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5
1991	718.479	233.55	22.921	2.842	0.507	1.561
1992	2741.14	595.235	189.015	10.529	1.583	0.396
1993	577.382	605.99	140.146	37.604	2.36	0.372
1994	1781.191	195.331	262.643	32.423	8.383	0.381
1995	520.855	1019.607	106.642	97.383	8.06	3.131
1996	627.502	247.469	428.471	30.426	20.215	2.649
1997	195.255	347.567	123.793	149.048	6.672	5.282
1998	276.401	257.14	164.853	53.69	42.66	3.093
1999	6904.537	176.457	94.108	47.947	13.268	9.904
2000	1092.754	2504.185	44.3	19.502	10.287	4.264
2001	34.751	360.427	1099.298	30.289	6.371	3.648
2002	137.707	45.969	237.729	573.752	9.826	2.485
2003	163.931	69.348	31.171	199.259	368.665	2.942
2004	183.977	69.539	40.556	23.119	82.685	154.82
2005	1412.973	67.605	45.54	16.254	9.845	37.095
2006	191.608	547.284	27.543	11.709	3.612	3.352
2007	111.475	149.743	385.791	10.354	5.35	1.126
2008	126.428	86.627	89.934	174.968	5.206	2.253
2009	909.334	77.703	79.994	38.131	73.972	1.643
2010	30.294	557.39	59.017	34.214	25.186	53.33
2011	30.64	77.035	344.508	27.159	12.209	9.196
2012	68.068	31.515	40.248	132.237	7.344	4.397
2013	86.249	58.345	25.17	18.291	82.779	2.515
2014	747.522	48.207	58.51	5.216	9.093	51.625
2015	104.274	463.428	22.807	15.993	1.662	2.307
2016	351.819	94.564	220.165	8.057	3.669	0.4
2017	146.171	167.605	72.398	130.786	2.896	1.290

Table 7.3.2. Haddock in Subarea 4 and divisions 3.a and 6.a. RCT3 input file. Data from surveys in autumn 2017 are shaded grey.

Year	TSA	IBTS Q1 Age 1	IBTS Q1 Ag2	IBTS Q3 Age 0	IBTS Q3 Age 1	IBTS Q3 Age 2
1981	19597.462	-11	403.079	-11	-11	-11
1982	11798.299	302.278	221.275	-11	-11	-11
1983	38263.370	1072.285	833.257	-11	-11	-11
1984	7488.605	230.968	266.912	-11	-11	-11
1985	12354.367	573.023	328.062	-11	-11	-11
1986	23431.090	912.559	677.641	-11	-11	-11
1987	462.922	101.691	97.372	-11	-11	-11
1988	1429.202	219.060	139.114	-11	-11	-11
1989	2610.815	217.448	134.076	-11	-11	22.921
1990	11064.560	680.231	331.044	-11	233.55	189.015
1991	12227.448	1141.396	519.521	718.479	595.235	140.146
1992	20442.383	1242.121	491.051	2741.14	605.99	262.643
1993	5175.016	227.919	201.069	577.382	195.331	106.642
1994	20115.763	1355.485	813.268	1781.191	1019.607	428.471
1995	5564.074	267.411	354.766	520.855	247.469	123.793
1996	7877.682	848.966	420.926	627.502	347.567	164.853
1997	4659.272	357.597	222.907	195.255	257.14	94.108
1998	3478.206	211.139	107.125	276.401	176.457	44.3
1999	51745.407	3734.200	2220.593	6904.537	2504.185	1099.298
2000	10121.234	893.460	473.461	1092.754	360.427	237.729
2001	956.807	57.304	39.261	34.751	45.969	31.171
2002	1327.967	89.981	79.256	137.707	69.348	40.556
2003	1499.661	71.745	51.885	163.931	69.539	45.54
2004	1470.407	70.189	46.081	183.977	67.605	27.543
2005	14198.200	1158.194	963.393	1412.973	547.284	385.791
2006	3009.409	109.440	107.390	191.608	149.743	89.934
2007	1972.905	61.357	141.444	111.475	86.627	79.994
2008	1361.509	75.068	71.132	126.428	77.703	59.017
2009	10391.533	674.962	781.507	909.334	557.39	344.508
2010	933.840	46.068	66.523	30.294	77.035	40.248
2011	88.555	14.103	24.585	30.64	31.515	25.17
2012	1242.318	58.249	104.034	68.068	58.345	58.51
2013	632.681	24.067	32.612	86.249	48.207	22.807
2014	5809.046	388.241	413.503	747.522	463.428	220.165
2015	-11	111.384	138.465	104.274	94.564	72.398
2016	-11	218.515	-11	351.819	167.605	-11
2017	-11	-11	-11	146.171	-11	-11

Table 7.3.3. Haddock in Subarea 4 and divisions 3.a and 6.a. RCT3 output file.

ANALYSIS BY RCT3 VER4.0

Haddock

Data for 5 surveys over 37 years : 1981 - 2017

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2017

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
ibtsq11	1.123	2.1329	0.5348	0.8776	33	NA	NA	NA	NA
ibtsq12	1.392	0.9472	0.6085	0.8477	34	NA	NA	NA	NA
ibtsq30	1.033	2.2424	0.5337	0.8783	24	4.985	7.392	0.572	1
ibtsq31	1.315	1.3138	0.4895	0.894	25	NA	NA	NA	NA
ibtsq32	1.476	1.4447	0.7237	0.7876	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	34	NA	8.374	1.413	0
	WAP	logWAP	int.se						
yearclass:2017	1623	7.392	0.5303						

Table 7.3.4. Haddock in Subarea 4 and divisions 3.a and 6.a. Updated catch option table following RCT3 analysis.

Basis: F(2017) = TSA projection = 0.183; SSB (2018) = 229.910; TAC 4 (2017) = 33.643; TAC 3.a (2017) = 2.069; TAC 6.a (2017) = 3.697; HC landings (2017) = 39.409; Discards+BMS (2017) = 5.556, IBC (2017) = 0.000; Recruitment (2017) = TSA projection = 1623 millions. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 2019 relative to SSB 2018. 2) Wanted catch 2018 relative to TAC 2017.

Rationale	Total catch 2018	Wanted catch 2018	Unwanted catch 2018	IBC 2018	Basis	Total F 2018	F(land) 2018	F(disc) 2018	F(IBC) 2018	SSB 2019	% SSB	% TAC change (2)
MSY	**48.990**	**43.437**	**5.552**	**0.000**	**New F(msy) estimate**	**0.194**	**0.166**	**0.028**	**0.000**	**266.941**	**16%**	**10%**
Management plan	72.788	64.436	8.352	0.000	MP target F	0.300	0.257	0.043	0.000	243.573	6%	63%
IBC only	0.000	0.000	0.000	0.000	No HC fishery	0.000	0.000	0.000	0.000	315.692	37%	-100%
Other options	35.350	31.369	3.981	0.000	0.75 * F(sq)	0.137	0.118	0.019	0.000	280.386	22%	-20%
	46.353	41.106	5.247	0.000	Fsq	0.183	0.157	0.026	0.000	269.537	17%	0%
	56.967	50.485	6.482	0.000	1.25 * F(sq)	0.229	0.196	0.032	0.000	259.094	13%	28%
	38.871	34.486	4.385	0.000	15% TAC decrease	0.152	0.130	0.022	0.000	276.912	20%	-15%
	46.353	41.106	5.247	0.000	Rollover TAC	0.183	0.157	0.026	0.000	269.537	17%	0%
	53.654	47.559	6.095	0.000	15% TAC increase	0.214	0.184	0.030	0.000	262.351	14%	15%
	67.145	59.464	7.681	0.000	F(pa)	0.274	0.235	0.039	0.000	249.102	8%	51%
	87.355	77.244	10.111	0.000	F(msy) long time-series	0.370	0.317	0.053	0.000	229.341	0%	96%
	160.314	140.441	19.873	0.000	F(pa) long time-series	0.830	0.712	0.118	0.000	159.552	-31%	257%
	90.158	79.704	10.454	0.000	F(lim)	0.384	0.330	0.054	0.000	226.609	-1%	102%
	192.923	166.695	26.228	0.000	B(lim)	1.264	1.084	0.179	0.000	94.000	-43%	328%
	175.109	152.807	22.302	0.000	B(trigger)	0.975	0.837	0.138	0.000	132.000	-36%	290%
	45.690	40.519	5.170	0.000	Fmsylower	0.180	0.154	0.026	0.000	270.190	18%	3%
	48.051	42.607	5.444	0.000	Fmsyupper	0.190	0.163	0.027	0.000	267.865	17%	8%

Table 7.3.5. Haddock in Subarea 4 and divisions 3.a and 6.a. Previous catch-option table from ICES advice released on 30 June 2017.

Basis: F(2017) = TSA projection = 0.183; SSB (2018) = 229.910; TAC 4 (2017) = 33.643; TAC 3.Intercatha (2017) = 2.069; TAC 6.a (2017) = 3.697; HC landings (2017) = 39.409; Discards+BMS (2017) = 5.675, IBC (2017) = 0.000; Recruitment (2017) = TSA projection = 4235 millions. Units: 000 tonnes. Under the assumption that effort is linearly related to fishing mortality. 1) SSB 2019 relative to SSB 2018. 2) Wanted catch 2018 relative to TAC 2017

Rationale	Total catch 2018	Wanted catch 2018	Unwanted catch 2018	IBC 2018	Basis	Total F 2018	F(land) 2018	F(disc) 2018	F(IBC) 2018	SSB 2019	% SSB	% TAC change (2)
MSY	**51.037**	**43.555**	**7.482**	**0.000**	**New F(msy) estimate**	**0.194**	**0.166**	**0.028**	**0.000**	**266.941**	**16%**	**11%**
Management plan	75.937	64.617	11.320	0.000	MP target F	0.300	0.257	0.043	0.000	243.573	6%	64%
IBC only	0.000	0.000	0.000	0.000	No HC fishery	0.000	0.000	0.000	0.000	315.692	37%	-100%
Other options	36.689	31.357	5.332	0.000	0.75 * F(sq)	0.137	0.117	0.019	0.000	280.492	22%	-20%
	48.140	41.095	7.045	0.000	F(sq)	0.182	0.156	0.026	0.000	269.673	17%	0%
	59.200	50.476	8.724	0.000	1.25 * F(sq)	0.228	0.195	0.032	0.000	259.257	13%	28%
	40.351	34.474	5.877	0.000	15% TAC decrease	0.151	0.130	0.021	0.000	277.028	20%	-15%
	48.140	41.095	7.045	0.000	Rollover TAC	0.182	0.156	0.026	0.000	269.673	17%	0%
	55.746	47.549	8.197	0.000	15% TAC increase	0.213	0.183	0.030	0.000	262.506	14%	15%
	70.025	59.630	10.395	0.000	F(pa)	0.274	0.235	0.039	0.000	249.102	8%	51%
	91.224	77.466	13.757	0.000	F(msy) long time-series	0.370	0.317	0.053	0.000	229.341	0%	96%
	168.784	140.928	27.856	0.000	F(pa) long time-series	0.830	0.712	0.118	0.000	159.552	-31%	259%
	94.171	79.935	14.236	0.000	F(lim)	0.384	0.330	0.054	0.000	226.609	-1%	103%
	205.519	167.418	38.101	0.000	B(lim)	1.264	1.084	0.179	0.000	94.000	-43%	329%
	184.980	153.374	31.606	0.000	B(trigger)	0.975	0.837	0.138	0.000	132.000	-36%	291%
	47.591	40.629	6.962	0.000	Fmsylower	0.180	0.154	0.026	0.000	270.190	18%	3%
	50.056	42.722	7.334	0.000	Fmsyupper	0.190	0.163	0.027	0.000	267.865	17%	8%

7.4 Saithe in Subarea 4, 6 and Division 3a

7.4.1 New survey information

New survey data are available from the 2017 international third quarter IBTS survey (IBTS Q3) for a potential autumn forecast. The following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2017), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008). DATRAS survey indices are used in the analysis.

7.4.2 RCT3 analysis

An RCT3 analysis, following the protocol outlined by AGCREFA (ICES-AGCREFA 2008), was run to provide an estimate of the abundance of the incoming age 3 and age 4 year-classes. The RCT3 input and output files are given in tables 7.4.1 to 7.4.3.

7.4.3 Update protocol calculation

The outcome of following the protocol was:

Calculation of 2014 year-class at:	Age 3	Age 4
Log WAP from RCT3 (*R*)	11.613	11.40
Log of recruitment assumed in spring (*A*)	11.611	11.59
Int SE of log WAP (*S*)	0.21	0.26
Distance D $\left(D = \frac{R-A}{S}\right)$	0.01	-0.75

7.4.4 Conclusions from protocol

The autumn indices suggest that the size of the incoming year-class is not larger than the median value assumed in the forecast produced by WGNSSK in May 2016 for age 3. Age 3 is only partially recruited to the survey/fishing area, which is evident in the generally poor internal consistency of the Q3 survey between age 3 and age 4 (correlation = 0.28; Figure 7.4.1). This indicates that the age 3 index value is very uncertain and the perception of the year class strength can change considerably in the following year, when information at age 4 becomes available.

Age 4 can be seen as the first fully recruited year class although the assessment starts with age 3. Therefore, an RCT3 analysis for age 4 was also explored; D = -0.75, indicating that age 4 is marginally smaller than expected.

The overall conclusion is that **the advisory process for North Sea saithe does not have to be reopened.**

7.4.5 Updated forecast

Not required

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2017). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 25 April-5 May 2017, Copenhagen, Denmark. ICES CM 2017/ ACOM:21.

Table 7.4.1. Saithe in subareas 4 and 6 and Division 3a. RCT3 data input file for the age 3 and age 4 year-classes.

Year class	Age 3		Age 4	
	Recruitment	IBTS Q3	Recruitment	IBTS Q3
1987	–	–	71305	0.402
1988	174149	1.946	88805	2.760
1989	104585	1.077	59319	2.781
1990	175575	7.965	97347	1.615
1991	118405	1.117	66960	2.501
1992	213393	13.959	148203	6.533
1993	119173	3.825	79410	3.351
1994	149745	3.756	120791	4.134
1995	88800	1.181	56009	1.907
1996	112273	2.086	93770	8.836
1997	97570	3.479	67606	6.173
1998	202590	21.494	142708	18.974
1999	162163	10.748	122700	23.802
2000	167325	19.272	110306	6.727
2001	117047	4.930	76212	7.512
2002	142683	8.916	123047	29.579
2003	100788	10.553	55325	5.578
2004	152005	34.006	97281	5.584
2005	73322	3.312	51538	1.703
2006	58977	1.346	38593	0.964
2007	89587	1.361	78115	8.451
2008	81755	4.520	47824	2.497
2009	138077	11.134	104416	16.279
2010	98200	14.701	73118	3.923
2011	62041	1.649	46382	5.613
2012	110334	11.001	79070	17.307
2013	142625	37.74	NA	13.172
2014	NA	11.468		

Table 7.4.2. Saithe in subareas 4 and 6 and Division 3a. RCT3 data output file for the age 3 year-class.

```
Analysis by RCT3_R ver3.1 of data from file: RCT3 Saithe AGE 3 2017.txt
RCT3 input for D calculations for sai3a46 age 3
Data for 1 surveys over 27 years:  1988 - 2014

Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

Year class = 2014

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

 IBTS      0.44  10.61   0.25  0.684     26   2.52   11.71    0.281    0.567

                                  Assessment Mean =   11.49    0.322    0.433

 Year     Weighted      Log     Int     Ext     Var
 Class     Average      WAP     Std     Std    Ratio
          Prediction           Error   Error
 2014      110544     11.61    0.21    0.11     0.26
```

Table 7.4.3. Saithe in subareas 4 and 6 and Division 3a. RCT3 data output file for the age 4 year-class.

```
Analysis by RCT3_R ver3.1 of data from file: RCT3 Saithe AGE 4 2017.txt
RCT3 input for D calculations for sai3a46 age 4

Data for 1 surveys over 27 years:  1987 - 2013
Regression type = c
Tapered time weighting applied
Power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.000
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

Year class = 2013

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

 IBTS    0.58  10.00   0.28  0.672     26   2.65   11.55    0.328    0.607

                                  Assessment Mean =   11.17    0.408    0.393

 Year     Weighted      Log     Int     Ext     Var
 Class     Average      WAP     Std     Std    Ratio
          Prediction           Error   Error
 2013       89217     11.40    0.26    0.18     0.52
```

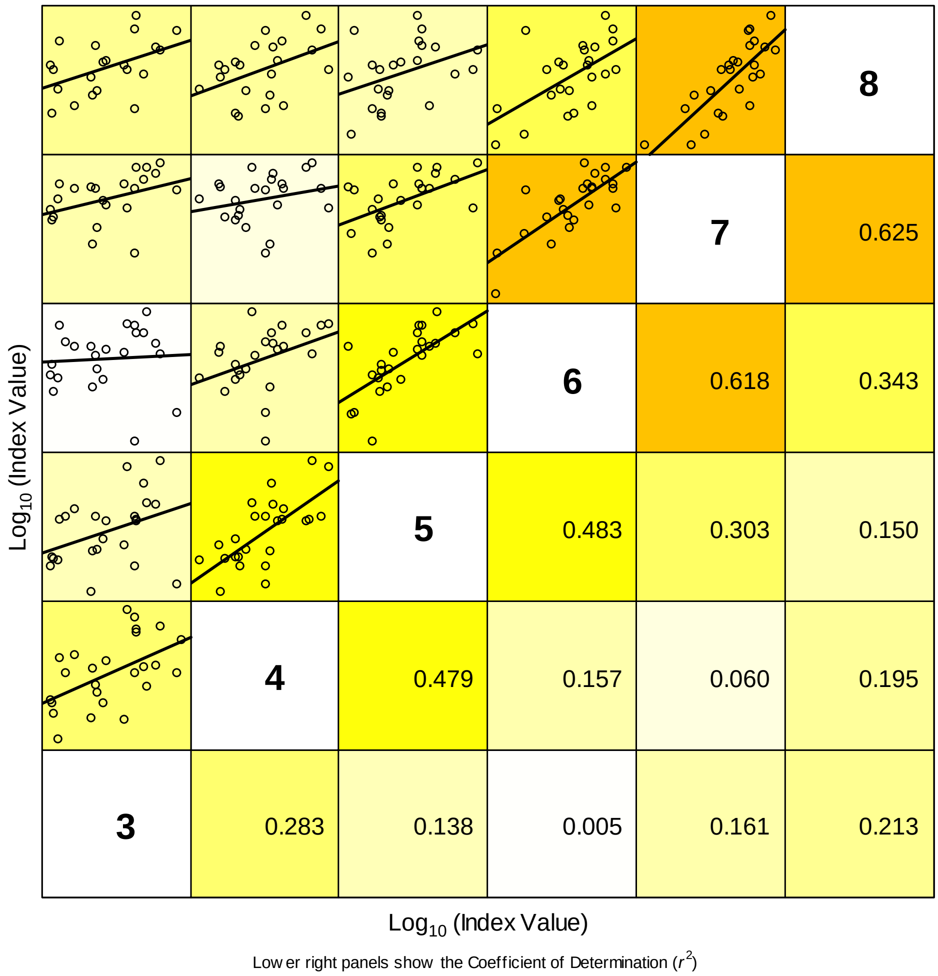

Figure 7.4.1. Saithe in subareas 4 and 6 and Division 3a. Internal consistencies between subsequent ages in the IBTS Q3 survey.

7.5 Whiting in Subarea 4 and Division 7.d

7.5.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 7.5.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK, 2017), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA, 2008).

7.5.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA, 2008), an RCT3 analysis was run to provide an estimate of the abundance of the 2016 year-class, and the incoming (2017) year-class. The RCT3 input and output files are given in tables 7.5.2 and 7.5.3.

7.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2016 year-class at age 1 (in 2017)	
Log WAP from RCT3 (R)	15.15
Log of recruitment assumed in spring (A)	15.02
Int SE of log WAP (S)	0.155
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.83**

Calculations for 2017 year-class at age 1 (in 2018)	
Log WAP from RCT3 (R)	13.83
Log of recruitment assumed in spring (A)	14.71
Int SE of log WAP (S)	0.288
Distance D $\left(D = \frac{R-A}{S}\right)$	**-3.06**

7.5.4 Conclusions from protocol

- 2016 year class at age 1 (in 2017): as the distance is -1.0<D< 1.0, the protocol concludes that the RCT3 estimate used for 2016 recruitment was appropriate
- 2017 year class at age 1 (in 2018): in the spring advice, a geometric mean value was used for this year class. As the distance is D< -1.0 for this year-class, the protocol concludes that the original geometric mean overestimates the true size of the 2017 year class by a significant amount.

The overall conclusion is that **the advisory process for North Sea whiting should be reopened based on the RCT3 analysis.**

7.4.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea whiting using the new estimate of recruitment in 2017 (3 815 millions for the 2016 year-class at age 1) and in 2018 (1 013 millions for the 2017 year-class at age 1; see Table 1.1.3). The settings and assumptions for the forecast were otherwise unchanged from those presented in ICES-WGNSSK (2017). The survey predicts relatively low recruitment (below the geometrical mean of the time series) for the 2017 year class.

Table 7.5.4 shows the updated advice option table from the new October 2017 run. The previous advice option table from spring 2017 is given in Table 7.5.5.

The baseline advice uses the MSY approach with a target F of 0.15. On this basis, predicted total catch in 2018 decreases from 26 804 t (spring results) to **26 191 t** (October results), while the corresponding TAC change (relative to landings in Subarea 4 only) changes slightly from -33% (spring results) to **-31%** (October results). The forecast for SSB in 2019 decreases from 354 527 t (spring results) to 293 339 t (October results). The corresponding change in SSB in 2019 from 2018 is predicted to be -18% (instead of 0.1%, spring results).

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2017). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2017/ACOM:21.

Table 7.5.1. Whiting in Subarea 4 and Division 7d. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2017 are shaded grey.

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1991	536.99	703.368	158.594	79.024	14.568	5.183	1.018
1992	1379.459	600.867	296.1	72.451	57.498	10.273	6.212
1993	919.193	638.722	177.377	66.118	14.711	15.904	3.039
1994	610.743	677.645	219.541	74.71	19.506	4.722	3.16
1995	729.246	619.786	291.18	107.195	21.512	6.013	3.464
1996	316.501	545.708	278.218	129.356	34.003	6.893	4.1
1997	2062.67	332.968	180.681	108.985	28.006	10.711	4.245
1998	2631.69	330.6	150.205	52.766	31.01	11.179	4.695
1999	2498.55	1203.501	190.643	53.932	24.452	9.529	4.179
2000	1961.467	940.784	326.515	64.396	13.597	6.534	4.861
2001	3548.815	668.907	283.081	93.978	19.076	4.279	6.023
2002	269.285	811.915	257.157	131.47	35.034	5.45	2.835
2003	356.523	257.637	292.805	128.67	67.944	17.313	4.767
2004	714.27	150.623	59.032	66.326	45.724	27.103	9.711
2005	169.321	171.386	68.259	31.433	45.616	33.96	28.704
2006	198.949	174.625	86.336	32.619	13.511	23.287	25.714
2007	822.902	95.495	63.592	37.636	11.482	8.405	20.747
2008	764.759	362.299	68.886	30.907	13.774	4.081	14.791
2009	593.801	585.529	384.777	40.984	12.295	8.037	6.808
2010	510.123	224.321	145.671	54.635	12.844	5.996	7.795
2011	247.085	446.812	144.439	47.243	16.217	6.929	4.635
2012	306.812	256.718	193.523	57.001	20.081	10.644	5.384
2013	334.257	67.451	60.102	65.787	17.504	7.08	3.725
2014	1401.008	223.4	97.962	65.552	33.278	10.311	6.849
2015	2091.636	312.453	222.551	43.072	24.038	18.433	10.853
2016	971.588	297.165	243.653	77.673	12.211	8.059	9.95
2017	176.649	950.96	200.82	77.706	25.397	7.021	10.552

Table 7.5.2 Whiting in Subarea 4 and Division 7d. RCT3 input file. Data from surveys in autumn 2017 are highlighted.

Year class	VPA Recruits at age 1	IBTS Q1 Age 1	IBTS Q1 Age 2	IBTS Q3 Age 0	IBTS Q3 Age 1	IBTS Q3 Age 2
1989	3602224	518.936	686.445	-11	-11	158.594
1990	3559519	1007.621	665.714	-11	703.368	296.1
1991	3426549	907.297	522.811	536.99	600.867	177.377
1992	3906041	1075.624	627.406	1379.459	638.722	219.541
1993	3661737	721.709	448.484	919.193	677.645	291.18
1994	3282168	678.59	485.968	610.743	619.786	278.218
1995	2335674	502.361	342.246	729.246	545.708	180.681
1996	1782753	287.779	160.695	316.501	332.968	150.205
1997	2478930	543.117	305.445	2062.67	330.6	190.643
1998	4042873	676.266	544.86	2631.69	1203.501	326.515
1999	4799029	767.887	592.395	2498.55	940.784	283.081
2000	3992721	614.174	342.774	1961.467	668.907	257.157
2001	3428809	558.505	298.426	3548.815	811.915	292.805
2002	1208118	131.593	90.134	269.285	257.637	59.032
2003	1223023	184.399	97.824	356.523	150.623	68.259
2004	1596036	112.663	125.057	714.27	171.386	86.336
2005	1598134	184.411	147.304	169.321	174.625	63.592
2006	1523410	64.53	205.798	198.949	95.495	68.886
2007	2764813	268.598	295.812	822.902	362.299	384.777
2008	2259351	211.202	224.795	764.759	585.529	145.671
2009	2330274	326.192	337.096	593.801	224.321	144.439
2010	3028641	184.867	588.451	510.123	446.812	193.523
2011	1579943	231.34	163.022	247.085	256.718	60.102
2012	1125900	54.451	184.583	306.812	67.451	97.962
2013	2220038	265.333	212.707	334.257	223.4	222.551
2014	2668688	315.05	323.571	1401.008	312.453	243.653
2015	-11	302.186	248.57	2091.636	297.165	200.82
2016	-11	612.863	-11	971.588	950.96	-11
2017	-11	-11	-11	176.649	-11	-11

Table 7.5.3. Whiting in Subarea 4 and Division 7d. RCT3 output file.

Analysis by RCT3 ver4.0

Whiting
Data for 5 surveys over 29 years : 1989 - 2017
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.
yearclass: 2016

index	slope	intercept	se	r square	n	indices	prediction	se. pred	WAP. weights
IBTSq11	0.6017	11.22	0.2548	0.742	26	6.418	15.08	0.2731	0.3717
IBTSq12	0.773	10.32	0.2061	0.8147	26	NA	NA	NA	NA
IBTSq30	0.6286	10.58	0.3505	0.6071	24	6.879	14.9	0.3748	0.1973
IBTSq31	0.6607	10.8	0.2307	0.7796	25	6.857	15.33	0.2536	0.4311
IBTSq32	0.8406	10.43	0.257	0.7386	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	26	NA	14.72	0.4233	0

	WAP	logWAP	int.se
Year class: 2016	3815195	15.15	0.1549

yearclass: 2017

index	slope	intercept	se	r square	n	indices	prediction	se. pred	WAP. weights
IBTSq11	0.6017	11.22	0.2548	0.742	26	NA	NA	NA	NA
IBTSq12	0.773	10.32	0.2061	0.8147	26	NA	NA	NA	NA
IBTSq30	0.6286	10.58	0.3505	0.6071	24	5.174	13.83	0.3923	1
IBTSq31	0.6607	10.8	0.2307	0.7796	25	NA	NA	NA	NA
IBTSq32	0.8406	10.43	0.257	0.7386	26	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	26	NA	14.72	0.4233	0

	WAP	logWAP	int.se
Year class: 2017	1012691	13.83	0.2877

Table 7.5.4. Whiting in Subarea 4 and Division 7d. Updated catch option table following RCT3 analysis, October 2017.

Basis: F(2017) = average exploitation (2014-2016), scaled to 2016 Fsq = 0.244; SSB (2017) = 312.257; Recruitment (2017)=RCT3 Forecast=3815 million , Recruitment (2018)= RCT3 forecast=1013 million; TAC 27.4 (2017) = 16.003; Landings (2017) = 21.036; Discards (2017) = 16.395; IBC (2017=

Rationale	Total catch 2018	Wanted catch 27.4+27.7d 2018	Unwanted catch 2018	Total IBC 2018	Wanted catch 27.4[1] 2018	Wanted catch 27.7d[1] 2018	Basis	Total F 2018	F(wanted) 2018	F(unwanted) 2018	F(IBC) 2018	SSB 2019	% SSB change [2]	% TAC change [3]
MSY target	**26.191**	**13.799**	**8.546**	**3.846**	**11.040**	**2.759**	**Fmsy**	**0.150**	**0.088**	**0.040**	**0.023**	**293.339**	**-18.2%**	**-31%**
IBC only	4.008	0.000	0.000	4.008	0.000	0.000	No HC fishery	0.023	0.000	0.000	0.023	311.439	-13.2%	-100%
Other options	42.196	23.731	14.737	3.728	18.986	4.745	Fsq	0.244	0.152	0.069	0.023	280.305	-21.9%	19%
	36.266	20.002	12.492	3.771	16.003	3.999	Rollover TAC	0.213	0.131	0.060	0.023	285.191	-20.5%	0%
	31.395	17.002	10.585	3.807	13.603	3.400	15% TAC decrease (27.4)	0.182	0.110	0.050	0.023	289.132	-19.4%	-15%
	41.137	23.003	14.399	3.735	18.403	4.599	15% TAC increase (27.4)	0.243	0.151	0.069	0.023	281.250	-21.6%	15%
	32.372	17.605	10.967	3.800	14.085	3.520	0.75 * Fsq	0.188	0.114	0.052	0.023	288.339	-19.6%	-12%
	50.190	28.578	17.944	3.669	22.864	5.714	1.25 * Fsq	0.299	0.190	0.087	0.023	273.928	-23.7%	43%
	47.142	26.701	16.750	3.691	21.362	5.339	Fpa	0.280	0.177	0.081	0.023	276.393	-23.0%	33%
	64.869	37.618	23.692	3.560	30.096	7.522	Flim	0.390	0.252	0.115	0.023	262.055	-27.0%	88%
	89.780	52.958	33.446	3.376	42.369	10.589	Bpa, MSY Btrigger	0.545	0.359	0.163	0.023	241.837	-32.6%	165%
	175.057	105.472	66.838	2.747	84.383	21.089	Blim	1.074	0.722	0.329	0.023	172.741	-51.8%	427%

Units: 000 tonnes.

Under the assumption that effort is linearly related to fishing mortality

[1] Total human consumption landings are assumed to be split 80% (Subarea 27.4), 20% (Division 27.7d).

[2] SSB 2019 relative to SSB 2018.

[3] Landings 27.4 in 2018 relative to TAC 27.4 in 2017 = 3634

Table 7.5.5. Whiting in Subarea 4 and Division 7d. Previous catch option table, spring 2017.

Basis: F(2017) = average exploitation (2014–2016),scaled to 2016 F_{sq} = 0.244; SSB (2017) = 305.405; Recruitment (2017)=RCT3 Forecast=3340 million , Recruitment (2018)= geom. mean(1990–2016)=2444 million; TAC 27.4 (2017) = 16.003; Landings (2017) = 20.916; Discards (2017) = 15.550; IBC (2017) = 3.544.

Rationale	Total catch 2018	Wanted catch 27.4+27.7d 2018	Unwanted catch 2018	Total IBC 2018	Wanted catch 27.4[1] 2018	Wanted catch 27.7d[1] 2018	Basis	Total F 2018	F(wanted) 2018	F(unwanted) 2018	F(IBC) 2018	SSB 2019	% SSB change [2]	% TAC change [3]
MSY target	**26.804**	**13.445**	**9.429**	**3.929**	**10.757**	**2.688**	**Fmsy**	**0.150**	**0.088**	**0.040**	**0.023**	**354.527**	**0.1%**	**-33%**
IBC only	4.088	0.000	0.000	4.088	0.000	0.000	No HC fishery	0.023	0.000	0.000	0.023	372.875	5.3%	-100%
Other options	43.207	23.122	16.271	3.814	18.499	4.623	Fsq	0.244	0.152	0.069	0.023	341.306	-3.6%	16%
	38.040	20.002	14.187	3.850	16.003	3.999	Rollover TAC	0.218	0.134	0.061	0.023	345.534	-2.4%	0%
	32.901	17.002	12.012	3.886	13.603	3.400	15% TAC decrease (27.4)	0.187	0.113	0.051	0.023	349.648	-1.3%	-15%
	43.179	23.003	16.362	3.814	18.403	4.599	15% TAC increase (27.4)	0.249	0.155	0.071	0.023	341.420	-3.6%	15%
	33.156	17.153	12.119	3.884	13.723	3.430	0.75 * Fsq	0.188	0.114	0.052	0.023	349.443	-1.3%	-14%
	51.466	27.840	19.871	3.756	22.273	5.567	1.25 * Fsq	0.299	0.190	0.087	0.023	334.786	-5.5%	39%
	48.334	26.012	18.545	3.778	20.811	5.201	Fpa	0.280	0.177	0.081	0.023	337.293	-4.8%	30%
	66.551	36.644	26.257	3.650	29.317	7.327	Flim	0.390	0.252	0.115	0.023	322.711	-8.9%	83%
	167.379	95.493	68.945	2.941	76.400	19.094	Bpa, MSY Btrigger	0.999	0.671	0.306	0.023	241.837	-31.7%	377%
	253.557	145.792	105.430	2.335	116.641	29.151	Blim	1.519	1.028	0.469	0.023	172.741	-51.1%	629%

Units: 000 tonnes.

Under the assumption that effort is linearly related to fishing mortality

1) Total human consumption landings are assumed to be split 80% (Subarea 27.4), 20% (Division 27.7d).

2) SSB 2019 relative to SSB 2018.

3) Landings 27.4 in 2018 relative to TAC 27.4 in 2017

7.6 Plaice in Subarea 4 and Subdivision 20

7.6.1 Short term forecast and June advice

At WGNSSK 2017 (ICES, 2017), the following short term forecast settings were used:

Year class	Age in 2017	AAP survivors	RCT3	GM 1957-2013	Accepted estimate
2015	2	967855	801152	706596	AAP survivors
2016	1		1055007	969504	RCT3
2017	0			969504	GM 1957–2013

7.6.2 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS), that was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea. Since IBP-plaice (ICES, 2013), the assessment uses the combined BTS-Isis and BTS-Tridens index. This index has a shorter time series due to the BTS-Tridens only starting in 1996.

Since the plaice benchmark in 2017, the survey indices were calculated though a delta-GAM model (Berg *et al.*, 2014). This means the generated indices will differ after every update of the survey data input.

The 2017 BTS-Q3 survey included in the autumn re-opening analysis is incomplete and has a greater uncertainty for the following reasons:

- The 2017 German and UK BTS-Q3 has not been imported into DATRAS, therefore the 2017 data from these two countries were missing in the update analysis
- In 2017, only the minimum required number of sampling stations were sampled to cover the spatial distribution for the original TRI2 index area, owing to technical and staffing issues

7.6.3 RCT3 Analysis

The RCT3 analysis on the BTS-combined survey indices for ages 1 and 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES, 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE’s greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 42 years including the assessment estimates for the two ages are presented in Table 7.6.1. In 2017, the new data comprises age 1 of year class 2016 and age 2 of year class 2015. The last 4 years from the assessment estimates were removed from the time series.

Table 7.6.1 North Sea plaice RCT3 input data

YCL	N@A1	N@A2	SNS0	SNS1	SNS2	BTSC1	BTSC2	DFS0
1975	684635	435068	NA	NA	3423.8	NA	NA	NA
1976	1030590	632554	NA	NA	12678	NA	NA	NA
1977	875828	547616	NA	NA	9828.8	NA	NA	NA
1978	910524	608159	NA	NA	12882.3	NA	NA	NA
1979	1080290	768191	NA	NA	18785.3	NA	NA	NA
1980	1010250	734361	NA	NA	8642	NA	NA	NA
1981	1941050	1384900	NA	NA	13908.6	NA	NA	NA
1982	1363380	939956	NA	NA	10412.8	NA	NA	NA
1983	1282770	864014	NA	NA	13847.8	NA	NA	NA
1984	1806160	1205880	NA	NA	7580.4	NA	NA	NA
1985	4389140	2933270	NA	NA	32991.1	NA	NA	NA
1986	1953250	1323660	NA	NA	14421.1	NA	NA	NA
1987	1724090	1207450	NA	NA	17810.2	NA	NA	NA
1988	1224500	891580	NA	NA	7496	NA	NA	NA
1989	1110790	822672	NA	NA	11247.2	NA	NA	NA
1990	1004210	730412	NA	NA	13841.8	NA	NA	439.6
1991	838128	594078	NA	NA	9685.6	NA	NA	332.4
1992	511439	367488	NA	NA	4976.6	NA	NA	180.3
1993	572617	431643	NA	NA	2796.4	NA	NA	217
1994	1071900	843745	NA	NA	10268.2	NA	26413	283.4
1995	1004330	809656	NA	NA	4472.7	27439	17914	146.1
1996	2308750	1867230	NA	NA	30242.2	94247	90431	619.6
1997	774939	613911	NA	NA	10272.1	37735	19663	229.2
1998	728518	559556	NA	NA	2493.4	48475	23661	NA
1999	916459	699920	NA	22855	2898.5	45597	21736	NA
2000	601963	467837	24213.5	11510.5	1102.7	31721	18033	124.9
2001	1659280	1286580	99628	30809.2	NA	144777	50316	313.2
2002	568719	421666	31202	NA	1349.7	34872	14808	122.9
2003	1331210	942424	NA	18201.6	1818.9	48419	30397	238.6
2004	853271	621382	13537.2	10118.4	1571	40989	18510	126.7
2005	832698	639450	27390.6	12164.2	2133.9	44912	24007	85.9
2006	1357950	1054550	51124.2	14174.5	2700.4	90800	50639	168
2007	1186450	896178	40580.9	14705.8	2018.7	73512	25333	98.3
2008	1086170	815425	50179.3	14860	1811.5	70512	30999	129.7
2009	1353540	1069570	53258.8	11946.9	1142.5	87815	46188	141.9
2010	1574020	1294900	49347.2	18348.6	2928.6	136492	70145	179.6
2011	1272860	1047670	52643	5893.4	3021.3	63573	60137	93
2012	1449990	1162340	45027.1	15394.9	2258.3	96411	66125	181.1
2013	NA	NA	44327.5	17312.7	5040.4	154174	72975	168.5
2014	NA	NA	11722.3	16726.5	2434.3	60313	32641	108
2015	NA	NA	30494.5	10384.8	NA	88808	54400	100.2
2016	NA	NA	44111	NA	NA	157433	NA	78.5

7.6.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in Table 7.6.2.

For age 1, the D value for this age indicates 3.51, a substantial positive signal (i.e. >1). For age 2 the D value=1.52, also indicating a substantial positive signal when compared to the spring assumptions.

Table 7.6.2 North Sea plaice RCT3 output for age 1 and 2 and D calculation

```
D calculation North Sea plaice age 1
Analysis by RCT3 ver4.0: Plaice

Data for 1 surveys over 42 years : 1975 - 2016
Regression type = C, Tapered time weighting not applied, Survey weighting not
applied
Final estimates not shrunk towards mean, Estimates with S.E.'S greater than
that of mean included, Minimum S.E. for any survey taken as    .00, Minimum of
3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
  index slope intercept  se rsquare  n  indices  prediction se.pred WAP.weights
  BTSC1 0.916   3.818  0.2705  0.6672 18   11.97    14.78   0.3241        1
 VPA Mean    NA     NA     NA      NA 38      NA      13.93  0.4301       0
                  WAP logWAP int.s
yearclass:2016 2622092  14.78 0.2589

Spring assumption for age 1: 1055007; log(1055007) = 13.869
```

Calculations for 2013 year-class at age 1	
Log WAP from RCT3 (R)	14.78
Log of recruitment assumed in spring (A)	13.87
Int SE of log WAP (S)	0.259
Distance D $\left(D = \frac{R-A}{S}\right)$	**3.513**

Hence, the new information suggests a positive signal, that is substantially different from spring assumptions.

```
D calculation North Sea plaice age 2
Analysis by RCT3 ver4.0: Plaice

Settings are the same as for age 1

yearclass:2015
    index slope intercept  se rsquare  n indices prediction se.pred WAP.weights
    BTSC2 0.759   5.77 0.1767  0.8288 19    10.9      14.05  0.1964        1
 VPA Mean    NA     NA     NA      NA 38      NA     13.62  0.4334        0
                  WAP logWAP int.se
yearclass:2015 1258385  14.05 0.1789
Spring assumption for age 2: 967855; log(967855) = 13.78284
```

Calculations for 2012 year-class at age 2	
Log WAP from RCT3 (R)	14.05
Log of recruitment assumed in spring (A)	13.78
Int SE of log WAP (S)	0.178
Distance D $\left(D = \frac{R-A}{S}\right)$	**1.52**

Hence, the new information suggests a positive signal, that is substantially different from spring assumptions.

7.6.5 Revised forecast

7.6.5.1 Full RCT3 analyses

Since the new survey indices indicates a substantial difference in perceived recruitment (compared to the spring assumptions), a new STF was done. To this end, we first recalculated the RCT3 recruitment estimates (for age 1 and age 2) using the full set of surveys that is now available. The settings are the same as during the working group in spring. Clearly, the added surveys (BTSC1 and BTSC2) have a substantial part of the weight in the predictions, and these RCT3 estimates are higher than those in spring. The results are in Table 7.6.3.

Table 7.6.3 North Sea plaice RCT3 output for age 1 and 2 and full RCT with all available survey information

Age 1

```
Analysis by RCT3 ver4.0: Plaice

Data for 6 surveys over 42 years : 1975 - 2016
Regression type = C, Tapered time weighting not applied, Survey weighting not
applied
Final estimates not shrunk towards mean, Estimates with S.E.'S greater than
that of mean included, Minimum S.E. for any survey taken as .00, Minimum of 3
points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
    index  slope intercept se rsquare  n indices prediction se.pred WAP.weights
     SNS0 0.9644 3.675 0.3417  0.5500 12  10.694  13.99  0.3902     0.29780
    BTSC1 0.9160 3.818 0.2705  0.6672 18  11.967  14.78  0.3241     0.43161
     DFS0 2.3267 1.703 1.1643  0.1088 21   4.363  11.85  1.3321     0.02555
 VPA Mean   NA    NA     NA     NA 38     NA     13.93  0.4301      0.24505

                    WAP logWAP int.se
yearclass:2016 1562822  14.26 0.2129
```

D value: (14.26-13.87)/0.2129=1.832

Age 2

```
Analysis by RCT3 ver4.0: Plaice

Settings are the same as for age 1

yearclass:2015
    index slope intercept  se rsquare  n indices prediction se.pred WAP.weights
     SNS0 1.018  2.8548 0.3563 0.56081 12  10.325    13.36  0.4114    0.122150
     SNS1 2.675  -11.9152 1.0779 0.08302 13   9.248   12.82  1.2463    0.013309
    BTSC1 0.959  3.0894 0.2833 0.66685 18  11.394   14.02  0.3140    0.209704
    BTSC2 0.759  5.7696 0.1767 0.82880 19  10.904    14.05  0.1964    0.536044
     DFS0 2.738  -0.7088 1.3854 0.08876 21   4.607    11.91  1.5396    0.008722
 VPA Mean    NA     NA     NA      NA 38     NA      13.62  0.4334    0.110070
                    WAP logWAP int.se
yearclass:2015 1060739  13.87 0.1438
```

D value: (13.87-13.78)/0.1438=0.626

The updated recruitment table is in Table 7.6.4. In this table we removed the underlining of the forecast assumptions, but it is clear that both RCT3 estimates have gone up compared to the spring estimates.

Table 7.6.4 Updated recruitment estimate table (without indication of used assumptions in forecasts.

Year class	Age in 2017	AAP survivors	RCT3	GM 1957-2013	Accepted estimate
2015	2	967855	1060739	706596	AAP survivors
2016	1		1562822	969504	RCT3
2017	0			969504	GM 1957–2013

7.6.5.2 Updated forecasts

If we only update the RCT3 analysis for age 1, then we get the following recruitment estimates table (including the underlining for the estimate used in the forecast) (Table 7.6.5). This option (Tables 7.6.5-8) is illustrative only and is not used for re-opening.

Table 7.6.5 Updated recruitment estimate table (with indication of used assumptions in in this forecast; using RCT3 for age1, assessment survivors for age 2).

Year class	Age in 2017	AAP survivors	RCT3	GM 1957-2013	Accepted estimate
2015	2	<u>967855</u>	1060739	706596	AAP survivors
2016	1		<u>1562822</u>	969504	RCT3
2017	0			<u>969504</u>	GM 1957–2013

The updated forecast tables are in Table 7.6.6 and 7.6.7:

Table 7.6.6 Forecast table assumptions (using RCT3 for age1, assessment survivors for age 2).

Variable	Value	Source	Notes
F ages 2–6 (2017)	0.202	ICES (2017a)	Average exploitation pattern in 2014–2016, rescaled to 2016.
SSB (2018)	975419	ICES (2017a)	Short-term forecast (STF), tonnes.
Rage1 (2017)	1562822	ICES (2017a)	RCT3, thousands.
Rage1 (2018)	969504	ICES (2017a)	Geometric mean (GM, 1957–2013), thousands.
Total catch (2017)	139383	ICES (2017a)	Short-term forecast (STF), tonnes.
Commercial landings (2017)	96768	ICES (2017a)	Average landings rate by age 2014–2016, tonnes.
Unwanted catch (2017)	42664	ICES (2017a)	Average discard rate by age 2014–2016, tonnes.

Table 7.6.7 Updated forecast (using RCT3 for age1, assessment survivors for age 2).

Basis	Catch	Wanted catch	Unwanted catch	F total (2–6)	F wanted (2–6)	F unwanted (2–3)	SSB 2019	% SSB change	% TAC change
Fmsy	140059	95254	44805	0.21	0.1	0.19	995709	2	-35
Fmp	193364	131859	61505	0.3	0.15	0.27	943084	-3	-11
Fsq*0	0	0	0	0	0	0	1136334	16	-100
Fpa	231600	158256	73344	0.369	0.18	0.33	905475	-7	7
Flim	306167	210113	96054	0.516	0.25	0.46	832501	-15	42
SSB>Bpa	891477	652664	238813	3.288	1.6	2.95	290203	-70	340
SSB>Blim	992091	742114	249977	4.786	2.33	4.3	207288	-79	400
SSB>MSYBtrig	585791	410813	174978	1.296	0.63	1.16	564599	-42	177
TACsq	216123	147556	68567	0.341	0.17	0.31	920684	-6	0
Fsq*1	135123	91875	43248	0.202	0.1	0.18	1000594	3	-37

The age structured detailed input data for this short term forecast are in Table 7.6.8.

Table 7.6.8 Updated forecast (using RCT3 for age1, assessment survivors for age 2). Detailed age structured forecast for F=Fsq forecast. Recruitment assumptions in bold

age	year	F	f. disc	f. land	stock. n	ctc. wt	lnd. wt	dsc. wt	stk. wt	mat	M	ctc. n	ctc	lnd. n	lnd	dsc. N	dsc	SSB	TSB
1	2017	0.119	0.12	0	**1562822**	0.03	0.07	0.03	0.03	0	0.1	167385	5524	2	0	167382	5524	0	53136
2	2017	0.184	0.18	0	**967855**	0.09	0.25	0.08	0.08	0.5	0.1	155172	13319	3544	888	151628	12433	37908	75815
3	2017	0.241	0.18	0.06	611043	0.16	0.28	0.13	0.13	0.5	0.1	124845	20429	30478	8534	94367	11890	40227	80454
4	2017	0.244	0.09	0.15	718703	0.25	0.31	0.15	0.2	1	0.1	148610	37360	91909	28645	56701	8713	145418	145418
5	2017	0.197	0.05	0.15	431151	0.31	0.36	0.16	0.28	1	0.1	73622	23120	56539	20297	17084	2819	122303	122303
6	2017	0.142	0.02	0.13	292176	0.38	0.4	0.19	0.34	1	0.1	36786	14007	32709	13214	4078	783	100509	100509
7	2017	0.097	0.01	0.09	287580	0.45	0.47	0.21	0.4	1	0.1	25199	11391	23752	11100	1447	308	114840	114840
8	2017	0.056	0	0.05	191648	0.5	0.52	0.26	0.45	1	0.1	9915	4917	9171	4772	744	193	86433	86433
9	2017	0.028	0	0.03	121499	0.59	0.59	0.3	0.47	1	0.1	3190	1878	3190	1878	0	0	56780	56780
10	2017	0.028	0	0.03	439512	0.64	0.64	0	0.53	1	0.1	11540	7439	11539	7439	1	0	232355	232355
1	2018	0.119	0.12	0	**969504**	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837	3427	0	32963
2	2018	0.184	0.18	0	1255103	0.09	0.25	0.08	0.08	0.5	0.1	201226	17272	4596	1152	196629	16124	49158	98316
3	2018	0.241	0.18	0.06	728435	0.16	0.28	0.13	0.13	0.5	0.1	148830	24354	36333	10173	112496	14175	47955	95911
4	2018	0.244	0.09	0.15	434426	0.25	0.31	0.15	0.2	1	0.1	89829	22583	55555	17315	34273	5267	87899	87899
5	2018	0.197	0.05	0.15	509293	0.31	0.36	0.16	0.28	1	0.1	86966	27310	66786	23976	20180	3330	144469	144469
6	2018	0.142	0.02	0.13	320234	0.38	0.4	0.19	0.34	1	0.1	40319	15352	35850	14483	4469	858	110160	110160
7	2018	0.097	0.01	0.09	229435	0.45	0.47	0.21	0.4	1	0.1	20104	9088	18950	8856	1155	246	91621	91621
8	2018	0.056	0	0.05	236272	0.5	0.52	0.26	0.45	1	0.1	12224	6062	11307	5883	917	238	106559	106559
9	2018	0.028	0	0.03	163987	0.59	0.59	0.3	0.47	1	0.1	4306	2534	4305	2534	1	0	76636	76636
10	2018	0.028	0	0.03	493621	0.64	0.64	0	0.53	1	0.1	12961	8354	12959	8354	1	0	260961	260961
1	2019	0.119	0.12	0	**969504**	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837	3427	0	32963
2	2019	0.184	0.18	0	778609	0.09	0.25	0.08	0.08	0.5	0.1	124831	10715	2851	715	121980	10002	30496	60991
3	2019	0.241	0.18	0.06	944625	0.16	0.28	0.13	0.13	0.5	0.1	193001	31582	47117	13193	145884	18381	62188	124376
4	2019	0.244	0.09	0.15	517886	0.25	0.31	0.15	0.2	1	0.1	107086	26921	66228	20641	40858	6279	104786	104786
5	2019	0.197	0.05	0.15	307846	0.31	0.36	0.16	0.28	1	0.1	52567	16508	40369	14493	12198	2013	87326	87326
6	2019	0.142	0.02	0.13	378273	0.38	0.4	0.19	0.34	1	0.1	47626	18134	42347	17108	5279	1014	130126	130126
7	2019	0.097	0.01	0.09	251468	0.45	0.47	0.21	0.4	1	0.1	22035	9961	20769	9706	1265	270	100420	100420
8	2019	0.056	0	0.05	188501	0.5	0.52	0.26	0.45	1	0.1	9753	4836	9021	4694	732	190	85014	85014
9	2019	0.028	0	0.03	202170	0.59	0.59	0.3	0.47	1	0.1	5308	3125	5307	3124	1	0	94481	94481
10	2019	0.028	0	0.03	578614	0.64	0.64	0	0.53	1	0.1	15192	9793	15190	9793	2	0	305894	305894

If both age 1 and age 2 are updated (because the new survey information suggests that the survivors used in spring are an underestimate), then we get the following tables. This option (Tables 7.6.9–12) follows the approach used in previous years, and is used for re-opening.

Table 7.6.9 Updated recruitment estimate table (with indication of used assumptions in in this forecast; using RCT3 for age1, RCT3 for age 2).

Year class	Age in 2017	AAP survivors	RCT3	GM 1957-2013	Accepted estimate
2015	2	967855	1060739	706596	RCT3
2016	1		1562822	969504	RCT3
2017	0			969504	GM 1957–2013

Table 7.6.10 Forecast table assumptions (using RCT3 for age1, RCT3 for age 2).

Variable	Value	Source	Notes
F ages 2–6 (2017)	0.202	ICES (2017a)	Average exploitation pattern in 2014–2016, rescaled to 2016.
SSB (2018)	980 021	ICES (2017a)	Short-term forecast (STF), tonnes.
Rage1 (2017)	1 562 822	ICES (2017a)	RCT3, thousands.
Rage1 (2018)	969 504	ICES (2017a)	Geometric mean (GM, 1957–2013), thousands.
Total catch (2017)	140 662	ICES (2017a)	Short-term forecast (STF), tonnes.
Commercial landings (2017)	96 853	ICES (2017a)	Average landings rate by age 2014–2016, tonnes.
Unwanted catch (2017)	43 857	ICES (2017a)	Average discard rate by age 2014–2016, tonnes.

Table 7.6.11 Updated forecast (using RCT3 for age1, RCT3 for age 2).

Basis	Catch	Wanted catch	Unwanted catch	F total (2-6)	F wanted (2-6)	F unwanted (2-3)	SSB 2019	% SSB change	% TAC change
Fmsy	142481	96266	46215	0.21	0.1	0.19	1005667	3	-35
Fmp	196653	133233	63420	0.3	0.15	0.27	952027	-3	-10
Fsq*0	0	0	0	0	0	0	1149133	17	-100
Fpa	235496	159884	75612	0.369	0.18	0.33	913710	-7	8
Flim	311202	212217	98985	0.516	0.25	0.46	839408	-14	44
SSB>Bpa	902729	657496	245233	3.292	1.6	2.95	290203	-70	343
SSB>Blim	1003350	746845	256505	4.787	2.33	4.3	207288	-79	404
SSB>MSYBtrig	597365	416579	180786	1.307	0.64	1.17	564599	-42	181
TACsq	217551	147556	69995	0.337	0.16	0.3	931396	-5	0
Fsq*1	137462	92852	44610	0.202	0.1	0.18	1010647	3	-37

The age structured detailed input data for this short term forecast are in Table 7.6.12.

Table 7.6.12 Updated forecast (using RCT3 for age1, assessment survivors for age 2). Detailed age structured forecast for F=Fsq forecast. Recruitment assumptions in bold

age	year	F	f. disc	f. land	stock. n	ctc. wt	lnd. wt	dsc. wt	stk. wt	mat	M	ctc. n	ctc	lnd. n	lnd	dsc. N	dsc	SSB	TSB
1	2017	0.119	0.12	0	**1562822**	0.03	0.07	0.03	0.03	0	0.1	167385	5524	2	0	167382	5524	0	53136
2	2017	0.184	0.18	0	**1060739**	0.09	0.25	0.08	0.08	0.5	0.1	170064	14597	3885	974	166179	13627	41546	83091
3	2017	0.241	0.18	0.06	611043	0.16	0.28	0.13	0.13	0.5	0.1	124845	20429	30478	8534	94367	11890	40227	80454
4	2017	0.244	0.09	0.15	718703	0.25	0.31	0.15	0.2	1	0.1	148610	37360	91909	28645	56701	8713	145418	145418
5	2017	0.197	0.05	0.15	431151	0.31	0.36	0.16	0.28	1	0.1	73622	23120	56539	20297	17084	2819	122303	122303
6	2017	0.142	0.02	0.13	292176	0.38	0.4	0.19	0.34	1	0.1	36786	14007	32709	13214	4078	783	100509	100509
7	2017	0.097	0.01	0.09	287580	0.45	0.47	0.21	0.4	1	0.1	25199	11391	23752	11100	1447	308	114840	114840
8	2017	0.056	0	0.05	191648	0.5	0.52	0.26	0.45	1	0.1	9915	4917	9171	4772	744	193	86433	86433
9	2017	0.028	0	0.03	121499	0.59	0.59	0.3	0.47	1	0.1	3190	1878	3190	1878	0	0	56780	56780
10	2017	0.028	0	0.03	439512	0.64	0.64	0	0.53	1	0.1	11540	7439	11539	7439	1	0	232355	232355
1	2018	0.119	0.12	0	**969504**	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837	3427	0	32963
2	2018	0.184	0.18	0	1255103	0.09	0.25	0.08	0.08	0.5	0.1	201226	17272	4596	1152	196629	16124	49158	98316
3	2018	0.241	0.18	0.06	798341	0.16	0.28	0.13	0.13	0.5	0.1	163113	26691	39820	11150	123293	15535	52557	105115
4	2018	0.244	0.09	0.15	434426	0.25	0.31	0.15	0.2	1	0.1	89829	22583	55555	17315	34273	5267	87899	87899
5	2018	0.197	0.05	0.15	509293	0.31	0.36	0.16	0.28	1	0.1	86966	27310	66786	23976	20180	3330	144469	144469
6	2018	0.142	0.02	0.13	320234	0.38	0.4	0.19	0.34	1	0.1	40319	15352	35850	14483	4469	858	110160	110160
7	2018	0.097	0.01	0.09	229435	0.45	0.47	0.21	0.4	1	0.1	20104	9088	18950	8856	1155	246	91621	91621
8	2018	0.056	0	0.05	236272	0.5	0.52	0.26	0.45	1	0.1	12224	6062	11307	5883	917	238	106559	106559
9	2018	0.028	0	0.03	163987	0.59	0.59	0.3	0.47	1	0.1	4306	2534	4305	2534	1	0	76636	76636
10	2018	0.028	0	0.03	493621	0.64	0.64	0	0.53	1	0.1	12961	8354	12959	8354	1	0	260961	260961
1	2019	0.119	0.12	0	**969504**	0.03	0.07	0.03	0.03	0	0.1	103838	3427	1	0	103837	3427	0	32963
2	2019	0.184	0.18	0	778609	0.09	0.25	0.08	0.08	0.5	0.1	124831	10715	2851	715	121980	10002	30496	60991
3	2019	0.241	0.18	0.06	944625	0.16	0.28	0.13	0.13	0.5	0.1	193001	31582	47117	13193	145884	18381	62188	124376
4	2019	0.244	0.09	0.15	567587	0.25	0.31	0.15	0.2	1	0.1	117363	29505	72584	22622	44779	6881	114842	114842
5	2019	0.197	0.05	0.15	307846	0.31	0.36	0.16	0.28	1	0.1	52567	16508	40369	14493	12198	2013	87326	87326
6	2019	0.142	0.02	0.13	378273	0.38	0.4	0.19	0.34	1	0.1	47626	18134	42347	17108	5279	1014	130126	130126
7	2019	0.097	0.01	0.09	251468	0.45	0.47	0.21	0.4	1	0.1	22035	9961	20769	9706	1265	270	100420	100420
8	2019	0.056	0	0.05	188501	0.5	0.52	0.26	0.45	1	0.1	9753	4836	9021	4694	732	190	85014	85014
9	2019	0.028	0	0.03	202170	0.59	0.59	0.3	0.47	1	0.1	5308	3125	5307	3124	1	0	94481	94481
10	2019	0.028	0	0.03	578614	0.64	0.64	0	0.53	1	0.1	15192	9793	15190	9793	2	0	305894	305894

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ICES. 2013. Report of the Inter-Benchmark Protocol for Plaice in Subarea 4 (IBP Plaice), April 2013, By correspondence. ICES CM 2013/ACOM:63. 78 pp.

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7.7 Sole in Subarea 4

7.7.1 Short term forecast and June advice

At WGNSSK 2017 (ICES, 2017), the following short term forecast settings were used:

Table 7.7.1 spring assumption recruitment table

Year Class	Age in 2017	AAP thousands	RCT3 thousands	GM (1957–2013) thousands
2015	2	42068	57339	98980
2016	1		86425	112078
2017	Recruit (0)			112078

Population numbers in the intermediate year for age 2 are taken from the AAP survivor estimates. Numbers at age 1 in 2017 are taken from the RCT3 output and age 1 in 2018 are taken from the long-term geometric mean. Both age 1 and age 2 assumptions are checked with the new survey information.

7.7.2 New survey information.

There is new survey information available from the quarter three Beam Trawl Survey (BTS), that was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole.

The survey was not conducted on the RV Isis but on the RV Tridens this year. The RV Tridens was equipped with the original gears of the RV Isis BTS survey.

7.7.3 RCT3 Analysis

The RCT3 analysis on the "BTS ISIS" survey indices for age 1 and age 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES, 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 42 years including the assessment estimates are presented in Table 7.7.2. In autumn 2017, the new data derived from the recently conducted "BTS-ISIS" survey comprises age 1 of year class 2016 and age 2 of year class 2015.

Table 7.7.2. North Sea sole RCT3 input data for age 1 and age 2

yearclass	N_Age_1	N_Age_2	DFS0	SNS0	SNS1	BTS1	BTS2
1975	136518	120973	NA	577.5	1399.4	NA	NA
1976	168197	149389	NA	464.6	3742.9	NA	NA
1977	63044.3	56504.9	NA	1585	1547.7	NA	NA
1978	18291.3	16465.7	NA	10370.5	93.8	NA	NA
1979	187369	168599	NA	3922.7	4312.9	NA	NA
1980	221990	198541	NA	5145.8	3737.2	NA	NA
1981	200654	177122	NA	3240.7	5856.5	NA	NA
1982	197456	173556	NA	2147	2621.1	NA	NA
1983	94911.2	84288.8	NA	769.1	2493.1	NA	7.121
1984	115068	103152	NA	3334	3619.4	7.031	5.183
1985	167104	150464	NA	2713.4	3705.1	7.168	12.548
1986	82857.6	74742.7	NA	742	1947.9	6.973	12.512
1987	667131	602167	NA	13610.1	11226.7	83.111	68.084
1988	133529	120510	NA	522.7	2830.7	9.015	24.487
1989	253242	228340	NA	1743.4	2856.2	37.839	28.841
1990	91031.4	81887.4	6.38	50.8	1253.6	4.035	22.284
1991	448133	401062	167.56	3639.7	11114	81.625	42.345
1992	87271.7	77465.2	9.27	302.9	1290.8	6.35	7.121
1993	63189.1	55705.8	15.32	231.3	651.8	7.66	8.458
1994	110762	97551.7	22.06	4692.7	1362.1	28.125	7.634
1995	75317.6	66452.6	7.06	1374.9	218.4	3.975	4.919
1996	336195	296696	40.27	2322.3	10279.3	169.343	27.422
1997	156889	138214	26.94	803	4094.6	17.108	18.363
1998	118445	104134	NA	327.9	1648.9	11.96	6.144
1999	138196	121424	NA	2187.9	1639.2	14.594	9.963
2000	71605	62879	9.5	70	970.3	7.998	4.182
2001	220969	193382	51.42	8340	7547.5	20.989	9.947
2002	99002.7	85892.4	58.58	1127.7	NA	10.507	4.354
2003	53342.1	45847.2	10.61	NA	1369.5	4.192	3.395
2004	49858.3	42906.9	31.25	162	568.1	5.534	2.332
2005	181664	158395	40.99	305	2726.4	17.089	19.504
2006	68706.6	60556.6	12.57	16	848.6	7.498	9.062
2007	78724.3	69598.2	13.73	466.9	1259.1	15.247	4.999
2008	103983	91599.9	11.77	754.7	1931.6	15.95	10.707
2009	221683	194161	27.33	2291	2636.9	54.811	17.387
2010	219556	192086	42.86	333.9	1248	26.166	18.212
2011	56462.5	49541.1	12.13	136.3	226.6	5.149	3.558
2012	127683	111999	11.23	144.7	967.4	6.844	15.576
2013	NA	212710	44.82	237.3	2849	18.926	25.601
2014	NA	NA	23.62	126	3192	21.099	11.832
2015	NA	NA	7.45	109.7	733.8	6.454	7.098
2016	NA	NA	12.28	373.2	NA	16.279	NA

7.7.4 Update protocol calculations

The autumn update protocol checks the spring assumptions of age 1 and age 2 with the new information.

The D value for age 1 is 1.480402, significantly different from the spring assumption (D < 1). The D-value for age 2 is 1.43872, also significantly different from the spring assumption.

Hence, **the short-term forecast is re-run** with a full RCT3 for age 1 and age 2.

The outcomes from the RCT3 analyses for the ages 1 and 2 are presented in Table 7.7.3.

Table 7.7.3 North Sea sole RCT3 output for age 1 and age 2 - D calculation

```
Analysis by RCT3 ver4.0

Data for 1 surveys over 42 years : 1975 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
    index  slope intercept     se rsquare  n indices prediction se.pred
     BTS1 0.7646     9.757 0.3939  0.7327 29    2.79      11.89  0.4155
 VPA Mean     NA        NA     NA      NA 38      NA      11.73  0.6728
 WAP.weights
           1
           0

                  WAP logWAP int.se
yearclass:2016 145853  11.89 0.3535
```

Spring assumption for age 1: 86 425; log(86 425) = 11.36703

Calculations for age 1	
Log WAP from RCT3 (R)	11.89035
Log of recruitment assumed in spring (A)	11.367039
Int SE of log WAP (S)	0.3535
Distance D $\left(D = \dfrac{R-A}{S}\right)$	**1.480402**

```
Analysis by RCT3 ver4.0

Data for 1 surveys over 42 years : 1975 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2015
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS2 0.9234     9.441 0.3926  0.7316 30    1.96      11.25  0.4147           1
 VPA Mean     NA        NA     NA      NA 38      NA      11.61  0.6755           0

                 WAP logWAP int.se
yearclass:2015 76958  11.25 0.3534
```

Spring assumption for age 2: 42068; log(42068) = 10.64704

Calculations for age 1	
Log WAP from RCT3 (R)	11.25
Log of recruitment assumed in spring (A)	10.64704
Int SE of log WAP (S)	0.3534
Distance D $\left(D = \frac{R-A}{S}\right)$	**1.70**

7.7.5 Revised forecast

7.7.5.1 Full RCT3 analyses

Since the new information from the surveys indicate a substantial difference in perceived recruitment compared to the spring assumptions, a new STF is run. To this end, we first recalculated the RCT3 recruitment estimates (for age 1 and age 2) using the full set of surveys that is now available (DFS, SNS, and BTS). The settings are the same as during the demersal working group in spring (WGNSSK, 2017). The results are in Table 7.7.4.

Table 7.7.4 North Sea sole full RCT3 output for age 1 and 2 with all available survey information.

Age 1

```
Analysis by RCT3 ver4.0

Data for 4 surveys over 42 years : 1975 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2016
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     DFS0 1.0302     8.534 0.6022  0.5284 21   2.508      11.12  0.6537     0.21767
     SNS0 1.0501     4.623 1.4964  0.1697 37   5.922      10.84  1.5659     0.03794
     SNS1 0.7572     6.032 0.4131  0.7365 37      NA         NA      NA          NA
     BTS1 0.7646     9.757 0.3939  0.7327 29   2.790      11.89  0.4155     0.53887
 VPA Mean     NA        NA     NA      NA 38      NA      11.73  0.6728     0.20552

                  WAP logWAP int.se
yearclass:2016 114581  11.65  0.305
```

D value with full RCT3: (log(114581) – log(86425)) / 0.305 = 0.9246066

Age 2

```
Analysis by RCT3 ver4.0

Data for 5 surveys over 42 years : 1975 - 2016
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as    .00
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2015
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     DFS0 1.0444     8.362 0.6161  0.5197 21   2.008     10.459  0.6859     0.10013
     SNS0 1.0398     4.571 1.4779  0.1740 37   4.698      9.456  1.5778     0.01893
     SNS1 0.7591     5.896 0.4128  0.7383 37   6.598     10.905  0.4347     0.24936
     BTS1 0.7749     9.606 0.4043  0.7259 29   1.865     11.051  0.4303     0.25444
     BTS2 0.9234     9.441 0.3926  0.7316 30   1.960     11.251  0.4147     0.27391
 VPA Mean     NA        NA     NA      NA 38      NA     11.606  0.6755     0.10323

                 WAP logWAP int.se
yearclass:2015 62152  11.04 0.2171
```

D value with full RCT3: (log(62152) – log(42068)) / 0.2171 = 1.79777

The updated recruitment table is in Table 7.7.5.

Table 7.7.5: updated recruitment table (spring assumptions are in *italics*.

Year Class	Age in 2017	AAP thousands	RCT3 thousands	GM (1957–2013) thousands
2015	2	(*42 068*)	62 512 (*57 339*)	98 980
2016	1		114 581 (*86 425*)	112 078
2017	Recruit (0)			112 078

The updated forecast tables, assuming only age 1 in 2017 is updated, are in Table 7.7.6 and 7.7.7. These forecast tables are illustrative only and are not used for re-opening.

Table 7.7.6. Forecast assumptions assuming only age 1 in 2017 is updated

Variable	Value	Source	Notes
F ages 2–6 (2017)	0.205	ICES (2017a)	TAC constraint for total catch based on TAC for 2017 (16123 tonnes)
SSB (2018)	63488	ICES (2017a)	Short-term forecast (STF), tonnes.
Rage1 (2017)	114581	ICES (2017a)	RCT3, thousands.
Rage1 (2018)	112078	ICES (2017a)	Geometric mean (GM, 1957–2013), thousands.
Total catch (2017)	16123	ICES (2017a)	Short-term forecast (STF), tonnes.
Commercial landings (2017)	14991	ICES (2017a)	Average landings rate by age 2014–2016, tonnes.
Unwanted catch (2017)	1132	ICES (2017a)	Average discard rate by age 2014–2016, tonnes.

Table 7.7.7. Short-term forecast assuming only age 1 in 2017 is updated

basis	catch	landings	Discards	f2-6	f_hc2-6	f_dis1-3	SSB 2019	% SSB change	% TAC change
Fmp	15227.85	14265.57	962.2729	0.200	0.171	0.048	64023.3	0.84	-5.55
Fmsy	15227.85	14265.57	962.2729	0.200	0.171	0.048	64023.3	0.84	-5.55
Fsq*0	0	0	0	0.000	0.000	0.000	78090.8	23.00	-100.00
Fpa	29840.75	27900.19	1940.56	0.440	0.376	0.105	50623.9	-20.26	85.08
Flim	38707.49	36138.01	2569.477	0.620	0.530	0.147	42560.0	-32.96	140.08
SSB>Bpa	44864.9	41838.16	3026.742	0.767	0.655	0.182	37000.0	-41.72	178.27
SSB>Blim	56860.52	52877.49	3983.029	1.133	0.968	0.269	26300.0	-58.58	252.67
SSB>MSY Btrig	44864.9	41838.16	3026.742	0.767	0.655	0.182	37000.0	-41.72	178.27
TACsq	16123	15102.52	1020.476	0.213	0.182	0.051	63199.3	-0.46	0.00
Fsq*1	15562.59	14578.57	984.0142	0.205	0.175	0.049	63715.1	0.36	-3.48

If both age 1 and age 2 are updated (because the new survey information suggests that the survivors used in spring are an underestimate), then we get tables 7.7.8 and 7.7.9. This option follows the approach used in previous years, and is used for re-opening.

Table 7.7.8. Forecast assumptions assuming both age 1 age 2 in 2017 are updated

Variable	Value	Source	Notes
F ages 2–6 (2017)	0.201	ICES (2017a)	TAC constraint for total catch based on TAC for 2017 (16 123 tonnes)
SSB (2018)	66060	ICES (2017a)	Short-term forecast (STF), tonnes.
Rage1 (2017)	114581	ICES (2017a)	RCT3, thousands.
Rage1 (2018)	112078	ICES (2017a)	Geometric mean (GM, 1957–2013), thousands.
Total catch (2017)	16123	ICES (2017a)	Short-term forecast (STF), tonnes.
Commercial landings (2017)	14942	ICES (2017a)	Average landings rate by age 2014–2016, tonnes.
Unwanted catch (2017)	1181	ICES (2017a)	Average discard rate by age 2014–2016, tonnes.

Table 7.7.9. Short-term forecast assuming both age 1 age 2 in 2017 are updated

basis	catch	landings	Discards	f2-6	f_hc2-6	f_dis1-3	SSB 2019	% SSB change	% TAC change
Fmp	15726.09	14702.5	1023.597	0.200	0.171	0.048	66383.22	0.49	-2.46
Fmsy	15726.09	14702.5	1023.597	0.200	0.171	0.048	66383.22	0.49	-2.46
Fsq*0	0	0	0	0.000	0.000	0.000	80919.3	22.49	-100.00
Fpa	30830.22	28767.63	2062.593	0.440	0.376	0.105	52523.5	-20.49	91.22
Flim	40002.13	37272.76	2729.369	0.620	0.530	0.147	44174.71	-33.13	148.11
SSB>Bpa	47946.24	44610.36	3335.879	0.807	0.689	0.192	37000	-43.99	197.38
SSB>Blim	59951.39	55628.86	4322.533	1.174	1.003	0.279	26300	-60.19	271.84
SSB>MSYBtrig	47946.24	44610.36	3335.879	0.807	0.689	0.192	37000	-43.99	197.38
TACsq	16123	15072.88	1050.122	0.206	0.176	0.049	66017.58	-0.06	0.00
Fsq*1	15816	14786.82	1029.632	0.201	0.172	0.048	66299.97	0.36	-1.90

References

ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2017. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM.

7.8 North Sea *Nephrops*

7.8.1 *Nephrops* FU6 (Farn Deeps)

The annual underwater TV survey of the Farn Deeps area was undertaken 19 – 26th June 2017 (Figures 7.8.1.1 and 7.8.1.2).

The survey was completed without any technical issues and the visibility was again excellent. All 110 stations were completed with valid counts generated using the standard protocols for counting and quality assurance.

Total abundance in 2017 is estimated to be 902 million with a 95% CI of 21 million (Table 7.8.1.1). The advice in June 2017 was based upon the 2016 survey which showed 697 million with a 95% CI of 19 million. The increase in abundance from 2016 to 2017 was 205 million, well beyond the confidence envelope of the 2016 survey. In addition, the estimated abundance in 2017 (and its confidence intervals) are above the MSY $B_{trigger}$ (858 million) (Figure 7.8.1.1).

<u>It is therefore recommended that the advice be reopened.</u>

Catch and landing predictions for 2018 are given in the text table below. This assumes that the absolute abundance estimate made in June 2017 is relevant to the stock status for 2018. As the stock is now above MSY Btrigger, no adjustment to the MSY harvest rate is required, so the full 8.12% is used.

Headline advice for total catch (assuming the current discarding arrangements continue) is 1876 t (compared to 1178t in the June 2017 advice).

The updated catch tables are shown below.

Catch options for 2018 assuming zero discards

Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
ICES advice basis				
MSY approach	1808	1615	193	8.12%
Other options				
$F_{2014–2016}$	2819	2518	300	12.66%

* Wanted" and "unwanted" catch are used to described Norway lobster that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2014–2016.

** Calculated for dead removals and applied to total catch.

Discarding assumed to continue at recent average

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
ICES advice basis						
MSY approach	1876	1846	1676	170	30	8.12%
Other options						
$F_{2014–2016}$	2925	2878	2613	265	47	12.66%

* Calculated for dead removals and applied to total catch.

*Discarding assumed below MCS only**

Basis	Total catch	Dead removals	Landings	Unwanted > MCRS**	Dead discards < MCRS	Surviving discards	Harvest rate***
	L+DD+SD	L+DD	L	L	DD	SD	for L+DD
ICES advice basis							
MSY approach	1835	1828	1640	145	43	8	8.12%
Other options							
$F_{2014–2016}$	2861	2849	2556	225	68	12	12.66%

* Assumed for all fleets.

** Unwanted landings (U) are animals >MCS that have historically been discarded.

*** Calculated for dead removals.

Table 7.8.1.1. Results of the UWTV surveys for FU6 *Nephrops*

Year	Stations	Season	Mean density (burrows·m^{-2})	Absolute Abundance (millions)	95% confidence interval (millions)	Method
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn		No survey		Box
2000	-	Autumn		No survey		Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	73	Autumn	0.33	1085	90	Box
2004	76	Autumn	0.43	1377	101	Box
2005	105	Autumn	0.49	1657	148	Box
2006	105	Autumn*	0.37	1244	114	Box
2007	105	Autumn*	0.28	858	23	Geostatistics
2008	95	Autumn*	0.31	987	39	Geostatistics
2009	76	Autumn*	0.22	682	38	Geostatistics
2010	95	Autumn*	0.25	785	21	Geostatistics
2011	97	Autumn*	0.28	878	17	Geostatistics
2012	97	Autumn*	0.24	758	13	Geostatistics
2013	110	Summer	0.23	706	18	Geostatistics
2014	110	Summer	0.24	755	18	Geostatistics
2015	110	Summer	0.18	565	13	Geostatistics
2016	110	Summer	0.22	697	19	Geostatistics
2017	110	Summer	0.29	902	20.6	Geostatistics

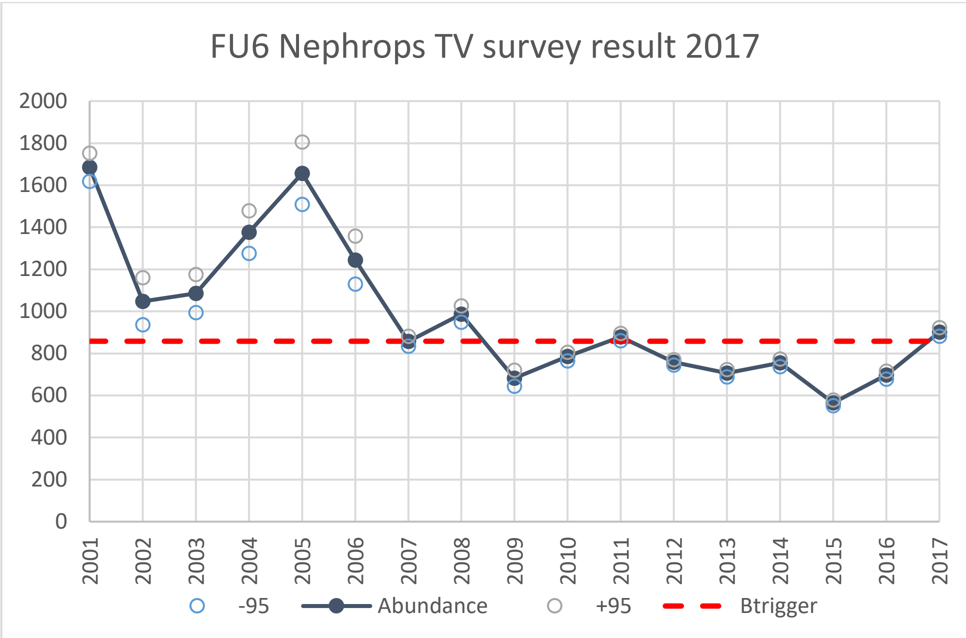

Figure 7.8.1.1. FU6 UWTV survey history

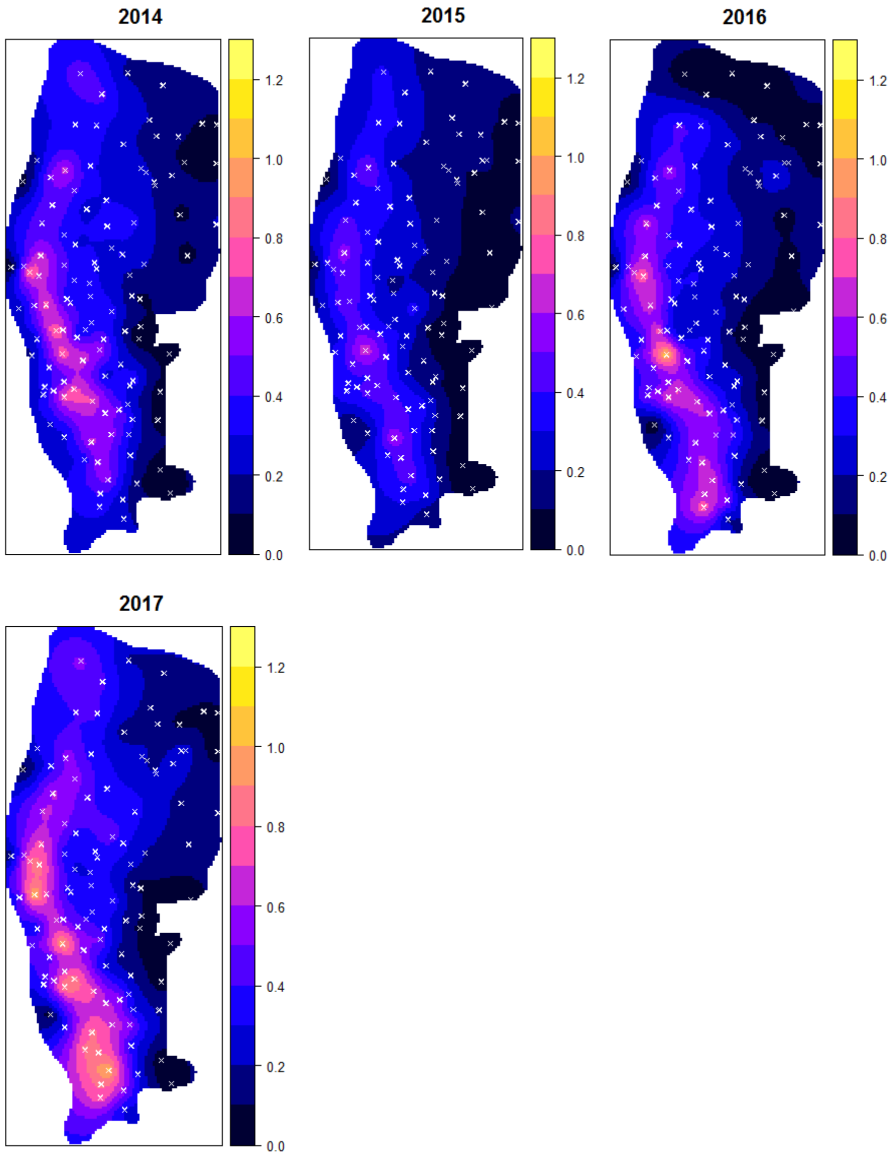

Figure 7.8.1.2. FU6 UWTV density maps (burrows·m-2) 2014–2017

7.8.2 *Nephrops* FU7 (Fladen)

The most recent UWTV survey for this stock was carried out in June 2017. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2017 advice and based on the 2016 survey was 4449 million with a 95 % CI of 662 million (Table 7.8.2.1; Figure 7.8.2.1 and 7.8.2.2). The estimate from the 2017 summer survey is 7036 million (58% increase on the 2016 value). The 2017 value is significantly different from that of 2016 (ACOM specifies 1 SD, this is well over the specified threshold) and therefore **the advice for FU7 may be reopened**.

The large abundance increase in 2016–2017 is likely to be related to a strong recruitment event. The size of *Nephrops* burrows is not quantified in the TV surveys but burrow counters participating in the last survey reported a large number of small burrows in FU7, in particular in 2016. In 2017, increased amounts of small *Nephrops* were reported anecdotally in the Fladen fishery by both fishermen and scientific staff working on-board FU7 vessels. To confirm this, 2017 sampling information (landings and discards) from FU7 were analysed (year 2017, quarters 1–3). Preliminary results in 2017 confirm a large decrease in the mean weight in landings (Figure 7.8.2.3), mean sizes in catches (Figure 7.8.2.4) and an increase in the discard rate by number to 14.6% (in 2011–2016 discard rates were close to zero). Landings in 2017 have also increased and from January to September total catches were higher than in the previous 2 years (Figure 7.8.2.5).

The mean weights for this stock have increased in the period 2010–2016. The most recent (preliminary 2017) estimate is significantly lower than the 3 year average used in the forecast (Figure 7.8.2.3). The evidence from sampling and survey data support a reduction in mean weights in the stock but there is no methodology to take this into account in the calculation of catch options, in particular if there are changes in the advice year. A long-term mean weight and discard rate (e.g. from 2000–2016) should be considered in this situation for the calculation of catch options. This approach has been recently used in FU16 (WGCSE, 2016) where a recruitment event was also recorded in recent years.

Two sets of catch options are provided for FU7: (i) unwanted catches assumed zero and mean weights based on the recent average, 2014–16 (Tables 7.8.2.2a-b; note that discard rates being zero implies that the other discard assumptions presented for scenario ii are not needed here); (ii) discard rates and mean weights based on a long term average, 2000–16 (Tables 7.8.2.3a-d). The catch prediction for 2018 under the landing obligation assuming mean weights based on a recent average (scenario i) is 20 976 tonnes. Under scenario ii the catch prediction for 2018 assuming mean weights, discard rates and fishery selection patterns do not change from the long term average (2000–2016) following the MSY approach is 16 577 tonnes. The June advice was 13 264 tonnes.

Table 7.8.2.1. ***Nephrops*****, Fladen (FU 7): Results of the 1992 –2017 TV surveys.**

Year	Stations	Abundance (millions)	Mean density (burrows/m2)	95% confidence interval (millions)
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996			No survey	
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	335
2014	70	2990	0.11	412
2015	71	2569	0.091	320
2016	78	4449	0.16	662
2017	71	7036	0.250	968

Table 7.8.2.2a. FU7 basis for the catch options assuming unwanted catches to be zero (recent average)

Variable	Value	Source	Notes
Stock abundance	7036 million	ICES (2017a)	UWTV 2017
Mean weight in landings	39.75 g	ICES (2017a)	Average 2014–2016
Mean weight in discards	-	ICES (2017a)	No discards in 2015–2016
Mean weight in unwanted catch >MCS	-	ICES (2017a)	No discards in 2015–2016
Mean weight in unwanted catch < MCS	-	ICES (2017a)	No discards in 2015–2016
Discard rate (total)	0%	ICES (2017a)	No discards in 2015–2016
Discard rate (>MCS)	0%	ICES (2017a)	No discards in 2015–2016
Discard rate (< MCS)	0%	ICES (2017a)	No discards in 2015–2016
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios where discarding is allowed.
Dead discard rate (total)	0%	ICES (2017a)	No discards in 2015–2016
Dead discard rate (< MCS)	0%	ICES (2017a)	No discards in 2015–2016

Table 7.8.2.2b. Revised Advice table assuming zero discards

Basis	Total catches	Wanted	Unwanted	Harvest
ICES advice basis				
MSY approach	20976	20976	0	7.5%
Other options				
F_{2016}	3916	3916	0	1.4%
$F_{2014–2016}$	6433	6433	0	2.3%
$F_{35\%SpR}$	31324	31324	0	11.2%
F_{max}	45868	45868	0	16.4%

* Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2015–2016.

** Calculated for dead removals and applied to total catch.

Catch options assuming that discarding continues at the recent average or that discarding would only occur below the MCS are equivalent to the above because the observed discard rate is negligible.

Table 7.8.2.3a FU7 basis for the catch options with long term average for mean weights and discards

Variable	Value	Source	Notes
Stock abundance	7036 m	ICES (2017a)	UWTV 2017
Mean weight in landings	32.08 g	ICES (2017a)	Average 2000–2016
Mean weight in discards	15.12 g	ICES (2017a)	Average 2000–2016
Mean weight in unwanted catch >MCS	16.36 g	ICES (2017a)	Average 2000–2016
Mean weight in unwanted catch < MCS	7.53 g	ICES (2017a)	Average 2000–2016
Discard rate (total)	7.3%	ICES (2017a)	Average 2000–2016 (proportion by number)
Discard rate (>MCS)	6.3%	ICES (2017a)	Average 2000–2016 (proportion by number)
Discard rate (< MCS)	1%	ICES (2017a)	Average 2000–2016 (proportion by number)
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios where discarding is allowed.
Dead discard rate (total)	5.6%	ICES (2017a)	Average 2000–2016 (proportion by number), only applies in scenarios where discarding is
Dead discard rate (< MCS)	0.8%	ICES (2017a)	Average (proportion by number) 2000–2016, only applies in scenarios where discarding is allowed below minimum conservation size

Table 7.8.2.3b. Revised Advice table assuming discarding continues at long term average

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
ICES advice basis						
MSY approach	16577	16428	15981	447	149	7.5%
Other options						
F_{2016}	3094	3066	2983	83	28	1.4%
$F_{2014–2016}$	5084	5038	4901	137	46	2.3%
$F_{35\%SpR}$	24753	24531	23864	667	222	11.2%
F_{max}	36247	35921	34944	977	326	16.4%

* Calculated for dead removals.

Table 7.8.2.3c. Revised Advice table assuming zero discards

Basis	Total catches	Wanted catches*	Unwanted catches*	Harvest rate**
ICES advice basis				
MSY approach	16275	15693	582	7.5%
Other options				
F_{2016}	3038	2929	109	1.4%
$F_{2014–2016}$	4991	4812	179	2.3%
$F_{35\%SpR}$	24305	23435	870	11.2%
F_{max}	35589	34315	1274	16.4%

* Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2014–2016.

** Calculated for dead removals and applied to total catch.

Table 7.8.2.3d. Revised Advice table assuming discarding below MCS only*

Basis	Total catch	Dead removals	Landings (wanted catch)	Unwanted >MCS**	Dead discards < MCS	Surviving discards	Harvest rate***
	L+U+DD+SD	L+U+DD	L	U	DD	SD	for L+U+DD
ICES advice basis							
MSYapproach	16312	16301	15724	545	32	11	7.5%
Other options							
F_{2016}	3045	3043	2935	102	6	2	1.4%
$F_{2014–2016}$	5002	4999	4822	167	10	3	2.3%
$F_{35\%SpR}$	24358	24342	23481	814	47	16	11.2%
F_{max}	35668	35645	34383	1192	70	23	16.4%

* Assumed for all fleets.

** Unwanted landings (U) are animals >MCS that have historically been discarded.

*** Calculated for dead removals.

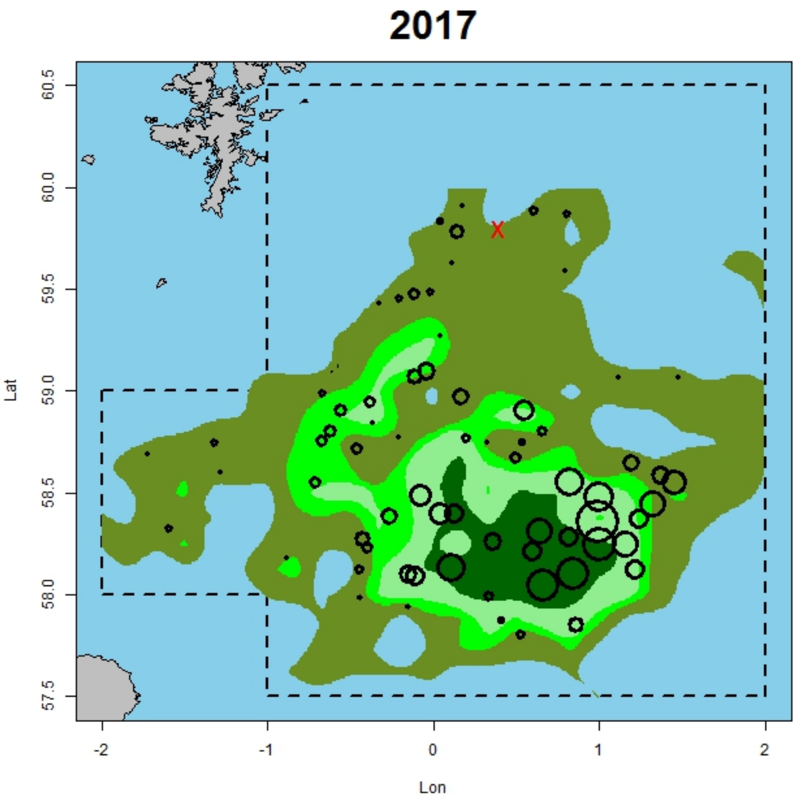

Figure 7.8.2.1. *Nephrops*, Fladen (FU 7). TV survey distribution and relative density in 2017. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

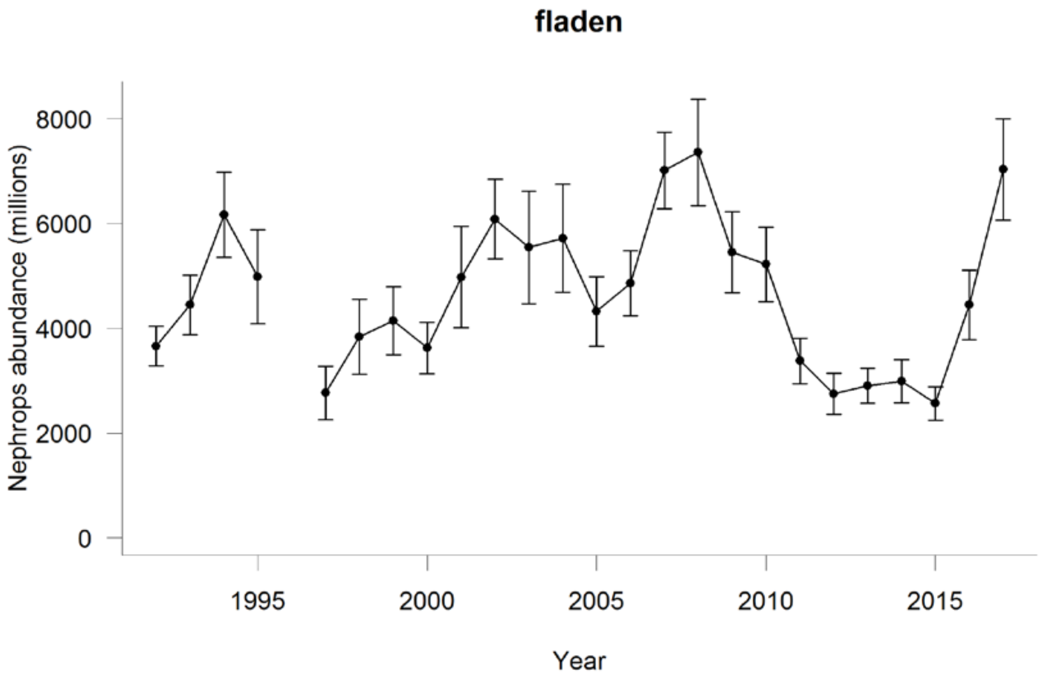

Figure 7.8.2.2. ***Nephrops*, Fladen (FU 7): Results of the 1992–2017 TV surveys.**

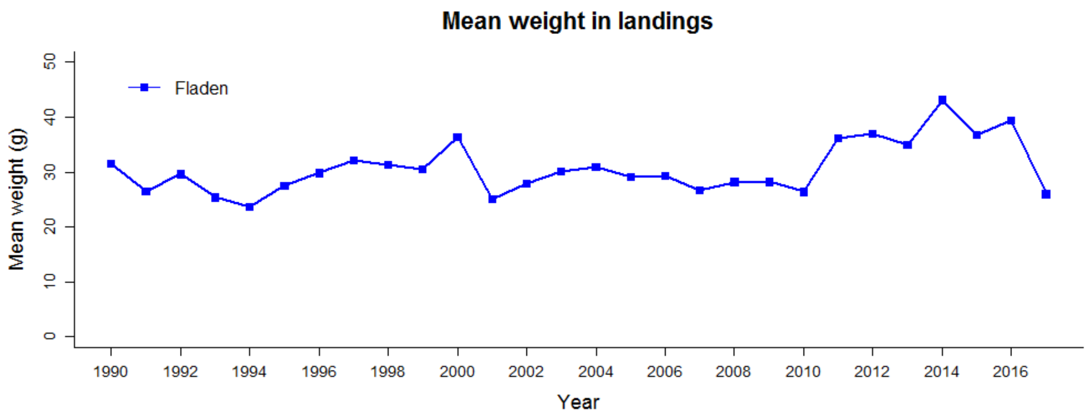

Figure 7.8.2.3 ***Nephrops*, Fladen (FU 7): Individual mean weight (g) in the landings from 1990–2017 (Scottish market sampling data). Year 2017 was based on preliminary data (quarters 1–3).**

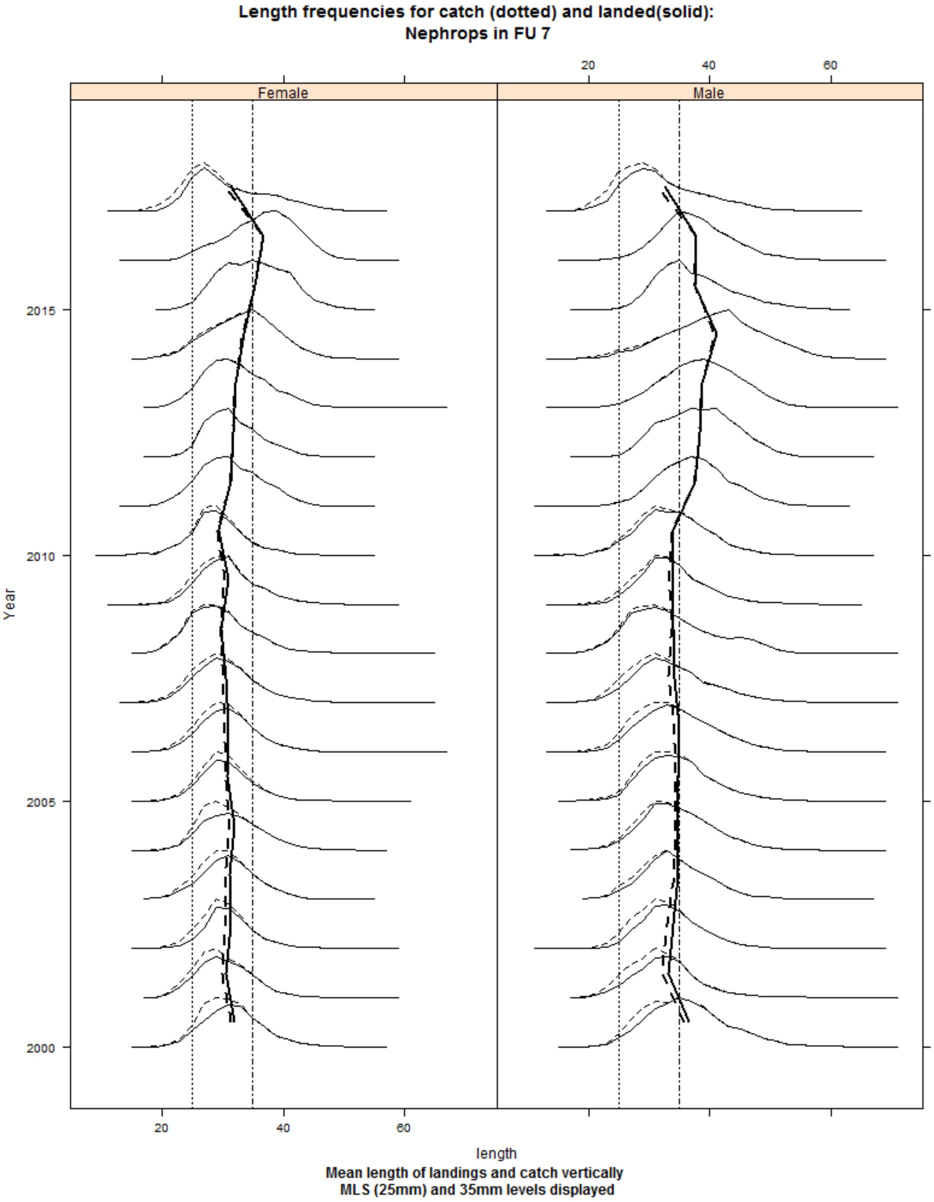

Figure 7.8.2.4. ***Nephrops*****, Fladen (FU 7): Length composition of catch of males (right) and females left from 2000 (bottom) to 2017 (top). Year 2017 was based on preliminary data (quarters 1–3).**

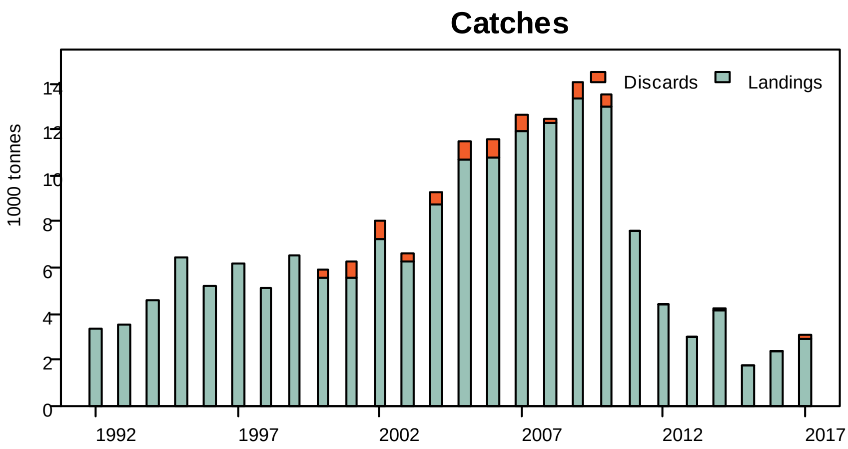

Figure 7.8.2.5 *Nephrops*, Fladen (FU 7): Time series of catches. Year 2017 was based on preliminary data (quarters 1–3).

7.8.3 *Nephrops* FU8 (Firth of Forth)

The most recent UWTV survey for this stock was carried out in August 2017. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2017 advice and based on the 2016 survey is 797 million with a 95 % CI of 146 million (Table 7.8.3.1; Figure 7.8.3.1 and 7.8.3.2). The estimate from the 2017 summer survey is 670 million (16% decrease on the 2016 value). The 2017 value is significantly different from that of 2016 (ACOM specifies 1 SD, this is approximately 2 SD) and therefore **the advice for FU8 may be reopened**.

The advice for 2018 for Category 1 stocks (where assessment includes landings and discards data) is based on catches. Assuming discard rates and fishery selection patterns do not change from the average of 2014–2016 (Table 7.8.3.2), the catch prediction for 2018 under the landing obligation following the MSY approach is 2376 tonnes (Table 7.8.3.3; the June advice was 2826 tonnes). Mean weights and discard rates have not been revised in October 2017 (as this update has only new 2017 summer survey data), so the update of the advice is only due to the change in the abundance estimate. Discards survival for *Nephrops* in FU8 is assumed to be 25%. ICES was also requested to provide two extra catch options table assuming zero discards (Table 7.8.3.4) and assuming discarding occurs below MCS only (Table 7.8.3.5).

Table 7.8.3.1. *Nephrops*, Firth of Forth (FU 8): Results of the 1993–2017 TV surveys.

Year	Stations	Mean Density (burrows/m²)	Abundance (millions)	95% conf interval (millions)
1993	37	0.61	555	142
1994	30	0.49	448	78
1995		no survey		
1996	27	0.41	375	88
1997		no survey		
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125
2014	51	0.47	428	80
2015	51	0.73	664	127
2016	50	0.87	797	146
2017	52	0.73	670	133

Table 7.8.3.2. *Nephrops*, Firth of Forth (FU 8) basis for the catch options

Variable	Value	Source	Notes
Stock abundance	670 million individuals	ICES (2017a)	UWTV 2017
Mean weight in landings	23.25 g	ICES (2017a)	Average 2014–2016
Mean weight in discards	10.75 g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch >MCS	13.98 g	ICES (2017a)	Average 2014–2016
Mean weight in unwanted catch < MCS	7.22 g	ICES (2017a)	Average 2014–2016
Discard rate (total)	21.2%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (>MCS)	11.1%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard rate (< MCS)	10.1%	ICES (2017a)	Average 2014–2016 (proportion by number)
Discard survival rate	25%	ICES (2017a)	Proportion by number, only applies in scenarios where discarding is allowed.
Dead discard rate (total)	16.8%	ICES (2017a)	Average 2014–2016 (proportion by number), only applies in scenarios where discarding is allowed.
Dead discard rate (< MCS)	7.8%	ICES (2017a)	Average (proportion by number) 2014–2016, only applies in scenarios where discarding is allowed below minimum conservation size (MCS).

Table 7.8.3.3. *Nephrops*, Firth of Forth (FU 8) revised advice table assuming discarding continues at recent average

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
ICES advice basis						
MSY approach	2376	2310	2113	197	66	16.3%
Other options						
$F_{0.1}$	1370	1332	1218	114	38	9.4%
F_{2016}	1793	1743	1594	149	50	12.3%
F_{35SpR}	1851	1800	1646	154	51	12.7%
$F_{2014-2016}$	2827	2749	2514	235	78	19.4%

* Calculated for dead removals.

Table7.8.3.4. ***Nephrops*, Firth of Forth (FU 8) revised advice table assuming zero discards**

Basis	Total catches	Wanted catches*	Unwanted catches*	Harvest rate**
ICES advice basis				
MSY approach	2250	2001	249	16.3%
Other options				
$F_{0.1}$	1298	1154	144	9.4%
F_{2016}	1698	1510	188	12.3%
F_{35SpR}	1753	1559	194	12.7%
$F_{2014-2016}$	2677	2381	296	19.4%

* Wanted" and "unwanted" catch are used to described *Nephrops* that would be landed and discarded in the absence of the EU landing obligation, based on average discard rate estimates for 2014–2016.

** Calculated for dead removals and applied to total catch.

Table 7.8.3.5. ***Nephrops*, Firth of Forth (FU 8) revised advice table assuming discarding below MCS only***

Basis	Total catch	Dead removals	Landings (wanted catch)	Unwanted >MCS**	Dead discards < MCS	Surviving discards	Harvest rate***
	L+U+DD+SD	L+U+DD	L	U	DD	SD	for L+U+DD
ICES advice basis							
MSY approach	2309	2288	2052	174	62	21	16.3%
Other options							
$F_{0.1}$	1330	1318	1183	100	35	12	9.4%
F_{2016}	1740	1725	1548	131	46	15	12.3%
F_{35SpR}	1798	1782	1599	135	48	16	12.7%
$F_{2014-2016}$	2746	2722	2442	207	73	24	19.4%

* Assumed for all fleets.

** Unwanted landings (U) are animals >MCS that have historically been discarded.

*** Calculated for dead removals.

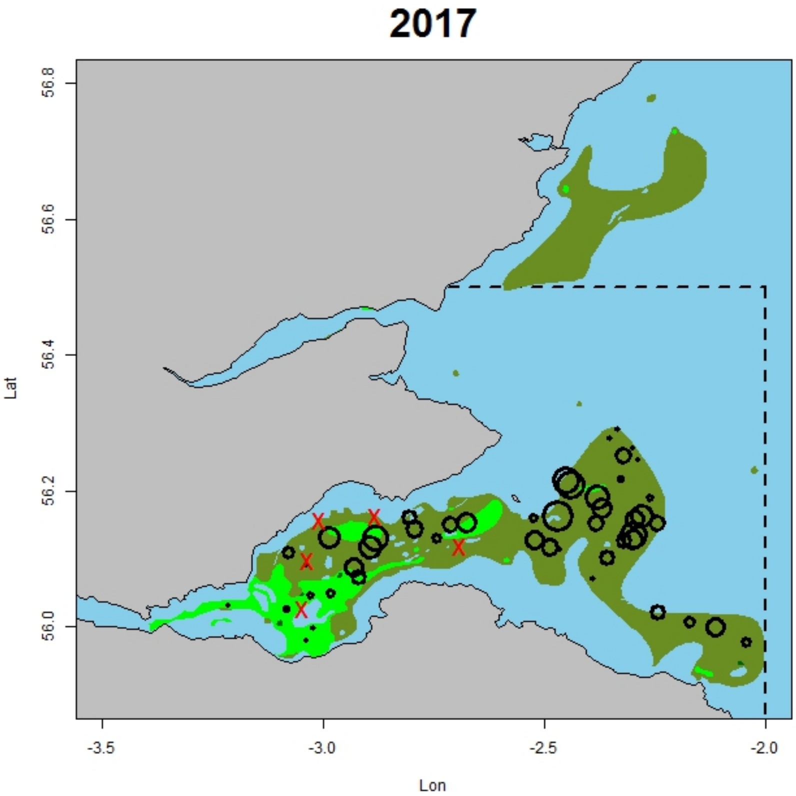

Figure 7.8.3.1. ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density in 2017. Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

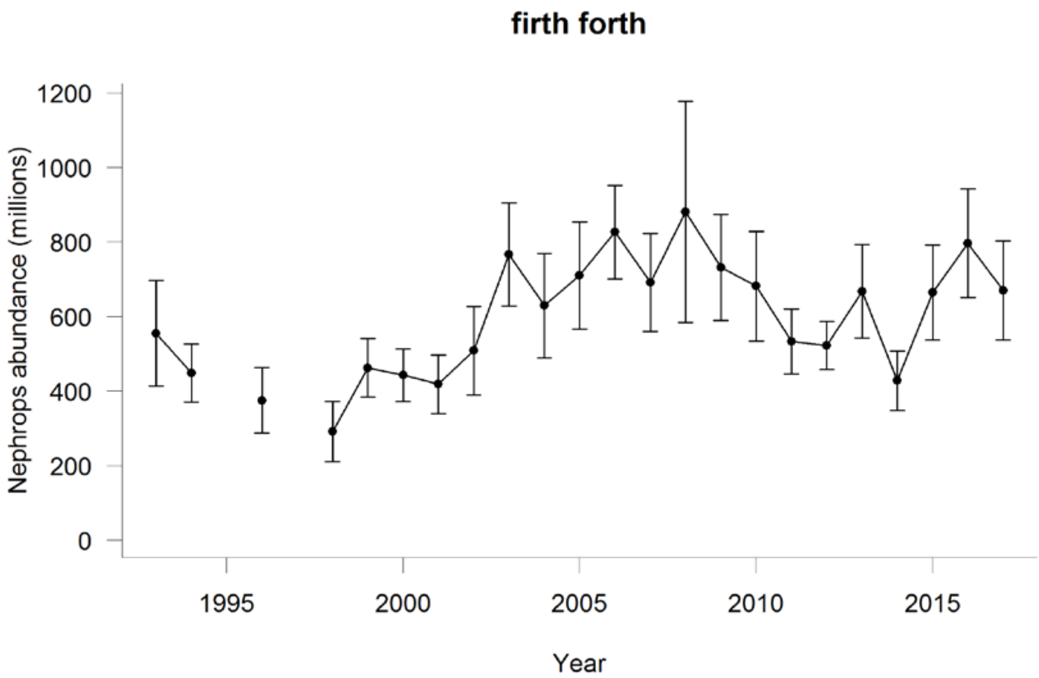

Figure 7.8.3.2. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1992–2017 TV surveys.**

7.8.4 Moray Firth (FU9)

The most recent UWTV survey for this stock was carried out in August 2017. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2017 advice and based on the 2016 survey is 388 million with a 95 % CI of 87 million (Table 7.8.4.1; Figure 7.8.4.1 and 7.8.4.2). The estimate from the 2017 summer survey is 412 million (6% increase on the 2016 value). The 2017 value is just within 1 SD of the 2016 abundance estimate and therefore **the advice for FU9 should not be reopened**.

Table 7.8.4.1. ***Nephrops*****, Moray Firth (FU 9): Results of the 1993-2017 TV surveys.**

Year	Stations	Mean density (burrows/m^2)	Abundance (millions)	95% confidence interval (millions)
1993	31	0.16	345	78
1994	29	0.32	702	176
1995		no survey		
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106
2014	52	0.15	331	90
2015	52	0.16	347	84
2016	53	0.18	388	87
2017	55	0.19	412	106

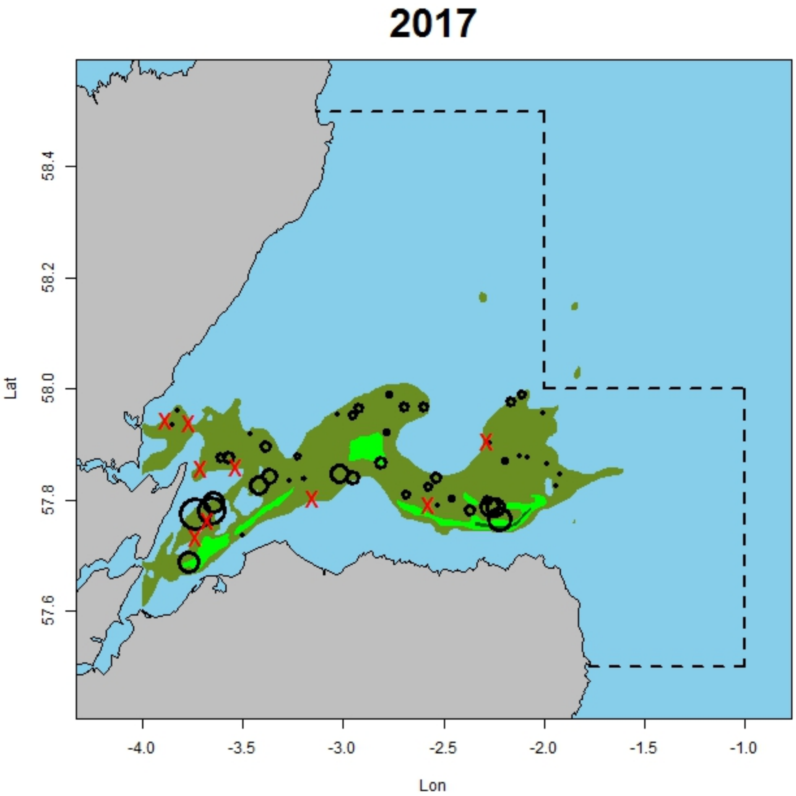

Figure 7.8.4.1. ***Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density in 2017. Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

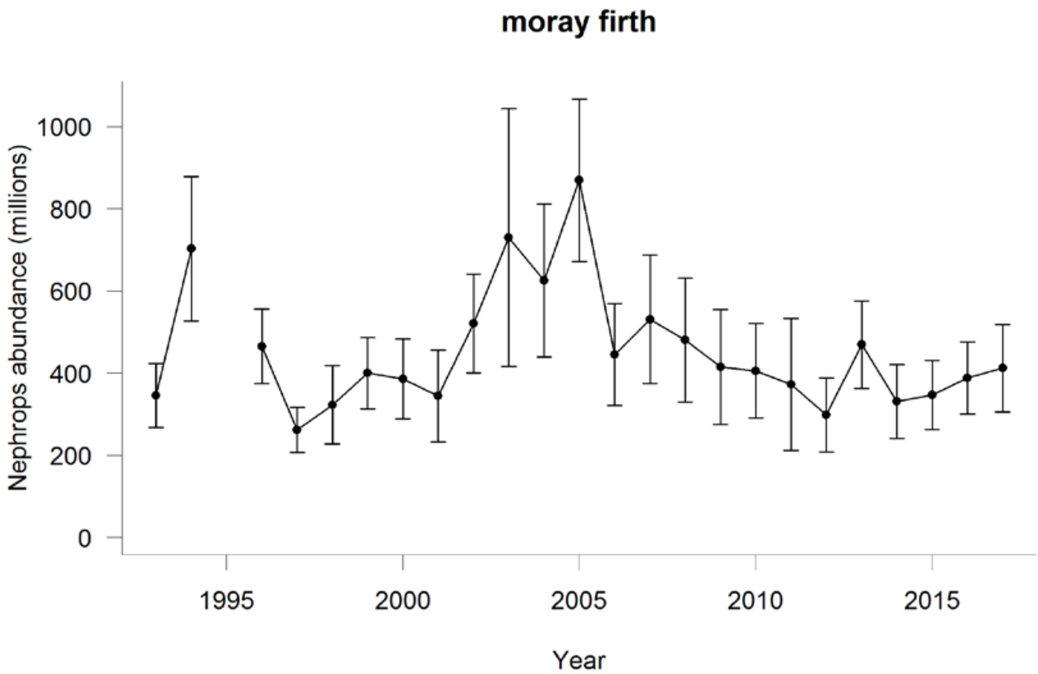

Figure 7.8.4.2. ***Nephrops*, Moray Firth (FU 9): Results of the 1992–2017 TV surveys.**

Annex 8: Data call: Data submission for ICES fisheries advisory work

Contents

1. Scope of the Data call

ICES Member Countries are requested to provide, for selected ICES fish and shellfish stocks:

- Landings [*], discards[*], biological and effort data from 2016 and other supporting information;
- For stocks identified in annex 1 with DLS under column " DLS proxy RP"; estimates of length compositions for historic landings and discards from at least the three most recent consecutive years (e.g. 2016, 2015, 2014) alongside data quantity and quality information[†] and supporting information on life history parameters[‡];

For some species, countries should also submit landings below minimum size and logbook registered discard. Those species are under NWWG, WGBFAS, WGNSSK, WGCSE and WGWIDE and relevant details are specified further under section 9.

A list of stocks included in the data call are provided in Annex 1. **All countries having catch or landings data on these stocks should submit data, even if not listed on the data request spreadsheets.** The countries listed on the data request spreadsheets were identified based on previous year catches and therefore new fisheries (in 2016) are not detected but should also be reported.

The requested data will be used by ICES advisory groups involved in the provision of ICES advice.

The current data call only requests data from 2016 for Norway pout in Subarea 4 and Division 3.a. However, changes made to the assessment method during 2016 benchmark require more recent data (2017 Q1 and Q2). ICES is discussing the viability of obtaining the necessary data with national correspondents of member states providing the bulk of the data for this stock.

This data call follows the principles of personal data protection as referred to in paragraph (16) of the preamble in Council Regulation (EC) No 199/2008.

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[*] Throughout the present document, the term "landings" includes BMS (Below Minimum Size) landings and the term "discards" includes logbook registered discards (see section 9).

[†] "Data quality and quantity information" includes a set of simple indicators that will allow ICES Expert Groups to get a general idea on the quantity and quality data submitted. See annex 3 for more details.

[‡] "Supporting information on life history parameters" includes information on specific life history traits, if available, noting that some candidate reference points require input on length at first maturity (L_{mat}), growth parameters (e.g., L_{inf}, K) and M (natural mortality). See annex 4 for more details.

2. Deadlines

ICES requests the data to be delivered by a working group specific date to provide enough time for additional quality assurance prior to the Working Group meeting. Data submission deadlines for each of the working groups are given in table 1. **Missing the reporting deadline will compromise the indispensable data quality checking (on a stock basis) before the use of that data to update assessments.**

The deadlines in table 1 do not apply to the survey data. It is expected that survey data will be sent to accessions@ices.dk prior to the assessment expert group meeting.

Table 1. Data submission deadline for ICES expert groups and respective chair contact.

Expert Group (EG)	Chair of the EG	Email address	Data submission deadline
AFWG	Daniel Howell	DANIEL.HOWELL@IMR.NO	03.04.2017
NWWG	Rasmus Hedeholm	RAHE@NATUR.GL	06.04.2017
WGBFAS	Tomas Gröhsler & Michele Casini	TOMAS.GROEHSLER@THUENEN.DE MICHELE.CASINI@SLU.SE	03.04.2017
WGBIE	Lisa Readdy	lisa.readdy@CEFAS.CO.UK	14.04.17
WGCSE	Timothy Earl & Helen Dobby	TIMOTHY.EARL@CEFAS.CO.UK H.DOBBY@MARLAB.AC.UK	18.04.2017
WGDEEP	Pascal Lorance & Gudmundur Thordarson	PASCAL.LORANCE@IFREMER.FR GUDTHOR@HAFRO.IS	03.04.2017
WGHANSA	Lionel Pawlowski	LIONEL.PAWLOWSKI@IFREMER.FR	30.05.2017
WGMIXFISH-Advice	Youen Vermard	YOUEN.VERMARD@IFREMER.FR	01.05.2017
WGNSSK	José de Oliveira	JOSE.DEOLIVEIRA@CEFAS.CO.UK	03.04.2017
WGWIDE	Gudmundur Oskarsson	gjos@hafro.is	1.08.2017

3. Data submission

ICES Member Countries are requested to supply data as specified on the Working Groups' data request spreadsheets (annex 1) to InterCatch, to ICES Secretariat via email (accessions@ices.dk) or both. Data include:

- Landings, discards, biological data and effort data from 2016 and other supporting information;
- For stocks identified in annex1 with DLS under column " DLS proxy RP"; estimates of length compositions for historic landings and discards from at least the three most recent consecutive years (e.g. 2016, 2015, 2014) of their commercial fisheries;
- Information on data quantity should be submitted to InterCatch (as specified in annex 2); Excel spreadsheets with simple quality/quantity indicators (see annex 3) and supporting information on life history parameters (see annex 4) should be submitted directly to accessions@ices.dk.

The list of species and stocks, for which data should be submitted, together with the information on the area descriptions and Working Group (WG) chairs' contact details are given in Annex 1 in separate sheets. ICES aims at maintain stable definitions over the years of species - stock - métier combinations to facilitate raising data at the institute level.

For stocks where discard data have been submitted in previous years to InterCatch, it should also be submitted to InterCatch (annex 1) for 2016.

If the format for submission of accession data (Annex 1) is not specified further through the provided templates (annex 1–5), the format should be the same as used in previous data calls and previous years (if anything is unclear please contact accessions@ices.dk).

If corrections for earlier years need to be made, please inform the Expert Group chair and advice@ices.dk (see e-mail contact details in table 1 and annex 1). A full corrected set of data may need to be uploaded.

The file will be forwarded to the respective stock coordinators and the Expert Group/workshop chairs.

Data emailed to accessions@ices.dk should have subject and filename as follows:

"2017 DC [expert group] [stock code/stock codes] [country] [type of data]"

(example: 2017 DC WGBFAS her.27.28 LV landings).

If data on both age and length are requested, please upload the biological age sample data first in one file and last the length sample data in another file to InterCatch, when marked with "IC" in annex 1. A more detailed description will follow later.

Several stocks in this data call for which both age and length data are being requested were also part of the 2016 data call. Last year due to limitations in InterCatch length data was submitted to ICES via accessions. However, InterCatch has been upgraded and can now deal with both age and length data in parallel so data should be submitted as requested in annex 1.

4. Métiers

Unspecified data accounting all together for less than 10 % of catches and effort, can be coded into a miscellaneous group named either MIS_MIS_0_0_0_HC (Miscellaneous Human Consumption) or MIS_MIS_0_0_0_IBC (Miscellaneous Industrial By-Catch) However, this métier aggregation label hinders the ability to effectively model the fishery interactions and whenever possible its use **should be minimised.**

If multiple metiers are aggregated or merged into dominant metiers, these should be clearly stated In the Info Stock Coordinator information text (field number 23 in the import file to InterCatch). If the data has been requested by WGMIXFISH please refer to section 16.2 of this document.

The following text will focus on the codes used for the field "Fleet", which in general is referred to as "métier". The métiers for each Working Group are listed in annex 1 (sheet "IC Métier tags"). If a metier needed is not available in InterCatch, please contact the Working Group chair (see email address in table 1).

The metier tag entries closely follow the naming convention used for the EU Data Collection Framework (DCF). Below is an explanation of the metier tag elements; an underscore separates each of the elements (Figure 1).

OTB_CRU_>=70_0_0_all

Bottom otter trawl_directed to crustaceans_(at least 70 mm)_with no selectivity device_no selectivity device mesh size_all vessel length classes

Figure 1. Explanation of the métier tag elements; an underscore separates each of the elements.

Landings and effort data by métier should be submitted to InterCatch in a consistent manner between Data Calls.

<u>Métier tag elements</u>

1. GEAR TYPE (gear types available under the DCF are shown in [2010/93/EU] Appendix IV). Note that WGCSE, WGNSSK, WGBIE and WGMIXFISH allow only specific métiers in specific areas (see Appendix 1–5).

2. TARGET ASSEMBLAGE CODE (code conforming to target assemblage under the DCF are shown in [2010/93/EU] Appendix IV). Data can be aggregated over more than one category but in this case the most significant *metier* code is entered).

3. MESH SIZE RANGE (mesh size ranges available under the DCF). If necessary data can be aggregated over more than one category but in this case the most significant mesh size range is entered. Exception to this general rules are cases where, for that gear type, data have been aggregated over all ranges used by a nation. In this case an additional entry "**0**" can be used (The metier should look like e.g. LHM_DEF_**0**_0_0. The use of "_all_" in this tag element should be avoided).

4. SELECTIVITY DEVICE (types of selectivity device available: 0: No selectivity device, 1: Exit window or panel, 2: Grid, 3: Square meshes (T90) under the DCF). See [2010/93/EU] Appendix IV.

5. SELECTIVITY DEVICE MESH SIZE (if the actual mesh size of any selectivity device is entered, this level is referred to as level 6). Data aggregation over several DCF level 6 categories is possible although should be avoided. In these cases the *metier* tag corresponding to the most significant category can be chosen e.g., a mobile gear with mesh sizes covering 70–119 mm (combining 70–99 and 100–119) but 70–99 mm is most significant code 70–99 will apply. Exceptions to this general rule are cases where data have been aggregated over all mesh size ranges within the national fleet. In these instances the mesh size is omitted and only a métier with level 5 (Gear code Target assemblage) is used.
6. VESSEL LENGTH CLASS (Member states have been indicated by national sampling scheme designs to not take account of vessel lengths. Therefore the standard entry of "all" or omitted is currently provided for in InterCatch). The option has been left open for length category specific métier tags to be added in future years if nations begin to sample and raise data independently for different vessel length categories.

5. NEAFC Areas and ICES subdivisions

Data should be reported by the lowest subdivision possible.
In addition, for stocks with catches in areas shared between ICES and NEAFC regulatory area; the areas should be reported with the correct NEAFC area (e.g. specifying 7.k.1, 7.k.2 vs. 7.k only, or 6.b.1, 6.b.2, vs. 6.b only). This is particularly relevant for deep water and widely distributed stocks.

Area-disaggregated catch data should be submitted to InterCatch in a consistent manner between Data Calls. If area aggregations must be made it should be clearly stated in the Info Stock Coordinator information text field (number 23 in the import file to InterCatch). Aggregations should not be beyond the assessment area of individual stocks.

6. Recreational fisheries data

Recreational fisheries should not be included as commercial landings, even if this has been the case in previous years. The data should be submitted via email to accessions@ices.dk. The respective Working Group chair (see e-mail addresses in table 1) and ICES Secretariat should be informed.

7. How to report to InterCatch

The InterCatch formatted national data should be imported into InterCatch, which is available at this link: https://intercatch.ices.dk/Login.aspx.

Please see the 'InterCatch Exchange Manuals' on the ICES website for information on the required exchange format and used codes at http://www.ices.dk/marine-data/data-portals/Pages/InterCatch.aspx. An overview of the data fields used in the InterCatch exchange format are detailed in annex 2.

8. Age and length data in parallel in InterCatch

InterCatch can now work with age and length data in parallel. But it demands that length sample data have to be imported last for species with both age and length distribution data. This is due to InterCatch ignoring strata of other sample types. However, InterCatch will always take the latest imported strata without samples. Also, there is no problem with overwriting data in InterCatch as long as length data are imported latest, for stocks with both length and age samples. There is still no age-length-keys in InterCatch. It is important that when importing catches with and without age samples all strata have to be imported, all strata also have to be imported when importing catches with and without length samples.

9. Catch categories in InterCatch

The following species under the relevant Working Groups should also submit data also for BMS landings and logbook registered discards:

- NWWG: Capelin.
- WGBFAS: Cod, herring and sprat.
- WGWIDE: Blue whiting, boarfish, herring, horse mackerel, mackerel.
- WGCSE: Cod, haddock, whiting, *nephrops*.
- WGNSSK: Saithe, sole, cod, haddock, whiting, hake.
- WGBIE: Sole, hake, *nephrops*, plaice.

In InterCatch only CATON is used to derive the total catch used for stock assessment. The values for the different categories in the OffLandings fields (OfficialLanding) are only informative and will not be used in the catch estimate.

Only use the Reporting Category R, in case there are black landings. Please use Reporting Category N for Non-reported.

9.1 Landing, 'L'

The 'Landing' catch category in InterCatch will cover the landing as it has done previously and it will apply to landings above minimum size.

9.2 Discard, 'D'

The 'Discard' catch category in InterCatch will cover the discard as it has done previously. This category is the part of the catch, which is thrown overboard into the sea and not registered in the logbook. This catch category is based on fishery observer estimations.

This component should be in the CATON field and in the OffLandings field a 0 (zero) should be inserted.

9.3 BMS Landing, 'B'

Relevant for stocks under landing obligation. The BMS landing will consist of fish Below Minimum Size, BMS, and damaged fish as registered in the logbook.

This component should be inserted in the OffLandings field as reported in the logbook. If the discard weight includes the BMS weight a 0 (zero) should be inserted into the CATON field. Otherwise, your best estimate should be inserted into the CATON field.

9.4 Logbook Registered Discard, 'R'

Relevant for stocks under landing obligation. Logbook registered discard are discards, which are registered in the logbook and are under the exemption rules (e.g. *de minimis*). Damaged fish can also be included under this Logbook registered discard.

This component should be inserted to the OffLandings field as reported in the logbook. A 0 (zero) has to be inserted in the CATON field as this component is already included in the discard estimates (9.2).

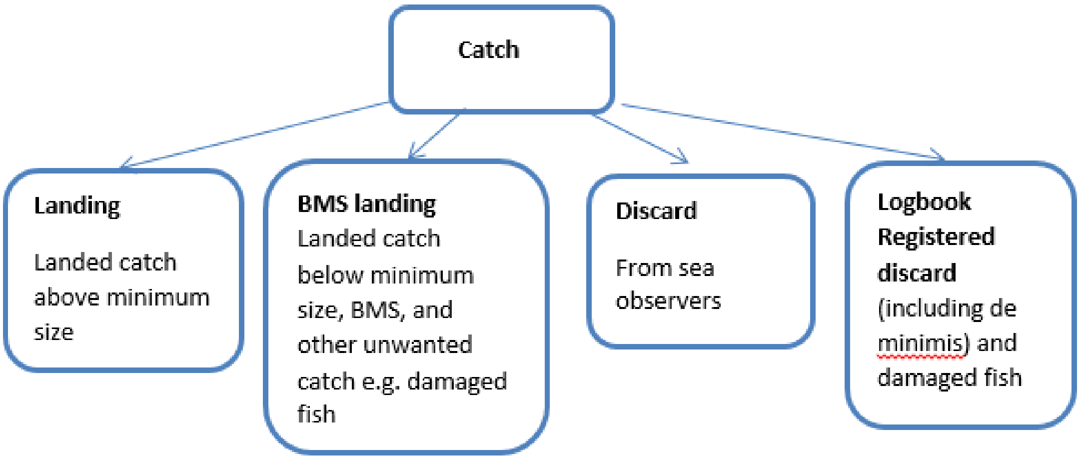

Figure 2. Description of the four current catch categories.

Table 2. The species information (SI) record in InterCatch: Landing obligation example.

							Comments
Record number	10	11	12	13	19	20	
Field code	Species	Stock	Catch Category	Reporting Category	CATON	OffLandings	
	COD	NA	D	R	1300	0	This is an estimate based on the observer sampling on board. The observer has access to discards and BMS fraction. Observer estimate includes both fractions
	COD	NA	B	R	0	0.1	The BMS registered in the logbook, should be inserted in the OffLandings field. CATON should be zero as the Catch category D already includes the BMS
	COD	NA	R	R	0	0.2	The Discards registered in the logbook, should be inserted in the OffLandings field. CATON will be zero as the Catch category D already includes all the Discards (the ones registered in the logbook and the ones not registered)

Table 3. The species information (SI) record in InterCatch: Landing obligation example.

							Comments
Record number	10	11	12	13	19	20	
Field code	Species	Stock	Catch Category	Reporting Category	CATON	OffLandings	
	COD	NA	D	R	1300	0	No observer effect identified in respect to the discard/BMS fraction, so the discard estimate is an estimate of the discard and do not include the BMS
	COD	NA	B	R	0.1	0.1	The BMS from the logbooks in both columns, see above
	COD	NA	R	R	0	0.2	

10. Effort data in InterCatch

Effort is recorded in position 11 of the InterCatch header information. Effort is required in kWdays for all species and areas, with the exception of WGBFAS (WGBFAS specifications are detailed in section 16.3). The effort in InterCatch supports WGMIXFISH which needs effort by metier and not by species. This means, that the effort value should be the same for all species, for a given strata. If landing data and discard data are imported in separated files then effort should only be imported once in the landings data. Effort for the discard data should be indicated with a '-9' (indicating no effort).

11. Zero Catch

Countries with no landings for stocks for which they usually report catches should enter a value of zero for landing to InterCatch. This will reassure the stock assessor that no data are missing. A single import of an annual zero landing stratum is acceptable.

For stocks where fishing only occurs in specific quarters, data for quarters with no catches should also be entered (by métier/fleet) to ensure that no data was missed. (e.g. for stocks where there are catches in quarter 1, 2 and 4, a catch of zero should be added for quarter 3).

12. Units used

Landings, discards, and biological sampling data: As specified in InterCatch Exchange Format.

Landings, discards: by number and in tons at 1 cm length intervals for fish and 1 mm intervals for Norway lobster.

Effort (WGNSSK, WGCSE, WGBIE, WGDEEP, WGHANSA): kW days (in InterCatch).
Effort (WGBFAS): see further WGBFAS specifications in annex 5.
Year must be entered as four digits, e.g. “2016”.

13. Sample information on length and age data

When age or length data are imported it is requested to fill in the following age and length sampling information fields for both landing and discard samples:

- Number samples of length, field: NumSamplesLngt
- Number length measured, field: NumLngtMeas
- Number samples of age, field: NumSamplesAge
- Number age measured, field: NumAgeMeas

The units of the samples in the record types "NumSamplesLngt" and "NumSamplesAge" of the species data record should be the number of primary sample units (vessel, trip, harbour day, etc.). The units should be given in the InterCatch species information field named "InfoFleet".

If there is any doubt, please contact the working group chair (see table 1) and ICES Secretariat at InterCatchsupport@ices.dk.

14. Conversions to InterCatch Format

To ease the process of converting the national data into the InterCatch format Andrew Campbell from Ireland has made the conversion tool "InterCatchFileMaker", which converts data manually entered in the 'Exchange format spreadsheet' into a file in the InterCatch format. **Be aware that the tool does not currently support the new catch categories BMS Landings and Logbook registered discards** (see section 19). The conversion tool "InterCatchFileMaker" can be downloaded from the ICES webpage for InterCatch exchange format under 'Format conversion tools' (link). The download includes a spreadsheet in which the landings and sampling data can be placed; the program then converts the data into the InterCatch format.

1) If the "InterCatchFilemaker" conversion program and the exchange format spreadsheet have been used to convert your data to InterCatch format, then the values in the data field "NumSamplesAge" in the InterCatch format file must be entered manually.

2) If in some areas and quarters there are only length samples available (age samples are missing), then it is possible to use ALKs from neighboring areas or quarters to calculate CANUM and WECA for "Species Data" records, before importing data to InterCatch. In this case "-9" must be entered in the data fields of "NumSamplesAge" and "NumAgeMeas".

15. Contacts

For support concerning InterCatch issues please contact: InterCatchsupport@ices.dk.
For questions about the content of the data call, please contact: advice@ices.dk
For questions on data submission, please contact: accessions@ices.dk

16. Expert group specific uploading information

16.1. WGDEEP specification

Data request to Portugal for black-scabbarbfish (*Aphanopus carbo*) from FAO Fishing Area 34, Division 1.2 (CECAF area).

Black scabbardfish is believed to constitute a unique stock with three migratory components in the West of the British Islands, Portugal mainland and Canary/Madeira areas. The southernmost component lies under the Fishery Committee for the Eastern Central Atlantic (CECAF) competence and it is believed to be an important spawning area for the species. In order to strengthen the ICES advisory process and a more comprehensive stock assessment of black scabbardfish, access to the southernmost component data (FAO Fishing Area 34, Division 1.2) is requested in this Data Call from all EU country members with data available from this area.

The data requested if available should be provided as follows:

- Landings and discards per month in tonnes.
- Fishing effort per month (KW days).
- Length frequency distribution per month or per quarter.
- Weight length relationship.
- Proportion of mature individuals (by sex) in the last quarter of the year.

ICES also advises NEAFC on systematic or occasional catches of other deep sea species. In annex 1, one of codes specified under “stock codes” is **oth-com** and all member countries are requested to submit data on catches IN and OUT of the NEAFC Regulatory Area for species which ICES does not provide single stock advice. The catch for these species will be reported in a combined chapter by WGDEEP. The following list (**not** comprehensive) shows examples of species that should be submitted:

Common Mora (*Mora moro*) and Moridae, rabbit fish (*Chimaera monstrosa* and *Hydrolagus* spp), Baird’s smoothhead (*Alepocephalus bairdii*) and Risso’s smoothhead (*A. rostratus*), wreckfish (*Polyprion americanus*), bluemouth (*Helicolenus dactylopterus*), silver scabbard fish (*Lepidopus caudatus*), deep-water cardinal fish (*Epigonus telescopus*) and deep-water red crab (*Chaceon affinis*) and any others that may occur in mix catches.

16.2. WGMIXFISH ADVICE specification (WGNSSK, WGCSE, WGBIE)

WGMIXFISH undertakes fleet-based mixed fisheries forecasts, and intends to develop advice for the North Sea, Celtic Sea and Iberian waters in 2017. However, for this data call ICES is requesting for member countries to **re-submit the last 8 years (2009-2016) of data for MIXFISH**. WGMIXFISH operates both at the level of the DCF *metier*, as explained above, AND at the level of the fleet segment, consistently with the approach for the collection of economic data. In addition WGMIXFISH needs specific information by vessel length categories and disaggregated area. Therefore we kindly request estimates of landings weight totals and effort in a format similar to previous WGMIXFISH Data calls, with the aforementioned parameters specified. Area should be at ICES division level, except for *Nephrops* where the InterCatch code for the relevant Functional Unit should be used (see Annex 1, worksheet “ICES area codes”).

WGMIXFISH doesn’t ask for discard data as these data are available for all *metiers* from the raising procedure done for the single species advice in InterCatch. Data submitters should aggregate discard InterCatch submissions to the level considered most appropriate for national sampling programs. However, consistency is requested in the aggregation level submitted year by year, to allow mapping to WGMIXFISH *metier* level 6 and vessel length data aggregations. It must be accepted that the InterCatch discard submission level will be proportioned out across all underlying metiers and vessel length for use with métier level 6 WGMIXFISH landings data (i.e. the assumption of the same discarding and age-distribution in catch will be made by WGMIXFISH). Additional information on discard rates is not needed if estimated discard rates are the same for all vessel length categories within a metier, as this information can be taken from InterCatch. However, if specific discard rates exist for each vessel length category, data submitters should provide differentiated discard estimates in an extra column labelled “discards” (see section 16.2.4. of this document and annex 1, sheet WGMIXFISH catch).

16.2.1. WGNSSK: All stocks (2009–2016 data requested)

Provide data by filling the spreadsheets described in section 16.2.4.

16.2.2. WGCSE: All stocks (2009–2016 data requested)

Provide data by filling the spreadsheets described in section 16.2.4.

Species catch data should be submitted according to the following:

ANF (aggregated ANF, MON, MNZ),
LEZ (aggregated LEZ, MEG),
RJA (aggregated RJC, SKA, RAJ, RJA, RJB, RJC, RJE, RJF, RJH, RJI, RJM, RJN, RJO, RJR, SKA, SKX, SRX),
SDV (aggregated DGS, DGH, DGX, DGZ, SDV),
COD, HAD, HKE, LIN, NEP, PLE, POK, POL, SOL, WHG.
All remaining catch to be aggregated into an '**OTH**' class.

16.2.3. WGBIE (2006–2016 data requested)

Provide data by filling the spreadsheets described in section 16.2.4.

Relevant stocks: southern hake (hke.27.8c9a), northern hake (hke.27.3a46-8abd), black anglerfish (ank.27.78ab), white anglerfish (mon.27.78ab), black anglerfish (mon.27.8c9a), white anglerfish (ank.27.8c9a), megrim (meg.27.8c9a), four-spot megrim (ldb.27.8c9a), megrim (meg.27.7b-k8abd) and a **new stock** four-spotted megrim (ldb.27.7b-k8abd).

16.2.4. WGMIXFISH ADVICE Data format

Information on vessel length and métier used is kept separately in two columns in the .csv files (Annex 1, sheet WGMIXFISH effort, sheet WGMIXFISH catch). **To specify the métier, use exactly the same tags as used for InterCatch** (annex 1, sheet IC Metier tags)**.**

A field is included to specifically flag FDF (Fully Documented Fisheries) Vessels. As some vessels are involved in FDF métiers in one area (e.g. North Sea), while being involved in non-FDF métiers in another (e.g. West of Scotland), it is important to flag these vessels at the fleet level, and not only at the métier level. Please leave the field blank for the non FDF fleet, and write "FDF" for the FDF flagged vessels.

Two comma separated (.csv) files should be provided:

1) A single .csv file reporting métier and vessel length disaggregated effort;
2) A single .csv file reporting métier and vessel length disaggregated catch.

Both files should be sent electronically as .csv files to accessions@ices.dk, clearly indicating in the subject of the file name "2017 WGMIXFISH ADVICE" [country] [métier_catch/métier_effort]" (example: 2017 WGMIXFISH ADVICE UKE metier catch).

1.) The CSV 'effort' file (see Annex 1, sheet WGMIXFISH effort) should be supplied containing the following entries:

ID (Unique identifier), Country, Year, Quarter, InterCatch métier Tag, Vessel Length Category, FDF vessel flag, Area, kW_Days, Days at Sea, No Vessels.

ID	Country	Year	Quarter	Intercatch Metier Tag	Vessel Length Ca	FDF vessel	Area	KW_Days	Days At Sea	No Vessel
dnk1	DK	2015	1	OTB_DEF>=120_0_0_all	<10m		27.4	1000	100	10
dnk2	DK	2015	1	OTB_DEF>=120_0_0_all_FDF	10<24m	FDF	27.4	1000	100	10
dnk3	DK	2015	1	OTB_DEF>=120_0_0_all	10<24	FDF	27.6.a	1000	100	10

Figure 3. Example of WGMIXFISH-ADVICE CSV 'effort' file.

2.) The CSV 'catch' file (see annex 1, sheet WGMIXFISH-Catch) should be supplied containing the following entries:

ID (Unique identifier), Country, Year, Quarter, InterCatch *Metier* Tag, Vessel Length Category, FDF vessel flag, Area, Species, Landings (tonnes), Value (average price*landings at first sale, expressed in Euros), Discards (only if discard rate differs from the one submitted to InterCatch).

ID	Country	Year	Quarter	Intercatch Metier Tag	Vessel Length Ca	FDF vessel	Area	Species	Landings	Value	Discards
dnk1	DK	2015	1	OTB_DEF>=120_0_0_all	<10m		27.4	COD	100	1000	
dnk2	DK	2015	1	OTB_DEF>=120_0_0_all_FDF	10<24m	FDF	27.4.b	NEP	100	1000	
dnk3	DK	2015	1	OTB_DEF>=120_0_0_all	10<24	FDF	FU.33	NEP	100	1000	

Figure 4. Example of WGMIXFISH ADVICE CSV 'catch' file.

Note that:

- Vessel length splits are only required for metier tags starting with OTB or TBB.
- Vessel length categories are: <10 m, 10<24 m, 24<40 m, >=40 m (Please use exactly these codes)

Sums of effort and landings across metier tags disaggregated by vessel length should equal the corresponding totals submitted to InterCatch.

16.3. WGBFAS specifications

- National landings processing of cod, flounder, dab, brill, turbot, plaice, herring, sprat and sole (All WGBFAS) stocks.
- National BMS landings processing of cod.

- National discard data processing of cod, plaice, flounder, dab, brill, turbot and sole.
- National logbook registered discard data processing of cod.

16.3.1. Data stratifications

All data should be stratified by:

- Quarter
- ICES subdivision
- Fleet segments to be considered as specified by stock (see Annex 1, IC Metier Tags tab).

NOT to use “TestA”, “TestB”, “TestC”, “trawl”, “All” or similar.

Particularly:

- For **sprat,** fleet segments to be considered are; "Pelagic trawlers" for all trawl gears and "Passive gears" for all passive gears
- For **her.27.30,** fleet segments to be considered are; “BOT”, “BT-Fi-Bal”, “GIL”, “Passive gears”, “PEL”, “Pelagic trawl”, “Trapnet”, and “Winter Seine”.

The same stratification should be used for both catch and additional supporting files for a given *stratum*.

16.3.2. Data submission formats

When submitting to InterCatch and/or sending to accessions@ices.dk:

Catch (landings, discards): (HI, SI)	InterCatch exchange format
Biological information: (SD)	InterCatch exchange format
Effort (demersal stocks, data year = 2016): (HI)	InterCatch exchange format
Effort (demersal stocks, data year = 2009–2016):	As specified in Figure 6 and annex 5
Hole filling guideline for demersal stocks:	As specified in Figure 5 and annex 5

16.3.3. Units for data submission

Numbers (in `000) and mean weight (in grams) by age or length (depending on the stock and according to Annex 1 specifications) per fleet/métier (active, passive), quarter, year, Subdivision, country, for landing as well as discards.

16.3.4. Data specification

- If estimates of recreational fishery are available, then the data should be provided in Excel sheets directly to accessions@ices.dk for the respective stock
- Discard survival rates **should not** be accounted for by the countries, when uploading the data
- **Landing obligation-cod:** Landing obligation has been mandatory for cod fisheries since 1 January 2015 in the Baltic and a new fraction of cod, the BMS (below minimum reference size) cod, has been introduced. It is important

that Member Countries are aware of this new fraction in the catch when data is uploaded.

InterCatch has included two new catch categories: i) BMS landings and ii) logbook registered discard (see section 9). It is important when Member Countries are uploading data to InterCatch that the four categories in CATON are summing up to the total catch. BMS landings can either be calculated as an estimate from the observer trips or from official registrations such as sale slips, logbooks or landing declarations. Both the landed BMS cod and the discard estimate will be needed for the WGBFAS.

16.3.5. Specifics of data requirements for eastern and western Baltic cod (cod.27.25-32 and cod.27.22-24)

Specifics of length/age distribution data in IC:

- For cod in SD 22–23, age distribution data should be uploaded to IC. No length distribution data should be uploaded to IC.
- For cod in SD 24, length distribution data should be provided through accessions@ices.dk (can be in the form of IC file or an Excel spreadsheet). No biological information (no age/length distribution data) should be uploaded to IC.

For Recreational catch from Germany of western Baltic cod (cod.27.22–24):

- Catch in weight, separately for SD 22 and 24
- Catch at age in numbers, separately for SD 22 and 24 (age readings originating from SD 22 should only be used. i.e. not age readings from SD 24)
- Mean weight at age in the catch

The data should be provided as Excel spreadsheets and submitted to accessions@ices.dk.

16.3.6 Hole filling guideline for demersal stocks.

When no discard weight or no biological information is available for discard or landing in a given *stratum*, hole filling should **not** be conducted by the data submitter but instead raw data should be submitted with guidelines directed to the stock coordinator on how to conduct the data processing. Such guidelines should be submitted to accessions@ices.dk. If no suitable source is available on the national level or the submitter does not have any suggestions, this should also be indicated (see format description in figure 5 and Annex 5). The guidelines should include information on the source stratum (subdivision, quarter, fleet) for which data should be used to fill in the data gaps in the target stratum.

Parameters defining data gap

Parameters defining the data to be borrowed

Target stratum						Source stratum					
T_Country	T_Year	Gear type	T_Sub-div.	T_Quarter	T_Stock	S_Country	S_Year	Gear type	S_Sub-div.	S_Quarter	S_Stock
DEN	2013	Active	BAL22	3	PLE21-23	DEN	2013	Active	BAL22	4	PLE21-23
	2013						2013				
	2013						2013				
	2013						2013				
	2013						2013				
	2013						2013				
	2013						2013				
	2013						2013				

!!! One data line for each stratum where data gap occurs.

Figure 5. Format for hole filling suggestions (provided in Annex 5).

16.3.6. Effort data for demersal stocks:

Effort data should be provided using the respective fields in the HI tables of InterCatch. If using the spreadsheet and then the converter (see section 14) for providing the data, fill in effort data under "Landing". **Be aware that the tool does not currently support the new catch categories BMS Landings and logbook registered discards** (see section 9).

The unit for commercial effort is **days-at-sea** and should be aggregated at the same level as the sampling data (i.e. effort per Sub-div, year, quarter and fleet).

Effort should be uploaded by fleet segment. For demersal stocks Fleet should be "active" or "passive" and include only gears/métiers catching demersal stocks in the given area (i.e. no pelagic trawl fishery or freshwater metiers such as crustacean or eel traps).

If prior effort data has been uploaded in another format, these data should be corrected and uploaded to InterCatch. Additionally, to make sure that prior data are updated according to the present data call format, effort data (day-at-sea) back to 2009 should be provided in an Excel sheet following the outlined format in Annex 5 and sent directly to the working group chairs and accessions@ices.dk .

Country	Year	Fleet	Area	Quarter	stock	Effort_das
GER	**2014**	Active	**BAL24**	1	**ple-2432**	348
GER	**2014**	Active	**BAL24**	2	**ple-2432**	234
GER	**2014**	Active	**BAL24**	3	**ple-2432**	140
GER	**2014**	Active	**BAL24**	4	**ple-2432**	457
GER	**2014**	Active	**BAL25**	1	**ple-2432**	99
GER	**2014**	Active	**BAL25**	2	**ple-2432**	439

Figure 6: Example of effort data (see Annex 5).

APPENDIX 1

Gear coding (as defined under the EU Data Collection Framework), allowed for WGNSSK and WGMIXFISH ADVICE. Based on information from countries fishing in areas 27.3.a.20, 27.4 and 27.7.d and significant fishing gears.

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
27.3.a.20 (Skagerrak) and 27.3.a.21 (Kattegat) Area Type = SubDiv	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_90-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_CRU_32-69_2_22_all
		OTB_CRU_70-89_2_35_all
		OTB_CRU_90-119_0_0_all OTB_CRU_90-119_0_0_all_FDF
		OTB_DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all SSC_DEF_>=120_0_0_all_FDF
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all GNS_DEF_120-219_0_0_all_FDF
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all LLS_FIF_0_0_0_all_FDF
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
27.4 – (North Sea) Area type = SubArea & 27.7.d (Eastern Channel) Area Type = Div & 27.6.a (for saithe and haddock only) Area Type = Div	Beam trawl	TBB_CRU_16-31_0_0_all
		TBB_DEF_70-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_SPF_32-69_0_0_all
		OTB_CRU_70-99_0_0_all OTB_CRU_70-99_0_0_all_FDF
		OTB_ DEF _>=120_0_0_all OTB_DEF _>=120_0_0_all_FDF

Area	Gear type	Available metier tags For fully documented fisheries add "_FDF" after length class
		OTB_DEF_70-99_0_0_all
	Seines	SDN_DEF_>=120_0_0_all SDN_DEF_>=120_0_0_all_FDF
		SSC_DEF_>=120_0_0_all SSC_DEF_>=120_0_0_all_FDF
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all GNS_DEF_120-219_0_0_all_FDF
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all LLS_FIF_0_0_0_all_FDF
	Pots and Traps	FPO_CRU_0_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC

*** The use of metiers under the MIS_MIS category should be minimized.**

APPENDIX 2

Gear coding (as defined under the DCF), allowed for WGCSE and WGMIXFISH-ADVICE in specific areas. Note that the vessel length category (currently '_all') must appear at the end of every métier tag except the MIS_MIS métier tags.

AREA	GEAR TYPE	AVAILABLE METIER TAGS
West of Scotland (27.6.a) and Rockall (27.6.b)	Pots and traps	FPO_CRU_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
	Longline	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_>=120_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DWS_>=120_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_>=120_0_0_all
		OTB_MOL_100-119_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Irish Sea (27.7.a)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_120-219_0_0_all
		GNS_DEF_90-99_0_0_all
	Otter trawl	OTB_CRU_70-99_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_MOL_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)	MIS_MIS_0_0_0_IBC
West of Ireland (27.7.b–c) and Celtic Sea slope (27.7.k–j)	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_DWS_100-119_0_0_all
	Otter trawl	OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_100-119_0_0_all
		OTB_CRU_100-119_0_0_all
	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all

		OTM_DEF_100-119_0_0_all
		OTM_LPF_70-99_0_0_all
		OTM_LPF_100-119_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Celtic Sea Shelf (27.7.f–h)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_DEF_>=220_0_0_all
		GNS_DEF_120-219_0_0_all
		GNS_SPF_10-30_0_0_all
		GTR_DEF_>=220_0_0_all
	Lines	LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MCD_70-99_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
	Midwater trawl	OTM_DEF_32-69_0_0_all
		OTM_SPF_32-69_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_100-119_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC
Western Channel (27.7.e)	Pots and traps	FPO_CRU_0_0_0_all
		FPO_MOL_0_0_0_all
	Gillnets	GNS_CRU_0_0_0_all
		GNS_DEF_>=220_0_0_all
		GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all
		GTR_CRU_0_0_0_all
		GTR_DEF_>=220_0_0_all
		GTR_DEF_120-219_0_0_all
	Lines	LLS_DEF_0_0_0_all
		LLS_FIF_0_0_0_all
	Otter trawl	OTB_CRU_100-119_0_0_all
		OTB_CRU_70-99_0_0_all
		OTB_DEF_100-119_0_0_all
		OTB_DEF_70-99_0_0_all
		OTB_DWS_100-119_0_0_all
		OTB_MOL_100-119_0_0_all
		OTB_MOL_70-99_0_0_all
		OTB_SPF_70-99_0_0_all

	Midwater trawl	OTM_SPF_16-31_0_0
		OTM_SPF_32-69_0_0_all
		OTM_DEF_70-99_0_0_all
		OTM_DEF_100-119_0_0_all
	Seines	SSC_SPF_0_0_0_all
		SSC_DEF_70-99_0_0_all
	Beam trawl	TBB_DEF_70-99_0_0_all
	Others (Human consumption)*	MIS_MIS_0_0_0_HC
	Others (Industrial bycatch)*	MIS_MIS_0_0_0_IBC

*** The use of metiers under the MIS_MIS category should be minimized.**

APPENDIX 3

Gear coding (as defined under the DCF), allowed for WGBIE and WGMIXFISH ADVICE in specific areas.

MÉTIER LEVEL 6	DESCRIPTION
DRB_MOL_0_0_0_all	Boat dredge, molluscs, no selectivity devise, all vessels
FPO_CRU_0_0_0_all	Pots and Traps, Crustaceans, no selectivity device, all vessels
GN_DEF_100–109_0_0_all	Gill nets, demersal fish, mesh size 100–109 mm, no selectivity device, all vessels
GNS_DEF_>=100_0_0	Set gillnet, Demersal fish, mesh size more than 100 mm, no selectivity device
GNS_DEF_>=220_0_0_all	Set gillnet, Demersal fish, mesh size more than 220 mm, no selectivity device, all vessels
GNS_DEF_>=220_0_0_all_FDF	Set gillnet, Demersal fish, mesh size >=220 mm, no selectivity device, all vessels, Fully Documented Fisheries
GNS_DEF_100–119_0_0_all	Set gillnet, Demersal fish, mesh size 100–119 mm, no selectivity device, all vessels
GNS_DEF_100–219_0_0	Set gillnet directed to demersal fish (100–219 mm)
GNS_DEF_10–30_0_0_all	Set gillnet, Demersal fish, mesh size 10–30 mm, no selectivity device, all vessels
GNS_DEF_120–219_0_0_all	Set gillnet, Demersal fish, mesh size 120–219 mm, no selectivity device, all vessels
GNS_DEF_120–219_0_0_all_FDF	Set Gillnet, Demersal Fish, Mesh size 120–219, All Vessels, No grid selectivity, Fully Documented Fisheries
GNS_DEF_45–59_0_0	Set gillnet directed to demersal fish (45–59 mm)
GNS_DEF_60–79_0_0	Set gillnet, Demersal fish, mesh size 60–79 mm, no selectivity device
GNS_DEF_80–99_0_0	Set gillnet directed to demersal fish (80–99 mm)
GNS_DEF_all_0_0_all	Set gillnet, Demersal fish, all mesh sizes, no selectivity device, all vessels
GTR_DEF_60–79_0_0	Trammel nets, Demersal fish, mesh size 60–79 mm, no selectivity device
GTR_DEF_all_0_0_all	Trammel nets, Demersal fish, all mesh sizes, no selectivity device, all vessels
LHM_DEF_0_0_0 LLS_DEF_0_0_0	Hand lines directed to demersal fish Set longline directed to demersal fish
LLS_DEF_0_0_0_all	Set longlines, Demersal fish, mesh size not specified, no selectivity device, all vessels.
LLS_FIF_0_0_0_all	Set longlines, Finfish, no selectivity device, all vessels
MIS_DEF_all_0_0_all*	Demersal fisheries, Demersal fish, mesh size any, no selectivity device, all vessels
MIS_MIS_0_0_0_IBC*	Demersal fisheries - Miscellaneous Industrial bycatch
MIS_MIS_All_0_0_All*	Demersal fisheries - Miscellaneous
OTB_CRU _>=70_0_0	Bottom otter trawl directed to crustaceans (at least 70 mm)
OTB_CRU_100–119_0_0_all	Otter trawl, Crustaceans, mesh size 100-119, no selectivity device, all vessels
OTB_CRU_32–69_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 32–69, no selectivity device, all vessels
OTB_CRU_32–69_2_22_all	Otter trawl, Crustaceans, mesh size 32–69, selectivity device - grid 22 mm, all vessels
OTB_CRU_70–89_2_35_all	Otter trawl, Crustaceans, mesh size 70–89, selectivity device - grid 35 mm, all vessels
OTB_CRU_70–99_0_0	Bottom otter trawl directed to crustaceans (70–99 mm)

Métier Level 6	Description
OTB_CRU_70–99_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 70–99, no selectivity device, all vessels
OTB_CRU_90–119_0_0_all	Otter trawl, Crustaceans and Demersal fish, mesh size 90–119, no selectivity device, all vessels
OTB_CRU_90–119_0_0_all_FDF	Bottom otter trawl, Crustaceans, mesh Size 90–119, Selectivity Device - none, All vessel types, Fully Documented Fisheries
OTB_CRU_All_0_0_All	Bottom otter trawl, Crustaceans, all mesh sizes, no selectivity devise, all vessel types
OTB_DEF _100-119_0_0	Bottom otter trawl directed to demersal fish (100–119 mm)
OTB_DEF_>=120_0_0_all	Otter trawl, Demersal fish and Crustaceans, mesh size more than 120mm, no selectivity device, all vessels
OTB_DEF_>=120_0_0_all_FDF	Bottom otter trawl, Demersal fish, Mesh Size 120 or greater, Selectivity Device - none, All vessel types, Fully Documented Fisheries
OTB_DEF_>=55_0_0	Bottom otter trawl directed to demersal fish (at least 55 mm)
OTB_DEF_>=70_0_0	Bottom otter trawler targeting demersal fish with a mesh size > 70 mm
OTB_DEF_100–119_0_0_all	Bottom otter trawler targeting demersal fish with a mesh size 100–119 mm
OTB_DEF_70–99_0_0	Bottom otter trawl directed to demersal fish (70–99 mm)
OTB_DEF_All_0_0_All	Bottom otter trawl directed to demersal fish, all mesh sizes, no selectivity devise
OTB_MCD_>=55_0_0	Otter trawl, Mixed crustaceans and demersal fish, mesh size more than 55mm, no selectivity device.
OTB_MCF_>=70_0_0	Otter trawler targeting cephalopods and fish
OTB_MOL_70–99_0_0_all	Otter trawl, Molluscs, mesh size 70–99 mm, no selectivity device, all vessels
OTB_MPD _>=70_0_0	Bottom otter trawl directed to mixed pelagic and demersal fish (at least 70 mm)
OTB_MPD_>=55_0_0	Bottom otter trawl directed to pelagic and demersal fish (at least 55 mm)
OTB_SPF_32–69_0_0_all	Otter Bottom trawl, Small pelagic fish, 32–69 mm, no selectivity devise, all vessels
OTM_DEF_100–119_0_0_all	Midwater otter trawl, Demersal species, mesh size 100–119 mm, no selectivity device, all vessels
OTM_DEF_32–54_0_0_all	Midwater otter trawl, Demersal species, mesh size 32–54 mm, no selectivity device, all vessels
OTM_DEF_55–69_0_0_all	Midwater otter trawl, Demersal species, mesh size 55–69 mm, no selectivity device, all vessels
OTM_DEF_70-99_0_0_all	Midwater otter trawl, Demersal species, mesh size 70–99 mm, no selectivity device, all vessels
OTM_DEF_80–89_0_0_all	Midwater otter trawl, Demersal species, mesh size 80–89 mm, no selectivity device, all vessels
OTT_CRU _>=70_0_0	Multi-rig otter trawl directed to crustaceans (at least 70 mm)
OTT_DEF _>=70_0_0	Multi-rig otter trawl directed to demersal fish (at least 70 mm)
OTT_DEF_>=120_0_0_all	Multi-rig otter trawl, demersal fish, mesh size more than 120 mm, no selectivity device, all vessels
OTT_DEF_100-119_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 100–119 mm, no selectivity device, all vessels
OTT_DEF_16-31_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 16–31 mm, no selectivity device, all vessels

MÉTIER LEVEL 6	DESCRIPTION
OTT_DEF_80-89_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 80–89 mm, no selectivity device, all vessels
OTT_DEF_90-99_0_0_all	Multi-rig otter trawl, demersal fish, mesh size 90–99 mm, no selectivity device, all vessels
PS_SPF_0_0_0	Purse seine, Small pelagic fish, no selectivity device.
PTB_DEF _>=70_0_0	Bottom pair trawl directed to demersal fish (at least 70 mm)
PTB_DEF_>=120_0_0_all	Pair bottom trawl, demersal fish, mesh size more than 120 mm, no selectivity device, all vessels
PTB_DEF_>=70_0_0	Pair bottom trawler targeting demersal fish
PTB_DEF_80–89_0_0_all	Pair bottom trawl, demersal fish, mesh size 80–89 mm, no selectivity device, all vessels
PTB_MPD_>=55_0_0	Bottom pair trawl directed to mixed pelagic and demersal fish (at least 55 mm)
PTM_DEF_90-104_0_0	Midwater pair trawl, demersal fish, mesh size 90–104 mm, no selectivity device
SDN_DEF_>=120_0_0_all	Anchored seine, Demersal fish, mesh size more than 120 mm, no selectivity device, all vessels
SDN_DEF_>=120_0_0_all_FDF	Anchored Seine, Demersal Fish, Mesh Size 120 or above, Selectivity Device - none, All vessels, Fully Documented Fisheries
SSC_DEF_>=120_0_0_all	Fly shooting seine, Demersal fish, mesh size more than 120mm, no selectivity device, all vessels
SSC_DEF_>=120_0_0_all_FDF	Fly shooting seine, Demersal Fish, Mesh Size 120 or greater, Selectivity Device - none, All vessels, Fully Documented Fisheries
SSC_DEF_100-119_0_0_all	Fly shooting seine, Demersal fish, mesh size 100–119 mm, no selectivity device, all vessels.
SSC_DEF_80-89_0_0_all	Fly shooting seine, Demersal fish, mesh size 80–89 mm, no selectivity device, all vessels
SSC_DEF_All_0_0_All	Fly shooting seine, , Demersal fish, all mesh sizes, no selectivity, all vessels
TBB_CRU_16-31_0_0_all	Beam trawl, Crustaceans, mesh size 16-31mm, no selectivity device, all vessels
TBB_DEF_<16_0_0_all	Beam trawl, Demersal fish, mesh size 16mm or less, no selectivity device, all vessels
TBB_DEF_>=120_0_0_all	Beam trawl, Demersal fish, mesh size more than 120, no selectivity device, all vessels
TBB_DEF_100-119_0_0_all	Beam Trawl, mesh size 100–119 mm
TBB_DEF_70–99_0_0_all	Beam trawl, Demersal fish, mesh size 70–99, no selectivity device, all vessels
TBB_DEF_90–99_0_0_all	Beam trawl, Demersal fish, mesh size 90–99, no selectivity device, all vessels
TBB_DEF_all_0_0_all	Beam trawl, Demersal fish, all mesh sizes, no selectivity, all vessels

*** The use of metiers under the MIS_MIS category should be minimized.**

APPENDIX 4

The information request in this appendix is only required for stocks identified in annex 1 with DLS under column "DLS proxy RP".

Data quality and quantity information in the 2017 ICES data call in annex 3.

"Data quality and quantity information" includes a set of simple indicators that will allow ICES Expert Groups to get a general idea on the quantity and quality data submitted.

The aggregation should be as in the IC.

A set of simple indicators on data quantity and quality indicators are requested to be used by ICES EGs in preliminary checking of the quality and quantity of the length compositions made available. These indicators should be sent directly to accessions@ices.dk and are supplemental to the quantity indicators submitted to InterCatch, including: total landings in kg, number of fishing trips (total and with target stock; at national level and observed by national programme), number of fishing trips where stock was length-measured and number and whole-weight of specimens actually measured for length.

ID Fields									Questionnaire							
Country	Species	Species 3 letter code	2016 Stock code	Geographical area	Fleet / Gear type / Metier	Year	Quarter	Catch Category	Total volume (in kg, whole weight)	Total number of trips (country level)	Number of trips with target specie (country level)	Total number of trips (observed in programme)	Total number trips observed with stock	Total number of trips where stock was length-measured	Total number of fish length-measured	Weight of fish measured (in kg, whole weight)
xxx	Clupea harengus	HER	her.27.6a7bc	subarea 4	OTM_SPF_32-69_0_0_all	2015	1	L	500	244	186	47	2	2	8	25

Quantitative info tab

Information on thresholds used to define the data submitted (e.g., was data considered good enough for submission only if more than a minimum number of fish was measured per quarter?) and the general opinion of data providers on the quality of the data submitted and possible estimation issues are also request.

ID Fields									Questionnaire	
Country	Species	Species 3 letter code	Stock code	Geographical area	Fleet / Gear type / Metier	Year	Quarter	Catch Category	Did you use any kind of threshold to define the data you uploaded (e.g., minimum number of fish measured, minimum number of hauls/trips with stock, absence of gaps in Length frequency, other?). If yes, please specify.	General opinion of data providers on the quality of the data submitted
xxx	Clupea harengus	HER	her.27.6a7b	subarea 4	OTM_SPF_32-69_0_0_all	2015	1	L	Yes. Only fleets*quarter*stock*area with >5 individuals measured in >=2 trips were used	Data is very scarce but total landings too - should not be much of a problem

Qualitative info tab

APPENDIX 5

The information request in this appendix is only required for stocks identified in annex 1 with DLS under column ”DLS proxy RP”.

Supporting life history information in the 2017 ICES data call in Annex 4.

“Supporting life history information” would include information on life history traits, if available, noting that some candidate reference points may require input on L_{mat} (length at first maturity), growth parameters (e.g., L_{inf}, K), and M (natural mortality). ICES recognizes that for countries which are also EU members, this type of information is not under the DCF regulation ((EC) No 199/2008). That said, this type of information is important to the delivery of advice associated with this data call. ICES asks that countries report this information if they are aware of it, but it is not obligatory.

^ If information is provided on traits not listed in the template, include them in these rows with the parameter name in the comments column.

	Value	Reference	Country code	Stock code	Species code	Comments
Lmat						
Linf						
K						
M						
Unspecified parameter^						
Unspecified parameter^						

Annex 9: Working documents

Working Document to the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), Copenhagen, 26 April–5 May 2017.

Working document 1: Calculation and smoothing of an area-weighted variable maturity ogive for North Sea cod.

Nicola D. Walker[1] and Jan Jaap Poos[2]

Summary

Until 2015 the maturity values used in the assessment of North Sea cod were left unchanged from year to year. However, the benchmark in 2015 (ICES, 2015) noted a positive trend in maturity-at-age over time and substantial subpopulation level differences in maturation change. To address these changes in the stock, the benchmark introduced a smoothed annually varying maturity ogive to the assessment. Since its introduction, two issues have been noted:

Inconsistencies in the methodology used to calculate raw maturity-at-age from new data compared to historic maturity calculated at the benchmark.

High sensitivity of the smoother to raw maturity estimates at the end of the time-series.

Here the raw maturity-at-age key is re-estimated to produce a time-series of maturity estimates that are calculated consistently over time in a manner that is transparent and reproducible, according to the methodology of the benchmark. Retrospective plots are produced to examine the effect of re-smoothing with new maturity estimates and a series of alternative smoothing options explored.

Maturity at age key

The original maturity-at-age key for North Sea cod was produced at the benchmark (ICES 2015) following a request at the meeting, and a script for the routine estimation of maturity-at-age with estimates for 2008–2016 provided to WGNSSK in 2016. Several differences in methodology between the script and the benchmark description of the calculations have been noted, including:

- subarea definitions
- raising of SMALK data to the population level
- calculation in terms of biomass rather than numbers

The following sections document the methodology adopted by WGNSSK to estimate raw maturities and compares the resulting maturity-at-age key to that produced by the benchmark.

Methods

IBTS data for 1978–2017 were downloaded from the ICES database of trawl surveys (DATRAS; http://datras.ices.dk) in exchange format on 19/04/2017, and read into R as

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DATRAS raw objects (Kristensen and Berg, 2012). These data contain three components: haul meta-data (HH), species length-based information (HL; all fish caught) and species age-based information (CA; only fish sampled for biological information). Data were read in using function read Exchange with strict = FALSE to avoid dropping of age data (Kristensen and Berg, 2012), and the data subset to consider only Q1 valid hauls. Fish in the CA data were assigned as either immature or mature following Table 1. Records with abnormal or missing maturity were removed, resulting in the removal of 0–46% of CA records over the time–series (mean = 12%), although the proportion reduced notably from 1998 with a maximum of 6% (mean = 2%). The raw number of observed individuals per length group (HL data) was added to the HH data and scaled to 60 minutes of effort. Each record was assigned to a population subarea following the definitions adopted for North Sea cod at the benchmark (Figure 1), but as data from the Skagerrak are only available after 1991 this subarea was excluded from the construction of the maturity–age key (ICES 2015).

Table 1. Finfish maturity key for the IBTS survey and assignment as immature (0) or mature (1).

Code	Description	Mature
1	Juvenile/Immature (4–tage scale)	0
2	Maturing (4–stage scale)	1
3	Spawning (4–stage scale)	1
4	Spent (4–stage scale)	1
6	Abnormal (4–stage scale, additional option)	-
61	Juvenile/Immature (6–stage scale)	0
62	Maturing (6–stage scale)	1
63	Spawning (6–stage scale)	1
64	Spent (6–stage scale)	1
65	Resting/Skip of spawning (6–stage scale)	1
66	Abnormal (6–stage scale)	-
I	Immature	0
M	Mature	1

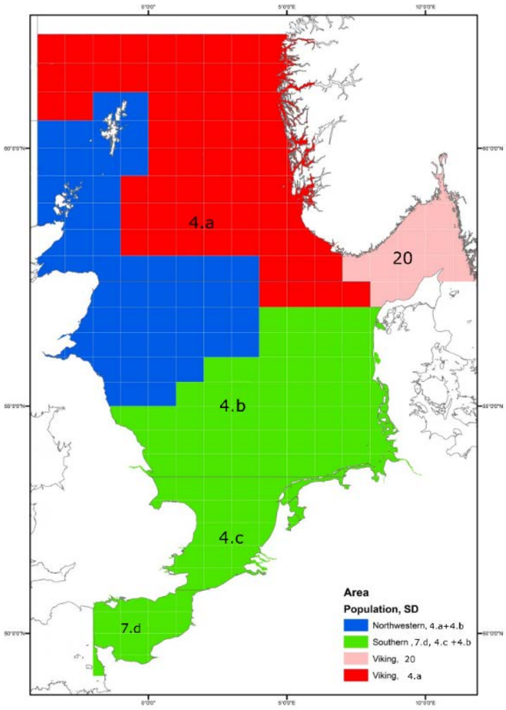

Figure 1. Subareas adopted for the spatial analysis of North Sea cod at WKNSEA (ICES, 2015). The subareas are referred to: Sk (Skagerrak); V (Viking); NW (north western) and S (southern), corresponding to pink, red, blue and green colours on the map, respectively.

The benchmark calculations of maturity raised CA data to the subpopulation level directly. However, not all fish caught in the IBTS Q1 survey are aged, but do need to be accounted for when raising to the subpopulation level. Age-length keys were fit to the CA data of the three subpopulations considered (NW, S, and V) using continuation-ratio logits (Berg and Kristensen, 2012; Kristensen and Berg, 2012), consistent with the methodology used to derive ALKs when constructing Delta–GAM indices for the assessment. Age 6 was modelled as a plus group and subsequently discarded as only fish <6 years old were considered in the maturity calculations (ICES, 2015). The ALKs were multiplied by total numbers-at-length (now in the HH data) to get an estimate of numbers-at-age for all fish caught in the survey scaled to 60 minutes of effort ($n_{a,y,p}$).

The script provided to WGNSSK in 2016 estimates maturity as the ratio of mature stock biomass to total stock biomass. However, individual weights required for this calculation are not available in the CA data prior to 2000. Proportion mature in each subarea ($M_{a,y,p}$) was derived by dividing the number of mature fish-at-age in the CA data by the total number of fish-at-age in the CA data. Proportion mature-at-age by year was then estimated as:

$$M_{a,y} = \frac{\sum N_{a,y,p} \cdot M_{a,y,p}}{\sum N_{a,y,p}}$$

Where $N_{a,y,p}$ is the total number of cod-at-age in a subarea, obtained by raising the survey numbers-at-age ($n_{a,y,p}$) according to:

$$N_{a,y,p} = \frac{A_p}{A_s} \cdot n_{a,y,p}$$

Where A_p is the area of a population subarea (NW: 209 822 km^2, S: 732 104 km^2 and V: 233 372 km^2; ICES, 2015) and A_s is the swept area of the GOV (0.065 km^2; ICES, 2015).

This gave an estimate of the numbers-at-age per year and subpopulation to weight maturity across the stock.

R-scripts used to produce the maturity-at-age key are provided in Appendix 1.

Results and further analyses

Figure 2 plots the maturity-at-age key produced here against that produced by the benchmark. Although there are clear positive trends over time, there is high inter annual variability. As a sensitivity test, a logistic regression was used to estimate maturity-at-length per year and converted to mean maturity-at-age (Appendix 2). This analysis was performed without splitting the data into subpopulations and showed little reduction in inter annual variability when fitting maturity as opposed to calculating it (Appendix 2).

A second sensitivity test removed skip-spawners (maturity stage 5; 65 in Table 1) from the calculation. This was because stage 5 is not included in the maturity staging historically and past studies undertaken have shown some observers to mistake stage 5's for immature and vice-versa (Peter Wright, personal communication). Removing skip-spawners from the calculation had very little impact on the maturity-at-age key (Appendix 3).

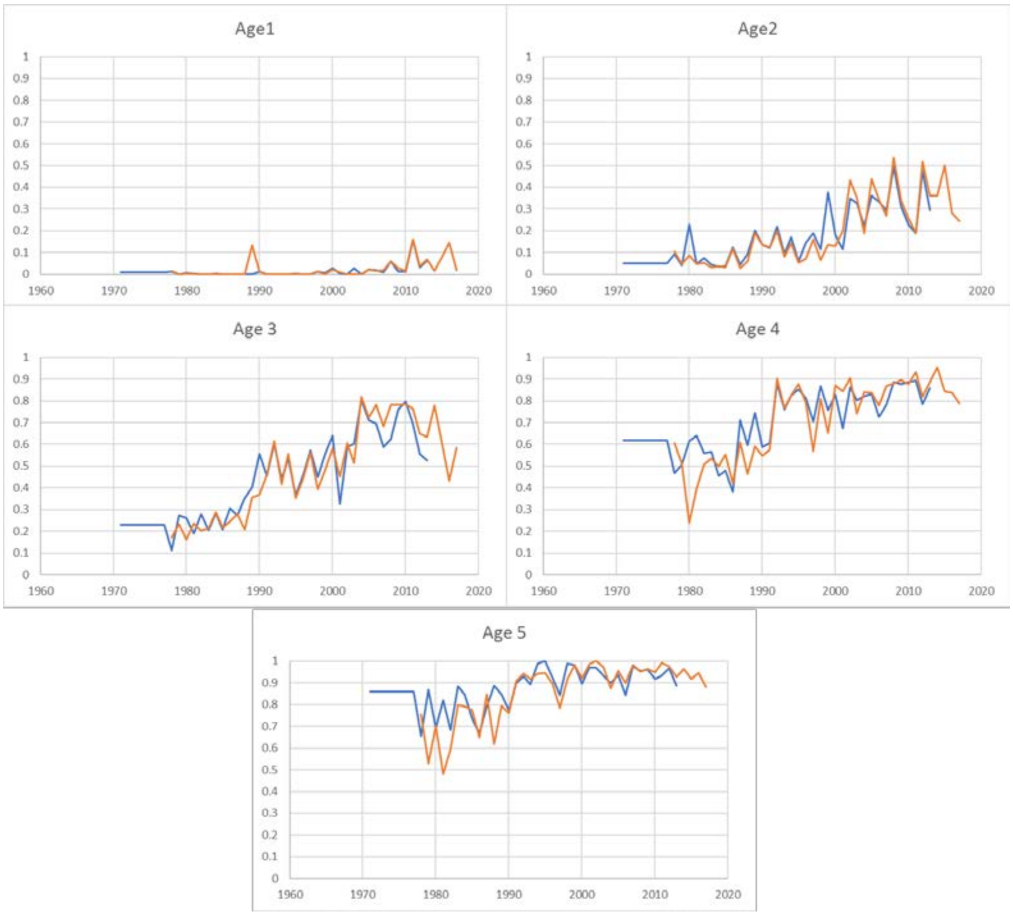

Figure 2. Comparison of the maturity-at-age keys estimated here (orange) and at the benchmark (blue).

There are several possible reasons for differences between the maturity-at-age key produced here and by the benchmark including (but not limited to):

- The procedure used to raise SMALK (CA) data to the population level
- Exclusion of invalid hauls
- Invalid hauls were excluded here because HL (length) data were used, resulting in exclusion of 0–9% of CA records each year over the time-series (mean=1%). It is unclear whether these hauls were excluded from benchmark calculations.
- Revisions to the underlying DATRAS data between 2015–2017

Due to high inter-annual variability, the current procedure is to smooth the maturities-at-age and feed these smoothed maturities into the assessment (see below). Figure 3 plots the resulting smooth maturity ogives for both the benchmark and re-calculated maturity-at-age keys while Figure 4 shows the effect of re-estimating the maturity-at-age key on SSB. The re-estimation of maturity will have no further impact on the assessment because recruitment is modelled as a random-walk process independent of SSB. Note that the maturity-at-age key presented here has been smoothed only to 2013 for consistency with the benchmark and that the assessment runs in Figure 4 use 2017 data truncated to 2013.

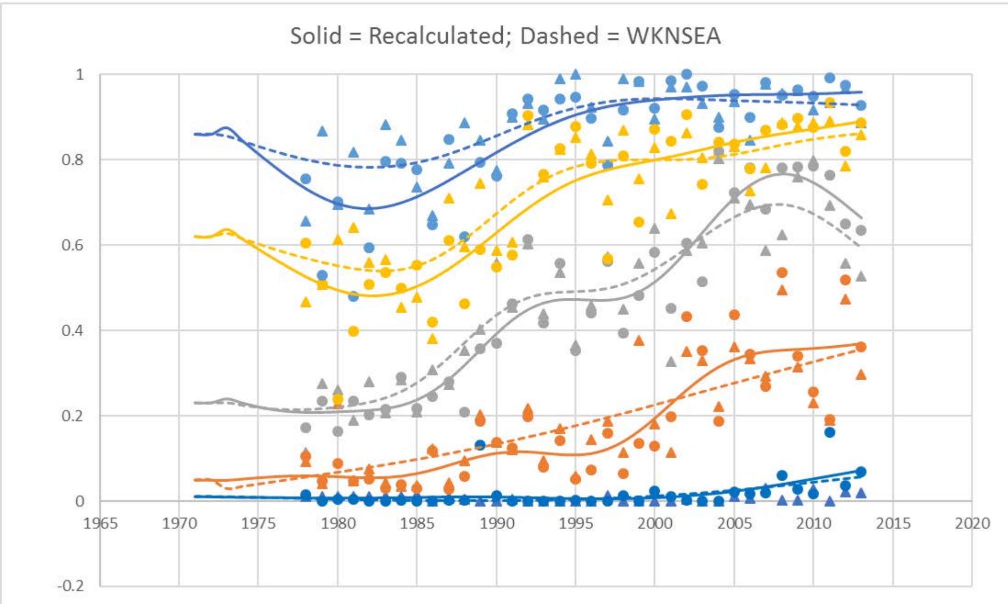

Figure 3. Comparison of the maturity ogives resulting from smoothing the recalculated (circles and solid line) and benchmark (triangles and dashed line) maturity-at-age keys.

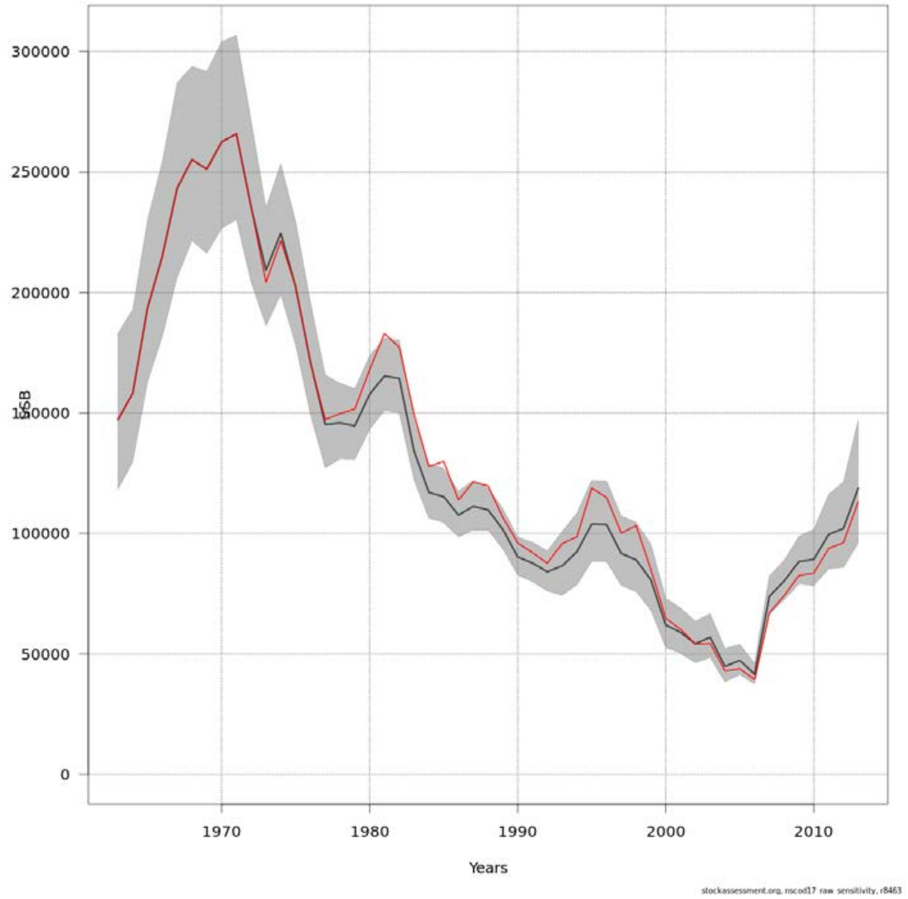

Figure 4. SSB estimated from running the North Sea cod assessment to 2013 with recalculated (black) and benchmark (red) maturities. The shaded area shows the point–wise 95% confidence interval for the run with recalculated maturities.

Conclusions

Although it has not been possible to reproduce the maturity-at-age key of the benchmark and therefore determine the exact sources of differences, the methodology described here has been discussed with experts on use of DATRAS data, the DATRAS R package and members of the IBTS Working Group, and WGNSSK is now satisfied that it has a time-series of maturity estimates that are consistently calculated over time in a manner that is transparent and reproducible, according to the methodology of the benchmark (ICES 2015). As such, these re-estimated maturities replace the benchmark maturities in the 2017 assessment of North Sea cod (ICES 2017). This caused a rescaling of SSB, to an extent that necessitated the recalculation of reference points. This work is in described in the Working Group report (ICES 2017).

Maturity smoothing

Due to high inter-annual variability, the assessment procedure is to fit a simple GAM with a spline smooth over time (from 1973) to each age in the raw maturity ogive using the mgcv package in R (Wood, 2006). Re-smoothing the ogive each year with an additional row of new maturity data changes the estimates back in time, which caused problems for the 2016 assessment of North Sea cod. Low sample size that year led to a very low estimate of maturity for age three cod and significantly changed the smoothed maturities back in time. The Working Group rejected the 2016 maturity estimates and instead smoothed maturities to 2015 assuming the smoothed 2015 maturity values in

2016: this resulted in an SSB estimate that was almost 15 thousand tonnes higher than had the 2016 maturity estimates been included in the assessment (ICES, 2016).

New maturity records have been added to the DATRAS database since last year's assessment and more reasonable estimates of maturity for 2016 now obtained. Nevertheless, the extent to which re-smoothing the raw ogive affects maturity and SSB estimates was investigated and alternative methods of smoothing explored.

Retrospective plots

Retrospective plots produced for the assessment of North Sea cod sequentially remove one year of data from each of the final input files. For maturity, this means that data are sequentially removed from the pre-smoothed maturity ogive. To examine the full effect of adding new maturity data, a retrospective analysis was performed where data are sequentially removed from the raw maturity ogive and re-smoothed before entering the assessment (Figure 5). Reapplying the smoother in this way notably changes the maturity estimates back in time for age 2 cod but has little impact on the other ages or on the estimates of SSB (Figure 5).

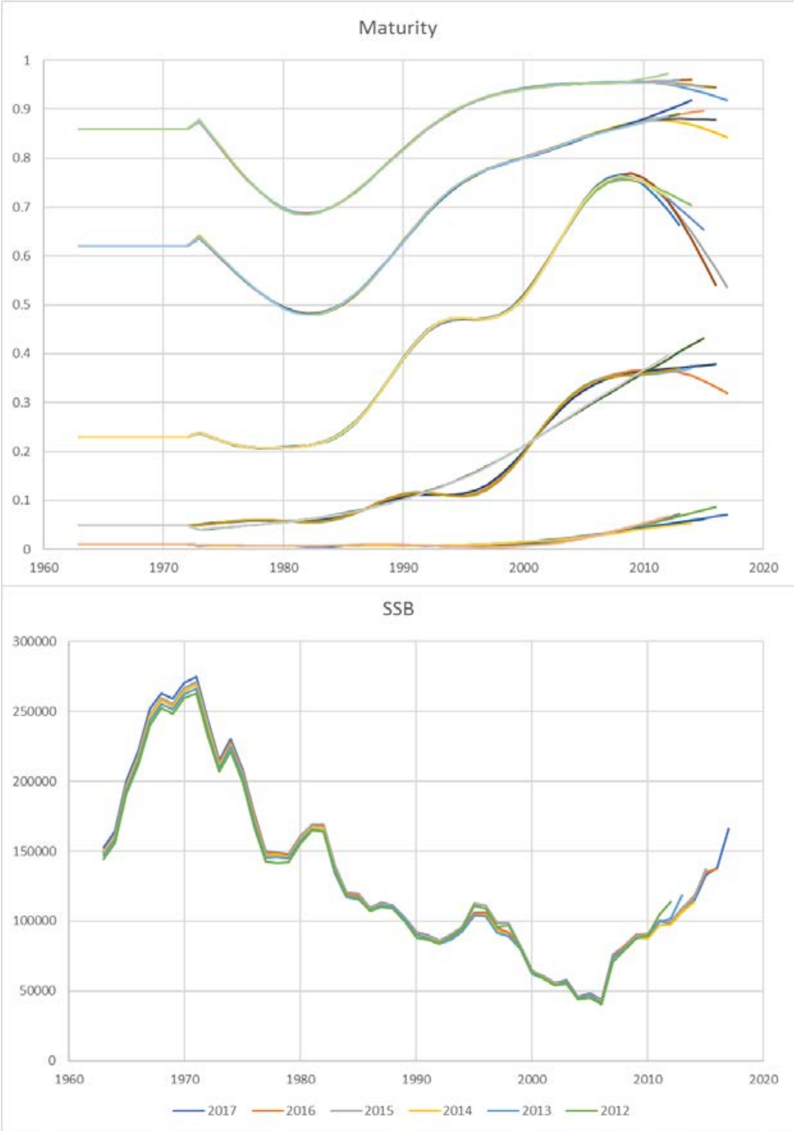

Figure 5. Retrospective estimates of maturity and SSB produced by sequentially removing data from the raw maturity ogive and re-smoothing before feeding into the assessment.

Alternative smoothers

GAMs with a tensor product smooth were explored as an alternative to the current spline method. Use of a two dimensional smoother allows both age and year/cohort effects to describe changes in the maturity ogive. Specification of knots was also explored as an option to minimise the effect of new data on the smoothed maturity estimates back in time.

Three separate GAM models with tensor product smooths were considered. The first models maturity as a smoothly varying function of both age and year with 4 knots for age and 18 knots for year. Selection of 18 knots gives approximately one knot every 2.5 years, and should be increased proportional to the data if adopted in the future. The binomial family was used to constrain the estimates between 0 and 1. Using R's notation, syntax for the year and age effects model is:

```
gam(Freq ~ te(age, year, k = c(4,18), fx=T), data = matdf, fit = T, family="bi-
nomial")
```

The age and year effects model was run both for the full smoothing period (1973–2017) and for a reduced period (1973–2007 with 14 knots for the year effect) to illustrate knot specification as a tool to minimise the effect of new data on maturity estimates back in time (Figure 6 top panel).

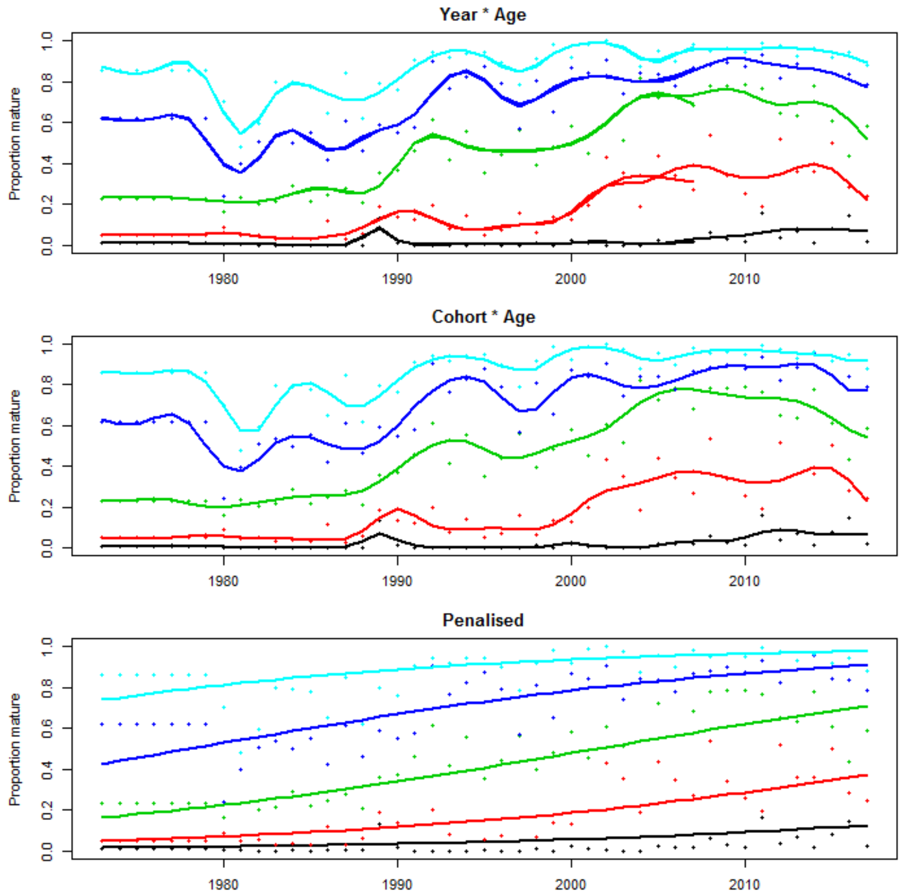

Figure 6. Maturity-at-age smoothed using a GAM with tensor product smooth over year and age (top), cohort and age (middle) and penalised cohort and age (bottom). The top pane compares the full smoothing period (1973–2017) with a reduced smoothing period (1973–2007).

The second GAM models maturity as a smoothly varying function of age and year-class (cohort) keeping all other settings the same. Syntax for the cohort and age effects model is:

```
matdf$cohort <- matdf$year-matdf$age
```

```
gam(Freq ~ te(age, cohort, k = c(4,18), fx=T), data = matdf, fit = T, family="bi-
nomial")
```

The third GAM is a penalised cohort and age effects model that automatically selects the degrees of freedom used for the smooth, as is done for the spline smoothing of maturities currently used in the assessment of North Sea cod. Syntax for the penalised cohort and age effects model is:

```
gam(Freq ~ te(age, cohort, k = c(4,18), fx=F), data = matdf, fit = T, family="bi-
nomial")
```

Figure 6 plots the smoothed maturities resulting from each of the GAM models while Table 2 presents model diagnostics. The fixed regression GAMs with age and year/cohort effects performed similarly but with a slight improvement in fit for the year and age effects model. The penalised model has a lower AIC resulting from lower degrees of freedom but performed less well in other areas. Furthermore, allowing the model to reduce the number of knots reduces its ability to minimise changes to the smoothed estimates when new data are included. Figure 7 plots the SSB resulting from using a GAM with tensor product smooth over age and cohort against the simple spline currently employed in the assessment.

Table 2. Diagnostics (effective degrees of freedom [edf], adjusted r-squared [adj R–sq], deviance explained [dev.expl] and AIC) for the GAM models with tensor product smooths.

Model	edf	adj R-sq	dev.expl	AIC
Year * Age	71	0.964	96.8%	252.2255
Cohort * Age	71	0.963	96.7%	252.2279
Penalised	3	0.923	90.1%	127.752

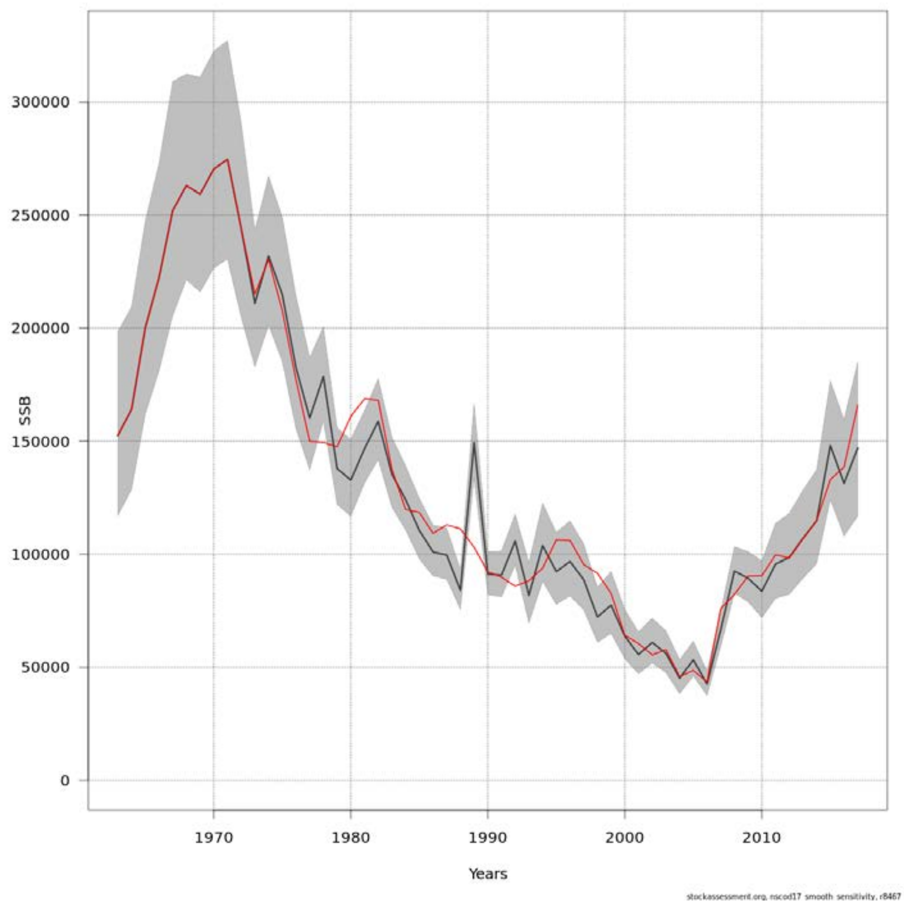

Figure 7. SSB estimated from running the North Sea cod assessment with maturities smoothed using a GAM with (black) a fixed tensor product smooth over age and cohort and (red) a simple spline over years. The shaded area shows the point–wise 95% confidence interval for the run with the tensor product smooth.

Conclusions

The large difference in SSB between assessment runs in 2016 resulted from holding the age 3 maturity at the relatively high 2015 value as opposed to letting the smooth be pulled down by the extremely low 2016 estimate. New DATRAS records have improved the 2016 estimate of age 3 maturity and, although still low, a decline in proportion mature at age 3 is confirmed by the 2017 data. Retrospective plots where maturity-at-age is re-smoothed prior to entering the assessment show some sensitivity of the smoothed maturities to the current method of smoothing (especially age 2) but little impact on SSB. Consequently, the Working Group decision is to carry on with the benchmarked spline smoother, although alternate smoothers such as those explored here may be considered in future benchmarks.

Acknowledgements

The authors of this document would like to thank Casper Berg, Vaishav Soni, Jennifer Devine, Peter Wright and David Stirling as well as the members of WGNSSK for their help and advice in various aspects of this work.

Reference

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APPENDIX 1

Scripts used to produce the maturity-at-age-key

```
working_year <- 2017
years <- 1978:2017

wd=paste0("C:/Users/nw03/Documents/MA011A Stock assess/WGNSSK/",working_year,"/software/ma-
turity/")
data.wd=paste0("C:/Users/nw03/Documents/MA011A Stock assess/WGNSSK/",working_year,"/data/sur-
vey/datras/")
out=paste0("C:/Users/nw03/Documents/MA011A Stock assess/WGNSSK/",working_year,"/data/survey/ma-
turity/")

# Load packages and functions
library(DATRAS)
library(dplyr)
library(plyr)
library(XLConnect)
source(paste0(wd, "functions.R"), echo=TRUE, max.deparse.length = 1500)

# Species specific parameters
genus = "Gadus"
bfamily = "morhua"

# Subareas
fil <- "C:/Users/nw03/Documents/MA011A Stock assess/WGNSSK/2017/software/indices/Area_defini-
tion_060115.xlsx"
wb=loadWorkbook(fil)
areadef=readWorksheet(wb,sheet=1)
areadef[is.na(areadef[,1]),]=NA
ad = areadef[,c(4,3)];
ad = ad[-nrow(ad),]
names(ad)<-c("x","y")
sm = splitMap(ad)
names(sm) <- c("V","Sk","NW","S")


##########################################################
# Load data
##########################################################

# Storage
mat <- matrix(0, nrow=length(years), ncol=5)
rownames(mat) <- years
sample <- data.frame()

for (yr in years){

  print(yr)

  # Unpack and read raw exchange zipfile
  dAll = readExchange(paste0(data.wd,yr,".zip"), strict = FALSE)

  # Q1 cod data
  cod <- subset(dAll, Species==paste(genus,bfamily), Quarter==1, HaulVal=="V", Country!="DUM",
!is.na(Maturity))

  # Recode Maturity 0 == Imature, 1 == Mature
  cod[["CA"]]$Maturity = as.character(cod[["CA"]]$Maturity)
  cod[["CA"]]$Maturity = revalue(cod[["CA"]]$Maturity, c("61"="0", "62"="1", "63"="1", "64"="1",
"65"="1", "1"="0", "2"="1", "3"="1", "4"="1", "5"="1", "I"="0", "M"="1"))
  cod[["CA"]]$Maturity = as.numeric(cod[["CA"]]$Maturity)
  cod[["CA"]] = filter(cod[["CA"]], Maturity!=66 & Maturity!=6) # Remove abnormal

  # Add raw number of observed individuals per length group to HH data and calculate CPUE (based
on 60 mins effort)
  cod = addSpectrum(cod,by=1)
  cod[[2]]$N <- cod[[2]]$N / cod[[2]]$HaulDur * 60

  # Assign cod hauls to population sub areas
  cod$SubArea = cut.polygonGrid(cod[[2]],sm)
  cod[["HH"]] = transform(cod[["HH"]], SubArea=as.character(SubArea), haul.id=as.charac-
ter(haul.id))

  # Add SubArea column to CA dataframe and set to character
  SUBA = as.data.frame(cbind(haul.id = cod[["HH"]]$haul.id, SubArea = cod[["HH"]]$SubArea))
  cod[["CA"]] = merge(cod[["CA"]], SUBA, by=c("haul.id"))
  cod[["CA"]]$SubArea = as.character(cod[["CA"]]$SubArea)

  # Create a coded column giving age and subarea
  cols = c("Age", "SubArea")
  cod[["CA"]]$ID = do.call(paste, c(cod[["CA"]][cols], sep=""))

  # Split by population subarea
  Scod = subset(cod, SubArea=="S")
```

```
  NWcod = subset(cod, SubArea=="NW")
  Vcod = subset(cod, SubArea=="V") ;
  Skcod = subset(cod, SubArea=="Sk") ;


  #### ALKs

  ###################################

  # Calculate numbers at age from HH data for each sub population area

  png(paste0(out,yr,"ALKs.png"), width = 17, height = 15, units = "cm", res = 500)
  par(mfrow=c(2,2))

  ###################################
  # Southern sub area
  ###################################
  if (nrow(Scod[["CA"]])>0){
    S_alk <- fitALK(Scod, 1, 6)
    plotALKraw(Scod,1,6, main = "Southern")
    plotALKfit(S_alk, 1,add=TRUE)
    predicted <- predict(S_alk, type = "ALK")[[1]]
    S_N_per_Age <- data.frame(Age=1:6, N=colSums(colSums(Scod[[2]]$N) * predicted))[-6,]
  }

  ###################################
  # Northwestern sub area
  ###################################
  if(nrow(NWcod[["CA"]])>0){
    NW_alk <- fitALK(NWcod, 1, 6)
    plotALKraw(NWcod,1,6, main="Northwestern")
    plotALKfit(NW_alk, 1,add=TRUE)
    predicted <- predict(NW_alk, type = "ALK")[[1]]
    NW_N_per_Age <- data.frame(Age=1:6, N=colSums(colSums(NWcod[[2]]$N) * predicted))[-6,]
  }

  ###################################
  # Viking sub area
  ###################################
  if (nrow(Vcod[["CA"]])>0){
    V_alk <- fitALK(Vcod, 1, 6)
    plotALKraw(Vcod,1,6, main = "Viking")
    plotALKfit(V_alk, 1,add=TRUE)
    predicted <- predict(V_alk, type = "ALK")[[1]]
    V_N_per_Age <- data.frame(Age=1:6, N=colSums(colSums(Vcod[[2]]$N) * predicted))[-6,]
  }

  dev.off()


  #### Proportion mature at-age per subarea

  ################
  # Southern
  ################
  if (exists("S_N_per_Age")){
    S_W_at_Age = ddply(Scod[["CA"]], .(Age, ID, SubArea), summarise, N.CA = sum(NoAtALK), N.Mat =
sum(Maturity))
    S_data = merge(S_N_per_Age, S_W_at_Age, by="Age")
    S_data$M.prop = with(S_data, N.Mat/N.CA)
    S_data$SSN = with(S_data, N*M.prop)
    S_data
  }

  ################
  # Northwestern
  ################
  if (exists("NW_N_per_Age")){
    NW_W_at_Age = ddply(NWcod[["CA"]], .(Age, ID, SubArea), summarise, N.CA = sum(NoAtALK), N.Mat
= sum(Maturity))
    NW_data = merge(NW_N_per_Age, NW_W_at_Age, by="Age")
    NW_data$M.prop = with(NW_data, N.Mat/N.CA)
    NW_data$SSN = with(NW_data, N*M.prop)
    NW_data
  }

  ################
  # Viking
  ################
  if (exists("V_N_per_Age")){
    V_W_at_Age = ddply(Vcod[["CA"]], .(Age, ID, SubArea), summarise, N.CA = sum(NoAtALK), N.Mat =
sum(Maturity))
    V_data = merge(V_N_per_Age, V_W_at_Age, by="Age")
    V_data$M.prop = with(V_data, N.Mat/N.CA)
    V_data$SSN = with(V_data, N*M.prop)
    V_data
  }
```

```
  # Combine subareas
  Tot_at_Age.y.p = do.call("rbind", mget(ls(pattern = "_data")))
  rownames(Tot_at_Age.y.p) <- NULL
  Tot_at_Age.y.p
  Tot_at_Age.y.p[, c(2,5:8)] = sapply(Tot_at_Age.y.p[, c(2,5:8)], as.numeric)

  # Raising factors
  RF <- data.frame(SubArea=c("S","NW","V"), RF=c(732104,209822,233372)/0.065)
  Tot_at_Age.y.p <- merge(Tot_at_Age.y.p, RF, by = "SubArea")
  Tot_at_Age.y.p$SN.r <- Tot_at_Age.y.p$N * Tot_at_Age.y.p$RF
  Tot_at_Age.y.p$SSN.r <- Tot_at_Age.y.p$SSN * Tot_at_Age.y.p$RF
  Tot_at_Age.y.p$N <- round(Tot_at_Age.y.p$N)

  # Sum over subareas and calculate maturity
  Tot_at_Age.y = ddply(Tot_at_Age.y.p, .(Age), summarise, N.a.y = sum(N), N.CA.a.y = sum(N.CA),
N.Mat.a.y = sum(N.Mat),  SSN = sum(SSN), SN.r = sum(SN.r), SSN.r = sum(SSN.r))
  Tot_at_Age.y$M.a.y.r = with(Tot_at_Age.y, SSN.r/SN.r)
  Tot_at_Age.y[, 1] = sapply(Tot_at_Age.y[, 1], as.numeric)
  sapply(Tot_at_Age.y, class)
  Tot_at_Age.y

  # Outputs
  mat[rownames(mat)==yr, Tot_at_Age.y$Age] <- Tot_at_Age.y$M.a.y.r
  Tot_at_Age.y.p$Year <- rep(yr, nrow(Tot_at_Age.y.p))
  sample <- rbind(sample,Tot_at_Age.y.p)

  rm(list=setdiff(ls(), c("working_year","years","wd","data.wd","out","genus","bfam-
ily","sm","mat","cut.polygonGrid", "sample")))
}

write.csv(mat, file=paste0(out,"maturity.csv"), row.names = FALSE)
write.csv(sample, file=paste0(out, "sampling.csv"), row.names = FALSE)
```

```
## Points in polygon
cut.polygonGrid <- function(x,polygons=splitMap(makeMap(x,"worldHires")),...){
  if(is.list(polygons)){
    if(!is.list(polygons[[1]])) polygons <- list(polygons)
  } else stop("polygons must be list or data.frame")
  if(is.null(names(polygons))) names(polygons) <- 1:length(polygons)
  require(sp)
  mat <- sapply(polygons,function(y)point.in.polygon(x$lon,x$lat,y[[1]],y[[2]]))
  fac <- mat %*% (1:ncol(mat))
  fac[!fac] <- NA
  fac <- factor(names(polygons)[fac])
  fac
}

splitMap <- function(map){
  i <- cumsum(is.na(map$x))
  ans <- split(as.data.frame(map[c("x","y")]),i)
  names(ans) <- map$names
  lapply(ans,na.omit)
}
```

APPENDIX 2

Maturity fitting

Data were read into R, subset and assigned immature or mature following the same procedures as in the main text. A logistic regression was used to estimate maturity-at-length $m(L)$ per year:

$$\operatorname{logit} m(L) = \alpha + \beta L$$

The distribution of length given age $P(L_i|a)$ was calculated from the raw proportions of age per length group $P(a|l)$ and the length distribution $P(l)$ using Bayes rule:

$$P(L = L_i|A = a) = \frac{P(A = a|L = L_i)P(L = L_i)}{\sum_k P(A = a|L = L_k)P(L = L_k)}$$

Mean maturity-at-age was estimated by applying the maturity function $m(L)$ to the length distribution and integrating out:

$$E(m(L)|A = a) = \sum_k m(L_k)P(L = L_k|A = a)$$

Casper Berg (personal communication)

Figure A2. Comparison of the maturity-at-age keys estimated using the methodology described here (blue) and a logistic regression on length converted to age (orange).

APPENDIX 3

Exclusion of skip-spawners

Figure A3. Comparison of the maturity-at-age keys estimated including (blue) and excluding (orange) skip-spawners.

Annex 10: Review of the estimation of maturity ogives and stock predictions for North Sea cod

REQUEST (by email, May 16th 2017)

Essentially the following has been done during the WGNSSK this year:

(a) Maturity re-estimation

Maturities have been re-estimated, and the WG is now satisfied that it has a time series of maturity estimates that are consistently calculated over time in a manner that is transparent and reproducible, according to the methodology described by the recent benchmark (WKNSEA 2015). Several errors in coding and data used were "cleaned up" in the process. The re-estimated maturities caused a re-scaling of the SSB, to the extent that the reference points were out of sync with the new SSB time series, and therefore needed to be re-calculated. The changes are:

Blim: 118 000 tons -> 107 000 tons

Bpa=MSY-Btrigger: 165 000 tons -> 150 000 tons

Fmsy: 0.33 -> 0.31

FMSY-lower: 0.22 -> 0.2

FMSY-upper: 0.49 -> 0.48

Flim: 0.58 -> 0.54

Fpa: 0.41 -> 0.39

The review would imply a check of the derivation of reference points and of the re-estimation of the maturities

(b) Forecast

A problem has arisen with the current methodology for the stochastic forecast. The May procedure currently ignores the SAM estimate of recruitment for the intermediate year, 2017 (which is uncertain and based only on one data point: the IBTS Q1 data available for the intermediate year) and replaces this with re-sampled recruitment from the recent low period (1998 the final year of catch data, 2016). The October procedure is that if the update protocol is triggered, the forecast is re-run, this time using the SAM estimate of recruitment (which is then based on 2 data points, both the IBTS Q1 and IBTS Q3 age 1 data available for the intermediate year). The problem we have encountered this year is that the 2016 year class (i.e. recruitment at age 1 in 2017) is a large year class, the largest for quite some time (larger than any since 1997). This year class has an important impact on the advice (instead of a 28% cut, it would lead to a 12% cut – these cuts are due to two very weak year classes that immediately preceded the 2016 year-class). If this year-class is confirmed by the IBTS Q3 survey later this year, a re-opening of the advice will be triggered. Despite the uncertainty associated with this year-class (being based only on one data point in the assessment), the WG felt that putting forward a forecast in May that ignores this large year class is difficult to defend, given that:

There is a good consistency for age 1 between the IBTS–Q1 survey and the subsequent IBTS–Q3 survey the same year (cor=0.95), and

There is also a good consistency for cohorts at age 1 in the IBTS–Q1 survey the one year, and at age 2 in the IBTS Q1 survey the following year (cor=0.86)

Re-opening of advice in October is highly likely, thus undermining the May advice.

The WG is therefore proposing to implement the October forecast procedure (without the IBTS Q3 survey estimates for the intermediate year, which is not yet available), which will utilise the recruitment estimate for the intermediate year (the large 2017 recruitment), which is 6-7 times larger than the median from the resampled recruitment from 1998+.

The review would imply a check of the October forecast procedure.

Reviewer 1: Daniel Ricard, Fisheries and Oceans Canada, June 20th 2017

Reviewer comments about (a) Maturity re-estimation

Working document "Calculation and smoothing of an area-weighted variable maturity ogive for North Sea cod" by Walker and Poos.

The methodology described in this working document, and its associated scripts, does improve the reproducibility and transparency of the maturity analyses. However, I do want to raise a few questions that will hopefully further clarify the methodologies used to estimate maturity ogives.

A number of minor modifications will be required if the document is meant as a standalone piece of work accessible to a general scientific audience that may not be familiar with ICES acronyms. For example, "SMALK data" and "GOV" are undefined. The mathematical notation needs to be better defined (subscripts "a", "y" and "p" are undefined in the text). Figures need consistent axis labels and legends.

The script presented in Appendix 1 contains a source call to a file called "functions.R" which seemingly contains the actual details about fitting the age-length key. It would be very useful to see what goes on in there, particularly what the function "fitALK" does exactly. One question that I still had after reading the working document was about the uncertainty associated with the proportion mature at age. The way things are presented now in Figure 3 suggests that no uncertainty estimates exist for the proportion mature at age in each year, but there is likely a fair amount of variability in the proportion mature at age when looking at tows conducted in the different regions of the North Sea.

I think that it is defensible to move forward with the new reproducible methodology without actually identifying the exact reasons for the discrepancies between the benchmark and the revisions made by WGNSSK. The working document identifies possible reasons for the discrepancies and I believe that this is a sufficient attempt to move this process forward.

The smoothing procedures presented to obtain time-varying estimates of proportion mature at age capture the trends well. The document suggests that the "problematic" 2016 estimate for age 3 might be caused by the small sample size in that year. Would it then be possible to use some weighting in the GAM fitting procedure so that the effect of years with fewer data points is diminished? In terms of exploring alternative smoothers, I believe that the GAM with cohort effect is more biologically defensible and should be explored further. And again, having an idea of the uncertainty associated with the proportion mature at age would put the fit of the smoother in better context.

The main points that I make from the working document are twofold: 1) Prior to 2002–2003, the estimates of proportions mature at age from the benchmark are above those from the WGNSSK resulting in SSB estimates that are above those that were recalculated. Since 2002–2003 the recalculations result in higher proportions mature at age and higher estimates of SSB. 2) The marked recent decreases in proportion mature at age 3 impact the SSB estimates, which in turn require the redefinition of reference points.

The biologically interesting question, which is beyond the scope of the working document, is how fast sexual maturity can revert to older ages after monotonically moving towards younger ages for decades. This warrants further research since it has important ecological implications and suggests reversibility of the effects of fisheries-induced evolution.

Overall, I find that the revised methodology to calculate maturity-at-age is transparent and defensible.

<u>Biological reference points, section 4.9 of the WGNSSK report</u>

Choosing Blim as the last SSB level that produce "reasonable" recruitment is a necessary method to use when the assessment model does not allow for the analytical computation of reference points. That being said, it is difficult to review the appropriateness of the reference point without seeing a clearly labelled stock-recruitment plot. My apologies if it was available, but I did not find it in the large amount of materials that was shared for this review. I do not doubt the numbers presented in the report and support the methodology, but would've benefitted from having detailed instructions on where to find the information necessary to make a constructive review.

Reviewer comments about (b) Forecast

Short-term forecasts, section 4.7 of the WGNSSK report, "The October forecast"

I do not want to cause a diplomatic row here, but I am always amazed at how quickly an estimate of a good recruitment year is used to increase harvest levels for North Sea cod. The estimate for the 2016 year-class is higher than those observed since 1996. Which raises two questions: 1) How uncertain is the estimate of the 2016 year class? The error bars on the bottom-right panel of Figure 4.6 are large and suggest that the 2016 year-class could also be similar to the mean recruitment since 1997. 2) Did the strong 1996 year-class contribute to the SSB and to the fishery to its full extent? I see no indication of increasing SSB or total biomass in the years following 1996, meaning that strong year classes must be coupled with reductions in fishing mortality to be allowed to benefit the fishery.

The strong year-class is also seemingly restricted to the northwestern part of the North Sea (top panel Figure 4.16b). For a stock that is above Blim and just above Bpa, it seems a bit optimistic to immediately modify the advice based on one strong year-class.

This is beyond the review I was asked to provide, and probably discussed at length by the working group already, but based on the painful Canadian experiences with cod populations I would err on the side of caution and apply the precautionary approach in the short-term forecasts. I am not familiar with natural mortality on the North Sea cod stock, but based on the story documented by Cook et al. (2015) for the West of Scotland cod stock it would be prudent to rebuild the North Sea cod stock to healthy levels where it can sustain a fishery while also avoid being jeopardised by increased natural mortality.

I do, however, understand the reasons behind using the October forecast procedure in the May forecast since the results of the Q3 survey results will be reviewed in October. As such, I have no objections to deviating from the ICES norm and to apply the October forecast procedure in the May forecast.

References

Cook, R. M., Holmes, S. J. and Fryer, R. J. (2015), Grey seal predation impairs recovery of an over-exploited fish stock. J Appl Ecol, 52: 969–979. doi:10.1111/1365–2664.12439

Reviewer 2: Joanne Morgan, Fisheries and Oceans Canada, May 31st 2017

Reviewer comments about (a) Maturity re-estimation

Maturity

The area weighting seems appropriate. However, there is a large difference between the recalculated and benchmark maturity at age for age 2 in two years. There are some other large differences but these are at older ages where larger differences would be expected. The GAMs are sensitive to the new data point in 1989, producing a large difference in SSB in that year between the SSB using the GAM and the one using the spline. This may be the result of some of the 'cleaning up' of errors in the data, but should be checked.

The use of the spline seems to give a good representation of trends. As suggested in the WD the use of GAM (or other fitting method) should be explored further. Particularly with a cohort effect as this is biologically realistic.

Reference points

The reference points seem to be estimated in a standard manner. The choice for B_{lim} as the last SSB to have produced a reasonably-sized recruitment (the 1996 year class), seems reasonable. However, I would have benefitted from seeing a S/R plot.

A lot depends on the years of recruitment that are used. A different approach was used in the estimation of Flim and Fmsy. The reason for using different recruitments is not explained. Further, in the estimation of Flim the change point of the segmented regression was estimated rather than forced at B_{lim}. Again this is difficult to evaluate without seeing a S/R plot with the estimated regression.

Overall the changes in the reference points are not large and the new F reference points are lower than the previous estimation. The approach seems to have been well thought out.

The estimation of maturities and reference points is appropriate.

Reviewer comments about (b) Forecast

A review of this would benefit greatly (as would the WG report) from a plot of the correlations of the indices. I made such a plot for my own use (from the table of assessment inputs…..which is a picture not a table and so can't be copied). There is a very strong relationship between the two, and this holds up even when only the highest Q1 estimates are examined. Unless there was some issue with the Q1 survey that would cast doubt in the numbers at age, it seems reasonable to expect that the Q3 survey will also show the 2016 year class to be strong. In addition, there seems to be little retrospective in the estimated recruitment in the SAM. Therefore, it is likely that using the resampled recruitment instead of the SAM estimate will result in a reopening of advice in October.

The major concern here is that the estimate of recruitment from the SAM is 3 times higher than the average of the 1998-2016 estimates. It is based only on a single survey observation which means that it is inherently uncertain. The estimated uncertainty is included in the projection. However, only 4 of the estimates in the 1998-2016 period are higher than the lower bound of the uncertainty in the 2017 estimate i.e. most of the data points that would be used in the resampling method are outside of the estimated bounds of the 2017 estimate. This estimated recruitment could indicate a return to higher levels or it could be wrong. The implications of it being wrong depend a lot on what the TAC will be based on: the MSY approach or the management plan. If advice is based on the estimate but recruitment is more in line with resampling then the MSY approach would suggest a decrease in SSB of about 8% while using the Management plan would imply a decrease of more than 16%. Both of these scenarios would see the SSB fall below Btrigger. But, the results of the Q3 survey will be reviewed in October. If the results are significantly different than that used in the projections the advice will be reopened.

If the estimated recruitment is used for the intermediate year the rationale will need to be carefully, and fully described (it is not currently well described in the report) particularly since this approach was not used for the very low recruitment of the 2015 year class. The reason for not using this approach last year may be (I am speculating) that there are some similar (although only two lower) values in the resampled time series. If this change is made it should probably be maintained and not only implemented when there is an unusual recruitment.

Given that the results of the Q3 survey will be reviewed in October, the use of the October forecast procedure in the May forecast is appropriate.

Annex 11: RGProxy reviews for Category 3 stocks

Content

1 Brill in Subarea 4, Divisions 3.a and 7.d–e

General comments

1) Assessment method(s): Length Based Indicators (LBI) and SPiCT

2) Evaluating Uncertainties

- Uptake percentages for brill in the Greater North Sea assessment area cannot be reliably calculated, as the TAC is set combined with turbot.
- Survey abundance series and indices do not provide a good representation of the stock. Low catch numbers in the surveys lead to underrepresentation of certain year- and length-classes (mainly the older/bigger ones).
- There remains uncertainty in the maturity schedule.
- The EG does not have access to a fisheries independent index series from a survey that targets large flatfish species like brill and appropriately covers the stock area as whole.
- Brill exhibit sexually dimorphic growth (with females reaching larger maximum body sizes than males) and sexual differences in size at 50% maturity. However, catch data are provided for undetermined sex so Linf and Lmat values were obtained by averaging sizes for males and females assuming a 50/50 sex ratio.

3) Consistency

Results from LBI and SPiCT both indicate that the health of the stock has been improving in recent years and that overfishing is not occurring.

4) Proxy reference points & stock status

Proxy reference points:

LBI: Lc/Lmat; L25%/Lmat; $L_{max\ 5\%}$ / $L_{inf;}$; P_{mega}; L_{mean} / L_{opt} ; Lmean / $L_{F=M}$

SPiCT: Bt/Bmsy, Ft/Fmsy

LBI analyses were carried out over three years of data (2014–2016). Results indicate that overfishing is not occurring and has not been occurring in the last three years and that though the stock may have been overfished in the past, it presently does not appear to be overfished.

The accepted run from SPiCT model indicates that the stock is not overfished and overfishing is not occurring.

5) Comments & Suggestions

Given that surveys BTS_ISI_Q1 & BITS_Q4 cover an area (27.3.a) that represents just 7% of the total landings for this stock, the RG agrees with the EG's decision to exclude them from the SPiCT analysis and to instead use the BTS_ISI_Q3 fisheries independent survey and the Dutch beam trawl fleet fisheries dependent index, which cover an area (27.4) where the majority (60–70%) of brill catches occur.

The RG recalculated the LBI reference points assuming 100% of the catch was female (see table 1. below) to get a conservative estimate of whether the stock is in good shape and whether overfishing is occurring. Results indicate that overfishing is not occurring and that the stock has been improving in the last three years, with 2016 showing only L25%/Lmat in the red. This result reinforces the EGs conclusions that the stock is not overfished and overfishing is not occurring. The RG suggests the EG carry out this exercise in the future when carrying out LBI analyses to get a lower bound on the proxy reference points.

Given the available relative abundance data and known sexual dimorphism for this species, the RG agrees with the EG that SPiCT was the most appropriate model to use for assessing this stock and agrees with the EG's conclusions that the stock is not overfished and overfishing is not occurring.

Proxy reference points: conclusions

Proxy Reference Points:

F/Fmsy and B/Bmsy produced by SPiCT.

LBI: Lc/Lmat; L25%/Lmat; $L_{max\ 5\%}$ / L_{inf}; ; P_{mega}; L_{mean} / L_{opt} ; Lmean / $L_{F=M}$

EG Conclusions:

The stock is not overfished with no overfishing occurring.

RG Conclusions:

The stock is not overfished with no overfishing occurring.

Table 1. LBI reference points recalculated assuming female biological parameters.

Traffic light indicators

	Conservation				Optimizing Yield	MSY
	Lc/Lmat	L25%/Lmat	Lmax5%/Linf	Pmega	Lmean/Lopt	Lmean/$L_{F=M}$
Ref	>1	>1	>0.8	>30%	~1 (>0.9)	≥1
2014	0.67	0.38	0.94	NA	0.87	1.19
2015	0.29	0.46	0.94	NA	0.87	1.74
2016	1.06	0.52	0.95	NA	1.04	1.07

2 Dab in Subarea 4 and Division 3.a

Assessment Type: Benchmark report

Assessment method(s): SPiCT

Evaluating Uncertainties

- N/A. No summary of the stock history was provided.

Consistency:

- N/A. Only SPiCT was presented.

Proxy reference points & stock status:

- The SPiCT method estimated *F/Fmsy < 1* and *B/Bmsy > 1*. The EG did not explicitly accept or reject the method.
- The relative benchmark quantities are more precise than the absolute quantities (*F* and *B*) in the model. The EG rejected the use of the absolute quantities and the RG agrees with this decision.

Comments & Suggestions:

- The RG assumes that the EG had limited or no length data and/or life history parameters to use the length-based category 3 methods. The EG should confirm in the report that this is the case.
- The RG would have liked to see an explanation for the increase in biomass in the most recent years without any reduction in catch. Is recruitment increasing? Can this hypothesis be corroborated in the index of age-0 dab?
- Simpler model runs (e.g. with some combination of n = 2, alpha = 1, beta = 1) may decrease the uncertainty in the absolute values of *F* and *B*.

Proxy Reference Points: conclusions

- The EG did not explicitly accept or reject the results from SPiCT.
- The RG accepts the results of SPiCT and concludes that overfishing is not currently occurring and the stock is currently not overfished. The RG believes the model performs well in estimating the relative management quantities.

3 Flounder in Subarea 4 and Division 3.a

General comments

1) Assessment method(s): SPiCT, Mean Length Z (MLZ) and Length Based Indicator (LBI).

2) Evaluating Uncertainties

- There is no information about stock identity and possible stock assessment areas in the North Sea, Skagerrak and Kattegat.
- Landings data may have been misreported in previous years.
- The official landings may not reflect the total catches.
- Underestimation of the discard from the German fleet.
- Not all métiers were sampled in every quarter and that the raising procedure may not be adequate for all cases.
- The IBTS Q1 uses a bottom trawl which is not very well suited to catch demersal flatfishes.
- The IBTS was not fully standardized before 1983.

3) Consistency

- The results of SPiCT and LBI are consistent. However, the mean length Z method resulted in contradicting results.

4) Proxy reference points & stock status

- Proxy reference points:

SPiCT: *F/Fmsy < 1* and *B/Bmsy > 1*. However, the uncertainties are far too large to draw any meaningful conclusions based on these results.

Mean Length Z: The MLZ method produced contradicting results: The results of the mean-length-with-effort (THoG) models using InterCatch length distribution suggested that overfishing is occurring. However, the results of the model with a fixed M and surveying data suggested that overfishing is not occurring in the current stock.

LBI: Lc/Lmat > 1; L25%/Lmat>1; $L_{max\ 5\%}$ / $L_{inf;}$ >0.8; $P_{mega>}$30%; L_{mean} / L_{opt} >0.9; Lmean / $L_{F=M}$ >1; where Lmat = 21cm and Linf =41cm.

- The EG accepted the LBI method and rejected the SPiCT method and the MLZ method.
- EG's conclusions: Overfished/Overfishing occurring?
- The EG concluded that the stock was not overfished and the overfishing was not occurring based on the LBI results.
- RG's conclusions: Overfished/Overfishing occurring? The RG concludes that the stock is not overfished and the overfishing is not occurring.

5) Comments & Suggestions

The EG attempted to apply three methods that ICES recommended for category 3 stock and explained the details on rejecting the SPiCT method and the MLZ method. The RG agrees with the EG to reject the SPiCT method and the MLZ method.

Since the LBI method is very sensitive to the values of Lmat and Linf, the RG would have liked to have seen more justification on how these estimates were obtained (sample sizes, models, years, …) to better evaluate the uncertainty surrounding these estimates and also determine their potential use for other length based methods.

The RG suggests that the EG should run sensitivity analysis on different Lmat and Linf values. The RG calculated the traffic table (table 1.) assuming Linf=46mm (the largest fish length observed from the length frequency from Fig.6.23) and Lmat=22m (assuming more conservative mature size). Increasing these parameters should give a less rosy picture of stock status. The results indicate that the LBI results are quite robust. However, the stock condition does change slightly.

It is unclear to RG the M/K value that EG used in the LBI. The EG considered the uncertainty on the M value (see MLZ method section). The RG suggests that EG should justify the M/K value used in the LBI. The RG also suggests that EG should test the sensitivity on different M/K value (Jardim *et al.*2015).

The RG suggests the LBI be computed for every year for which length data is available. This gives a better idea of the variability in the indicators and also the trends in the indicators can be informative, especially when they are compared to trends in effort, survey data, etc.

Proxy reference points: conclusions

- **Proxy Reference Points**

Lc/Lmat ; L25%/Lmat; $L_{max\ 5\%}$ / L_{inf}; P_{mega}; L_{mean} / L_{opt}; Lmean / $L_{F=M}$ produced by LBI. These were accepted by the EG and RG.

- **EG Conclusions**

The stock is not overfished and the overfishing is not occurring.

- **RG Conclusions**

The stock is not overfished and overfishing is not occurring.

Table 1. Traffic light table with Linf=46cm and Lmat=22cm.

Ref	Lc/Lmat	L25/Lmat	Lmatx5%/Linf	Pmega	Lmean/Lopt	Lmean/LF=M
2014	1.18	1.16	0.8353	NA	1.0105	0.999
2015	1	1.06	0.8461	NA	0.9357	1.02
2016	1	0.977	0.8614	NA	0.9806	1.07

Reference

Jardim, Ernesto, Manuela Azevedo, and Nuno M. Brites. "Harvest control rules for data limited stocks using length-based reference points and survey biomass indices." *Fisheries Research* 171 (2015): 12–19.

4 Lemon Sole in Subarea 4, Divisions 3.a and 7.d

General comments

1) Assessment method(s): Length Based Indicators (LBI) and SPiCT

2) Evaluating Uncertainties

- Little is known about stock structure.
- The time-series of landings is incomplete.
- Age samples may not be representative of the fishery as a whole.
- Index data should be interpreted with caution: IBTS gear was not standardized until 1983 and several countries involved in the IBTS survey did not report lemon sole in earlier years.
- The IBTS Q1 survey (which was used in the SPiCT analysis) uses a GOV demersal trawl which may not be the optimal gear to catch flatfish. The other survey, beam trawl survey, is more appropriate for flatfishes but does not cover the entire range of the distribution of lemon sole (it misses the northern area where some of the highest concentrations of lemon sole occur).
- Age readings and maturity assessment are uncertain and still under development.
- Discard estimates were made available only starting in 2015

3) Consistency

The results from the LBI contradicted the results from SPiCT.

4) Proxy reference points & stock status

Proxy reference points:

LBI: Lc/Lmat; L25%/Lmat; $L_{max\ 5\%}$ / $L_{inf;}$; P_{mega}; L_{mean} / L_{opt} ; Lmean / $L_{F=M}$

SPiCT: Bt/Bmsy, Ft/Fmsy

Results from the LBI analysis indicated that the stock was overfished and overfishing was occurring. The EG rejected this method due to concerns that the selectivity of the gear (thought to be domed-shaped) caused the proxy reference points to be overly pessimistic. The RG agrees with the EG's decision to reject the LBI analysis on those grounds and also because there appears to be considerable uncertainty in the Linf and Lmat estimates the analysis is based on.

The SPiCT model estimated F < F(msy) and B > B(msy) for lemon sole, indicating that overfishing is not occurring and that the stock is not overfished. The EG accepted the proxy reference points produced in the final SPiCT run (using the Scotland/Netherlands time series from the IBTS Q1 survey as an index of abundance). The RG agrees with the EG's decision to subset the survey data to only include countries that fully reported their data over the entire time series (to avoid bias in survey trends due to incomplete reporting by other countries) and agrees with the EG's decision to accept the SPiCT results based on the current data availability.

5) Comments & Suggestions

The RG thought the report was clear and well organized and the RG agrees with the EG's overall conclusions.

The RG agrees with the EG that although the LBI method indicates that the stock status is in poor health, the method should be used with great precaution due to the potential impact of dome-shaped selectivity of the gear. However, the EG only applied the LBI to the catch-length data from 2016. The RG recommends that the EG apply the LBI on all the available catch-length data (for each year) in order to better understand the stock status and check that this pattern holds throughout the years where length data are available.

Since the LBI method is very sensitive to the values of Lmat and Linf, the RG would have liked to have seen more justification on how these estimates were obtained (sample sizes, models, years, …) to better evaluate the uncertainty surrounding these estimates and also determine their potential use for other length based methods.

In the conclusion section, the EG stated that the age readings and maturity status evaluation techniques were still uncertain and under development. The LBI, LB-SPR and MLZ require reliable biological information to give robust results. The RG therefore agrees with the EG that the SPiCT method was the most appropriate method in this case. However, the RG encourages the EG to try multiple methods for the assessment once these biological information become available (perhaps using upper and lower limits for the biological parameters in question as a sensitivity analysis) to check that conclusions hold across methods.

The EG stated in the conclusion section that the use of the IBTS surveys was a limitation since the gear used in this survey may not be optimal for catching flatfish. The RG agrees with the EG that this is an issue and suggests that the EG look into this issue.

There were two surveys mentioned in the report (IBTS and BTS), however, the final SPiCT model only used data from IBTS Q1 because using multiple survey series led to poor performance of the model. The RG agrees with the EG that contradicting trends in the survey data could have contributed to the poor performance of the model. However, the RG would have liked to see more justification on why these contradicting trends might be happening. There was no information revealed regarding the BTS survey trends. The RG suggests that the EG attempt to make use of the BTS survey data to increase the amount information to the model.

It was unclear to the RG whether or not the EG attempted to fix or give very informative priors to any of the parameters in the SPiCT model (e.g., $\alpha = 1$, $\beta = 1$, $n = 2$). Letting too many parameters be freely estimated could explain the poor performance of the first three SPiCT assessment runs. Since fixing these parameters can reduce uncertainty and improve the stability of estimated parameters, the RG suggests attempting to fix these parameters as a sensitivity run when including additional CPUE series.

Proxy reference points: conclusions

- **Proxy Reference Points**

F/Fmsy and B/Bmsy produced by SPiCT.

- **EG Conclusions**

The stock is not overfished with no overfishing occurring.

- **RG Conclusions**

The stock is not overfished with no overfishing occurring.

5 Striped red mullet in Subarea 4, Divisions 7.d and 3.a

General comments

1) Assessment method(s): Length Based Indicators (LBI) and Mean Length Z (MLZ). SPiCT was tried but not discussed.

2) Evaluating Uncertainties

- The EG acknowledges that there are issues with the "quantity and representativeness of the observational data," for the various subareas. Results from the eastern English Channel can be extrapolated to the southern North Sea, but the extrapolation for subarea III (Skagerrak – Kattegat) is less clear given the small catches and sparse data.
- There are changes in recruitment between 2014 and 2016 that affect the results of the LBI.

3) Consistency

When the precautionary approach is applied the EG states that the catches should be no more than 552 tons in 2017 and 2016 but in 2018 they advise that it should not be more than 530 tons.

The EG states that both the LBI and MLZ methods assess the stock as being fished beyond reference limits.

4) Proxy reference points & Stock status

Reference points: methods tried

LBI: Lc/Lmat > 1; L25%/Lmat>1; $L_{max\ 5\%}$ / $L_{inf;}$ <0.8; P_{mega}<30%; L_{mean} / L_{opt} <0.9; Lmean / $L_{F=M}$ < 1; where Lmat = 16cm and Linf =40cm.

Mean Length Z: Total mortality is estimated to be 0.9. Considering a natural mortality of 0.4, the F is 0.5. The YPR methods estimate F0.1 at 0.41.

Although not discussed the SPiCT method estimated *F/Fmsy > 1* and *B/Bmsy < 1* with very large confidence intervals.

The EG did not explicitly accept or reject any of the reference points. The EG's reasons for not accepting or rejecting these reference points were not clearly stated in the text

EG's conclusions: Overfished/Overfishing occurring?

The EG suggested that growth overfishing was occurring. The EG also stated that both the LBI and MLZ methods assess the stock as being fished beyond reference limits. However, it is unclear to the RG if a general conclusion of the stock being overfished/overfishing occurring was made by the EG.

RG's conclusions: Overfished/Overfishing occurring?

Given the results of the LBI, MLZ and SPiCT analysis the RG concludes that the stock is overfished but there a few caveats to each of the model's results (see comments).

5) Comments & Suggestions

The EG has results for a SPiCT run in the Figures document but does not explicitly explain in the text why the results from this method were not considered.

The RG believes the SPiCT model may be useable under a certain parameterization. The RG believes that the model cannot decide whether the large jumps in the survey values and catch occur due to process error or observation error. The RG suggests fixing the standard deviation of the catch and survey to be low, allowing the process errors to be freely estimated; this may reduce the confidence intervals.

The RG suggests that each of the four methods be discussed in terms of its pros and cons in reference to the stock and the available data.

The RG believes that more detail and discussion on acceptance or rejection of each method is needed.

The EG presents aggregated length distributions from 2014 to 2016. It would be useful to see the years separately to determine if there was a change in mean length which can affect results of LBI, e.g., due to a pulse of recruitment moving through the length-frequency distributions.

Overall, model diagnostics from the LBI and MLZ analysis would be useful to see how recruitment may be affecting the calculations.

Proxy reference points: conclusions

Reference points are available for this stock but they were not explicitly accepted or rejected by the EG.

The RG agrees with the EG's hesitation to explicitly state support for any of the reference points from the length based methods as they may not be appropriate due to changes in recruitment (see comments). SPiCT may have been a more appropriate option if the confidence intervals were better on B/Bmsy and F/Fmsy (see suggestions). Additional discussion of model diagnostics is needed for the RG to come to a firm conclusion in support of the presented reference points.

6 Turbot in Division 3.a

General comments

1) Assessment method(s): Length Based Indicators (LBI) and SPiCT.

2) Evaluating Uncertainties

- The EG stated that survey indices "are of poor quality," but it was unclear to the RG if the indices should be considered representative. For example, if the indices are noisy then they could still be reliable. But the issue appears to be that the surveys used only sample a portion of the population raising the concern they might not be valid data inputs.
- The EG did not discuss the validity of the biological parameters obtained from FishBase, so the uncertainty around these parameters is unknown.

3) Consistency

- 2017 is the first year that the IBTS survey was used to create a biomass index, whereas previously the BITS survey was used. The IBTS survey only covers a small portion of the stock's range. However, the EG pointed out that the two surveys have similar catch rates and variability throughout the time series.
- LBI suggests full or possibly slight overexploitation while SPiCT trends suggest that recent F is less than half of Fmsy.

4) Stock status

- **Reference points:** the EG did not generate absolute reference points, but used and accepted the proxy reference points produced by the LBI and SPiCT methods.
- **Stock status**

i) EG's Conclusions

- Overfished/Overfishing occurring? No.
- The EG noted that LBI showed that all indicators except Pmega were close or above their length proxies.
- The EG rejected the absolute reference points from SPiCT due to high uncertainty, but accepted the relative proxies (trends compared to F/Fmsy, B/Bmsy) from the SPiCT run with no priors, which showed that the stock was in good shape.

ii) RG's Conclusions

- Overfished/Overfishing occurring? No.
- The RG would like to note that in the LBI method the MSY indicator was slightly less than 1 (0.94 in 2016), meaning that the LBI method suggests minor overexploitation and/or fishing close to MSY.
- The RG agrees that there is high uncertainty in the SPiCT results, and there is some cause for concern in the retrospective analysis. The RG questions if the IBTS survey is most representative of the population given that it only samples a small portion of the stock's range.
- Given that the EG explored and presented several model runs and data inputs, the RG accepts the relative trends in the SPiCT run that the EG accepted (using IBTS surveys and no priors).

5) Comments & Suggestions

- The RG believes the EG has very thoroughly explored the SPiCT model for this stock.
- The RG would have liked to see a comparison between the SPiCT results that used other data inputs. The EG used the IBTS Q1 and Q3 surveys and provided a thoughtful explanation regarding why this was done, but the RG was interested in the potential differences in model results and diagnostics if the BITS survey was used, or if only one IBTS survey was used.
- The RG was wondering how certain the biological parameters for this stock are. Given that the growth parameters came from FishBase it would have been useful for the EG to comment on the parameters. If there is some uncertainty, the EG could determine robustness and sensitivity by running the analyses with a range of biological parameters.
- The RG was curious if the EG had an explanation for the lack of mega spawners in the population (e.g., dome–shaped selectivity, overestimate of Linf) or if it should be inferred from the Pmega indicator that the population truly has very few mega spawners.
- The RG suggests exploring the other two length-based methods, mean-length Z and LB–SPR (which may be more appropriate given the short time series of lengths).

Proxy Reference Points: conclusions

The EG concluded the stock is not overfished and overfishing is not occurring based on SPiCT and LBI. The RG accepts this conclusion.

7 Witch in Subarea 4, Divisions 3.a and 7.d

Assessment Type

- Benchmark report

Assessment method(s)

- SPiCT

Evaluating Uncertainties

- Witch is primarily a bycatch species and managed under a combined TAC with lemon sole. Discards is approximately 10-20% of landings.

Consistency

- N/A. Only SPiCT was presented.

Proxy reference points & stock status:

- The SPiCT method estimated $F/Fmsy < 1$ and $B/Bmsy > 1$. The EG did not explicitly accept or reject the method.
- The relative benchmark quantities are more precise than the absolute quantities (F and B) in the model.

Comments & Suggestions:

- No length based methods were attempted by the EG. The RG assumes that the EG had limited or no length data and/or life history parameters, but the EG should confirm.
- The EG noted the lack of model convergence when the 1992 Q1 survey value was included and the strong retrospective pattern in $F/Fmsy$ when the most recent 5 years of data are removed. Based on the values of the Q1 survey time series presented in Table 24.4.1, the RG observes that the 1992 value is an outlier. The EG placed a high standard deviation for this value. The RG believes this is appropriate practice.
- The RG believes the model performs well. The Q1 survey biomass index shows more contrast over time compared to the Q3 index.
- No retrospective pattern was observed when fewer than 5 years of data were removed. Simpler model runs (e.g. with some combination of n = 2, alpha = 1, beta = 1) may provide insight as to why the retrospective pattern occurs with 5 years of data removed.

Proxy Reference Points: conclusions

The EG did not explicitly accept or reject the results from SPiCT,

The RG accepts the results of SPiCT and concludes that overfishing is not occurring and the stock is not overfished. The RG believes the relative management quantities should be used as opposed to absolute values of F and B.