2 Cod in the Baltic Sea

2.1 Cod in Subdivisions 25–32

2.1.1 The fishery

The complete description of eastern Baltic fisheries development is presented in the Stock Annex.

2.1.1.1 Landings

From 2015 there is a landing obligation for cod in the Baltic Sea. Thus there is no minimum landing size, but a minimum conservation reference size (MCRS) of 35 cm is in force, which is a change from earlier years minimum landings size (MLS) of 38 cm. Cod below MCRS cannot be sold for human consumption and has to be landed as a separate fraction of the catch. The landed cod below MCRS is here referred to as 'BMS landings' (BMS=Below Minimum Size). National landings of cod from the eastern Baltic management area (Subdivisions 25–32) by year are given in Table 2.1.1 as provided by the Working Group members. Landings by country, fleet and subdivision in 2016 are shown in Table 2.1.2. The total provided landings in SD 25-32 in 2016 summed up to 29 313 t, whereof 99% were above MCRS and only 316 t were BMS landings. It is however not clear exactly how large the BMS landings were in total since countries have chosen different approaches in the data submission. BMS landings were provided by Latvia, Lithuania and Sweden. Poland and Denmark included BMS landings in the discard estimate in the data submission and provided separate information on the "official" BMS landings (not included in the 316 t mentioned above), indicating very small amounts of BMS (<1% of the landings). Remaining countries did not provide information on BMS landings. Germany used a knife-edge approach for catch estimation and all fish below 35 cm were submitted as discards. The total landings in the management area in 2016 declined by 8 030 t compared to 2015. The available TAC for eastern Baltic cod has not been taken since 2009. In 2016, 70% of the TAC was caught, BMS landings and discards included (Fig.2.1.1)

Part of the landings of Eastern Baltic cod stock are taken in SD 24, i.e. the management area of Western Baltic cod (Fig. 2.1.2). The total landings in SD 24 are divided between the two stocks using stock identification information derived from otolith shape analyses combined with genetics (ICES WKBALTCOD 2015). Approximately 10-15 % of total landings of Eastern Baltic stock are estimated to be taken in SD 24 in later years (Fig.2.1.2; Table 2.1.3).

2.1.1.2 Unallocated landings

For 2016, similar to 2010–2015, information on unreported landings was not available and the Working Group was not in a position to quantify them. Unallocated landings have been a significant problem during 1993–1996 and 2000–2007 when the unreported landings have been 35–40%. More detailed information of unreported landings is given in Stock Annex. Misreporting significantly declined in 2008–2009 and amounted to 6–7%. The decrease of unreported landings in recent years obviously is related to a decreasing fishing fleet due to EU vessel scrapping program and improvement of fishing control. Since the TAC has not been taken since 2009, misreporting is considered a minor problem in recent years.

2.1.1.3 Discards

In addition to landings above MCRS and BMS landings, discard estimates were also submitted from most countries. Even though there is a landing obligation in the Baltic Sea from 2015, discards were still estimated from on-board sampling by most countries (Denmark, Finland, Germany, Latvia, Poland and Sweden). It should also be noted that the German discard amount was estimated with a knife-edge approach, meaning that all catch above 35 cm was submitted as landings and all catch below 35 cm as discards regardless of the fate of the catch, and that a few other countries discard estimates also include small amounts of BMS landings (at most 6% of the total discard amount reported by the country, according to additional information submitted on BMS landings). The total discards in 2016, in subdivision 25-32, were estimated to 3 620 t, which constituted 11% of the total catch in weight and 20% in numbers; 11 million individuals. 97% of discards in numbers was caught by active gears (Table 2.1.4). This was a decrease from 2015, when the discard rate was 14% of total catch in weight and 24% in numbers (Table 2.1.5). Since the reported BMS landings (landings of cod below 35 cm) were very small, only 1% of total catch and 1.1% of the total landings in weight, they did not have a significant impact on the discard rate in 2016. As no adjustments for misreporting in landings were made, no adjustments of the discards were made.

The most abundant length class discarded in 2016 was length class 30-34 cm (55% in numbers) followed by length classes 35-37 cm and 25-29 cm 4 (21% and 15%, respectively). Table 2.1.6 gives a comparison between landed and discarded numbers by length class for the year 2016.

The annual estimations of discards (and thus also the variation in discard figures from year to year) must be taken with caution because of the general low sampling intensity, of particularly passive gears, and thus large uncertainties in the estimates.

Discards included, the total catch in subdivision 25-32 was 32 933 t.

The total discards in tons estimated for SD 24 were divided between eastern and western Baltic cod using the same stock splitting information as for landings, which resulted in 293 tons of estimated discards of eastern Baltic stock in SD 24 in 2016 (Table 2.1.3). This results in discard rate of 10 % in weight, for the entire eastern Baltic stock, including both the SDs 25-32 and the fraction of the stock in SD24.

2.1.1.4 Effort and CPUE data

No data on commercial CPUEs was presented at WGBFAS. The effort data from EU STECF (2016) shows a decline in kw-days both for trawls and gill-nets in the central Baltic Sea in 2012-2015.

2.1.2 Biological information for catch

2.1.2.1 Catch in numbers of the stock

Catch numbers at length of the fraction of the Eastern Baltic cod stock distributed in SD 24 were derived by upscaling the numbers at length estimated for SD 25 by the fraction of catch originating from SD 24, separately for landings and discards. The catch numbers for SDs 25-32 were derived from compilation of biological information submitted to Intercatch.

2.1.2.2 Length composition of catch

The most abundant length class in the total catch 2016 was 38-44 cm (45% in numbers), followed by 35-37 cm (21%) and 30-34 cm (15%) (Table 2.1.6). Table 2.1.7 shows the total catch in numbers by length class, quarter, sub-division and gear. Table 2.1.8 gives the estimated mean weight per length class and gear in the landings and discards 2016.

Due to issues with age reading of eastern Baltic cod (ICES WKBALTCOD 2015) information on age structure of catches is not available.

2.1.2.3 Quality of biological information from catch

Due to issues with age determination of eastern Baltic cod, only numbers and mean weight at length were requested from commercial catches for the data year 2016. All countries biological data was estimated nationally before being uploaded and further processed in InterCatch. Numbers and mean weight at length were provided for 68% of the total landings (>MCRS) in weight and 61% of the estimated discards. This was a decrease from 2015, when 90% of the landings and 69% of the discards were covered with sample data. Length distributions for discards should be considered more uncertain than length distributions for landings due to a lower sampling coverage, especially for passive gears that are poorly sampled in many strata. The BMS landings (<MCRS) were in most cases not sampled for length and were assumed to have the same length structure as the discards in the extrapolation procedure. However, since the reported BMS landings were very low (1% of total catch in weight) this was of minor importance for the overall length structure. As in previous years since 2013, the input data for SDs 25-32 were prepared solely using InterCatch. The use of only one reporting format (in this case InterCatch) provides a more transparent way to record how the input data for assessment have been calculated. However, due to the large methodological differences in the data reporting and preparation, some inconsistencies could be expected between the data compiled in 2013–2016 and the data compiled in previous years.

2.1.3 Fishery independent information on stock status

The main source of fishery independent information on the stock is the Baltic International Trawl survey (BITS) conducted in Q1 and Q4 that is used for stock assessment. The following sections summarize the available biological information on stock status.

Stock distribution

Data from BITS surveys do not indicate notable changes in cod distribution in most recent surveys (Fig. 2.1.3). The highest cpue values are generally recorded in SD 25, followed by SD 26. Relatively high cpue values are recorded also in SD 24 that is a mixing area for eastern and western Baltic cod; in the easternmost areas of SD 24 most of the cod are of eastern origin. The cpue values further north-east (SD 27-28) are generally very low indicating that the bulk of the stock is concentrated in southern Baltic Sea, i.e. in SDs (24)25-26. However, in 2017 Q1 survey, relatively high cpue values were recorded in SD 28 compared to the former surveys. Time series of cpue by SDs and size-groups of cod shows that highest concentrations of smaller individuals (<35cm) are found in SD 25. For larger cod (>35cm) the cpue in SDs 24-26 is relatively similar. It should be noted that survey coverage in SD 26 is relatively poor in later years, with few stations in areas where relatively high abundances of cod have been found in some available surveys (e.g. 2016 Q4; Fig. 2.1.3).

Nutritional condition

Nutritional condition (Fulton K) of eastern Baltic cod has substantially declined since the 1990s in all SDs 24-28 (Fig. 2.1.4). The proportion of cod with very low condition (Fulton K <0.8) in samples from Q1 surveys has been increasing from below 5% in the 1990s and early 2000s to close to 20% in 2013-2014, for cod at 40-60cm in length. In more recent surveys since 2015 Q1, the condition has improved and the proportion of cod at low condition has declined to around 10%. Also, average condition is showing some improvement in these later surveys in Q1. In Q4 survey, no change in condition is apparent in latest years. For smaller cod (25-40cm), the improvement in condition in Q1 is less clear, while the condition appears further deteriorated in Q4 (Fig. 2.1.5).

Growth and natural mortality

It is hypothesized that growth of EB cod has reduced since the 1990s, due to reduced size at maturation, poor condition of cod, hypoxia, and parasite infestation, however clear evidences are not available (ICES WKBEBCA 2017). For smaller (<30 cm cod), counts of daily rings on otoliths suggest stable growth rate from 2001 to 2013 (ICES WKBEBCA 2017). Natural mortality of cod is hypothesized to have increased due to reduced size at maturation, poor condition, seal predation, cannibalism and parasite infestation. However, similar to growth, the magnitude of change is not quantified (ICES WKBEBCA 2017).

Maturity

Size at first maturation has substantially declined in the period from the 1990s to 2000s (Fig. 2.1.6). The L50 (50% percent mature and contributing to spawning) has been estimated at around 35-40cm in the early 1990s and has declined to 20cm since late 2000s to 2015 (males and females combined). Being mature is defined as having entered the maturity stage 62 (based on DATRAS scale). In Q1 surveys from 2016-2017 L50 is estimated to have remained at around 20cm. The effect of this change on reproductive capacity of the stock is unknown.

Recruitment

Larval abundances from ichthyoplankton surveys suggest that stronger year-classes occurred in 2011 and 2012 (Köster et al. 2016), which are also visible in length frequency data from Q1 BITS survey at around 20cm in 2013 and 2014 (Fig. 2.1.7). These strong year-classes have sustained the stock until 2016. No strong year classes are apparent in the data for later years. The CPUE of <25cm cod has been variable over time, the most recent values from 2016 and 2017 surveys are around the average since the 1990s (Fig. 2.1.8).

Adult biomass and size distribution

Relative abundance of cod follows similar trends in Q1 and Q4 surveys (Fig. 2.1.8). The combined data for Q1 and Q4 (Q1 is combined with Q4 data the year before) show that since 2013, biomass of cod >40 cm has substantially declined from the relatively high levels recorded in 2009-2012 (Fig. 2.1.9). The 2016 estimate shows a slight increase in the biomass of these larger cod compared to 2013-2015, but declined again to close to the lowest level in the time series in 2017.

The indices for cod at 30-40cm were relatively stable and high until 2016 but dropped substantially in 2017. For cod <30cm in length, the values in 2013-2014 have been at a

highest level in the time series since 2003 (due to the strong year-classes from 2011 and 2012). In 2015-2017 the abundance and biomass of <30cm cod has remarkably declined.

2.1.4 Assessment

No analytical assessment for the stock is presently available, mainly due to uncertainties in age information, and presumed changes in growth and natural mortality, which have not been quantified. The challenges for analytical assessment for this stock are described in Eero et al. (2015).

2.1.4.1 Stock trends from BITS survey

The assessment is based on trends in BITS survey index. An index of SSB was produced using the combined time-series of BITS Q1 and Q4 surveys.

CPUE (No./h) per length-class by quarter and SD was derived from the DATRAS database. CPUE in weight (Kg/h) was estimated by Quarter and SD and year using length-weight relationships based on individual fish data from the DATRAS database. Mean CPUE (Kg/h) for Q1 and Q4 for the whole stock were thereafter obtained as a weighted average over SDs, by using area size of SDs as weightings. The CPUEs (Kg/h) from Q1 and Q4 were combined as a geometric mean (Q1 raw and Q4 shifted 1 year ahead) to produce an index of SSB from 2003 to 2017 (Fig. 2.1.10). The index used for assessment is based on cod >= 30 cm. The index based on SD 25-28 is considered to represent the relative dynamics of the entire EB cod stock (i.e. representing the relative dynamics of EB cod also in SD 24).

After a steep increase between 2005 and 2010, the SSB index (for cod >30 cm) abruptly decreased between 2012 and 2013, and remained relatively stable for 2013-2015 with an average of 140 Kg/h. In 2016, cpue increased to around 180 Kg/h, but declined sharply to 96 Kg/h in 2017. Until 2016, the stock has been sustained by larger year-classes from 2011-2012. These year-classes increased the cpue of relatively larger (40-45 cm) cod in 2016, resulting in increased biomass index. In 2016 Q4 and 20017 Q1 these strong year-classes from 2011 and 2012 had apparently disappeared from the stock or diminished to very low numbers, while no stronger year-classes have appeared since. Thus, the reduction in biomass index in 2017 is due to low recruitment in later years, in combination with mortality.

The average CPUE of the last two years (2016-2017) was 4% lower than the average CPUE of the previous three years (2013-2015).

2.1.4.2 Harvest rate

Time-series of harvest rates between 2003 and 2016 were created as ratio between total catches for the stock (including landings and discards and the proportion of EB cod catch taken in SD 24) and the biomass index for >=30cm cod (Fig. 2.1.9). The harvest rate was highest in 2004, followed by a substantial reduction. Between 2009-2011, the harvest rate was stable at the lowest level in the time series since 2003. Thereafter, harvest rate increased by more than 30% from 2011 to 2015. Due to increased biomass in 2016 (combination of Q4 in 2015 and Q1 in 2016), the harvest rate in 2016 shows a decline from previous level. Harvest rate estimates by size-groups (catch of given length groups divided by biomass index of the same length-group) show that larger cod >40cm in length is exposed to a higher fishing pressure compared to the average of > 30cm cod used in the final assessment. The 2016 value for harvest rate declined for all size groups (Fig. 2.1.9).

2.1.5 Short term forecast and management options

No short-term forecast was performed for the stock.

2.1.6 Reference points

There are no reference points defined for Eastern Baltic cod, in terms of absolute values.

Three approaches, recommended by ICES, were considered at WGBFAS 2017 for estimating MSY Proxy reference points for Eastern Baltic cod:

i) Length based indicators (LBI)

ii) Mean-length Z, Gedamke Hoenig

iii) SPICT model

The LBI and Mean-length Z methods (i and ii) were concluded not to be applicable for this stock, due to likely changes in growth and natural mortality, which are not quantified. Thus, the parameters used in these approaches (Linf, K, M/K) are not known and different conclusions in terms of stock status can be obtained by making different assumptions (see the chapter 2.1.6.1 for details).

SPICT model has the advantage that it is not dependent on being able to quantify growth or natural mortality separately, and this model was considered useful for defining the stock status of Eastern Baltic cod. SPICT provides relative estimates for stock status (F/FMSY and B/BMSY), which are estimated with reasonably low uncertainty for EB cod. The absolute estimates separately for F, B, FMSY and BMSY are associated with much larger uncertainties than the relative values F/FMSY and B/BMSY, therefore the absolute values should not be used. Further explanations and description of the SPICT model are provided in chapter 2.1.6.2 and Annex 2.1.

2.1.6.1 LBI and Mean-length Z approach

This section describes the background for why the LBI and Mean-length Z approaches are not applicable for Eastern Baltic cod for defining the stock status.

Length data

Length frequency data for catches of EB cod are available from Intercatch from 2000 onwards, shown in Fig. 2.1.11. Lc is calculated from these data. In LBI analyses Lc is defined as length at 50% mode; in mean-length Z approach, Lc is the first fully selected length.

Size at maturity

Size at first maturation was estimated from Q1 BITS survey, for females and males combined. The fish which had reached the stage "maturing" (scale 62 in DATRAS) were considered as mature. Size at first maturation (L50) of EB cod has reduced from ca 35 cm in 2000 to ca 20 cm at present.

Von Bertalanffy growth parameters

Growth parameters for Eastern Baltic cod have always been poorly estimated, as has been pointed out already years ago, in a study summarizing growth studies from before the 1990s (Bagge et al. 1994). The problem that was identified was that the differences in mean length of successive age-groups were almost constant, and thus not fitting the von Bertalanffy growth model. This was suggested to possibly be due to age-reading errors. The same issue is apparent in a more recent data, using BITS survey

information for 1997-2006 (Fig. 2.1.12), where the age groups seem to grow at a constant rate, in the range where data are available, not fitting the vBL growth model.

Furthermore, age reading data since 2007 is considered to be of reduced quality (ICES WKBALCOD 2015), while it is hypothesized that EB cod growth (possibly both K and Linf) has reduced in later years. The possible drivers for reduced growth include reduced nutritional condition, maturation at a smaller size, direct effects of hypoxia etc (ICES WKBEBCA 2017). These variables have similar trends over time and, if influencing growth, suggest a reduced growth from the 1990s to late 2000s, and stable low level since around 2011 (Fig. 2.1.13).

The potential change in growth parameters has until now not been possible to quantify. Thus, the current levels of K and Linf are unknown, which limits the use of the indicators that require these parameters to be known or assume equilibrium status with stable growth.

Natural mortality

Natural mortality has historically been used as constant at 0.2. However, several changes in cod biology and in the ecosystem suggest that natural mortality has increased in later years. The potential drivers include reduced size at maturation, low nutritional condition, and increased seal abundance possibly increasing mortality both via predation and parasite infestation (ICES WKBEBCA 2016). The trends in these potential drivers are relatively similar suggesting an increased M since the early 2000s, with some drivers levelling off in the late 2000s (Fig. 2.1.14). The magnitude of change in M has not been quantified.

LBI

The length based indicators suggested by ICES to measure conservation status of large individuals are measured relative to Linf, and include i) maximum length of the largest 5% (Lmax5%) ; ii) 95 th percentile (L95%) and iii) Pmega. For EB cod, the indicators i) and ii) can be used to describe the developments in respective indicators over time, but not to define conservation status, as the value for Linf is not known. Calculation of Pmega requires knowledge of Linf as well as M/K which are not available for EB cod presently. Thus, this indicator cannot be calculated. The Lmax5% indicator has declined from around 65 cm in early 2000s to 52 cm in 2015. L95 has a similar trend, being presently around 50cm (Fig. 2.1.15a)

In relation to conservation of immature fish, both Lc (length at first catch, 50% of the mode) and L25 (25^{th} percentile of length distribution) are considerably above Lmat (size at first maturation). This is largely because Lmat has substantially declined over time, while Lc and L25 are relatively stable, showing a minor decline. Thus, fishery is not exploiting immature individuals (Fig. 2.1.15). The indicators L25 and L75 (75th percentile of length distribution) (Fig. 2.1.15b) demonstrate a very narrow length range in catches of EB cod, with only 5cm interval between these two indicators.

The length based indicator for MSY (Lmean/LF=M) is using Linf and additionally M/K ratio that is often assumed to be 1.5. This ratio would apply K at 0.13 when assuming natural mortality at 0.2, as has been assumed for EB cod in former times. This is in line with the growth parameters estimated for EB cod historically. Thus, in former times, using the value 1.5 for EB cod could be reasonable. In recent decade, natural mortality is considered to have increased and growth likely declined (ICES WKBEBCA 2017). Thus, the M/K is likely considerably higher for EB cod in present situation than 1.5,

though the value cannot be quantified. Different scenarios were explored, with realistic combinations of M/K and Linf values. The results demonstrated that depending on the scenario applied, different conclusion can be obtained concerning Lmean relative to LF=M that defines the reference point for MSY. The scenarios assuming a high Linf and low M/K indicated an overexploited status in recent years, while in scenarios with lower Linf and a higher M/K , LF=M was lower than Lmean, suggesting good status in recent years.

In conclusion, this approach is not applicable for defining the status of EB cod in relations to MSY, as the values for Linf and M/K are not known, and different assumption can lead to contrasting conclusions. Additionally, it is questionable whether the concept of LF=M is applicable for EB cod in present situation, given the non-equilibrium status and presumably large changes in cod biology in recent decade (ICES WKBEBCA 2017).

Mean Length estimate of Z

The Gedamke-Hoenig method to estimate total mortality Z from length frequency data uses as well von Bertalanffy growth parameters. In exploratory analyses, growth parameters were chosen for the years 2000-2005 so that it would result in a similar level of Z as estimated from former analytical stock assessments for Eastern Baltic cod for that period. For the more recent period (2011-2015), different sets of growth parameters were applied to demonstrate the sensitivity of the obtained mortality estimate to assumptions on growth. Assuming that growth has not changed compared to the first period, this would apply a slight increase in Z from 1.1 to 1.2 in later period. Opposite, if growth is assumed to have reduced, considerably lower values of Z could be obtained. The next step would be an assumption on natural mortality that likely has increased in later years, but by unknown magnitude. Thus, the level and change in fishing mortality compared to previous period, obtained from this approach is entirely dependent on assumptions on changes in growth and natural mortality. Consequently, the YPR reference points were not calculated as these would as well depend on assumptions on growth and mortality.

In conclusion, this approach is not considered applicable for Eastern Baltic cod in present situation given the likely changes in growth and natural mortality, which have so far not been quantified.

2.1.6.2 SPICT model

SPICT stands for a stochastic surplus production model in continuous time (Pedersen and Berg, 2016). SPICT does not need to separate between growth and natural mortality of the fish, which is a strong advantage in situations where these cannot be separated, like is presently the case for Eastern Baltic cod. A specific version of SPICT was applied for Eastern Baltic cod, to allow taking into account a potential change in surplus production over time. The time period with a separate productivity "regime" was estimated in the model, based on maximum likelihood value, thus not making explicit assumption on when the productivity change should take place and by which level. The new productivity regime was estimated in SPICT to start from 2010 (giving the best likelihood value). This is in line with the trends in major drivers considered to affect productivity changes (in terms of growth and natural mortality), which were levelling off in the late 2000s (Fig. 2.1.13, 2.1.14).

SPICT operates internally with absolute values, but produces output, including the uncertainties also in relative terms (F/FMSY and B/BMSY), because the relative estimates are considerably more certain compared to the absolute ones. This is because the same parameters are included in both numerator and denominator of the relative values, which reduces the uncertainty in the relative estimates. The absolute catch corresponding to MSY is also reasonably well estimated, as the product of F*B is considerably better estimated than the F and B individually, because these estimates are strongly negatively correlated. Therefore, the absolute values for F, B, FMSY and BMSY are not recommended to be used. The relative values for F/FMSY and B/BMSY are reasonably well estimated in the model for Eastern Baltic cod and can be used to define the stock status relative to the reference points. The technical specifics of the SPICT model for Eastern Baltic cod and the model outputs are given in Annex 2.1.

2.1.7 Quality of the assessment

The presumable decrease in growth has possibly affected the catchability of the BITS surveys. Survey coverage in SD 26 is relatively poor in later years, with few stations in areas where relatively high abundance of cod have been found in some years, which could affect the time-series.

2.1.8 Comparison with previous assessment

The assessment is based on survey index following the same approach as in last year. Thus, the perception of the stock status for earlier years has not changed. New data points are added to survey series, and respective trends are described in section 2.1.4.

2.1.9 Management considerations

BMS landings in 2016 were very low and discarding still occurs, with estimated discard rate at 10% for the Eastern Baltic stock.

The present distribution pattern of cod, sprat and herring (cod mainly concentrated in Subdivision 25 and 26, and clupeids in the more northern Subdivisions), implies that an increase in F on cod, not necessarily will result in increasing the Baltic clupeid stock sizes. Conversely, a decrease in F on cod will not necessarily result in a decrease of the Baltic clupeid stock size if it will not be accompanied by a cod expansion to northern areas. A reduction of clupeid F in Subdivision 25 can possibly improve growth and condition of cod as well as reduce cannibalism. However, as the relative contribution of different factors to poor condition of cod is not fully understood, the effect of reduced clupeid F on cod condition and growth is unclear.

Table 2.1.1 Cod SDs 25-32. Total landings (tons) by country.

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
1965	35313		23	10680	15713			41498		21705	22420				147352
1966	37070		26	10589	12831			56007		22525	38270				177318
1967	39105		27	21027	12941			56003		23363	42980				195446
1968	44109		70	24478	16833			63245		24008	43610				216353
1969	44061		58	25979	17432			60749		22301	41580				212160
1970	42392		70	18099	19444			68440		17756	32250				198451
1971	46831		53	10977	16248			54151		15670	20910				164840
1972	34072		76	4055	3203			57093		15194	30140				143833
1973	35455		95	6034	14973			49790		16734	20083				143164
1974	32028		160	2517	11831			48650		14498	38131				147815
1975	39043		298	8700	11968			69318		16033	49289				194649
1976	47412		287	3970	13733			70466		18388	49047				203303
1977	44400		310	7519	19120			47702		16061	29680				164792
1978	30266		1437	2260	4270			64113		14463	37200				154009
1979	34350		2938	1403	9777			79754		20593	75034	3850			227699
1980	49704		5962	1826	11750			123486		29291	124350	1250			347619
1981	68521		5681	1277	7021			120901		37730	87746	2765			331642
1982	71151		8126	753	13800			92541		38475	86906	4300			316052
1983	84406		8927	1424	15894			76474		46710	92248	6065			332148
1984	90089		9358	1793	30483			93429		59685	100761	6354			391952
1985	83527		7224	1215	26275			63260		49565	78127	5890			315083
1986	81521		5633	181	19520			43236		45723	52148	4596			252558
1987	68881		3007	218	14560			32667		42978	39203	5567			207081
1988	60436		2904	2	14078			33351		48964	28137	6915			194787
1989	57240		2254	3	12844			36855		50740	14722	4520			179178
1990	47394		1731		4691			32028		50683	13461	3558			153546
1991	39792	1810	1711		6564	2627	1865	25748	3299	36490		2611			122517
1992	18025	1368	485		2793	1250	1266	13314	1793	13995		593			54882
1993	8000	70	225		1042	1333	605	8909	892	10099		558		18978	50711
1994	9901	952	594		3056	2831	1887	14335	1257	21264		779		44000	100856
1995	16895	1049	1729		5496	6638	4513	25000	1612	24723		777	293	18993	107718
1996	17549	1338	3089		7340	8709	5524	34855	3306	30669		706	289	10815	124189
1997	9776	1414	1536		5215	6187	4601	31396	2803	25072		600			88600
1998	7818	1188	1026		1270	7765	4176	25155	4599	14431					67428
1999	12170	1052	1456		2215	6889	4371	25920	5202	13720					72995
2000	9715	604	1648		1508	6196	5165	21194	4231	15910				23118	89289
2001	9580	765	1526		2159	6252	3137	21346	5032	17854				23677	91328
2002	7831	37	1526		1445	4796	3137	15106	3793	12507				17562	67740
2003	7655	591	1092		1354	3493	2767	15374	3707	11297				22147	69476
2004	7394	1192	859		2659	4835	2041	14582	3410	12043				19563	68578

2005	7270	833	278	2339	3513	2988	11669	3411	7740	14991	55032
2006	9766	616	427	2025	3980	3200	14290	3719	9672	17836	65532
2007	7280	877	615	1529	3996	2486	8599	3383	9660	12418	50843
2008	7374	841	670	2341	3990	2835	8721	3888	8901	2673	42235
2009	8295	623		3665	4588	2789	10625	4482	10182	3189	48439
2010	10739	796	826	3908	5001	3140	11433	4264	10169		50277
2011	10842	1180	958	3054	4916	3017	11348	5022	10031		50368
2012	12102	686	1405	2432	4269	2261	14007	3954	10109		51225
2013	6052	249	399	541	2441	1744	11760	2870	5299		31355
2014	6035	166	350	676	1999	1088	11026	3444	4125		28908
2015	9652	189	388	1477	2586	1974	12937	3512	4628		37343
2016	6756	2	57	918	2717	1698	9583	3392	4189		29313

*** Provisional data.**

**** Includes landings from October to December 1990 of Fed.Rep.Germany.**

***** Working group estimates. No information available for years prior to 1993.**

^ Landings for 1997 were not officially reported – estimated by ICES.

Table 2.1.2. Cod in SD 25-32. Total landings (tons) by fleet, country and subdivision in 2016. BMS landings are included.

Subdivision		25	26	27	28	29	30	31	32	Total 25–32
Fleet	Country									
Active	Denmark	4320	2057	33	0	0				6410
	Estonia	0	0		0	0			0	0
	Finland	0					0		0	0
	Germany	879	39							918
	Latvia	343	1994		66					2404
	Lithuania	3	1380							1383
	Poland	3091	3848	0	0	0				6939
	Russia		3024							3024
	Sweden	2768	854	1	0			0		3623
Total Active gears		11405	13198	33	66	0	0	0	0	24702
Passive	Denmark	293	47	5	0	0				345
	Estonia				1	0			1	2
	Finland					57	0	0	0	57
	Latvia	124	153		36					313
	Lithuania		315							315
	Poland	2409	235	0	0	0				2644
	Russia		368							368
	Sweden	452		23	2	88	1	0		566
Total Passive gears		3278	1118	28	39	145	1	0	1	4610
Total all gears		14683	14316	61	105	145	1	0	1	29313

Table 2.1.3. Eastern Baltic cod stock in Subdivisions 25–32 and Subdivision 24. History of ICES estimates of landings, discards, and catch by area. Weights in tonnes.

	Eastern Baltic cod stock in Subdivisions 25–32				Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24 and 25–32
Year	Unallocated*	Discards	Landings	Catch	Landings	Discards	Catch	Total catch
1965			147352	147352				
1966		8735	177318	186053				
1967		11733	195446	207179				
1968		9700	216353	226053				
1969		10654	212160	222814				
1970		7625	198451	206076				
1971		5426	164840	170266				
1972		8490	143833	152323				
1973		7491	143164	150655				
1974		7933	147815	155748				
1975		9576	194649	204225				
1976		4341	203303	207644				
1977		2978	164792	167770				
1978		9875	154009	163884				
1979		14576	227699	242275				
1980		8544	347619	356163				
1981		6185	331642	337827				
1982		11548	316052	327600				
1983		10998	332148	343146				
1984		8521	391952	400473				
1985		8199	315083	323282				
1986		3848	252558	256406				
1987		9340	207081	216421				
1988		7253	194787	202040				
1989		3462	179178	182640				
1990		4187	153546	157733				
1991		2741	122517	125258				
1992		1904	54882	56786				
1993	18978	1558	50711	52269				
1994	44000	1956	100856	102812	1784	166	1950	104762
1995	18993	1872	107718	109590	4041	541	4582	114172
1996	10815	1443	124189	125632	10210	1087	11297	136929
1997**		3462	88600	92062	6615	629	7244	99306
1998		2299	67428	69727	4588	630	5218	74945
1999		1838	72995	74833	6338	588	6926	81759
2000	23118	6019	89289	95308	6694	1153	7847	103155
2001	23677	2891	91328	94219	7261	383	7644	101863
2002	17562	1462	67740	69202	4566	548	5114	74316
2003	22147	2024	69477	71501	6569	854	7423	78924

2004	19563	1201	68578	69779	4925	184	5109	74888
2005	14991	1670	55032	56702	5191	1808	6999	63701
2006	17836	4644	65531	70175	6279	142	6421	76596
2007	12418	4146	50843	54989	7876	856	8733	63722
2008	2673	3746	42234	45980	8934	768	9702	55682
2009	3189	3328	48438	51766	8456	474	8930	60696
2010		3543	50276	53819	6479	559	7037	60856
2011		3850	50368	54218	7487	521	8009	62227
2012		6795	51225	58020	8419	564	8982	67002
2013		5020	31355	36375	5226	1331	6557	42932
2014		9627	28909	38536	5439	1268	6707	45243
2015		6328	37342	43670	5047	912	5959	49629
2016		3620	29313	32933	4430	293	4723	37656

***ICES estimates. No information available for years prior to 1993.**

****For 1997 landings were not officially reported – estimated by ICES**

Table 2.1.4. Cod in SD 25-32. Discard (in numbers ('000)) by gear type and year.

Year	Passive gear	Active gear	Grand Total
1996	2037	5318	7355
1997	2255	15325	17580
1998	12772	9565	22337
1999	865	21314	22179
2000	14471	8822	23293
2001	1920	9008	10929
2002	1283	5841	7125
2003	3933	4315	8248
2004	1349	2324	3673
2005	799	4396	5195
2006	2786	9937	12722
2007	496	10562	11058
2008	2452	6275	8728
2009	1244	7538	8782
2010	1595	7482	9078
2011	584	9367	9950
2012	268	18367	18635
2013	1132	12688	13820
2014	1836	26027	27864
2015	2386	15964	18350
2016	296	10889	11185

Table 2.1.5. Cod in SD 25-32. Landings, discards and discard rate of cod in subdivision 25-32, BMS landings are included since 2015.

Year	Landings (t)	Discards (t)	Discard rate (% of catch)
2000	52304	1452	3%
2001	53771	1813	3%
2002	39081	2880	7%
2003	43990	3665	8%
2004	41599	1690	4%
2005	34214	2573	7%
2006	41331	5466	12%
2007	34163	4594	12%
2008	36742	2540	6%
2009	38181	4561	11%
2010	47337	4140	8%
2011	47352	6405	12%
2012	49027	8222	14%
2013	29770	6930	19%
2014	28908	9627	25%
2015	37342	6328	14%
2016	29313	3620	11%

Table 2.1.6. Cod in SD 25-32. Landings (>MCRS), BMS landings (<MCRS) and discards in numbers ('000) by length class in 2016, from subdivision 25-32.

Length class (cm)	Landings (Human consumption)	BMS landings	Discards	Total
<20	3			3
20-24	21	13	203	237
25-29	208	107	1707	2022
30-34	1534	532	6184	8250
35-37	9506	251	2339	12096
38-44	24757	50	664	25471
45-49	6129	2	67	6199
>=50	2235	1	20	2256
Total	44393	955	11185	56533

Table 2.1.7. Cod in SD 25-32.Numbers ('000) by length class, quarter, gear and SD in total catch in SD 25-32, in 2016.

			Length class (cm)								
Quarter	Gear	Subdivision	<20	20-24	25-29	30-34	35-37	38-44	45-49	>=50	Total
1	Active	25		12	209	1607	2406	3725	467	159	8586
		26		17	100	723	1163	3643	963	364	6973
		27		0	1	10	17	32	6	2	67
		28		0	0	0	0	0	0	0	0
		29		0	0	0	0	0	0	0	0
	Passive	25	0	17	23	83	279	538	98	46	1085
		26	0	7	11	24	51	134	50	20	298
		27	0	0	0	1	5	9	2	1	18
		28	0	0	0	0	2	4	1	0	7
		29	0	0	1	2	9	18	3	2	35
		32	0	0	0	0	0	0	0	0	0
Total Q1			0	54	345	2451	3932	8102	1589	595	17069
2	Active	25		78	826	2214	2876	3942	943	273	11151
		26		37	211	1226	1745	4449	756	338	8762
		27		0	0	0	0	0	0	0	0
		28		0	1	8	13	29	5	3	59
		29		0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	0
	Passive	25	0	5	16	36	107	1068	357	91	1680
		26	0	3	10	23	23	260	111	28	459
		27	0	0	1	1	1	11	4	1	19
		28	0	0	0	0	0	4	1	0	6
		29	0	0	1	2	6	59	20	5	93
		30	0	0	0	0	0	0	0	0	0
		31	0	0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	1
Total Q2			0	125	1065	3511	4771	9822	2198	739	22232
3	Active	25		7	71	403	774	880	193	74	2402
		26	3	5	85	261	243	732	215	146	1690
		27		0	0	0	0	0	0	0	0
		28		0	1	5	11	25	8	6	56
		29		0	0	0	0	0	0	0	0
		30		0	0	0	0	0	0	0	0
		31		0	0	0	0	0	0	0	0
		32				0	0	0	0	0	0
	Passive	25	0	1	4	13	13	136	183	92	442
		26	0	1	5	11	7	134	72	30	261
		27	0	0	0	0	0	1	1	0	2
		28	0	0	0	1	1	7	10	5	24
		29	0	0	1	1	1	13	17	9	43
		30	0	0	0	0	0	0	0	0	0
		31		0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	0
Total Q3			3	15	168	695	1049	1928	699	363	4919
4	Active	25		32	311	907	1211	1456	375	141	4433
		26		8	124	632	1064	3547	743	276	6394
		27		0	0	0	0	1	0	0	1
		28		0	0	0	0	0	0	0	0
		29		0	0	0	0	0	0	0	0
		31			0	0	0	0	0	0	0
		32				0	0	0	0	0	0
	Passive	25	0	2	2	23	45	432	431	94	1028
		26	0	1	6	29	21	175	155	46	433
		27	0	0	0	0	0	1	1	0	2
		28	0	0	0	0	0	4	4	1	8
		29	0	0	0	1	2	4	4	1	13
		30	0	0	0	0	0	0	0	0	1
		31		0	0	0	0	0	0		0
		32		0	0	0	0	0	0	0	0
Total Q4			0	42	444	1593	2343	5619	1713	559	12314
Total 2016			3	237	2022	8250	12096	25471	6199	2256	56533

Table 2.1.8. Cod in SD 25-32.Mean weight (g) by length class and catch category for cod in subdivision 25-32, in 2016.

Gear	Length class	Landings (human consumption)	BMS landings	Discards	Total catch
Active	<20	43			43
	20-24	115	108	115	114
	25-29	234	199	195	199
	30-34	349	310	313	319
	35-37	443	398	391	432
	38-44	614	496	494	610
	45-49	912	670	715	910
	>=50	1412	1093	1097	1410
Passive	<20	48	73	80	65
	20-24	97	114	109	109
	25-29	220	206	181	192
	30-34	367	330	320	342
	35-37	479	444	450	475
	38-44	725	548	682	725
	45-49	974	723	925	973
	>=50	1425	1036	1269	1423

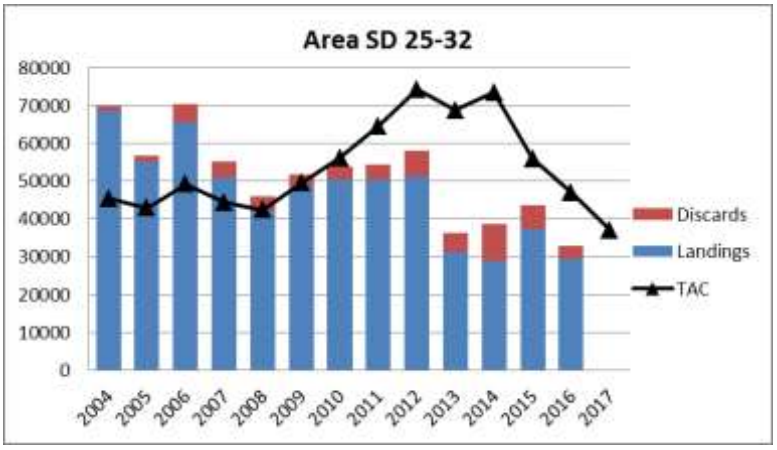


Figure 2.1.1 **Cod in SD 25-32. Landings (incl. unallocated for historical period), discards and TAC for management area of SD 25-32.**

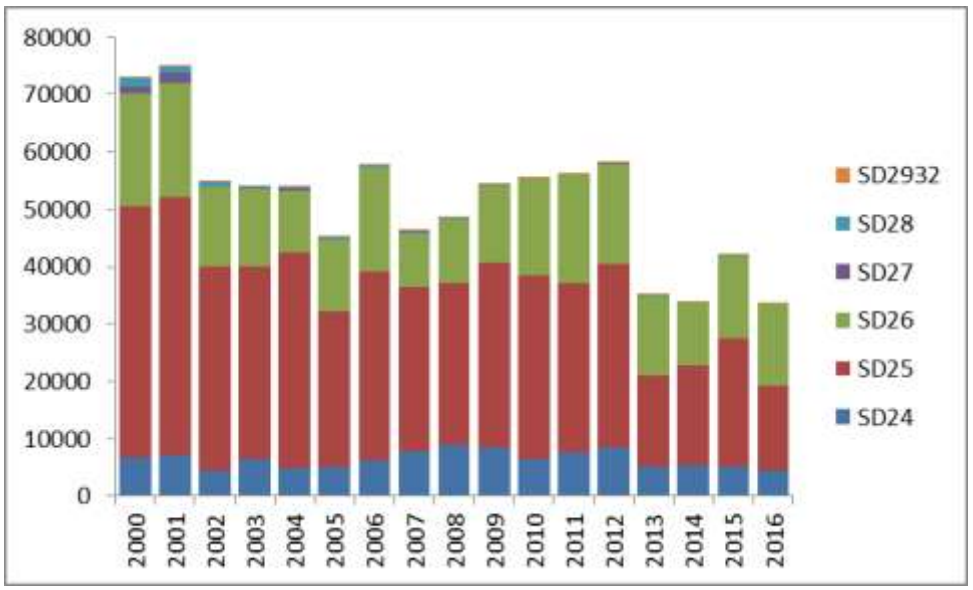


Figure 2.1.2 **Cod in SD 25-32. Landings of eastern Baltic cod stock by SD, including the fraction of landings taken in SD 24.**

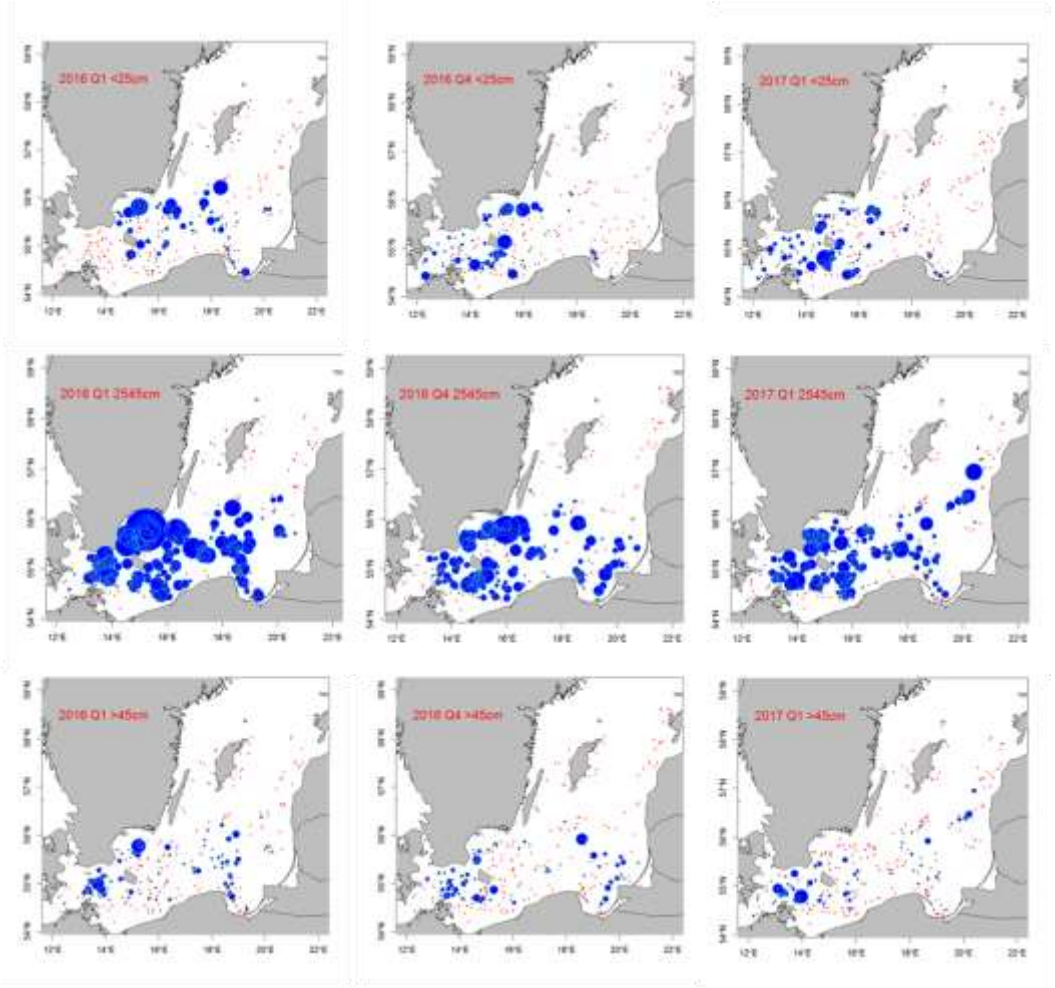


Figure 2.1.3. Cod in SD 25-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2016 and Q1 in 2017, by 3 size-groups (<25cm, 25-45cm and >45cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

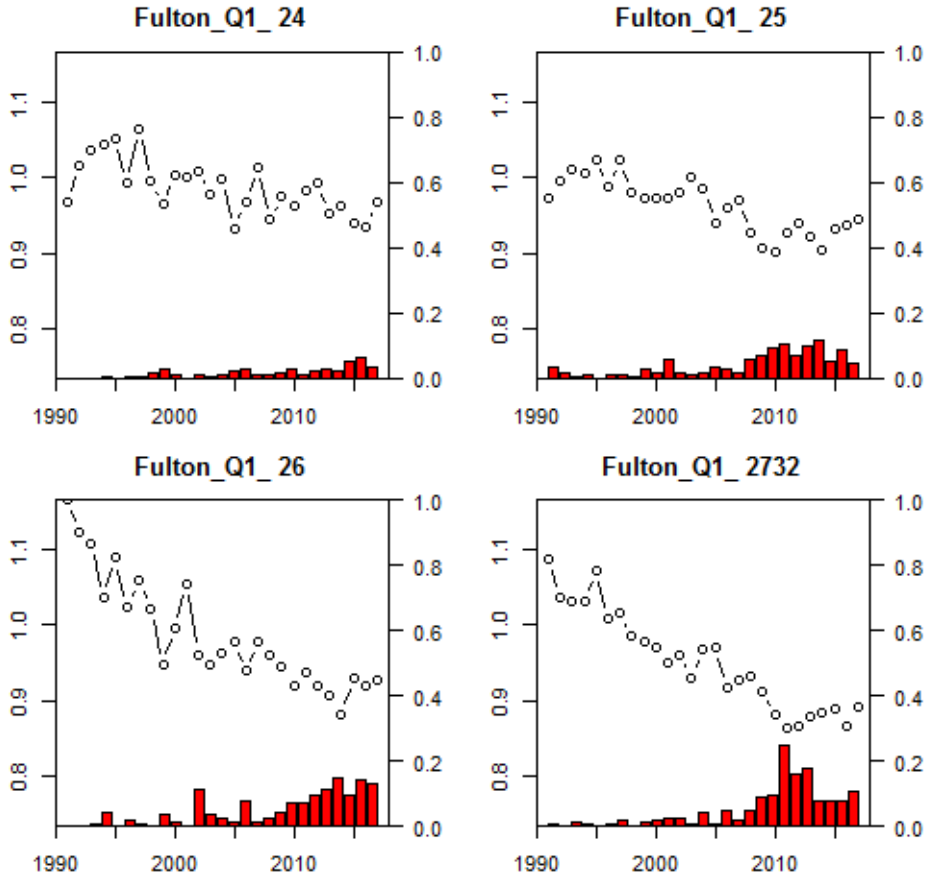


Figure 2.1.4. **Cod in SD 25-32. Condition (Fulton K) of cod at 40-60cm in length in Q1 BITS survey, by SDs. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.**

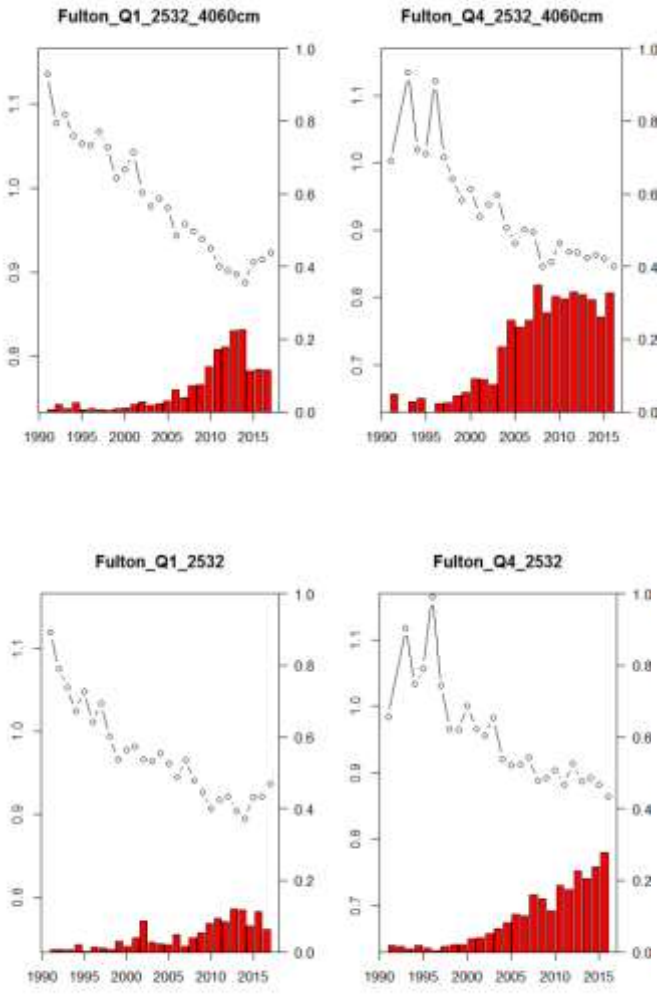


Figure 2.1.5. **Cod in SD 25-32. Mean condition (Fulton K) (shown as lines) of cod at 40-60cm (upper panels) and 25-40cm (lower panels) in length, in Q1 and Q4. The bars show the proportion of cod at Fulton K <0.8.**

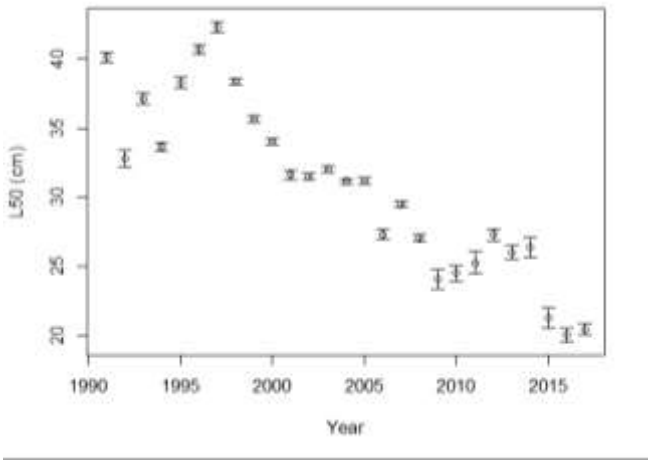


Figure 2.1.6. **Cod in SD 25-32. Size at first maturation (L50), for females and males combined, estimated from BITS Q1 survey.**

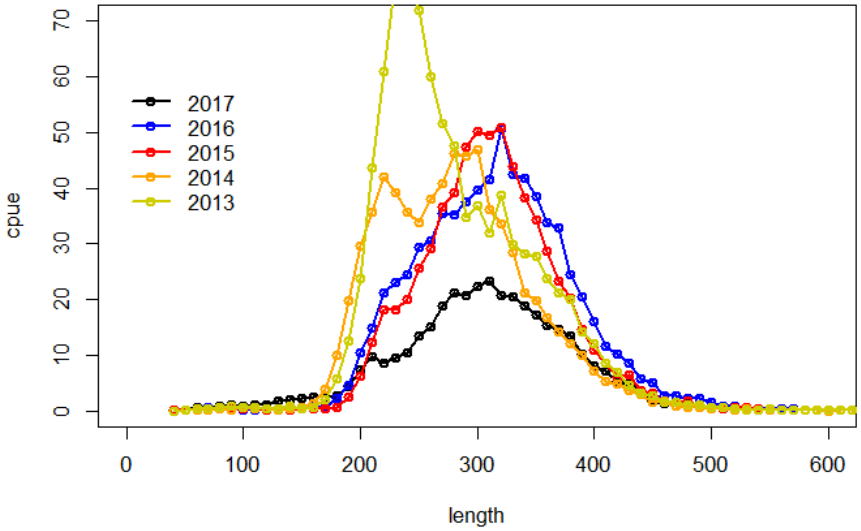


Figure 2.1.7. **Cod in SD 25-32. Length distribution of cod in BITS Q1 surveys in 2013-2017, following the stronger year-classes from 2011-2012 (visible first at around 20 cm in length in 2013 and 2014 surveys, respectively).**

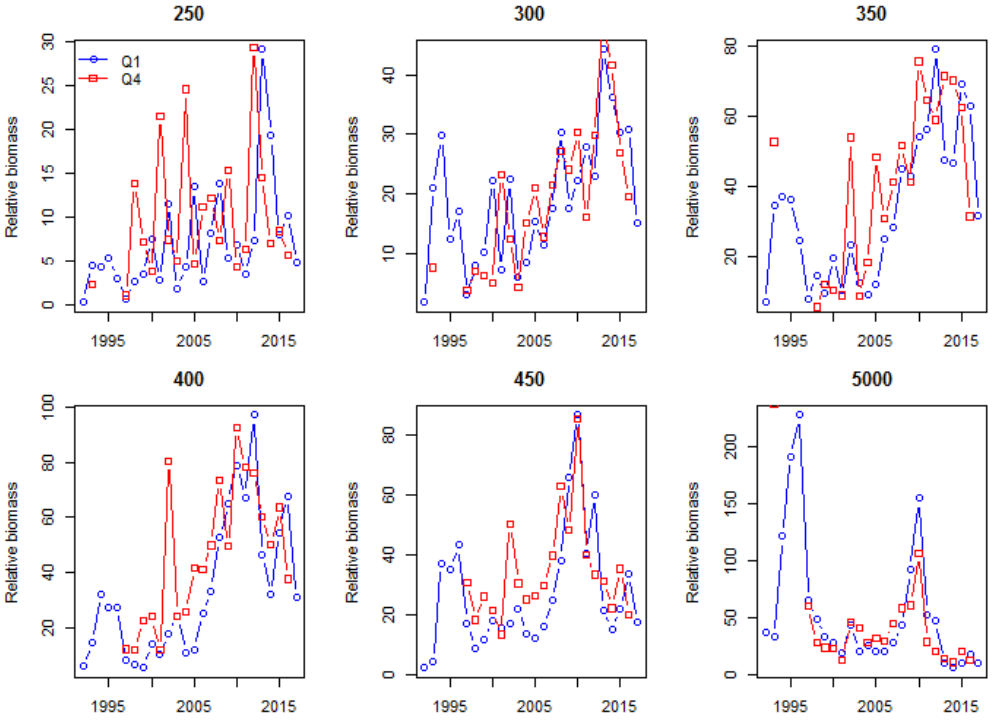


Figure 2.1.8. **Cod in SD 25-32. CPUE of cod by size-groups (<250, 250-300, 300-350, 350-400, 400-450 and >450mm) in Q1 and Q4.**

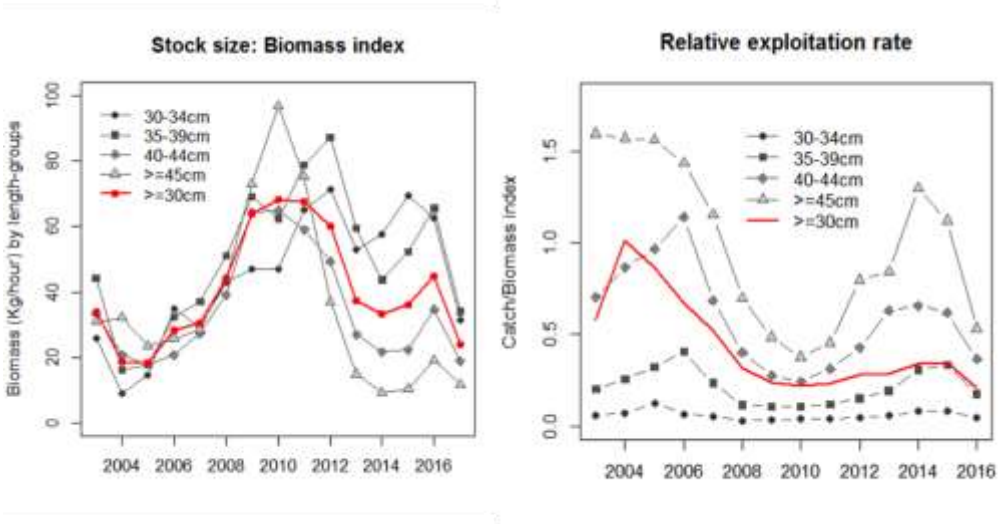


Figure 2.1.9. **Cod in SD 25-32. Relative biomass for cod by length groups, for Q1 and Q4 combined (left panel). Exploitation rate (catch divided by combined survey index for Q1 and Q4) by length groups, compared to the average exploitation rate for the stock (total catch divided by survey index for >=30cm cod; red line).**

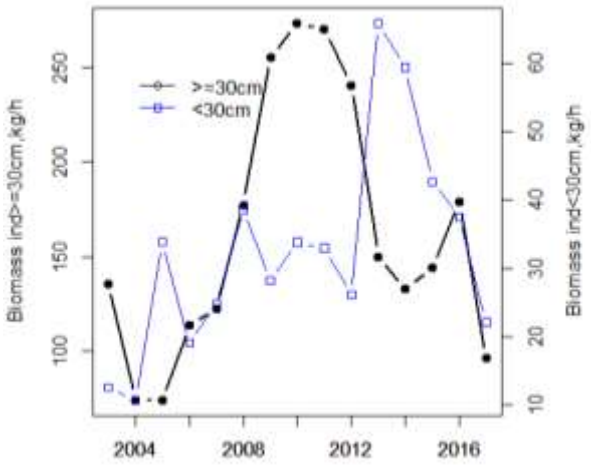


Fig. 2.1.10. **Cod in SD 25-32. Relative biomass index of >=30 cm and <30cm cod, estimated from Q1 and Q4 BITS surveys combined.**

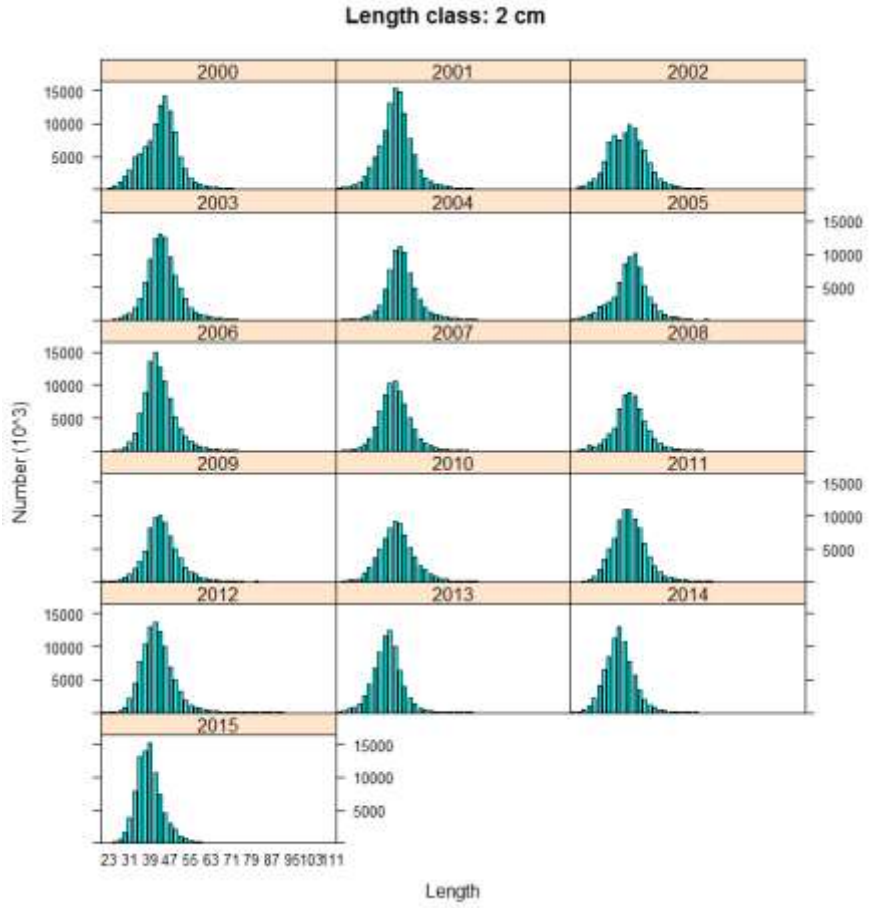


Figure 2.1.11. Cod in SD 25-32. Length distribution of catches.

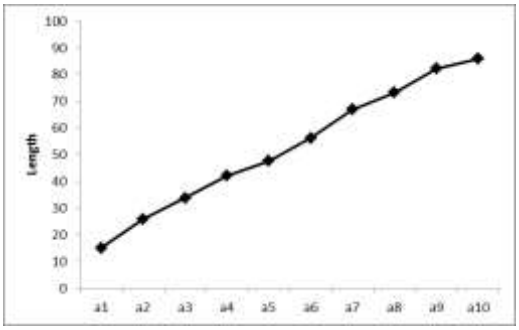


Figure 2.1.12. Cod in SD 25-32. Mean length at age of cod, estimated based on BITS Q1 survey data, combined for years 1997-2006.

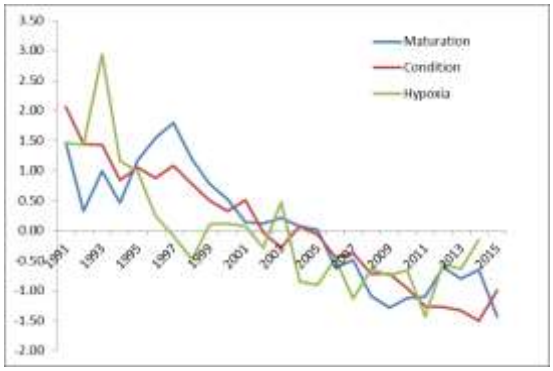


Figure 2.1.13. Cod in SD 25-32. Standardized trends in size at first maturation, nutritional condition (average for 40-60cm fish) (estimated from BITS Q1 data) and the extent of hypoxic areas in the Baltic Sea (from Casini et al. 2016).

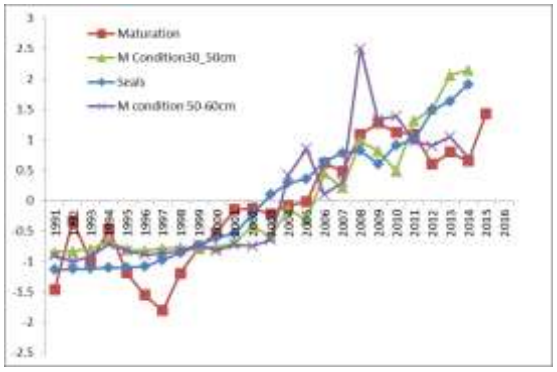


Figure 2.1.14. Cod in SD 25-32.Standardized trends in size at first maturation (from Q1 BITS), estimated M due to low condition for 30-50 and 50-60 cm cod (from Casini et al. 2016) and abundance of seals in the Baltic Sea (HELCOM estimates).

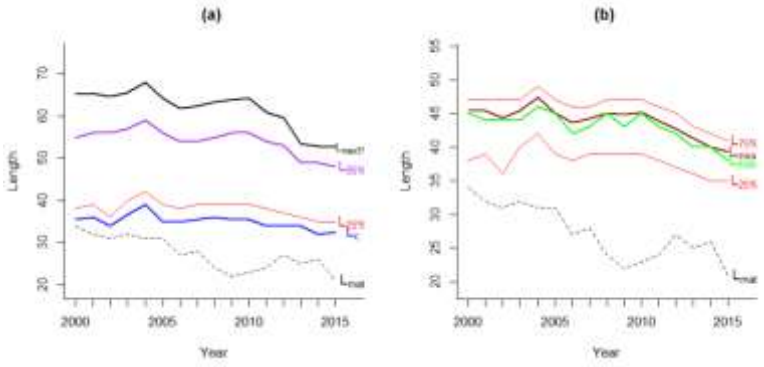


Figure 2.1.15. Cod in SD 25-32. Length based indicators for EB cod.

2.2 Cod in Kattegat

2.2.1 The fishery

2.2.1.1 Recent changes in fisheries regulations

TAC is mainly regulating the fishing in Kattegat since the effort limitation was stopped in 2016. The effort system was introduced in the first cod recovery plan (EC No. 423/2004). Effort was limited by allowed number of fishing days for individual fishing vessels. In 2009, following the introduction of the new cod management plan (EC No. 1342/2008) for North Sea (incl. Kattegat), a new effort system was introduced. In this system each Member State was given kWdays for different gear groups. It is then the MS responsibility to distribute the kWdays among fishing vessels. MS could apply for derogation from the kWdays system if the catches in a certain part of the fleet was shown to consist of less than 1.5% cod (article 11(2)(b)) or avoid cuts (or part of cuts) if they introduce highly selective gear and cod avoidance plans (article 13). Sweden has used this derogation from the kWday system for the part of the fishery using sorting grids. This fishery constituted since 2010 more than half of the Swedish effort. Denmark introduced in 2010 a cod recovery plan covering their entire Kattegat fishery. As a part of this plan, since 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with at least 180 mm panel.

In 2009, as a part of the attempts to rebuild of the cod stock in Kattegat, Denmark and Sweden, introduced protected areas on historically important spawning grounds in South East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year. Since 2012 the cod quota in Kattegat was considered to be a by-catch-quota where the landings of cod should constitute of 50 % of the total landings.

The main fishery mortality for Kattegat cod is as bycatch in the *Nephrops* fishery. The decrease in minimal landings size in *Nephrops* enforced in 2015 (from 40 mm carapace to 32mm carapace) might have an effect on the exploitation pattern for *Nephrops* (new areas exploited, new temporal trends in the fishery pattern) etc. These potential changes will most certainly affect the Kattegat cod stock development. Additionally, the termination of the effort system may also affect the fishery mortality for Kattegat cod. The effect of these changes on cod mortality is however hard to foresee.

2.2.1.2 Trends in landings

Agreed TACs and reported landings have been significantly reduced since 2000 to the present historical low level. The reported landings of cod in the Kattegat in 2016 were 299 tons, higher levels as last year (Table 2.2.1)

2.2.1.3 Discards

Both Sweden and Denmark implemented the TAC regulation through a ration-period system until 2007. The ration sizes were reduced substantially since 2000—2001 and the rations in the Kattegat were lower than those in adjacent areas, giving incentives for misreporting of catches by area (Hovgård, 2006), which could potentially have biased landings statistics for these years.

Discard estimates were available from Sweden for 1997—2016 and from Denmark for 2000—2016.The estimated discard numbers by age and total discards in tons are presented in Table 2.2.2. The sampling levels are shown in Table 2.2.3.

In 2016, the estimated discards formed about 43 percent of the catch weight and the proportion of discards in catch has decreased the last year compared to the previous years (Figure 2.2.1). In numbers, the available data indicates that close to 72 % of the cod caught in the Kattegat is discarded. Discarding has in previous years mostly affected ages 1-2 but in 2015 and 2016 it also included both age 3 and 4+. The inclusion of 3 and 4-year-old classes in the discard could be related to the poor recruitment in the last three years. The increasing number of older fish in the Kattegat and poor recruitment can be observed in the age structure of the survey catches (Table 2.2.2; Figure 2.2.2, Figure 2.2.4).

2.2.1.4 Unallocated removals

Unreported catches have historically been considered to be an issue for this stock, estimated as part of unallocated removals within the assessment model. Last benchmark (WKBALT 2017) concluded the catch data to be of reasonable quality from 2011 onwards. Major issues identified at WKBALT (2017) that could explain the unallocated removals estimated in the model include inflow of recruits from the North Sea cod and their return migration when they become mature, as well as possibly increased natural mortality due to seal predation.

2.2.2 Biological information

2.2.2.1 Catch in numbers

Historical total landings in numbers by age and year are given in Table 2.2.6.

2.2.2.2 Maturity at age

The historical time series of visual based maturity estimations used in the assessment are presented in Table 2.2.9. The estimates are based on IBTS 1st quarter survey. Due to low number of cod in the survey, the maturities in recent years are based on a running mean of 3 years.

2.2.2.3 Natural mortality

A constant natural mortality of 0.2 was assumed for all ages for the entire time series.

2.2.2.4 Quality of catch and biological information

Both Danish and Swedish sampling data were available from the commercial fishery in 2016. Danish and Swedish commercial sample sizes are shown in Table 2.2.3. and table 2.2.4. Landings were allocated to age groups using the Danish and Swedish age information as shown in Table 2.2.5. The catch numbers followed the same procedure as the landings and catch in numbers by age is presented in Table 2.2.6)

Mean weight at age in the landings in 2016, presented in Table 2.2.7, and was provided by Sweden and Denmark. Historical weight at age in the landings is given in Table 2.2.7 for all years included in the assessment.

Mean weight at age in the stock is based on the IBTS 1st quarter survey for age-groups 1—3. Due to low number of cod in the survey, the weights in the stock in recent years are based on a running mean of 3 years. The weight of ages 4—6+ were set equal to the mean weights in the landings. The historical time series of mean weight at age in the stock is given in Table 2.2.8.

2.2.3 Fishery independent information

The CPUE-values used were from IBTS 1st and 3rd quarter surveys ,from the BITS surveys in the 1st quarter (Danish R/V Havfisken) and from the Cod survey 4th Quarter. The internal consistency of surveys (numbers at age plotted against numbers at age+1 of the same cohort in the following year) are shown in Figure 2.2.3a–d. The survey indices available for the Working Group are presented in Table 2.2.10.

The tuning series available for assessment:

FLEET	DETAILS
BITS-1Q	Danish survey, 1st quarter, R/V Havfisken (age 1-5) (1997-2017)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-6) (1997-2016)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2017)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2016)

2.2.4 Assessment

2.2.4.1 Future plans after benchmark in 2017

The issues identified at WKBALT (2017) that could explain the unallocated removals estimated in SAM include inflow of recruits from the North Sea and their return migration when they become mature. WKBALT 2017 suggested intersessional work to be continued looking into possibilities to take migration more explicitly into account in the SAM model, to be able to separate fishing mortality from migration. A modified version of SAM model was presented at WGBFAS 2017, incorporating proportions of juvenile North Sea and Kattegat cod, estimated in the model, and assuming return migration to take place when the fish become mature (WD by Vinther, M. WGBFAS 2017).

WGBFAS concluded that data on the proportions of juvenile cod in the Kattegat originating from North Sea are needed, to be incorporated in the model, or used to validate the values estimated in the model. The first step would be to analyze historical samples to determine stock origin for individuals at age 1, for the latest 10 years (200 individuals per year). These data could then be included in the new version on SAM model, to account for the North Sea component in the Kattegat. The time line for this work to be completed is considered to be 2 years.

A longer term step would be to gather genetic samples from the whole size range of cod, and also analyse the samples back in time that would be needed in order to split the different cohorts between North Sea and Kattegat cod, to assess the developments in Kattegat stock alone. This could be done using the traditional SAM or possibly other models (e.g SS3).

2.2.4.2 State–space model (SAM)

A stochastic state-space model (SAM) (Nielsen, 2008, 2009) was used for assessment of cod in the Kattegat link to the model. The model allows estimation of possible bias (positive or negative) in the data on removals from the stock in specific years. Settings of the model were used as specified in the Stock Annex. Two runs was performed

Catch (landings and discards) from 1997—2016 with estimating total removals from 2003—2015 within the model based on survey information. (SPALY _Scaling)

Catch (landings and discards) from 1997—2016 without estimating total. (SPALY _)

Unallocated removals were estimated separately for the years 2003—2016, but common for all age-groups within a year. The scaling factors estimated for 2005—2016 were significant for all the years in the SAM run with landings and total removals estimated. For the SAM run with discard and total removals estimated all years(except for 2003) significant. The total removals were estimated several fold higher than reported landings, and are not explainable by the estimated discard data only (Figure 2.2.12).

Estimates of recruitment, SSB and mortality (Z-0.2) with confidence intervals from the two runs with total removals estimated are presented in Figure 2.2.7—2.2.9 and Tables 2.2.11—2.2.12. All information about the residuals and results from the two SAM runs Fig 2.2.11; 2.2.13; 2.2.14; 2.215-2.2.15.

2.2.4.3 Conclusions on recruitment trends

The absolute values of recruitment estimated from the assessment analyses are considered uncertain, mainly due to mixing with North Sea cod and possibly also uncertain natural mortality estimates. Additionally, discards are associated with uncertainties; at least for part of the time series. The year classes of 2015 and 2016 are the lowest in the times serie Fig 2.2.6.This can be contrasted to the biggest year class in the time series from 2011.

2.2.4.4 Conclusions on trends in SSB and fishing mortality

The assessment is indicative of trends only and shows that spawning-stock biomass (SSB) has strongly increased since 2009 from a historical low level, from 2015 the SSB has levelled out and decreased 2016. The mortality has shown a decreasing trend since 2008, followed by a slight increase 2016. However, the exact level of fishing mortality can still not be reliably estimated. The runs that estimated total removals show estimated mortality (Z-0.2) in the interval of 0,293 to 0,62. In contrast the run without estimating total removals in the interval of 0.056 to 0.165. However, the overall perception is that the total mortality has gone down since 2008 (Table 2.2.11—2.2.12, Fig 2.2.8).

2.2.5 Short term forecast and management options

No short term forecast was produced in this year's assessment

2.2.6 Reference points

Two different methods have been used to explore proxies for MSY reference points.

One of the main issues with the assessment of cod in the Kattegat is the inflow on young cod from the North Sea and return migration when they become mature. This implies that the basis for calculation of the proxies for reference points are constructed from life history and stock dynamics data, originating from possibly two stocks. The issue with unallocated removals (migration, possibly unallocated natural mortality) that bias the current SAM assessment are not solved by applying a production model (SPICT). If the problem with stock mixing is resolved, the SPiCT as well as an age based analytical assessment could likely be used for determining reference points for cod in the Kattegat.

Another problem is the large change in size distribution the last couple of years, which is especially a problem in the LBI- analysis. Hence, this makes it highly questionable to use these two methods as a basis for proxies for new reference points.

The sections below describe the analyses conducted.

2.2.6.1 LBI

To use the LBI Application (https://scott.shinyapps.io/LBIndicator_shiny/) you need: 1) a length frequency distribution (table 3) 2) weight at length data, (table 3) and 3) estimates of the life history parameters including L_{inf} and L_{mat}. The length and weight distribution used was based on the WECA and CANUM from the 3 last years (2014-2016). To determine L_{inf} and L_{mat}, age, length and maturity data was used for the time period 1997-2017 (survey). The calculated L_{inf} gave was unrealistically high (1498 mm). Hence, L_{inf} from Fishbase was used as a proxy. L_{inf} was calculated as the average for all data in the near vicinity (North sea and the Baltic) of Kattegat (36 references) and the average value was 1140 mm. the survey data suggested that L_{mat} should be 275 mm, which is rather low. Based on the references in Fishbase suggest that L_{mat} should be 390 mm (13 references) and was used in the analysis. The results are presented below and indicate that the stock is below MSY 2014 and 2015 but above MSY in 2016 (table 2).

Table 1 Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

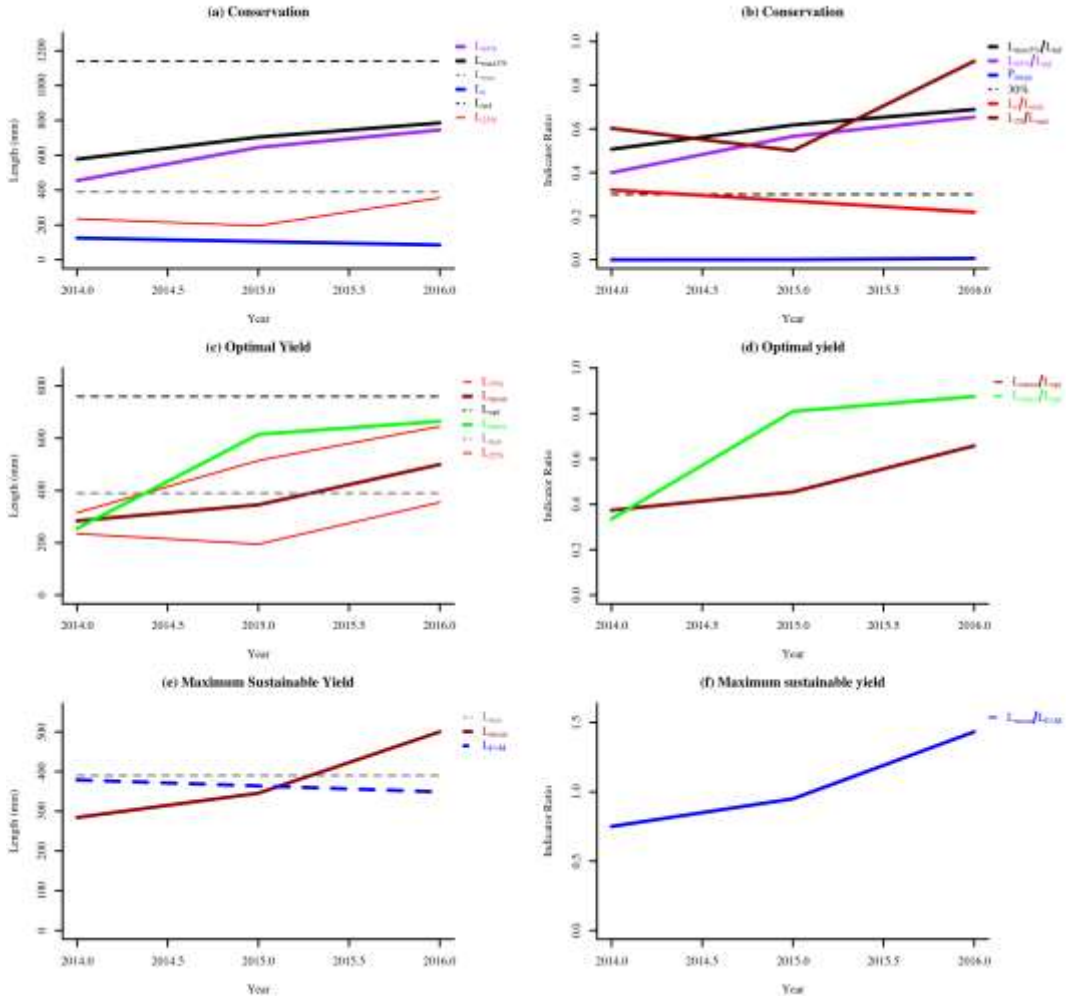


Table 2. Indicator status for the most recent three years

	Conservation				Optimizing Yield	Lmean	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	mm	Lmean / LF = M
2014	0.32	0.60	0.51	0.00	0.37	304	0.75
2015	0.27	0.50	0.62	0.00	0.45	381	0.95
2016	0.22	0.91	0.69	0.01	0.66	568	1.43

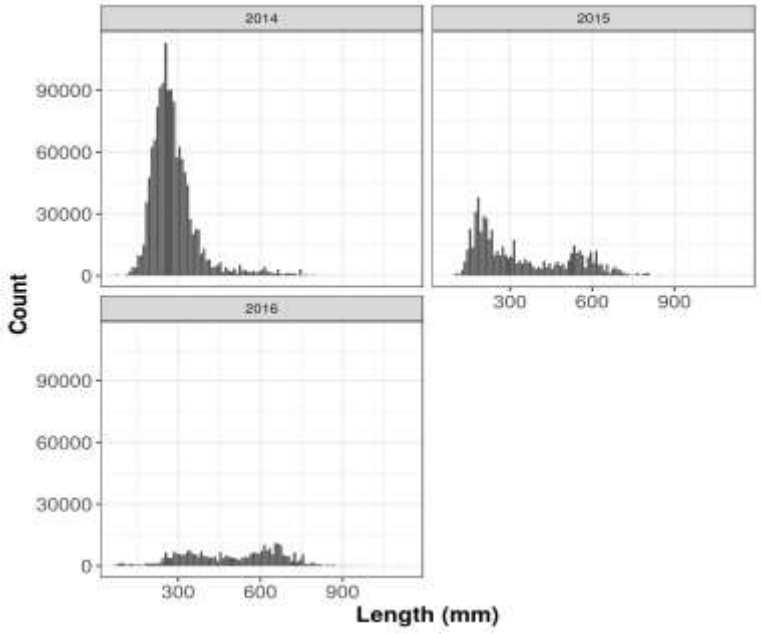


Figure 2. Binned length frequency distributions

2.2.6.2 SPiCT

Survey data

The fraction of the population in terms of age/size used to represent biomass trends should correspond to the fraction represented in commercial catches. At first step, survey indices in numbers at age as used in the SAM assessment were converted to biomass at age, using mean weight at age in the stock. Catch numbers at age were converted to biomass at age, using mean weight in the stock from age 2 onwards; and mean weight in discards for age 1. Next, relative age structure in survey biomass was compared to that in commercial catch (Fig. 1). Based on this comparison, cod survey seems to cover relatively older cod compared to catches, and the time series is relatively short. BITS (Havfisken) Q1 is considered only useful for the assessment up to age 3. Therefore, the time series of relative biomasses from IBTS Q1 and Q3 that both have longer time series and include most ages were chosen to be included in the SPICT analyses (Fig. 3). The time series started from 1997. All runs used IBTS Q1 and Q3 series of survey biomass.

Catch data

Two versions of catch data were used: i) catches in tons were set equal to reported landings in tons plus estimated discards from observer programs; ii) catch was increased for years 2005-2010, where substantial missing removals have been estimated, and it is known that there have been issues with the quality of catch data in this period. Since 2011, WKBALT considered the quality of catch data to be of reasonable quality. The two catch time series are shown in Fig. 2.

Effort

A run was made that included trend in fishing impact (estimated from VMS, cod distribution and gear selectivity data) (WKBALT 2017), for 2007-2015, as a measure of effort.

Results

Figures 4-6 present SPICT model results from 3 runs:

1) Catches set equal to reported landings and estimated discards from observed program

2) Catches increased for 2005-2010, to account for possible underestimation of catch for these years

3) Same as Run 2, but including additionally time series of relative effort.

The diagnostics reveals some issues with all three models (Fig 4b-6b), least for Run 1#.

All three runs estimate F/FMSY below one for recent years, suggesting low fishing pressure. Biomass is mostly estimated to be below BMSY, however, the estimates have a high uncertainty, and the result therefore less conclusive.

The analyses are conducted for the Kattegat area, where the issue of inflow of North Sea cod into the Kattegat and return migration is not taken into account, which may bias the results.

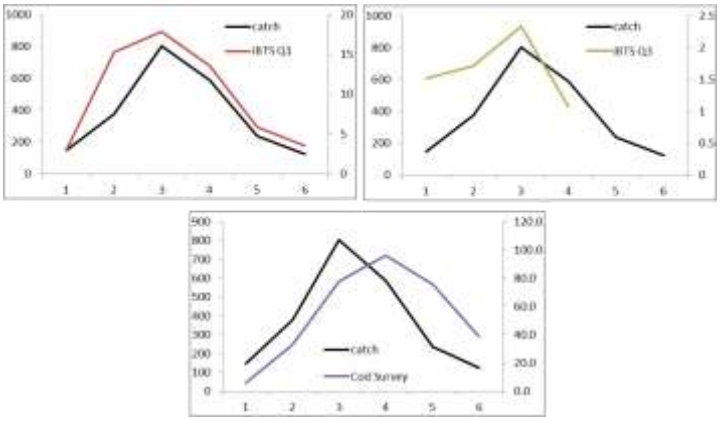


Fig. 1. Biomass at age in commercial catch compared to surveys.

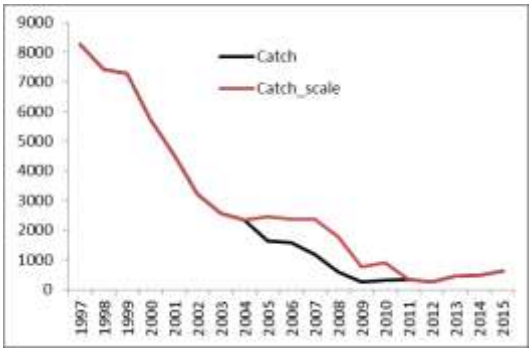


Fig. 2. Catch of Kattegat cod (landings plus discards) as reported (black line), compared to when the catches are increased in 2005-2010, to account for possible missing catch.

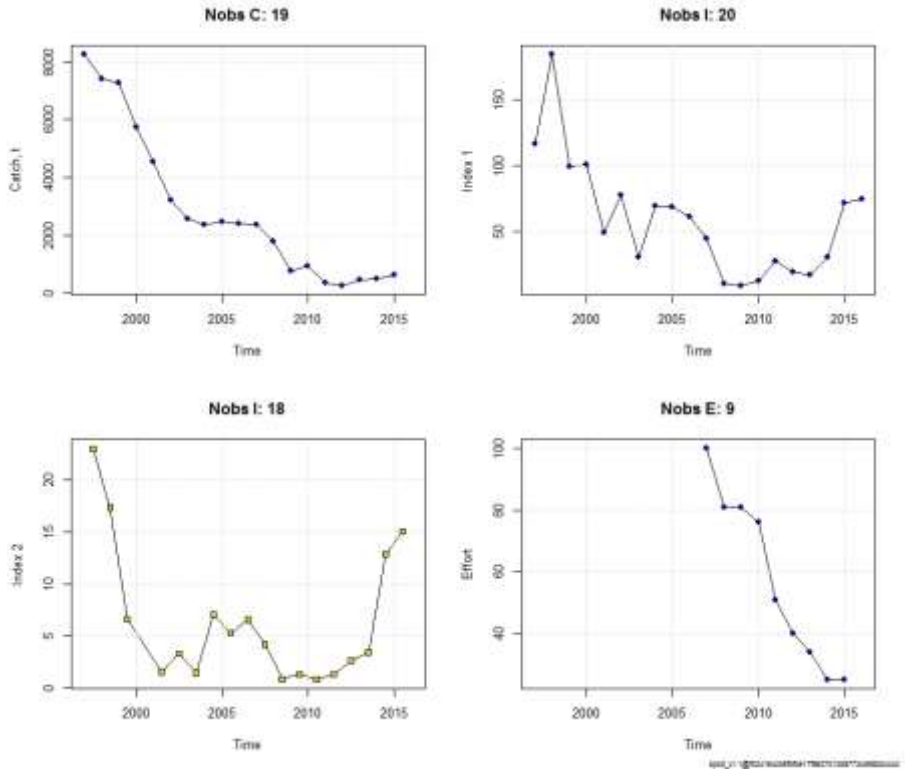


Fig. 3. Input data used in SPICT (shown for Run 3#).

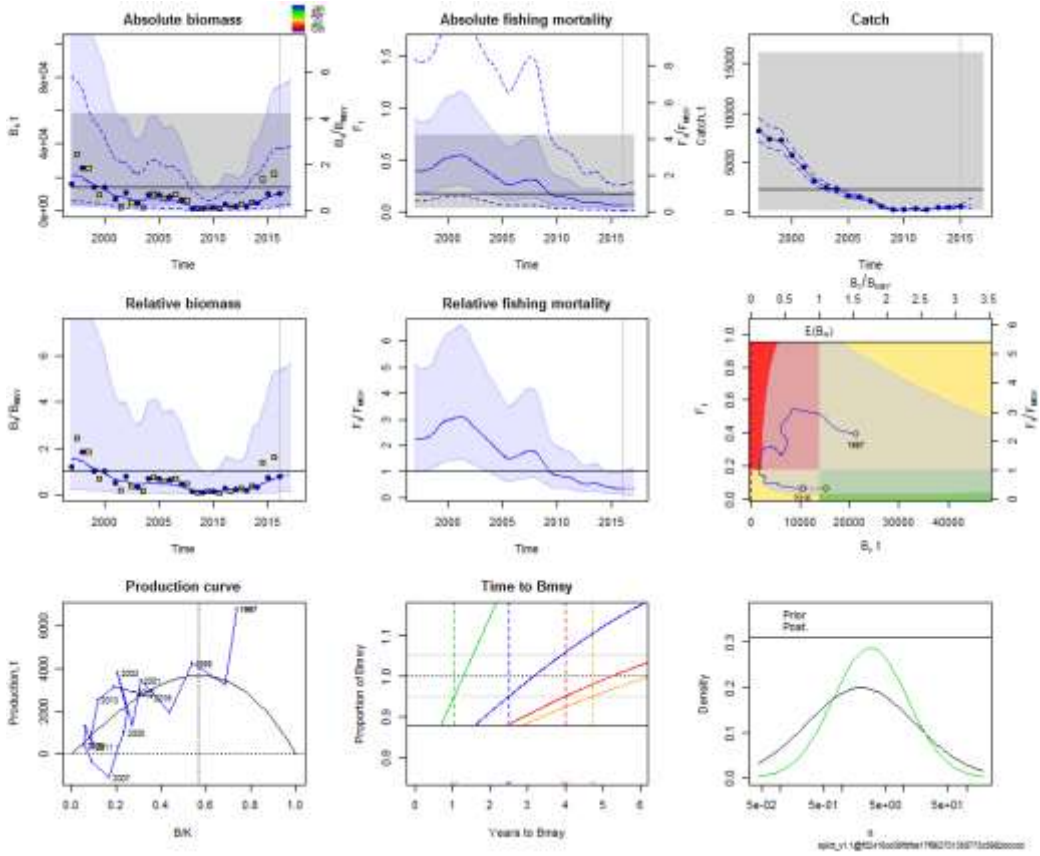


Fig. 4a. Output from SPICT using reported catch (Run 1#).

2.2.7 Quality of the assessment

Indices from for different surveys that provide information on cod in the Kattegat were used in the assessment. All available survey indices are relatively noisy, however contain information that is to a certain extent consistent between years in single surveys and agrees on the same level with the estimates from other surveys. In 2003—2016, the survey data indicates significantly higher total removals from the stock than can be explained by the reported catch data.

WKBALT 2017 concluded that the unallocated removals can largely be explained by mixing with North Sea cod and potentially increased natural mortality. Also, uncertainties in catch numbers at least for some years in the time series likely contribute to this mis-match.

Therefore, current level of fishing mortality cannot be reliably estimated and are in the range of 0,62-0,056 in the SPALY runs. The highest estimate of the amount of unallocated removals was found in the year 2014 (Fig 2.2.12).

The exact estimates of SSB are considered uncertain, however all available information consistently indicates that SSB is has increased from low levels and in 2016 are in the vicinity of 5271 to 6140 t.

2.2.8 Comparison with previous assessment

The input data were updated from the time series used in last year's assessment, besides the changes made to input data at WKBALT 2017 (revised discard time series and

excluding BITS Q4 survey). The assessment was performed using state-space assessment model (SAM) as in last year. The results from this year's assessment can be found in table 2.2.11 and 2.2.12.

2.2.9 Management considerations

It should be taken into consideration that:

The year class of 2015 is the lowest observed in the time series. The recruitment in the last 3 years has been very low.

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2015.

Year	Kattegat			Total	
	Denmark	Sweden	Germany1		
1971	11748	3962	22	15732	
1972	13451	3957	34	17442	
1973	14913	3850	74	18837	
1974	17043	4717	120	21880	
1975	11749	3642	94	15485	
1976	12986	3242	47	16275	
1977	16668	3400	51	20119	
1978	10293	2893	204	13390	
1979	11045	3763	22	14830	
1980	9265	4206	38	13509	
1981	10693	4380	284	15337	
1982	9320	3087	58	12465	
1983	9149	3625	54	12828	
1984	7590	4091	205	11886	
1985	9052	3640	14	12706	
1986	6930	2054	112	9096	
1987	9396	2006	89	11491	
1988	4054	1359	114	5527	
1989	7056	1483	51	8590	
1990	4715	1186	35	5936	
1991	4664	2006	104	6834	
1992	3406	2771	94	6271	
1993	4464	2549	157	7170	
1994	3968	2836	98	7802	2
1995	3789	2704	71	8164	3
1996	4028	2334	64	6126	4
1997	6099	3303	58	9460	5
1998	4207	2509	38	6835	
1999	4029	2540	39	6608	
2000	3285	1568	45	4897	
2001	2752	1191	16	3960	
2002	1726	744	3	2470	
2003	1441	603 7	1	2045	
2004	827	575	1	1403	
2005	608	336	10	1070	6
2006	540	315	21	876	
2007	390	247	7	645	
2008	296	152	1	449	
2009	134	62	0.3	197	
2010	117	38	0.3	155	
2011	102	42	1.4	145	
2012	63	31	0.0	94	
2013	60	32	0.0	92	
2014	75	32	0.0	108	
2015	68	38	0.0	106	
2016	185	114	0.0	299	

1 Landings statistics incompletely split on the Kattegat and Skagerrak

2 Including 900 t reported in Skagerrak.

3 Including 1.600 t misreported by area.

4 Excluding 300 t taken in Sub-divisions 22–24.

5 Including 1.700t reported in Sub-division 23.

6 Including 116 t reported as pollack7 the catch reported to the EU exceeds the catch reported to the WG (shown in the table) by 40%

Table 2.2.2 Cod in Kattegat. Estimates of discard in numbers (in thousands) by ages and total weight in tonnes. The estimation of total discards is not entirely consistent between the years.

DENMARK						
Year	a1	a2	a3	a4	a5	a6
1997						
1998						
1999						
2000	880	1634	22	3	0	0
2001	1365	386	3	0	0	0
2002	2509	1226	290	0	0	0
2003	114	876	40	0	0	0
2004	2562	352	58	0	0	0
2005	616	1285	0	0	0	0
2006	614	752	203	0	0	0
2007	135	1098	259	20	0	0
2008	20	99	57	4	1	0
2009	210	41	2	0	0	0
2010	367	224	14	0	0	0
2011	559	354	22	0	0	0
2012	707	161	10	0	0	0
2013	517	322	8	3	0	0
2014	431	621	22	4	2	0
2015	120	86	82	19	7	0
2016	9	40	17	33	13	4
SWEDEN						
Year	a1	a2	a3	a4	a5	a6
1997	567	678	212	13	0	0.0
1998	684	641	157	8	0	0.0
1999	579	663	177	10	0	0.0
2000	922	876	153	19	2	0.0
2001	745	720	142	17	2	0.0
2002	667	419	93	12	1	0.0
2003	514	715	49	3	1	0.2
2004	982	583	533	2	2	0.3
2005	237	464	6	5	0	0.0
2006	784	448	182	7	3	0.3
2007	534	278	32	12	0	0.1
2008	148	48	10	0.1	0	0.0
2009	179	14	0.1	0.1	0	0.0
2010	63	58	0	0	0	0
2011	71	51	9	0	0	0
2012	180	54	5	0	0	0
2013	550	190	21	1	2	0
2014	79	174	20	1	2	0
2015	119	57	58	24	4	4

2016	7	43	11	5	3	1	
	DK AND SWE DISCARD NUMBERS COMBINED						TOTAL DISCARD IN
Year	a1	a2	a3	a4	a5	a6	tons
1997	1398	2102	478	26	0.4	0.1	881
1998	1369	1454	284	23	0.3	0.0	664
1999	1158	1964	314	18	0.5	0.0	764
2000	1802	2510	175	22	1.9	0.0	992
2001	2110	1105	146	17	1.7	0.0	823
2002	3176	1645	383	12	1.3	0.0	577
2003	628	1591	89	3	0.9	0.2	750
2004	3544	934	591	2	2.1	0.3	1063
2005	853	1749	6	5	0.0	0.0	575
2006	1398	1200	386	7	2.6	0.3	849
2007	668	1377	291	32	0.5	0.1	577
2008	168	147	67	4	1	0	165
2009	389	55	2	0	0	0	77
2010	430	282	14	0	0	0	167
2011	631	405	31	0	0	0	216
2012	887	215	15	0	0	0	142
2013	1067	512	29	4	2	0	351
2014	510	795	42	5	4	0	339
2015	239	143	140	43	11	4	401
2016	16	83	28	38	16	5	222

Table 2.2.3 Cod in the Kattegat. Numbers of discard samples by years and countries.

COUNTRY /YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark				52	68	43	30	47	33	22	10
Sweden	45	50	55	63	40	63	38	26	48	66	72
Total	45	50	55	115	108	106	68	73	81	88	82

Country /Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	24	38	34	43	48	58	55	46	37
Sweden	50	49	58	48	41	44	39	40	40
Total	74	87	92	91	89	102	94	86	77

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2016.

	N. OF SIZE DISTRIBUTIONS	N. OF COD	N. OF COD	N. OF COD
Quarter	sampled	aged	weighed	measured
1	6	79	79	79
2	8	78	78	78
3	5	57	57	57
4	4	90	90	90
Total	23	304	304	304

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2016.

	N. OF SIZE DISTRIBUTIONS	N. OF COD	N. OF COD	N. OF COD
Quarter	sampled	aged	weighed	measured
1	20	411	411	411
2	17	270	270	270
3	15	257	257	257
4	17	365	365	365
Total	69	1303	1303	1303

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2016

Sub-div	21					
Year	2016 Quarter	1				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	0.81009	1203	0.5801	728.4	1.39	1004.96
3	2.649421	1323.106	2.4135	1264.3	5.06	1295.07
4	7.707155	2906.639	5.172	1827.2	12.88	2473.16
5	0.356902	5219.535	5.7785	2443.5	6.14	2604.98
6	0.475267	3242.097	1.2082	3629.1	1.68	3519.84
7	0.24	3689.00	0.4054	4676.8	0.64	4310.37
8			0.0767	5809.5	0.08	5809.50
9			0.01	4240.00	0.01	4240.00
10						
SOP (t)	28.74			33.32	64.49	
Landings (t)	28.56			30.97	59.53	

Sub-div	21					
Year	2016 Quarter	3				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2			1.0057	751.6	1.01	751.60
3	1.61124	2296.54	0.6787	1884.9	2.29	2174.54
4	3.604535	2663.924	2.9321	2571	6.54	2622.24
5	1.131036	2591.68	3.7788	2669.8	4.91	2651.80
6	0.199067	3551	1.1683	3463.7	1.37	3476.41
7			0.2854	5070	0.29	5070.00
8			0.0168	8143.2	0.02	8143.20
9						
10						
SOP (t)	16.23			25.16	42.10	
Landings (t)	16.70			24.40	41.10	

Sub-div	21					
Year	2016 Quarter	2				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2			0.1573	894.6	0.16	894.60
3	1.173824	1480.938	0.8192	1327.8	1.99	1417.99
4	6.974087	2707.137	2.9314	2084.4	9.91	2522.85
5	1.368926	4542.518	3.3119	2858	4.68	3350.64
6	0.76845	3719.788	1.1059	3919.5	1.87	3837.62
7			0.6456	5303	0.65	5303.00
8			0.2327	5402.7	0.23	5402.70
9			0.02	5194.80	0.02	5194.80
10			0.01	4949.10	0.01	4949.10
SOP (t)	26.84			24.56	54.26	
Landings (t)	29.00			25.00	54.00	

Sub-div	21					
Year	2016 Quarter	4				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	7.53869	1432.868	1.8313	1227.5	9.37	1392.73
3	26.72072	2978.35	3.3885	1561.8	30.11	2818.93
4	2.890909	3737.352	3.2628	2171.2	6.15	2906.95
5	0.815697	5750	4.8435	2929.2	5.66	3335.78
6			1.8693	3654.2	1.87	3654.20
7			0.244	5634.7	0.24	5634.70
8			0.1693	3506.1	0.17	3506.10
9			0.01	19024.20	0.01	19024.20
10						
SOP (t)	105.88			37.02	142.90	
Landings (t)	108.40			35.00	143.40	

Sub-div	21					
Year	2016 Quarter	all				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	8.34878	1432.868	3.5744	1227.5	11.92	1371.30
3	32.15521	2978.35	7.2999	1884.9	39.46	2776.04
4	21.17669	3737.352	14.2983	2571	35.47	3267.25
5	3.672561	5750	17.7127	2929.2	21.39	3413.63
6	1.442784	3719.788	5.3517	3919.5	6.79	3877.09
7	0.24	3689.00	1.5804	5634.7	1.82	5379.04
8			0.4955	8143.2	0.50	8143.20
9			0.03	5194.80	0.03	5194.80
10			0.02	19024.20	0.02	19024.20
SOP (t)	207.99			136.67	355.40	
Landings (t)	185.00			113.00	298.00	

Table 2.2.6 Cod in the Kattegat. Catches (Landings +Discards) in numbers (in thousands) by year and age. In the assessment the plus-group is defined as 6+.

	Age					
Year	1	2	3	4	5	6
1997	1456	2540	5137	891	222	88
1998	1499	3587	1595	1908	283	76
1999	1201	3859	3972	455	409	77
2000	1819	3942	2346	1027	125	103
2001	2166	2012	2034	703	187	45
2002	3190	2161	1062	391	85	40
2003	628	2441	650	184	65	16
2004	3547	1077	1195	206	65	39
2005	854	2169	121	167	21	12
2006	1406	1305	796	36	33	9
2007	668	1446	383	190	16	26
2008	175	191	136	40	33	7
2009	400	92	30	22	9	4
2010	433	361	33	8	4	2
2011	631	445	84	6	2	1
2012	889	231	30	13	2	0
2013	1068	533	49	12	3	1
2014	510	804	66	20	6	0
2015	239	144	167	56	15	6
2016	16	95	68	75	38	13

Table 2.2.7 Cod in the Kattegat. Weight at age (kg) in the landings by year and age.In the assessment the plus-group is defined as 6+.

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1972	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1973	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1974	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1975	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1976	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1977	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1978	0.699	0.880	1.170	1.690	2.860	4.120	5.180	6.900
1979	0.708	0.868	1.086	1.890	2.215	3.382	7.314	6.101
1980	0.691	0.893	0.951	1.440	2.478	3.157	3.526	6.903
1981	0.604	0.799	1.123	1.432	2.076	3.532	4.420	4.644
1982	0.600	0.784	1.233	1.391	2.078	2.911	3.698	6.480
1983	0.595	0.752	1.129	1.943	3.348	3.141	5.301	6.325
1984	0.711	0.745	1.133	1.687	2.798	3.022	5.273	7.442
1985	0.606	0.839	0.986	1.614	2.575	4.090	6.847	7.133
1986	0.671	0.705	1.253	1.955	2.956	4.038	7.100	7.290
1987	0.483	0.716	1.118	1.972	2.868	4.200	5.185	8.288
1988	0.541	0.784	1.099	1.792	2.880	4.283	5.852	7.073
1989	0.621	0.921	1.269	2.296	3.856	5.733	5.166	6.527
1990	0.618	0.973	1.584	2.323	3.288	5.383	6.412	10.337
1991	0.578	0.861	1.533	2.986	4.548	4.179	9.127	12.055
1992	0.610	0.707	1.291	2.662	4.048	5.888	7.067	7.895
1993	0.567	0.862	1.583	2.321	4.970	7.566	9.391	8.705
1994	0.549	0.783	1.276	2.652	3.526	7.279	9.793	10.130
1995	0.598	0.799	1.121	1.947	2.404	3.537	9.973	10.708
1996	0.469	0.669	1.088	1.771	2.638	3.773	4.677	7.871
1997	0.450	0.621	0.959	1.950	2.806	3.877	5.756	7.213
1998	0.623	0.697	0.853	1.680	2.497	4.317	6.669	8.948
1999	0.496	0.624	0.911	1.616	2.588	4.665	5.376	8.040
2000	0.487	0.611	0.868	1.332	2.779	3.944	5.069	9.020
2001	0.466	0.646	0.901	1.585	2.597	4.693	7.117	7.691
2002	0.546	0.711	1.120	2.052	3.539	4.814	6.915	7.833
2003	0.550	0.700	1.370	2.460	3.750	5.920	7.840	10.890
2004	0.570	0.700	1.010	1.630	2.700	3.920	6.180	9.420
2005	0.428	0.854	1.623	2.343	3.584	5.442	6.439	8.307
2006	0.480	0.880	1.519	3.130	3.995	4.222	5.264	6.713
2007	0.48	0.802	1.482	2.275	3.344	3.829	1.802	7.897
2008	0.574	1.075	1.837	3.210	4.097	4.437	5.552	5.827
2009	0.717	0.976	1.493	2.651	4.069	4.693	4.870	5.792
2010	0.412	0.879	1.910	3.081	4.038	3.592	4.252	6.404
2011	0.444	0.915	1.498	2.695	3.372	4.997	4.059	7.569
2012	0.545	1.191	1.769	3.174	4.004	5.224	4.305	6.921
2013	0.488	0.888	1.702	2.545	3.726	3.310	5.100	NA
2014	0.434	1.007	1.907	2.523	3.938	5.431	NA	NA
2015	0.434	1.343	1.879	2.597	3.726	3.777	NA	NA
2016	0.434	1.267	2.472	2.534	2.793	3.665	NA	NA

Table 2.2.8 Cod in the Kattegat. Weight at age (kg) in the stock by year and age. In the assessment the plus-group is defined as 6+.

	AGE							
Year	1	2	3	4	5	6	7	8+
1971	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1972	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1973	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1974	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1975	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1976	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1977	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1978	0.059	0.355	1.006	1.69	2.86	4.12	5.18	6.9
1979	0.059	0.35	0.934	1.89	2.215	3.382	7.314	6.101
1980	0.058	0.361	0.817	1.44	2.478	3.157	3.526	6.903
1981	0.051	0.323	0.965	1.432	2.076	3.532	4.42	4.644
1982	0.05	0.317	1.06	1.391	2.078	2.911	3.698	6.48
1983	0.05	0.304	0.971	1.943	3.348	3.141	5.301	6.325
1984	0.06	0.301	0.974	1.687	2.798	3.022	5.273	7.442
1985	0.051	0.339	0.848	1.614	2.575	4.09	6.847	7.133
1986	0.056	0.285	1.077	1.955	2.956	4.038	7.1	7.29
1987	0.041	0.289	0.961	1.972	2.868	4.2	5.185	8.288
1988	0.045	0.317	0.945	1.792	2.88	4.283	5.852	7.073
1989	0.052	0.372	1.091	2.296	3.856	5.733	5.166	6.527
1990	0.052	0.393	1.362	2.323	3.288	5.383	6.412	10.337
1991	0.06	0.415	1.799	2.986	4.548	4.179	9.127	12.055
1992	0.052	0.34	1.191	2.662	4.048	5.888	7.067	7.895
1993	0.056	0.353	1.086	2.321	4.97	7.566	9.391	8.705
1994	0.035	0.269	1.225	2.652	3.526	7.279	9.793	10.13
1995	0.032	0.148	1.31	1.947	2.404	3.537	9.973	10.708
1996	0.027	0.22	0.496	1.771	2.638	3.773	4.677	7.871
1997	0.034	0.179	0.743	1.95	2.806	3.877	5.756	7.213
1998	0.049	0.213	0.442	1.68	2.497	4.317	6.669	8.948
1999	0.046	0.207	0.625	1.616	2.588	4.665	5.376	8.04
2000	0.046	0.176	0.624	1.332	2.779	3.944	5.069	9.02
2001	0.065	0.269	0.72	1.585	2.597	4.693	7.117	7.691
2002	0.045	0.29	1.334	2.052	3.539	4.814	6.915	7.833
2003	0.066	0.224	1.054	2.46	3.75	5.923	7.835	10.891
2004	0.052	0.407	1.007	1.63	2.7	3.916	6.181	9.423
2005	0.058	0.349	1.187	2.343	3.584	5.442	6.439	8.307
2006	0.064	0.280	1.083	3.130	3.995	4.222	5.264	6.713
2007	0.058	0.289	1.060	2.275	3.344	3.829	1.802	7.897
2008	0.045	0.335	1.010	3.210	4.097	4.437	5.552	5.827
2009	0.053	0.300	1.069	2.651	4.069	4.693	4.870	5.792
2010	0.052	0.285	1.171	3.081	4.038	3.592	4.252	6.404
2011	0.051	0.269	0.905	2.695	3.372	4.997	4.059	7.569
2012	0.044	0.251	0.923	3.174	4.004	5.224	4.305	6.921
2013	0.041	0.255	1.043	2.545	3.726	3.310	5.1	NA
2014	0.049	0.285	1.050	2.541	3.869	5.431	NA	NA
2015	0.055	0.311	1.036	2.023	3.385	2.873	NA	NA
2016	0.045	0.338	1.041	2.448	2.72	3.665	NA	NA

Table 2.2.9 Cod in the Kattegat. Proportion mature at age (combined sex). In the assessment the plus-group is defined as 6+

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1972	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1973	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1974	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1975	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1976	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1977	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1978	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1979	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1980	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1981	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1982	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1983	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1984	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1985	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1986	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1987	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1988	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1989	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1990	0.02	0.61	0.62	0.99	0.93	1.00	1.00	1.00
1991	0.02	0.62	0.64	0.88	1.00	1.00	1.00	1.00
1992	0.07	0.51	0.99	1.00	1.00	1.00	1.00	1.00
1993	0.03	0.49	0.73	0.95	0.87	1.00	1.00	1.00
1994	0.01	0.60	0.96	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.12	0.97	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.29	0.57	0.95	1.00	1.00	1.00	1.00
1997	0.00	0.19	0.90	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.38	0.65	1.00	1.00	1.00	1.00	1.00
1999	0.02	0.58	0.87	1.00	1.00	1.00	1.00	1.00
2000	0.02	0.42	0.92	1.00	1.00	1.00	1.00	1.00
2001	0.02	0.44	0.91	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.57	0.92	0.99	1.00	1.00	1.00	1.00
2003	0.00	0.54	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.74	0.86	1.00	1.00	1.00	1.00	1.00
2005	0.01	0.53	0.83	0.92	1.00	1.00	1.00	1.00
2006	0.00	0.59	0.81	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.60	0.89	0.93	1.00	1.00	1.00	1.00
2008	0.00	0.35	1.00	1.00	1.00	1.00	1.00	1.00
2009	0.00	0.54	0.90	0.95	1.00	1.00	1.00	1.00
2010	0.00	0.48	0.94	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.60	0.90	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.49	0.87	0.92	1.00	1.00	1.00	1.00
2013	0.00	0.37	0.46	0.91	1.00	1.00	1.00	1.00
2014	0.00	0.37	0.59	0.83	1.00	1.00	1.00	1.00
2015	0.00	0.51	0.57	0.83	1.00	1.00	1.00	1.00
2016	0.00	0.59	0.72	0.82	1.00	1.00	1.00	1.00

Table 2.2.10 Cod in the Kattegat. Tuning data (from trawl surveys) available for assessment.

```
Tuning Data; Cod in the Kattegat (part of Division IIIa)_30/03/11
  104
Havfisken_SD21_Q1
1997  2017
1   1   0   0.25
1   3
    1        104.5521      24.10579      16.37002
    1              -9            -9            -9
    1        464.8633      25.74058      8.849065
    1        97.61678      44.32915      5.524313
    1        25.78994      30.09901      11.12194
    1          98.273      16.65293      3.154041
    1        8.341221      47.24216      5.778205
    1        175.0556      11.18347      5.333215
    1        83.14981      86.67933      2.545501
    1        122.1756      39.54309      10.57858
    1        28.87485      46.52737      8.608119
    1        13.09734      6.648041      1.012895
    1        16.21239      0.908864             0
    1        38.50059      21.42233      1.388748
    1        46.24852      15.00446      14.26268
    1        86.61548       10.8254      1.844459
    1        212.3437      51.34188      10.25782
    1        98.78039      781.8792      12.40911
    1         37.3475         17.53       15.1715
    1            2.06          8.22          3.59
    1          115.11          3.41          3.63
IBTSQ1_1-6
1997  2017
1   1   0   0.25
1   6
    1          174.47        54.179       108.874         6.336         1.379         1.052
    1          199.37       470.649        47.071        24.617         2.672         1.321
    1          237.68       167.799        62.984         2.257         3.114         0.583
    1           74.85       233.688         47.39        14.025         1.313          1.16
    1           47.05        46.059        24.373         5.276         1.692         0.748
    1           93.05        20.843        15.715        14.689         3.273         1.066
    1            2.34        52.554          3.58         2.626         1.713         0.375
    1           91.02        14.122        32.847         6.007         2.051         2.649
    1           19.99        86.948         5.061        10.697           1.2         0.388
    1           67.31        21.883         27.47         2.661         2.247         0.987
    1           41.61        41.937         7.399         7.523         0.766         0.828
    1           8.392         2.409         2.224         0.858         0.583         0.417
    1          25.383         0.925         0.442         2.042             0         0.333
    1          14.636         22.46         0.242         0.333         0.529         0.542
    1          43.727        24.426        17.362           0.6         0.177         0.125
    1          46.955         9.528         2.019         4.056             0         0.083
    1          31.394         14.16          3.62          0.88          1.41          0.27
    1            3.45         30.82          9.95          3.21          0.47          0.21
    1          18.334        10.184         27.36         9.498         4.189         2.151
    1           0.522        14.551         4.311        18.679         5.759             3
    1           23.69           0.8          0.93          1.92           6.2          15.4
```

continued

Table 2.2.10 Cod in the Kattegat. Tuning data (from trawl surveys) available for assessment.

```
IBTS_Q3
1997  2016
1     1     0.75  0.83
1     4
            1      141.86      32.69      14.63       0.78
            1      141.92      38.42       1.57       0.92
            1       85.73       6.18       1.64        0.2
            1          -9         -9         -9         -9
            1        6.03       2.11       0.46       0.12
            1       46.53       1.51       0.26       0.19
            1         1.7        4.5       0.13       0.05
            1       67.12       2.28       2.43       0.08
            1       12.17      10.94       0.08       0.26
            1       25.69        4.2       2.94       0.17
            1        5.33       4.22       1.15       0.62
            1        1.94       0.47       0.07       0.15
            1       19.49       0.13          0       0.08
            1         2.5       1.28          0       0.08
            1       8.348       1.59       0.45          0
            1        8.29       1.25       0.05      0.583
            1        9.95       6.78       1.08       0.05
            1       3.646      9.836      7.433      0.812
            1        4.71       2.12      7.361      3.229
            1       0.376      0.654       1.63       2.17
CODS_Q4
         2008       2016
            1          1       0.83       0.92
            1          6
            1       52.8       17.8       11.3        7.3        4.3        2.3
            1      166.3        8.2        2.1          2        2.2          1
            1      113.2       64.3        2.4        0.4        0.5        0.1
            1       91.1         54       24.4        5.1        0.8        0.2
            1         -9         -9         -9         -9         -9         -9
            1      207.9      209.5       63.1       30.4        5.4        0.8
            1      144.5      277.3      231.7       93.6       41.3       17.7
            1       92.6      126.7      125.2      105.6       68.9       38.7
            1       57.5       37.1       48.9       48.7       42.9       43.3
```

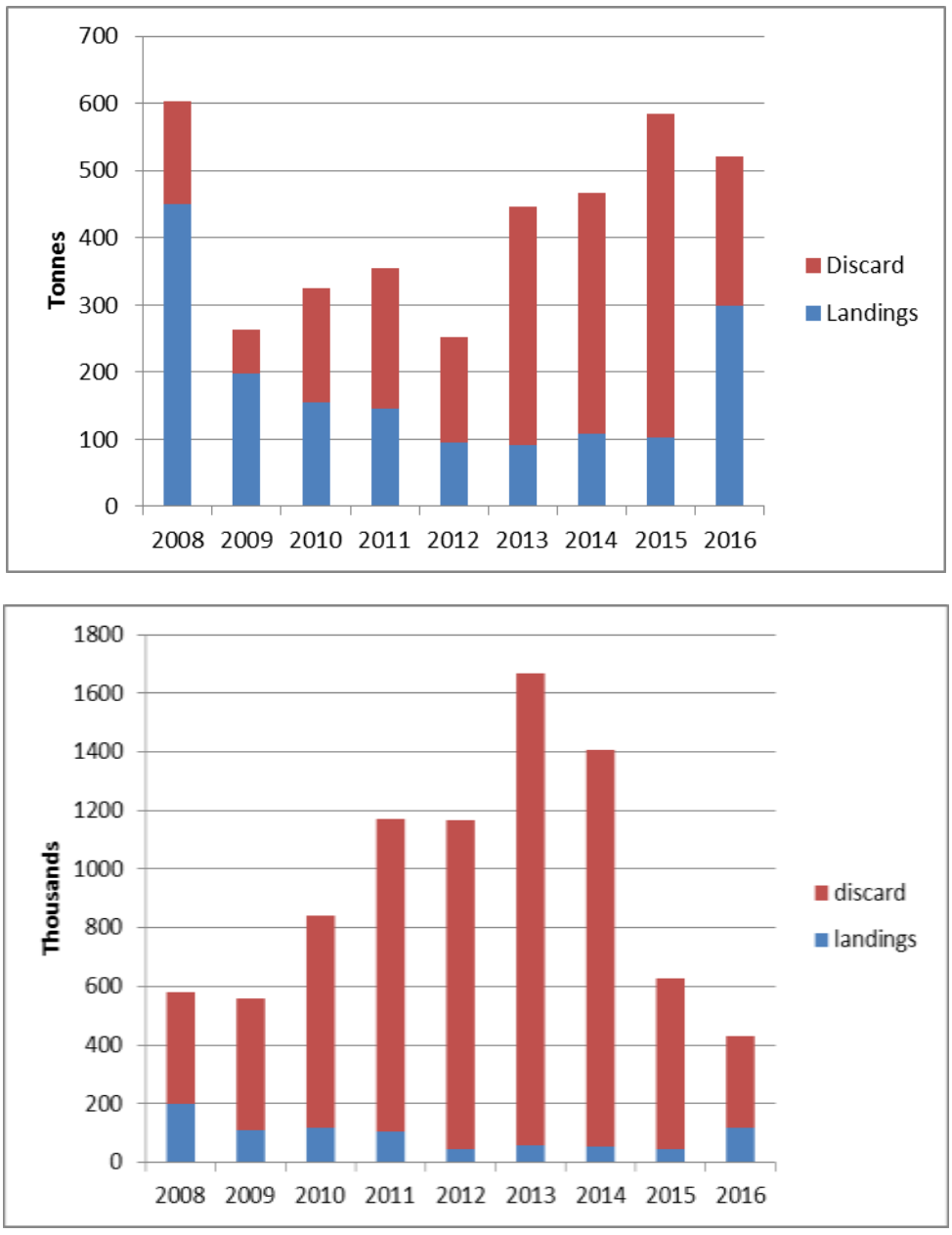


Figure. 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, both in tons (upper panel) and in numbers (lower panel).

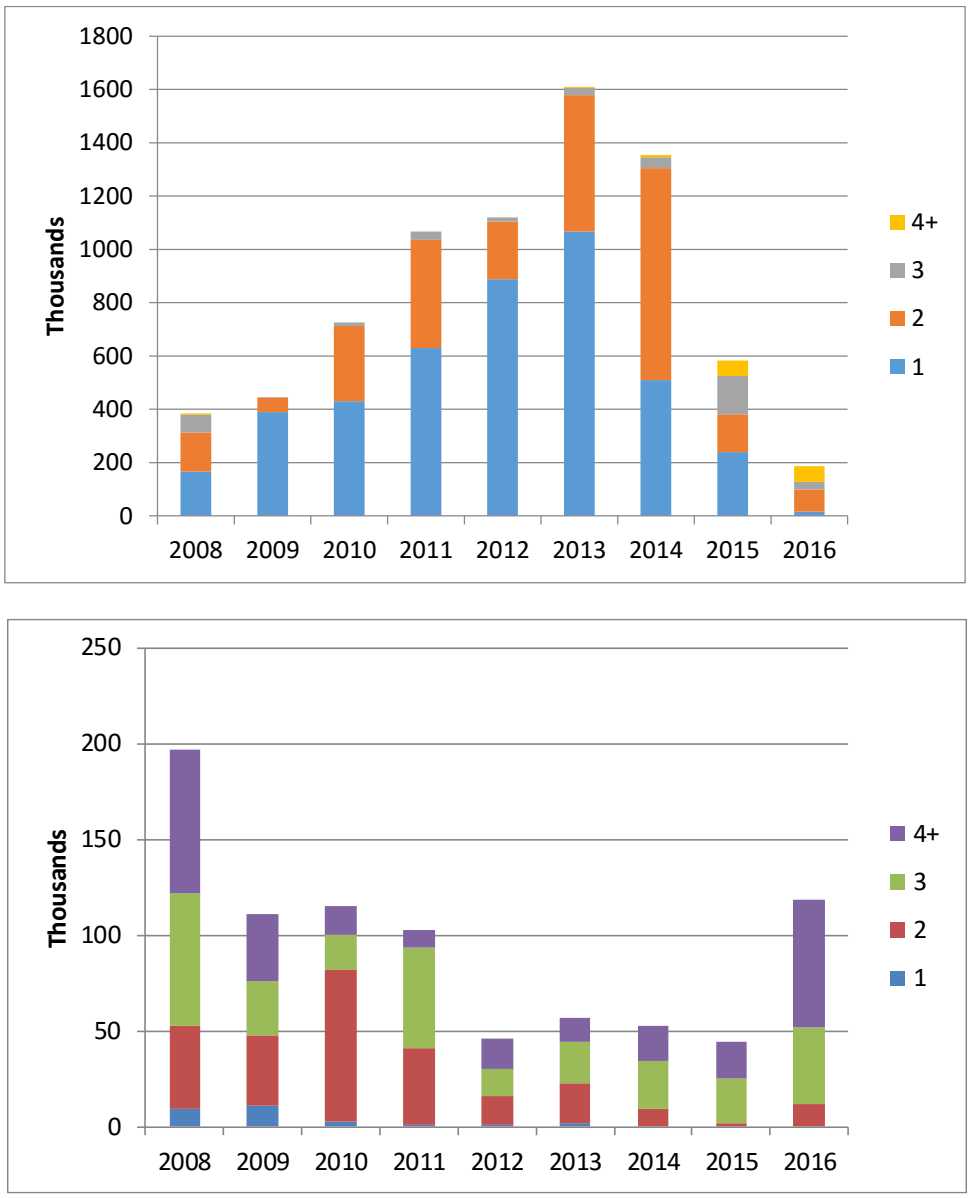
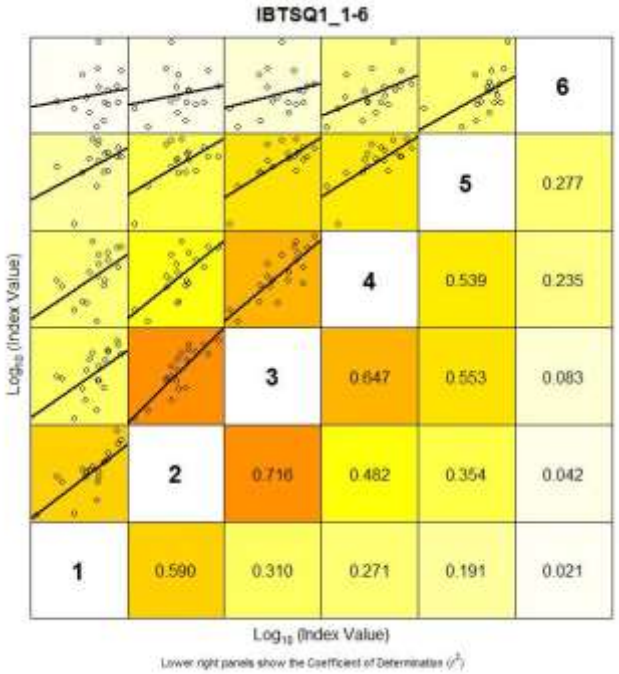
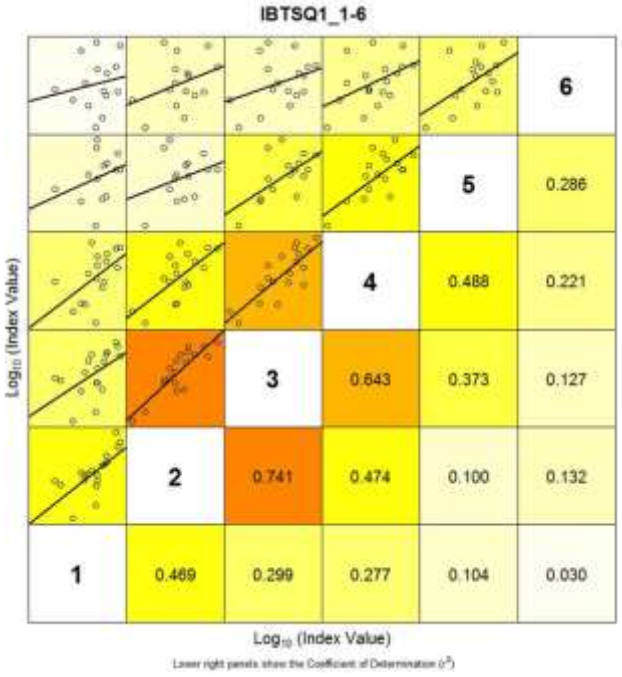


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards age in numbers by upper panel. Landings in numbers by age, lower panel (Sweden and Denmark combined).

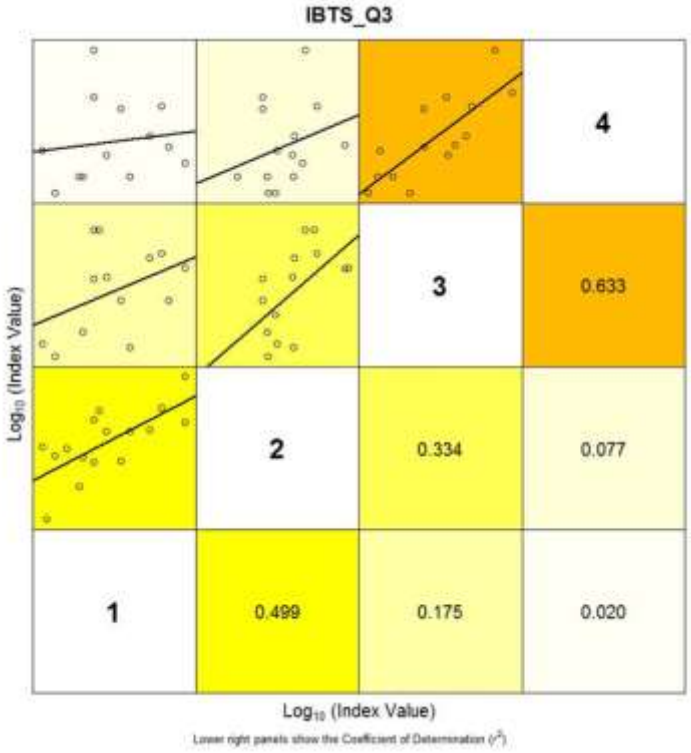


2016

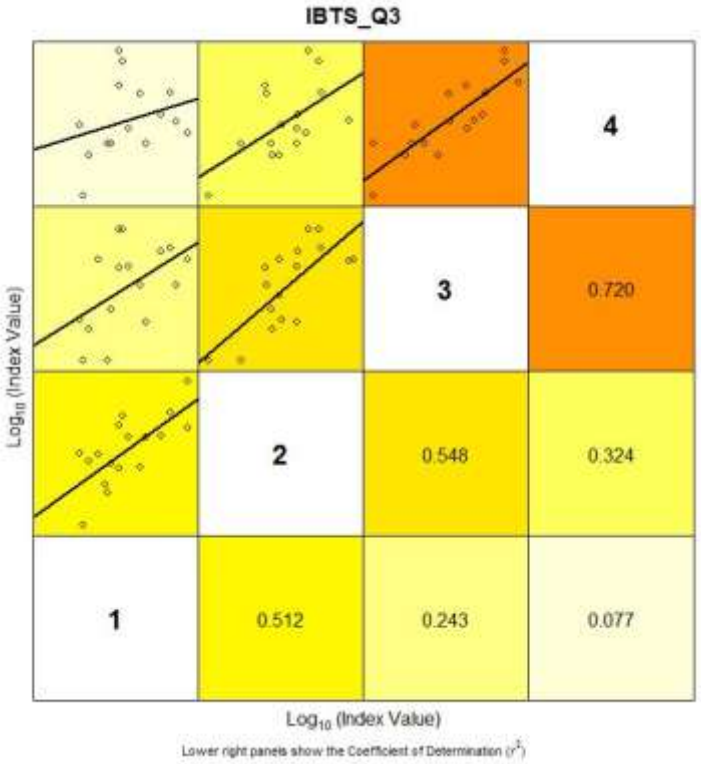


2015

Figure 2.2.3a.Cod in Kattegat. IBTS 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2016. Upper 2016 and lower 2015.

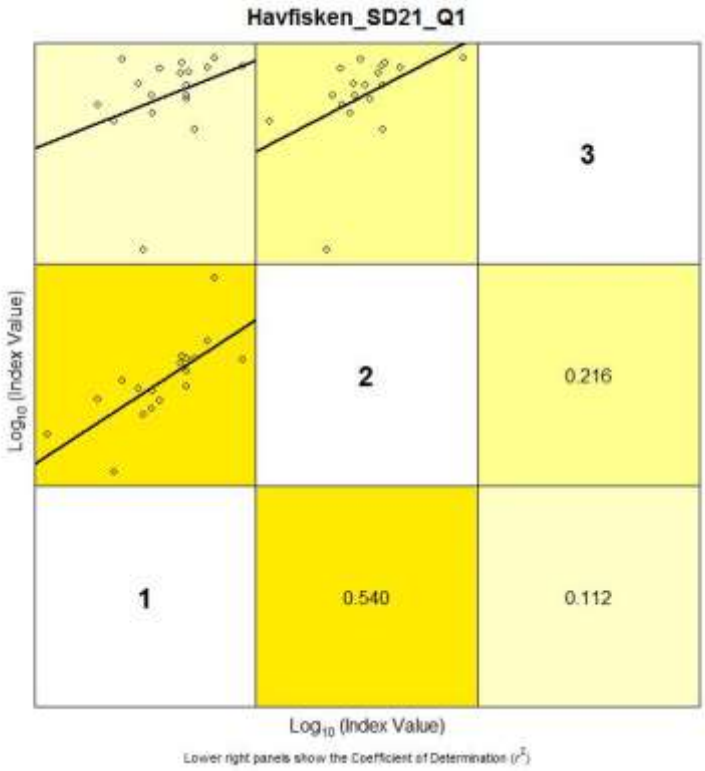


2015

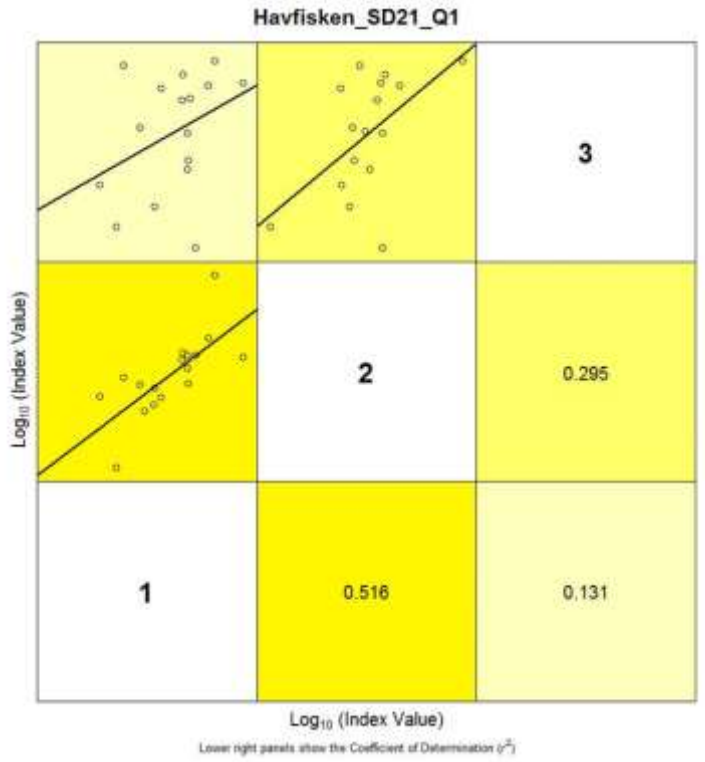


2016

Figure 2.2.3 b. Cod in Kattegat. IBTS 3rd quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2015. Individual points are given by year-class. Upper plot 2015 and lower 2016.

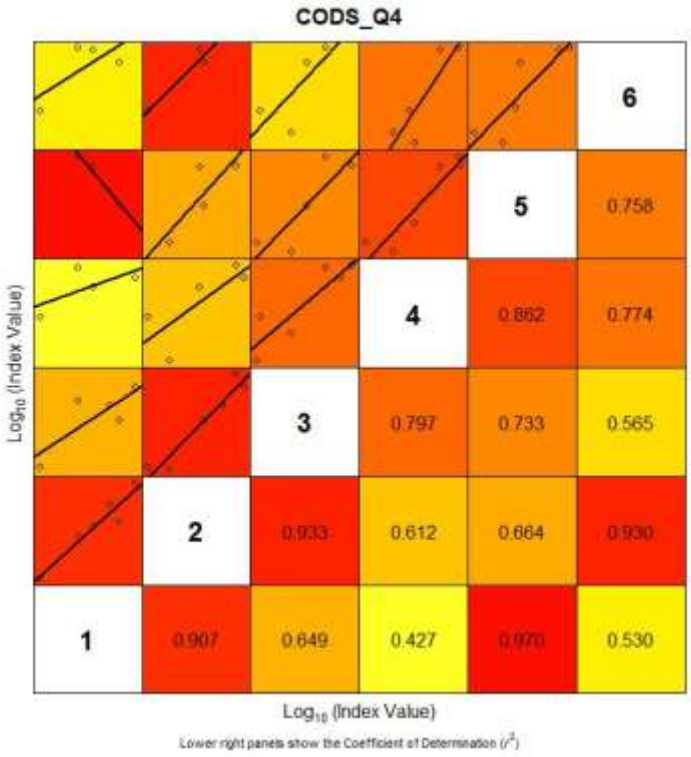


2016

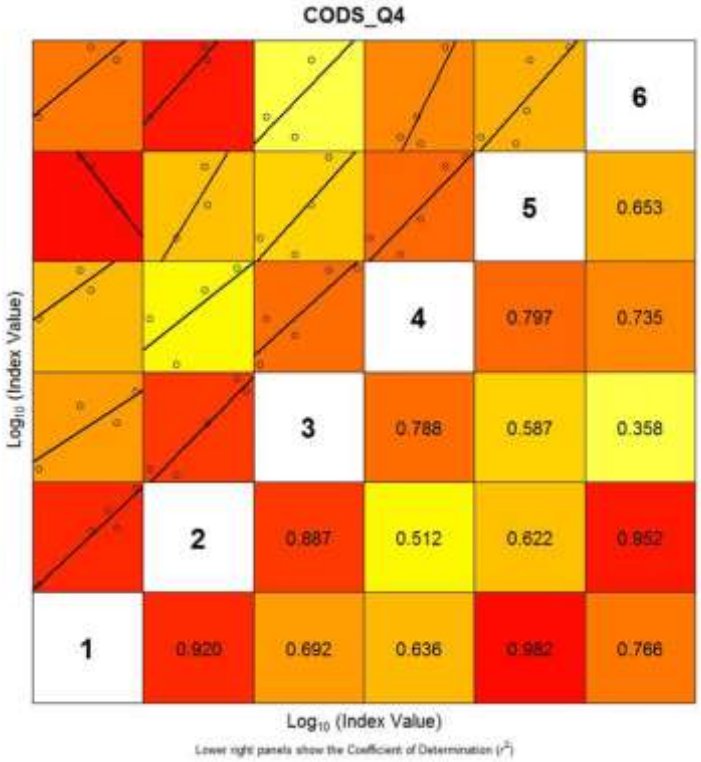


2015

Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2016.. Upper plot 2016, lower 2015.



2016



2015

Figure 2.2.3d .Cod in Kattegat. Cod survey quarter 4survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2015. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2016, lower plot 2015.

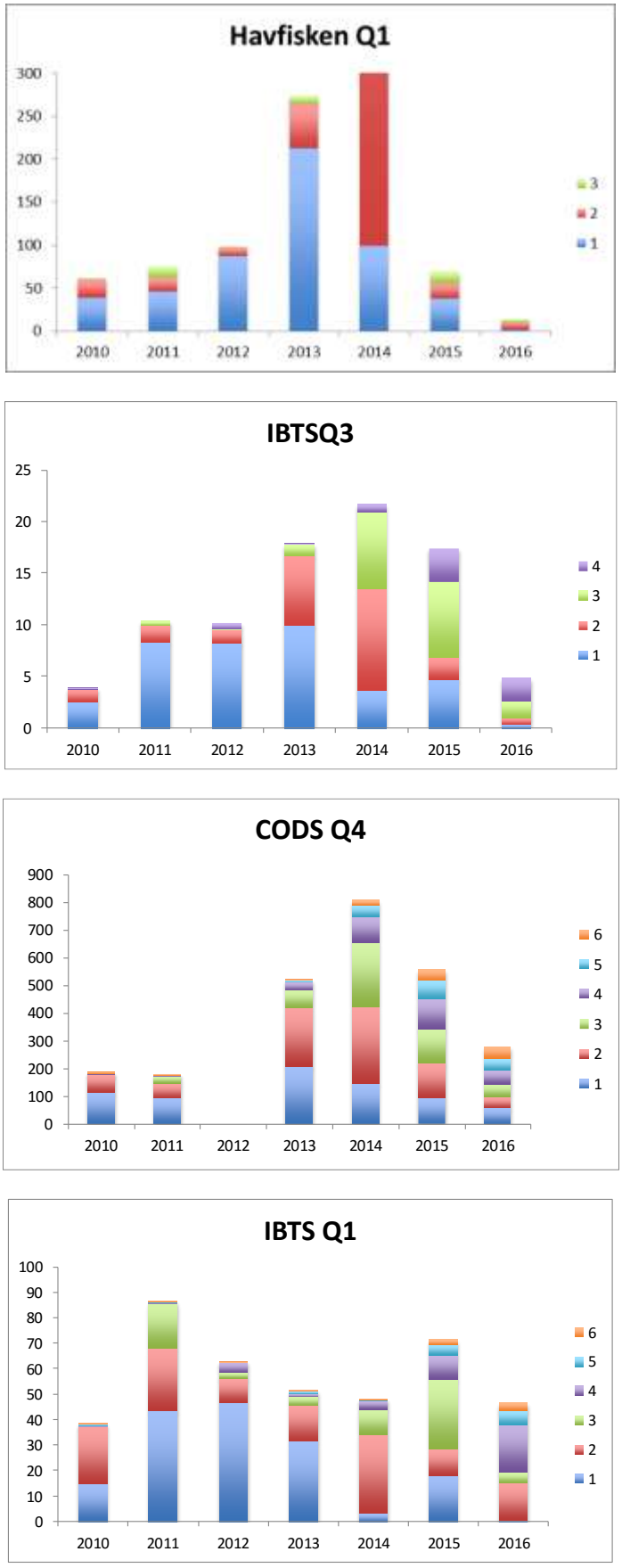


Figure.2.2.4. Cod in the Kattegat. Age structure of the four surveys used as stock indices in Kattegat 2010-2016.

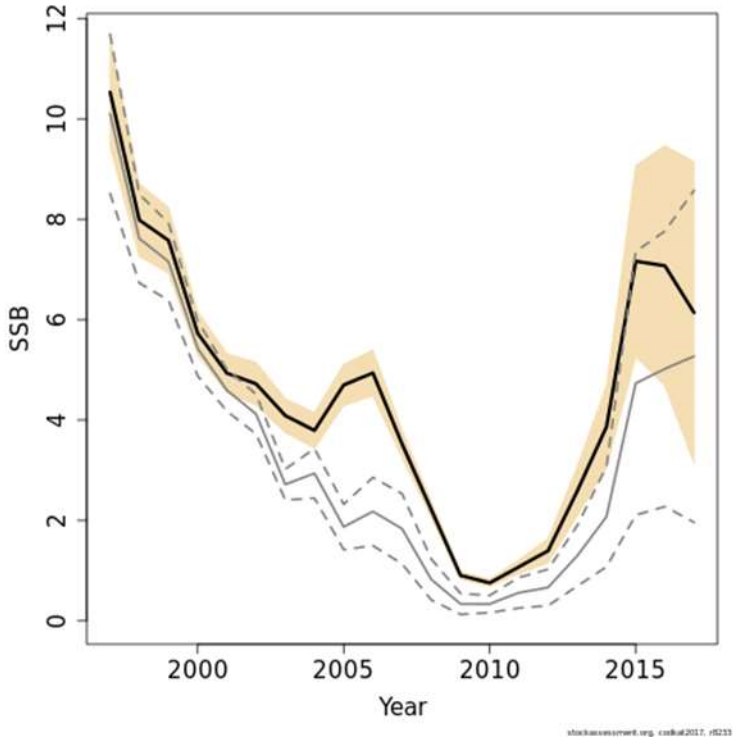


Fig 2.2.7 Cod in the Kattegat. SSB. SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95 % confidence interval).

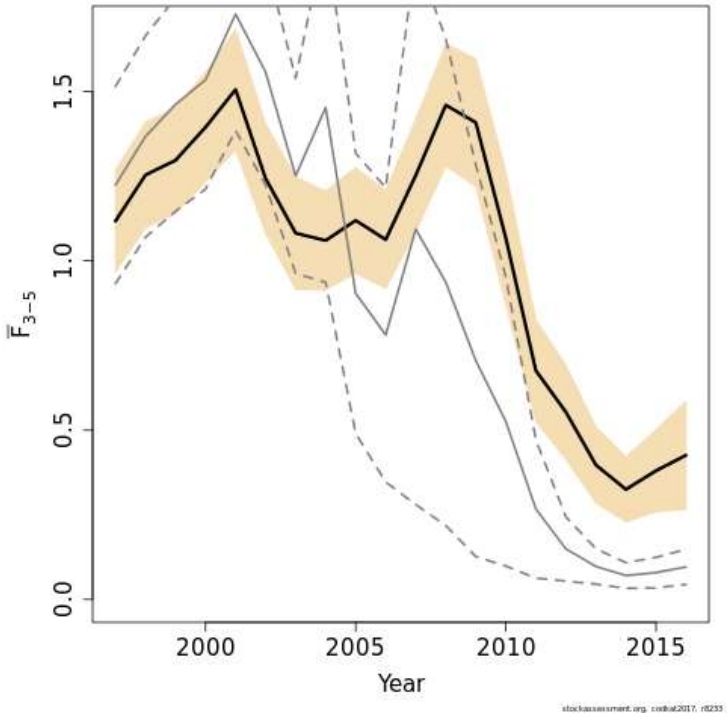


Fig 2.2.8 Cod in the Kattegat. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and Sam run with scaling (black line with brown 95 % confidence interval).

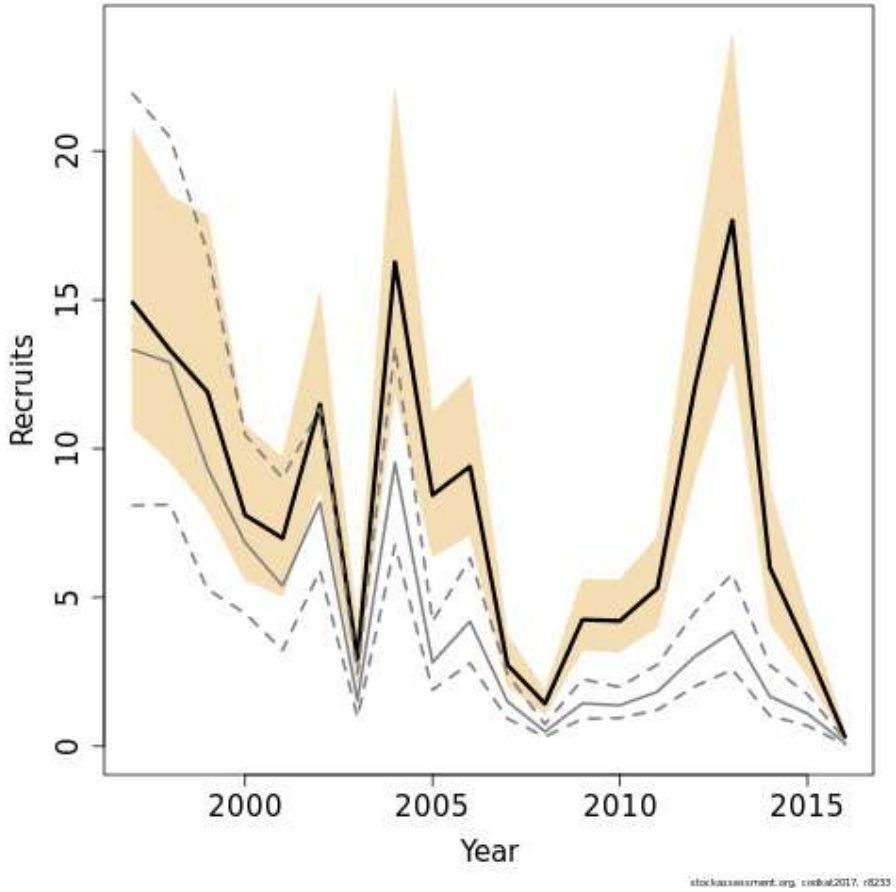


Fig 2.2.9 Cod in the Kattegat. Recruitment. SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95 % confidence interval).

Year	Catch multiplier
2003	1,4
2004	1,1
2005	2,8
2006	2,7
2007	2,0
2008	3,5
2009	4,1
2010	3,4
2011	3,5
2012	5,8
2013	6,2
2014	6,8
2015	6,4
2016	6,0

Fig 2.10 Cod in the Kattegat. Catch multiplier. The scaling factor by year from the SAM run with scaling.

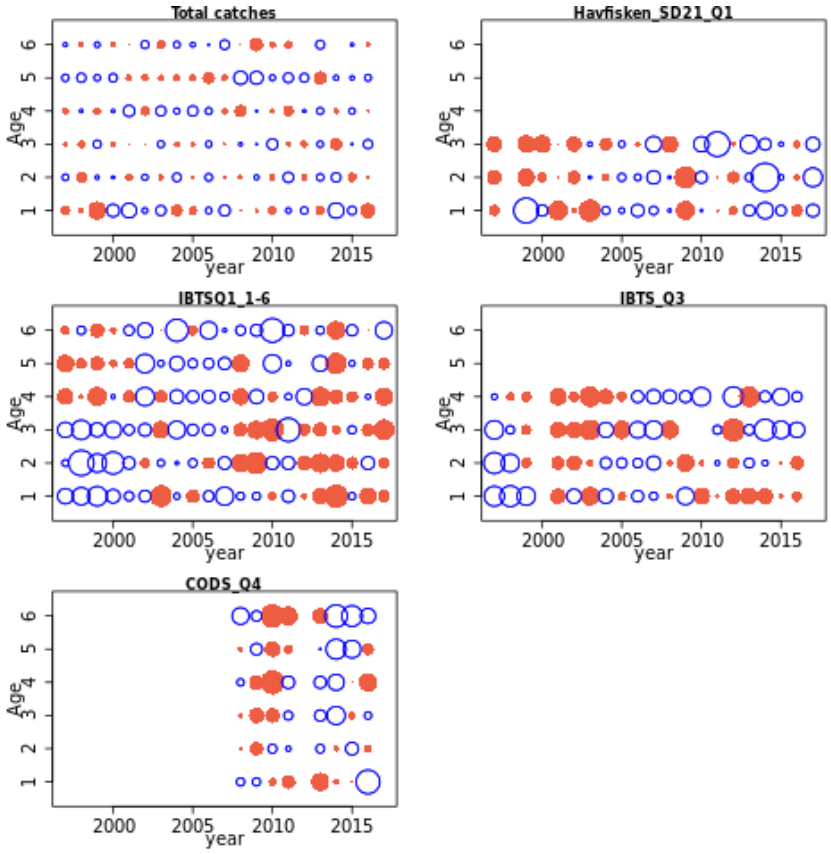
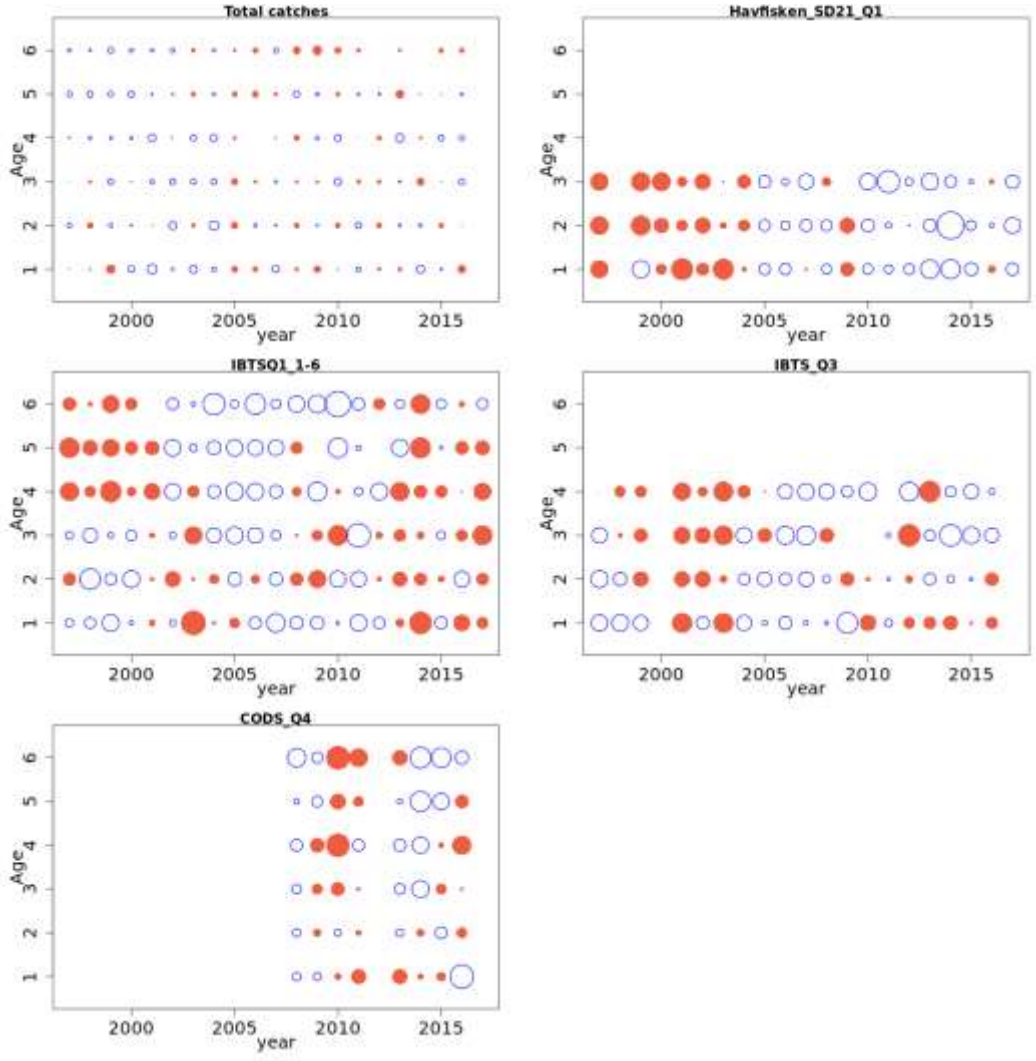


Fig 2.2.11a **Cod in the Kattegat. Residuals. SPALY with scaling. The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).**



b)

Fig 2.2.11b Cod in the Kattegat. SPALY without scaling .The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).

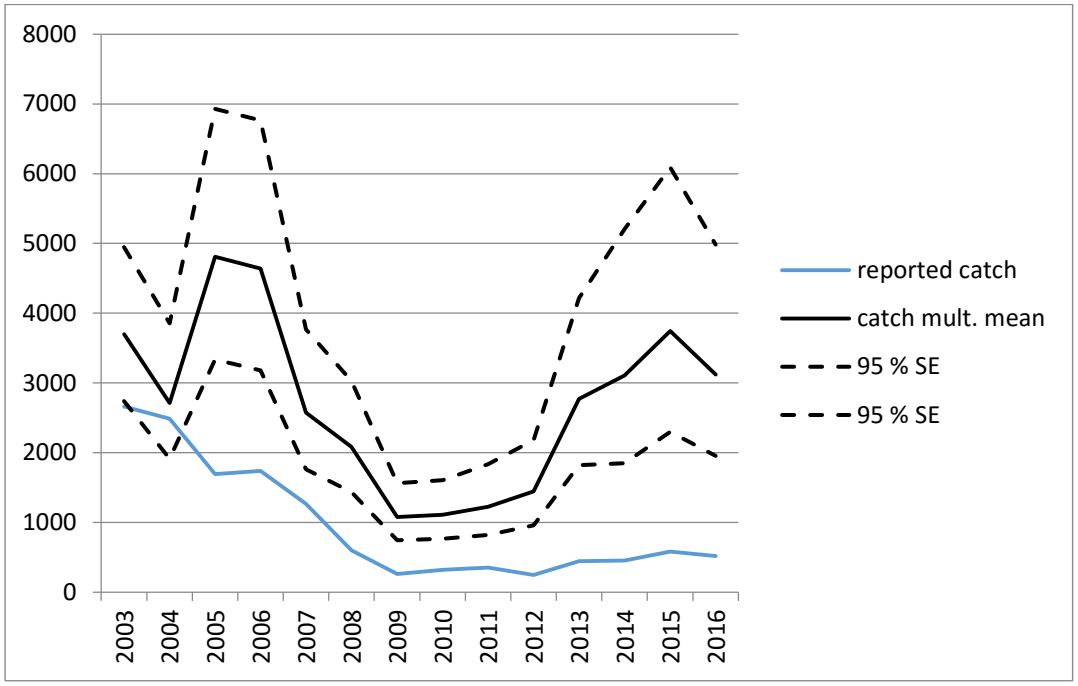
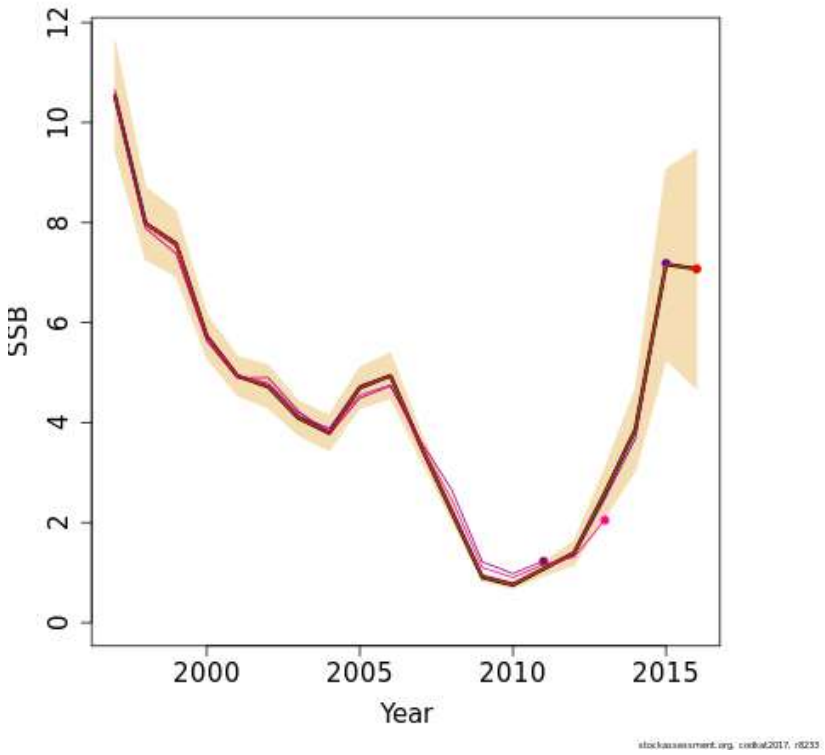
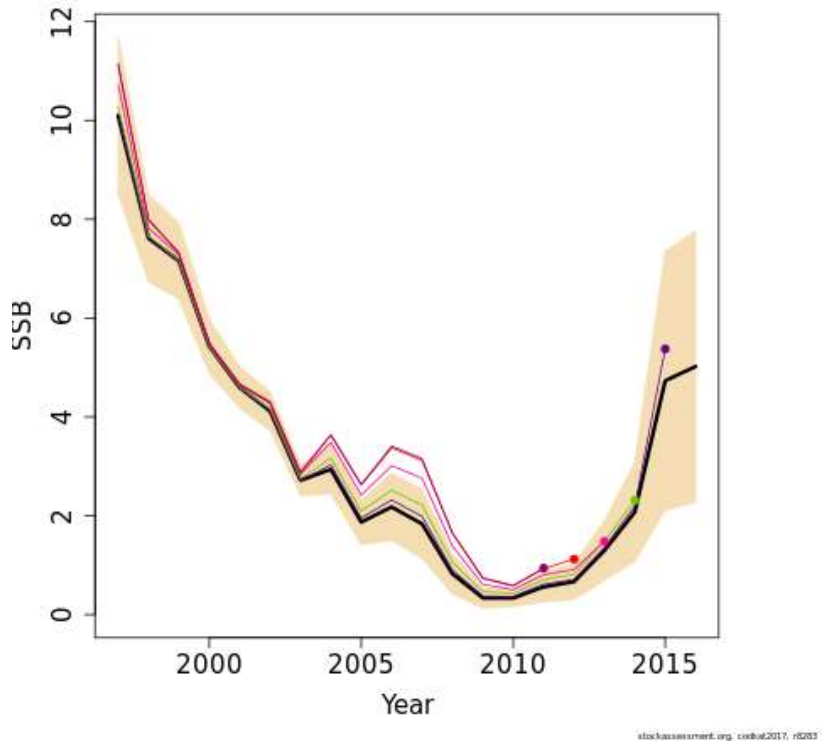


Fig 2.2.12 Cod in the Kattegat. Reported catch and the catch achieved by using the multiplier, mean and upper an lower 95 % estimates.

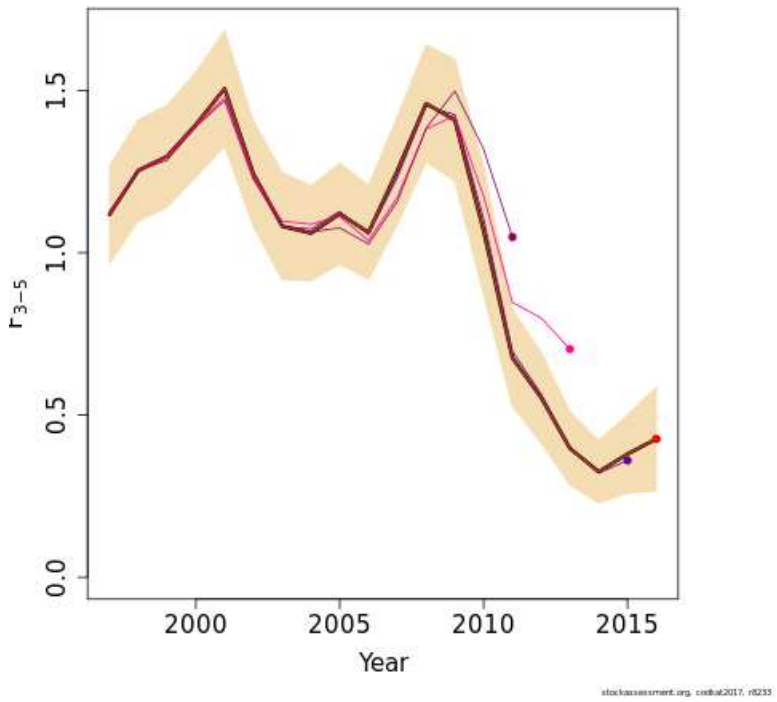


a)

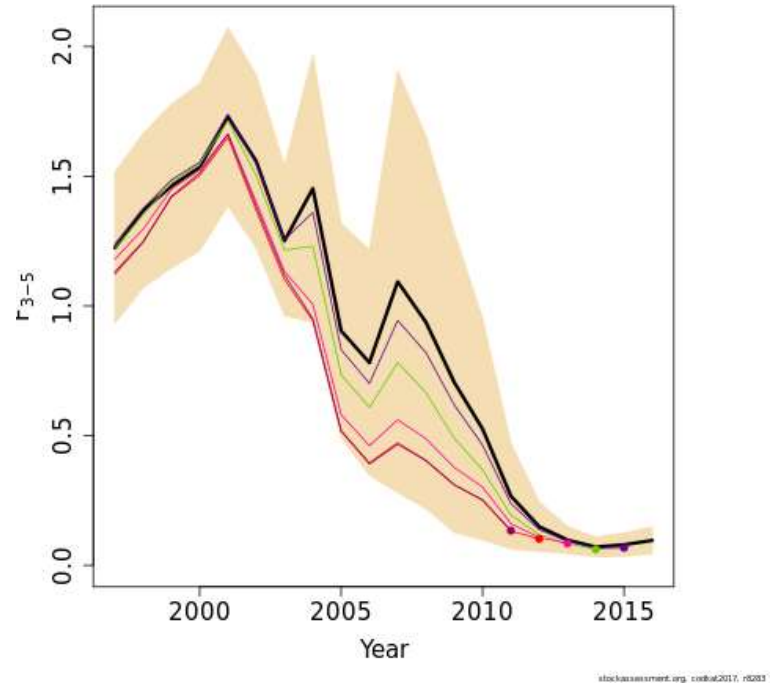


b)

Fig 2.2.13 Cod in the Kattegat. Retrospective SSB. a) SPALY with scaling b) SPALY without scaling

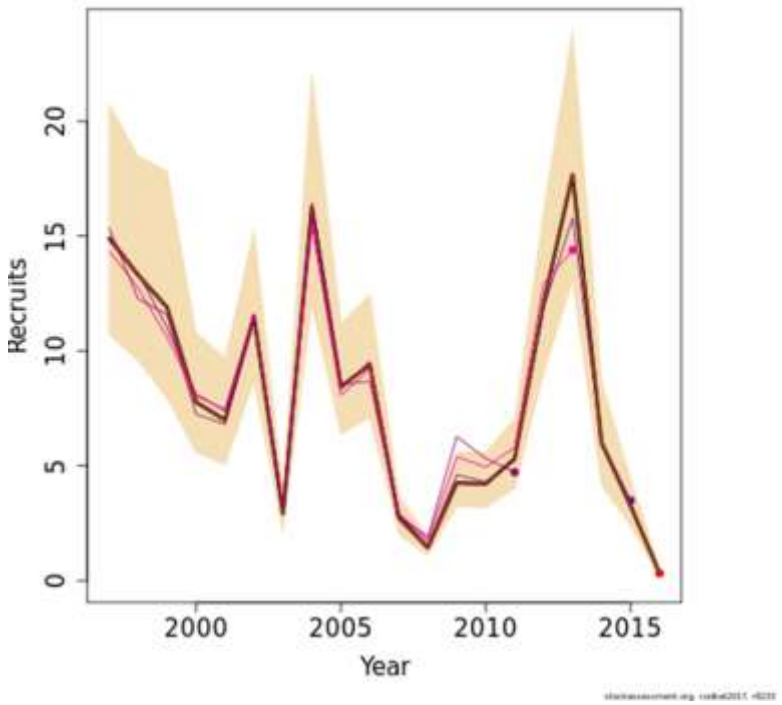


a)

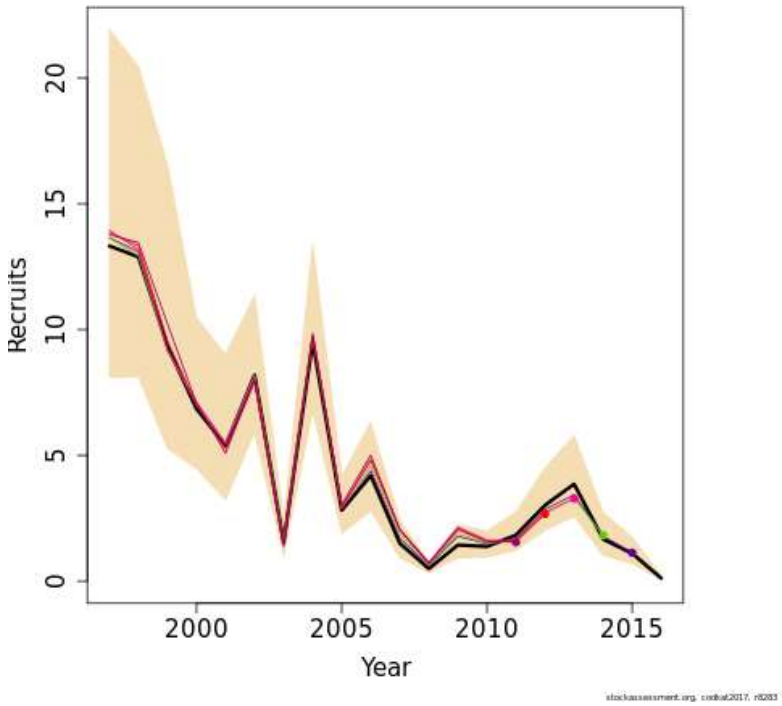


b)

Fig 2.2.14 Cod in the Kattegat. Retrospective Z. a) SPALY with scaling b) SPALY without scaling.



a)



b)

Fig 2.2.15 Cod in the Kattegat. Retrospective Recuitment. a) SPALYwith scaling b) SPALY without scaling.

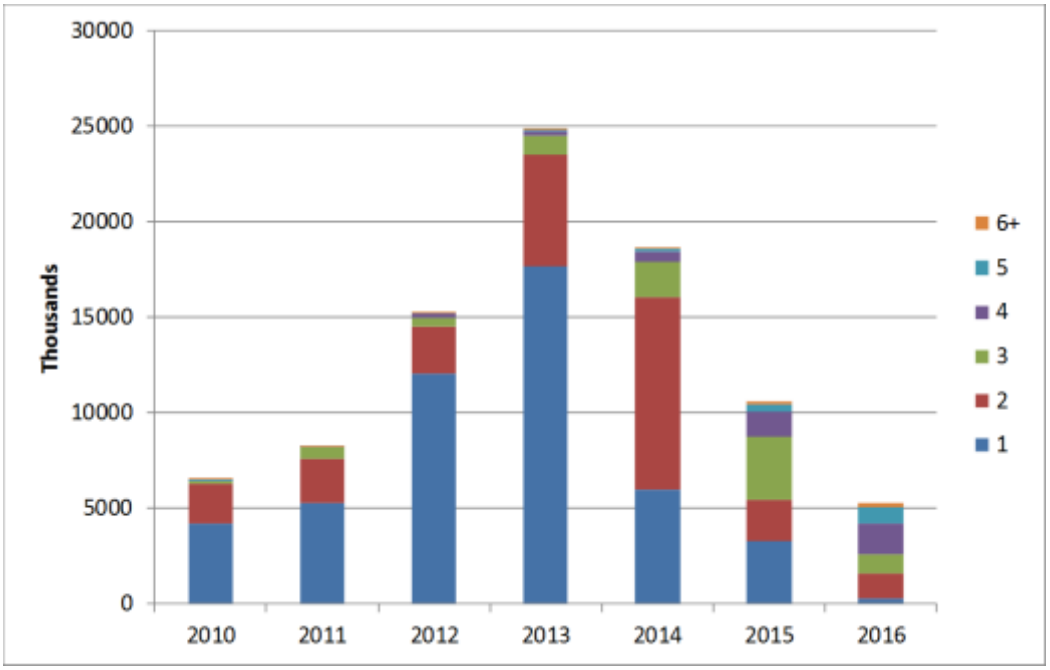


Figure. 2.2.17. Cod in the Kattegat. Estimates of stock numbers by age and year 2010-2016- Estimates from SAM output with scaling.

2.3 Western Baltic cod (update assessment)

4) Assessment type: Update assessment

5) Assessment: Analytical

6) Forecast: SAM

7) Assessment model: SAM

8) Stock status: SSB < B_{lim} in 2017. F (3–5) is in 2016 estimated to be 0.93.

9) Management plan. A new multi annual Baltic management plan has been implemented in 2016

2.3.1 The Fishery

Commercial catches are mainly taken by trawlers and gillnetters; and to a small degree by Danish Seines on the transitional area between subdivisions 22 and 24 (eastern Mecklenburg Bight/Darss sill). There is a trawling ban in place in subdivision (SD) 23 (the Sound) since 1932, but a small area in the north of SD 23 is open for trawlers in January and since 2016 the first 2 weeks of February; however, gillnetters are taking the major part of the commercial cod catches in SD 23. In SD 22 and 24 the main part of the catches are taken by trawlers. The major part of western Baltic cod stock landings is taken in SD 22 (Figure 2.3.1). Overall catches are predominantly Danish, German and Swedish, with smaller amounts from Poland and occasionally reported by other Baltic coastal states, mainly from SD 24. Time series of total cod landings by SD in the management area of SD 22–24 are given in Table 2.3.1; and landings by passive and active gear in 2016 are given in Table 2.3.2 (both include eastern Baltic cod landings in SD 24).

In 2016 decision makers decided to change the spawning closure in the western Baltic (SD22-24) from 4 weeks April in 2015 to 6 weeks covering the period from 15th of February to 31st of March which is more in correspondence with the peak spawning time. Since 01.01.2015, the EU landing obligation is in place, obliging the fisheries to land the entire catch of cod. There is a "minimum conservation reference size" of ≥ 35 cm, i.e. cod below this size cannot be sold for human consumption but has to be landed whole. This regulation replaced the minimum landing size of 38 cm valid until the end of 2014. For information on historical regulations, see Stock Annex.

2.3.1.1 Landings

In 2016, the reported commercial landings of the Western Baltic (WB) cod stock were estimated at 6.4 thousand tonnes, 68% of the commercial catches in 2016 were taken in SD 22-23 (Table 2.3.1, Table 2.3.2). The landings of cod in SD 22 and SD 23 by EU sorting categories are shown in Figure 2.3.2.

A comparison of the cod landings by EU size sorting category in SD 22 by countries showed that larger sized cod (particularly cod of the 4–7 kg segment) consistently contribute to the Danish landings while the German landings from SD 22 are mainly composed of cod < 4 kg (commercial size sorting groups 5-3). Size sorting composition of the landings in SD 23 was relatively similar between Denmark and Sweden –and similar to the landings of Germany in SD 22 (Figure 2.3.2).Hence, the remarkable proportion of large-sized cod almost exclusively comes from Danish landings in SD 22. The landings by commercial sorting, year and area can be seen in Figure 2.3.4.

As the western and eastern cod stock is mixing in SD 24, a splitting factor (based on genetics and otolith shape analysis) was applied to the commercial cod landings in SD 24 to include only those fish belonging to the WB cod stock. To do this, a weighted average of the proportions of WB cod in SD 24 in the two sub-areas (Area 1 and Area

2 in Figure 2.3.5 for separation between the stocks) was applied. The weightings for each year represented relative proportions of commercial Danish and German cod landings (main part of fisheries in SD 24) taken in Areas 1 and 2.

In 2016, 3 352 kg of BMS cod (below minimum conservation reference size) or 0.078% of the total landings in SD 22-23 were landed. In SD 24, 30 922 kg of BMS landings were reported. As the amount of cod landed below the minimum conservation reference size was much lower than the amounts registered in the at-sea observer programs, discard estimates from the at-sea observer programs and BMS landings were summed in the total discard estimates. It is legal to discard damaged cod if it is registered in the log-book, however, no logbook registered discards were reported for SD 22–24 in 2016.

2.3.1.2 Discards

All relevant countries uploaded their data to InterCatch. Discard data from at-sea observer programs for 2016 were available from Germany, Sweden, Denmark and Poland for SD 22–24. Denmark does not sample and report discards of passive gears, assuming zero discards. Discards of the passive gear of Denmark were raised using mainly discard ratios from Germany and Sweden (Table 2.3.4).

The overall discard rate in SD 22 and SD 23 was below 1%. The very low discard rates could be due to the combined effect of the reduction of the minimum landing size from 38 cm to 35 cm, very weak recruitment in 2015 and 2014 and the landing obligation.

For cod in SD 24, the discard rate was estimated to be 6.2%. This is due to the larger amount of smaller cod in the area (Figure 2.3.4 compared to Figure 2.3.2). Catches of long-liners was very low in 2016.

The discard weights at age for 2016 were included in the catch-at-age weights (see section 2.3.2.3).

2.3.1.3 Recreational catch

At the benchmark 2013 (WKBALT 2013), recreational catches were included in the assessment, which was confirmed and updated in the 2015 benchmark (WKBALTCOD 2015). Currently the recreational catch included in the assessment represents German data only, the amount varying between 1500–3200 t in the years 2005–2016. The earlier years are extrapolated based on the estimates for the recent period (WKBALT 2013). German recreational catches are mainly taken by private and charter boats and to a small degree by land-based fishing methods. The amount in 2016 is estimated to be 2316 t.

Since 2009, an investigation of the Danish recreational fishery was initiated (Sparrevohn and Storr-Paulsen 2010). Danish and Swedish recreational data are currently not included in the assessment, but efforts to incorporate these data are ongoing. A preliminary estimate from the Danish recreational fishery in 2016 is 970 t a 22% decrease compared to 2015. No recreational data was available from Sweden for 2016. The amount of German recreational catch included in the assessment compared to commercial landings and discards is shown in Figure 2.3.3 and Table 2.3.6.

All German recreational cod catch in SD 22–24 is assumed to be WB cod (WKBALTCOD, 2015).

2.3.1.4 Unallocated removals

German recreational fisheries data are included in the assessment. Danish and Swedish recreational fisheries data are not yet included but are under preparation (see above).

Another potential source of unallocated removals is the passive gear fishing fleet without the obligation to keep a daily logbook or where official sale notes are not available (e.g. vessels < 8 m and German part-time fishers). However, reliable estimates of the potentially unallocated removals are not available for this fleet segment.

In 2015, Germany included for the first time cod discard estimates from the German pelagic trawl fishery for herring in SD24 (PTB_SPF; mainly from the ICES rectangles 37G3 and 38G3, in Q1, Q2, Q4). In 2016, this estimate amounted to approximately 35 t.

2.3.1.5 Total catch

Total catches in the management area of western Baltic (SD 22–24), including commercial landings, discards and German recreational catches of western Baltic cod stock, and landings and discards of eastern Baltic cod in SD 24 are shown in Table 2.3.6.

2.3.1.6 Data quality

Denmark, Germany, Sweden, and Poland provided quarterly landings, LANUM and WELA by gear type (active, gillnets set, longline set) and Subdivision (Table 2.3.7). Finland provided landings only.

In 2015 a landing obligation was introduced in the Baltic and therefore the observer trips conducted by the national institutes have changed from observing a mandatory behaviour towards observing an illegal act. This could have an influence on the fishers´ behaviour and give more biased estimates. However, both Denmark and Germany has been able to conduct observer trips on board commercial vessels in 2016.

Denmark and Sweden sample landings via harbour-sampling and sample discard via at-sea sampling. Germany samples catches (i.e. both landings and discards) via at-sea observers and purchased samples from commercial vessels. The German catch sampling program samples length distributions of catches and uses a knife-edge approach to separate the catch into landings and discards (i.e. presently 35 cm). Poland has an at-sea observer program (where both discards and landings are sampled) and a harbour sampling for landings. Sampling levels of commercial catch in 2016 are given in Table 2.3.3.

All data were successfully uploaded to and processed in InterCatch. There was no national filling of empty strata prior to upload to InterCatch so that bias due to undocumented national extrapolations could be reduced. The list of unsampled strata and their allocated sampled strata in 2016 (i.e. the allocation overview) applied in InterCatch is given in Table 2.3.4 for landings and discards. However, the Danish port sampling scheme (where commercial size sorting categories are sampled) result in national raising of passive and active gear landings strata with the same data sets. Both Denmark and Sweden are sampling boxes as the secondary sampling unit. In Denmark this is presently done under the assumption that the age and length distribution within a box does not depend on the gear that caught the fish. Information on the number of boxes per size sorting category and strata would be very important to assess the quality of the data submitted to the assessment. However, presently size sorting category data cannot be hold within InterCatch. If these data were to be assessed in the future, the data would have to be provided outside InterCatch, e.g. in the RDB which can contain this information.

The different sampling units (number of boxes vs number of trips) render between-country comparisons difficult. However, differences in sampling intensity between countries are obvious. While Denmark has 44% of the TAC, they contributed only 8%

of the length measurements and 14% of age readings (Table 2.3.4). Possible effects of the differences between national sampling levels on data quality of the international data set have not been assessed.

The reported numbers at age in SD 22 peaked at age 3 for Germany and at age 4-5 for Denmark, which was in line with the differences in size sorting categories between countries (Figure 2.3.2).

Sampling levels in German recreational fisheries are shown in Tables 2.3.8 and 2.3.9.

2.3.2 Biological data

2.3.2.1 Proportion of WB cod in SD 22–24

Time series of estimated proportions of eastern and western Baltic cod within SD 24 are available from 1996 onwards from otolith shape analyses, using genetically validated baselines (WKBALTCOD 2015). Systematic differences in the proportion of mixing were found by sub-areas within SD 24, with a higher proportion of eastern Baltic cod closer to SD 25. Thus, the proportions of eastern and western cod in SD 24 were estimated separately for 2 sub-areas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.3.5.

In 2016, 58% of cod in SD 24 was found to be WB cod in Area 1 and 24% in Area 2 based on the otolith shape of 708 cod (Table 2.3.10). The split is conducted on the cod otoliths sampled from the Danish trawl fisheries in SD 24. Samples for otolith shape analysis were collected during all four quarters. The spilt is weighted with landings from both Germany and Denmark based on landings by ICES square in SD 24.

Germany analyzed the mixing proportions using >11 000 otoliths from the quarter 4 BITS surveys conducted annually between 1992 and 2016 in SD 24. A genetically validated baseline from 2015/16 was used to assign otoliths shapes. The mixing proportions were similar to Danish estimates from commercial trawl samples in recent years while in the early 1990s the proportion of EB cod in the German estimates was very high while it was very low in Danish estimates. The German time series is being extended backwards to the late 1970s using historical otoliths. Possibilities to merge the German and Danish data sets and the incorporation of additional otoliths from Sweden and Poland will be explored for a future benchmark.

2.3.2.2 Catch in numbers

Time series of commercial landings, discards, recreational catch and total catch at age are shown in tables 2.3.11, 2.3.12, 2.3.13 and 2.3.14, respectively. Given the aging issues with EB cod that have a major contribution in SD 24, age composition information is only used from SD 22–23 (WKBALTCOD, 2015). Commercial catch at age for the entire western cod stock (i.e. including western Baltic cod in SD 24) were obtained by upscaling the catch at age in SD 22 by the catch of WB cod taken in SD 24 compared to SD 22. Catch at age in SD 23 were subsequently added, to obtain the catch at age of WB cod stock for SD 22–24.

The major part of commercial landings in 2016 was age-group 3. However, it was not as abundant as in the last year where the relatively large 2012 year class was present as age 3. The share of age 1 cod in terms of numbers is less than 2%, due to the very low 2015 year class (Figure 2.3.6). The main part of estimated discards for the western Baltic cod stock is age-groups 1 and 2 in numbers (Figure 2.3.6 and 2.3.7).

2.3.2.3 Mean weight at age

Mean weight at age in commercial landings, discards and in total catch is shown in tables 2.3.15, 2.3.16 and 2.3.17, respectively. This is based on data from SD 22–23. The mean weight at age in total catch is estimated as a weighted average of mean weights at age in commercial landings, discards and recreational catch, weighted by the respective catch numbers.

Weight-at-age in the stock for ages 1–3 is obtained from BITS 1st quarter survey data for SD 22–23. Weights at ages 4–7 in the stock were set equal to the annual mean weights in the catch (Table 2.3.18).

2.3.2.4 Maturity ogive

The maturity ogive estimations are based on data from BITS 1st quarter surveys in SD 22–23 (Table 2.3.19) and represent spawning probability (see Stock Annex and WKBALT 2013 for details). A moving average over 3 years is applied.

Spawning stock biomass is calculated at the start of the year, i.e. the proportion of fishing and natural mortality before spawning is assumed to be zero for all years and ages.

2.3.2.5 Natural mortality

Natural mortality at age 0 was assumed to be 0.8. The natural mortality values for cod at age 1 incorporate predation mortalities derived from an earlier MSVPA key run. These predation mortalities have not been updated since 1997; and presently the value 0.242 is applied for age 1. A constant value of 0.2 is used for older ages in the entire time series (Table 2.3.20).

2.3.3 Fishery independent information

In the western Baltic area two vessels are contributing to the survey used in the assessment, the German "Solea" and the Danish "Havfisken". Both vessels are part of the international coordinated BITS (Baltic international trawl survey). In 2016 the old Danish vessel Havfisken was replaced by a new Havfisken. A calibration study was conducted in connection to the survey and a working document #9 on calibration has been provided on the subject in last years´ report.

BITS Q1 and Q4

The tuning series used in the assessment are BITS Q1 and BITS Q4 surveys. The years and age-groups included in the assessment are shown in the table below and the time series of CPUE indices in Table 2.3.21. The CPUE by age from all tuning series are shown in Figure 2.3.11. Survey indices are calculated using a model-based approach and the area included in the indices is SD 22–23 and the western part of SD 24 (longitude 12° to 13°). Presently the area covering the eastern part of the SD24 is not included in the index.

FLEET	YEAR RANGE	AGE RANGE
BITS, Q4, SD22–24W (13 degrees)	2001–2016	age 0–4
BITS, Q1, SD22–24W (13 degrees)	2001–2017	age 1–4

Internal consistency of all tuning series is presented in Figure 2.3.8 and the time series in Figure 2.3.9.

2.3.3.1 Recruitment estimates

The moderately strong 2012 year class can be followed in the survey as age 3 in 2016 and age 4 in 2016. The 2015 year class was very low and among the lowest in the time series. In contrast to 2015, a very strong year class (age 0) was detected in the Q4 BITS 2016 and in both the German and Danish pound net in SD 22. The strong 2016 year class was confirmed in Q1 BITS 2017 as age 1 cod (Figure 2.3.10, 2.3.10).

2.3.4 Assessment

A stochastic state-space model (SAM) is used for assessment of cod in the western Baltic Sea.

The configuration of the model used in the assessment is specified in the Stock Annex.

Exploratory runs leaving out one tuning series at a time were conducted (Figure 2.3.12), which indicated relatively consistent influence of both surveys on the assessment results and that BITS Q4 has the highest impact on the 2017 estimation of SSB and F.

Several exploratory runs were conducted as the assessment showed a large downscaling of SSB in 2016. One exploratory run was conducted with a fixed stock weight to test the effect of an annual updated stock weight; however; this had a relatively small effect on SSB the final year. Further, different retrospective options were conducted where only one time series at a time was used for the retrospective going 2 years back (BITS Q1, BITS Q4 or CANUM). This exercise indicated that it was the new updated data from 2016 that downscaled the SSB. The reason for this could be due to an inconsistency between survey data and commercial catch data. A relatively large part (1/3) of the total catch is from SD 24 where only a limited area is used from the survey index. However, from the survey plots (Figure 2.3.11) it can be seen that a large part of the medium-sized cod (between 25 and 45 cm) are caught in the area that is presently not included in the survey. The reason for excluding this part of the survey at the benchmark was due to lack of a split in the survey data. An exploratory run was conducted during this meeting including the whole survey area from SD 24 and with some assumptions on the split of data based on German otolith shape analyses (see section 2.2.2.1). The retrospective pattern on SSB improved, suggesting that a more thorough analysis on how to include the whole survey area would be beneficial.

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.14 and Table 2.3.22. Stock number and fishing mortalities are presented in tables 2.3.23 and 2.3.24, respectively. The residuals of the final run are presented in Figure 2.3.15. The standard deviation of the different estimates used in the model is shown in Figure 2.3.16.

The retrospective analysis (Figure 2.3.17) indicates systematic overestimation of SSB, especially in the last year. For F, the retrospective pattern is also large but does not seem to be biased. The reason for the bias is elaborated on earlier in this section.

The input data and settings are visible in www.stockassessment.org, the stock is "WBcod_2017".

2.3.5 Short-term forecast and management options

The short term forecast is based on the SAM short term forecast module.

From the assessment model the final estimates with a full dataset of fishing mortality and stock numbers is used, and their estimation variances and co-variances. These

quantities are then simulated forward in time for a number of specified scenarios. The uncertainties are propagated forward in time, and the process variation (as estimated from the historic period) is added. These uncertainties are propagated all the way through the calculations.

The simulation is carried out at logarithmic scale, and medians are used as main summary statistic on the untransformed scale.

The input data for short-term forecast are shown in Table 2.3.26. Last year a TAC (catch) constraint was used in the intermediate year. This was derived from the splitting factor (0.58) applied to the TAC (5597 t) and recreational catches added (1754 t). This gives a total catch of 5090 t in 2017 and an F at 0.37.

The recreational catch in the intermediate year was derived by using a 3 year mean in catch 2014-2016 (2654 t) where the assumed reduction in catch due to the introduced bag limitation of a maximum of 5 cod per angler per day has been introduced in 2017. The bag limitation of 5 cod per angler per day has been estimated to reduce the catch by approximately 900 t (Strehlow 2016, unpublished data).

As in last years´ advice calculations have been conducted on how the stock advice can be transformed into an area management advice. The assumption for this calculation is that the relative catch distribution between subdivisions is stable. The total commercial catch of WB cod stock commercial catch have on average in the most recent three years been quite stable between subdivisions 22–23 and Subdivision 24, amounting to 69% and 31%, respectively,. Further, in the most recent three years, the overall ratio EB cod / WB cod in the commercial catch in Subdivision 24 has been 2.30. This means that every time 1 WB cod is caught in SD 24, 2.30 eastern Baltic cod is caught at the same time. The advice based on the management plan indicates that the total catch (excluding the recreational fishery at 1754 t) can be 3541 t for the western Baltic cod stock in 2018. From these 31% will be caught in SD 24 (if the distribution is similar as in the former year), making a catch of west Baltic cod at 1098 t. To this value the eastern Baltic cod fraction can be applied (2.30) giving a catch of eastern Baltic cod of 2525 t. This would altogether give a total catch in the western Baltic management area of 6066 t in 2108.

2.3.6 Reference points

In 2016 a Baltic multiannual management plan has been introduced with F ranges (0.15-0.26 and 0.26-0.45) depending on the SSB in the intermediate year compared to the MSY B-trigger level.

Biomass reference points B_{lim}= 27.4kt and B_{pa} at 38.4kt (WKBALT COD 2015). B_{pa} is considered to correspond to B_{MSY} trigger.

F_{lim} and F_{pa} were estimated using EqSim with the same settings and dataset as used for the F_{MSY} calculation, however, calculated without trigger and F_{cv}=0, F_{phi}=0. This estimation gave a F_{lim} at 1.01 and an F_{pa} at 0.74.

2.3.7 Quality of assessment

The uncertainty on the catch matrix is relativity high in this assessment. Normally the catches from age 2–7 are close to 0.2; however, in this assessment the standard deviation from the catches age 2–7 is 0.4 indicting a relatively high uncertainty on catches. The reason for the high uncertainty could be the splitting factor applied in SD 24, recreational catches.

Mixing of the eastern and western Baltic cod stocks is a major issue in SD 24. The stock mixing within SD 24 is variable spatially and possibly between seasons and age-groups of cod. This introduces uncertainty to the stock separation keys presently applied in the assessment. Also, for some years in the time series the stock separation keys are based on extrapolations from other years. Further, the preparation of assessment input data to separate between western and eastern Baltic stock involves a number of additional assumptions which introduces uncertainty to the assessment. However, separating the western Baltic cod (SD 2223 + the component of western Baltic cod in SD 24) within the management area SD 22–24 after WKBALTCOD (2015) removed several sources of uncertainty characterizing the previous years´ assessments (e.g. age reading issues, higher discards in SD 24). Therefore, despite the uncertainties mentioned above, this years´ assessment is considered to provide a relatively reliable perspective of the stock status of the western Baltic cod stock. Furthermore, an age reading calibration has been conducted between Denmark and Germany in 2015 and the agreement is now 94%, which is considered very well.

Recreational fishery catches have been included from Germany and used in the assessment not only as topping up the catches but as an age-based input in the catch and weight matrix. In 2016 German recreational catches for this stock were close to 27% of the total catch and can therefore not be ignored in the assessment. The present lack of the Danish and Swedish recreational fishery adds to uncertainty in the assessment; however, it is the plan to include the Danish and Swedish recreational data at the next benchmark when the data have been verified by on-site studies and include biological data such as length and weight.

Issue list:

The stock has been suggested as a candidate for a next benchmark and a relatively long issue list was compiled and is present at the SharePoint. Among the most important things to look at are:

- Apply the stock split on the survey using German otolith shape data from 1992 to present, and then test if it is possible to include a larger part of the survey area in SD 24.
- Extend and complete the otolith shape analyses of the German surveys in SD24 back to the late 1970s to cover the peak period of Baltic cod (relevant for reference points); and provide more years with genetic validation
- Include Danish and German and preferably Swedish and Polish data on otolith shape to conduct the split on commercial data.
- Include Danish and Swedish recreational data, including biological data
- Reconsider the reference point, especially the breaking point
- Assess the number of boxes per size sorting category and strata from the port samples and compare in detail the age, weight and length distributions with German sampling data.
- Include Swedish data from survey in SD 23 (IBTS).
- Consider German pound net data for an additional cod recruitment index from the commercial fisheries (since 2011)

2.3.8 Comparison with previous assessment

In previous years the assessment was conducted for the area of SD 22–24 that includes a significant fraction of the eastern Baltic cod stock. The last two years, the assessment has been conducted for the western Baltic cod stock only. The assessment this year has

downscaled the 2016 SSB by 29% compared to last year. The 2016 recruitment was upscaled slightly, however, still at a historic low level. In last year's assessment for 2017 and 2018 a 10 year resampling from recruits were used as standard in the forecast but in 2017 the recruitment (age 1) has been record high (65578 millions or an increase by 85% of the level used in the forecast).

2.3.9 Management considerations

The management area of SD 22–24 contains a mixture of eastern and western Baltic cod populations, particularly in SD 24. This has been shown by genetic analyses. Thus, part of the catches taken in the management area of SD 22–24 is cod that genetically is eastern Baltic cod but lives in SD 24. Management should consider how to protect the western Baltic cod stock when the two stocks are fished within the same area. This could be done by implementing a sub-TAC.

Table 2.3.1. Cod in management area of SD 22–24. Total landings (tons) of cod in the ICES Sub-divisions 22, 23, 24 (includes eastern Baltic cod landings in SD 24).

Table 2.3.1 Cod in SD 22-24. Total landings (tons) of COD in the ICES Sub-divisions 22, 23, 24.

	Denmark			Finland	German Dem.Rep.[1]	Germany, FRG		Estonia		Lithuania	Latvia	Poland	Sweden			Total				
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	Unalloc.	Grand total
1965			19457		9705		13350								2182	27867		17007		44874
1966			20500		8393		11448								2110	27864		14587		42451
1967			19181		10007		12884								1996	28875		15193		44068
1968			22593		12360		14815								2113	32911		18970		51881
1969			20602		7519		12717								1413	29082		13169		42251
1970			20085		7996		14589								1289	31363		12596		43959
1971			23715		8007		13482								1419	32119		14504		46623
1972			25645		9665		12313								1277	32808		16092		48900
1973			30595		8374		13733								1655	38237		16120		54357
1974			25782		8459		10393								1937	31326		15245		46571
1975			23481		6042		12912								1932	31867		12500		44367
1976		712	29446		4582		12893								1800	33368	712	15353		49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079		46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603		40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290		45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366		41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933		53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775		47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750		48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506		49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757		40159
1986		748	16195		2998		2902							227	3622	11975	975	13742		26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821		28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203		29159
1989		636	8059		2144		2498							192	4987	5738	828	11950		18516
1990		722	8584		1629		3054							120	3671	5361	842	11577		17780
1991		1431	9383				2879							232	2768	7184	1663	7846		16693
1992		2449	9946				3656							290	1655	9887	2739	5370		17996
1993		1001	8666				4084							274	1675	7296	1275	7129	5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	7502	30695
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801		33895
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	2300	50845
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995		43624
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049		34216
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225		42155
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264		38347
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451		34244
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781		24158
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127		24624
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	13	20854
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	9	22045
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858		22751
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183		23736
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256		20082
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259		15549
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016		14120
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641		16332
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053		17072
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333		12968
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862		13538
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193		13418
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313		10629

[1] Includes landings from Oct.-Dec. 1990 of Fed.Rep.Germany.

Table 2.3.2. Cod in management area of SD 22–24. Total landings (t) by Sub-division (includes Eastern Baltic cod in SD 24) sorted by column "22–24".

Year:	2016		Gear:	**Active and passive gea**
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	1576	675	3305	5555
Germany	1617		773	2390
Sweden	0	448	1550	1998
Poland	0	0	657	657
Finland		0	29	29
Latvia	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	3193	1123	6313	10629

Year:	2016			Gear: **Active gear**
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	657	104	2869	3630
Germany	1014	0	395	1408
Sweden	0	6	980	986
Poland	0	0	430	430
Finland	0	0	29	29
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Latvia	0	0	0	0
Total	1671	110	4702	6484

Year:	2016		Gear:	**Passive gea**
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	919	571	436	1925
Germany	603		378	981
Sweden	0	442	570	1012
Poland	0	0	227	227
Latvia	0	0	0	0
Estonia	0	0	0	0
Finland	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	1522	1013	1611	4146

Table 2.3.3. Cod in Sub-divisions 22–23. Overview of the number of samples (number of trips or number of boxes), number of length measurements and number of otoliths available per stratum in 2016 (upper, middle and lower table, respectively). Color codes indicate sampling coverage (see legend below).

			Area	Season									
Number of samples			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	15			7					22		
TAC 44%		Gillnets set										45	**237%**
		Longline set											
	Landings *2	Active	8	8	2	2			2	1	23		
		Gillnets set	8	8	2	2			2	1	--		
		Longline set							2		--		
Germany	Discards *1	Active	4	3							7		
TAC 21%		Gillnets set	4								4	70	**368%**
		Longline set											
	Landings *1	Active	7	4	3	3					17		
		Gillnets set	7	28		7					42		
		Longline set											
Sweden	Discards *1	Active											
TAC 16%		Passive					5	6	2	6	19		
	Landings *2	Active										36	**189%**
		Passive					4	5	2	6	17		
Total			45	43	5	19	9	11	8	13	151		

*1: number of trips; *2: number of boxes

			Area	Season									
Number of length measurements			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	88			26					114		
TAC 44%		Gillnets set										525	**603%**
		Longline set											
	Landings	Active	120	90	43	57			57	44	411		
		Gillnets set	120	90	43	57			57	44	--		
		Longline set							57		--		
Germany	Discards	Active	42	27							69		
TAC 21%		Gillnets set	39								39	4954	**5694%**
		Longline set											
	Landings	Active	1222	732	347	24					2325		
		Gillnets set	1193	764		564					2521		
		Longline set											
Sweden	Discards	Active										872	**1002%**
TAC 16%		Passive					10	23	16	38	87		
	Landings	Active											
		Passive					176	263	82	264	785		
Total			2704	1613	390	671	186	286	212	346	6351		

Number of otoliths age-read											Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	25			26					51		
TAC 44%		Gillnets set										462	**531%**
		Longline set											
	Landings	Active	120	90	43	57			57	44	411		
		Gillnets set	120	90	43	57			57	44	--		
		Longline set							57		--		
Germany	Discards	Active	10	26							36		
TAC 21%		Gillnets set	25								25	2031	**2334%**
		Longline set											
	Landings	Active	563	476	347	5					1391		
		Gillnets set	347	127		105					579		
		Longline set											
Sweden	Discards	Active											
TAC 16%		Passive					10	23	16	38	87	717	**824%**
	Landings	Active											
		Passive					176	188	82	184	630		
Total			1090	719	390	193	186	211	212	266	3210		

	sampled stratum
	extrapolation of landed size sorting samples
	not sampled but L or D

Table 2.3.4. Cod 22–23. Unsampled landing and discard strata and allocated sampled strata in 2016.

Unsampled landings strata and allocated sampled strata in 2016.

DE_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Longline set_3_L,X
DK_27.3.b.23_Active_1_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Gillnets set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_2_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_2_L,DE_27.3.d.24_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.b.23_Longline set_3_L,X
SE_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X
SE_27.3.b.23_Active_2_L,DE_27.3.d.24_Active_2_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_1_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_2_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_3_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_4_L,X
SE_27.3.c.22_Passive_2_L,DE_27.3.c.22_Gillnets set_2_L,X
SE_27.3.c.22_Passive_2_L,DE_27.3.d.24_Gillnets set_2_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_1_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_2_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_3_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_4_L,X

Unsampled discard strata and allocated sampled strata for Western Baltic cod in 2016 (SD22-23).

DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DE_27.3.c.22_3_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DE_27.3.c.22_4_Active_D,DE_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Active_D,DE_27.3.c.22_2_Active_D,X
DE_27.3.c.22_4_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.c.22_2_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.c.22_2_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_3_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_3_Active_D,DK_27.3.c.22_4_Active_D,X

Table 2.3.5. Cod 22–23. 2016. Discard (Number * 1000) by quarter and gear type.

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	8	5	14	3	30
Active gears	22	17	0*	10	49
Grand Total	30	22	14	13	79

*, stratum active-quarter3: few samples without discards (trawling with rock-hopper gear)

Table 2.3.6. Western Baltic cod. Catches in the WB management area (SD 22–24) for WB and EB stocks (in tonnes). Recreational catch: German data only.

Year	WB cod stock					EB cod stock					EB+WB cod stock
	Landings	Discards	Recreational catch	% of comm. catch in SD 22-23	% of comm. catch in SD 24	Landings in SD 24	Discards in SD24	Landings in SD 25-32	Discards in SD 25-32	% of catch in SD 24	Catch in SD 22-24
1994	21409	2069	1828	0.46	0.54	1784	166	100856	1956	2	27256
1995	29854	3143	2133	0.66	0.34	4041	541	107718	1872	4	39712
1996	38335	6897	2190	0.68	0.32	10210	1087	124189	1443	8	58719
1997	37009	3994	2280	0.67	0.33	6615	629	88600	3462	7	50526
1998	29628	5577	2372	0.63	0.37	4588	630	67428	2299	7	42795
1999	35817	4390	2243	0.68	0.32	6338	588	72995	1838	8	49376
2000	31653	3794	2386	0.68	0.32	6694	1153	89289	6019	8	45680
2001	26983	2456	2494	0.67	0.33	7261	383	91328	2891	8	39576
2002	19592	1410	2215	0.72	0.28	4566	548	67740	1462	7	28331
2003	18055	3482	2361	0.66	0.34	6569	854	69476	2024	9	31321
2004	15916	2193	2284	0.74	0.26	4925	184	68578	1201	7	25503
2005	16845	3186	2835	0.63	0.37	5191	1808	55032	1670	11	29866
2006	16472	1689	1887	0.74	0.26	6279	142	65532	4644	8	26468
2007	15859	1344	1698	0.66	0.34	7876	855	50843	4146	14	27634
2008	11148	355	1513	0.69	0.31	8934	768	42235	3746	17	22717
2009	7093	341	1921	0.60	0.40	8456	474	48439	3328	15	18285
2010	7641	814	2287	0.67	0.33	6479	557	50276	3543	12	17778
2011	8845	272	1794	0.75	0.25	7487	508	50368	3850	13	18907
2012	8654	349	2657	0.69	0.31	8419	556	51225	6795	13	20634
2013	7742	945	2029	0.70	0.30	5226	1305	31355	5020	15	17248
2014	8099	867	2485	0.67	0.33	5439	1268	28909	9627	15	18158
2015	8372	449	3161	0.71	0.29	5047	912	37342	6328	12	17941
2016	6233	156	2316	0.68	0.32	4430	293	29312	3620	13	13428

Table 2.3.7. Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings by Sub-division, quarter and gear in 2016.

Year:			Gear:	Trawl, gillnet and longlines combined			
Year:	**2016**	**Quarter:**	**1**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	33	751	15	769	48	762
3	404	1517	74	1202	478	1382
4	327	2435	83	1745	409	2139
5	39	3835	18	2900	57	3434
6	16	5177	5	4730	21	4986
7	7	7386	3	5791	10	6589
8	1	8882	0.4	7266	2	8074
9	1	8260	1	4676	2	5572
10						
11						
SOP [t]	1587		317		1904	
Landings (t)	1571		314		1885	

Year:	**2016**	**Quarter:**	**2**			
Sub-div,	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	54	872	15	872	69	872
3	245	1673	34	1202	279	1459
4	104	2427	31	1723	135	2107
5	9	3807	11	2585	20	3252
6	8	4751	2	4089	11	4457
7	3	4062	1	4739	5	4352
8	2	6663	0.1	6549	2	6618
9		2884	0.2	5572	0.2	4676
10						
11						
SOP [t]	676		153		829	
Landings (t)	676		153		829	

Year:	**2016**	**Quarter:**	**3**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	66	1012	83	974	149	987
3	50	2225	19	1214	69	1719
4	60	3449	28	2008	88	2728
5	6	3856	10	2591	16	3223
6	1	4158	1	3489	3	3712
7			1	3406	1	3406
8	3	9760	0.2	3761	3	8260
9						
10						
11						
SOP [t]	426		191		617	
Landings (t)	426		191		617	

Continued on next page.

continued

Table 2.3.7. Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings by Sub-division, quarter and gear in 2016.

Year:	**2016**	**Quarter:**	**4**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	227	1516	156	1159	383	1278
3	49	2957	73	1389	122	2173
4	35	4065	64	2008	99	2890
5	5	5139	9	2923	14	3661
6	2	4285	3	3707	5	3900
7			0.1	4992	0.1	4992
8			0.001	9200	0.001	9200
9			0.003	8260	0.003	8260
10						
11						
SOP [t]	520		464		984	
Landings (t)	520		464		984	

Year:	**2016**	**Quarter:**	**All**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	380	1019	269	950	649	975
3	748	2046	200	1252	948	1672
4	526	2959	205	1870	731	2431
5	59	3993	48	2730	107	3361
6	27	4719	12	3955	39	4310
7	10	5487	5	4998	16	5212
8	6	8435	1	6837	7	7736
9	1	5572	1	5572	2	5572
10						
11						
SOP [t]	3193		1123		4316	
Landings (t)	3193		1123		4316	

Table 2.3.8. Western Baltic Cod. Overview of the numbers of on-site surveys and interviewed anglers, 2005–2016.

Year	Angling method	Number of on-site surveys	Numbers of interviews
2005	Charter boat angling	93	1114
	Boat angling		200
	Trolling		13
	Shore angling	90	130
	Wading		37
	Total	**183**	**1494**
2006	Charter boat angling	89	1905
	Boat angling		316
	Trolling		4
	Shore angling	79	115
	Wading		46
	Total	**168**	**2386**
2007	Charter boat angling	80	1256
	Boat angling		202
	Trolling		4
	Shore angling	82	353
	Wading		73
	Total	**162**	**1888**
2008	Charter boat angling	81	786
	Boat angling		128
	Trolling		6
	Shore angling	48	89
	Wading		43
	Total	**129**	**1052**
2009	Charter boat angling	204	1690
	Boat angling		346
	Trolling		29
	Shore angling	49	172
	Wading		51
	Total	**253**	**2288**
2010	Charter boat angling	233	1730
	Boat angling		366
	Trolling		40
	Shore angling	57	173
	Wading		50
	Total	**290**	**2359**
2011	Charter boat angling	283	2181
	Boat angling		411
	Trolling		7
	Shore angling	58	166
	Wading		51
	Total	**341**	**2816**
2012	Charter boat angling	258	1465
	Boat angling		358
	Trolling		24
	Shore angling	58	111
	Wading		25
	Total	**316**	**1983**
2013	Charter boat angling	240	1116
	Boat angling, Trolling		287
	Shore angling, Wading	84	184
	Total	**324**	**1587**

Continued

Table 2.3.8. Western Baltic Cod. Overview of the numbers of on-site surveys and interviewed anglers, 2005–2016.

Year	Angling method	Number of on-site surveys	Numbers of interviews
2014	Charter boat angling	231	1143
	Boat angling, Trolling		217
	Shore angling, Wading	84	175
	Total	**315**	**1535**
2015	Charter boat angling	236	1072
	Boat angling, Trolling		231
	Shore angling, Wading	87	166
	Total	**323**	**1469**
2016	Charter boat angling	252	1195
	Boat angling, Trolling		244
	Shore angling, Wading	77	165
	Total	**329**	**1604**

Table 2.3.9. Western Baltic cod. Overview of the number of samples and length measurements of cod from recreational fishing events (charter vessels trips & shore fishing), boat and trolling self-measurements, as well as charter vessel sampling, 2005–2016.

Year	Sample Type	Number of Samples	Harvest n	Release n
2005	Boat, charter boat angling	13	435	
	Shore angling	4	1026	
	Total	**17**	**1461**	
2006	Boat, charter boat angling	5	352	
	Shore angling	1	10	
	Total	**6**	**362**	
2007	Charter boat angling	1	18	8
	Shore angling	5	498	
	Total	**6**	**516**	**8**
2008	Boat, charter boat angling, trolling	24	275	7
	Shore angling	8	345	26
	Total	**32**	**620**	**33**
2009	Boat, charter boat angling, trolling	84	1351	885
	Shore angling	3	3	10
	Total	**87**	**1354**	**895**
2010	Charter vessel sampling – survey agent	74	2567	1604
	Shore fishing – self-measurement	13	1067	31
	Total	**87**	**3634**	**1635**
2011	Boat, charter boat angling, trolling	65	4089	1089
	Shore angling	15	584	13
	Total	**80**	**4673**	**1102**
2012	Boat, charter boat angling, trolling	32	1546	533
	Shore angling			
	Total	**32**	**1546**	**533**
2013	Boat, charter boat angling, trolling	47	2257	1345
	Shore angling			
	Total	**47**	**2257**	**1345**
2014	Boat, charter boat angling, trolling	42	3318	1104
	Boat angling – self-measurement	3	403	
	Total	**45**	**3721**	**1104**
2015	Boat, charter boat angling, trolling	42	2853	949
	Total	**42**	**2853**	**949**
2016	Boat, charter boat angling, trolling	53	2521	398
	Total	**53**	**2521**	**398**

Table 2.3.10. Western Baltic cod. Percentage of western cod in Area 1 (W: western part of SD 24, 12- 13 degrees longitude) and Area 2 (E: eastern part of SD 24, from 13 -15 degrees longitude); and weighted average of those percentages applied to extract the WB cod landings in SD 24.

year	Area 1 _ W	Area 2 E	Procent west cod in ladnings for SD 24
1994	90	85	87
1995	80	65	71
1996	66	49	56
1997	69	60	65
1998	72	71	71
1999	72	60	65
2000	71	49	59
2001	65	48	56
2002	63	45	53
2003	62	43	50
2004	61	40	48
2005	59	48	51
2006	58	34	42
2007	57	34	40
2008	46	20	27
2009	51	21	25
2010	55	21	28
2011	51	15	22
2012	52	19	24
2013	53	23	29
2014	51	25	31
2015	50	23	30
2016	58	24	30

Table 2.3.11. Western Baltic cod. Landings (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	861	4813	14354	2167	78	18	15
1995	713	11353	4891	5607	1204	130	3
1996	95	23493	17313	717	2059	107	2
1997	1828	1996	28790	2559	322	324	77
1998	2412	18594	2129	5720	654	105	76
1999	658	23476	12518	1597	1214	244	92
2000	809	6454	20432	3065	126	244	47
2001	1409	10463	6630	4812	793	46	89
2002	437	8189	8295	1581	878	258	17
2003	649	10155	4551	1310	231	192	66
2004	65	1510	8780	1909	337	122	83
2005	267	8381	1666	2982	342	91	50
2006	259	1549	10879	513	570	77	15
2007	58	3311	2617	3638	411	219	33
2008	20	601	2599	946	871	257	128
2009	177	444	1497	981	506	184	81
2010	185	3320	1022	609	429	133	54
2011	72	864	3439	1285	288	81	41
2012	113	1307	1270	1929	525	60	14
2013	287	600	1729	806	738	313	68
2014	42	2662	1079	821	139	145	24
2015	172	940	3012	376	226	34	61
2016	1	889	1398	1046	142	56	35

Table 2.3.12. Western Baltic cod. Discard (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	3680	1787	758	10	0	0	0
1995	3690	5106	313	30	0	0	0
1996	22714	2418	10	0	0	0	0
1997	15255	0	0	0	0	0	0
1998	17009	2709	121	0	0	0	0
1999	2670	9026	303	0	0	0	0
2000	2719	4456	2523	0	0	0	0
2001	1987	4475	306	49	0	0	0
2002	1526	2266	219	16	0	0	0
2003	1067	7605	415	13	0	0	0
2004	2244	866	2375	0	0	0	0
2005	945	7455	43	0	0	0	0
2006	873	2637	764	43	2	0	0
2007	281	2502	511	40	5	0	0
2008	76	574	204	4	0	0	0
2009	191	484	179	12	0	0	0
2010	218	915	475	303	7	0	0
2011	6	151	105	256	77	1	0
2012	30	268	204	231	42	0	0
2013	37	705	469	701	170	5	0
2014	691	1649	50	8	0	0	0
2015	229	862	315	24	0	0	0
2016	44	307	54	1	0	0	0

Table 2.3.13. Western Baltic cod. German recreational catch (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	464	801	726	86	14	2	1
1995	448	1219	608	233	34	3	1
1996	265	1371	683	158	32	3	1
1997	715	713	900	142	24	4	1
1998	490	1251	540	225	29	3	1
1999	213	1336	639	168	31	4	1
2000	463	1075	775	168	27	3	1
2001	370	1168	530	280	31	2	1
2002	472	1236	613	94	61	11	1
2003	220	1324	662	148	19	7	1
2004	623	970	822	88	23	3	2
2005	96	2169	406	324	9	1	1
2006	82	445	1232	57	30	1	1
2007	9	753	681	262	55	3	2
2008	1	327	870	147	50	1	0
2009	235	1482	484	225	42	14	4
2010	213	1693	235	142	41	9	19
2011	149	517	1178	27	8	0	1
2012	336	1083	399	550	22	3	1
2013	942	758	657	51	30	0	0
2014	279	2041	511	171	9	2	0
2015	146	1067	1393	134	33	2	1
2016	67	799	824	246	52	6	2

Table 2.3.14. Western Baltic cod. Catch in numbers ('000) at age (incl. Landing, discards, recreational catch).

age	a1	a2	a3	a4	a5	a6	a7+
1994	5005	7401	15838	2263	92	20	16
1995	4851	17678	5812	5870	1237	133	4
1996	23074	27282	18006	875	2090	111	3
1997	17798	2709	29690	2701	345	328	78
1998	19911	22553	2790	5946	683	108	77
1999	3541	33839	13461	1765	1246	248	93
2000	3992	11984	23730	3233	153	247	49
2001	3766	16106	7467	5140	824	48	90
2002	2436	11691	9128	1692	939	269	18
2003	1937	19085	5628	1471	250	198	67
2004	2932	3346	11977	1997	361	125	85
2005	1307	18005	2115	3305	351	92	50
2006	1214	4631	12876	612	602	78	15
2007	348	6566	3808	3939	472	222	35
2008	98	1502	3674	1098	921	258	128
2009	603	2410	2160	1218	549	198	85
2010	617	5928	1732	1054	477	142	72
2011	226	1533	4722	1568	373	82	42
2012	478	2658	1874	2709	589	63	15
2013	1266	2063	2855	1558	938	318	69
2014	1012	6351	1640	999	148	147	24
2015	547	2870	4719	534	259	35	63
2016	112	1995	2277	1293	194	62	37

Table 2.3.15. Western Baltic cod. Mean weight at age in commercial landings.

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.445	0.834	1.367	2.378	4.491	6.436	5.659
1995	0.398	0.792	1.215	2.112	3.643	6.064	11.622
1996	0.442	0.685	1.086	2.091	2.879	5.544	8.372
1997	0.503	0.753	0.993	1.685	2.195	4.043	6.407
1998	0.524	0.737	1.155	1.915	2.960	3.940	6.444
1999	0.528	0.666	1.133	1.405	3.141	3.920	4.978
2000	0.509	0.707	0.957	1.655	3.479	5.174	7.302
2001	0.519	0.688	1.082	1.756	3.181	5.090	7.026
2002	0.512	0.716	1.124	1.701	3.386	4.079	6.586
2003	0.593	0.810	1.092	2.002	3.679	5.162	7.224
2004	0.517	0.776	1.008	1.487	3.376	4.179	6.131
2005	0.599	0.738	1.270	2.207	3.362	4.875	6.868
2006	0.217	0.625	1.086	2.485	3.674	4.205	5.730
2007	0.412	0.862	1.186	2.093	3.185	4.747	6.421
2008	0.437	0.906	1.347	2.187	3.234	4.352	6.955
2009	0.768	0.702	1.158	1.794	3.120	4.979	4.985
2010	0.807	0.944	1.111	1.805	2.924	3.384	4.306
2011	0.955	1.212	1.292	1.382	1.905	2.551	2.117
2012	0.902	0.976	1.189	2.000	2.610	2.506	3.504
2013	0.832	1.035	1.288	1.843	2.517	3.301	3.534
2014	0.859	0.988	1.467	2.793	3.857	5.577	5.453
2015	0.625	0.807	1.585	2.601	4.759	4.507	6.926
2016	0.000	1.027	1.239	2.488	3.273	4.947	6.309

Table. 2.3.16. Western Baltic cod. Mean weight at age in discards.

age	a1	a2	a3	a4	a5
1994-2014	0.082	0.262	0.391	0.531	0.469
2015	0.082	0.155	0.333	0.363	0.352
2016	0.082	0.297	0.371	0.487	0.962

Table 2.3.17. Western Baltic cod. Mean weight at age in catch (combined for commercial landings, discards, recreational catch).

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.309	0.711	1.314	2.369	4.322	6.189	5.582
1995	0.287	0.669	1.162	2.086	3.620	6.009	9.181
1996	0.262	0.660	1.088	2.033	2.872	5.494	6.699
1997	0.297	0.754	0.996	1.697	2.226	4.041	6.372
1998	0.296	0.699	1.171	1.901	2.950	3.938	6.408
1999	0.313	0.595	1.123	1.454	3.120	3.918	4.970
2000	0.325	0.597	0.919	1.676	3.338	5.158	7.220
2001	0.369	0.611	1.082	1.763	3.181	5.057	6.995
2002	0.332	0.654	1.113	1.702	3.343	4.097	6.527
2003	0.384	0.641	1.073	1.981	3.654	5.136	7.178
2004	0.301	0.680	0.927	1.504	3.375	4.195	6.093
2005	0.334	0.598	1.256	2.165	3.377	4.874	6.833
2006	0.260	0.500	1.053	2.298	3.621	4.215	5.700
2007	0.293	0.674	1.044	2.029	3.030	4.736	6.331
2008	0.303	0.672	1.226	2.105	3.191	4.354	6.952
2009	0.405	0.454	1.144	1.816	3.081	4.852	4.977
2010	0.410	0.814	1.006	1.514	2.865	3.450	4.625
2011	0.484	0.974	1.228	1.239	1.618	2.542	2.177
2012	0.538	0.830	1.139	1.868	2.450	2.558	3.538
2013	0.634	0.704	1.133	1.220	2.134	3.258	3.536
2014	0.294	0.749	1.350	2.590	3.750	5.547	5.453
2015	0.355	0.635	1.443	2.458	4.433	4.448	6.900
2016	0.363	0.827	1.219	2.377	3.120	4.836	6.281

Table 2.3.18. Western Baltic cod. Mean weight (kg) at age in stock.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1994	0.005	0.063	0.301	0.874	2.369	4.322	6.189	5.582
1995	0.005	0.063	0.301	0.874	2.086	3.620	6.009	9.181
1996	0.005	0.057	0.259	0.990	2.033	2.872	5.494	6.699
1997	0.005	0.050	0.327	0.896	1.697	2.226	4.041	6.372
1998	0.005	0.081	0.316	0.735	1.901	2.950	3.938	6.408
1999	0.005	0.042	0.285	0.801	1.454	3.120	3.918	4.970
2000	0.005	0.059	0.234	0.801	1.676	3.338	5.158	7.220
2001	0.005	0.043	0.388	0.895	1.763	3.181	5.057	6.995
2002	0.005	0.043	0.433	1.117	1.702	3.343	4.097	6.527
2003	0.005	0.054	0.321	1.032	1.981	3.654	5.136	7.178
2004	0.005	0.067	0.536	0.870	1.504	3.375	4.195	6.093
2005	0.005	0.051	0.350	1.038	2.165	3.377	4.874	6.833
2006	0.005	0.043	0.310	0.795	2.298	3.621	4.215	5.700
2007	0.005	0.073	0.411	0.908	2.029	3.030	4.736	6.331
2008	0.005	0.043	0.465	1.019	2.105	3.191	4.354	6.952
2009	0.005	0.051	0.559	1.327	1.816	3.081	4.852	4.977
2010	0.005	0.066	0.369	1.082	1.514	2.865	3.450	4.625
2011	0.005	0.045	0.360	0.767	1.239	1.618	2.542	2.177
2012	0.005	0.050	0.301	0.882	1.868	2.450	2.558	3.538
2013	0.005	0.049	0.391	0.866	1.220	2.134	3.258	3.536
2014	0.005	0.039	0.345	0.965	2.590	3.750	5.547	5.453
2015	0.005	0.055	0.409	0.924	2.458	4.433	4.448	6.900
2016	0.005	0.047	0.341	0.690	2.377	3.120	4.836	6.281

Table 2.3.19. Western Baltic cod. Proportion mature at age (spawning probability).

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1995	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1996	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1997	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1998	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1999	0.03	0.35	0.74	0.78	1.00	1.00	1.00
2000	0.04	0.52	0.83	0.81	1.00	1.00	1.00
2001	0.01	0.49	0.82	0.92	1.00	1.00	1.00
2002	0.01	0.40	0.79	0.82	1.00	1.00	1.00
2003	0.02	0.39	0.72	0.77	1.00	1.00	1.00
2004	0.02	0.46	0.77	0.79	1.00	1.00	1.00
2005	0.02	0.53	0.79	0.92	1.00	1.00	1.00
2006	0.01	0.70	0.88	0.98	1.00	1.00	1.00
2007	0.02	0.79	0.91	0.98	1.00	1.00	1.00
2008	0.03	0.81	0.87	0.95	1.00	1.00	1.00
2009	0.03	0.70	0.85	0.88	1.00	1.00	1.00
2010	0.17	0.69	0.80	0.84	1.00	1.00	1.00
2011	0.14	0.67	0.86	0.88	1.00	1.00	1.00
2012	0.19	0.67	0.81	0.89	1.00	1.00	1.00
2013	0.10	0.67	0.86	0.88	1.00	1.00	1.00
2014	0.08	0.67	0.81	0.89	1.00	1.00	1.00
2015	0.05	0.65	0.83	0.89	1.00	1.00	1.00
2016	0.08	0.71	0.85	0.83	1.00	1.00	1.00

Table 2.3.20. Western Baltic cod. Natural mortality at age.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1994	0.8	0.266	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1997-2016	0.8	0.242	0.2	0.2	0.2	0.2	0.2	0.2

Table 2.3.21. Western Baltic cod. Tuning fleets BITS Q4 and Q1.

BITS Q4	a0	a1	a2	a3	a4
2001	15858	798	349	41	88
2002	1994	1897	263	82	14
2003	19618	1235	739	33	45
2004	6556	11010	914	123	32
2005	5328	2499	1572	49	72
2006	2875	3631	316	314	80
2007	614	380	166	80	297
2008	24712	53	56	38	80
2009	3266	2363	61	49	25
2010	12132	853	522	14	13
2011	4304	1658	123	87	8
2012	19564	1648	391	45	58
2013	9085	3901	189	42	24
2014	7350	1631	750	74	63
2015	371	894	311	111	55
2016	62809	360	70	14	111

contiuned

Table 2.3.21. Western Baltic cod. Tuning fleets BITS Q4 and Q1.

BITS Q1	a1	a2	a3	a4
2001	5116	3866	836	396
2002	11877	2269	1294	81
2003	923	3279	364	110
2004	10478	1188	1650	41
2005	7332	25298	995	469
2006	10961	4691	5850	93
2007	2039	7590	1757	958
2008	99	792	872	216
2009	7525	609	661	198
2010	2741	8157	279	104
2011	10514	5677	10606	34
2012	1904	2703	1245	726
2013	7101	2379	1805	158
2014	4375	3820	494	142
2015	2866	4247	1469	100
2016	102	1224	726	375
2017	13786	581	989	140

Table 2.3.22. Western Baltic cod. Estimated recruitment (millions), total stock biomass (TBS), spawning stock biomass (SSB) (tonnes), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1994	64602	86267	427966	49613	35380	69571	31729	21640	46523	1.184	0.97	1.444
1995	90219	28633	160123	50413	39270	64717	29822	22700	39178	1.246	1.043	1.487
1996	27889	85193	395268	53210	40844	69319	33124	25350	43281	1.19	1.01	1.403
1997	85050	111911	515318	52313	38873	70399	34475	24877	47777	1.19	1.012	1.4
1998	114005	40538	184241	52365	40482	67736	26930	20809	34851	1.209	1.03	1.419
1999	37235	39698	171603	53370	40338	70612	31445	24061	41095	1.296	1.104	1.521
2000	37647	27560	111734	47715	35939	63349	36279	26822	49071	1.294	1.108	1.51
2001	24077	45040	160284	38292	30682	47790	29057	23065	36605	1.314	1.115	1.548
2002	40135	15108	62630	32112	25726	40085	22494	17824	28388	1.268	1.079	1.491
2003	14241	70085	252342	28311	22743	35242	17361	14070	21422	1.181	1.011	1.38
2004	67711	27465	96117	30915	24531	38960	19205	14870	24803	1.123	0.957	1.318
2005	23225	24631	87224	38832	30412	49584	26635	21129	33576	1.047	0.886	1.239
2006	22948	8417	29483	35882	27795	46323	30853	23773	40043	0.951	0.775	1.167
2007	6920	3430	16305	33827	26794	42705	31008	24387	39426	0.964	0.806	1.152
2008	3298	30444	122558	23412	18944	28933	21314	17172	26453	0.992	0.839	1.173
2009	27695	13308	46812	17429	14351	21168	14098	11491	17297	1.003	0.848	1.187
2010	11015	19205	72917	17389	13827	21868	13100	10501	16343	0.996	0.841	1.18
2011	15891	14252	50380	16463	12597	21516	13212	9999	17457	0.971	0.818	1.153
2012	11509	35265	131313	18787	14787	23868	15205	11826	19551	0.964	0.809	1.149
2013	30333	20226	73666	15559	12610	19197	12087	9694	15072	1.056	0.852	1.308
2014	16543	12035	46092	19716	15829	24558	15387	12390	19109	0.99	0.8	1.224
2015	10098	2542	14529	20910	16297	26830	16828	13063	21679	0.948	0.729	1.233
2016	2600	38307	548312	16895	12232	23337	13479	9689	18752	0.93	0.668	1.294
2017	65408	15580	272653				12932	7448	20492			
Avr.	**35429**	**33964**	**168745**	**33206**	**25708**	**42942**	**22836**	**17444**	**29927**	**1.10**	**0.92**	**1.32**

Table 2.3.23. Western Baltic cod. Estimated stock numbers (SAM).

Year\Age	0	1	2	3	4	5	6	7+
1994	192144	64602	18162	31195	4498	218	24	20
1995	67711	90219	45252	8266	8761	1335	60	8
1996	183506	27889	67508	21049	1907	2414	274	10
1997	240145	85050	13308	33962	4782	563	545	80
1998	86422	114005	56162	5755	8182	1228	153	148
1999	82537	37235	78747	23766	1514	1963	305	87
2000	55492	37647	25059	33223	5391	307	412	82
2001	84965	24077	26450	9822	6981	1373	67	111
2002	30761	40135	17445	11119	2043	1542	342	35
2003	132986	14241	32533	7372	2296	505	349	91
2004	51380	67711	10778	16300	1986	558	142	115
2005	46351	23225	54014	5221	4707	550	128	65
2006	15753	22948	15880	25362	1763	1340	143	41
2007	7479	6920	15722	8023	7377	745	417	55
2008	61084	3298	5176	6966	2565	1830	263	154
2009	24959	27695	3893	3618	2130	812	406	116
2010	37421	11015	22137	2875	1424	621	202	123
2011	26796	15891	7842	12613	1456	500	135	73
2012	68050	11509	11138	4361	4564	672	135	44
2013	38600	30333	7790	5863	1537	1384	221	59
2014	23553	16543	21043	3858	1806	342	306	57
2015	6078	10098	10850	10409	1243	490	80	99
2016	144929	2600	6782	4863	3477	380	124	53
2017	144929	65408	1997	4155	1684	1169	107	50

Table 2.3.24. Western Baltic cod. Estimated fishing mortalities by age from SAM.

Year\Age	1	2	3	4	5+
1994	0.107	0.585	1.168	1.103	1.28
1995	0.111	0.612	1.233	1.164	1.34
1996	0.111	0.605	1.208	1.119	1.244
1997	0.11	0.607	1.213	1.13	1.229
1998	0.11	0.619	1.234	1.157	1.235
1999	0.113	0.655	1.32	1.248	1.32
2000	0.111	0.661	1.331	1.245	1.306
2001	0.11	0.668	1.354	1.266	1.321
2002	0.103	0.637	1.299	1.224	1.282
2003	0.093	0.579	1.189	1.139	1.214
2004	0.084	0.527	1.097	1.081	1.19
2005	0.076	0.483	1.003	1.004	1.135
2006	0.069	0.439	0.909	0.907	1.038
2007	0.067	0.432	0.904	0.922	1.065
2008	0.064	0.42	0.899	0.948	1.129
2009	0.062	0.409	0.884	0.961	1.165
2010	0.059	0.392	0.858	0.956	1.175
2011	0.057	0.376	0.833	0.935	1.146
2012	0.057	0.377	0.835	0.933	1.124
2013	0.06	0.406	0.91	1.023	1.233
2014	0.059	0.392	0.868	0.956	1.145
2015	0.058	0.383	0.842	0.911	1.092
2016	0.057	0.379	0.831	0.89	1.068

Table 2.3.25. Western Baltic Cod. Input to short-term forecast.

2017									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	65408	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23
2018									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	14206	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23
2019									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	14499	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23

Input units are thousands and kg -

M = Natural Mortality

Mat = Maturity ogive

PF = Proportion of F before spawning

PM = Proportion of M before spawning

SWt = Weight in stock (Kg); * updated numbers in September 2016 because of a typo.

Sel = Exploitation pattern

CWt = Weight in catch (Kg)

LWt = Weight in commercial landings (Kg)

Natural mortality (M): Constant

Weight in the landing, catch (LWt, CWt): average of 2014-2016

Weight in the stock (SWt): average of 2014-2016

Exploitation pattern (Sel.): average of 2015

Table 2.3.26. Western Baltic Cod. Output of short-term forecast.

Basis	Total catch (2018)*	Commercial catch, assuming recreational catch of 1754 tonnes	Wanted catch** (2018)	Unwanted catch** (2018)	F_{total} (2018)	F_{wanted} (2018)	$F_{unwanted}$ (2018)	SSB (2019)	% SSB change **	% Advice change ***
ICES advice basis										
MSY approach: F_{MSY} $F = F_{MSY} \times (SSB_{2018}/ MSY B_{trigger})$ EU multi annual management plan	5295	3541	3454	87	0.19	0.12	0.003	48929	76	286
F = MAP^ $F_{MSY\ lower}$ $F = MSY F_{lower(AR)} \times (SSB_{2018}/ MSY B_{trigger})$	3130	1376	1342	34	0.11	0.05	0.001	51190	84	50
Other options										
F_{MSY}	7154	5400	5268	132	0.26	0.19	0.005	46848	69	489
Zero commercial catch	1754	0	0	0	0.06^^	0	0	52747	90	-100
F_{pa}	17569	15815	15428	387	0.74	0.65	0.016	35931	29	1625
F_{lim}	22078	20324	19827	497	1.01	0.91	0.023	31076	12	2116
SSB (2019) = B_{lim}	25804	24050	23462	588	1.27	1.15	0.029	27399	-1	2523
SSB (2019) = B_{pa}	15195	13441	13112	329	0.62	0.54	0.013	38399	38	1366
SSB (2019) = MSY $B_{trigger}$	15195	13441	13112	329	0.62	0.54	0.013	38399	38	1366
$F = F_{2017}$	9792	8038	7841	197	0.37	0.30	0.007	43779	58	777

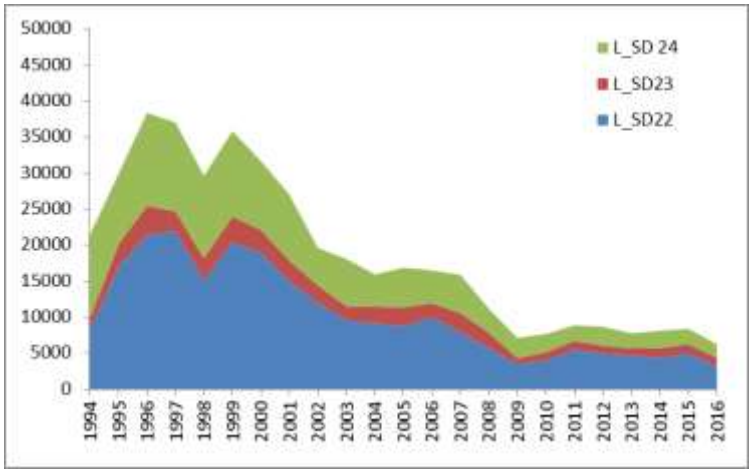


Figure 2.3.1. **Western Baltic cod. Landings by SD (tonnes).**

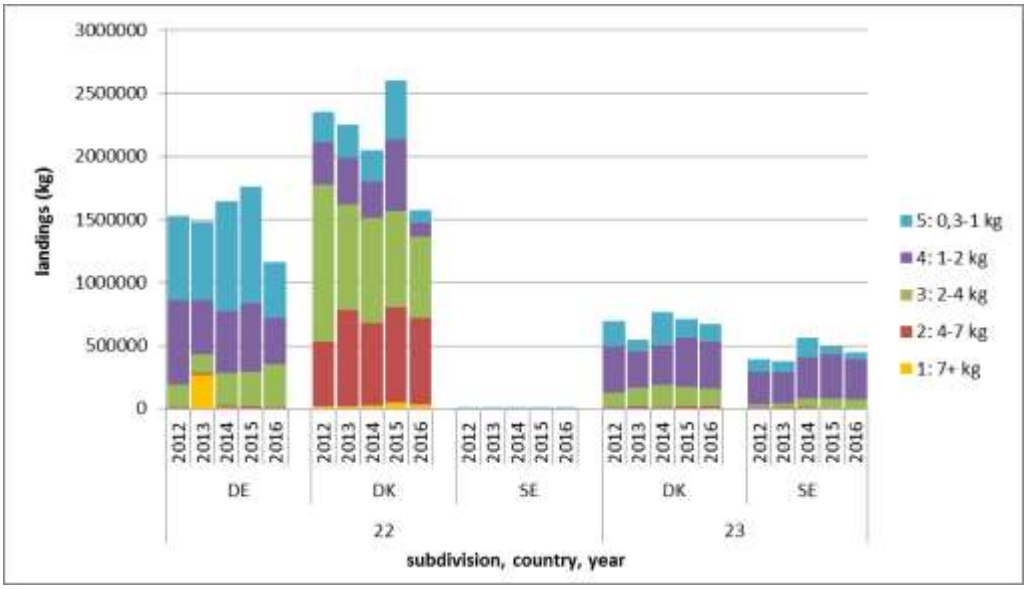


Figure 2.3.2. **Western Baltic cod stock. Landings of cod by commercial size sorting categories in SD22 and SD23 by country (DE: Germany; DK: Denmark; SE: Sweden) and year (2002–2016).**

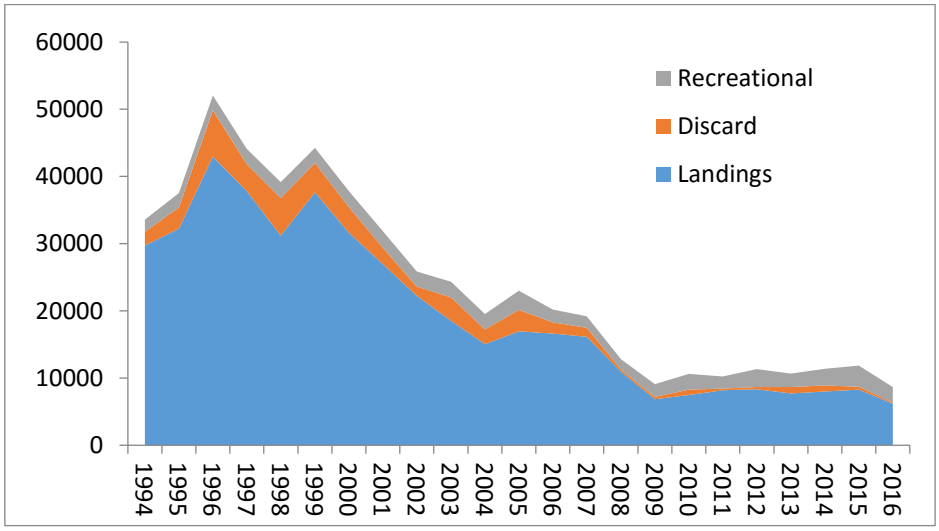


Figure 2.3.3. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes).

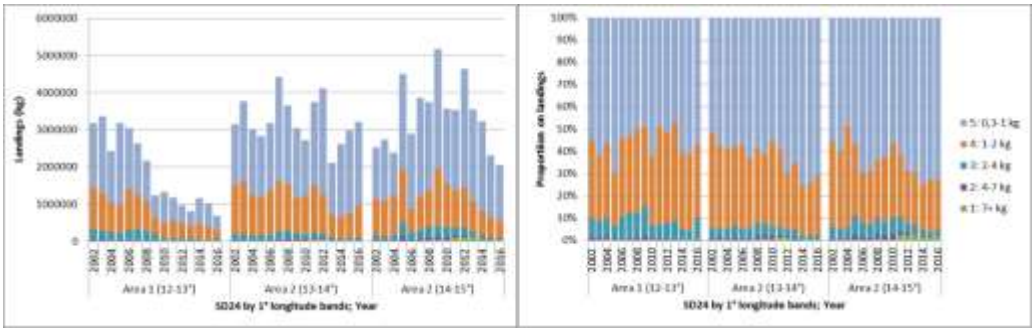


Figure 2.3.4. Western Baltic cod. Landings of cod by commercial size sorting categories in SD24 by 1° longitude bands and year (2002–2016). Data from DK, GER, SWE, POL. Left panel: Absolute values; right panel: relative values.

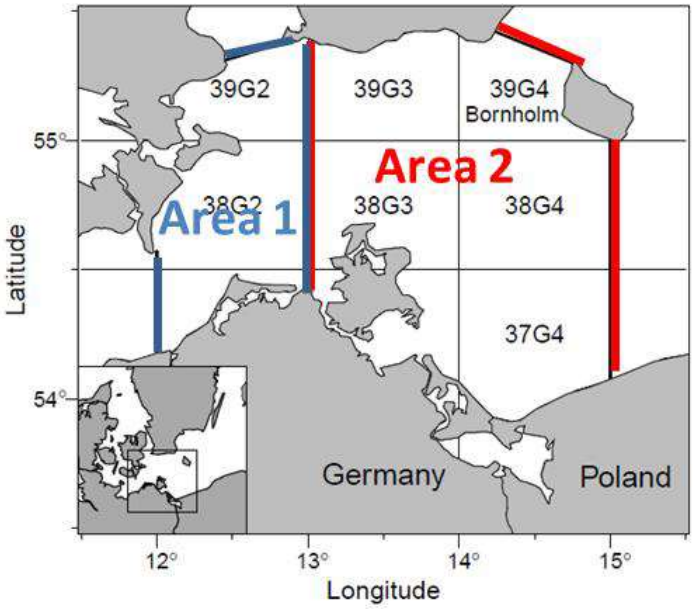


Figure 2.3.5. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

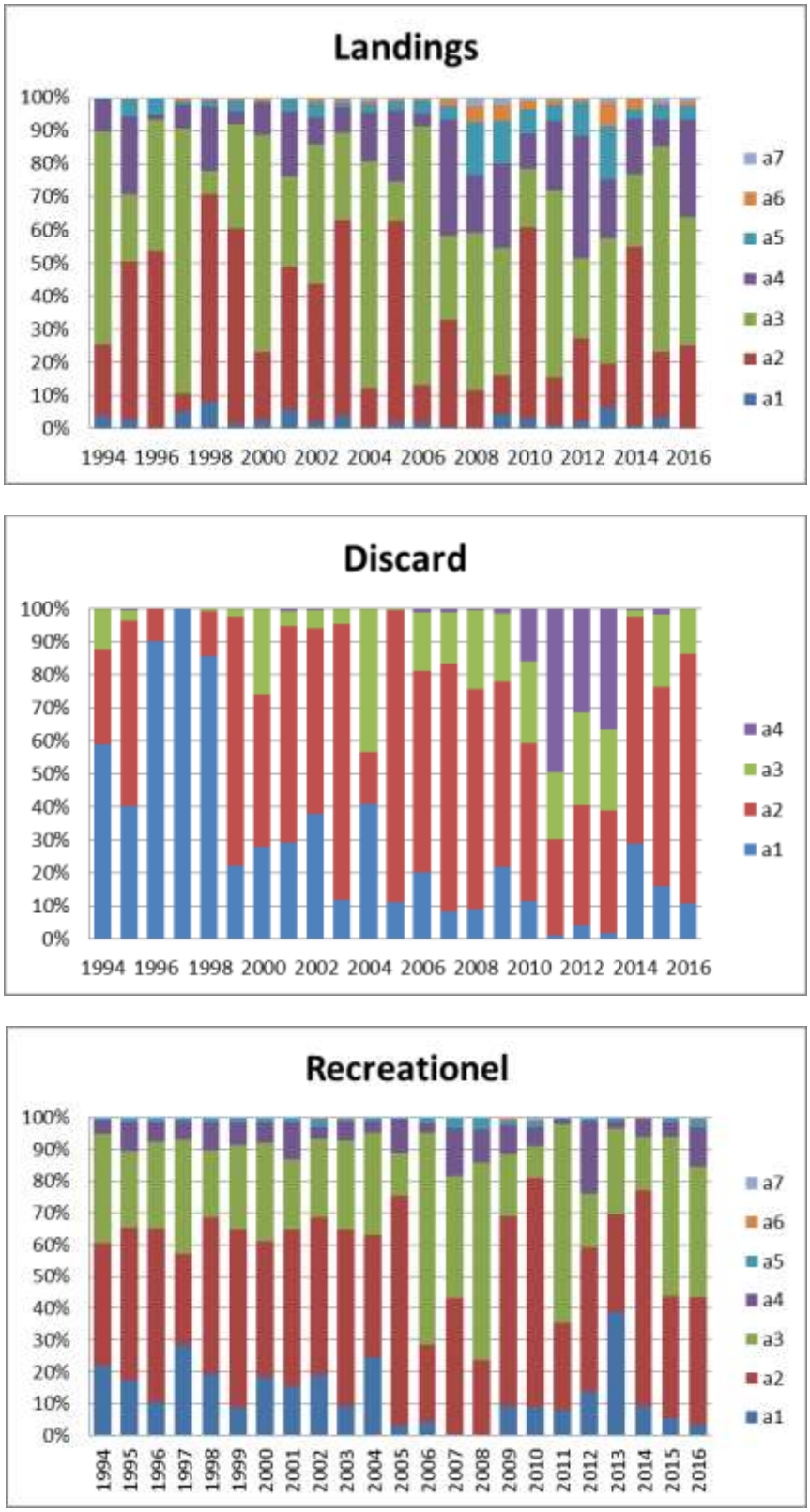


Figure 2.3.6. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

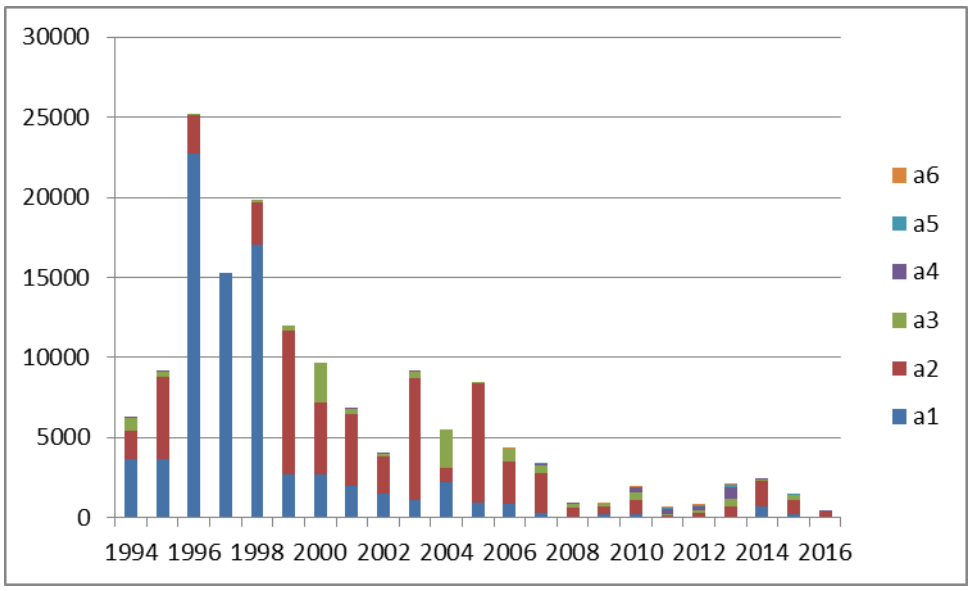


Figure 2.3.7. **Western Baltic cod. Commercial discards in numbers by age (absolute values).**

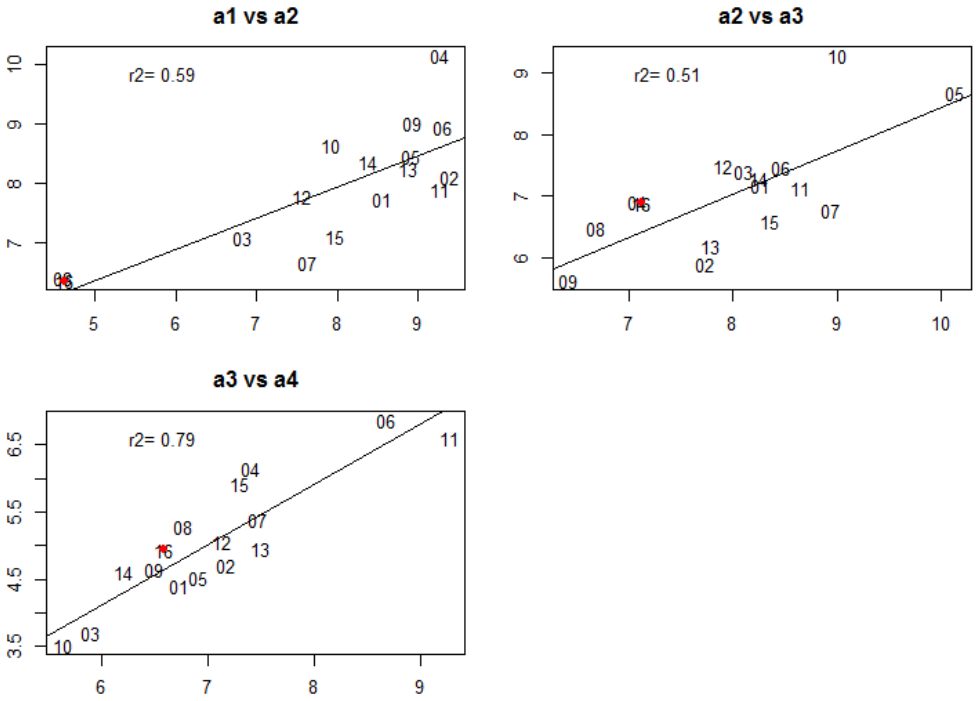


Figure 2.3.8. **Western Baltic cod. CPUE at age *i* vs numbers at age *i* +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.**

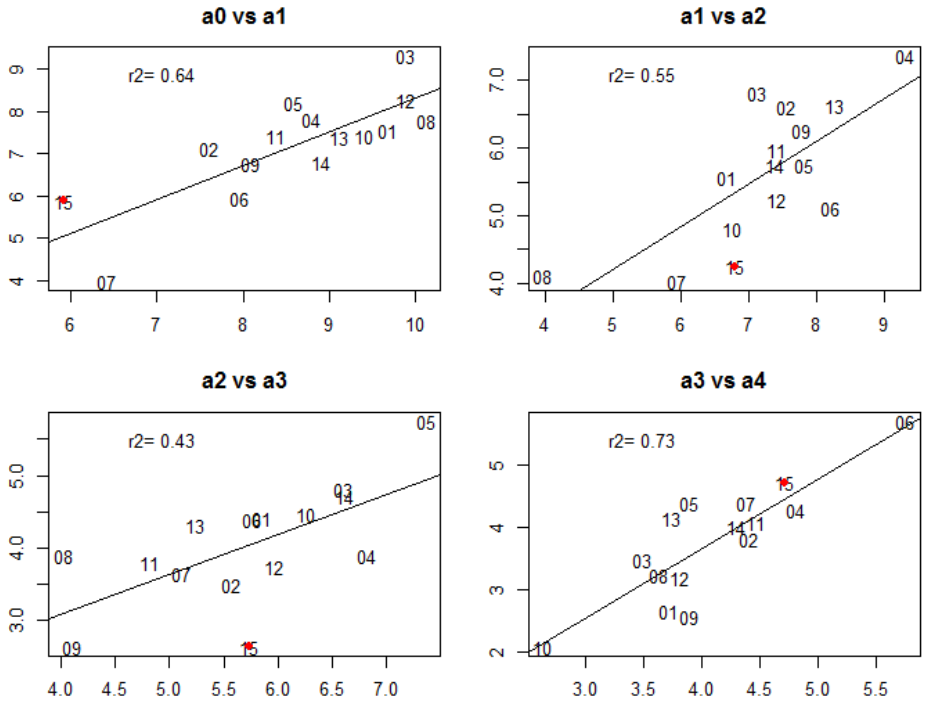


Figure 2.3.9. Western Baltic cod. CPUE at age *i* vs numbers at age *i* +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

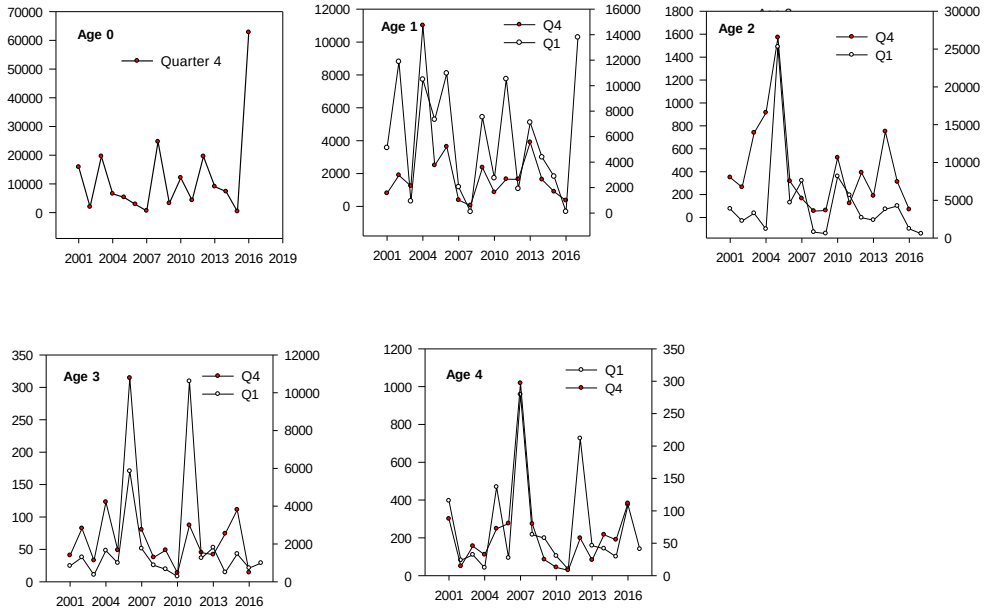


Figure 2.3.10. Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.

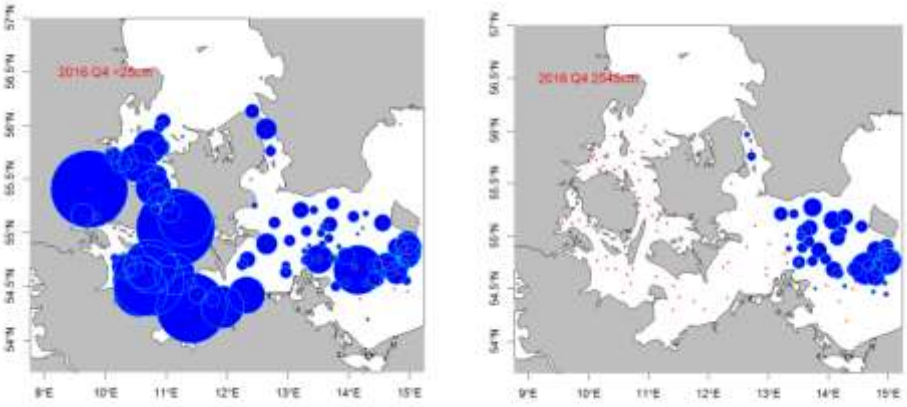


Figure 2.3.11. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2016 (left) and cod 25-45 cm (right).

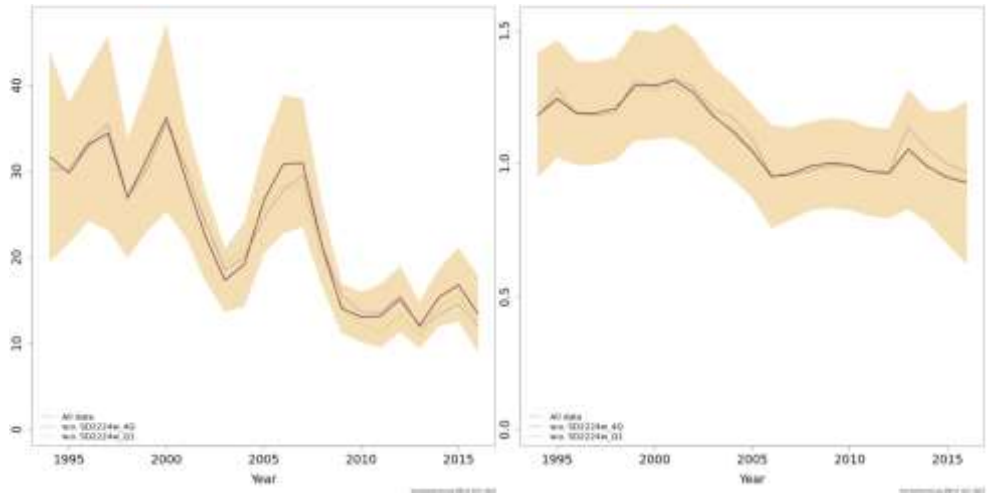


Figure 2.3.12. Western Baltic cod. The SSB and F from exploratory runs leaving out one tuning series at a time.

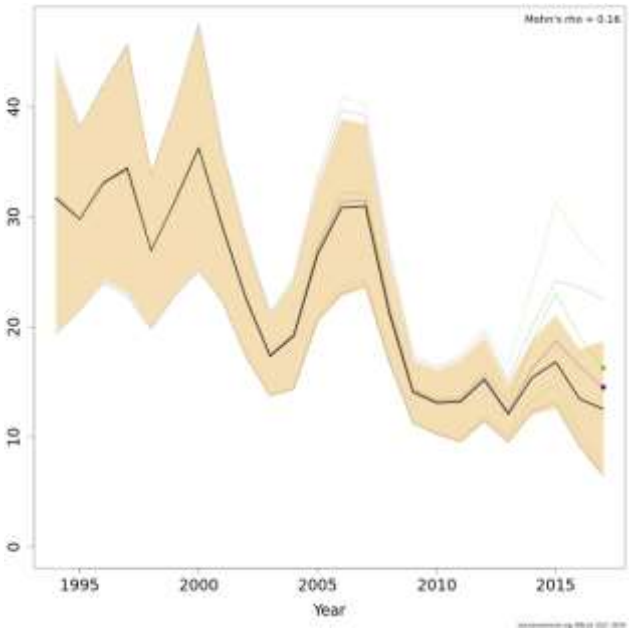


Figure 2.3.13. Western Baltic cod. The retro SSB from exploratory runs excluding the catch data of the last 2 years.

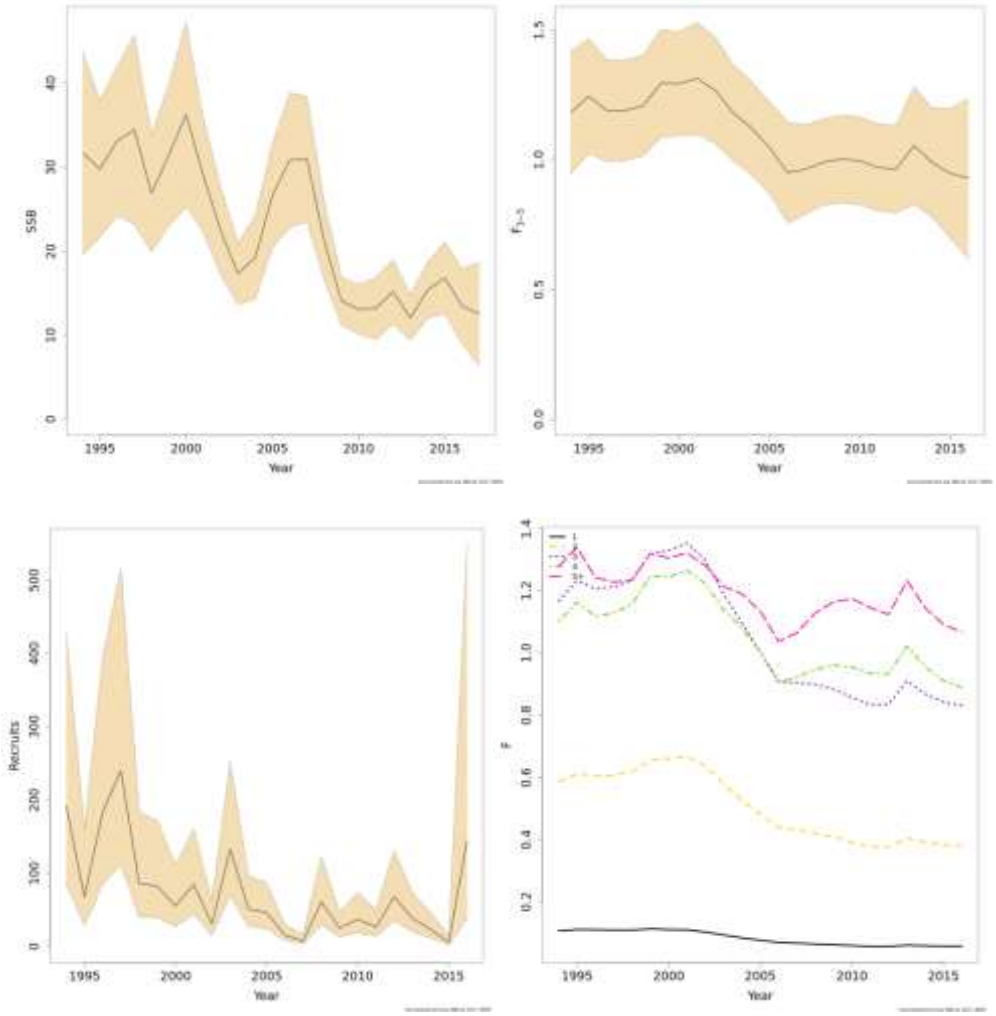


Figure 2.3.14. Western Baltic cod. SSB (upper left), F (3–5) (upper right) and stock numbers at age 0 (lower left) and F by age groups (lower right) from the final assessment.

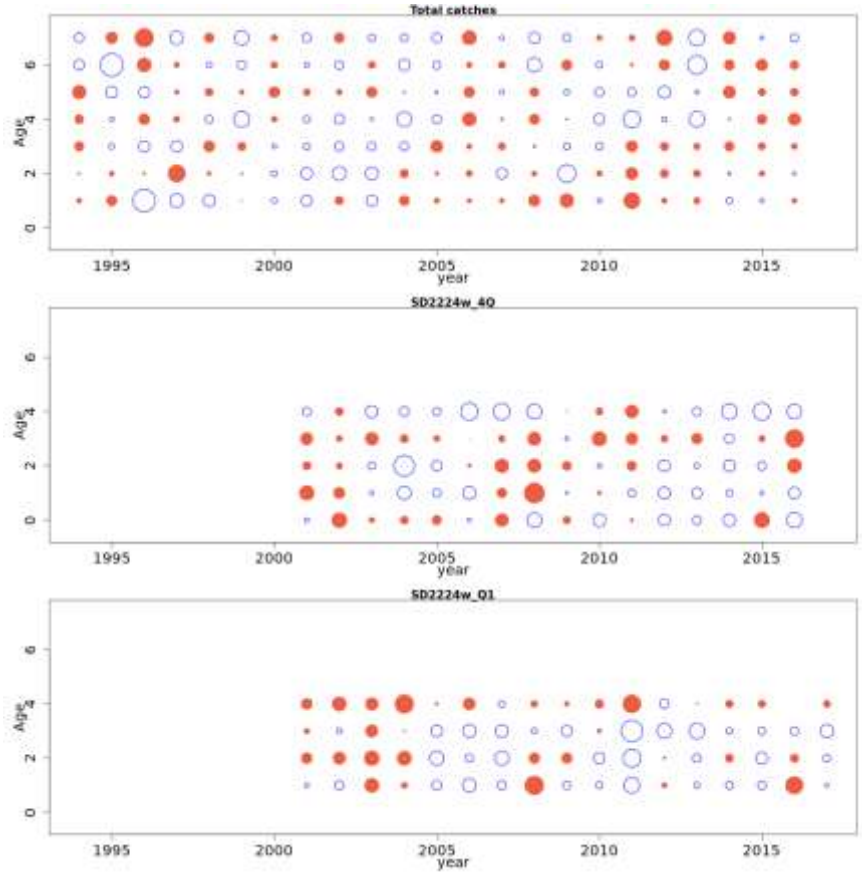


Figure 2.3.15. Western Baltic cod. Standardized residuals from the final SAM run where open circles are positive and filled circles are negative residuals.

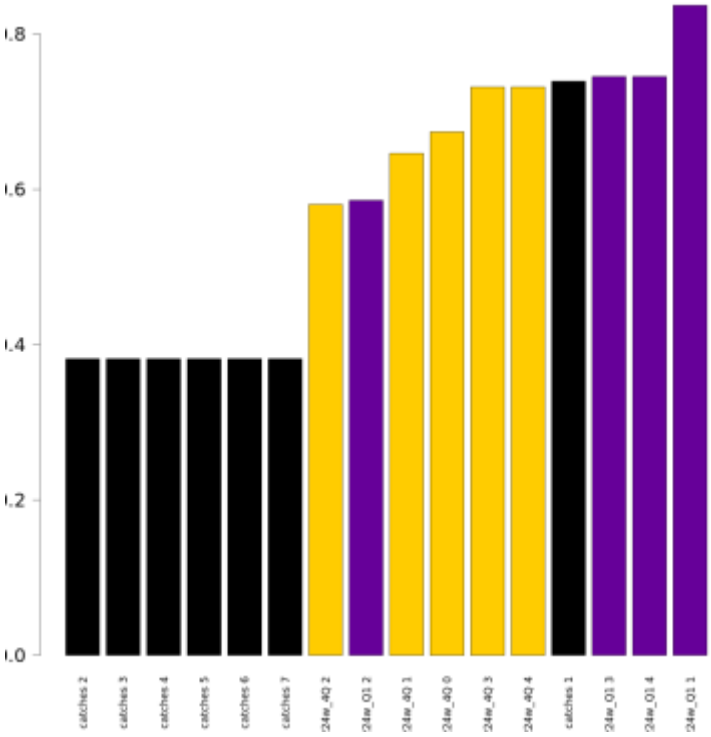


Figure 2.3.16. Western Baltic cod. SD of log observations from catch data and surveys by age, Y scale is from 0.0 to 0.8.

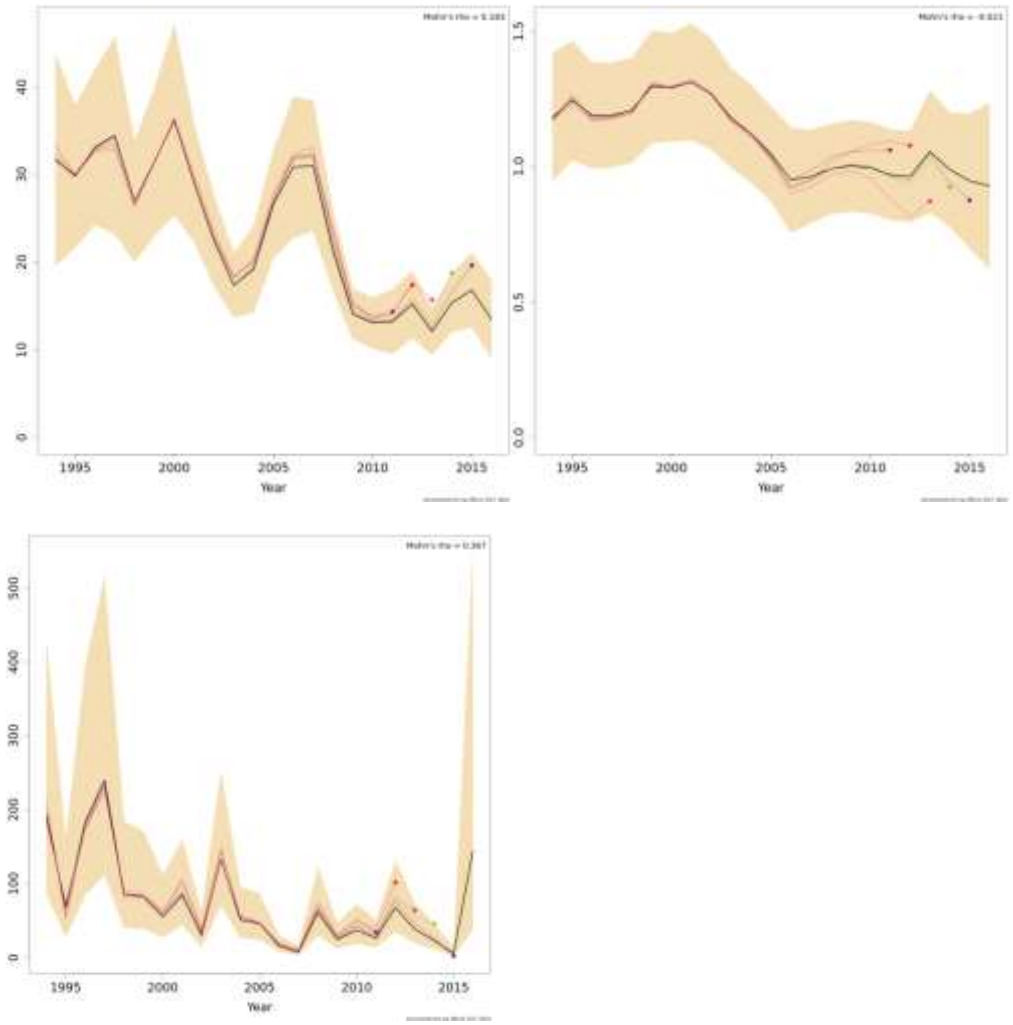


Figure 2.3.17. Western Baltic cod. Retrospective analyses of SSB, F(3–5) and recruitment (age 0).