HERRING ASSESSMENT WORKING GROUP (HAWG)

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i Executive summary

The ICES herring assessment working group (HAWG) met in Aberdeen, Scotland from 12-21 March 2024 to assess the state of six herring (*Clupea harengus*) and one sprat (*Sprattus sprattus*) stock. Additionally, HAWG provided advice for eight Sandeel (*Ammodytes spp.*) in January 2023. The working group conducted update category 1 assessments for four of the herring stocks and category 3 assessments for 2 herring stocks. An analytical assessment was performed for the combined North Sea and Division 3.a sprat, and data limited assessment (ICES category 3) was conducted for English Channel sprat (spr.27.7de). Biennial advice is given for sprat in the Celtic Seas and West of Scotland with advice provided in 2023.

North Sea autumn spawning herring (her.27.3a47d). SSB in 2023 was estimated at 1.52 million tonnes while $F_{2\text{–}6}$ in 2023 was estimated at 0.23, which is below FMSY. Recruitment is at a stable level, which is expected to contribute positively to SSB levels from 2024 onwards. ICES considers that the stock is still in a low productivity phase.

Western Baltic spring-spawning herring (her.27.20-24). SSB in 2023 was estimated at 66,152 tonnes and is below MSY $B_{trigger}$, B_{pa}, and B_{lim}. Recruitment has been low since 2007 and has been deteriorating further with time. $F_{3\text{-}6}$ has been decreasing since 2018 and is now well below F_{MSY} (0.31) at 0.053. The stock has decreased consistently during the second half of the 2000s and given the continued low recruitment, the stock is not able to recover above Blim unless a drastic reduction in fishing effort is applied for several years.

Celtic Sea autumn and winter spawning stock (her.27.irls). SSB in 2023 was estimated at 15,157 tonnes, though is increasing from its lowest level seen in 2018 (6,474 tonnes), but remains below B_{lim} (34,000 tonnes). $F_{(2\text{-}5\text{ rings})}$ in 2022 was estimated at 0.058, having decreased from a peak of 1.16 in 2017. Recruitment has been consistently below average since 2013.

Irish Sea autumn spawning herring (her.27.nirs). SSB in 2023 was estimated at 91350 tonnes and is above MSY Btrigger, Bpa, and Blim. Recruitment in 2023 is slightly below the 2022 recruitment, which was the highest on record. The trend of large incoming year-classes in recent years continues. F4-6 is estimated at 0.49 which is slightly above FMSY (0.35). The assessment model of her.27.nirs was changed in 2024 due to issues with the old model.

6aN autumn spawning herring (her.27.6aN). SSB in 2023 was estimated at 22,463 tonnes using the genetically split, Malin Shelf Herring Acoustic Survey (MSHAS). Whilst SSB has increased since its lowest level in 2019. Indicators show that stock size is above $I_{trigger}$ and harvest rate below $HR_{MSY\ proxy}$ (0.28).

Herring in 6.aS/7.b, c (her.27.6aS7bc). SSB in 2023 was estimated at 100,523 tonnes using the genetically split, Malin Shelf Herring Acoustic Survey (MSHAS) and has been increasing since the lowest point in 2016 (36,707 t). Recent catches are among the lowest in the time series. Fishing pressure on the stock is below $HR_{MSY\ proxy}$ (0.26) and the stock size index is well above $I_{trigger}$ (51 390 t).

Sprat in the North Sea and 3.a (spr.27.3a4). SSB in 2024 was estimated at 83,754 tonnes and is below MSY $B_{escapement}$, B_{pa}, and B_{lim}. $F_{1\text{-}2}$ has been decreasing since 2016, but was estimated at a high level in 2024. There are high levels of fluctuations in F throughout the time series. Low recruitment in recent years had contributed to the stock being below MSY $B_{escapement}$.

Sprat in the English Channel (spr.27.7de). Biomass in 2023 was estimated at 61 270 tonnes using the Pelagic Ecosystem Survey in the Western Channel and Celtic Sea (PELTIC). The catch advice applies a constant harvest rate (CHR) of 8.57% to the survey biomass. Fishing pressure is below $F_{MSY\ proxy}$ with stock size above MSY $B_{trigger}$ (I_{stat}).

Sprat in the Celtic Seas and West of Scotland (spr.27.67a-cf-k). Catch advice was given for 2024 and 2025 using the ICES Category 5 method where only landings data are available. The precautionary buffer (20% reduction) was applied in 2021, and thus was not applied in this advice year.

Sandeel in Divisions 4b–c (Sandeel area 1r). SSB in 2023 was estimated at 159,384 tonnes and is above MSY $B_{escapement}$, B_{pa}, and B_{lim}. Although recruitment has been below average between 2020–2023, it has been slowly increasing and has allowed a fishery in 2024. $F_{1\text{-}2}$ is estimated at 0.26, which is below Fcap of 0.36.

Sandeel in Divisions4b–c (Sandeel area 2r). SSB in 2023 was estimated at 44,234 tonnes and is above MSY $B_{escapement}$, B_{pa} and B_{lim}. Recruitment in 2023 is one of the lowest recruitment years on record. $F_{1\text{-}2}$ (0.43) is below Fcap (0.52).

Sandeel in Divisions 4a–b and Subdivision 20 (Sandeel area 3r). SSB in 2023 was estimated at 247,285 tonnes and is above MSY $B_{escapement}$, B_{pa}, and B_{lim}. Recruitment in 2023 has been continuously decreasing the last three years, and is nearing one of the lowest observed years, leading to the only catch opportunities being a monitoring quota. $F_{1\text{-}2}$ is estimated at 0.13, which is lower than Fcap of 0.47.

Sandeel in Divisions 4a–b (Sandeel area 4). SSB in 2023 was estimated at 81,750 tonnes and is below MSY $B_{escapement}$ and between B_{pa} and B_{lim}. Recruitment in 2022 is higher than that in 2021. $F_{1\text{-}2}$ has decreased since the previous year.

Sandeel in Division 4a (Sandeel area 5r). Catch advice was given for 2023 and 2024 using the ICES Category 5 method where only catch data are available. The precautionary buffer (20% reduction) was applied in 2021, and thus was not applied in this advice year.

Sandeel in Subdivisions 20–22 (Sandeel area 6). Catch advice was given for 2023 and 2024 using the ICES Category 5 method where only catch data are available. The precautionary buffer (20% reduction) was applied in 2021, and thus was not applied in this advice year.

Sandeel in Division 4a (Sandeel area 7r). Catch advice was given for 2023 and 2024 using the ICES Category 5 method where only catch data are available. The precautionary buffer (20% reduction) was applied in 2021, and thus was not applied in this advice year.

Sandeel in Division 6a. Zero catch advice was given for 2024, 2025, 2026 following the ICES Category 6 method.

Standard issues such as benchmark planning, the quality and availability of data, availability of data through industry surveys and scientific advances particularly with respect to the use of genetics for stock discrimination were discussed.

All data and scripts used to perform the assessments and the forecast calculations are available at https://github.com/ICES-dk/wg_HAWG and accessible to anyone.

ii Expert group information

Expert group name	Herring Assessment Working Group (HAWG)
Expert group cycle	Annual
Year cycle started	2023
Reporting year in cycle	1/1
Chair(s)	Aaron Brazier, United Kingdom
	Nis Sand Jacobsen, Denmark
Meeting venue and dates	12-21 March 2024, Aberdeen, Scotland and online (53 participants)

1 Introduction

1.1 HAWG 2024 Terms of Reference

The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Aaron Brazier, United Kingdom, and Nis S Jacobsen, Denmark will meet: in ICES and online 23th –25th January 2024 to:

a) Compile the catch data of sandeel in assessment areas 1r, 2r, 3r, 4, 5r, 6, and 7r and address generic ToRs for Regional and Species Working Groups that are specific to sandeel stocks in the North Sea ecoregion;

and in Aberdeen and online 11h –21nd March 2024 to:

b) address generic ToRs for Regional and Species Working Groups for all stocks assessed by HAWG.

The assessments will be carried out based on the Stock Annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2024 ICES data call.

A summary of the HAWG stocks and assessment method is given in the table below.

Stock Name	Stock Coord.	Assess. Coord.	Assessment Method
Sandeel in Divisions 4b-c, SA1r (central and southern North Sea, Dogger Bank)	Denmark	Denmark	SMS-effort
Sandeel in Divisions 4b-c and SD20, SA2r (central and southern North Sea)	Denmark	Denmark	SMS-effort
Sandeel in Divisions 4b-c and SD20, SA3r (northern and central North Sea, Skagerrak)	Denmark / Norway	Denmark	SMS-effort
Sandeel in Divisions 4a-b, SA4 (northern and central North Sea)	Denmark	Denmark	SMS-effort
Sandeel in Division 4a, SA5r (northern North Sea, Viking and Bergen banks)	Denmark / Norway		No assessment
Sandeel in SD20-22, SA6 (Skagerrak, Kattegat and Belt Sea)	Denmark		No assessment
Sandeel in Division 4a, SA7r (northern North Sea, Shetland)	Denmark / UK (Scotland)		No assessment
Sandeel in Division 6a (West of Scotland)	ICES		No assessment
Herring in Subdivisions 20–24 (Western Baltic Spring spawners)	Denmark	Denmark	SAM
Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	The Netherlands	SAM
Herring in Division 7.a South of 52° 30’ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Ireland	Ireland	ASAP
Herring in Divisions 6.aN	UK (Scotland)	UK (Scotland)	Survey biomass index and *chr* rule for advice

Stock Name	Stock Coord.	Assess. Coord.	Assessment Method
Herring in Divisions 6.aS and 7.b and 7.c	Ireland	Ireland	Survey biomass index and *chr* rule for advice
Herring in Division 7.a North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)	SAM
Sprat in Division 3.a (Skagerrak - Kattegat) and Subarea 4 (North Sea)	Denmark	Denmark	SMS
Sprat in the Divisions 7.d and 7.e (English Channel)	UK (E&W)	UK(E&W)	Survey biomass
Sprat in Subarea 6 and Divisions 7a-c,f-k	UK(E&W)		No assessment

1.2 Generic ToRs for Regional and Species Working Groups

2021/2/FRSG01 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries overviews where available;

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

  i) descriptions of ecosystem impacts on fisheries

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries considerations, and

  iv) emerging issues of relevance for management of the fisheries;

c) Conduct an assessment on the stock(s) to be addressed in 2024 using the method (assessment, forecast or trends indicators) as described in the stock annex; - complete and document an audit of the calculations and results; and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

  i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.

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

  iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2021.

  iv) For category 3 and 4 stocks requiring new advice in 2024, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks

v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

1) for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an inter-benchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

vi) The state of the stocks against relevant reference points;

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

1) 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

2) 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

3) 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

viii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention *(restricted access)* and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks in SID;

ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2023 for conclusion in 2024;
iii) determine the prioritization score for benchmarks proposed for 2023–2024;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

Information of the stocks to be considered by each Expert Group is available here.

1.3 Reviews of groups or projects important for the WG

HAWG was briefed throughout the meeting about other groups and projects that were of relevance to their work. Some of these briefings and/or groups are described below.

1.3.1 Working Group for International Pelagic Surveys (WGIPS)

The Working Group of International Pelagic Surveys (WGIPS) met in Torshavn, The Faroes and online on Teams 22nd–26th January 2024. Among the core objectives of the Expert Group are combining and reviewing results of annual pelagic ecosystem surveys to provide indices for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in the Northeast Atlantic, Norwegian Sea, North Sea, and Western Baltic; and to coordinate timing, coverage, and methodologies for the upcoming 2024 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2024 pelagic acoustic surveys are available from the WGIPS report (ICES 2024, WGIPS). The following text refers only to the surveys of relevance to HAWG.

North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys (HERAS) in 2023: Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland, Malin Shelf.

The estimate of **North Sea Autumn Spawning herring** spawning stock biomass is slightly lower than the previous year at 1.89 million tonnes (2022: 1.96 million tonnes) despite an increase in the number of mature fish from 10 348 million fish in 2022 to 11 069million fish in 2023.

The 2023 estimate of **Western Baltic Spring Spawning herring** 3+ group is 45 000 tonnes and 319 million. Compared to the 2022 estimates of 77 000 tonnes and 483 million fish, this equals a further decrease of 42% in biomass and is yet again the lowest estimate in the time series.

The **West of Scotland herring** estimate (6.a.N) of SSB in 2023 is 144 000 tonnes and 943 million individuals, which is a ~19% decrease in biomass and a ~10% decrease in abundance compared to the 177 000 tonnes and 1 052 million herring estimate in 2022.

The 2023 SSB estimate for the entire **Malin Shelf area (6.a and 7.b, c combined)** is 167 000 tonnes and 1 158 million individuals. This is 28% lower than the 2022 SSB estimate (233 000 tonnes) and 20% lower than the 2022 abundance estimate (1 442 million herring). There were again low numbers of herring found in the northernmost strata (to the north of Scotland and east as far as the 4˚W line) in 2023, which is similar to recent years. Mature herring were distributed mostly in deeper and cooler areas (>150m deep) in 2023, to the southwest of Barra between the 56°N and 57°N degree lines, and also in an area south of St. Kilda in deep water. There were more immature herring found in 2023, particularly to the north of Lough Swilly where there was good evidence of 0-wr and 1-wr herring. There were also 0-wr herring found in the Minch in 2023

For consistency, the survey results continue to be presented separately for sprat in the North Sea and Skagerrak-Kattegat although these two stocks were combined in a benchmark in 2018 (ICES 2018 WKSPRAT).

The total abundance of **North Sea sprat** (Subarea 4) in 2023 was estimated at 73 402 million individuals and the biomass at 707 000 tonnes. This is around the same level as the previous year, and above the long-term average of the time series (44% in terms of abundance and 50% for biomass). The stock is dominated by 1-year-old sprat (55% in biomass). The estimate of 0-group sprat, which only occasionally is observed in the HERAS survey, was 6% in numbers and 1% in biomass compared with the totals.

For **Div. 3.a,** the sprat age 1+ abundance in 2023 was estimated at 280 million individuals and the biomass at 3 345 tonnes. This is the lowest estimate of the time series in terms of biomass, and well below the long-term average both in terms of abundance (84% below) and biomass (86% below). The estimate is dominated by 1-year-old sprat.

Irish Sea Acoustic Survey: The herring abundance for the Irish Sea and North Channel (7.a.N) during 27 August – 11 September 2022 was reported by Northern Ireland. The herring stock estimate in the Irish Sea/Northern Channel area was estimated to be 118,023 tonnes. The major contribution of ages to the total estimates are from ages 1–3 fish by number and weight. The herring were fairly widely distributed within mixed schools at low abundance with a few distinct, high abundance areas. The bulk of age-1+ herring were observed west of the Isle of Man and off the eastern Northern Irish coast. The estimate of herring SSB of 61,805t is within the observed range for the time series and the biomass estimate of 111,012t for 1+ ringers for 2022 also remains within the observed range since 2011. Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the most abundance of 0-group herring in the eastern side and in areas along the northern Irish coast to the west.

Irish Sea spawning acoustic survey: A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The survey uses a stratified design similar to the Irish Sea Acoustic survey [AC(7.aN)]. Survey methodology, data processing and subsequent analysis is the same as for AC(7.aN) and follows standard protocols for surveys coordinated by WGIPS. The survey is included in the assessment as an SSB index. The major contribution of ages to the total estimates is from ages 2 fish by number and 3 by weight. The herring were distributed within a few distinct high abundance areas to the west and east of the Isle of Man. The estimate of herring SSB of 58,267 tonnes for the 2022 acoustic survey is a decrease from 70,859 tonnes in 2021. The survey estimates are influenced by the timing of the spawning migration.

Celtic Sea herring acoustic survey (CSHAS): Herring and sprat abundance for the Celtic Sea in October 2022 was reported by the Marine Institute, Ireland. The survey was carried onboard the new

RV Tom Crean. Geographical coverage was 21% lower than in 2020 due to the availability of the vessel to conduct the work program fully. Effort was focused on core distribution areas and these were covered successfully and with comparable effort and timing. The stock was considered contained within the core Celtic Sea survey area.

The 2022 total standing stock estimate was 12,533 t and 113 million individuals (CV 1.24) and represents an increase of 21% from the 2020 estimate in terms of total stock biomass and a reduction in terms of abundance of 174%. The reduction in abundance can be accounted for by the contribution of mature individuals encountered compared to 2020 estimate that was dominated by immature fish.

The stock is dominated by 3-wr fish representing 52.2% of the total biomass (TSB) and 50.6% of total abundance (TSN). Immature 0-wr fish accounted for 1.1% of TSB and 10% of TSN.

The biomass of sprat (TSB) was 34,508 t and the TSN 5,235 mill individuals, an increase on the 2021 estimates (12,376 t and 3,018 mill ind.). The inshore distribution of sprat observed in 2021 was not observed in 2022 with fish widespread across the survey area.

Pelagic ecosystem survey in Western Channel and eastern Celtic Sea (PELTIC): This survey was conducted by Cefas, UK, in the Western Channel and eastern Celtic Sea in October 2022. Significant issues, including catastrophic engine failure, reduced the survey from its scheduled 35 days to 13. Coverage was reduced to less than 30% of the originally planned area and the English waters of the western Channel were prioritised as this would minimise impact on the two stock assessments (sprat in 7.d.e and sardine in 7). The "sprat stratum", used in the assessment, was completed but the scheduled French waters of the English Channel, Bristol Channel and Cardigan Bay were not. Even when the vessel was operational, fishing activities were compromised (trawl number = 12), although the catches provided good quality biological data and sufficient information to identify the species composition of the acoustic backscatter. Sprat biomass in the core survey area used for the assessment was 28,439 t which was a significant reduction from the exceptionally high 2021 value but more in line with the average biomass since 2017. Another recruitment pulse was observed in the data. As in previous years, the highest quantities were found in Lyme Bay, although high numbers of sprat were also found further west, around Eddystone.

Baltic International Acoustic Survey (BIAS): This survey is conducted throughout the Baltic Sea during the months of September-October with participation of the different Baltic countries. BIAS is coordinated by the Working Group on Baltic International Fish Survey (WGBIFS). Germany is responsible for the survey covering the western Baltic and the Kattegat (SDs 21-24). The results of the **German Autumn Acoustic Survey (GERAS)** are presented to WGIPS and WGBIFS, whereas mainly the herring data are of interest for WGIPS and the sprat data for WGBIFS, respectively. The GERAS-index, which refers only to Western Baltic Spring-spawning herring (WBSSH), is used within the assessment of the Herring stock in Division 3a and subdivisions 22–24 (see Chapter 3). Mixing with the adjacent central Baltic herring stock generally occurs in SD 24 and in 2021 also in SD 21-23. The GERAS-index is routinely adjusted to account for the mixing of the two stocks. The adjustment is based on growth parameters.

The 2022 GERAS-index was estimated to be 0.25 x 10^9 fish or about 15.79 x 10^3 tonnes in subdivisions 21–24. The biomass index in 2022 represents the lowest in the time series.

1.3.2 WGQUALITY, WGBIOP and WGCATCH

Operationalising the outputs from the former PGDATA (final report), now falls within the remit of the ICES working group on the Governance of Quality Management of Data and Advice (WGQuality), which held its first meeting in January 2021. Supporting the objectives of the ICES Advisory Plan, WGQuality work focusses on developing and promoting quality assurance within ICES advisory processes - from data management, data integration, data analysis, and data use, to the process of translating that data into ICES advice. It is affiliated to the Data Science and Technology Steering Group (DSTSG), which is also the parent group for WGBIOP and WGCATCH. These three groups work together to ensure the quality of data going into stock assessments and development of methods for identifying improvements in data quality, or collections of new data, that have the greatest impacts on the quality of advice.

WGBIOP focusses on the quality of biological parameters collected and used in assessments and advice. This includes age and maturity, but also other biological parameters. WGBIOP coordinates the practical implementation of quality assured and statistically sound development of methods, standards, and guidelines for the provision of accurate biological parameters for stock assessment purposes. The overall aim for WGBIOP is to review the status of current issues, achievements and developments of biological parameters and identify future needs in line with ICES requirements and the wider European environmental monitoring and management.

As biological parameters are among the main input data for most stock assessment and mixed fishery modelling, these activities are considered to have a very high priority. The main link between assessment working groups and WGBIOP is through the benchmark process. WGBIOP works in association with the BOG (ICES Benchmark Oversight Group), reviewing all available issue lists, providing information on listed issues, identifying missing issues in relation to specific stocks and guiding the process to get issues related to biological parameters resolved. WGBIOP tries to align its scheduling of age and maturity calibration exchanges and workshops with the ICES benchmark prioritization system. WGBIOP has a close working relationship with WGSMART (The Working Group on SmartDots Governance) and have in cooperation developed and keep advancing the SmartDots tool as a platform for supporting the provision of quality assured biological parameter data to the end-users.

The last WGBIOP (October 2023) reviewed the following activities falling within its remit and of interest for HAWG:

- There were no workshops or exchanges planned for herring (*Clupea harengus*) and sprat (*Sprattus sprattus)* stocks assessed by HAWG.

Planning of future workshops and exchanges

- An otolith exchange of Western Baltic spring spawning will be conducted in 2024.

.WGCATCH continues to document national fishery sampling schemes, establish best practice and guidelines on sampling and estimation procedures, and provide advice on other uses of fishery data. The group evaluates how new data collection regulations, or management measures (such as the landings obligation) will alter how data need to be collected and provide guidelines about biases and disruptions this may induce in time-series of commercial data. WGCATCH also develop and promote the use of a range of indicators of fishery data quality for different types of end-users. These include indicators to allow stock assessment and other ICES scientists to decide if data are of sufficient quality to be used, or how different datasets can be weighted in an assessment model according to their relative quality.

WGCATCH 2021 continued to focus on how to communicate relevant information about sampling design and estimation to ICES assessment working groups, how to get a better process around delivering quality catch data for benchmarks. In respect to estimation, the focus was and will be on how to incorporate none-responses in the estimation and estimation of rare event. The first will be explored intersessional and the latter will be explored in an ICES workshop in autumn 2022. In respect to the small-scale fisheries, WGCATCH 2021 updated and refined the risk assessment for transversal data quality methodology and continued to document the sampling effort on biology for this part of the fleet. Further, the group continued the close relation to WGBYC and the RDBES.

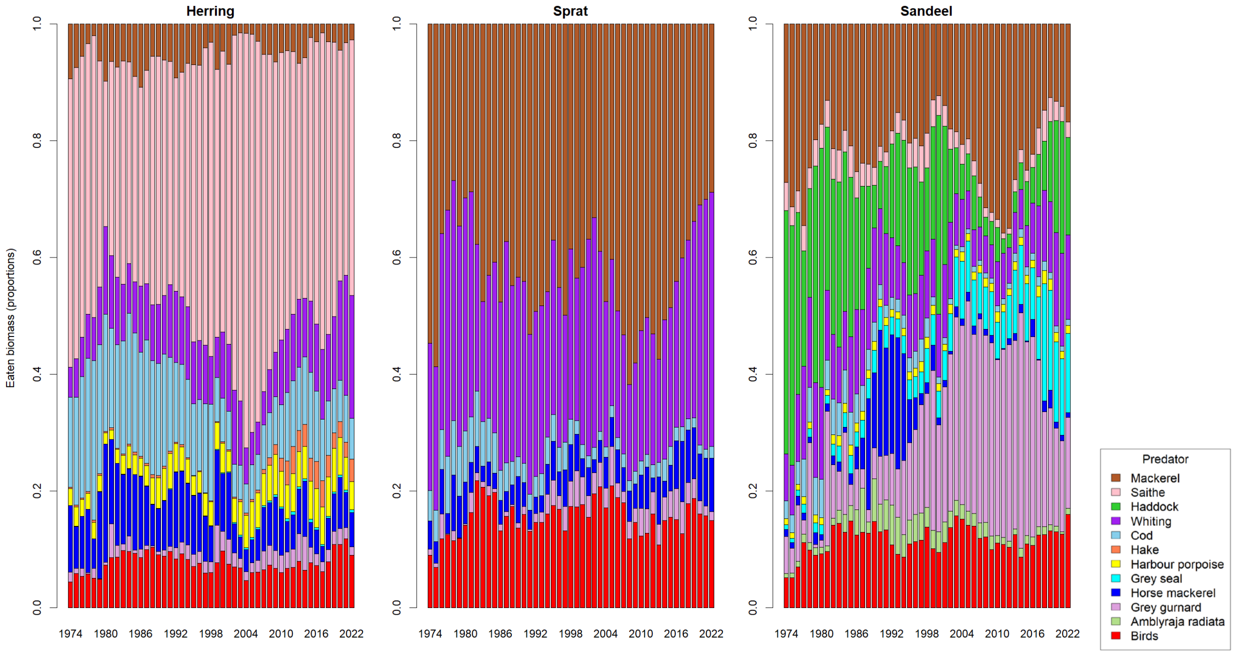
1.3.3 WGSAM

The Working Group on Multispecies Assessment Methods WGSAM provides estimates of natural mortality (M) for a number of fish stocks based on estimates from multispecies models. WGSAM provides M estimates for the following HAWG stocks: North Sea herring, North Sea sprat, sandeel in SA1r, and SA3r. At the end of 2023, new estimates of predation mortality became available based on an updated stochastic multispecies model (SMS, Lewy and Vinther 2004) for the North Sea (ICES 2024. The updated SMS model extends to input time-series to 2022 and includes a more extensive revision of the time-series of marine birds and grey seal population numbers. WGSAM recommended the use of natural mortality estimates from the North Sea SMS keyrun for use in the single specie stock assessment models for the HAWG stocks mentioned above.

In the SMS model, predators include both assessed species (i.e., cod, haddock, saithe, whiting, mackerel) and species with given input population size (North Sea horse mackerel, western horse mackerel, grey gurnard, starry ray, hake, fulmar, gannet, great black backed gull, guillemot, herring gull, kittiwake, puffin, razorbill, grey seal, and harbour porpoise). The assessed predators are parametrised using a combination of commercial and survey data (i.e., same input as for the single species assessments) except saithe and mackerel which are closely tuned to the ICES stock assessment by using number-at-age from the single species assessment models as input of SMS.

Main changes to input data of the 2023 keyrun include:

- Update of “single-species data” (catch-at-age numbers, mean weights, proportion mature, survey indices, etc.) with use of the most recent ICES assessment input data for all predator and prey fish stock. In many cases the time series are the results of revisions through benchmarks and inter-benchmarks
- Complete revision of the time series of sea birds abundance which is now based on information from Dierschke et al. (2022)
- Update of the time series of grey seal number. Grey seal numbers were last updated in 2011 and assumed a stable seal population after 2009 based on the old impression at that time that the seal population was levelling off. The following assessments of the seal population carried on by OSPAR proved this assumption to be wrong as the North Sea grey seal population has been steadily increasing until present. Moreover, the estimated number of seals is now extrapolated from the UK coast to the whole North Sea, although is noted that most grey seals are on the UK coast.
- Update of the grey seal diet data with one extra year of data now including the years 1985, 2002, 2010
- Calculation of fish diet from compilation of fish stomachs used the new R-package ‘FishStomach’ https://github.com/MortenVinther/FishStomachs. Other than enhanced transparency and reproducibility, the new approach to the caculation of fish diet allowed estimation of variance of the estimated prey proportions from the observed stomachs which could be used as input to the multispecies model.



Comparison with previous values of predation mortalities suggest:

- **Herring** - Predation mortalities of herring follows the same trends in the two key-runs, despite some annual differences. The most consistent changes are a lower M2 for age 0-1 and a higher M2 for ages 2- 4 in the 2023 key-run. For age 4, the increase in M2 is due to a higher partial M2 from saithe and harbour porpoise.
- **Sprat** - For sprat, is downscaled for age0-1 at the beginning of the time series while for ages 2+ an upward scaling is estimated in the 2023 run, mainly due to a higher M2 from mackerel and in the last decade due to an increasing predation pressure from whiting.
- **Sandeel** - M2 for the northern sandeel (used as proxy for SA3r) is generally lower in the 2023 keyrun. This can be explained mainly by the fact that sandeel in the grey seal diet was in the past assumed to be entirely composed by the northern sandeel while in the 2023 keyrun the seal diet is split into a northern and southern sandeel. For the same reason, M2 for the southern sandeel (used as proxy for SA1r) for ages 2-4 is upscaled especially since the early 2000s as the southern sandeel now contributes to the grey seals diet.

Overall, the model structure and main assumptions are consistent with the previous key run. Based on an internal review process, WGSAM considered the new key run appropriate in relation to the purpose of providing predation mortality estimates.

1.3.4 MIK surveys

Down's herring recruitment information

Following a period of good agreement, the numbers of 0- and 1-ringers derived from the IBTS-Q1 (MIK and Bottom Trawl, respectively) have recently differed in their trends (year classes 2019-2022). The Downs component, which in 2023 represented half of the overall spawning stock biomass, is not included in the IBTS-Q1 0-ringer index due to the late emergence of Downs larvae relative to the timing of the IBTS-Q1 survey. In contrast, the IBTS-Q1 1-ringer index includes all components of the NSAS herring stock. The recent increase of the Downs component is probably one of the main reasons for the observed differences between the trends in the two time-series. The potential effect of not including all components in the 0-ringer index is illustrated in Figure 4.3.4.1, which shows that the variance of the 0-ringer index, as estimated by the SAM model, has dramatically increased over the period 2013-2023. During this period the contribution of the

Downs herring component to the overall SSB has increased from 20% to over 50% (see Figure 4.3.4.1). The Downs Recruitment Survey (DRS) in April, which-started in 2018, is expected to provide a consistent abundance index for the Downs component. Combining this DRS index and the IBTS Q1 0-ringer index will probably lead to lower variance.

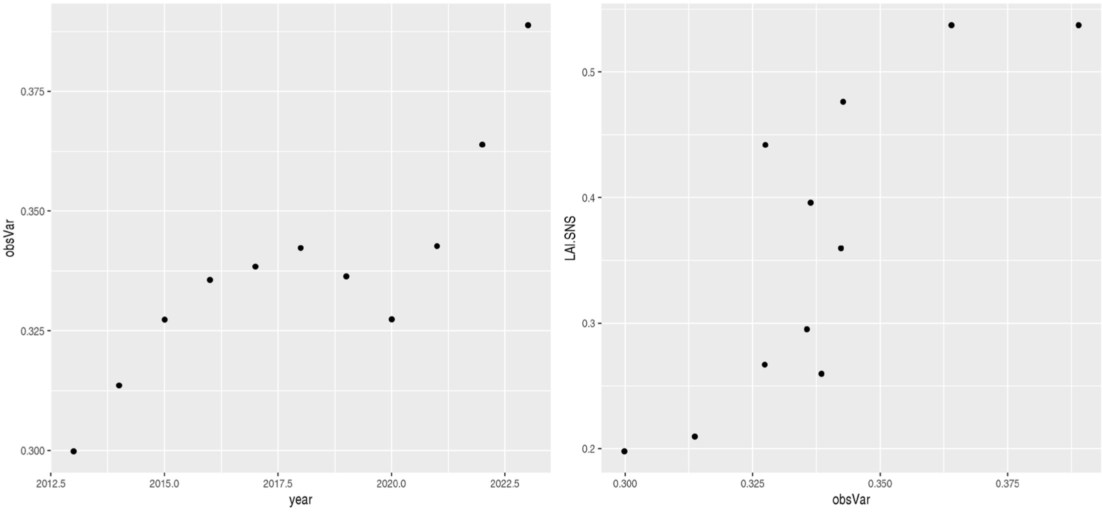


Figure 4.3.4.1. NSAS herring age 0 index: Observed variance of the IBTS0 index by the SAM model over time (left), and contribution of the Downs component (LAI SNS) to the overall LAI index (right).

In 2016, WKHERLARS evaluated the North Sea herring larvae surveys (ICES, 2016), and concluded that the current IBTS-Q1 MIK recruitment index does not contain information on the Downs spawning component. It was recommended to investigate the possibility to collect data to include information on Down's recruitment. In 2017, the effect of omitting one of the three IHLS surveys, carried out on the Downs component, from the herring assessment was investigated. The omission resulted in a negligible effect, and it was, thus, decided to drop the Dutch IHLS participation in the second half of January. The vessel time and budget of this survey was instead used to conduct a Downs Recruitment Survey (DRS) in April.

The DRS was carried out in April from 2018 to 2023. But due to COVID-19 measures it was not possible to carry out a DRS in 2020. The DRS is carried out following the IBTS-Q1 MIK protocol. However, sampling has been carried out both day and night, instead of only at night. Comparative fishing trials to check for difference in catchability between day and night were undertaken in April 2021 and 2023. The results showed that night time catches are much higher, and WGSINS decided that sampling should only be undertaken during night time from 2024 onwards. Furthermore, the previous survey capacity (Netherlands and Norway) will be expanded in 2024, with participation of Germany and an additional week of sampling by the Netherlands. It is planned to cover the southern North Sea and German Bight only sampling at night, in an area similar to the surveys from 2018 to 2023.

HAWG has a positive view on the continuation of the Downs Recruitment Survey (DRS) but cannot include the survey in the advice based on the current time series available. HAWG foresees potential future use of a combined IBTS0-DRS recruitment index for NSAS in the advice if the DRS surveys are continued.

HAWG recommends that WGSINS investigates calculation of a separate Downs and a combined NSAS recruitment index based on the combination of the IBTS0 and DRS data. WGSINS started investigating a combined index calculation. This work will be continued and is planned to befinalised at the WGSINS meeting in November 2024.

1.3.5 Stock separation of herring in surveys and catches

The mixing of herring stocks in surveys and catches is an issue in many of the stock assessments carried out in HAWG. Until 2022 only the mixing between North Sea herring and Western Baltic Spring-spawning herring (in the catches, in the HERAS and IBTS surveys) and between Western Baltic Spring-spawning herring and Central Baltic herring (limited to the GERAS survey) were routinely quantified and accounted for in the assessments. In 2022 the 6.a, 7.b-c stocks were delineated based on the results of genetic stock identification for the first time, thus enabling separate assessments for the 6.a.S, 7.b.c stock and the 6.a.N autumn spawning stock. The development of operational methods to enable estimation of proportion contribution from different stock in catches and survey indices throughout the management areas for herring assessed by HAWG is a topic that HAWG continues to have high on the list of issues to solve to improve upon assessments. Several ICES workshops have been held to progress this topic, most recently and WKSIDAC2 in 2023 and WKMIXHER in 2018. Another meeting of WKSIDAC is schedule in June 2024. An update on progress of those projects dealing with stock identification and mixing of relevance to HAWG is provided below.

Update on Stock Identification of 6.a, 7.b-c Herring

Atlantic herring west of Scotland and northwest of Ireland comprise at least two reproductively isolated biological populations. A comprehensive update on the stock identification and discrimination of herring in 6.a, 7.b-c is provided in Chapter 1 of the 2022 HAWG report. Significant updates for 2024 include:

Genetic sampling of the commercial catch, which began in 6a South in the 2022 fishing season, was continued in 2023. This is hugely important and will allow the splitting of the commercial catch index when the stocks expand and fishing returns to mixed feeding aggregations on the Malin Shelf. Until now, regular genetic sampling was only conducted on the acoustic survey (MSHAS). Splitting of the commercial catch was not yet necessary as the low monitoring TAC resulted in catches being taken close to shore at times when the stocks were geographically isolated.

It is also important to periodically update the genetic baseline (i.e. spawning samples) to guard against temporal drift and to continually improve the power of the assignment model. There is a particular need for more baseline samples of spring-spawners in order to reduce the 6.a Spring and unassigned categories of the split index. Recently, two spring spawning samples were secured and added to the potential baseline and efforts continue to secure more.

Updates on tools to split herring populations

Atlantic herring has one of the, to date, best described genomes which has allowed for a genetic inventory of a broad representation of all major stock units in the Northeast Atlantic (Han et al. 2020; Bekkevold et al. 2023). Based on recent work, robust genetic assays to split mixed-stock aggregations have been developed and implemented (Bekkevold et al. 2023; Farrell et al. 2022; ICES 2024). Work has e.g., demonstrated unprecedented accuracy in stock-splitting between North Sea autumn spawning herring, NSAS, her.27.3a47d, and Downs winter spawning herring, her.27.3a47d; between Western Baltic spring spawning herring, WBSSH, her.27.20-24, and NSAS; between WBSS and central Baltic Sea spring spawning herring, CBH (her.27.25-2932); and between Norwegian spring spawning herring, NSS, her.27.1-24a514a, and WBSS (Bekkevold et al. 2023). The work has facilitated the development of a comprehensive genetic database of all main spawning components feeding in areas 4ab and 3a. Genetic splitting of NSAS and WBSS is now fully implemented in data from the Danish, Swedish and Norwegian commercial catches, in the Danish and Norwegian parts of HERAS, and in the Danish and Swedish parts of the IBTS.

Currently, information about additionally occurring stocks in 4ab/3a, such as NSS, Baltic Sea Autumn Spawning herring and Baltic Sea spring spawning herring is not used, and fish of other origin have been assigned as either NSAS or WBSS for consistency with previously used methods (see WD XXX). Genetic marker-based splitting has thus replaced the methods of vertebral count, otolith shape and microstructure data. Applied splitting methods will become consistent between labs and countries as of 2022. The benefit of using genetic methods to identify stock components, in comparison with traditionally implemented phenotyping methods, has been demonstrated for different approaches (Berg et al. 2021; Farrell et al. 2022, Bekkevold et al. 2023).

1.3.6 WKDLSSLS

The Workshop on Data Limited Stocks of Short-Lived Species 3 (WKDLSSLS3) held in 2021 built on the work of the previous two workshops in 2019 (WKDLSSLS) and 2020 (WKDLSSLS2) to further develop methods for stock assessment and catch advice for category 3–4 short-lived species. Work was carried out to evaluate the appropriateness of the management procedures based on direct use of survey indices (for category 3 stocks). For sprat in 7d,e, the effect of seasonal advice schedule (July-June) was investigated. During the stock's inter-benchmark, an annual MSE was not able to investigate within-year processes. A novel intra-annual MSE (Mildenberger et al., 2021) was parameterised for the stock, accounting for seasonal growth and exploitation. The timing and lag between events within the year (e.g., survey observation, implementation of advice, recruitment) affect the performance of Harvest Control Rules (HCR). WKDLSSLS3 concluded that the inter-benchmark decision of 8.57% Constant Harvest Rate (CHR) seems to be appropriate. The group examined the effect of applying an 80% uncertainty cap (UC) to the CHRs. The conclusion from this was an UC resulted in minimal risk reduction for CHR's below the 5% risk threshold. It did reduce risk for CHR's that are too high but could not bring them below the ICES risk threshold. The only significant difference between CHR and CHR+UC was a decrease in interannual variability in the stock. The group found that unconstrained CHRs appear robust to past fishing history, initial stock status and advice schedule but are sensitive to survey catchability. No recommendations from the WKDLSSLS were made in regard to applying a UC to CHR's.

1.3.7 Other activities relevant to HAWG

Ichthyophonus

Ichthyophonus hoferi is a parasite found in fish. It has a low host-specificity, has been observed in more than 80 fish species, mostly marine, and is common in herring, haddock, and plaice. *Ichthyophonus* belong to the Class Mesomycetozoea, a group of micro-organisms residing between the fungi and animals (McVivar and Jones, 2013). Epidemics associated with high mortality have been reported several times for Atlantic herring: in 1991–1994 for herring in the North Sea, Skagerrak, Kattegat, and the Baltic Sea (Mellergaard and Spanggaard, 1997), and in 2008–2010 for Icelandic summer-spawning herring (Óskarsson and Pálsson, 2011). A time-series of the Norwegian data on *Ichthyophonus* was presented at HAWG 2017. The occurrence is usually below 1%, except for the beginning of the 1990s, but high occurrences (22%) were again observed again in the Norwegian IBTSQ1 2017 in the North Sea. Because of the high lethal level of this parasite and episodic outburst, HAWG 2017 decided to continue monitoring the level of *Ichthyophonus* infestation in the following years and Sweden extended the coverage of the sampling to the Skagerrak and Kattegat since 2017 IBTSQ3. In the 2018-2024 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again low: 4.4%, <1%, 1.2%, 0.6%, zero, the last two years 0.2%, respectively. In the Kattegat-Skagerrak, the IBTS data suggests levels of incidence generally < 3% but occasionally ICES rectangles with > 20% infestation have been observed in some recent years 2017-2018. The level of infection is comparable between the two quarters of the IBTS, and it remains low in 2022 in both the quarters and among all the ages. Swedish commercial samples from 2022 confirm low levels of infection in both the Kattegat and Skagerrak (average infestation <1.5%) and throughout all the quarters sampled based on visual inspection. It is relevant that all countries continue to screen herring for *Ichthyophonus* during the IBTS surveys (both Q1 and Q3) and HERAS, as well as for the commercial sampling.

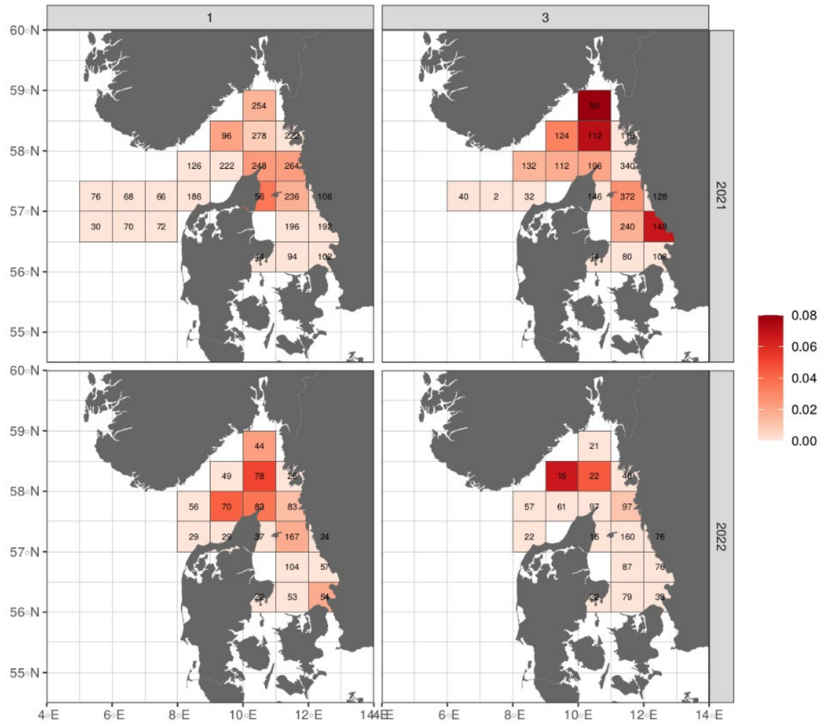


Figure 1.3.8.1 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ1,3 2021-2022. The maps with distribution of the proportion of infested herring and number of samples in each rec- tangle.

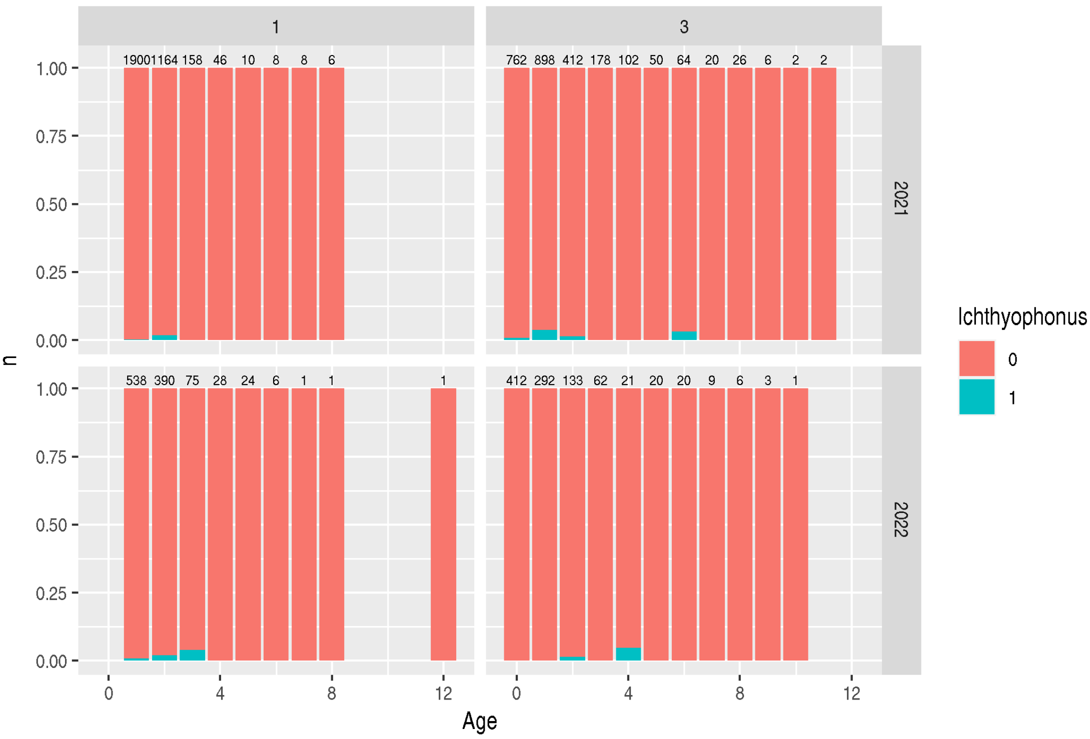


Figure 1.3.8.2 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ1,3 2021-2022. Distribution of infestation among ages.

Regional Database and Estimation System (RDBES)

The RDBES will be in production late summer 2023 – and ICES will launch a data call including commercial effort statistic, landings statistics and sample data for all species and including HAWG stocks.

In 2023, three workshops will be held in relation to the RDBES, WKRDB-INTRO, WKRDBES-RAISE&TAF-FLOW and WKRDBES-RAISE&TAF). The latter will be held in autumn and supports the migrating of present estimation routines to TAF. Furter, an ICES working grouping, WGRDBES-EST, is developing a R package, RDBEScore, with design based and model assisted estimators using the RDBES format as input.

Further information about the RDBES status and roadmap can be found in ICES (2023).

1.4 Commercial catch data collation, sampling, and terminology

1.4.1 Commercial catch and sampling: data collation and handling

Input spreadsheet and initial data processing

Since 1999, the Working Group members have used a spreadsheet to provide all necessary landing and sampling data. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the required standard outputs on sampling status and biological parameters. It documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another dataset.

Since 2015, ICES requested relevant countries within a data call to submit the national catches into InterCatch or to accessions@ices (via the standard exchange files). National catch data submission was due by 27th February 2024. All but two countries delivered their data in due time.

"InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models". Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. However, InterCatch does not provide the output as needed for the assessment of NSAS and WBSS. Both data collation methods are, therefore, still used in parallel.

Excel was used to allocate samples to catches for 6.a following the same procedure outlined in WD01 to HAWG 2017.

More information on data handling transparency, data archiving and the current methods for compiling fisheries assessment data are given in the Stock Annex for each stock. Figure 1.5.1 shows the separation of areas as applied to the data in the archive.

1.4.2 Sampling

Quality of sampling for the whole area

The level of catch sampling by area is given in the table below for all herring stocks covered by HAWG (in terms of fraction of catch sampled and number of age readings per 1000 tonnes catch). There is considerable variation between areas. Further details of the sampling quality and the level of samples can be found by stock in the respective sections in the report and the stock annexes.

Area	Working Group Catch	Sampled Catch	Age Readings	Age Readings per 1000t
4.a(E)	93663	91753	3345	36
4.a(W)	251426	212844	7757	31
4.b	34560	22432	2268	66
4.c	7008	2121	50	7
7.d	34042	24923	815	24
7.a(N)	7208	6329	1680	233
3.a	727	167	149	205
SD22-24	637	470	2056	3228
7g, 7.j, 7aS	764	764	600	786
6.aN	1115	671	43	39
6.aS, 7.b and 7.c	1255	1255	1203	959

Given the diversity of the fleets harvesting most stocks assessed by HAWG, an appropriate spread of sampling effort over the different métiers is more important to the quality of catch-at-age data than a sufficient overall sampling level. The WG therefore recommends that all métiers with substantial catch should be sampled (including bycatches in the industrial fisheries), that catches landed abroad should be sampled, and information on these samples should be made available to the national laboratories and incorporated into the national InterCatch upload.

1.4.3 Terminology

The WG noted that for herring the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout the report. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age-based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

1.5 Methods Used

1.5.1 SAM

The Spate-space stock Assessment Model SAM described in described in Nielsen and Berg (2014) is currently used to assess several of the HAWG stocks. This model has the standard exponential decay equations to carry forth the Ns (with appropriate treatment of the plus-group), and the Baranov catch equation to calculate catch-at-age based on the Fs. The additional components of SAM are the introduction of process error down the cohort (additional error term in the exponential decay equations), and the random walk on Fs. The steps (or deviations) in the random walk process are treated as random effects that are "integrated out", so are not viewed as estimable parameters. The sigma parameter controls how large the random walk deviations are, and this parameter is estimated. SAM provides the option of correlated errors across ages for the random walks on F, where the correlation is an additional parameter estimated to be estimated. The current implementation of SAM is an R-package based on Template Model Builder (TMB) (Kristensen *et al.*, 2016) and is maintained and available at https://github.com/fishfollower/SAM. At WKPELA 2018 a multi-fleet version of SAM was presented (ICES, 2018) and it is currently used for the assessment and forecasts of Western Baltic Spring-spawning herring, and to provide fleet specific selection patterns for short and medium-term forecasts for the North Sea herring (Nielsen *et al.*, 2021).

SAM is currently run by HAWG via both the web browser at www.stockassessment.org and within the FLR (Fisheries Library in R) system (www.flr-project.org) which is an attempt to implement a framework for modelling integrated fisheries systems including population dynamics, fleet behaviour, stock assessment and management objectives. The stock assessment tools in FLR can also be used on their own in the WG context. The combination of the statistical and graphical tools in R with the stock assessment aids the exploration of input data and results.

Recent developments of SAM include notably the internal estimation of reference points (Albertsen and Trijoulet, 2020; Trijoulet *et al.*, 2021).

1.5.2 ASAP

The ASAP 3 (http://nft.nefsc.noaa.gov) model has been used for Celtic Sea herring. ASAP (A Stock Assessment Program) is an age-structured stock assessment modelling program (Legault and Restrepo, 1998). ASAP is a variant of a statistical catch-at-age model that can integrate annual catches and associated age compositions (by fleet), abundance indices and associated age compositions, annual maturity, fecundity, weight, and natural mortality-at-age. It is a forward projecting model that assumes separability of fishing mortality into year and age components but allows specification of various selectivity time blocks. It is also possible to include a Beverton-Holt stock-recruit relationship and flexible enough to handle data poor stocks without age data (dynamic pool models) or with only new and post-recruit age or size groups.

1.5.3 SMS

SMS is a stochastic multispecies assessment model, including seasonality, used for sandeel in Division 3.a and Subarea 4, and for sprat in the North Sea and 3.a. The model is run in single-species mode for these stock assessments. Major differences with the other stock assessment models used by HAWG is the ability to assess in seasonal time-steps, necessary to distinguish the fishing season and off-season for both the sandeel and sprat stocks. Furthermore, it integrates catches, effort time-series, maturity, weight, and natural mortality-at-age. The model allows to set separate selectivity year blocks to account for changes in the fishing fleet.

1.5.4 Short-term predictions

Short-term predictions for the North Sea used a code developed in R. The method was developed in 2009 and intensively compared to the MFDP approach. Celtic Sea herring and Irish Sea herring forecast used the standard projection routines developed under FLR package FLCore (version 2.6.0.20170228). For sprat in the North Sea, a forecast using the FLR framework is in use. North Sea herring is assessed using a fleet-wise projection method using native R and FLR routines (some maintenance of the code has been done this year mainly to improve readability and documentation). Herring in 6.a South, 7.b-c and herring in 6.a North do not utilise short term predictions. The Western Baltic Spring-spawning herring uses an R-based multi-fleet forecast routine available at www.stockassessment.org.

1.5.5 Reference Points

The eqsim software (https://github.com/ices-tools-prod/msy) was used in recent benchmarks to estimate MSY reference points for herring stocks of HAWG.

For sprat in the North Sea (Division 4) and sandeel in management area 1–4, the ICES guide for setting management reference points for category 1 stocks is used to find B_{lim}. MSY $B_{escapement}$ is equal to B_{pa} and is calculated as $B_{lim} \times e^{\sigma \times 1.645}$. An upper level on the fishing mortality is implemented (F_{cap}) if the average probability of getting below B_{lim} in long-term simulations is more than 5% per year. F_{cap} is calculated/optimized using a management strategy evaluation framework (MSE).

The 2018 benchmark (WKPELA 2018) of the North Sea herring, Western Baltic herring and Celtic Sea herring presented considerable challenges in the estimation of reference points and their calculation remains at times still controversial. An overview and critical discussion of those main challenges are provided in last year's report (ICES 2018, Section 1.2.6) and maintain their validity in the ongoing discussion on reference points.

New reference points were calculated for North Sea Herring during the 2021 inter-benchmark meeting (ICES, 2021). This resulted in a downward revision of the estimate of B_{lim} and MSY$B_{trigger}$ and an upward revision of the estimate of F_{msy}. Sensitivity testing revealed that the derivation of reference points for herring in the North Sea is very sensitive to the choice of time periods and stock–recruitment models used.

F_{pa} is defined as the exploitation rate reference point below which exploitation is considered to be sustainable, having accounted for assessment uncertainty. In 2020 a decision was made by ACOM to standardize the basis for F_{pa} whereby it is equal to the fishing mortality including the advice rule that, if applied as a target in the ICES MSY advice rule (AR) would lead to SSB ≥ B_{lim} with a 95% probability (also known as Fp05). The derivation of F_{pa} should include the expected stochastic variability in biology and fishery, as well as advice error.

Proxy reference points were derived for the category 3 stocks - herring in 6.a South, 7.b-c and 6.a North at the benchmark in 2022 (ICES, 2022). $F_{proxy\ MSY}$ for both stocks was calculated using data from 2014-2021. MSY $B_{trigger}$ is derived from the split acoustic survey biomass index and is 1.4*I_{loss} where I_{loss} is the lowest observed index value.

1.5.6 Repository setup for HAWG

To increase the efficiency and verifiability of the data and code used to perform the assessments as well as the short-term forecasts within HAWG, the resources for calculations are made available on github through the Transparent Assessment Framework (TAF)[1] and on https://www.stockassessment.org.

There is a dedicated github TAF that stored all repositories: https://github.com/ices-taf. The code and packages dependencies for each stock are stored under separate repositories each year, following ices stock code convention. The resources for the assessment model and forecast are also separated. For example, the resources for North Sea herring at HAWG 2023 are under:

- Assessment: git@github.com:ices-taf/2023_her.27.3a47d_assessment.git
- Forecast: git@github.com:ices-taf/2023_her.27.3a47d_forecast.git

The repositories under TAF are private and access should be requested (taf@ices.dk). The repositories are maintained by members of the WG. Contributing to the repository is not possible for outsiders as a password is required.

The work from HAWG was previously stored on https://github.com/ICES-dk/wg_HAWG.

1.6 Ecosystem overview and considerations

General ecosystem overviews for the areas relevant to herring, sprat and sandeel stocks covered by the Herring Assessment Working Group for herring stocks south of 62°N (HAWG) are given for the Greater North Sea and Celtic Seas Ecoregions (ICES, 2020e, f).

A more detailed account specific to herring is documented in ICES HAWG (2015). A number of topics are covered in this section including the use of single species assessment and management, the use of ecosystem drivers, factors affecting early life-history stages, the effects of gravel extraction, variability of the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that while numerous studies have greatly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics, further work is still required to move beyond simple correlative understanding and elucidate the underlying mechanisms. One specific case is the persistent decrease in mean weight-at-age for many of the herring stocks in the region (Figure 1.7.6). Furthermore, mechanisms to incorporate this understanding into the provision of management advice are limited. ICES could therefore benefit greatly from developments that unify these two aspects of its community.

[1] https://www.ices.dk/data/assessment-tools/Pages/transparent-assessment-framework.aspx

1.7 Summary of relevant Mixed fisheries overview and considerations, species interaction effects and ecosystem drivers, ecosystem effects of fisheries, and effects of regulatory changes on the assessment or projections for all stocks.

Brief summaries are given here; more detailed information can be found in the relevant stock summaries.

North Sea Autumn spawning herring (her.27.3a47d):

The North Sea herring fishery is a multinational fishery that seasonally targets herring in the North Sea and Eastern English Channel. An industrial fishery, which catches juvenile herring as a by-catch operates in the Skagerrak, Kattegat and in the central North Sea. Most fleets that execute the fishery on adult herring target other fish at other times of the year, both within and beyond the North Sea (e.g., mackerel *Scomber scombrus*, horse mackerel *Trachurus trachurus* and blue whiting *Micromestistius poutasou*). In addition, Western Baltic Spring spawners are also caught in this fishery at a certain time of the year in the northern North Sea to the west of the Norwegian coast. The fishery for human consumption has mostly single species catches, although some mixed herring and mackerel catches occur in the northern North Sea. The bycatch of sea mammals and birds is also very low, i.e., undetectable using observer programmes. There is less information readily available to assess the impact of the industrial fisheries that bycatch juvenile herring. The pelagic fisheries on herring and mackerel claim to be some of the "cleanest" fisheries in terms of bycatch, disturbance of the seabed and discarding. Herring like other pelagic forage fish has a central ecological role in the North Sea ecosystem, directly interacting with zooplankton, demersal fish, and other predators (sea mammals, elasmobranchs, and seabirds). Thus, a fishery on pelagic fish may impact on these other components via second order interactions. There is a paucity of knowledge of these interactions, and the inherent complexity in the system makes quantifying the impact of fisheries very difficult.

Another potential impact of the North Sea herring fishery is the removal of fish that could provide other "ecosystem services". The North Sea ecosystem needs a biomass of herring to graze the plankton and act as prey for other organisms. If herring biomass is very low other species, such as sandeel and sprat, may replace its role or the system may shift in a more dramatic way. Likewise, large numbers of herring can have a predatory impact on species with pelagic egg and larval stages.

The populations of herring constitute some of the highest biomass of forage fish in the North Sea and are thus an integral and important part of the ecosystem, particularly the pelagic components. North Sea herring has a complex sub-stock structure with different spawning components, producing offspring with different morphometric and physiological characteristics, different growth patterns and differing migration routes. Productivity of the spawning components varies. The three northern components (Autumn spawners) show similar recruitment trends and differ from the Downs component (Winter spawners), which appears to be influenced by different environmental drivers. Having their spawning and nursery areas near the coasts, means herring are particularly sensitive and vulnerable to anthropogenic impacts. The most serious of these is the ever-increasing pressure for marine sand and gravel extraction and the development of wind farms. Climate models predict a future increase in air and water temperature and a change in wind, cloud cover and precipitation. Analysis of early life stages' habitats and trends over time suggests that the projected changes in temperature may not widely affect the potential habitats but may influence the productivity of the stock. Relatively major changes in wind patterns may affect the distribution of larvae and early stage of herring.

Western Baltic Spring-spawning herring (her.27.20-24):

The Western Baltic herring fishery is a multinational fishery that seasonally targets herring in the eastern parts of the North Sea (Eastern 4.a and 4.b), the Skagerrak and Kattegat (Division 3.a) and Western Baltic (SD 22–24). The fishery for human consumption has mostly single-species catches, although in recent years some mackerel by-catch occurred in the trawl fishery for herring. In addition, North Sea herring are also caught within Division 3.a. The bycatch of sea mammals and birds is low enough to be below detection levels based on observer programmes. At present, there is a very limited and progressively decreasing fishery in Division 3.a and hence a limited by-catch of juvenile herring. The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of by-catch, disturbance of the seabed and discarding. Pelagic fish interact with other components of the ecosystem, including demersal fish, zooplankton, and predators (sea mammals, elasmobranchs, and seabirds). Another potential impact of the Western Baltic herring fishery is the removal of fish that could provide other "ecosystem services." There is, however, no recent research on multispecies or ecosystem interactions in which the WBSS interact. However, a fishery on pelagic fish may affect these other components via second-order interactions.

Dominant drivers of larval survival and year-class strength of recruitment are considered to be linked to oceanographic dispersal, sea temperatures and food availability in the critical phase when larvae start feeding actively. However, research on larval herring survival dynamics indicates that driving variables might not only vary at the population level and by region of spawning but also by larval developmental stage. Since WBSS herring relies on inshore, transitional waters for spawning and larval retention, the suite of environmental variables driving reproduction success potentially differs from other North Atlantic stocks recruiting from coastal shelf spawning areas.

Herring in the Celtic Sea and 7.j (her.27.irls):

There are few documented reports of bycatch in the Celtic Sea herring fishery. Small quantities of non-target whitefish species were caught in the nets. Of the non-target species caught whiting was most frequently followed by mackerel and haddock. The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. Occasional entanglement of cetaceans may occur, but overall incidental catches are thought to be minimal.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing. Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions. However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock. Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain in the Irish Sea for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock. The residence of Celtic Sea fish in the Irish Sea may have an influence on growth and maturity rates.

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. Herring are an important component of the Celtic Sea ecosystem. There is little information on the specific diet of this stock. Herring form part of the food source for larger gadoids such as hake. Research showed that fin whales *Balaenoptera physalus* are an important component of the Celtic Sea ecosystem, with a high re-sighting rate indicating fidelity to the area. There is the suggestion that the peak in fin whale sightings in November may coincide with the inshore spawning migration of herring.

Herring in 6.a North (her.26.6aN):

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish. Herring fisheries tend to be clean with little bycatch of other fish. Herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and seabirds.

The benthic spawning behaviour of herring makes this species vulnerable to anthropogenic activities such as offshore oil and gas industries, gravel extraction and the construction of wind farms. There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The 6.aN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then.

Herring in 6.a South and 7.b and 7.c (her.27.6aS7bc):

Sea surface temperatures from Malin head on the North coast of Ireland since 1958 indicate that since 1990 sea surface temperatures have displayed a sustained increasing trend, with winter temperatures > 6°C and higher summer temperatures. Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during winter larval drift.

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s.

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast and tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Herring in the Irish Sea (her.27.nirs):

The targeted fishery for herring in the Irish Sea is considered to have limited bycatch of other species. Herring are preyed upon by many species but at present the extent of this is not quantified. The main fish predators on herring in the Irish Sea include spurdog (*Squalus acanthias*), whiting (*Merlangius merlangus*) (mainly 0–1 ring) and hake (*Merluccius merluccius*) (all age classes). Small clupeids are an important source of food for piscivorous seabirds and marine mammals which can occur seasonally in areas where herring aggregate. While small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprat (*Sprattus sprattus*).

Stock discrimination techniques, tagging, and otolith microstructure and shape show that juveniles originating in the Celtic Sea are present in the Irish Sea. The majority of mixing between these populations occurs at winter rings 1–2. Over the period 2006 to 2010 interannual variation in the proportion of mixing was large, with between 15% and 60% observed in the wintering 1+ biomass estimate during the study period. Further work on stock identity is ongoing. There are irregular cycles in the productivity of herring stocks which are probably caused by changes in the environment (e.g., transport, prey, and predation).

North Sea and 3a sprat (spr.27.3a4):

Sprat is a short-lived forage fish that is predated by a wide range of marine organisms, from predatory gadoids, through birds to marine mammals. Therefore, the dynamics of sprat populations are affected by the dynamics of other species through annually varying natural mortality rates. Because sprat interacts with many other components of the ecosystem (fish, zooplankton, and predators) the fishery may impact on these other components via these food web interactions. It is uncertain how many sprat migrate into and out of adjacent management areas, i.e. the English Channel (7.d and 7.e) and the western Baltic and the Sound (SD22–24), or how this may vary annually. Uncertain is also the boundary with local populations occurring along the Scandinavian Skagerrak coasts. While genetic information has supported the exclusion of sprat along the Norwegian coasts from the current assessment unit, similar information was insufficient for the Swedish coasts despite the fact that local populations likely exist. Young herring as a bycatch is acknowledged for this fishery with bycatch regulations in force. The bycatch of marine mammals and birds is considered to be very low (undetectable using observer programs).

Sprat in the English Channel (7.d and 7.e) (spr.27.7de):

The fishery considered here is primarily in Lyme Bay with small trawlers targeting sprat with very little to no bycatch of other species. The relationship of the sprat in this area to the sprat stock or population in the adjacent areas is unknown: Sprat larvae most likely drift away from the main spawning area in Lyme Bay, but to which extent they expand westward into the Celtic Sea or eastern deep into the Eastern English Channel and the North Sea is unknown. The potential for mixed fisheries, if the fisheries are expanded to cover the whole of the English Channel, is unknown at present. It is acknowledged that sprat is prey for many species, and these will affect the natural mortality, however, this has not been quantified in this area. In addition, changes in the size of the sprat population through fishing will affect the available prey for a number of commercially exploited species.

Sprat in the Celtic Seas ecoregion (6 and 7 (excluding 7.d and 7.e)) (spr.27.67a-cf-k):

This ecoregion currently has fisheries in the Celtic Sea, northwest of Ireland and a variety of Scottish Sea lochs with the possibility of fisheries being revived in the Clyde. Generally, mixed fisheries are not an issue as sprat are targeted with very little to no other species caught as a bycatch. If a fishery was to be prosecuted in the Clyde and Irish Sea, then bycatch of young herring may become an issue due to the overlap in distribution between young herring and sprat. It is acknowledged that sprat are prey for many species and these will affect the natural mortality, however, this has not been quantified in this area. Since sprat preys on e.g., zooplankton and is preyed upon by many species fisheries for sprat can have effects on the ecosystem dynamics.

Sandeel in the North Sea ecoregion (san.sa.1r-7r)

A mosaic of sandeel fishing grounds occur throughout different areas of the North Sea ecoregion. The grounds present different degrees of larval connectivity which has supported the division of sandeel in the North Sea into a number of more or less reproductively isolated subpopulations. Whereas the fishing grounds are assumed to remain relatively constant over time, the actual distribution of the fishery varies greatly from year to year in response to both changes in the availability of sandeel and changes in management between areas.

Sandeel is targeted by a highly seasonal industrial fishery which has experienced a progressive change towards fewer larger vessels owing most of the quota since the introduction of ITQ in 2004. Time and area restrictions and bycatch limits represent the main management measures. Although the fishery has little bycatch of protected species, competition with other predators is a central aspect of the sandeel management within an ecosystem approach. Worth mentioning, although the fishery targets a single species of sandeel (*Ammodytes marinus*), several other species of sandeel are caught in the fishery, but not really quantified because it is assumed that they contribute to a minority of the catches in most areas.

Sandeel play an important role in the North Sea food web as they are a high quality, lipid-rich food resource for many predatory fish, seabirds, and marine mammals. Concerns of local depletion exist, especially for those sandeel aggregations occurring at less than 100 km from sea-bird colonies as some bird species (i.e., black-legged kittiwake and sandwich tern) may be particularly affected. More mobile marine mammals and predatory fish are likely to be less vulnerable to local sandeel depletion.

1.8 Stock overview

The WG was able to perform analytical assessments for 9 of the 17 stocks investigated. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in figures 1.8.2–1.8.5.

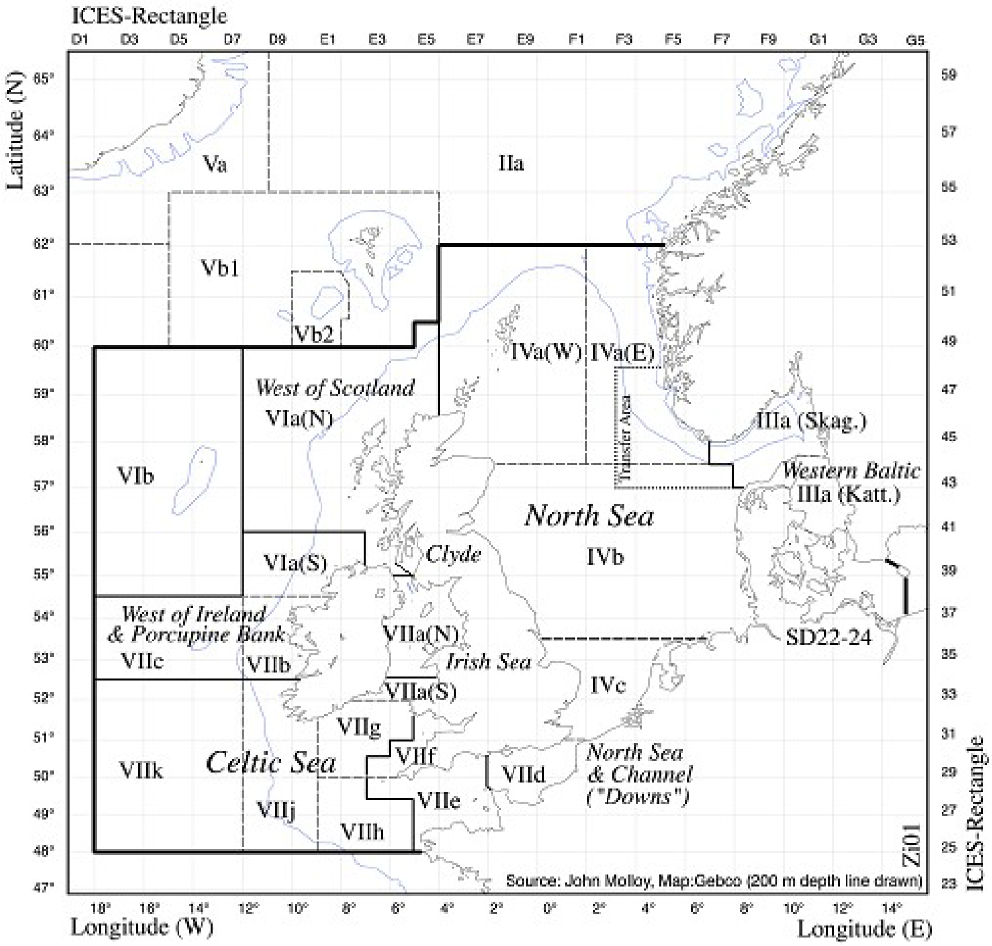


Figure 1.8.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North Sea to the Baltic Assessment.

North Sea autumn spawning herring (her.27.3a47d) is the largest stock assessed by HAWG. The spawning-stock biomass was low in the late 1970s and the fishery was closed for a number of years. This stock began to recover until the mid-1990s when it appeared to decrease again. A management scheme was adopted to halt this decline. Since 2019, no management plan is in place for North Sea Herring. The input of new natural mortality derived from the most recent SMS key run (2023) resulted in a revision of the reference points. Based on the WG assessment, the stock has been harvested at MSY since 1997 (fishing mortality below F_{MSY}=0.32 and SSB above MSY $B_{triggger}$=1 131 601 t). The SSB in 2023 (1 519 404= t) is estimated to be similar to that predicted in the previous advice (+3%). The 2025 advised catch of NSAS herring is decreased by 2.5% compared to last year. This decrease mainly results from the substantial downward revision of the 2022 year class contributing to the SSB in the advice year, which is now estimated to be lower than that estimated in the previous advice (-62%)..

Western Baltic Spring Spawners (her.27.20-24) are distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the subdivisions 22, 23 and 24. In the eastern part of North Sea and Division 3.a, the stock is considered to mix with North Sea autumn spawners and mixing with Central Baltic herring stock has been taken into account in the GERAS survey indices. Recent genetic work shows high mixing in the whole management units with other herring populations, and this mixing is not currently taken into account in the assessment. The stock has decreased consistently since the late 2000s. The 2020 SSB (41 929 t) and 2022 recruitment (475 494 thousand) are record low. The estimate of SSB in 2023 (66 152 t) is considered low, below both B_{pa} and B_{lim}. Fishing mortality (F_{3-6}) was reduced from 0.57 in 2008 to 0.30 in 2011. It increased and remained above F_{MSY} (0.31) over the period 2012-2019. F_{3-6} then decreased below F_{MSY} from 0.30 in 2020 to 0.05 in 2023, which is the lowest F_{3-6} on records. The 2025 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 72 116 t in 2024 to 79 917 t in 2025. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2026 (91 000 t). A medium-term forecast to 2027 showed that SSB can increase to 101 998 t if F=0 in 2025-2026 but will still remain below B_{lim}.

Herring in the Celtic Sea and 7.j (her.27.irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division 7.j have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The stock has fluctuated over time. Low stock size was observed from the mid-70s to the early 80s. The SSB increased again before declining in the late 90s. From 2005 the stock increased when several strong cohorts (2004, 2008, 2009, 2010 and 2013) entered the fishery and as they gained weight, they maintained the stock at a high level. The SSB has decreased since its peak in 2011 and is estimated to be 15 157 t in 20223 which is well below B_{pa} (54 000 t) and B_{lim} (34 000 t). Short-term projections predict an increase in SSB to increase to 21 017 t in 2024. Recruitment has been below average since 2013 and no strong cohorts have entered the fishery. The update assessment estimated mean F (2–5 ring) in 2023 to be 0.058, an increase from 0.028 in 2022 but decreasing from the high of 1.1 in 2017. F was estimated to be above F_{pa} (0.26), F_{MSY} (0.26) and F_{lim} (0.45) from 2015 until 2019. Since the introduction of the monitoring TAC in 2020, low F values between 0.02 and 0.058, have been seen each year.

Herring in 6.aN (her.27.6aN): Off the west of Scotland, the herring stock is composed of two groups - one spawning during spring (February until April) in the Minch and the other during autumn (late August until October) off Cape Wrath. Fisheries have historically targeted both groups, and their relative contribution is believed to have varied over time. These stocks were assessed together with herring in 6.a.S, 7.b.c during 2015-2021. The development of a genetically split acoustic survey index for the Malin Shelf Herring Acoustic Survey (MSHAS) from 2014-2023 into the component stocks means that separate advice for 6.aN autumn spawners and 6.a.S, 7.b.c is now possible. 6.aN spring spawners are not fully resolved by the present method and are not assessed. The Malin Shelf herring estimate of SSB for autumn spawning herring in

6.aN in 2023 is 23 117 tonnes, which represents a decrease compared to 2022. Although estimates appear to be overall improving from the minimum value in 2019, it should be noted that numbers of herring to the West of Scotland are very low compared to historical estimates prior to the genetic split (ICES 2021a). Fishing pressure on the stock is at or below $F_{MSY\ proxy}$ (0.335) and the stock size index is above MSY $B_{trigger\ proxy}$ (14 711 t). There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys.

Herring in 6aS, 7b,c (her.27.6aS7bc): Herring to the northwest and west of Ireland in ICES Divisions 6.a.S, 7.b,c are primarily a winter spawning (Nov-Jan) stock, though later spawning in spring (Feb-Apr) also occurs. This stock was assessed together with herring in 6aN from 2015-2022. Following a benchmark which took place in 2022 these two stocks are now assessed separately. This was made possible by the development of a genetically split acoustic survey index. The ability to split the summer acoustic survey (MSHAS) from 2014-present into the component stocks means that separate advice is now possible. The survey index for herring in 6aS, 7b,c has generally increased since the lowest point in 2016 (36 707 t), however a declining trend has been observed since 2021 with SSB in the latest year, 2023, estimated to be 100 523 t. Recent catches are among the lowest in the time series. Fishing pressure on the stock is above $F_{MSY\ proxy}$, and the stock size index is above $I_{trigger}$ (51 390 t). There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Recruitment of the 2018 year-class was good and this year class is now 4 winter ring and accounted for 26% of the catch numbers at age in 2023.

Herring in the Irish Sea (her.27.nirs): comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its decline from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability of spawning migrations and mixing with the Celtic Sea stock. In addition, a technical issue was identified in the code of the wrapper package applied in the stock assessment model before HAWG met in 2024. The correct code was used in 2024, which resulted in a revision of the absolute perception both stock assessment and biological reference points compared to last year. In 2023, SSB and recruitment have been estimated at 9 135 t and 173 835 thousand respectively. $F_{4\text{–}6}$ is estimated at 0.49 in 2023 . Under the MSY approach the stock is expected to show a decrease to 10 800 t in 2025.

North Sea and 3a sprat (spr.27.3a4): The catches are dominated by age 1–2 fish. Due to the short life cycle and early maturation, most of the stock consists of mature fish. To undertake the assessment and fit with the natural life cycle of sprat the assessment model is shifted by six months so that an assessment year and advice runs from 1 July to 30 June each year, and thus provide in-year advice. Since the last benchmark (ICES 2018), sprat in Division 3.a and Subarea 4 are combined into a single assessment unit. The input of new natural mortality derived from the most recent SMS key run (2023) resulted in a revision of the reference points. The advice is based on the MSY escapement strategy with an additional precautionary F_{cap}. The F_{cap} of 1.00 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. The estimates for 2024 show an SSB of 83 754 t which is below B_{lim} (107 598 t). The ICES advise for the period 1 July 2024–30 June 2025 is that catches of sprat should not exceed 74 784 t which represents a 48% decrease compared to last year's advice. This decrease is due to a combination of a below-average recruitment in 2023 and a decreased SSB in 2023.

Sprat in the English Channel (7.d and 7.e) (spr.27.7de): The fishery consists of a small midwater trawl fleet targeting sprat primarily in the vicinity of Lyme Bay, western English Channel. The stock identity of sprat in the English Channel relative to sprat in the North Sea and Celtic Seas is unknown. This year, ICES has provided catch advice for sprat in divisions 7.d and 7.e (primarily in the vicinity of Lyme Bay) based on criteria for data limited stocks. Data available are catches, a time-series of LPUE (1988–2016) and one acoustic survey that has been carried out since 2013 in the area where the fishery occurs and further offshore, also including the waters north off the Cornish Peninsula and, from 2017, the French part of the Western English Channel. The 2021 and 2023 surveys also extended into Cardigan Bay, while the 2022 survey was confined in and around Lyme Bay, due to poor weather conditions. The advice provided is based on the application of a constant harvest rate of 8.57% to the 2023 acoustic survey biomass estimate. The advised catch of 5 250 t for 202514 is 115% higher compared to last year. Since sprat is a short-lived species and given the timing of the survey (October), an advice period, valid from 1 July to 30 June in the following year, has been adopted for this stock starting in 2022. This will mitigate the problem of the lag between the survey information and the advice year which occurred previously. This has also been extended to the TAC which will also run from 1 July to 30 June. The fishing season for sprat runs from August to February.

Sprat in the Celtic Seas (spr.27.67a-cf-k): The stock structure of sprat populations in this ecoregion (subareas 6 and 7 (excluding 7.d and 7.e)) is not clear, and further work for the identification of management units for sprat is required. Most sprat in the Celtic Seas ecoregion are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. The quality of information available for sprat is heterogeneous across this composite area. There is evidence from different survey sources of significant interannual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., 6.a and 7.a), while Irish acoustic surveys started in 1991, with some gaps in the time-series provide sprat estimates but their validity to provide a reliable sprat index is questionable because they do not always cover the core of sprat distribution in the area. Acoustic estimates in the Irish Sea are more reliable. The state of the stock of sprat in the Celtic Seas ecoregion is uncertain. ICES advised in 2023 a catch of no more than 2240 tonnes for 2025 in this ecoregion based on the precautionary approach.

Sandeel in the North Sea and Skagerrak: A decline in the sandeel population in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence. Since 2010 this has been accounted for by dividing the North Sea into 7 management areas. Denmark and Norway are responsible for most of the sandeel fishery in the North Sea. The fleets represent a so-called "recruitment fishery", where the majority of catches are largely represented by age 1 fish. Analytical assessments are performed in four of the management areas (SA1r–4) where most of the fishery takes place and data are available. Note that a benchmark in 2016 revised most of the area definitions, and these areas were maintained in the most recent benchmark.

SA1r: Historically, SSB has been above B_{pa} (145 000 t) in all years until 2000. Since 2000, a regime shift or at least a change in productivity for North Sea sandeel has been in place. After 2000, SSB has been below B_{pa} in seventeen out of 22 years, in the periods 2004-2010, 2012-2017 and 2019-2022. In the latter period, only 2022 was above B_{lim} (105 809 t). Forecasting indicates that SSB will increase to a level above B_{pa} in 2023. Recruitment in 2021 and 2022 was above the geometric mean of the time-series. Fishing mortality (F) has fluctuated, showing a declining trend since the mid-2000s followed by an increase in 2017 to approximately the long-term average where it remained relatively stable till 2020 (~ 0.5) but dropped in 2021 and 2022 due to low catch advice and zero advice, respectively.

SA2r: Historically, SSB was above B_{pa} (27 757 t) in all years except. The Bpa reference point was revised in the 2023 benchmark to a lower value. Since 2000, a regime shift or at least change in productivity for North Sea sandeel has been in place (see above SA1r). Various reasons have been proposed in the literature, such as food availability, predation, fisheries and global warming.

After 2000, SSB has been below B_{lim} (18 949 t) in 4. SSB increased above B_{pa} in 2018 as the result of the exceptionally high 2016 year-class, but fell below again from 2021. In the most recent years, SSB was above B_{lim} in 2022 and based on forecasting will remain above in 2023. The incoming year-classes have been above long-term average for the preceding years. Fishing mortality (F) has fluctuated from very low mortalities in years with small or zero TAC to high mortalities approximately similar to the long-term average in years with substantial TAC.

SA3r: The stock has increased from the record low SSB in 2004 when it was below B_{lim} (72 713 t) to above B_{pa} (108 978 t) in all years after 2010. SSB had a peak of more than 820 000 t in 2018, but has since declined heavilyand is estimated to 227 167 t in 2023. The recruitments in 2016 and 2019, respectively, were the second and third highest highest on record. Forecast indicates an SSB in 2024 of 135 112 t. Fishing mortality (F) declined in the early 2000s and has been low until 2019, but increased in 2020, before it was reduced in 2021-2023.

SA4: Fishing mortality (F) has been low since 2005 but increased in 2018, decreased again in 2019-2020, increased to a close-to record high level in 2021 before decreasing to a low level in 2022. SSB has fluctuated above the limit reference point (B_{lim}) since 2011. Recruitment was low in 2018, high in 2019 and around the long-term average in 2020. Recruitment was above average in 2021 and 2022, but estimated to be one of the lowest recruitment years in 2023.

Figure 1.8.2 WG estimates of catches of the category 1 herring, sprat and sandeel stocks presented in HAWG 2024

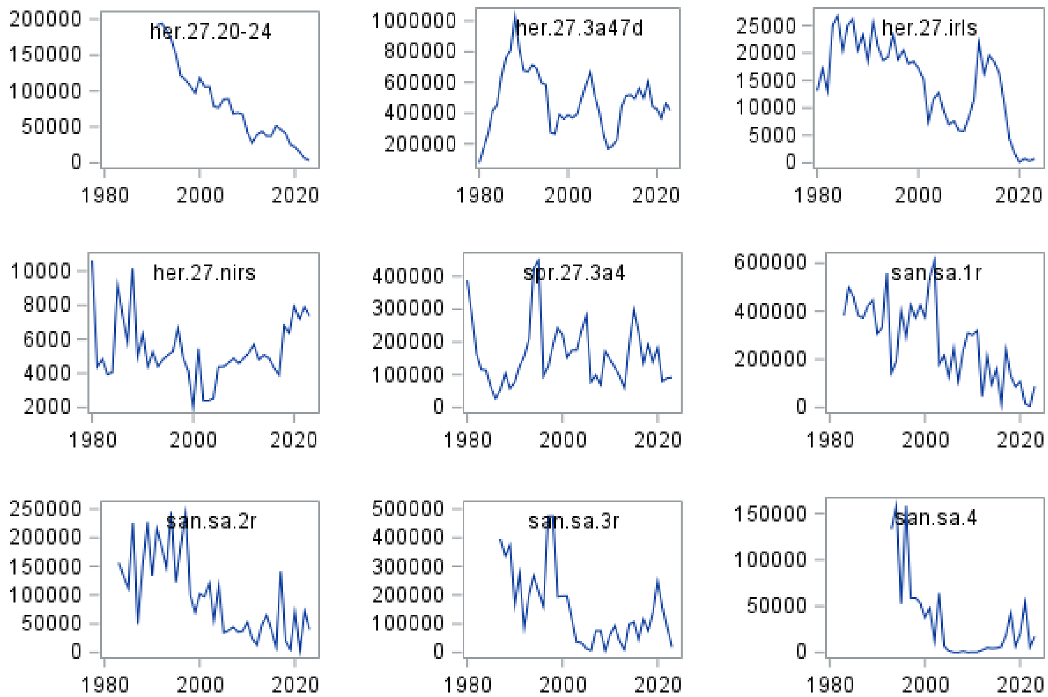


Figure 1.8.3 Spawning-stock biomass estimates for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2024

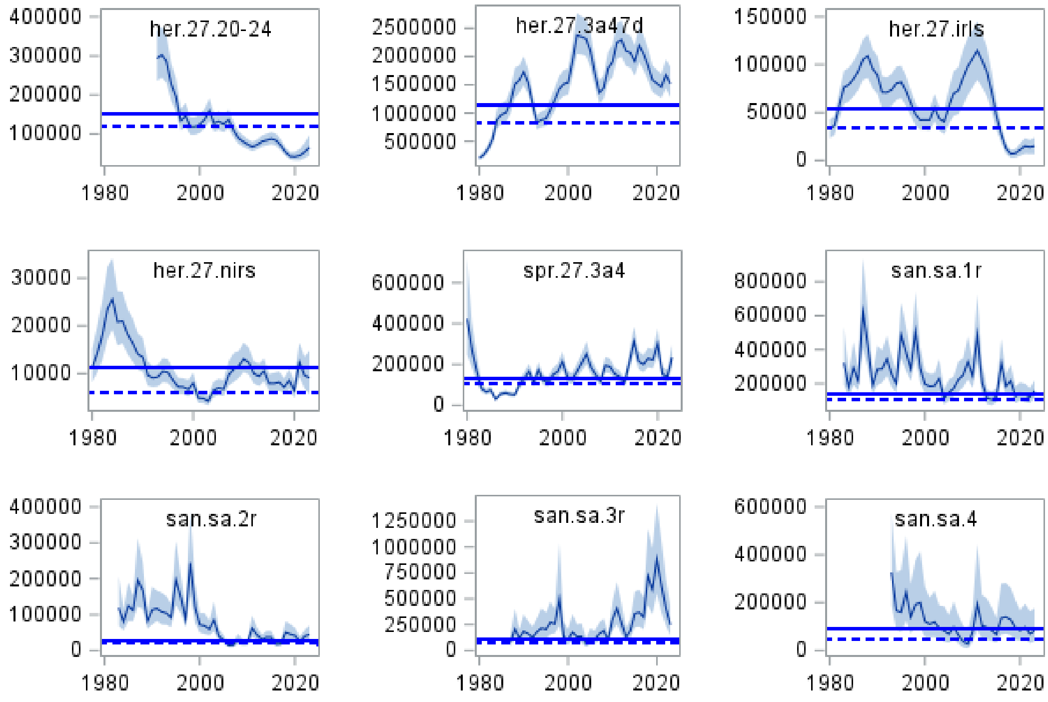


Figure 1.8.4 Estimates of mean F for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2024

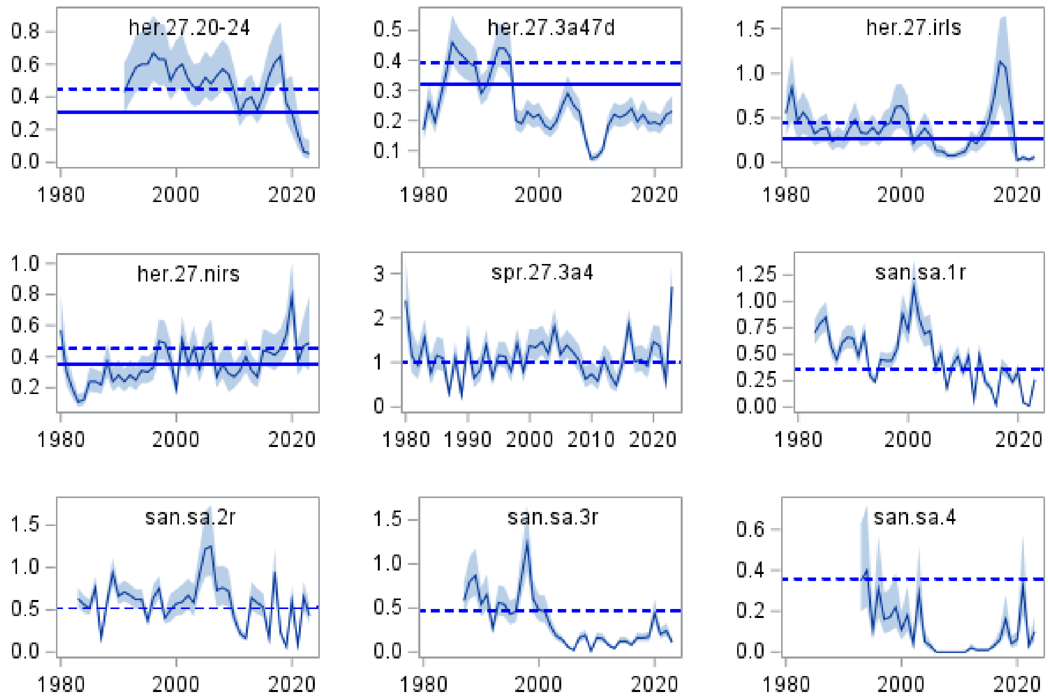
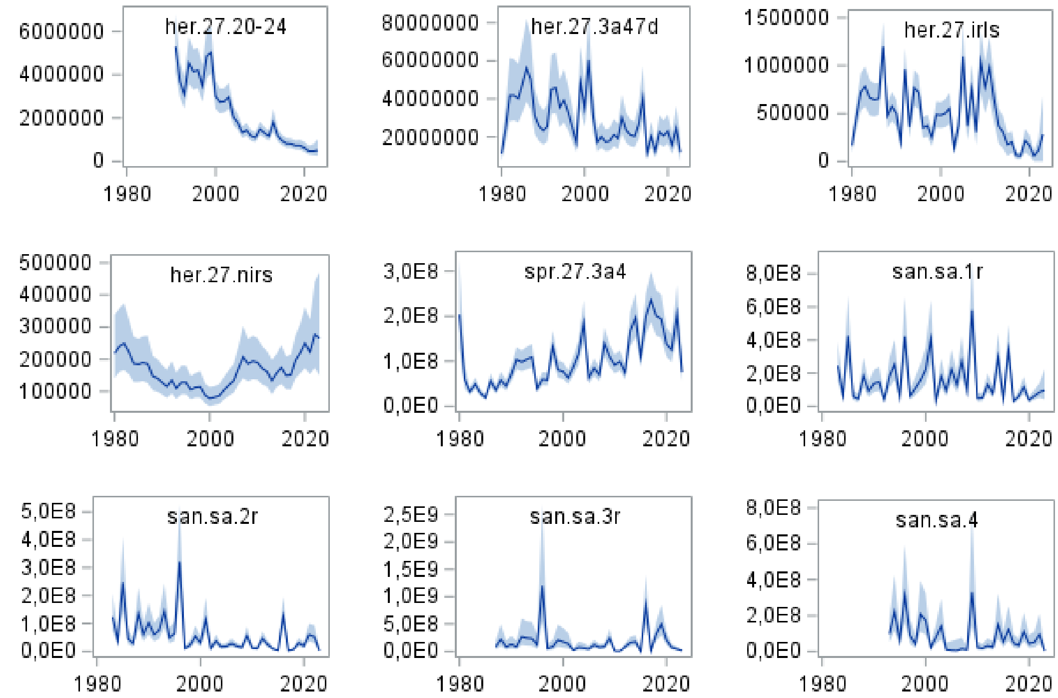


Figure 1.8.5 Estimates of recruitment for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2024



Given the marked decrease in the weight-at-age of several of the stocks assessed by HAWG, the time-series of the relative weight change are presented for comparative reasons (Figure 1.8.6).

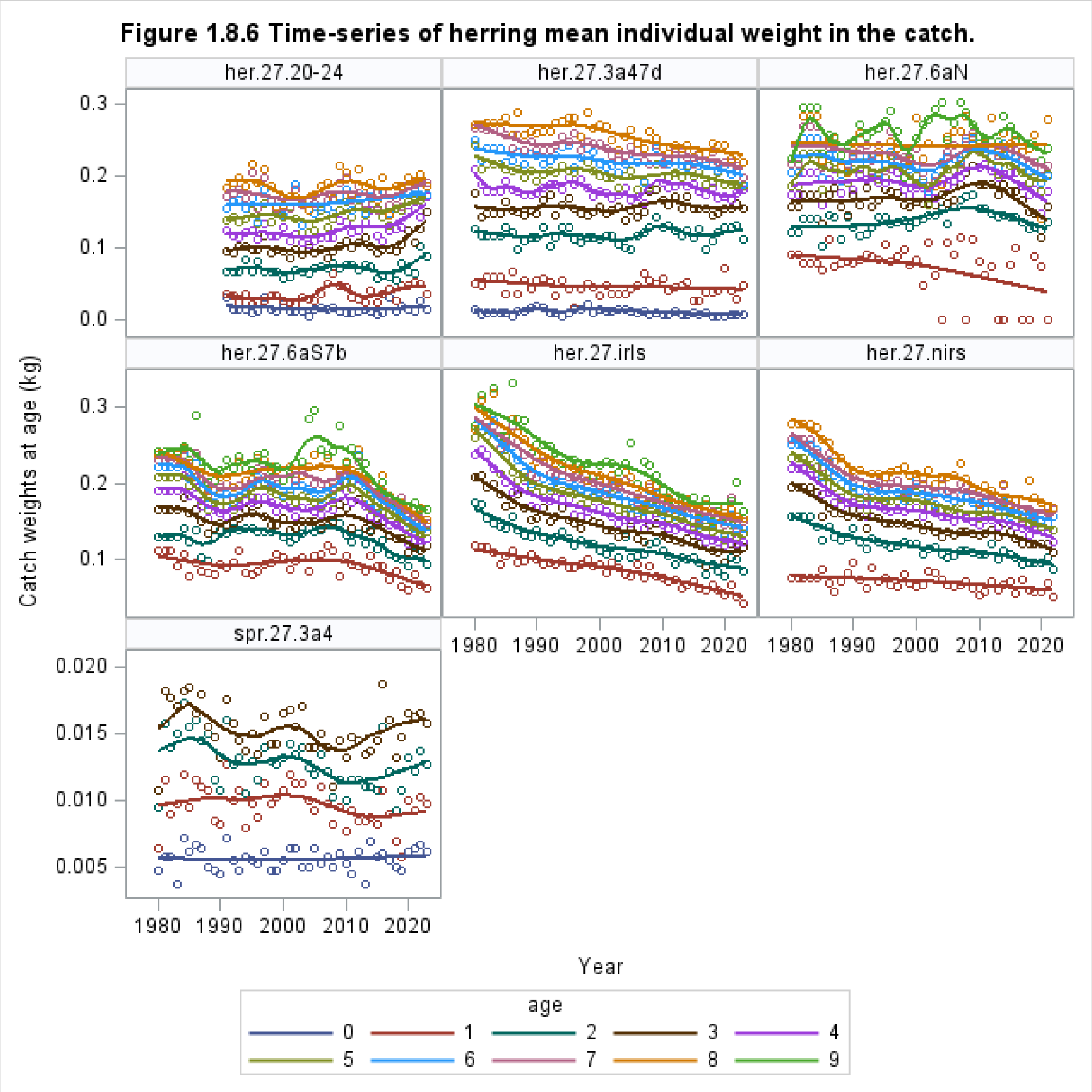


Figure 1.8.6 Time-series of herring and sprat mean individual weight in the catch.

1.9 Mohn's rho and retrospective patterns in the assessments

The analysis of retrospective patterns is one of the core diagnostics of the analytical assessments performed by ICES working groups, including HAWG. Mohn's rho (ϱ) is the metric which is currently used to quantify retrospective patterns.

Mohn's rho (ϱ) is calculated as the relative difference between an estimate from an assessment with a truncated time-series and an estimate of the same quantity from an assessment using the exact same methodology over the full time-series. The average of the relative change over a series of years is calculated as[2]:

$$\rho_n = \frac{1}{n} \sum_{i=1}^{n} \frac{X_{y=T-i,dd=T-i} - X_{y=T-i,dd=T}}{X_{y=T-i,=T}}$$

where $X_{y,d}$ is the assessment quantity, e.g. SSB or F_{bar}, for year y from the assessment with terminal year d, T is the terminal year of the most recent assessment (the year of the most recent catch-at-age data), and n is the number of retrospective assessments used to calculate rho.

The two-year subscripts for quantity X refer to the year for the quantity and the terminal year of the assessment from which the quantity was derived. For example, for an assessment WG in 2018, using catch-at-age up to 2017, the relevant quantities for the first retrospective ($i = 1$) calculation are: $X_{y=T-i,d=T} = X_{y=2016,dd=2017}$ which corresponds to the assessment quantity for 2016(T-i) derived from the assessment using the full time-series with terminal year 2017 (T); and $X_{y=T-i,=T-i} = X_{y=2016,dd=2016}$ which is the estimate of the assessment quantity for the same year T-i = 2016) estimated from an assessment where the data are truncated to have terminal year 2016 (T-i).

Mohn's rho values have been uploaded at https://community.ices.dk/ExpertGroups/Lists/Retrobias/overview.aspx and they are included in this report in Table 1.9.1.

[2] From ICES guidelines

Table 1.9.1 Mohn's rho value calculated by HAWG on category 1 and 2 stocks with age-based fish stock assessments.

Stock code	Terminal year of catch data	Number of retrospec-tive assess-ments used	F_{bar} rho value	SSB rho: was the inter- me-diate year used as the terminal year?	SSB rho value	Recruitment rho: was the intermedi-ate year used as the terminal year?	Recruit-ment rho value
her.27.20-24	2023	5	-0.24	No	0.40	No	0.11
her.27.3a47d*	2022	5	-0.10	No	0.09	No	-0.04
her.27.irls	2023	5	0.077	No	0.193	No	1.75
her.27.nirs	2022	5	-0.222	No	0.081	No	-0.296
san.sa.1r	2022	5	-0.07	No	0.56	No	1.09
san.sa.2r	2022	5	-0.03	No	0.45	No	0.45
san.sa.3r	2022	5	0.34	No	-0.3	No	0.08
san.sa.4	2022	5	-0.1	No	0.46	No	0.59
spr.27.3a4	2022	5	-0.01	Yes	0.14	No	0.12

1.10 Transparent Assessment Framework (TAF)

TAF (https://taf.ices.dk) is a framework to organize all ICES stock assessments. Using a standard sequence of R scripts, it makes the data, analysis, and results available online, and documents how the data were pre-processed. Among the key benefits of this structured and open approach are improved quality assurance and peer review of ICES stock assessments. Furthermore, a fully scripted TAF assessment is easy to update and rerun later, with a new year of data.

The following HAWG scripts are now available on TAF (https://taf.ices.dk/app/stock#!/):

1. North Sea herring (her.27.3a47d) update single-fleet SAM assessment, multi-fleet model run required for the forecast, and the forecast analysis (Update in progress 2021)
2. Herring west of Scotland (her.27.6aN) WKLIFE method 2.2 chr (Updated in 2023)
3. Herring west of Scotland and Ireland (her.27.6aS7bc) WKLIFE method 2.2 *chr* (Updated in 2024)
4. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment (Updated in 2024)
5. Sprat in 7d, e Category 3, biomass trends (Last updated 2018)
6. Sandeel in area 1r (san.sa.1r) SMS assessment (Last updated 2019)
7. Sandeel in area 5r (san.sa.5r) category 5.4 analysis (Last updated 2019)
8. Sandeel in area 6 (san.sa.6) category 5.2 analysis (Last updated 2019)
9. Sandeel in area 7r (san.sa.7r) category 5.3 analysis (Last updated 2019)

A draft TAF workflow is currently being tested by HAWG members. This involves checking the code and providing feedback. A score will be given which reflects the cleanliness, readability and if the code is easy to understand.

WKREPTAF

The TAF Reporting Workshop (WKREPTAF) met in January 2021 and explored the reporting process for ICES expert groups (with special focus on stock assessment groups) and how this could become simpler, less time consuming, and of better quality. The workshop focussed on how to expand TAF to facilitate the reporting process within working groups. The workshop concluded that 1. Script-based reports (i.e. markdown) would allow stock assessment groups to automate the process of inserting and formatting tables and figures in the report. 2. The data to be held within TAF can be documented within the report sections of the current ICES report in a standardized manner. With more data becoming available in TAF, there is the opportunity to more easily link ecosystem considerations and mixed fisheries considerations within stock specific chapters. 3. The transition from conventional reporting to script-based reports would benefit from agreeing on standardized stock assessment inputs for TAF. 4. The script-based reports open up the opportunity to directly incorporate information from the regional database (RDBES), DATRAS, Stock Information Database and Stock Assessment Graph database (SAG). 5. Training in TAF and markdown reporting are essential for the ICES community (ICES, 2021, WKREPTAF).

1.11 Benchmark process

HAWG has made some strategic decisions regarding the future benchmarking of its stocks listed in the table below.

Stock	Assessment category	Latest benchmark	Benchmark or Interbechmark in the next 12 months	Further planning	Comments
NSAS herring	1	2018 Interbenchmark 2021	No	Exploration of M scaling methodologies, model configuration, new M values	Issue list available
WBSS herring	1.2	2018	Yes, benchmark in 2025	Revise fleet definition in the 3.a catches, make the assumption on Winter spawners consistent between Danish and Swedish catches, revise the mean weight at age in the transfer area, etc. (see issue list)	Issue list and roadmap for next benchmark available, benchmark planned for December 2025 with DEWK in September 2025
6aN herring	3	2022	No	Continue genetic sampling on the acoustic survey. Start genetic sampling of the catches. Further investigate additional survey indices. Explore stock identity issues. Further work on model development.	Issue list in prepavailable
6.aS, 7.bc herring	3	2022	No	Further work on model development for possible category 1 assessment. Continue genetic sampling on the survey. Continue genetic sampling of the catch. Further investigate survey indices.	Issue list available
Celtic Sea herring	1	2015 Interbenchmark 2018	No	Mixing with Irish Sea herring, recruitment signal	Issue list available
7.aN herring	1	2017	No	Explore stock mixing, recruitment signal and F in the assessment	Issue list available
Sprat NS.3a	1	2018	No	Consider stock component, local components in 3a, boundary with the Baltic	Issue list available
Sprat 7.de	3	2018 Interbenchmark 2021	No	Consider stock components, review advice guidance for short lived species	Issue list available
Sprat Celtic	5	2013	No	Research roadmap to review and plan sprat work in 2022	Issue list available
Sandeel areas 1r–4	1	2016	Yes	Benchmark is in progress	Issue list available

Contents

2 Herring (Clupea harengus) in Subearea 4 and divisions 3.a and 7.d, autumn spawners

2.1 Introduction

The WG noted that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout this section. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter

spawning stocks, there is a difference of one year between “age” and “rings”, which is not the case for spring spawners. Further elab- oration on the rationale behind this, specific to the North Sea autumn spawners, Western Baltic spring spawners and the mixed stock catches, can be found in the Stock Annexes. It is the re- sponsibility of any user of age-based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

2.1.1 ICES advice and management applicable to 2023 and 2024

There is currently no agreed management plan (Anon, 2019), although a Working Group has been set up by Norway, UK, and the European Union to recommend a way of optimally and sustainably utilizing the North Sea autumn spawning herring stock. Until new agreed man-agement strategies will become available, the MSY approach is used as the basis of ICES advice.

The final TAC adopted by the management bodies for 2024 was 404 272 tonnes for Area 4 and Division 7.d, where no more than 43 621 t should be caught in Division 4.c and 7.d. The TAC for the A-Fleet was set to 396 556 t. For 2024, the total TAC is 518 039 t (510 323 t for the A-Fleet), including a TAC of 56 135 t for Division 4.c and 7.d.

The bycatch TAC for the B-Fleet in the North Sea (and Division 2.a) was 7 716 t in 2023 and is the same amount in 2024. As North Sea autumn spawners are also caught in Division 3.a, regulations for the fleets operating in this area have to be considered for the management of the WBSS stock (see Section 3). Catches of spring-spawning herring in the Thames estuary are in general low and not included in the TAC. For a definition of the different fleets har-vesting North Sea herring see the Stock Annex and Section 2.7.2.

2.1.2 Catches in 2023

Total landings and estimated catches are given in the Table 2.1.1 for the North Sea and for each Division in tables 2.1.2 to 2.1.5. Total Working Group (WG) catches per statistical rectan-gle and quarter are shown in figures 2.1.1 (a–d), the total for the year in Figure 2.1.1(e). Each nation pro-vided most of their catch data by statistical rectangle. Some catch figures in tables 2.1.1–2.1.5 are provided by WG members and may or may not reflect national catch statistics. These figures can therefore not be used for legal purposes.

The total WG catch of all herring caught in the North Sea amounted to 421 404 t in 2022. Offi-cial catches by the human consumption fishery were 413 686 t, above the TAC for the human consumption fishery (396 556 t). To what extend this overshot is the results of quota transfers or quota banking and borrowing is unknown by the WG.

As in previous years, the vast majority of catches are taken in the 3rd quarter in Division 4.a.w.

In the southern North Sea and the eastern Channel, the total catch sums to 41 075 t. The separate TAC for this area was 43 621 t, so the TAC in Division 4.c and 7.d was not fully taken (but due to catch regulations, 50% of the TAC could have been taken in Division 4.b).

Information on bycatches in the industrial fishery is provided by Denmark and Sweden. While the Norwegian bycatches are included in the A-fleet figure for Norway, catches taken in the small-meshed fishery by Denmark and Sweden are accounted to a separate EU quota (B-fleet).

Landings of herring taken as bycatch in the small-meshed fishery were 7 718 tonnes in 2023. The bycatch ceiling for the B-Fleet was 7 716 t. Since the introduction of yearly bycatch ceil-ings in 1996, these ceilings have fully been taken in 2014, 2016, 2020, 2021 and 2024.

The total North Sea TAC and catch estimates for the years 2018 to 2023 are shown in the table below (adapted from Table 2.1.6).

Year	2018	2019	2020	2021	2022	2023
TAC HC (‘000 t)	601	385	385	356	428	397
“Official” landings HC (‘000 t) *	594	439	415	356	458	413
Working Group catch HC (‘000 t)	594	440	417	356	461	414
Excess of landings over TAC HC (‘000 t)	-7	55	32	0	33	17
Bycatch ceiling (‘000 t) **	10	13	9	8	8	8
Reported bycatches (‘000 t) ***	8	5	10	9	6	8
Working Group catch North Sea (‘000 t)	602	446	427	365	467	421

HC = human consumption fishery

*** Working Group catches may differ from official catches and cannot be used for management purposes. Norwegian bycatches included in this figure.**

**** bycatch ceiling for EU industrial fleets only, Norwegian bycatches included in the HC figure.**

***** prior to 2019 provided by Denmark only. Since 2019 by Denmark and Sweden.**

2.1.3 Regulations and their effects

In 2024, the TAC in Division 3.a (HER/03A) is 29 735 tonnes. However, catches in 3.a are limited to 969 tonnes for the Union fleets and 200 tonnes for the Norwegian Fleet.

Half of the EU and UK quota for Division 3a (HER/03A.) can be taken in UK waters of the North Sea (HER/*04-UK) and 50% of the EU and UK quota can be taken in 4b (HER/*4B-EU).

Also 100% of the EU bycatch quota in the small-meshed fishery in 3.a can be fished in Union waters in 4 (HER/*4-EU-BC).

In the North Sea, Norway can fish 20 000 tonnes in UK waters and 2700 tonnes in EU waters in Division 4.b (HER/*4B-C). Likewise, EU vessels can fish 2700 tonnes of herring in Norwegian waters south of 62°N (HER/*4N-S62). In addition, Sweden has a quota of 1128 tonnes in this area.

Half of the EU and UK quotas for divisions 4.c and 7.d can be taken in Division 4.b (HER/*04B.).

In 2014, an agreed record between EU and Norway was applied, enabling an interannual quo-ta flexibility of 10% of the TAC. Each party could transfer non-utilized quota of up to 10% of its quota into the next year, where it is added to the quota allocated to the party concerned in the following year (or borrow 10% of the TAC, to be subtracted the following year). This in-terannual flexibility was changed in 2015 due to the Russian embargo on EU fishing products, so that 25% of the TAC could be transferred into the next year, while up to 10% could be bor-rowed. Subsequent year, the quota flexibility has been set to 10% again. Since 2021, this inter-annual quota flexibility is in place also for UK herring quotas.

At HAWG 2024, the effect of quota swaps and banking and borrowing could not be assessed by the WG.

Since 2015, a landing obligation is in place for the European pelagic fleets operating in the North Sea and the Baltic. All catches of (quota) regulated species have to be landed into port. Since 2020, the landing obligation also applies to all demersal fisheries although some exemp-tions have been agreed in the regional discard plans.

2.1.4 Changes in fishing technology and fishing patterns

There have been no major changes to fishing technology of the fleets that target North Sea herring. However, in the Norwegian fleet, more pelagic trawlers and less purse-seiners have been engaged in fishing. In 2023, 79% of the Norwegian herring catch is taken by pelagic trawlers and 20% by purse-seiners.

As in preceding years, the herring fishery concentrated in the north-western part of the North Sea, around the Fladen Ground area (figures 2.1.1 a–e). The majority of catches are taken in Subdivision 4.a West, in the order of 60% of the total. Subdivision 4.a East provided 22% of the catches in 2023 and Division 4.b contributed 8%. Catches in Division 4.c amounted to 2% only, while Division 7.d yielded 8%.

In 2023, catches in the transfer area (specific rectangles in Subdivision 4.a.e and 4.b) were 18 686 tonnes. This is much lower compared to 2022 (90 861 t) and more in line to levels of 2 000 – 18 000 tonnes in the preceding 10 years.

The bycatch ceiling for the small-meshed fishery (B-Fleet) has not fully been taken in 2023. Reported catches were distributed almost exclusively in Division 4.b (95%).

After a substantial decline in misreporting since 2009, misreporting is regarded as a minor problem in the herring fishery.

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in tables 2.2.1–2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, for West-ern Baltic spring spawners (only in 4.a.e), and for the total NSAS stock, including catches in Division 3.a.

Biological information on the NSAS caught in Division 3.a was obtained using splitting pro-ce-dures described in Section 3.2 and in the Stock Annex.

The tables are laid out as follows:

- Table 2.2.6: Total catches of NSAS (SOP figures), mean weights- and numbers-at-age by fleet
- Table 2.2.7: Data on catch numbers-at-age and SOP catches for the period 2008–2023 (her- ring caught in the North Sea)
- Table 2.2.8: WBSS taken in the North Sea (see below)
- Table 2.2.9: NSAS caught in Division 3.a
- Table 2.2.10: Total numbers of NSAS
- Table 2.2.11: Mean weights-at-age, separately for the different Divisions where NSAS are caught, for the period 2013–2023.

Note that SOP catch estimates may deviate in some instances slightly from the WG catch used for the assessment.

2.2.1 Catch in numbers-at-age

The total number of herring taken in the North Sea is 3.58 billion fish and NSAS amounts to 3.173 billion fish in 2023. The proportion of 0- and 1-ringers of herring taken in the North Sea is 27% of the total catch in numbers (Table 2.2.5), compared to 24% in 2022. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 81% of the total catch in numbers in 4.b (67% in 2022).

The proportion of 3+ winter ring herring is 64% of the total catch in numbers taken in the North Sea (compared to 51% in 2022).

In terms of biomass, the 3- and 5-ringers contributed most to the catches of North Sea herring (18%, 23% and 16%, respectively).

Western Baltic (WBSS) and local Division 3.a spring spawners are taken in the eastern North Sea during summer feeding migration (see Stock Annex and Section 3.2.2). These catches are in-cluded in Table 2.1.1 and listed as WBSS. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the as-sessment of Division 3.a/Western Baltic in 2013-2023. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 419 774 tonnes.

Area	Allocated	Unallocated	BMS/Discard	Total
4.a West	251 426		680	252 106
4.a East	93 663			93 663
4.b	34 560			34 560
4.c/7.d	41 050		25	41 075
	Total catch in the North Sea			421 404
	Autumn spawners caught in Division 3.a (SOP)			732

Baltic spring spawners caught in the North Sea (SOP)	-2 361
Total catch NSAS used for the assessment	419 774

2.2.2 Other spring-spawning herring in the North Sea

Norwegian spring spawners and local fjord-type spring-spawning herring are taken in Division 4.a.e close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in tables 2.1.1–2.1.6 but are listed separately in the respective catch tables. Along with the reduction in biomass of these spring-spawning herring in recent years, the catches have decreased in recent years. Since 2021, they have been reported to be zero.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England and Wales. In recent years, these catches have been relatively small. The TAC 2023 was set at 10 tonnes and reported catches amount to only 0.047 tonnes.

2.2.3 Data revisions

No data revisions were applied in this year's assessment.

2.2.4 Quality of catch and biological data

Annual misreporting and unallocation of catches are regarded as a minor issue in the North Sea herring fishery. In 2023, no unallocated catches were reported.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches have to be landed into port. Reported catches in the BMS category (be-low minimum landing size, including any fish lost or damaged during processing proce-dures) were 2 tonnes in 2023. Some countries stated these to be zero, and other countries have not reported any catches in this category. In accordance with the landing obligation, no discards were reported in the 2023 North Sea herring fishery. However, discards occurred in other fisheries not targeting on herring, mainly in the crustacean fishery. These discards sum to 703 tonnes in 2023. Reported BMS (below minimum size) landings are only 2 tonnes.

The sampling of commercial landings covers 84% of the total catch.

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different métiers (here defined as each combination of fleet/nation/area and quarter). Of 118 different reported métiers, 39 were sampled in 2023. The sampling level of more than 1 sample per 1000 t catch has been met for 28 métiers. With regards to age read-ings, 34 métiers appear to be sampled sufficiently (>25 fish aged per 1000 t catch).

However, some of the métiers yielded very little catch. In 75 métiers, the catch is below 1000 t. The total catch in these métiers sums to 13 044 t, so the remaining 43 métiers represent 407 655 t of the working group catch (97%). Of these 43 métiers, 29 were sampled. 18 métiers have more than 1 sample per 1000 t catch and 24 métiers more than 25 age readings per 1000 t catch.

According to the DCF regulations, some catches were landed into and sampled by other na-tions.

The WG recommends that all métiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled and their biological data be made available to the national laboratories (see Section 1.5).

2.3 Fishery independent information

2.3.1 Acoustic Surveys in the North Sea (HERAS), West of Scotland 6.a (N) and the Malin Shelf area (MSHAS) in June–July 2022

Six national surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland, and the Malin Shelf. The survey methods and full results are given in the report of the Working Group for International Pelagic Surveys (WGIPS; ICES 2023). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

The global survey results provide spatial distributions of herring, abundance by number and biomass-at-age by strata and distributions of mean weight- and proportion mature-at-age for the assessment (Table 2.3.1.2-3).

The estimate of North Sea Autumn Spawning herring spawning stock biomass (SSB) has decreased by 4% from 1.96 million tonnes in 2022 to 1.89 million tonnes this year. The abundance of mature fish has increased from 10 348 million in 2022 to 11 069 million in 2023. The mean weight of mature fish is 10% lower than last year at 170.3 g, and the decrease in biomass of mature fish can be attributed to this change in condition of individual fish. The strong 2012 and 2013 year classes are both in the 9+ group now and no longer contributing significantly to the stock. The ages 1 - 4 winter rings (wr) make up the majority of the stock now. It should be noted that several year classes from 2014 onwards are well below the average level since 2010 (and the long-term average). The 2016 year class (6-wr in 2023) is particularly weak with abundance at only 49% of the average level since 2010.

Distribution of herring in the North Sea area (Figure 2.3.1.2) is similar to that seen since 2017 and does not extend as far south as was the norm in the years prior to 2017. Abundance of NSAS herring was slightly higher compared to recent surveys in the North Sea area.

The abundance of immature fish in the stock has increased by 116% from 19 780 million in 2022 to 42 775 million. This is due to a large number of age 1-wr in the survey this year. The estimate for this age group is associated with high uncertainty in the survey though, so the impact of this increase on future stock development is still uncertain.

Maturities for all ages were comparable to the long-term average with 67% maturity for 2-wr, 97% maturity of 3-wr, 99% or higher maturity for all ages 4-wr and above. Since 2015, actual observed maturities are reported for all age groups. Prior to 2015 maturity was fixed at 100% for ages above 4-wr.

2.3.2 International Herring Larvae Surveys in the North Sea (IHLS)

Five areas were covered within the framework of the International Herring Larvae Surveys in the North Sea during the sampling period 2023–2024. They monitored the abundance and distribution of newly hatched herring larvae in the Orkney/Shetlands area, in the Buchan area (two observation periods) and the central North Sea (CNS) in September and in the southern North Sea (SNS) in December 2023 (Figures 2.3.2.1). While four cruises were conducted as scheduled, the survey in the English Channel in January 2024 had to be cancelled due to technical problems of the vessel. No replacement or charter vessel could be arranged due to other commitments of the ships.

The survey around the Orkneys revealed relatively low quantities of newly hatched larvae. Their distribution was in line with previous years, catching most larvae just east of the Orkney. The strikingly different distribution observed in 2022, when most larvae were found much more easterly than usual, was not present in 2023.

In the Buchan and the central North Sea, larger concentrations of newly hatched larvae were observed in two areas, while the remaining stations contributed only very low numbers of larvae (Figure 2.3.2.1).

On average, most larvae in the southern North Sea in the December survey are found on stations in the western part of the survey area. This was also observed in 2023. However, larvae were distributed somewhat closer towards the English and French coast line than usual. This may be a result of wind-induced larvae drift, or changes in preference of, or absence on, used spawning grounds.

No survey was planned for the second half of January 2024. Instead, an additional MIK sampling is scheduled for April 2024 in the German Bight and southern North Sea. This sampling should shed light on the foraging and recruitment of herring larvae originating from the Downs stock component.

At the last benchmark of the North Sea herring assessment (ICES, WKPELA 2018), it was decided to use the Larvae Abundance Index (LAI) as direct input into the assessment model and to resolve spatial stock dynamics inside the model.

For the second year in a row, in almost all observed areas in the North Sea, newly hatched herring larvae at the spawning grounds were less abundant compared to previous years (Tab.2.3.1, Fig 2.3.2.2). To what extend this is due to only partial coverage of the hatching period, changes in spawning time or mortality (in egg mortality and reduced larvae survival due to a mismatch with food occurrence and food size) can't be disentangled.

However, the low abundance of herring larvae observed in the last two years in the IHLS and low numbers of 0-ringers found in the MIK sampling somewhat later in the year, could be taken as a signal of reduced herring reproduction.

2.3.3

During the International Bottom Trawl Survey in the first quarter (Q1 IBTS), night-time catches are conducted with the MIK net, a fine meshed (1600 µm) 2-m-midwater ring net (ICES 2017) providing abundance estimates for large herring larvae (0-ringers) of the autumn spawning stock components. In addition, the Q1 IBTS also provides the time series for the 1-ringer herring abundance index in the North Sea from GOV catches carried out during daytime. For more details on the times series, the reader is referred to the previous reports of the working group.

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area from the MIK sampling is used as a recruitment index for the stock. Since 2017, this 0-ringer index (also called MIK index) time series is calculated with a new algorithm, which excludes larvae of Downs origin more rigorously. This is done by excluding the smaller larvae – presumably of Downs origin – from the analyses in certain parts of the survey area. Index values are calculated as described in detail in the Stock Annex. (Note that this new time-series based on the new algorithm only dates back to 1992, and that all French data before 2008 are excluded because of data quality issues). The results of the calculation can be found in Table 2.3.3.1. The index from the 2024 survey (corresponding to the 2023 year-class) is 62.47. This is clearly below the long-term average of 99.5 (in the time-series since 1992), and only 11 years in the time series had a lower index while 21 years had a higher index than in 2024.

The previous MIK-IBTS surveys in 2022 and 2023 had been faced with numerous challenges including technical/mechanical problems, issues with Covid-19 infections and severe weather (see previous HAWG reports for details). The 2024 survey was only faced with some minor challenges concerning technical/mechanical problems. However, there were again issues with severe weather conditions during large parts of the survey period, including very strong winds and wave heights up to 8-10 meters. As a result, basically all survey participants lost several days of survey time. None of the survey participants was able to conduct 100% of the planned MIK stations, and some only managed to conduct between 50-75% of planned stations. Nevertheless, due to intense coordination during the survey, it was possible to obtain a good coverage of the survey area.

A total of 581 MIK hauls were conducted in 2024, which is very similar to the 586 hauls conducted in 2023 and 148 hauls more than in 2022. For the 2024 MIK 0-ringer index (corresponding to the 2023 year-class), all hauls north of 51° N were used, in total 565 hauls (for comparison: 2023 = 569 hauls and 2022 = 410 hauls).

A total of 716 MIK hauls were planned according to the 2024 NSIBTS Q1 program (the target is 4 hauls per ICES rectangle) and 581 were conducted, i.e. 81% of the planned MIK-stations were sampled in 2024. However, there has been a general increase in the number of MIK hauls throughout the time-series, and the 581 MIK hauls achieved in 2024 are above the long-term average of 507 hauls (time-series since 1992). Besides, thanks to intense coordination between participants during the survey, almost all ICES squares in the survey area were covered (except for 3 squares), and the majority of ICES squares in the main distribution area of the herring larvae in the central and southern North Sea was well covered with 3 to 4 MIK hauls. However, in some cases the weather conditions and associated swapping of squares between participants resulted in a slightly uneven coverage, i.e. some squares were covered with even 5-6 hauls, while others were covered with only 1 or 2 hauls. Overall, the coverage achieved during the 2024 MIK survey was good and can be regarded to provide a representative 0-ringer index.

Figure 2.3.3.1.1 shows the size distribution of herring larvae caught in the MIK in 2024. Herring larvae measured between 6 and 41 mm standard length (SL), which is similar to previous years. In most previous years, the smallest larvae <12 mm (which most likely are originating from the Downs component) are very numerous and often accounted for around 50 to 60% of the total number of larvae. At first glance, the size distribution for the 2024 survey gives the impression that there have been relatively many larger larvae in the size range 19-32 mm. However, looking at the absolute numbers reveals that there were actually rather few larvae in 2024 (total number of herring larvae in 2024 = 17899, in 2023 = 74801, in 2022 = 53697). Particularly the smaller larvae <12 mm were much less abundant than in other years, and they only made up 33% of the total number of larvae. Thus, the larger larvae actually only seem relatively numerous in relation to the few smaller larvae, but are not very abundant in absolute terms. The lower proportion of smaller larvae in 2024 may indicate a reduction or a shift in spawning time of the Downs component.

In the two previous surveys in 2022 and 2023, larvae in the size range between 13 and 17 mm were also numerous, with another peak at 15 mm. In contrast, the 2024 length distribution does not show this “intermediate” peak around 15 mm, but only two rather distinct peaks at 11 and 25 mm. This is also reflected in the relative share of larger larvae >18 mm SL in 2024 which was 36%, compared to only 20, 11 and 12% in the three previous years 2023, 2022 and 2021, respectively.

Figure 2.3.3.1.2 illustrates the spatial distribution of 0-ringers in 2022, 2023 and 2024. The 2024 distribution is partly similar to 2023, with higher abundances east of Scotland and along the UK coast. However, in the southeastern and eastern part of the North Sea, the potential nurseries, abundance of larger herring larvae in 2024 was higher than in the previous year, and the larvae seemed generally more spread out over the central North Sea in 2024. Furthermore, the rather high abundances in the English channel/Southern Bight area which were observed in 2022 and in particular in 2023 - and which had a relatively strong impact on the index values for these years - were not observed in 2024.

As in previous years, sardine larvae were again found in the samples of the 2024 MIK survey. They occurred mainly in the southern and south-eastern North Sea as well as in the Skagerrak, but some were also found relatively far north up to ICES squares 44F4 and 44F5. However, their abundance was relatively low compared to previous years. A sardine larvae index was calculated with the same method as for the herring larvae. The sardine larvae index for 2024 was 3.94, while it was 7.84, 8.15 and 7.63 for 2023, 2022 and 2021, respectively.

2.3.3.2 The 1-ringer herring abundances (IBTS-1)

The 1-ringer recruitment estimate (IBTS-1 index) is based on GOV catches in the entire survey area. The time series for year classes 1991 to 2022 is shown in Table 2.3.3.2. The index from the 2024 survey (corresponding to the 2022 year-class) is 184. This is the 2nd lowest index in the entire time series since 1979 (long-term average = 1930), and only the very first year 1979 had an even lower index of 168.

Figure 2.3.3.2.1 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2022, 2023 and 2024, corresponding to year-classes 2020, 2021 and 2022. As in most previous years, the majority of the 1-ringers of the 2022 year-class were found in the German Bight area, along the Danish west coast and in the Kattegat/Skagerrak area. However, as already indicated by the extremely low 1-ringer index described above, the abundances were considerably lower than in previous years.

The extremely low abundances found in the 2024 survey are rather surprising, as they follow the record high 1-ringer index of 5015 in the previous 2023 survey. Moreover, also the age 2 index in the 2024 survey, which was expected to be high after the record high age 1 index in the 2023 survey, was way below average, as were the indices for older age classes. This may indicate a general issue with catchability of herring (and other pelagic species) during the 2024 IBTS Q1 due to the severe weather conditions encountered during part of the survey period. Preliminary analyses showed high turbidity in bottom layers in the usual herring areas, i.e. in the German Bight and along the Danish coast. This may have caused the herring to migrate higher up in the water column to layers not affected by turbidity but out of the sampling depth of the GOV. However, further analyses are needed to corroborate and quantify such an effect.

After a longer period where the trajectories of 1-ringer abundance and 0-ringer index seemed to be uncoupled (year-classes 2003-2012), the two trajectories corresponded better again for the year-classes 2013 – 2018 (Fig. 2.3.3.2.2). Since the 2019 year-class the two indices seem to be uncoupled again, with most pronounced differences for the two most recent year-classes 2021 & 2022 which show completely opposite trends. This may to some extent be related to variability in recruitment of the Downs component, which is not reflected in the 0-ringer index but is included in the 1-ringer abundance. However, other factors may also play a role, e.g. the potential effect of weather conditions on the catchability of herring in the GOV bottom trawl used on the IBTS. For further details on this it is referred to section 2.5.1 on the "Relationship between 0-ringer and 1-ringer recruitment indices".

2.4 Mean weights-at-age, maturity-at-age, and natural mortality

2.4.1 Mean weights-at-age

Table 2.4.1.1 shows the historic mean weights-at-age (winter ringers, wr) in the North Sea stock during the third quarter in divisions 4 and 3.a from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 2000 to 2023 for comparison. The data for 2023 were sourced from tables 2.3.1.2. and 2.2.2. In the third quarter (timing of the HERAS survey), most fish are approaching their peak weights just prior to spawning.

After three years with increasing mean weights-at-age, the trend towards smaller mean weights-at-age observed in preceding years in the acoustic survey and, but less pronounced, in the catch in the third quarter (Figure 2.4.1.1), seems to have been re-occurred in 2023. Almost all ages, in both the acoustic survey and the catch, had lower weights-at-age compared to 2022, with the only exception of 4-wr fish in the catch. In the survey, 4-wr fish had almost the same weight compared to 2022.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2023 were estimated from the North Sea acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data were described fully in ICES (1996/ACFM:10). While 5+ group herring were considered fully mature in the period prior to 2015, WGIPS reported maturity stage for all groups up to 7+ separately in the most recent years.

In 2023, 2 winter ringers were to 67% mature. This is in line with previous years, while in 2018 and 2019, maturity of 2 ringers was only 37% and 59%, respectively. Maturity of winter ringers 3 (97%) and 4 (99%) are also comparable to the long-term average. 100% maturity was achieved by winter ringers 5.

2.4.3 Natural mortality

One of the improvements of the 2012 benchmark of the North Sea herring stock (ICES WKPELA, 2012) was the integration of fundamental links between the North Sea ecosystem and the NSAS stock dynamics.

From 2012 onwards, the assessment of NSAS includes variable estimates of natural mortality (M) at age derived directly from a multispecies stock assessment model, the SMS model, used in WGSAM (Lewy and Vinther, 2004; ICES 2011). The input data to the assessment are the smoothed values of the raw SMS model annual M values, which are variable both at-age and over the time. Natural mortality in years outside the time-period covered by the model are filled and estimated for each age as a five-year running mean in the forward direction and in the reverse direction for years prior. The M estimates are variable along the time period covered by the assessment and are the result of predator–prey overlap and diet composition. The trends in total M of NSAS are a result of the contribution of each of the predators to the predation mortality of the NSAS stock. The time-series of M adopted at the benchmark in 2012 was from the 2011 key run of the SMS model covering the period 1963–2010 (ICES WGSAM, 2011). Since 2012, the M time-series were updated following the latest key runs of the SMS model (ICES WGSAM, 2014; 2016, 2021, 2024).

Natural mortality for the assessment is updated when a new SMS keyrun is available from WGSAM. However, because of the substantial impact the absolute level of M has on the assessment (ICES IBPNSHerring, 202 1), an age and year independent offset is applied. The comparison between the different keyruns without offset is shown in Figure 2.4.2.1. The offset is calculated using a likelihood profiling of the assessment model which allows one to find the M that best fits the input data to the assessment. The procedure and model configuration was developed during the 2018 benchmark report (WKPELA2018, ICES, 2018) and further corrected for a fundamental discrepancy during a dedicated inter-benchmark (IBPNSherring2021, ICES, 2021). The profiling of the 2024 assessment models, using the 2023 SMS keyrun is shown in Figure 2.4.2.2 and leads to an offset of 0.02.

The latest natural mortality vector from WGSAM (WGSAM , ICES, 2024) spans the 1974-2023 period. Values outside this year range is computed using a three-year moving average. With the inclusion of profiling, natural mortality is consistent with the 2019 SMS keyrun (Figure 2.4.2.3).

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and IBTS-1 indices are derived. Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery-independent indices is incorporated. Of importance is the fact that IBTS0 allows the assessment model to estimate recruitment levels in the assessment year. This is subsequently used in the short-term forecast for the intermediate year. The recruitment trends from the assessment are dealt with in Section 2.6.

2.5.1

The estimation of 0-ringer abundance (IBTS0 index) predicts the year-class strength one year before the strength is estimated from abundance of 1-ringers (IBTS-1 index). The relationship between year-class estimates from the two indices is illustrated in Figure 2.5.1.1 and is described by the fitted linear regression.

The time series of 0- and 1-ringer abundance from the Q1 IBTS survey exists since the 1977 year-class. For more than a decade until the mid 1990s, there has been very good agreement between the indices in their description of temporal trends in recruitment, with the 0-ringer index explaining more than 70% of the variability of the respective 1-ringer abundance.

It has to be borne in mind that the IBTS 0-ringer (or MIK) index only reflects recruitment in the autumn spawning components (NSAS). Hence, once the contribution of the winter spawning Downs component to the total North Sea herring stock increased and of the autumn spawning components decreased, the relationship between the two indices started to erode.

This was particularly true during the first decade of the 21st century (for the year-classes 2003 - 2012), when the predicted trends in recruitment deviated between the two indices.

Since 2017, the MIK index time series is calculated with a new algorithm, which only dates back to 1992 and excludes larvae of Downs origin more rigorously. The correlation between 0- and 1-ringer indices utilizing the newly calculated MIK index time series is much weaker (Figure 2.5.1.1).

However, starting with the 2013 year-class, there was once again good agreement between the trends of the two indices. In the 2014 MIK survey, the 2013 year-class was recorded as the largest 0-ringer abundance since 2002, and the strength of this year-class was confirmed in 2015 with one of the largest 1-ringer abundances. This was the first strong year-class observed since 2002. Since then, the IBTS 1-ringer index followed the ups and downs of the MIK 0-ringer index for the respective year-classes until the 2018 year-class (Figure 2.3.3.2.2). Beginning with the 2019 year-class, the relationship between the MIK 0-ringer and the IBTS 1-ringer index decreased again. The most recent data that can be compared between 0-ringers and 1-ringers are for the 2022 year-class, corresponding to the 0-ringers from the 2023 MIK survey and the 1-ringers from the 2024 GOV survey. For this year-class the two time-series seem to be highly uncoupled, due to the extremely low 1-ringer abundance index. The differences in the trends of the two time series in recent years are also reflected in the explained variability of the correlation between 0- and 1-ringers, which was about 30% until the 2018 year-class, but with the large discrepancies between the 0-ringer and 1-ringer indices for the most recent year-classes, this value has now further diminished to 14% (Figure 2.5.1.1).

The variable correspondence in the 0-ringer and 1-ringer indices in the later part of the time-series may be related to variable but generally increasing recruitment of the Downs component and its contribution to the North Sea herring stock. This also corresponds to recent results of genetic studies (Bekkevold et al. 2023), which show high shares of individuals of Downs origin amongst in particular juvenile herring in the eastern North Sea area.

However, variable weather conditions and associated effects on the catchability of 1-ringers from the Q1 IBTS may also play a role, in particular for the 2022 year-class (2024 survey) as well as the 2020 year-class (2022 survey). Preliminary analyses showed high turbidity in bottom layers in the usual herring areas, i.e. in the German Bight and along the Danish coast, in 2022 and 2024. This may have caused the herring to migrate to layers not affected by turbidity, i.e. higher up in the water column where they are out of the sampling depth of the GOV. However, further analyses are needed to corroborate and quantify such an effect.

2.6 Assessment of North Sea Herring

2.6.1 Data exploration and preliminary results

The tool for the assessment of North Sea herring is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org, Nielsen and Berg 2014), embedded inside the FLR library (Kell et al., 2007).

Acoustic (HERAS ages 1–8+), bottom trawl (IBTS-Q1 age 1, IBTS-Q3 age 2–5), IBTS0 and larval index (LAI) indices are available for the assessment of North Sea autumn spawning herring. The surveys and the years for which they are available are given in Table 2.6.1.1. The input data and the performance of the assessment have been scrutinised to check for potential problems. In 2024, the 1 wr index was particularly low which impacts recruitment estimates by the mode. Though, despite stormy conditions in the Southern North Sea, the survey was not deemed abnormal by survey coordinators.

The proportion mature of 2, 3 and 4-wr individuals are 67%, 97%, and 99% respectively. The historical proportion mature at age are given in Table 2.6.1.2 and plotted in Figure 2.6.1.1. The maturity for age 2 is substantially higher compared to the lowest point in 2018. This is following a consistent decrease of proportion mature at this age since 2015. Other biological inputs to the assessment are presented in Figures 2.6.1.2-2.6.1.4 and Tables 2.6.1.3-2.6.1.5. Catch at age are given in Table 2.6.1.6 and the proportions are plotted in Figure 2.6.1.5.

The numbers-at-age over all ages in the HERAS acoustic survey are given in Table 2.6.1.7 and the proportions are plotted in Figure 2.6.1.6. In 2023, 1wr are particularly prominent, confirming the strong 2021 year class. For this survey, the internal consistency of the index remains high, as it has been for a long period (Figure 2.6.1.7). Other survey indices are presented in Tables 2.6.1.8-2.6.1.14. The internal consistency of the IBTSQ3 (the other multi-age index) is shown in Figure 2.6.1.8 and presents good cohort tracking.

2.6.2 NS herring assessment

In accordance with the settings described in the Stock Annex, the final assessment of North Sea herring was carried out by fitting the state space model (SAM, in the FLR environment). The input data are presented in Table 2.6.1.2-2.6.1.14 and model settings are given in Table 2.6.2.7. Estimated parameters and model outputs are given in Table 2.6.2.1-2.6.2.6.

A summary of assessment outputs is shown in Figure 2.6.2.1 (SSB, F averaged over age 2-6 and recruitment). The spawning stock at spawning time in 2023 is estimated at approximately 1.52 million tonnes, a slight decrease to 2022. As for recruitment, the 2023 estimate is low, which is a consequence of the 1 wr sampled in 2024 during the IBTS-Q1 survey. Recruitment of the 2021- and 2022-year classes are estimated to be high. Mean F2–6 in 2022 is estimated at approximately 0.23.

The SAM model fits the catch and the surveys well and residuals are random and small for all ages (figures 2.6.2.2–2.6.2.5). Only a small block of positive residuals can be observed for age 7 catch data over the years 2000–2006, while at age 8 for catch data, a similar block of negative residuals can be observed (figures 2.6.2.2). This likely indicates a trade-off in model fit to either the age 7 or age 8+ catch information. There is a methodological need however to link age 7 and age 8+ together in the stock assessment model. The residuals are very small and are not considered an issue for the performance of the assessment.

The fitting of the LAI index is poor due to the intrinsic noise to the larvae survey. However, this survey is the only one able to provide information on the strength of the different spawning components. Given the low impact of this survey on the overall assessment, this is not considered an issue.

The estimated observation variances and survey catchabilities are given in Tables 2.6.2.1-2.6.2.2 and plotted in Figures 2.6.2.6-2.6.2.8. Overall, the assessment is informed best by catch data and HERAS over the core ages of the stock (ages 2-6). With the updated assessment model from the latest inter-benchmark (ICES 2021), the catchability of the HERAS survey is close to 1, in line with the expectation for this survey that covers the stock in its entirety.

A feature of the assessment model is the estimation of an observation variance parameter for each dataset (Table 2.6.2.1, Figure 2.6.2.6). Overall, all data sources are associated with low observation variances. The catch-at-ages 1–5 stands out as the most precise data source while the LAI indices, IBTSQ3 age 0 and HERAS age 1 to be the noisiest data. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch-at-age

0 is some- what high (Figure 2.6.2.7). However, the CV quantities do not indicate a lack of convergence of the assessment model.

The analytical retrospective analysis (Table 2.6.2.5, Figure 2.6.2.9) has mean Mohn's rho values with a 5-year peel of: -7.3% (Fbar), -3.8% (rec), and 6.5% (SSB).

Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey and assessment parameters (Figures 2.6.1.7-2.6.1.8 and Figure 2.6.2.10).

The fishing selectivity at age is presented in Figure 2.6.2.11. Whilst dome shape selectivity was observed at the end of the 2000's, linearly increasing selectivity has been taking place since 2005, due to a large part of the biomass at old fish ages. In the last years, these linearly increasing selectivity shapes were dampened, potentially trending toward dome shapes.

2.6.3 Exploratory Assessment for NS Herring

An exploratory assessment using fleet disaggregated data for (1) catches-at-age (2) weight in the catch-at-age was carried out (Figure 2.6.3.1). The fleets B and D are combined because of their similarity and to ease model convergence. More details on the model configuration exploration are provided in the 2018 benchmark report (ICES WKPELA, 2018) and 2021 inter-benchmark (ICES 2021). The latest configuration with 2023 data did not allow the model to converge. The multi-fleet model was initially configured with two time periods: 1947-1996 with combined fleets, 1997-onward with A-D disaggregated fleets. Model exploration during HAWG2024 revealed that this separation in two periods was the main cause of convergence problems. At HAWG2024, the data were split for the period 1947-1996 based on catch at age proportions and weight at age in 1997. The model configuration is the one from the 2021 inter-benchmark and is given in Table 2.6.3.8.

Tables for the multifleet assessment and results (including fleet wise fishing mortalities) are given in Table 2.6.3.1-2.6.3.7. Figure 2.6.3.2 shows a comparison between the single fleet and multi-fleet stock trajectory results, and these are very consistent.

Of particular relevance when running the SAM model using a multifleet configuration is the fishing mortality-at-age that is outputted for each fleet. The subsequent catch residuals for each fleet are shown in Figure 2.6.3.3 to Figure 2.6.3.5. The observation variance is shown in Figure 2.6.3.6, with high levels for fleet B and D and C. Expectedly, the model is driven by catch data from the fleet A which represents most of the overall catches. The model uncertainty and the correlation coefficients between the estimated parameters are shown in Figure 2.6.3.7 and 2.6.3.8 respectively.

The 2024 model converged with the new configuration (Table 2.6.3.8) for 10 year peels, as shown in Figure 2.6.3.9.

The fishing selectivity for the A fleet are shown in Figure 2.6.3.10 and present similar patterns to the single fleet model. This is expected as fleet A is the main fleet harvesting the stock. The development of selectivity patterns for the other fleets (C and B and D combined) are presented in Figure 2.6.3.11 and 2.6.3.12.

2.6.4 State of the stock

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as is being harvested sustainably. Fishing mortality is below the estimated FMSY (0.32).

The SSB in autumn 2023 was estimated at 1.52 million tonnes, which is above Bpa (0.90 million t) and MSY Btrigger(1.13 million t).

Since the strong 2013-year class, recruitment of herring has been low, but the 2021 and 2022 year class are higher than the 10-year rolling average.

2.7 Short-term predictions

Short-term predictions for the years 2024, 2025, and 2026 were done with a code developed in the R programming language. During HAWG 2019, a modification to the code was made because the 2015 EU-Norway management rule is no longer in force and because the ICES advice for WBSS herring resulted in a zero-catch advice. During HAWG 2020 a further modification to the code was made to allow for a combined scaling of the A and B fleets (see below).

The various assumptions for the short-term predictions for both the stock and the four different fleets are given in tables 2.7.1 and 2.7.2 respectively. The reference points are presented in Table 2.7.3. In 2024, because of the inclusion of new natural mortality, MSY and limit reference points were updated (see Section 2.9).

In the short-term predictions, recruitment is assumed constant at 19 billion for the years 2025 and 2026 following the same recruitment regime since 2002 (weighted mean of the past 10 year classes, weighted by the uncertainty in the estimate). The recruitment estimates of the 2023 year class, obtained from the assessment (informed by the 2024 IBTS0 survey) served as the estimate for 2024.

For the intermediate year (2024). No overshoot for the A fleet was assumed. Negotiations between the EU, Norway, and UK for 2024 resulted in the allowance of 29 123 t of the C-fleet and 6101 t of the D-fleet in the Kattegat-Skagerrak area to be taken in the North Sea. The arrangement is very different to the previous year's arrangements. The expected catches of NSAS herring during 2024 were estimated as given in Table 2.7.1.

The expected catches of Western Baltic Spring-spawning herring caught under the North Sea TAC are deducted from the expected A fleet catches in the intermediate year. In the projected year 2025, for most of the scenarios, the C and D fleet outtake was set to 0 in agreement with the 0-catch advice for WBSS for 2025. The catch scenarios with a zero-catch advice for WBSS are presented in Table 2.7.4.

Two additional scenarios with the inclusion of the C-fleet TAC rule were calculated at HAWG2024. The corresponding scenarios (with and without a TAC transfer to the North Sea) are given in Table 2.7.5 ("fmsyAR_TACrule_transfer" and "fmsyAR_TACrule_notransfer"). In practice, managers implement the following TAC rule in order to determine the TAC for the C-fleet:

TAC C = (5.7%* TAC A) + (TAC SD22-24*41%*2)

The final table as presented in the advice is given in Table 2.7.5.

In the absence of an agreed management plan for NSAS herring, it has not been possible to derive fleet-based fishing mortalities for the prediction year. Therefore, the ICES MSY Advice Rule (MSY AR) has been used as the basis for the advice. With the reference points derived during the HAWG 2024 meeting. The MSY AR stipulates a fishing mortality of FMSY = 0.32 when the stock is above MSY Btrigger (1 131 601 tonnes) and a linear decline in F when the stock is below MSY Btrigger. With the forecasted values in 2024, the SSB is calculated below MSY Btrigger which results in a target F(wr) 2–6 =0.313 (Figure 2.7.1.1).

There is no specific allowance in the ICES MSY AR for multiple fishing mortality targets, such as the fishing mortality for 0 and 1 WR herring, which were previously integral part of the management plans for NSAS herring. In the forecast, the combined selection pattern for the A and B fleets are scaled together to achieve the different targets of the forecast scenarios. Therefore, the fishing mortalities of the A and B fleets are both variable across the scenarios.

The 2025 advice exemplifies a 22.5% decrease. This is is mainly because of the downward revision of the 2022 year class (which contributes to SSB in the forecast year) due to the lowest observed survey abundance of IBTS-Q1 in 2024.

All predictions are for North Sea autumn spawning herring only.

2.7.1 Exploratory short-term projections

A direct comparison of the forecast results with the last two assessments (2024 and 2023) is given in Figure 2.7.2.1 for the total SSB, Figure 2.7.2.2 for the catches at age and Figure 2.7.2.3 as proportions. Overall, it is predicted that the contribution of old ages will be lessened in 2024 relative to 2023.

2.8 Medium-term predictions and HCR simulations

No medium-term prediction or HCR simulations were carried out during the Working Group. A new management strategy evaluation was carried out in 2019 (ICES WKNSMSE, 2019), following an EU-Norway request (EU–Norway, 2018). However, to date there is no agreement of management plan between EU, Norway, and UK.

2.9 Precautionary and Limit Reference Points and FMSY targets

The precautionary reference points for this stock were originally adopted in 1998 and updated in 2012, 2016, 2018 and 2021. At HAWG 2024, the refence points were updated again because of the include of new natural mortality vector.

New reference points were calculated using the msy package (https://github.com/ices-tools-prod/msy). The configuration of the model were kept the same as for the 2021 interbenchmark meeting (ICES, 2021). It resulted in a downward estimate of Blim (-5.2%) and MSYBtrigger (-8.2%) and an upward estimate of Fmsy (Table 2.9.1).

Overall, in light of the 2023 assessment, the fishing pressure remains below FMSY while the SSB is above MSY BTrigger.

2.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2018 benchmark (ICES WKPELA, 2018) and 2021 inter-benchmark (ICES, 2021). These are described in the North Sea Herring Stock Annex (a list of links to the Stock Annexes can be found in Annex 4). The changes made during the 2021 inter-benchmark overall improved the assessment model. Sensitivity testing revealed that the derivation of reference points for herring in the North Sea is very sensitive to the choice of time periods and stock–recruitment models used.

New natural mortality estimates were introduced in the assessment (ICES, 2024a) which resulted in re-evaluating reference points. The new estimates are similar to the previous reference points.

The results of the updated assessment for fishing mortality and SSB are consistent with last year. The 2022-2023 recruitment has been revised downward, especially the 2022 year class (recruitment in 2023).

2.11 North Sea herring spawning components

The North Sea autumn-spawning herring stock is generally understood as representing a complex of multiple spawning components (Cushing, 1955; Harden Jones, 1968; Iles and Sinclair, 1982; Heath et al., 1997). Monitoring and maintaining the diversity of local populations is widely viewed as critical to the successful management of marine fish stocks.

2.11.1 International Herring Larval Survey

The spawning component abundance index (SCAI: Payne, 2010) was developed to characterize the relative dynamics of the individual North Sea spawning components.

The dynamics of the components are documented in Table 2.3.2.1 and can be observed in Figure 2.11.1.

Prior to 2002 there were large differences in the contributions of each of the components to the total SSB with northern components (Orkney/Shetland and Buchan) being the major contributors. Since 2002 there has been a more even contribution from each of the four components with some interannual variability. However, the Downs component may be underrepresented in some years due late spawning and Orkney-Shetland due to a lack of sampling due to vessel constraints in 2016-2019. In recent years, the Downs component is dominating, an aspect that has been confirmed by a dedicated larvae survey conducted in April (Downs Recruitment Survey).

2.11.2 IBTS0 Larval Index

The ring net hauls for 0-ringers during the IBTS in the North Sea and eastern English Channel also include Downs herring larvae. These larvae are, however, too small to have passed their critical period of high and highly variable mortality. Their abundance cannot be used for recruitment prediction. These small larvae (separated as <19 mm) have been excluded from the standard estimation of 0-ringer recruitment (IBTS0 index).

A dedicated survey (Downs Recruitment Survey) in April has been carried out since 2018. In the future results of this survey are planned to be added to the IBTS0 larval index.

2.11.3 Component considerations

The Downs TAC was set up to conserve the spawning aggregation of Downs herring. Uncertainties concerning the status of, and recruitment to, this component of the North Sea herring stock are high, and HAWG is not aware of any evidence to suggest that this measure is inappropriate. HAWG therefore recommends that the 4.c–7.d TAC be maintained at 11% of the total North Sea TAC (as recommended by ICES). Any new management approach should provide an appropriate balance of F across stock components and be similarly conservative until the uncertainty about contribution of the Downs and other components to the catch in all fisheries in the North Sea is reduced.

2.12 Ecosystem considerations

The status as of 2015 can be found in ICES HAWG (2015) and the stock annex.

2.13 Changes in the environment

For several herring stocks in the working group, the mean weight-at-age in the catch and in the stock has been decreasing since the early 1980s. This applies to the Celtic Sea herring, Irish Sea herring and North Sea Autumn Spawning herring. No real pattern is observed for Western Baltic Spring-spawning herring and an increase in mean weight is seen in the combined Malin Shelf herring.

Decreases in mean weight in the catch could drive the recent increase in selectivity of the fisheries for older ages. The fisheries often target certain weight classes of herring which could be of an older age in the recent years.

The North Sea Autumn Spawning herring stock has, since 2002, produced a series of below average year classes, a situation which has not been observed previously (Payne et al., 2009): the most recent year class also appears to represent a continuation of this trend. This low recruitment has occurred despite a spawning-stock biomass that is well above the Blim of 828 874 tonnes (where impaired recruitment is expected to set in) (Figure 2.13.1).

Stock productivity, as represented by the number of recruits-per-spawner from the assessment, has been low for the last two decades (Figure 2.13.2). Although there have been changes during this low productivity regime, at no point has this metric approached the levels seen during the 1990s. The most recent recruits-per-spawner is amongst the lowest observed during the recent period.

Year-class strength in this stock is determined during the larvae phase (Dickey-Collas and Nash, 2005; Payne et al., 2009). Updating these analyses with the most recent datasets suggests that the trend of reduced larval survival between the early (as indicated by the SSB/LAI index) and the late (as indicated by the IBTS0 index) larval stages has continued in the most recent years (Figure 2.13.3). It should be noted that the IBTS0 index does not represent the Downs component of the larvae abundance and is prone to a mismatch as the proportion of the Downs in the overall stock varies (see below). In addition the switch from the SCAI calculation to the LAI calculation inside the assessment model, has caused a higher variability of the larvae survival relationship between SSB/LAI and IBTS0 indices. The most recent observation continues the trend of relatively poor survival.

The IBTS0 index is regarded by the working group as not being representative of recruitment to the Downs spawning component, as observations of small larvae in this region are removed from the index calculation. A more appropriate metric is therefore to base the metric of larval survival on the abundance of larvae from the three northern components (i.e., excluding the Downs). However, this refined metric shows a very similar trend (Figure 2.13.4) with continued poor survival.

All indicators therefore suggest that the stock remains in the low productivity regime observed in previous years.

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2.15 Tables and Figures

Table 2.1.1. Herring caught in the North Sea. Total catch (tonnes) by country, 2019–2023. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2019	2020	2021	2022	2023
Belgium	60	119	47	52	46
Denmark *	91 680	95 615	62 943	76 168	67 301
Faroe Islands	614	804	0	212	0
France	25 288	19 768	25 070	28 573	27 325
Germany	37 699	29 439	25 741	28 573	32 315
Netherlands	79 465	75 036	66 402	46 986	69 808
Norway	128 614	115 879	95 061	74 376	113 714

Lithuania	0	0	466	0	9 866
Sweden *	13 184	13 149	18 765	19 813	21 671
Ireland	3	235	414	306	266
UK (England)	12 685	16 241	13 174	15 590	15 397
UK (Scotland)	50 771	49 692	51 194	63 756	54 957
UK (N.Ireland)	3 938	2 681	5 176	3 866	8 033
Unallocated landings	0	0	0	0	0
Total landings	444 001	424 800	364 453	463 696	420 699
Discards/BMS	1 630	2 522	162	3 438	705
Estimates of the parts of the catches which have been allocated to spring-spawning stocks					
WBSS	8 832	6 802	3 505	5 402	2 361
Thames estuary **	-	-	2	0	0
Norw. Spring Spawners ***	5	88	0	0	0

*** Including any bycatches in the industrial fishery**

**** Landings from the Thames estuary area are included in the North Sea catch figure for UK (England).**

***** These catches (including some local fjord-type Spring Spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area.**

Table 2.1.2. Herring caught in the North Sea. Catch in tonnes in Division 4.a (West). These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2019	2020	2021	2022	2023
Denmark *	54 820	56 676	37 970	43 150	50 885
Faroe Islands	611	794	0	8	0
France	13 344	7 688	13 795	18 055	15 475
Germany	19 851	16 694	16 590	38 182	22 267
Lithuania	0	2 789	466	0	9 866
Netherlands	44 071	50 363	48 510	49 603	49 948
Norway	53 254	35 674	7 119	14 017	19 259
Sweden	8 557	7 718	11 100	10 412	12 267
Ireland	3	235	414	306	266
UK (England)	5 640	11 439	9 487	10 752	11 239

UK (Scotland)	50 771	42 581	33 416	53 829	51 922
UK (N. Ireland)	3 938	2 681	2 514	3 866	8 033
Total Landings	254 860	235 330	181 381	242 180	251 426
Discards/BMS	-	284	64	1 177	-
Total catch	254 860	235 613	181 445	243 357	251 426

Table 2.1.3. Herring caught in the North Sea. Catch in tonnes in Division 4.a (East). These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2019	2020	2021	2022	2023
Denmark *	0	62	18	618	1 097
Faroese	0	0	0	204	0
Netherlands	100	0	0	913	78
Norway	64 592	58 535	87 756	113 476	91 933
Sweden	0	0	479	1 356	555
Total landings	64 692	58 597	88 253	116567	93 663
Discards/BMS	-	-	-	-	-
Total catch	64 692	58 597	88 253	116 567	93 663
Norw. Spring Spawners **	5	88	0	0	0

*** Including any bycatches in the industrial fishery.**

**** These catches (including some fjord-type spring spawners) are taken by Norway under a separate quota south of 62°N and are not included in the Norwegian North Sea catch figure for this area.**

Table 2.1.4. Herring caught in the North Sea. Catch in tonnes in Division 4.b. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2019	2020	2021	2022	2023
Belgium	0	11	1	0	0
Denmark*	367 50	38 842	24 903	32 399	15 162
Faroe Islands	3	10	0	0	0
France	1 359	5 092	1 569	1 167	1 616
Germany	8 568	4 197	3 869	838	2 464
Netherlands	20 700	8 814	691	6 124	632
UK (N. Ireland)	0	0	2 662	0	0

Country	2019	2020	2021	2022	2023
Norway	10 768	21 671	186	6 505	2 522
Sweden*	4 627	5 431	7 166	8 045	8 817
UK (England)	2 750	919	4	695	319
UK (Scotland)	0	7 082	17 775	9 923	3 028
Unallocated landings	0	0	0	0	0
Total landings	85 525	95 422	58 826	65 696	34 560
Discards	800	-	-	-	-
Total catch	86 325	95 422	58 826	65696	34560

***Including any bycatches in the industrial fishery**

Table 2.1.5. Herring caught in the North Sea. Catch in tonnes in Division 4.c and 7.d. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2019	2020	2021	2022	2023
Belgium	60	108	46	52	46
Denmark*	110	36	53	1	157
France	10 585	6 988	9 705	9 351	10 234
Germany	9 280	8 548	5 282	7 966	7 584
Netherlands	14 594	15 859	17 202	17 736	19 150
Sweden	0	0	21	0	33
UK (England)	4 295	3 883	3 682	4143	3 839
UK (Scotland)	0	30	2	4	7
Unallocated landings	0	0	0	0	0
Total landings	38 924	35 451	35 992	39 252	41 050
Discards/BMS	830	2 238	99	2 261	25
Total catch	39 754	37 689	36 091	41 514	41 075
Coastal spring spawners included above**	0	0	2	0	0

*** Including any bycatches in the industrial fishery**

**** Landings from the Thames estuary area are included in the North Sea catch figure for UK (England).**

***** Negative unallocated catches due to misreporting into other areas.**

Table 2.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea 4, Division 7.d and Division 3.a.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Agreed Divisions 4.a,b	427.7	418.3	396.3	461.2	428.7	534.5	342.7	342.7	321.6	380.6	352.9	454.2
Agreed Div. 4.c, 7.d	50.3	51.7	49.0	57.0	53.0	66.0	42.4	42.4	34.8	47.0	43.6	56.1
Bycatch ceiling in the small mesh fishery *	14.4	13.1	15.7	13.4	11.4	9.7	13.2	9.0	7.8	8.2	7.7	7.7
National catch Divisions 4.a,b **	453.8	465.9	439	514.0	456.5	556.9	405.1	389.3	328.5	424.4	379.6	
Unallocated catch Divisions 4.a,b	0.0	3.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.a,b ***	-	0.0	-	0.1	-	0.0	0.8	0.3	0.1	1.2	0.7	
Total catch Divisions 4.a,b #	453.9	469.2	440.5	514.1	456.5	556.9	405.9	389.6	328.5	425.6	380.3	
National catch Divisions 4.c, 7.d **	44.7	38.2	41.1	45.8	35.2	45.4	38.9	35.5	36.0	41.5	41.0	
Unallocated catch Divisions 4.c,7.d	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.c, 7.d ***	-	-	-	0.1	-	0.1	0.8	2.2	0.1	0.0	0.0	
Total catch Divisions 4.c, 7.d	44.7	38.2	41.1	45.8	35.2	45.5	39.8	37.7	36.1	41.5	41.1	
Total catch 4 and 7.d as used by ICES #	498.5	507.5	481.6	559.9	491.7	602.3	445.6	427.3	364.6	467.1	421.4	
CATCH BY FLEET/STOCK (4 and 7.d) ##												
North Sea autumn spawners directed fisheries (Fleet A)	489.9	490.5	471.5	543.6	484.1	591.7	440.5	417.5	352.3	455.6	411.3	
North Sea autumn spawners industrial (Fleet B)	8.1	14.0	7.9	14.5	7.0	8.5	5.2	9.9	8.8	6.1	7.7	

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
North Sea autumn spawners in 4 and 7.d total	218.1	422.5	498.1	504.5	479.4	558.1	491.1	600.2	436.8	420.5	361.1	461.7	419.0
Baltic-3.a-type spring spawners in 4	0.3	2.1	0.5	3.0	2.2	1.8	0.6	2.2	8.8	6.8	3.5	5.4	2.4
Coastal-type spring spawners	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norw. Spring Spawners caught under a separate quota in 4 ###	12.2	9.6	3.2	2.3	2.2	0.2	0.1	0.3	0.0	0.1	0.0	0.0	0.0
Agreed herring TAC	30.0	45.0	55.0	46.8	43.6	51.1	50.7	48.4	29.3	24.5	21.6	25.0	23.3
Bycatch ceiling in the small mesh fishery	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
National catch	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	13.3	0.7	1.0
Catch as used by ICES	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	13.3	0.7	1.0
Autumn spawners human consumption (Fleet C)	6.6	7.8	11.8	9.5	10.2	4.1	7.4	3.2	5.8	6.0	4.1	0.3	0.6
Autumn spawners mixed clupeoid (Fleet D)	1.8	4.4	1.6	3.3	4.4	1.4	0.2	0.2	0.3	0.4	0.1	0.2	0.2
Autumn spawners in 3.a total	8.4	12.2	13.4	12.8	14.7	5.5	7.6	3.4	6.1	6.4	4.2	0.5	0.7
Spring spawners human consumption (Fleet C)	10.8	14.5	16.6	15.4	11.3	23.3	19.0	19.7	8.8	10.9	9.0	0.2	0.2
Spring spawners mixed clupeoid (Fleet D)	0.8	1.0	1.3	0.6	1.8	1.1	0.2	0.2	0.0	0.5	0.0	0.0	0.1
Spring spawners in 3.a total	11.6	15.5	17.9	16.1	13.1	24.4	19.2	19.9	8.8	11.4	9.1	0.2	0.3
North Sea autumn spawners Total as used by ICES	226.5	434.6	511.4	517.3	494.1	563.6	498.7	603.5	442.9	426.9	365.4	462.2	419.8

Table 2.2.1. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2023. Catch in numbers (millions) at age (CANUM), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea

Quarters: 1-4

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	1.5	0.0	0.0	0.0	9.8	571.1	15.6	0.0	580.9	15.6	598.0	596.5
1	16.7	83.9	0.1	83.9	32.7	137.8	2.3	0.1	254.4	2.4	273.0	256.8
2	0.6	108.0	4.9	103.	144.5	43.1	2.4	10.8	290.8	13.2	306.8	308.9
3	0.7	140.1	3.2	136.	288.2	32.1	10.4	32.9	457.2	43.2	501.6	503.6
4	0.1	79.6	3.2	76.4	351.0	27.3	15.4	47.3	454.7	62.8	517.6	520.6
5	0.0	60.2	2.2	58.1	233.4	23.0	10.6	39.5	314.5	50.1	364.6	366.7
6	0.0	25.0	1.6	23.4	71.7	6.7	1.3	21.2	101.7	22.5	124.6	125.8
7	0.0	33.2	1.2	32.0	82.5	10.1	2.8	31.7	124.6	34.6	159.2	160.4
8	0.0	11.9	0.2	11.7	56.9	4.9	2.1	11.7	73.4	13.7	87.3	87.4
9+	0.0	62.9	1.5	61.3	136.0	18.8	2.7	26.4	216.1	29.1	246.0	246.8
Sum	19.7	604.8	18.0	586.	1406.	874.9	65.6	221.	2868.2	287.	**3178.7**	**3173.4**

Quarter: 1

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	9.3	0.2	0.0	0.2	0.2	0.4	0.1	0.0	0.8	0.1	10.2	0.9
2	0.2	0.3	3.7	0.0	6.1	30.2	2.3	0.0	36.2	2.3	38.5	38.8
3	0.0	0.3	0.2	0.1	17.5	1.0	1.1	1.2	18.6	2.3	21.0	21.1
4	0.0	0.1	0.0	0.1	10.2	0.0	0.5	3.5	10.3	4.0	14.3	14.3
5	0.0	0.1	0.0	0.1	10.9	0.1	0.8	5.6	11.0	6.4	17.4	17.4
6	0.0	0.1	0.0	0.1	1.1	0.0	0.4	3.4	1.2	3.8	5.0	5.0
7	0.0	0.1	0.0	0.1	1.5	0.0	0.4	2.9	1.5	3.3	4.8	4.8
8	0.0	0.0	0.0	0.0	0.9	0.0	0.4	2.9	0.9	3.3	4.3	4.3
9+	0.0	0.1	0.0	0.1	1.9	0.0	0.3	1.9	2.0	2.2	4.2	4.2
Sum	9.6	1.3	4.0	0.7	50.2	31.6	6.3	21.4	82.5	27.	**119.7**	**110.8**

Quarter: 2

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	0.0	0.0	0.0	0.0	0.0	63.8	0.0	0.0	63.8	0.0	63.8	63.8
1	1.3	61.3	0.0	61.3	1.6	16.0	0.0	0.0	78.9	0.0	80.0	78.9
2	0.0	93.8	0.6	93.2	20.4	1.6	0.1	0.0	115.2	0.1	114.8	115.9
3	0.0	93.8	0.3	93.5	30.3	1.9	0.0	0.0	125.7	0.0	125.8	126.1
4	0.0	40.9	0.3	40.7	18.6	0.8	0.0	0.0	60.1	0.0	60.1	60.4
5	0.0	37.0	0.2	36.8	12.0	0.8	0.0	0.0	49.7	0.0	49.7	49.9
6	0.0	16.3	0.1	16.2	3.4	0.2	0.0	0.0	19.9	0.0	19.9	20.0
7	0.0	19.4	0.0	19.4	2.4	0.2	0.0	0.0	22.0	0.0	22.0	22.1
8	0.0	7.0	0.0	7.0	1.4	0.0	0.0	0.0	8.5	0.0	8.5	8.5
9+	0.0	23.3	0.0	23.3	3.1	0.4	0.0	0.0	26.8	0.0	26.8	26.8
Sum	1.4	392.9	1.5	391.	93.4	85.7	0.2	0.0	570.5	0.2	**571.6**	**572.2**

Quarter: 3

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	0.5	0.0	0.0	0.0	2.7	296.3	0.0	0.0	299.1	0.0	299.6	299.1
1	1.3	18.6	0.0	18.5	19.3	80.6	0.0	0.0	118.4	0.0	119.3	118.4
2	0.3	7.7	0.6	7.2	107.5	8.2	0.0	0.0	122.8	0.0	122.	123.4
3	0.6	22.1	2.6	19.4	221.5	24.8	0.0	0.1	265.7	0.1	267.2	268.4
4	0.1	31.5	2.7	28.9	290.2	19.1	0.0	0.1	338.2	0.1	338.5	341.0
5	0.0	18.8	1.9	16.9	192.1	14.3	0.0	0.1	223.3	0.1	223.4	225.3
6	0.0	5.8	1.2	4.7	63.4	3.5	0.0	0.0	71.5	0.0	71.6	72.7
7	0.0	11.6	1.2	10.4	75.0	4.6	0.0	0.1	90.1	0.1	90.1	91.3
8	0.0	4.7	0.1	4.6	50.7	2.5	0.0	0.0	57.8	0.0	57.8	57.9
9+	0.0	33.9	0.8	33.2	122.6	11.4	0.0	0.1	167.1	0.1	167.2	168.0
Sum	2.9	154.7	11.0	143.	1145.	465.3	0.0	0.4	1754.0	0.4	**1757.5**	**1765.5**

Quarter: 4

0	1.0	0.0	0.0	0.0	7.0	211.0	15.6	0.0	218.0	15.6	234.7	233.7
1	4.8	3.9	0.0	3.9	11.7	40.8	2.1	0.1	56.3	2.3	63.4	58.6
2	0.0	6.2	0.0	6.2	10.5	3.2	0.0	10.	19.9	10.	30.8	30.8
3	0.0	23.9	0.0	23.9	18.9	4.4	9.2	31.6	47.2	40.8	87.6	88.0
4	0.0	6.9	0.3	6.7	32.0	7.5	14.9	43.8	46.1	58.6	104.	105.0
5	0.0	4.3	0.0	4.3	18.4	7.8	9.8	33.7	30.5	43.6	74.1	74.1
6	0.0	2.8	0.3	2.4	3.7	3.0	0.9	17.8	9.0	18.7	28.1	28.1
7	0.0	2.2	0.0	2.2	3.6	5.2	2.4	28.	11.0	31.	42.2	42.2
8	0.0	0.2	0.1	0.1	3.8	2.4	1.7	8.7	6.2	10.	16.7	16.7
9+	0.0	5.5	0.7	4.8	8.3	7.0	2.4	24.4	20.2	26.8	47.7	47.7
Sum	5.8	55.8	1.4	54.4	117.9	292.3	59.0	199.	464.6	258.	729.9	724.8

Table 2.2.2. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2023. Mean weight-at-age (kg) in the catch (WECA), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aW	4.b	4.c	7.d	4.a & 4.b all	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4											
0	0.020	0.000	0.000	0.008	0.007	0.008	0.000	0.007	0.008	0.007	0.007
1	0.031	0.072	0.050	0.077	0.027	0.035	0.081	0.048	0.037	0.047	0.048
2	0.078	0.124	0.067	0.117	0.076	0.068	0.107	0.113	0.100	0.113	0.113
3	0.174	0.156	0.178	0.157	0.168	0.115	0.112	0.157	0.113	0.154	0.154
4	0.186	0.186	0.194	0.189	0.188	0.145	0.134	0.189	0.137	0.182	0.182
5	0.171	0.182	0.185	0.194	0.191	0.149	0.152	0.191	0.151	0.186	0.186
6	0.178	0.186	0.186	0.198	0.194	0.158	0.164	0.195	0.163	0.189	0.189
7	0.197	0.192	0.196	0.205	0.202	0.184	0.186	0.201	0.185	0.198	0.198
8	0.000	0.196	0.191	0.219	0.223	0.204	0.186	0.216	0.189	0.212	0.212
9+	0.000	0.210	0.198	0.232	0.226	0.183	0.203	0.226	0.201	0.223	0.223
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.025	0.072	0.030	0.075	0.030	0.034	0.000	0.052	0.034	0.027	0.049
2	0.036	-0.024	0.057	0.090	0.057	0.068	0.000	0.063	0.068	0.063	0.063
3	0.102	0.170	0.089	0.124	0.090	0.105	0.103	0.122	0.104	0.120	0.120
4	0.143	0.166	0.166	0.158	0.139	0.122	0.109	0.158	0.111	0.145	0.145
5	0.120	0.186	0.126	0.154	0.125	0.121	0.122	0.153	0.122	0.142	0.142
6	0.000	0.174	0.174	0.183	0.000	0.137	0.138	0.183	0.138	0.148	0.148
7	0.000	0.177	0.177	0.188	0.000	0.143	0.144	0.187	0.144	0.158	0.158
8	0.000	0.179	0.179	0.220	0.000	0.149	0.150	0.219	0.150	0.165	0.165
9+	0.000	0.190	0.190	0.192	0.000	0.150	0.155	0.192	0.154	0.172	0.172
Quarter: 2											
0	0.023	0.000	0.007	0.000	0.007	0.000	0.000	0.007	0.000	0.007	0.007
1	0.038	0.072	0.022	0.078	0.022	0.034	0.000	0.062	0.034	0.062	0.062
2	0.059	0.123	0.066	0.116	0.111	0.068	0.000	0.121	0.068	0.121	0.121
3	0.053	0.151	0.180	0.147	0.166	0.114	0.103	0.150	0.114	0.150	0.150
4	0.000	0.166	0.192	0.169	0.174	0.127	0.109	0.167	0.126	0.167	0.167
5	0.000	0.166	0.186	0.182	0.166	0.125	0.122	0.170	0.125	0.170	0.170
6	0.000	0.174	0.177	0.186	0.176	0.141	0.138	0.176	0.140	0.176	0.176
7	0.000	0.177	0.197	0.179	0.196	0.149	0.145	0.177	0.148	0.177	0.177
8	0.000	0.179	0.196	0.210	0.228	0.151	0.150	0.185	0.151	0.185	0.185
9+	0.000	0.190	0.216	0.203	0.219	0.162	0.158	0.192	0.161	0.192	0.192
Quarter: 3											
0	0.023	0.000	0.007	0.000	0.007	0.000	0.000	0.007	0.000	0.007	0.007

1	0.038	0.072	0.022	0.078	0.022	0.034	0.000	0.062	0.034	0.062	0.062
2	0.059	0.123	0.066	0.116	0.111	0.068	0.000	0.121	0.068	0.121	0.121
3	0.053	0.151	0.180	0.147	0.166	0.114	0.103	0.150	0.114	0.150	0.150
4	0.000	0.166	0.192	0.169	0.174	0.127	0.109	0.167	0.126	0.167	0.167
5	0.000	0.166	0.186	0.182	0.166	0.125	0.122	0.170	0.125	0.170	0.170
6	0.000	0.174	0.177	0.186	0.176	0.141	0.138	0.176	0.140	0.176	0.176
7	0.000	0.177	0.197	0.179	0.196	0.149	0.145	0.177	0.148	0.177	0.177
8	0.000	0.179	0.196	0.210	0.228	0.151	0.150	0.185	0.151	0.185	0.185
9+	0.000	0.190	0.216	0.203	0.219	0.162	0.158	0.192	0.161	0.192	0.192

Quarter: 4

0	0.023	0.000	0.000	0.008	0.008	0.008	0.000	0.008	0.008	0.008	0.008
1	0.040	0.093	0.099	0.078	0.037	0.035	0.081	0.049	0.038	0.048	0.049
2	0.062	0.132	0.137	0.116	0.100	0.078	0.107	0.118	0.107	0.114	0.114
3	0.060	0.149	0.153	0.156	0.143	0.116	0.112	0.151	0.113	0.134	0.134
4	0.000	0.175	0.180	0.184	0.187	0.146	0.136	0.183	0.139	0.158	0.158
5	0.000	0.183	0.183	0.195	0.188	0.151	0.157	0.191	0.155	0.170	0.170
6	0.186	0.199	0.203	0.210	0.198	0.168	0.169	0.203	0.169	0.180	0.180
7	0.000	0.194	0.194	0.225	0.197	0.191	0.190	0.206	0.190	0.194	0.194
8	0.000	0.187	0.188	0.223	0.216	0.218	0.199	0.220	0.202	0.209	0.209
9+	0.000	0.205	0.202	0.221	0.216	0.187	0.207	0.215	0.205	0.210	0.210

Table 2.2.3. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2023. Mean length-at-age (cm) in the catch, by quarter and division.

WR	3.a NSAS	4.aE all	4.aW WBSS	4.aW	4.b	4.c	7.d	4.a & 4.b all	4.c & 7.d	Herring caught in the North Sea
Quarters: 1-4										
0	n.d.	0.0	n.d.	10.1	9.9	10.2	0.0	9.9	10.2	9.9
1	n.d.	20.0	n.d.	21.0	15.1	16.3	21.8	17.5	16.6	17.5
2	n.d.	23.4	n.d.	23.9	21.4	21.6	23.7	23.4	23.3	23.3
3	n.d.	25.8	n.d.	26.2	26.1	24.3	24.2	26.0	24.2	25.9
4	n.d.	27.1	n.d.	27.8	27.6	26.1	25.6	27.6	25.7	27.4
5	n.d.	27.1	n.d.	28.0	27.7	26.2	26.7	27.8	26.6	27.6
6	n.d.	27.5	n.d.	28.1	28	27.5	27.5	27.9	27.5	27.8
7	n.d.	27.8	n.d.	28.3	28.1	28.1	28.1	28.2	28.1	28.2
8	n.d.	27.8	n.d.	29.1	29.2	28.2	28.5	28.9	28.4	28.8
9+	n.d.	28.6	n.d.	29.5	29.3	28.2	28.9	29.2	28.8	29.2
Quarter: 1										
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	n.d.	19.8	n.d.	20.6	17.0	17.8	0.0	18.6	17.8	18.5
2	n.d.	23.3	n.d.	22.2	20.4	21.6	0.0	20.7	21.6	20.8
3	n.d.	25.2	n.d.	25.0	23.2	25.2	25.3	24.9	25.2	24.9
4	n.d.	26.2	n.d.	26.9	27.8	26.6	25.8	26.9	25.9	26.6
5	n.d.	26.4	n.d.	27.0	25.0	26.9	26.9	27.0	26.9	26.9
6	n.d.	26.8	n.d.	28.2	0.0	27.8	27.8	28.1	27.8	27.9
7	n.d.	27.2	n.d.	28.6	0.0	28.0	28.1	28.6	28.1	28.2
8	n.d.	27.2	n.d.	29.7	0.0	28.5	28.5	29.7	28.5	28.8
9+	n.d.	27.8	n.d.	29.1	0.0	28.6	28.8	29.1	28.8	28.9

0	n.d.	0.0	n.d.	0.0	9.8	0.0	0.0	9.8	0.0	9.8
1	n.d.	19.8	n.d.	20.8	14.4	17.8	0.0	18.7	17.8	18.7
2	n.d.	23.3	n.d.	23.8	23.1	21.6	0.0	23.4	21.6	23.4

3	n.d.	25.2	n.d.	25.7	25.8	25.2	25.3	25.3	25.2	25.3
4	n.d.	26.2	n.d.	26.8	26.5	26.8	25.8	26.4	26.7	26.4
5	n.d.	26.4	n.d.	27.4	26.1	26.8	26.9	26.6	26.8	26.6
6	n.d.	26.8	n.d.	27.6	27.1	27.7	27.8	26.9	27.7	26.9
7	n.d.	27.2	n.d.	27.4	28	28.1	28.1	27.2	28.1	27.2
8	n.d.	27.2	n.d.	28.9	29.6	28.5	28.5	27.5	28.5	27.5
9+	n.d.	27.8	n.d.	28.3	29.1	28.9	29	27.9	28.9	27.9

Quarter: 2

Quarter: 3

0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	n.d.	19.9	n.d.	19.9	19.9	19.9	19.9	19.9	19.9	19.9
2	n.d.	23.3	n.d.	23.3	23.3	23.3	23.3	23.3	23.3	23.3
3	n.d.	27.1	n.d.	27.1	27.1	27.1	27.1	27.1	27.1	27.1
4	n.d.	28.1	n.d.	28.1	28.1	28.1	28.1	28.1	28.1	28.1
5	n.d.	28.2	n.d.	28.2	28.2	28.2	28.2	28.2	28.2	28.2
6	n.d.	28.3	n.d.	28.3	28.3	28.3	28.3	28.3	28.3	28.3
7	n.d.	28.6	n.d.	28.6	28.6	28.6	28.6	28.6	28.6	28.6
8	n.d.	28.6	n.d.	28.6	28.6	28.6	28.6	28.6	28.6	28.6
9+	n.d.	28.9	n.d.	28.9	28.9	28.9	28.9	28.9	28.9	28.9

Quarter: 4

0	n.d.	0.0	n.d.	10.2	10.2	10.2	0.0	10.2	10.2	10.2
1	n.d.	22.7	n.d.	21.4	16.6	16.2	21.8	18.0	16.5	17.9
2	n.d.	25.6	n.d.	24.2	22.6	21.5	23.7	24.4	23.7	24.1
3	n.d.	26.9	n.d.	26.4	25.2	24.2	24.1	26.5	24.1	25.4
4	n.d.	28.0	n.d.	27.9	27.6	26.1	25.6	27.9	25.7	26.7
5	n.d.	29.0	n.d.	28.5	27.6	26.1	26.7	28.4	26.5	27.3
6	n.d.	30.1	n.d.	29.1	28.0	27.3	27.4	29.1	27.4	28.0
7	n.d.	29.8	n.d.	29.4	27.7	28.1	28.0	28.7	28.1	28.2
8	n.d.	28.0	n.d.	29.9	29.0	28.1	28.5	29.5	28.4	28.8
9+	n.d.	30.6	n.d.	29.9	28.9	28.1	28.9	29.7	28.8	29.2

Table 2.2.4. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2023. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	0.0	0.0	0.0	0.0	0.1	4.2	0.1	0.0	4.2	0.1	4.4	4.4
1	0.5	6.1	0.0	6.0	2.5	3.7	0.1	0.0	12.3	0.1	12.9	12.4
2	0.0	13.3	0.3	13.0	16.9	3.3	0.2	1.2	33.2	1.3	34.5	34.8
3	0.1	21.9	0.6	21.5	45.1	5.4	1.2	3.7	72.0	4.9	76.9	77.3
4	0.0	14.8	0.6	14.2	66.4	5.1	2.2	6.4	85.8	8.6	94.4	95.0
5	0.0	11.0	0.4	10.6	45.2	4.4	1.6	6.0	60.2	7.6	67.7	68.1
6	0.0	4.7	0.3	4.4	14.2	1.3	0.2	3.5	19.9	3.7	23.5	23.8
7	0.0	6.4	0.2	6.2	16.9	2.0	0.5	5.9	25.1	6.4	31.5	31.7
8	0.0	2.3	0.0	2.3	12.5	1.1	0.4	2.2	15.9	2.6	18.4	18.5
9+	0.0	13.2	0.3	13.1	31.6	4.3	0.5	5.4	48.9	5.9	54.6	54.9
Sum	0.7	93.7	2.8	91.3	251.4	34.8	7.0	34.1	377.5	41.1	418.9	421.0

Quarter: 1

0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
2	0.0	0.0	0.2	0.0	0.5	1.7	0.2	0.0	2.3	0.2	2.2	2.4
3	0.0	0.0	0.0	0.0	2.2	0.1	0.1	0.1	2.3	0.2	2.5	2.5
4	0.0	0.0	0.0	0.0	1.6	0.0	0.1	0.4	1.6	0.4	2.1	2.1
5	0.0	0.0	0.0	0.0	1.7	0.0	0.1	0.7	1.7	0.8	2.5	2.5
6	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.5	0.2	0.5	0.7	0.7
7	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.4	0.3	0.5	0.8	0.8
8	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.4	0.2	0.5	0.7	0.7
9+	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.3	0.4	0.3	0.7	0.7
Sum	0.2	0.2	0.2	0.1	7.0	1.8	0.7	2.8	9.0	3.5	12.5	12.5

Quarter: 2

0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.4	0.4
1	0.1	4.4	0.0	4.4	0.1	0.4	0.0	0.0	4.9	0.0	4.9	4.9
2	0.0	11.4	0.0	11.4	2.4	0.2	0.0	0.0	13.9	0.0	14.0	14.0
3	0.0	14.2	0.1	14.1	4.5	0.3	0.0	0.0	18.9	0.0	18.9	18.9
4	0.0	6.8	0.1	6.8	3.1	0.1	0.0	0.0	10.0	0.0	10.0	10.1
5	0.0	6.2	0.0	6.1	2.2	0.1	0.0	0.0	8.4	0.0	8.4	8.5
6	0.0	2.8	0.0	2.8	0.6	0.0	0.0	0.0	3.5	0.0	3.5	3.5
7	0.0	3.4	0.0	3.4	0.4	0.0	0.0	0.0	3.9	0.0	3.9	3.9
8	0.0	1.2	0.0	1.2	0.3	0.0	0.0	0.0	1.6	0.0	1.6	1.6
9+	0.0	4.4	0.0	4.4	0.6	0.1	0.0	0.0	5.1	0.0	5.1	5.2
Sum	0.1	54.9	0.2	54.7	14.3	1.7	0.0	0.0	70.7	0.0	70.8	71.0

Quarter: 3

0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	2.1	0.0	2.1	2.1
1	0.0	1.3	0.0	1.3	1.5	1.9	0.0	0.0	4.6	0.0	4.6	4.6
2	0.0	1.0	0.1	0.8	12.8	1.1	0.0	0.0	14.7	0.0	14.8	14.8
3	0.1	4.2	0.5	3.8	35.5	4.4	0.0	0.0	43.7	0.0	43.7	44.1
4	0.0	6.8	0.5	6.3	55.8	3.6	0.0	0.0	65.7	0.0	65.7	66.2
5	0.0	4.0	0.4	3.7	37.8	2.8	0.0	0.0	44.2	0.0	44.2	44.6
6	0.0	1.2	0.2	1.0	12.6	0.7	0.0	0.0	14.3	0.0	14.3	14.5
7	0.0	2.5	0.2	2.3	15.4	1.0	0.0	0.0	18.6	0.0	18.6	18.9
8	0.0	1.1	0.0	1.0	11.1	0.6	0.0	0.0	12.7	0.0	12.7	12.7
9+	0.0	7.6	0.2	7.5	28.8	2.7	0.0	0.0	38.9	0.0	38.9	39.1
Sum	0.2	29.7	2.1	27.7	211.2	20.6	0.0	0.1	259.5	0.1	259.7	261.5

Quarter: 4

0	0.0	0.0	0.0	0.0	0.1	1.7	0.1	0.0	1.7	0.1	1.8	1.8
1	0.2	0.4	0.0	0.4	0.9	1.5	0.1	0.0	2.8	0.1	3.1	2.9
2	0.0	0.8	0.0	0.8	1.2	0.3	0.0	1.2	2.4	1.2	3.5	3.5
3	0.0	3.6	0.0	3.5	3.0	0.6	1.1	3.6	7.1	4.6	11.8	11.8
4	0.0	1.2	0.0	1.2	5.9	1.4	2.2	6.0	8.4	8.1	16.6	16.6
5	0.0	0.8	0.0	0.8	3.6	1.5	1.5	5.3	5.8	6.8	12.6	12.6
6	0.0	0.5	0.1	0.5	0.8	0.6	0.1	3.0	1.9	3.2	5.0	5.1
7	0.0	0.4	0.0	0.4	0.8	1.0	0.5	5.5	2.3	5.9	8.2	8.2
8	0.0	0.0	0.0	0.0	0.8	0.5	0.4	1.7	1.4	2.1	3.5	3.5
9+	0.0	1.1	0.1	1.1	1.8	1.5	0.5	5.0	4.5	5.5	9.9	10.0
Sum	0.2	8.9	0.3	8.8	18.9	10.6	6.3	31.2	38.3	37.6	75.9	75.9

Table 2.2.5. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2023. Percentage age composition (based on numbers, 3+ group summarized), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	8%	0%	0%	0%	1%	65%	24%	0%	20%	5%	19%	19%
1	85%	14%	1%	14%	2%	16%	3%	0%	9%	1%	9%	8%
2	3%	18%	27%	18%	10%	5%	4%	5%	10%	5%	10%	10%
3	3%	23%	18%	23%	21%	4%	16%	15%	16%	15%	16%	16%
4	1%	13%	18%	13%	25%	3%	24%	21%	16%	22%	16%	16%
5	0%	10%	12%	10%	17%	3%	16%	18%	11%	17%	12%	12%
6	0%	4%	9%	4%	5%	1%	2%	10%	4%	8%	4%	4%
7	0%	6%	7%	6%	6%	1%	4%	14%	4%	12%	5%	5%
8	0%	2%	1%	2%	4%	1%	3%	5%	3%	5%	3%	3%
9+	0%	10%	8%	11%	10%	2%	4%	12%	8%	10%	8%	8%
Sum 3+	4%	68%	73%	68%	87%	14%	69%	95%	61%	89%	63%	63%
Quarter: 1												
0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	97%	16%	0%	27%	0%	1%	2%	0%	1%	1%	9%	1%
2	2%	24%	94%	0%	12%	95%	36%	0%	44%	8%	32%	35%
3	0%	24%	5%	14%	35%	3%	18%	5%	23%	8%	18%	19%
4	0%	10%	0%	19%	20%	0%	8%	16%	13%	14%	12%	13%
5	0%	9%	1%	11%	22%	0%	12%	26%	13%	23%	15%	16%
6	0%	4%	0%	7%	2%	0%	7%	16%	1%	14%	4%	5%
7	0%	5%	0%	9%	3%	0%	6%	14%	2%	12%	4%	4%
8	0%	2%	0%	3%	2%	0%	6%	14%	1%	12%	4%	4%
9+	0%	6%	0%	11%	4%	0%	5%	9%	2%	8%	4%	4%
Sum 3+	0%	61%	6%	73%	88%	3%	62%	100%	55%	91%	59%	64%
Quarter: 2												
0	3%	0%	0%	0%	0%	74%	0%	0%	11%	0%	11%	11%
1	95%	16%	2%	16%	2%	19%	2%	0%	14%	2%	14%	14%
2	2%	24%	38%	24%	22%	2%	37%	0%	20%	34%	20%	20%
3	0%	24%	21%	24%	33%	2%	21%	6%	22%	20%	22%	22%
4	0%	10%	17%	10%	20%	1%	11%	17%	11%	11%	11%	11%
5	0%	9%	12%	9%	13%	1%	10%	26%	9%	11%	9%	9%
6	0%	4%	7%	4%	4%	0%	7%	16%	4%	7%	4%	4%
7	0%	5%	2%	5%	3%	0%	5%	13%	4%	6%	4%	4%
8	0%	2%	0%	2%	2%	0%	5%	14%	2%	6%	2%	2%
9+	0%	6%	2%	6%	3%	1%	2%	8%	5%	3%	5%	5%
Sum 3+	0%	61%	60%	61%	76%	5%	61%	100%	55%	64%	55%	55%
Quarter: 3												
0	17%	0%	0%	0%	0%	64%	0%	0%	17%	0%	17%	17%
1	44%	12%	0%	13%	2%	17%	0%	0%	7%	0%	7%	7%
2	11%	5%	5%	5%	9%	2%	0%	0%	7%	0%	7%	7%
3	22%	14%	24%	14%	19%	5%	0%	15%	15%	15%	15%	15%
4	4%	20%	24%	20%	25%	4%	0%	26%	19%	26%	19%	19%
5	1%	12%	18%	12%	17%	3%	0%	19%	13%	19%	13%	13%
6	0%	4%	11%	3%	6%	1%	0%	10%	4%	10%	4%	4%
7	0%	8%	11%	7%	7%	1%	0%	12%	5%	12%	5%	5%
8	0%	3%	1%	3%	4%	1%	0%	5%	3%	5%	3%	3%
9+	0%	22%	7%	23%	11%	3%	0%	13%	10%	13%	10%	10%
Sum 3+	28%	83%	95%	82%	89%	17%	0%	100%	69%	100%	69%	69%

Quarter: 4

0	17%	0%	0%	0%	6%	72%	26%	0%	47%	6%	32%	32%
1	82%	7%	0%	7%	10%	14%	4%	0%	12%	1%	9%	8%
2	0%	11%	0%	11%	9%	1%	0%	5%	4%	4%	4%	4%
3	0%	43%	0%	44%	16%	2%	16%	16%	10%	16%	12%	12%
4	0%	12%	18%	12%	27%	3%	25%	22%	10%	23%	14%	15%
5	0%	8%	0%	8%	16%	3%	17%	17%	7%	17%	10%	10%
6	0%	5%	24%	4%	3%	1%	2%	9%	2%	7%	4%	4%
7	0%	4%	0%	4%	3%	2%	4%	14%	2%	12%	6%	6%
8	0%	0%	9%	0%	3%	1%	3%	4%	1%	4%	2%	2%
9+	0%	10%	50%	9%	7%	2%	4%	12%	4%	10%	7%	7%
Sum 3+	0%	82%	100%	82%	75%	13%	70%	95%	37%	89%	55%	55%

Table 2.2.6. Total catch of herring caught in the North Sea and Division 3.a: North Sea autumn spawners (NSAS). Catch in numbers (millions) at mean weight-at-age (kg) by fleet, and SOP catches ('000 t). SOP catch might deviate from reported catch as used for the assessment. A fleet figure includes unsampled bycatch in the industrial fishery.

2023	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Winter rings	Numbers	Mean weight	Numbers	Mean weight	Numbers	Mean weight	Numbers	Mean weight	Numbers	Mean weight Mean
0	0.0	0.007	589.7	0.007	1.3	0.019	0.2	0.023	591.2	0.007
1	124.3	0.041	132.4	0.026	12.7	0.027	4.0	0.040	273.4	0.033
2	310.3	0.113	0.9	0.078	0.5	0.079	0.1	0.063	311.7	0.113
3	508.7	0.153	0.3	0.114	0.7	0.175	0.0	0.051	509.6	0.153
4	525.7	0.182	0.1	0.137	0.1	0.186	0.0	0.000	525.9	0.182
5	370.3	0.186	0.2	0.147	0.0	0.171	0.0	0.000	370.5	0.186
6	126.5	0.189	0.0	0.155	0.0	0.178	0.0	0.000	126.6	0.189
7	161.7	0.198	0.0	0.161	0.0	0.199	0.0	0.000	161.7	0.198
8	88.7	0.212	0.0	0.199	0.0	0.208	0.0	0.000	88.7	0.212
9+	249.9	0.223	0.0	0.183	0.0	0.000	0.0	0.000	249.9	0.223
TOTAL	2'466.0		723.5		15.4		4.3		3'209.2	
SOP catch		413.0		7.7		0.6		0.2		421.4

Table 2.2.7. Catch-at-age (numbers in millions) of North Sea herring, 2013–2023.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2013	461	327	239	482	571	422	327	145	153	160	3287
2014	1104	309	303	380	616	487	284	192	92	123	3890
2015	508	225	454	241	282	456	431	270	167	170	3204
2016	1450	86	578	813	293	280	368	307	186	173	4534
2017	462	133	74	1075	836	222	146	176	107	115	3345
2018	1323	54	178	200	1179	852	225	146	144	189	4491
2019	513	35	34	292	197	740	542	140	85	138	2717
2020	2048	86	505	210	290	146	515	349	69	108	4324
2021	527	97	372	420	185	270	120	322	212	81	2606
2022	717	161	885	600	408	156	204	105	202	140	357
2023	597	257	309	504	521	367	126	160	87	247	3173

Table 2.2.8. Catch-at-age (numbers in millions) of WBSS Herring taken in the North Sea, and transferred to the assessment of the spring-spawning stock in 3.a, 2013–2023.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2013	0.0	0.0	0.1	0.4	0.2	0.5	0.3	0.1	0.2	0.5	2.2
2014	0.0	0.0	2.5	3.4	5.4	0.8	2.1	1.0	0.5	1.1	16.8
2015	0.0	0.0	0.1	0.9	1.4	3.9	1.8	1.4	0.9	1.2	11.7
2016	0.0	0.0	1.2	4.1	1.0	1.1	1.2	0.7	0.4	0.8	10.6
2017	0.0	0.0	0.0	2.4	1.0	0.2	0.1	0.1	0.0	0.1	4.0
2018	0.0	0.0	0.3	0.9	2.3	4.3	1.7	0.9	0.3	0.4	11.0
2019	5.3	30.6	53.0	16.2	5.5	2.5	1.4	0.3	0.1	0.0	114.9
2020	0.0	1.8	3.2	5.8	7.5	1.2	10.7	5.3	1.8	2.8	40.2
2021	0.0	0.4	1.1	2.8	7.3	4.5	1.9	1.1	1.8	0.5	21.3
2022	0.0	0.1	6.2	6.7	7.2	5.1	4.5	2.5	2.5	0.8	35.6
2023	0.0	0.1	4.9	3.2	3.2	2.2	1.6	1.2	0.2	1.5	18.1

Table 2.2.9. Catch-at-age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2013– 2023.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2012	145.8	174.9	43.7	1.9	1.2	0.2	0.2	0.1	0.0	368.0
2013	0.9	86.2	85.8	2.4	0.4	0.3	0.0	0.0	0.0	175.9
2014	284.7	61.1	80.2	5.9	0.5	0.5	0.2	0.0	0.1	433.3
2015	30.7	169.6	97.6	7.0	1.3	4.9	1.1	1.2	0.4	313.6
2016	133.3	23.3	47.6	6.0	0.5	0.3	0.2	0.0	0.1	211.3
2017	0.1	76.0	34.4	6.9	3.0	1.2	0.1	0.0	0.0	121.8
2018	14.5	19.2	28.5	1.1	1.8	1.0	0.2	0.1	0.1	66.5
2019	23.7	101.3	19.8	4.6	0.1	0.1	0.1	0.0	0.0	149.8
2020	79.4	26.6	44.2	5.3	2.2	0.3	0.6	0.8	0.0	159.3
2021	6.9	15.7	36.3	2.8	1.5	0.8	0.5	0.1	0.1	64.8
2022	1.2	3.3	3.8	0.2	0.1	0.1	0.1	0.0	0.0	9.0
2023	0.0	0.1	4.9	3.2	3.2	2.2	1.6	1.2	0.2	1.5

Table 2.2.10. Catch-at-age (numbers in millions) of the total NSAS stock 2012–2023.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2013	462	413	325	484	571	422	327	145	152	160	3461
2014	1389	371	383	386	617	488	285	192	92	123	4323
2015	538	395	552	248	283	461	432	271	168	170	3517
2016	1584	109	625	819	293	280	368	307	186	173	4745
2017	462	209	109	1080	838	223	146	176	107	115	3463
2018	1337	73	206	201	1179	849	224	145	144	188	4546
2019	537	137	54	296	197	740	542	140	85	138	2866
2020	2127	112	549	215	292	146	515	349	69	108	4483
2021	534	112	407	420	179	266	118	321	210	81	2649
2022	718	164	882	593	401	151	200	103	199	139	3552
2023	598	273	307	502	518	365	125	159	87	246	3179

Table 2.2.11. Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring and NSAS caught in Division 3.a in 2013–2023

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	2013	0.075	0.134	0.160	0.201	0.000	0.000	0.000	-
	2014	0.074	0.109	0.162	0.191	0.209	0.221	0.228	-
	2015	0.068	0.133	0.157	0.180	0.196	0.197	0.215	-
	2016	0.059	0.123	0.149	0.157	0.208	0.211	0.235	-
	2017	0.068	0.103	0.139	0.173	0.171	0.185	0.162	-
	2018	0.058	0.103	0.156	0.179	0.190	0.187	0.203	-
	2019	0.062	0.085	0.116	0.118	0.164	0.202	0.159	-
	2020	0.066	0.139	0.168	0.175	0.199	0.216	0.000	-
	2021	0.071	0.116	0.159	0.174	0.192	0.206	0.186	-
	2022	0.061	0.117	0.158	0.170	0.193	0.198	0.205	-
	2023	0.078	0.174	0.186	0.171	0.178	0.197	0.000	-
4.a(E)	2013	0.129	0.147	0.184	0.191	0.205	0.215	0.215	0.228
	2014	0.146	0.161	0.167	0.195	0.200	0.216	0.227	0.224
	2015	0.127	0.148	0.163	0.178	0.191	0.203	0.212	0.227
	2016	0.129	0.153	0.167	0.183	0.195	0.205	0.216	0.229
	2017	0.132	0.154	0.170	0.182	0.193	0.198	0.203	0.209
	2018	0.125	0.152	0.173	0.188	0.201	0.212	0.219	0.230
	2019	0.134	0.155	0.173	0.212	0.204	0.209	0.220	0.250
	2020	0.126	0.144	0.158	0.169	0.180	0.191	0.197	0.210
	2021	0.126	0.149	0.162	0.178	0.180	0.200	0.203	0.220
	2022	0.129	0.140	0.179	0.215	0.250	0.205	0.215	0.234
	2023	0.124	0.156	0.186	0.182	0.186	0.192	0.196	0.210
4.a(W)	2013	0.139	0.158	0.201	0.197	0.218	0.234	0.234	0.251
	2014	0.143	0.172	0.184	0.215	0.212	0.227	0.246	0.242
	2015	0.124	0.158	0.198	0.211	0.233	0.228	0.239	0.252
	2016	0.138	0.161	0.189	0.215	0.227	0.242	0.233	0.250

	2017	0.120	0.160	0.177	0.192	0.218	0.226	0.236	0.236

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2018	0.114	0.156	0.188	0.193	0.220	0.241	0.250	0.258
	2019	0.134	0.154	0.174	0.205	0.206	0.220	0.246	0.248
	2020	0.138	0.160	0.174	0.195	0.216	0.218	0.239	0.246
	2021	0.138	0.160	0.174	0.195	0.216	0.218	0.239	0.246
	2022	0.138	0.160	0.174	0.195	0.216	0.218	0.239	0.246
	2023	0.117	0.157	0.189	0.194	0.198	0.205	0.219	0.232
4.b	2013	0.125	0.162	0.205	0.206	0.228	0.251	0.261	0.246
	2014	0.133	0.187	0.208	0.233	0.240	0.249	0.256	0.277
	2015	0.140	0.162	0.189	0.203	0.208	0.216	0.227	0.250
	2016	0.126	0.161	0.192	0.211	0.218	0.236	0.236	0.253
	2017	0.095	0.157	0.184	0.194	0.230	0.240	0.249	0.263
	2018	0.117	0.138	0.192	0.211	0.237	0.248	0.246	0.258
	2019	0.148	0.163	0.163	0.210	0.229	0.251	0.244	0.253
	2020	0.150	0.174	0.186	0.212	0.234	0.241	0.252	0.265
	2021	0.133	0.157	0.173	0.199	0.214	0.225	0.226	0.240
	2022	0.133	0.177	0.185	0.194	0.209	0.223	0.229	0.242
	2023	0.076	0.168	0.188	0.191	0.194	0.202	0.223	0.226

Table 2.2.12. Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2023 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. Métiers are each reported combination of nation/fleet/area/quarter.

Country (fleet)	Q	Méti-ers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	8	0	0	0	n
	2	2	0	0%	1	0	0	0	n
	4	3	0	0%	37	0	0	0	n
total		7	0	0%	46	0	0	0	n
Denmark (A)	1	3	2	100%	4560	10	259	964	y
	2	2	1	91%	2184	4	63	148	y
	3	3	2	98%	45598	59	1604	4288	y
	4	3	2	100%	7665	16	378	886	y
total	11	7	98%	60006	89	2304	6286	1.48	y
France	1	3	0	0%	1967	0	0	0	n
	2	3	0	0%	1531	0	0	0	n
	3	2	0	0%	12998	0	0	0	n
	4	4	0	0%	10828	0	0	0	n
total		12	0	0%	27325	0	0	0	n
Germany	1	1	1	100%	260	10	185	785	y
	2	2	1	98%	4567	5	206	829	y
	3	2	1	99%	15318	37	299	10086	y
	4	4	1	62%	12169	49	191	11015	y
total		9	4	85%	32315	101	881	22715	y
Ireland	1	1	0	0%	82	0	0	0	n
	4	2	0	0%	185	0	0	0	n
total		3	0	0%	266	0	0	0	n
Lithuania	3	1	0	0%	9866	0	0	0	n
total		1	0	0%	9866	0	0	0	n

Country (fleet)	Q	Méti-ers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
Netherlands	1	3	2	93%	1109	4	100	594	y
	2	3	1	97%	2852	12	298	1896	y
	3	3	1	99%	46052	38	948	5025	n
	4	4	3	98%	19795	29	724	4033	y
total	13	7	99%	69808	83	2070	11548	1.19	y
Northern Ireland	1	1	0	0%	429	0	0	0	n
	3	1	0	0%	7517	0	0	0	n
	4	1	0	0%	87	0	0	0	n
total	3	0	0%	8033	0	0	0	0.00	n
Norway	1	2	0	0%	300	0	0	0	n
	2	3	2	100%	54845	46	2242	3083	n
	3	3	2	95%	43394	28	1254	1514	n
	4	2	2	100%	15175	9	412	506	n
total		10	6	98%	113714	83	3908	5103	n
Scotland	1	3	0	0%	732	0	0	0	n
	2	3	1	100%	1726	3	169	1349	y
	3	4	1	94%	52035	32	1686	6395	n
	4	4	0	0%	465	0	0	0	n
total		14	2	92%	54957	35	1855	7744	n
Sweden (A)	1	2	1	81%	2043	1	75	75	n
	2	3	1	72%	2491	5	326	326	y
	3	3	2	98%	14223	14	820	820	n
	4	2	2	100%	2492	5	237	237	Y
total		10	6	94%	21248	25	1458	1458	Y
UK (E+W)	1	4	3	79%	888	7	175	1242	Y
	2	3	0	0%	18	0	0	0	n
	3	3	1	97%	10723	13	319	1793	y

Country (fleet)	Q	Méti-ers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
	4	4	0	0%	3768	0	0	0	n
total		14	4	72%	15397	20	494	3035	y
Period total	1	26	9	66%	12462	32	794	3660	y
Period total	2	26	7	95%	70985	75	3304	7631	y
Period total	3	28	12	86%	261453	283	7615	30650	y
Period total	4	38	11	73%	75799	142	2522	17257	y
Total 2023		118	39	84%	420699	532	14235	59198	y
Human Cons. Only		107	36	84%	412981	436	12970	57889	n
Total 2020		117	28	82%	427321	347	8226	66700	n
Total 2021		108	31	81%	364615	274	8531	42072	n
HC 2021		92	29	82%	355827	241	8164	41311	n

2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2023. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IE) EIGB	1 – 20 July	WoS, MSHAS (6.a.N and 6.a.S)	2, 3, 4, 5, 6
Scotia (GB-SCT) MXHR6	28 June – 20 July	MSHAS, WoS, NSAS, Sprat NS	1, 91 (north of 58°30’N), 111, 121
Johan Hjort (NO) LDGJ	01 – 18 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NL) PBVO	27 June – 19 July	NSAS, Sprat NS	81, 91 (south of 58°30’N), 101, 131
Solea (DE) DBFH	1 – 12 (19) July	NSAS, Sprat NS	51, 61, 71, (131)
Dana (DK) OXBH	27 June – 10 July	NSAS, WBSS, Sprat NS, Sprat 3.a	21, 31, 41, 42, 151, 152

Table 2.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2023. Total numbers (millions of fish) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the pelagic acoustic surveys, with mean weight and mean length by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	31 408	96	0.00	3.1	7.7
1	11 189	456	0.07	40.7	17.0
2	2 703	300	0.67	111.1	23.4
3	3 335	542	0.97	162.4	26.3
4	2 295	450	0.99	196.1	27.9
5	1 387	280	1.00	201.6	28.0
6	466	96	1.00	206.9	28.5
7	377	83	0.99	220.8	28.7
8	298	72	1.00	239.7	29.5
9+	385	96	1.00	249.3	29.8
Immature	42 775	585		13.7	10.3
Mature	11 069	1 885		170.3	26.1
Total	53 844	2 471	0.21	45.9	13.6

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2023. For 1986 the estimates are the sum of those from the Division 4.a summer survey, the Division 4.b autumn survey, and the divisions 4.c, 7.d winter survey. The 1987 to 2019 estimates are from summer surveys in divisions 4.a, b, c, and 3.a excluding estimates of Western Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed. Total numbers include 0-ringers from 2008 onwards.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1639	3206	1637	833	135	36	24	6	8	7542	942
1987	13736	4303	955	657	368	77	38	11	20	20165	817
1988	6431	4202	1732	528	349	174	43	23	14	13496	897
1989	6333	3726	3751	1612	488	281	120	44	22	16377	1637
1990	6249	2971	3530	3370	1349	395	211	134	43	18262	2174
1991	3182	2834	1501	2102	1984	748	262	112	56	12781	1874

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1992	6351	4179	1633	1397	1510	1311	474	155	163	17173	1545
1993	10399	3710	1855	909	795	788	546	178	116	19326	1216
1994	3646	3280	957	429	363	321	238	220	132	13003	1035
1995	4202	3799	2056	656	272	175	135	110	84	11220	1082
1996	6198	4557	2824	1087	311	99	83	133	206	18786	1446
1997	9416	6363	3287	1696	692	259	79	78	158	22028	1780
1998	4449	5747	2520	1625	982	445	170	45	121	16104	1792
1999	5087	3078	4725	1116	506	314	139	54	87	15107	1534
2000	24735	2922	2156	3139	1006	483	266	120	97	34928	1833
2001	6837	12290	3083	1462	1676	450	170	98	59	26124	2622
2002	23055	4875	8220	1390	795	1031	244	121	150	39881	2948
2003	9829	18949	3081	4189	675	495	568	146	178	38110	2999
2004	5183	3415	9191	2167	2590	317	328	342	186	23722	2584
2005	3113	1890	3436	5609	1211	1172	140	127	107	16805	1868
2006	6823	3772	1997	2098	4175	618	562	84	70	20199	2130
2007	6261	2750	1848	898	806	1323	243	152	65	14346	1203
2008	3714	2853	1709	1485	809	712	1749	185	270	20355	1784
2009	4655	5632	2553	1023	1077	674	638	1142	578	31526	2591
2010	14577	4237	4216	2453	1246	1332	688	1110	1619	43705	3027
2011	10119	4166	2534	2173	1016	651	688	440	1207	25524	2431
2012	7437	4718	4067	1738	1209	593	247	218	478	23641	2269
2013	6388	2683	3031	2895	1546	849	464	250	592	36484	2261
2014	11634	4918	2827	2939	1791	1236	669	211	250	61339	2610
2015	6714	9495	2831	1591	1549	926	520	275	221	24508	2280
2016	9034	12011	5832	1273	822	909	395	220	146	51686	2648
2017	3054	1761	6095	3142	787	365	298	153	140	30055	1943
2018	9938	4254	1692	5150	2440	719	529	293	111	32606	2337

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
2019	10146	1303	2345	1212	3506	1657	395	252	172	25560	1919
2020	7130	2736	1156	1371	1674	1666	504	164	188	23766	1717
2021	5196	2803	1800	773	877	915	1021	388	208	31481	1501
2022	3711	3814	3043	1743	822	662	718	619	249	30127	1963
2023	11189	2703	3335	2295	1387	466	377	298	385	53844	1885

Table 2.3.2.1. North Sea herring – LAI time-series of herring larval abundance <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The numbers of larvae are expressed as mean number per ICES rectangle * 10^9.

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea		
Period/ Year	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.
1972	1133	4583	30		165	88	134	2	46	
1973	2029	822	3	4	492	830	1213			1
1974	758	421	101	284	81		1184		10	
1975	371	50	312			90	77	1	2	
1976	545	81		1	64	108			3	
1977	1133	221	124	32	520	262	89	1		
1978	3047	50		162	1406	81	269	33	3	
1979	2882	2362	197	10	662	131	507		111	89
1980	3534	720	21	1	317	188	9	247	129	40
1981	3667	277	3	12	903	235	119	1456		70
1982	2353	1116	340	257	86	64	1077	710	275	54
1983	2579	812	3647	768	1459	281	63	71	243	58
1984	1795	1912	2327	1853	688	2404	824	523	185	39
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38
1986	3529	1842	3278	341	1611	6112	188	780	123	18
1987	7409	1848	2551	670	799	4927	1992	934	297	146

1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512
1990		10144	4590	2045	19955	1239	975	2552	1204	
1991	1021	2397		2032	4823	2110	1249	4400	873	
1992	189	4917		822	10	165	163	176	1616	
1993		66		174		685	85	1358	1103	
1994	26	1179				1464	44	537	595	
1995		8688					43	74	230	164
1996		809		184		564		337	675	691

	Orkney/ Shetland		**Buchan**		**Central North Sea**			**Southern North Sea**		
Period/ Year	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.
1997		3611		23				9374	918	355
1998		8528		1490	205	66		1522	953	170
1999		4064		185		134	181	804	1260	344
2000		3352	28	83		376		7346	338	106
2001		11918		164		1604		971	5531	909
2002		6669		1038			3291	2008	260	925
2003		3199		2263		12018	3277	12048	3109	1116
2004		7055		3884		5545		7055	2052	4175
2005		3380		1364		5614		498	3999	4822
2006	6311	2312		280		2259		10858	2700	2106
2007		1753		1304		291		4443	2439	3854
2008	4978	6875		533		11201		8426	2317	4008
2009		7543		4629		4219		15295	14712	1689
2010		2362		1493		2317		7493	13230	8073
2011		3831		2839		17766		5461	6160	1215
2012		19552		5856		517		22768	11103	3285

2013		21282		8618	7354	5	9314	2957
2014		6604		5033	1149			1851
2015		9631		3496	3424	2011	1200	645
2016				3872	3288	20710	1442	1545
2017				5833	3965	10553	5880	
2018		102		1740	1509	1140		
2019	2488		5654	3794	10605	14082	5258	
2020		3208		3418	7663	4077	9704	
2021		6651		1413	3282	8899	8764	
2022		2758		1471	188	3712	743	
2023	759		318	1049	1392	2474		

Table 2.3.3.2. North Sea herring – International herring larvae surveys summary 2022/2023.

Nation:	Vessel:	Dates
Germany	Walther Herwig 3	01 September – 12 September 2023
Netherlands	Tridens 2	18 September – 29 September 2023
Netherlands	Tridens 2	18 December – 21 December 2023
:		

Cruise	North Sea IHLS monitor the abundance and distribution of newly hatched herring larvae at the main spawning grounds of autumn spawning herring along the Scottish and English coast in September and on the Downs spawning ground in the English Channel in December and January.
Gear details:	Gulf-type high speed plankton sampler catches are taken during day and night time. Mesh size of the net is 280 microns. The sampler is equipped with a CTD for measurements of actual sampler depth, salinity and temperature profiles as well as internal and external flowmeters determining the filtered water volume. Samples are taken in a V-shape manner, e.g. from the sea surface down to near the seabed (5m above the bottom) and back to the surface.
Notes from survey (e.g. problems, additional work etc.):	Four survey areas could be sampled as scheduled. The German part of the survey in the English Channel had to be cancelled due to technical problems of the vessel. A replacement or charter vessel was not available. The resulting larvae index for this area is therefore based on the December estimate only. Larvae abundance around the Orkneys was low. This is may be due to the timing of the survey, right at the beginning of the hatching period, or shifts in spawning time. In the Buchan and the central North Sea, newly hatched larvae concentrated in two areas. In all survey areas, herring larvae abundance was relatively low.

	However, the estimated larvae abundance indices could be used in the assessment of North Sea autumn spawning herring.
Number of fish species recorded and notes on any rare species or unusual catches:	In total, 459 plankton samples were taken during the IHLS surveys between September 2023 and December 2023. They contained 22,548 herring larvae.

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
4a, 4b	N/A	Gulf	319	319	0	0	100 %	Extra hauls taken when abundance was dense.
4c, 7d	N/A	Gulf	140	72	0	0	51 %	Extra hauls taken when abundance was dense.
total	N/A	Gulf	459	381	0	0	83 %	Due to cancelled cruise in 01/24

Table 2.3.3.1 North Sea herring. Density and abundance estimates of 0-ringers caught in February during the IBTS. Values given for the 1991 to 2023 year-classes by areas are mean density estimates in numbers per square metre according to the new index calculation algorithm. Total abundance is found by multiplying density by area and summing up. Data for the year classes 1976 to 1990, calculated with the old algorithm, are stored in the stock annex.

Area	Northwest	Northeast	Central west	Central east	Southwest	Southeast	Division 3.a	South' Bight	IBTS-0 index
Area $m^2 \times 10^9$	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
1991	0.227	0.074	0.364	0.444	0.466	0.329	0.330	0.259	164.0
1992	0.191	0.037	0.576	0.387	0.638	0.300	0.359	0.871	195.8
1993	0.574	0.231	0.545	0.178	0.117	0.140	0.223	0.322	155.1
1994	0.131	0.023	0.438	0.359	0.360	0.174	0.503	1.277	170.5
1995	0.222	0.053	0.644	0.069	0.246	0.015	0.015	0.424	107.0
1996	0.026	0.003	0.878	0.099	0.443	0.298	0.040	0.034	134.5
1997	0.039	0.021	0.295	0.059	0.181	0.035	0.021	0.186	51.7

1998	0.095	0.054	1.074	0.543	0.994	0.296	0.242	0.839	255.5
1999	0.042	0.011	0.725	0.149	0.316	0.141	0.105	0.043	111.1
2000	0.237	0.005	0.764	0.161	0.813	0.790	0.065	4.354	342.0
2001	0.076	0.018	0.528	0.456	0.487	0.301	0.261	NA	152.9
2002	0.117	0.031	0.241	0.030	0.127	0.058	0.003	0.841	70.9
2003	0.044	0.004	0.248	0.068	0.119	0.019	0.036	0.145	43.9
2004	0.016	0.008	0.205	0.097	0.511	0.228	0.053	0.399	83.3
2005	0.013	0.018	0.315	0.079	0.291	0.154	0.011	0.068	64.5

Area m^2 x 10^9 Year class	**Northwest**	**Northeast**	**Central west**	**Central east**	**Southwest**	**Southeast**	**Division 3.a**	**South' Bight**	**IBTS-0 index**
2006	0.004	0.001	0.213	0.038	0.133	0.020	0.065	0.698	52.9
2007	0.013	0.009	0.185	0.031	0.084	0.058	0.019	0.320	39.5
2008	0.145	0.138	0.281	0.253	0.158	0.139	0.160	0.279	99.2
2009	0.073	0.074	0.194	0.052	0.390	0.291	0.000	0.042	73.5
2010	0.025	0.004	0.595	0.063	0.188	0.082	NA	0.096	77.6
2011	0.008	0.001	0.312	0.132	0.214	0.129	0.076	0.059	65.1
2012	0.022	0.003	0.193	0.072	0.144	0.257	0.005	0.195	61.2
2013	0.132	0.151	0.240	0.253	0.389	0.313	0.037	0.213	113.8
2014	0.009	0.006	0.150	0.047	0.038	0.002	0.009	0.038	21.7
2015	0.015	0.015	0.136	0.059	0.083	0.324	0.002	0.927	81.2
2016	0.005	0.001	0.143	0.020	0.082	0.035	0.020	0.196	27.8
2017	0.111	0.001	0.395	0.181	0.397	0.260	0.031	0.019	102.1
2018	0.017	0.023	0.290	0.103	0.112	0.029	0.083	0.144	51.6

2019	0.017	0.002	0.159	0.141	0.166	0.244	0.065	0.066	62.4
2020	0.015	0.005	0.447	0.070	0.328	0.255	0.019	0.304	93.0
2021	0.010	0.002	0.109	0.050	0.251	0.104	0.031	0.412	48.0
2022	0.004	0.001	0.243	0.031	0.165	0.112	0.008	1.606	90.8
2023	0.036	0.005	0.311	0.102	0.236	0.108	0.078	0.029	62.5

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2022 year-classes (the data for the 1977 to 1994 year-classes can be found in the stock annex). Estimation of the small sized component (possibly Downs herring) in different areas. "North Sea" = total area of sampling minus 3.a.

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs. small in total area
1995	1997	4403	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.20	0.09
1998	2000	3304	1068	0.32	939	0.28	0.18
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	3881	1520	0.39	1436	0.37	0.12

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs. small in total area
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1015	341	0.34	357	0.35	0.02
2004	2006	900	115	0.13	121	0.13	0.02
2005	2007	1322	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.01

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs. small in total area
2007	2009	2339	734	0.31	623	0.27	0.21
2008	2010	1206	279	0.23	286	0.24	0.05
2009	2011	2939	1331	0.45	1407	0.48	0.02
2010	2012	1353	279	0.21	288	0.21	0.04
2011	2013	1665	747	0.45	796	0.48	0.01
2012	2014	2615	1297	0.5	1245	0.48	0.11
2013	2015	3918	1808	0.46	1105	0.28	0.43
2014	2016	783	368	0.47	364	0.47	0.08
2015	2017	2396	1306	0.54	1008	0.42	0.28
2016	2018	778	406	0.52	424	0.55	0.03
2017	2019	1543	432	0.28	397	0.26	0.15
2018	2020	1021	168	0.16	150	0.15	0.17
2019	2021	3133	487	0.16	256	0.08	0.51
2020	2022	806	401	0.50	396	0.49	0.08
2021	2023	5016	2699	0.54	2470	0.49	0.15
2022	2024	184	89	0.48	74	0.40	0.22

Table 2.4.1.1. North Sea herring. Mean stock weight-at-age (wr) in the third quarter, in divisions 4.a, 4.b and 3.a. Mean catch weight-at-age for the same quarter and area is included for comparison. AS = acoustic survey, 3Q = catch.

age	0		1		2		3		4		5		6		7		8		9+	
Year	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS
2000	0.015	0.006	0.033	0.051	0.113	0.116	0.157	0.184	0.179	0.221	0.201	0.248	0.216	0.279	0.246	0.286	0.273	0.284	0.271	0.280
2001	0.012	0.006	0.048	0.051	0.118	0.122	0.149	0.172	0.177	0.210	0.198	0.233	0.213	0.255	0.238	0.275	0.270	0.274	0.298	0.294
2002	0.012	0.006	0.037	0.047	0.118	0.128	0.153	0.172	0.170	0.205	0.199	0.228	0.214	0.248	0.228	0.270	0.250	0.287	0.298	0.249
2003	0.014	0.007	0.037	0.047	0.104	0.123	0.158	0.173	0.174	0.202	0.184	0.222	0.205	0.242	0.222	0.266	0.237	0.285	0.282	0.307
2004	0.014	0.007	0.036	0.042	0.100	0.119	0.138	0.165	0.183	0.203	0.201	0.223	0.216	0.248	0.228	0.268	0.255	0.280	0.299	0.270
2005	0.011	0.006	0.044	0.041	0.099	0.118	0.153	0.164	0.166	0.198	0.208	0.225	0.223	0.248	0.240	0.265	0.265	0.285	0.270	0.295
2006	0.010	0.007	0.049	0.041	0.117	0.126	0.144	0.155	0.172	0.191	0.181	0.216	0.220	0.242	0.237	0.252	0.246	0.270	0.285	0.2265
2007	0.012	0.006	0.064	0.051	0.121	0.128	0.151	0.161	0.163	0.180	0.193	0.207	0.190	0.224	0.223	0.238	0.237	0.256	0.273	0.233
2008	0.008	0.008	0.054	0.058	0.129	0.130	0.180	0.164	0.181	0.181	0.183	0.195	0.216	0.218	0.216	0.226	0.262	0.256	0.312	0.282
2009	0.009	0.007	0.051	0.061	0.144	0.137	0.181	0.181	0.216	0.197	0.216	0.210	0.239	0.223	0.243	0.234	0.253	0.256	0.292	0.263
2010	0.008	0.007	0.057	0.052	0.129	0.142	0.167	0.190	0.191	0.216	0.220	0.224	0.219	0.234	0.216	0.240	0.238	0.261	0.271	0.251
2011	0.008	0.007	0.041	0.043	0.132	0.146	0.159	0.187	0.183	0.225	0.197	0.240	0.217	0.244	0.221	0.251	0.232	0.257	0.267	0.275
2012	0.011	0.006	0.046	0.040	0.124	0.138	0.171	0.182	0.185	0.211	0.206	0.233	0.222	0.241	0.239	0.243	0.243	0.253	0.268	0.243
2013	0.008	0.006	0.047	0.040	0.116	0.136	0.156	0.175	0.198	0.209	0.198	0.221	0.215	0.242	0.233	0.249	0.238	0.252	0.265	0.252
2014	0.008	0.006	0.052	0.043	0.124	0.129	0.172	0.177	0.186	0.204	0.215	0.216	0.212	0.229	0.226	0.241	0.243	0.247	0.266	0.246
2015	0.009	0.005	0.026	0.044	0.114	0.127	0.154	0.161	0.188	0.200	0.200	0.212	0.221	0.225	0.217	0.229	0.235	0.239	0.276	0.229
2016	0.007	0.005	0.027	0.043	0.127	0.121	0.155	0.160	0.180	0.189	0.206	0.216	0.215	0.224	0.231	0.224	0.230	0.234	0.263	0.236
2017	0.009	0.004	0.038	0.043	0.099	0.111	0.156	0.153	0.173	0.183	0.188	0.207	0.215	0.227	0.220	0.227	0.231	0.229	0.252	0.230

age	0		1		2		3		4		5		6		7		8		9+	
2018	0.005	0.005	0.039	0.040	0.109	0.101	0.145	0.153	0.184	0.186	0.191	0.215	0.215	0.229	0.234	0.239	0.246	0.247	0.270	.0273
2019	0.006	0.004	0.040	0.040	0.121	0.099	0.147	0.148	0.169	0.177	0.204	0.209	0.208	0.226	0.220	0.238	0.243	0.254	0.263	0.256
2020	0.004	0.004	0.071	0.041	0.130	0.107	0.155	0.150	0.171	0.182	0.189	0.217	0.214	0.229	0.219	0.242	0.243	0.264	0.270	0.268
2021	0.008	0.004	0.040	0.043	0.128	0.117	0.155	0.156	0.166	0.181	0.189	0.210	0.203	0.227	0.219	0.240	0.224	0.255	0.250	0.272
2022	0.007	0.005	0.043	0.040	0.143	0.132	0.171	0.178	0.187	0.195	0.216	0.210	0.234	0.232	0.237	0.244	0.249	0.244	0.272	0.267
2023	0.007	0.003	0.039	0.041	0.121	0.111	0.165	0.162	0.194	0.196	0.198	0.202	0.199	0.207	0.207	0.221	0.220	0.240	0.233	0.249

Table 2.4.2.1. North Sea herring. Percentage maturity at 2, 3, 4, 5, 6 and 7+ ring for autumn spawning herring in the North Sea. The values are derived from the acoustic survey for 1988 to 2023. In the period 1988–2014, maturity of age 5+ were set to 100%.

Year \ Ring	2	3	4	5	6	7+
1988	65.6	87.7	100	100	100	100
1989	78.7	93.9	100	100	100	100
1990	72.6	97.0	100	100	100	100
1991	63.8	98.0	100	100	100	100
1992	51.3	100	100	100	100	100
1993	47.1	62.9	100	100	100	100
1994	72.1	85.8	100	100	100	100
1995	72.6	95.4	100	100	100	100
1996	60.5	97.5	100	100	100	100
1997	64.0	94.2	100	100	100	100
1998	64.0	89.0	100	100	100	100
1999	81.0	91.0	100	100	100	100
2000	66.0	96.0	100	100	100	100
2001	77.0	92.0	100	100	100	100
2002	86.0	97.0	100	100	100	100
2003	43.0	93.0	100	100	100	100
2004	69.8	64.9	100	100	100	100
2005	76.0	97.0	96.0	100	100	100
2006	66.0	88.0	98.0	100	100	100
2007	71.0	92.0	93.0	100	100	100
2008	86.0	98.0	99.0	100	100	100
2009	89.0	100	100	100	100	100
2010	45.0	90.0	100	100	100	100
2011	87.0	84.0	99.0	100	100	100
2012	91.0	99.0	100	100	100	100
2013	83.0	96.0	98.0	100	100	100

Year \ Ring	2	3	4	5	6	7+
2014	85.0	100	100	100	100	100
2015	70.0	90.0	96.0	98.0	99.0	100
2016	71.0	89.0	95.0	97.0	98.0	100
2017	55.0	96.0	97.0	98.0	98.0	100
2018	37.0	91.0	98.0	100	100	100
2019	59.0	97.0	99.0	100	100	100
2020	75.0	98.0	100	100	100	100
2021	75.0	99.0	100	100	100	100
2022	70.0	95.0	97.0	99.0	100	100
2023	67.0	97.0	99.0	100	100	100

Table 2.6.1.1. North Sea herring. Years of duration of survey and years used in the assessment.

Survey	Age range	Years survey has been running	Years used in assessment
LAI (Larvae survey)	SSB	1972–2023	1973–2023
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2023	1984–2024
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2023	1998–2023
Acoustic (+trawl)	1 wr	1995–2023	1997–2023
	2-9+ wr	1984–2023	1989–2023
IBTS0	0wr	1977–2024	1992–2024

Table 2.6.1.2 North Sea herring input data. Maturity at age.

Year	0	1	2	3	4	5	6	7	8
1947	0	0	1	1	1	1	1	1	1
1948	0	0	1	1	1	1	1	1	1
1949	0	0	1	1	1	1	1	1	1
1950	0	0	1	1	1	1	1	1	1
1951	0	0	1	1	1	1	1	1	1
1952	0	0	1	1	1	1	1	1	1
1953	0	0	1	1	1	1	1	1	1
1954	0	0	1	1	1	1	1	1	1
1955	0	0	1	1	1	1	1	1	1
1956	0	0	1	1	1	1	1	1	1
1957	0	0	1	1	1	1	1	1	1
1958	0	0	1	1	1	1	1	1	1
1959	0	0	1	1	1	1	1	1	1
1960	0	0	1	1	1	1	1	1	1
1961	0	0	1	1	1	1	1	1	1

1962	0	0	1	1	1	1	1	1	1
1963	0	0	1	1	1	1	1	1	1
1964	0	0	1	1	1	1	1	1	1
1965	0	0	1	1	1	1	1	1	1
1966	0	0	1	1	1	1	1	1	1
1967	0	0	1	1	1	1	1	1	1
1968	0	0	1	1	1	1	1	1	1
1969	0	0	1	1	1	1	1	1	1
1970	0	0	1	1	1	1	1	1	1
1971	0	0	1	1	1	1	1	1	1
1972	0	0	0.82	1	1	1	1	1	1
1973	0	0	0.82	1	1	1	1	1	1
1974	0	0	0.82	1	1	1	1	1	1
1975	0	0	0.82	1	1	1	1	1	1
1976	0	0	0.82	1	1	1	1	1	1
1977	0	0	0.82	1	1	1	1	1	1
1978	0	0	0.82	1	1	1	1	1	1
1979	0	0	0.82	1	1	1	1	1	1
1980	0	0	0.82	1	1	1	1	1	1
1981	0	0	0.82	1	1	1	1	1	1
1982	0	0	0.82	1	1	1	1	1	1
1983	0	0	0.82	1	1	1	1	1	1
1984	0	0	0.82	1	1	1	1	1	1
1985	0	0	0.7	1	1	1	1	1	1
1986	0	0	0.75	1	1	1	1	1	1
1987	0	0	0.8	1	1	1	1	1	1
1988	0	0	0.85	0.93	1	1	1	1	1
1989	0	0	0.82	0.94	1	1	1	1	1
1990	0	0	0.91	0.97	1	1	1	1	1
1991	0	0	0.86	0.99	1	1	1	1	1
1992	0	0	0.5	0.99	1	1	1	1	1
1993	0	0	0.47	0.61	1	1	1	1	1
1994	0	0	0.73	0.93	1	1	1	1	1
1995	0	0	0.67	0.95	1	1	1	1	1
1996	0	0	0.61	0.98	1	1	1	1	1
1997	0	0	0.64	0.94	1	1	1	1	1
1998	0	0	0.64	0.89	1	1	1	1	1
1999	0	0	0.69	0.91	1	1	1	1	1
2000	0	0	0.67	0.96	1	1	1	1	1
2001	0	0	0.77	0.92	1	1	1	1	1
2002	0	0	0.87	0.97	1	1	1	1	1
2003	0	0	0.43	0.93	1	1	1	1	1
2004	0	0	0.7	0.65	1	1	1	1	1
2005	0	0	0.76	0.96	0.96	1	1	1	1
2006	0	0	0.66	0.88	0.98	1	1	1	1
2007	0	0	0.71	0.92	0.93	1	1	1	1
2008	0	0	0.86	0.98	0.99	1	1	1	1
2009	0	0	0.89	1	1	1	1	1	1
2010	0	0	0.45	0.9	1	1	1	1	1
2011	0	0	0.87	0.84	1	1	1	1	1
2012	0	0	0.91	0.99	1	1	1	1	1
2013	0	0	0.83	0.96	0.98	1	1	1	1
2014	0	0	0.85	1	1	1	1	1	1
2015	0	0	0.7	0.9	0.96	1	1	1	1
2016	0	0	0.71	0.89	0.95	1	1	1	1
2017	0	0	0.55	0.96	0.97	1	1	1	1
2018	0	0	0.37	0.91	0.98	1	1	1	1
2019	0	0	0.59	0.97	0.99	1	1	1	1
2020	0	0	0.75	0.98	1	1	1	1	1
2021	0	0	0.74	0.99	1	1	1	1	1
2022	0	0	0.7	0.95	0.97	1	1	1	1
2023	0	0	0.67	0.97	0.99	1	1	1	1

Table 2.6.1.3 North Sea herring input data. Natural mortality at age.

Year	0	1	2	3	4	5	6	7	8
1947	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1948	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1949	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1950	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1951	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1952	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1953	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1954	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1955	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1956	0.7123	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1957	0.7123	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1958	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1959	0.7124	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1960	0.7124	0.4973	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1961	0.7123	0.4973	0.3026	0.2727	0.252	0.2323	0.2219	0.2158	0.2159
1962	0.7123	0.4974	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1963	0.7124	0.4978	0.3027	0.2728	0.2519	0.2322	0.2218	0.2156	0.2158
1964	0.7124	0.4973	0.3026	0.2727	0.252	0.2323	0.2218	0.2157	0.2159
1965	0.7123	0.4969	0.3025	0.2727	0.252	0.2323	0.2219	0.2159	0.216
1966	0.7122	0.497	0.3025	0.2727	0.252	0.2323	0.2219	0.2158	0.216
1967	0.7123	0.4979	0.3028	0.2728	0.2519	0.2322	0.2217	0.2156	0.2158
1968	0.7128	0.4997	0.3032	0.273	0.2517	0.2319	0.2213	0.2151	0.2152
1969	0.7123	0.4951	0.302	0.2724	0.2522	0.2325	0.2223	0.2163	0.2165
1970	0.7119	0.4947	0.302	0.2724	0.2523	0.2326	0.2224	0.2164	0.2167
1971	0.7119	0.4975	0.3027	0.2729	0.2521	0.2323	0.2219	0.2158	0.216
1972	0.7129	0.5025	0.3039	0.2734	0.2514	0.2317	0.2208	0.2145	0.2145
1973	0.7149	0.5089	0.3052	0.2739	0.2503	0.2306	0.2193	0.2126	0.2124
1974	0.7099	0.4717	0.2964	0.2694	0.2548	0.2352	0.2268	0.222	0.2229
1975	0.7098	0.493	0.3018	0.2727	0.253	0.2332	0.2231	0.2172	0.2176
1976	0.7121	0.5116	0.3063	0.2749	0.2508	0.231	0.2194	0.2125	0.2124
1977	0.7176	0.5274	0.3096	0.2761	0.248	0.2283	0.2156	0.2079	0.2072
1978	0.725	0.5406	0.3121	0.2763	0.2449	0.2253	0.2118	0.2035	0.202
1979	0.7336	0.5514	0.3135	0.2757	0.2415	0.2221	0.208	0.1992	0.197
1980	0.7446	0.5596	0.3139	0.2742	0.2379	0.2187	0.2043	0.195	0.1921
1981	0.7581	0.5651	0.3133	0.2717	0.2339	0.2151	0.2006	0.1911	0.1873
1982	0.7713	0.5685	0.3119	0.2685	0.2299	0.2113	0.1969	0.1873	0.1827
1983	0.7914	0.5689	0.3094	0.2642	0.2252	0.2071	0.1932	0.1836	0.178
1984	0.8183	0.5662	0.3058	0.2585	0.2198	0.2023	0.1894	0.1801	0.1732
1985	0.8387	0.562	0.3015	0.2525	0.2146	0.1975	0.1854	0.1765	0.1686
1986	0.8493	0.5533	0.294	0.2437	0.2085	0.1915	0.1801	0.1723	0.1638
1987	0.8559	0.5406	0.2841	0.2327	0.2013	0.1844	0.174	0.1679	0.1587
1988	0.8584	0.53	0.2772	0.2249	0.1963	0.1794	0.1693	0.1642	0.1547
1989	0.8531	0.5217	0.274	0.2216	0.1952	0.178	0.1666	0.1615	0.1524
1990	0.8416	0.5131	0.2718	0.2199	0.1961	0.1783	0.1646	0.1594	0.1511
1991	0.8321	0.5061	0.271	0.2193	0.1967	0.1784	0.1631	0.1576	0.15
1992	0.8203	0.4994	0.2728	0.2211	0.197	0.1789	0.1622	0.1565	0.1495
1993	0.8033	0.4926	0.2767	0.2251	0.1982	0.1804	0.1619	0.1558	0.1496
1994	0.791	0.4883	0.28	0.228	0.199	0.1813	0.1617	0.1553	0.1497
1995	0.7803	0.4826	0.282	0.2284	0.1973	0.1799	0.1605	0.1541	0.1493
1996	0.772	0.4795	0.2848	0.2295	0.196	0.179	0.1599	0.1535	0.1493
1997	0.7734	0.4853	0.2888	0.232	0.1966	0.1785	0.1603	0.1534	0.1497
1998	0.7794	0.4948	0.2934	0.2348	0.1972	0.1776	0.1608	0.1535	0.1502
1999	0.7874	0.506	0.2988	0.2391	0.2	0.1788	0.1629	0.1551	0.1519
2000	0.8003	0.5269	0.3075	0.2464	0.2069	0.1835	0.1676	0.1588	0.1553
2001	0.818	0.5556	0.3182	0.2555	0.2164	0.19	0.1738	0.1636	0.1595
2002	0.8327	0.5748	0.3259	0.2626	0.2244	0.1962	0.18	0.1689	0.164
2003	0.846	0.5848	0.3318	0.2699	0.2338	0.2048	0.1884	0.1765	0.1704
2004	0.8616	0.594	0.3383	0.2786	0.2455	0.216	0.1993	0.1863	0.1783
2005	0.8745	0.598	0.3419	0.2839	0.253	0.2239	0.2071	0.1937	0.1844
2006	0.887	0.5914	0.3407	0.2838	0.2547	0.2275	0.2113	0.1987	0.1888
2007	0.9004	0.5777	0.3368	0.2814	0.2542	0.2299	0.2147	0.2036	0.1931
2008	0.9082	0.5656	0.3327	0.2788	0.2531	0.2313	0.217	0.2073	0.1966

2009	0.9104	0.5549	0.3273	0.2747	0.25	0.2305	0.217	0.2087	0.1983
2010	0.9099	0.542	0.3203	0.2687	0.2448	0.2279	0.2154	0.2087	0.1991
2011	0.9046	0.5311	0.3147	0.2647	0.2415	0.2266	0.2147	0.2093	0.2003
2012	0.8947	0.5218	0.3105	0.2623	0.2397	0.2262	0.2147	0.2102	0.2017
2013	0.8812	0.512	0.3058	0.2597	0.2375	0.2253	0.2141	0.2106	0.2026
2014	0.863	0.5031	0.3017	0.2578	0.2358	0.2246	0.2136	0.2108	0.2034
2015	0.84	0.4952	0.298	0.2566	0.2347	0.2242	0.2131	0.2109	0.204
2016	0.8128	0.4876	0.2945	0.2558	0.2337	0.2237	0.2123	0.2106	0.2043
2017	0.7812	0.4806	0.2912	0.2555	0.2332	0.2233	0.2116	0.2101	0.2045
2018	0.745	0.4746	0.2886	0.2563	0.2336	0.2235	0.2112	0.2098	0.2047
2019	0.7043	0.4691	0.2864	0.2578	0.2346	0.224	0.2109	0.2093	0.2049
2020	0.7767	0.4814	0.2918	0.2564	0.234	0.2237	0.2118	0.2101	0.2045
2021	0.7608	0.478	0.2902	0.2564	0.2338	0.2236	0.2115	0.2099	0.2046
2022	0.7435	0.4748	0.2888	0.2566	0.2338	0.2236	0.2113	0.2097	0.2047
2023	0.7246	0.4718	0.2875	0.2571	0.2341	0.2238	0.2111	0.2096	0.2048

Table 2.6.1.4 North Sea herring input data. Stock weight at age.

Year	0	1	2	3	4	5	6	7	8
1947	0.015	0.05	0.122	0.14	0.156	0.171	0.185	0.197	0.2625
1948	0.015	0.05	0.122	0.14	0.156	0.171	0.185	0.197	0.2625
1949	0.015	0.05	0.124	0.1417	0.1577	0.1727	0.1863	0.1983	0.263
1950	0.015	0.05	0.126	0.1453	0.161	0.1757	0.189	0.2007	0.264
1951	0.015	0.05	0.13	0.151	0.1677	0.1817	0.1943	0.2053	0.2658
1952	0.015	0.05	0.133	0.1577	0.175	0.1893	0.2013	0.2113	0.2683
1953	0.015	0.05	0.136	0.163	0.183	0.1977	0.2097	0.2187	0.2713
1954	0.015	0.05	0.1377	0.167	0.1887	0.205	0.217	0.226	0.2743
1955	0.015	0.05	0.1387	0.1687	0.1927	0.21	0.223	0.2323	0.2772
1956	0.015	0.05	0.1397	0.1703	0.195	0.2137	0.2273	0.2377	0.2795
1957	0.015	0.05	0.1403	0.1717	0.1967	0.216	0.2307	0.2413	0.2815
1958	0.015	0.05	0.1407	0.173	0.198	0.2177	0.2327	0.2437	0.2828
1959	0.015	0.05	0.1417	0.1743	0.1993	0.2193	0.2343	0.2453	0.284
1960	0.015	0.05	0.1463	0.179	0.2077	0.2263	0.2487	0.2637	0.2936
1961	0.015	0.05	0.151	0.1833	0.2157	0.233	0.2627	0.2817	0.3034
1962	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.309
1963	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3093
1964	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3101
1965	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.307
1966	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3103
1967	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3101
1968	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3112
1969	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3089
1970	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.309
1971	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.312
1972	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3076
1973	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3078
1974	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3081
1975	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3078
1976	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3077
1977	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.306
1978	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3096
1979	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3069
1980	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3072
1981	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.307
1982	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3074
1983	0.015	0.05	0.155	0.187	0.223	0.239	0.276	0.299	0.3091
1984	0.01733	0.05667	0.1503	0.1903	0.2297	0.2433	0.282	0.3107	0.3435
1985	0.01567	0.05633	0.138	0.187	0.2323	0.2467	0.2747	0.321	0.3544
1986	0.014	0.061	0.13	0.1833	0.2317	0.252	0.273	0.3147	0.3628
1987	0.009	0.05033	0.1217	0.17	0.2123	0.23	0.242	0.2747	0.3056
1988	0.008	0.04833	0.123	0.1663	0.2083	0.229	0.2483	0.2587	0.2854
1989	0.008667	0.04367	0.1223	0.1653	0.2047	0.2283	0.2523	0.2613	0.2886
1990	0.01233	0.052	0.1257	0.1743	0.2117	0.2437	0.2707	0.2837	0.3079

1991	0.01133	0.059	0.139	0.1837	0.212	0.2387	0.2653	0.2797	0.3095
1992	0.01033	0.06367	0.1367	0.194	0.214	0.2343	0.253	0.2717	0.2987
1993	0.005667	0.061	0.134	0.1843	0.213	0.2343	0.2617	0.2727	0.3079
1994	0.007333	0.06	0.1263	0.1917	0.2143	0.2397	0.2747	0.2913	0.3205
1995	0.006	0.05733	0.1293	0.1857	0.2107	0.2243	0.268	0.2933	0.3261
1996	0.006	0.054	0.1297	0.1993	0.2273	0.2343	0.2737	0.3007	0.3271
1997	0.005	0.04867	0.1233	0.1833	0.2303	0.2373	0.2567	0.2803	0.31
1998	0.005667	0.04733	0.116	0.1873	0.2413	0.2643	0.2837	0.2867	0.3083
1999	0.006	0.05067	0.116	0.1793	0.2263	0.256	0.2733	0.276	0.2781
2000	0.005667	0.05133	0.1157	0.1837	0.2213	0.2483	0.2787	0.286	0.2842
2001	0.006	0.05067	0.1217	0.1717	0.21	0.2327	0.2553	0.2747	0.2745
2002	0.006333	0.04733	0.128	0.1717	0.2053	0.2283	0.2483	0.2703	0.2865
2003	0.006667	0.047	0.123	0.173	0.2023	0.222	0.2423	0.2657	0.2849
2004	0.006667	0.042	0.1193	0.1653	0.2027	0.223	0.2477	0.2677	0.2805
2005	0.005667	0.04133	0.118	0.1643	0.198	0.2247	0.248	0.265	0.2849
2006	0.006667	0.041	0.1257	0.1553	0.191	0.216	0.242	0.2523	0.2702
2007	0.006	0.05133	0.128	0.1607	0.1797	0.207	0.2237	0.238	0.2564
2008	0.008	0.05767	0.1303	0.1643	0.1807	0.1953	0.2177	0.226	0.2556
2009	0.007333	0.06133	0.1373	0.181	0.1967	0.21	0.2227	0.2337	0.2557
2010	0.007333	0.052	0.1423	0.1903	0.216	0.2237	0.2343	0.24	0.2607
2011	0.006667	0.043	0.1457	0.1873	0.225	0.2397	0.2437	0.2507	0.2573
2012	0.006	0.04033	0.138	0.182	0.2113	0.233	0.241	0.2427	0.2525
2013	0.006	0.04033	0.1357	0.1747	0.2087	0.2213	0.242	0.2493	0.2518
2014	0.005667	0.04333	0.1287	0.1767	0.2037	0.2157	0.2287	0.2413	0.2466
2015	0.005333	0.04367	0.1273	0.1613	0.2	0.2117	0.2247	0.229	0.2394
2016	0.005	0.04333	0.121	0.1603	0.1887	0.216	0.2243	0.2243	0.2337
2017	0.004167	0.04287	0.1109	0.1532	0.183	0.2071	0.2265	0.2271	0.2292
2018	0.004567	0.03997	0.1013	0.153	0.1858	0.215	0.2292	0.2388	0.2468
2019	0.004	0.04023	0.099	0.1485	0.1774	0.209	0.2261	0.2379	0.2541
2020	0.0041	0.04073	0.1072	0.1495	0.1816	0.2168	0.2291	0.2424	0.2642
2021	0.003833	0.0432	0.1169	0.1563	0.1812	0.21	0.2267	0.2401	0.2551
2022	0.0045	0.04403	0.1259	0.1674	0.1922	0.2117	0.2288	0.2414	0.256
2023	0.004267	0.0429	0.1215	0.1687	0.194	0.2049	0.22	0.2328	0.2576

Table 2.6.1.5 North Sea herring input data. Catch weight at age.

Year	0	1	2	3	4	5	6	7	8
1947	0.015	0.05	0.122	0.14	0.156	0.171	0.185	0.197	0.242
1948	0.015	0.05	0.122	0.14	0.156	0.171	0.185	0.197	0.242
1949	0.015	0.05	0.128	0.145	0.161	0.176	0.189	0.201	0.2435
1950	0.015	0.05	0.128	0.151	0.166	0.18	0.193	0.204	0.245
1951	0.015	0.05	0.134	0.157	0.176	0.189	0.201	0.211	0.2475
1952	0.015	0.05	0.137	0.165	0.183	0.199	0.21	0.219	0.251
1953	0.015	0.05	0.137	0.167	0.19	0.205	0.218	0.226	0.254
1954	0.015	0.05	0.139	0.169	0.193	0.211	0.223	0.233	0.2565
1955	0.015	0.05	0.14	0.17	0.195	0.214	0.228	0.238	0.2595
1956	0.015	0.05	0.14	0.172	0.197	0.216	0.231	0.242	0.261
1957	0.015	0.05	0.141	0.173	0.198	0.218	0.233	0.244	0.2625
1958	0.015	0.05	0.141	0.174	0.199	0.219	0.234	0.245	0.2635
1959	0.015	0.05	0.143	0.176	0.201	0.221	0.236	0.247	0.2645
1960	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1961	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1962	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1963	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1964	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1965	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1966	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1967	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1968	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1969	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1970	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1971	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1972	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271

1973	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1974	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1975	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1976	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1977	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1978	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1979	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1980	0.015	0.05	0.126	0.176	0.211	0.243	0.251	0.267	0.271
1981	0.007	0.049	0.118	0.142	0.189	0.211	0.222	0.267	0.271
1982	0.01	0.059	0.118	0.149	0.179	0.217	0.238	0.265	0.2742
1983	0.01	0.059	0.118	0.149	0.179	0.217	0.238	0.265	0.2745
1984	0.01	0.059	0.118	0.149	0.179	0.217	0.238	0.265	0.2746
1985	0.009	0.036	0.128	0.164	0.194	0.211	0.22	0.258	0.2821
1986	0.006	0.067	0.121	0.153	0.182	0.208	0.221	0.238	0.2572
1987	0.011	0.035	0.099	0.15	0.18	0.211	0.234	0.258	0.2881
1988	0.011	0.055	0.111	0.145	0.174	0.197	0.216	0.237	0.2566
1989	0.017	0.043	0.115	0.153	0.173	0.208	0.231	0.247	0.2631
1990	0.019	0.055	0.114	0.149	0.177	0.193	0.229	0.236	0.2608
1991	0.017	0.058	0.13	0.166	0.184	0.203	0.217	0.235	0.263
1992	0.01	0.053	0.102	0.175	0.189	0.207	0.223	0.237	0.2632
1993	0.01	0.033	0.115	0.145	0.189	0.204	0.228	0.244	0.2735
1994	0.006	0.056	0.13	0.159	0.181	0.214	0.24	0.255	0.2762
1995	0.009	0.042	0.13	0.169	0.198	0.207	0.243	0.247	0.2809
1996	0.015	0.018	0.112	0.156	0.188	0.204	0.212	0.261	0.2815
1997	0.015	0.044	0.108	0.148	0.195	0.227	0.226	0.235	0.2549
1998	0.021	0.051	0.114	0.145	0.183	0.219	0.238	0.247	0.2879
1999	0.009	0.045	0.115	0.151	0.171	0.207	0.233	0.245	0.2677
2000	0.015	0.033	0.113	0.157	0.179	0.201	0.216	0.246	0.2731
2001	0.012	0.048	0.118	0.149	0.177	0.198	0.213	0.238	0.2697
2002	0.012	0.037	0.118	0.153	0.17	0.199	0.214	0.228	0.2504
2003	0.014	0.037	0.104	0.158	0.174	0.184	0.205	0.222	0.2366
2004	0.014	0.036	0.1	0.138	0.183	0.201	0.216	0.228	0.2545
2005	0.011	0.044	0.099	0.153	0.166	0.208	0.223	0.24	0.2654
2006	0.01	0.049	0.117	0.144	0.172	0.181	0.22	0.237	0.246
2007	0.0124	0.0638	0.1214	0.1513	0.1634	0.1933	0.19	0.2232	0.2375
2008	0.0079	0.0535	0.1288	0.1796	0.1812	0.1832	0.2157	0.2161	0.2621
2009	0.0094	0.0514	0.144	0.1811	0.2158	0.2162	0.239	0.2428	0.2533
2010	0.0075	0.0571	0.1292	0.1669	0.1912	0.2203	0.2193	0.216	0.2384
2011	0.008	0.0413	0.1317	0.1593	0.1831	0.197	0.2167	0.2211	0.2319
2012	0.0106	0.0463	0.1243	0.1706	0.1854	0.2058	0.2215	0.2387	0.2427
2013	0.0077	0.0468	0.1162	0.1563	0.1977	0.198	0.2154	0.2334	0.2378
2014	0.0075	0.0522	0.124	0.1719	0.1861	0.2148	0.2118	0.2264	0.2427
2015	0.0087	0.0261	0.1135	0.1538	0.1883	0.2001	0.2212	0.217	0.2347
2016	0.0071	0.0265	0.1267	0.1549	0.1803	0.2059	0.2151	0.2313	0.2299
2017	0.009	0.038	0.099	0.156	0.173	0.188	0.215	0.22	0.2305
2018	0.0054	0.0394	0.1085	0.1451	0.1838	0.1914	0.2151	0.2342	0.2456
2019	0.0064	0.0395	0.121	0.1465	0.1688	0.2036	0.2081	0.2195	0.2435
2020	0.004	0.0706	0.1303	0.1553	0.1707	0.1888	0.2135	0.219	0.2435
2021	0.008	0.0398	0.1284	0.1547	0.1659	0.1892	0.2032	0.2187	0.2241
2022	0.0067	0.0283	0.1308	0.1621	0.1762	0.1883	0.2078	0.2154	0.2298
2023	0.0074	0.0472	0.1128	0.1535	0.1824	0.1858	0.1892	0.1978	0.2198

Table 2.6.1.6 North Sea herring input data. Catch at age.

Year	0	1	2	3	4	5	6	7	8+
1947	0	0	494000	415000	638000	526000	756000	431000	1311000
1948	0	3000	247000	672000	328000	601000	487000	4e+05	917000
1949	0	0	478000	644000	396000	287000	652000	462000	1037000
1950	0	0	535000	1039000	617000	290000	254000	331000	597000

1951	0	462000	660000	959000	1255000	630000	262000	142000	445000
1952	0	722000	1346000	576000	610000	652000	464000	236000	554000
1953	150000	1023000	1322000	1003000	474000	386000	473000	278000	392000
1954	219000	1451000	1493000	1111000	591000	361000	330000	379000	511000
1955	164000	2072000	1931000	1032000	479000	337000	232000	120000	215000
1956	96000	1697000	1860000	1221000	516000	249000	194000	104000	292000
1957	279000	1483000	1644000	736000	644000	344000	207000	147000	253000
1958	97000	4279000	1029000	999000	322000	461000	147000	73000	118000
1959	0	1609000	4934000	488000	497000	233000	249000	120000	301000
1960	194600	2392700	1142300	1966700	165900	167700	112900	125800	270600
1961	1269200	336000	1889400	479900	1455900	124000	157900	61400	143500
1962	141800	2146900	269600	797400	335100	1081800	126900	145100	173100
1963	442800	1262200	2961200	177200	158300	80600	229700	22400	93000
1964	496900	2971700	1547500	2243100	148400	149000	95000	256300	84000
1965	157100	3209300	2217600	1324600	2039400	145100	151900	117600	491400
1966	374500	1383100	2569700	741200	450100	889800	45300	64800	331800
1967	645400	1674300	1171500	1364700	371500	297800	393100	67900	254400
1968	839300	2425000	1795200	1494300	621400	157100	145000	163400	105500
1969	112000	2503300	1883000	296300	133100	190800	49900	42700	52500
1970	898100	1196200	2002800	883600	125200	50300	61000	7900	24200
1971	684000	4378500	1146800	662500	208300	26900	30500	26800	12500
1972	750400	3340600	1440500	343800	130600	32900	5000	200	1500
1973	289400	2368000	1344200	659200	150200	59300	30600	3700	2000
1974	996100	846100	772600	362000	126000	56100	22300	5000	3100
1975	263800	2460500	541700	259600	140500	57200	16100	9100	4800
1976	238200	126600	901500	117300	52000	34500	6100	4400	1400
1977	256800	144300	44700	186400	10800	7000	4100	1500	700
1978	.	.	.	.	.	.	.	.	.
1979	.	.	.	.	.	.	.	.	.
1980	1262700	245100	134000	91800	32200	21700	2300	1400	500
1981	9519700	872000	284300	56900	39500	28500	22700	18700	6600
1982	11956700	1116400	299400	230100	33700	14400	6800	7800	4700
1983	13296900	2448600	573800	216400	105100	26200	22800	12800	23100
1984	6973300	1818400	1146200	441400	201500	81100	22600	25200	

									29700
1985	4211000	3253000	1326300	1182400	368500	124500	43600	20200	29200
1986	3724700	4801400	1266700	840800	465900	129800	62100	20500	28400
1987	8229200	6836300	2137200	667900	467100	245800	74700	23800	16200
1988	3164800	7867000	2232500	1090700	383700	255800	128100	38000	23800
1989	3057800	3145900	1593700	1363800	809300	211800	123700	61000	28200
1990	1302800	3020000	899300	779100	861000	387500	80200	54400	40700
1991	2386600	2138900	1132800	556700	548900	501200	205300	39300	38600
1992	10331300	2303100	1284900	442700	361500	360500	375600	152400	62500
1993	10265400	3826800	1176300	609000	305500	215600	226000	188000	129000
1994	4498900	1785200	1783200	489100	347600	109000	91800	76400	116600
1995	7438469	1664874	1444061	816703	231794	118536	55128	41409	98200
1996	2311226	1606393	642084	525601	172099	57586	22534	9264	21143
1997	431175	479702	687920	446909	284920	109178	31389	11832	24467
1998	259526	977680	1220105	537932	276333	175817	88927	15232	20550
1999	1566349	303520	616354	1058716	294066	135648	69299	27998	12228
2000	1105085	1171677	622853	463170	646814	213466	82481	35706	17087
2001	1832691	614469	842635	485628	278884	321743	90918	38252	20602
2002	730279	837557	579592	970577	292205	140701	174570	48908	43322
2003	369074	617021	1221992	529386	835552	244780	107751	123291	46715
2004	715597	206648	447918	1366155	543376	753231	169324	104945	97142
2005	1015554	715547	355453	485746	1318647	479961	576154	115212	146808
2006	878637	222111	401087	310602	464620	997782	252150	247042	106412
2007	621005	235553	219115	417452	285746	309454	629187	147830	156750
2008	798284	235022	331772	184771	199069	137529	118349	215542	117258
2009	650043	175923	259434	106738	93321	86137	37951	53130	143131
2010	574895	280728	293887	236804	126241	83893	61542	33305	113675
2011	778927	159504	367820	275016	218711	130127	62938	52081	125734
2012	773241	284906	455259	673465	404265	306234	152577	104461	205427
2013	461571	413000	324920	485185	571269	422765	327213	145330	313638
2014	1388685	370590	382990	386131	616563	487582	284562	191729	214513
2015	538228	394878	551802	247555	282813	461041	432034	271280	337811
2016	1583568	109135	625483	818585	293372	280451	367844	307347	359076
2017	462148	209356	108706	1079854	837770	222790	145511	175533	221296

2018	1337404	73260	206232	200527	1178604	848961	223637	144999	332482
2019	649197	172202	105505	307520	198443	730016	528327	133409	217686
2020	2127371	112088	549256	215250	291883	145821	515402	349435	176646
2021	534073	112447	407388	419770	179190	265946	118167	320792	291104
2022	717789	164187	882367	593215	401291	151310	200265	102906	338289
2023	598020	272983	306847	501607	517616	364637	124567	159170	333239

Table 2.6.1.7 North Sea herring input data. HERAS survey index at age.

Year	1	2	3	4	5	6	7	8+
1989	-1	4090000	3903000	1633000	492000	283000	120000	66000
1990	-1	3306000	3521000	3414000	1366000	392000	210000	176000
1991	-1	2634000	1700000	1959000	1849000	644000	228000	145000
1992	-1	3734000	1378000	1147000	1134000	1246000	395000	218000
1993	-1	2984000	1637000	902000	741000	777000	551000	296000
1994	-1	3185000	839000	399000	381000	321000	326000	350000
1995	-1	3849000	2041000	672000	299000	203000	138000	212000
1996	-1	4497000	2824000	1087000	311000	99000	83000	339000
1997	9361000	5960000	2935000	1441000	601000	215000	46000	237000
1998	4449000	5747000	2520000	1625000	982000	445000	170000	166000
1999	5087000	3078000	4725000	1116000	506000	314000	139000	141000
2000	24736000	2923000	2156000	3140000	1007000	483000	266000	217000
2001	6837000	12290000	3083000	1462000	1676000	450000	170000	157000
2002	23055000	4875000	8220000	1390000	794600	1031000	244400	270500
2003	9829400	18949400	3081000	4188900	675100	494800	568300	323200
2004	5183700	3415900	9191800	2167300	2590700	317100	327600	527650
2005	3114100	2055100	3648500	5789600	1212900	1174900	139900	233200
2006	6822800	3772300	1997200	2097500	4175100	618200	562100	154700
2007	6261000	2750000	1848000	898000	806000	1323000	243000	217000
2008	3714000	2853000	1709000	1485000	809000	712000	1749000	455000
2009	4655000	5632000	2553000	1023000	1077000	674000	638000	1720000
2010	14577000	4237000	4216000	2453000	1246000	1332000	688000	2729000
2011	10119000	4166000	2534000	2173000	1016000	651000	688000	1737000
2012	7437000	4719000	4067000	1738000	1209000	593000	247000	696000
2013	6388000	2683000	3031000	2895000	1546000	849000	464000	842000
2014	11634000	4918000	2827000	2939000	1791000	1236000	669000	461000
2015	6714000	9495000	2831000	1591000	1549000	926000	520000	496000
2016	9034000	12011000	5832000	1273000	822000	909000	395000	366000
2017	3054000	1761000	6095000	3142000	787000	365000	298000	293000
2018	9938000	4254000	1692000	5150000	2440000	719000	529000	404000
2019	10146000	1303000	2345000	1212000	3506000	1657000	395000	424000
2020	7130000	2736000	1156000	1371000	1674000	1666000	504000	352000
2021	5196000	2803000	1800000	773000	877000	915000	1021000	596000
2022	3711000	3814000	3043000	1743000	822000	662000	718000	868000
2023	11189000	2703000	3335000	2295000	1387000	466000	377000	683000

Table 2.6.1.8 North Sea herring input data. IBTS0 survey index at age.

Year	Value
1992	163
1993	195.8
1994	155.7
1995	171.2

1996	105.6
1997	133.5
1998	51.72
1999	255.2
2000	110.6
2001	341.5
2002	150.7
2003	72.44
2004	43.11
2005	68.73
2006	67.28
2007	50.76
2008	39.49
2009	92.36
2010	56.53
2011	77.62
2012	65.1
2013	61.55
2014	113.7
2015	21.76
2016	81.71
2017	27.83
2018	102.2
2019	51.63
2020	62.39
2021	92.97
2022	48.02
2023	90.84
2024	62.47

Table 2.6.1.9 North Sea herring input data. IBTSQ1 survey index at age. This index is normalized Using the data from DATRAS following the method described in the stock annex.

Year	Value
1984	1061606
1985	1457560
1986	1669638
1987	3184911
1988	1496976
1989	1606041
1990	759200
1991	1093304
1992	1132042
1993	1865379
1994	2742668
1995	2143521
1996	1262982
1997	837296
1998	1480457
1999	722006
2000	2088129
2001	1603021
2002	1776638
2003	1359736
2004	785094
2005	929561
2006	750288
2007	884515
2008	731483
2009	726247
2010	881467
2011	1542554

2012	801388
2013	504038
2014	1664391
2015	1935561
2016	557714
2017	1380833
2018	681056
2019	985586
2020	1148889
2021	1231068
2022	646817
2023	1542043
2024	71319

Table 2.6.1.10 North Sea herring input data. IBTSQ3 survey index at age. This index is normalized Using the data from DATRAS following the method described in the stock annex

Year	0	1	2	3	4	5
1998	727849	488988	321942	92038	26634	12044
1999	4528369	325386	208253	119064	53366	18611
2000	1709745	791742	291586	117467	71893	17017
2001	1805163	343572	216197	107923	46307	27180
2002	2243881	2035710	471942	332749	82235	32545
2003	884230	499809	566957	148491	115758	18839
2004	2200257	425223	304291	422717	98528	52364
2005	1118139	433999	111865	81226	106024	32657
2006	1021196	316507	192569	76568	46239	52100
2007	2225799	144677	93701	100601	50701	32744
2008	599909	171045	115452	59749	36598	19323
2009	2748438	219861	94904	65260	28324	12219
2010	1462531	529455	170146	84534	38343	16099
2011	868014	371066	175988	102694	52204	22254
2012	763045	222512	91531	69894	40014	23304
2013	1944888	295709	136506	124633	87807	41616
2014	7162833	465667	201172	89246	79266	46053
2015	500937	778955	360295	122341	69196	48390
2016	1757813	189761	370935	210891	73693	43765
2017	851131	299709	77801	197724	132601	42281
2018	1819143	344593	117888	50539	88153	40116
2019	1423658	144998	63201	41947	22807	35957
2020	1010518	339032	267289	71628	65900	25822
2021	768830	301422	107592	69395	24657	16808
2022	7222476	213632	261724	134074	85212	18139
2023	1632083	875452	226490	169633	73039	42298

Table 2.6.1.11 North Sea herring input data. LAI index from the IHLS larvae survey for the Southern North Sea component (Downs). The columns correspond to survey time windows: 0=16-31Dec, 1=01-15Jan, 2=16-31Jan.

Year	0	1	2
1972	2	46	0
1973	-1	-1	1
1974	-1	10	-1
1975	1	2	0
1976	-1	3	-1
1977	1	0	-1
1978	33	3	-1
1979	-1	111	89

1980	247	129	40
1981	1456	-1	70
1982	710	275	54
1983	71	243	58
1984	523	185	39
1985	1851	407	38
1986	780	123	18
1987	934	297	146
1988	1679	162	112
1989	1514	2120	512
1990	2552	1204	-1
1991	4400	873	-1
1992	176	1616	-1
1993	1358	1103	-1
1994	537	595	-1
1995	74	230	164
1996	337	675	691
1997	9374	918	355
1998	1522	953	170
1999	804	1260	344
2000	7346	338	106
2001	971	5531	909
2002	2008	260	925
2003	12048	3109	1116
2004	6528	2052	4175
2005	498	3999	4822
2006	10858	2700	2106
2007	4443	2439	3854
2008	8426	2317	4008
2009	15295	14712	1689
2010	7493	13230	8073
2011	5461	6160	1215
2012	22768	11103	3285
2013	5	9314	2957
2014	-1	-1	1851
2015	2011	1200	645
2016	20710	1442	1545
2017	10553	5880	-1
2018	1140	-1	-1
2019	14082	5258	-1
2020	4077	9704	-1
2021	8899	8764	-1
2022	3712	743	-1
2023	2474	-1	-1

Table 2.6.1.12 North Sea herring input data. LAI index from the IHLS larvae survey for the Central North Sea component (Banks). The columns correspond to survey time windows in: 0=01-15Sep, 1=16-30Sep, 2=01-15Oct, 3=16-31Oct.

Year	0	1	2	3
1972	165	88	134	22
1973	492	830	1213	152
1974	81	-1	1184	-1
1975	-1	90	77	6
1976	64	108	0	10
1977	520	262	89	3
1978	1406	81	269	2
1979	662	131	507	7
1980	317	188	9	13
1981	903	235	119	0
1982	86	64	1077	23
1983	1459	281	63	-1
1984	688	2404	824	433

1985	130	13039	1794	215
1986	1611	6112	188	36
1987	799	4927	1992	113
1988	5533	3808	1960	206
1989	1442	5010	2364	2
1990	19965	1239	975	-1
1991	4823	2110	1249	-1
1992	10	165	163	-1
1993	-1	685	85	-1
1994	-1	1464	44	-1
1995	-1	-1	43	-1
1996	-1	564	-1	-1
1997	-1	-1	-1	-1
1998	205	66	-1	-1
1999	-1	134	181	-1
2000	-1	376	-1	-1
2001	-1	1604	-1	-1
2002	-1	-1	3291	-1
2003	-1	12018	3277	-1
2004	-1	5545	-1	-1
2005	-1	5614	-1	-1
2006	-1	2259	-1	-1
2007	-1	291	-1	-1
2008	-1	11201	-1	-1
2009	-1	4219	-1	-1
2010	-1	2317	-1	-1
2011	-1	17766	-1	-1
2012	-1	517	-1	-1
2013	-1	7354	-1	-1
2014	-1	1149	-1	-1
2015	-1	3424	-1	-1
2016	-1	3288	-1	-1
2017	-1	3965	-1	-1
2018	-1	1509	-1	-1
2019	-1	10605	-1	-1
2020	-1	7663	-1	-1
2021	-1	3282	-1	-1
2022	-1	188	-1	-1
2023	-1	1392	-1	-1

Table 2.6.1.13 North Sea herring input data. LAI index from the IHLS larvae survey for the Bunchan component. The columns correspond to survey time windows in: 0=01-15Sep, 1=16-30Sep.

Year	0	1
1972	30	0
1973	3	4
1974	101	284
1975	312	-1
1976	0	1
1977	124	32
1978	-1	162
1979	197	10
1980	21	1
1981	3	12
1982	340	257
1983	3647	768
1984	2327	1853
1985	2521	1812
1986	3278	341
1987	2551	670
1988	6812	5248
1989	5879	692

1990	4590	2045
1991	-1	2032
1992	-1	822
1993	-1	174
1994	-1	-1
1995	-1	-1
1996	-1	184
1997	-1	23
1998	-1	1490
1999	-1	185
2000	28	155
2001	-1	164
2002	-1	1038
2003	-1	2263
2004	-1	3884
2005	-1	1364
2006	-1	280
2007	-1	1304
2008	-1	533
2009	-1	4629
2010	-1	1493
2011	-1	2839
2012	-1	5856
2013	-1	8618
2014	-1	5033
2015	-1	3496
2016	-1	3872
2017	-1	5833
2018	-1	1740
2019	5654	3794
2020	-1	3418
2021	-1	1413
2022	-1	1471
2023	318	1049

Table 2.6.1.14 North Sea herring input data. LAI index from the IHLS larvae survey for the Orkney/Shetland component. The columns correspond to survey time windows in: 0=01-15Sep, 1=16-30Sep.

Year	0	1
1972	1133	4583
1973	2029	822
1974	758	421
1975	371	50
1976	545	81
1977	1133	221
1978	3047	50
1979	2882	2362
1980	3534	720
1981	3667	277
1982	2353	1116
1983	2579	812
1984	1795	1912
1985	5632	3432
1986	3529	1842
1987	7409	1848
1988	7538	8832
1989	11477	5725
1990	-1	10144
1991	1021	2397
1992	189	4917

1993	-1	66
1994	26	1179
1995	-1	8688
1996	-1	809
1997	-1	3611
1998	-1	8528
1999	-1	4064
2000	-1	3972
2001	-1	11918
2002	-1	6669
2003	-1	3199
2004	-1	7055
2005	-1	3380
2006	6311	2312
2007	-1	1753
2008	4978	6875
2009	-1	7543
2010	-1	2362
2011	-1	3831
2012	-1	19552
2013	-1	21282
2014	-1	6604
2015	-1	9631
2016	-1	-1
2017	-1	-1
2018	-1	102
2019	2488	-1
2020	-1	3208
2021	-1	6651
2022	-1	2785
2023	759	-1

Table 2.6.2.1 North Sea herring single fleet assessment. Observation variance per data source and at age.

fleet	age	value	CV	lbnd	ubnd
catch unique	0	0.4138	0.1282	0.3219	0.532
catch unique	1	0.4138	0.1282	0.3219	0.532
catch unique	2	0.1288	0.1581	0.09452	0.1756
catch unique	3	0.1288	0.1581	0.09452	0.1756
catch unique	4	0.1288	0.1581	0.09452	0.1756
catch unique	5	0.1288	0.1581	0.09452	0.1756
catch unique	6	0.1288	0.1581	0.09452	0.1756
catch unique	7	0.1923	0.1856	0.1337	0.2767
catch unique	8	0.1923	0.1856	0.1337	0.2767
HERAS	1	0.4633	0.148	0.3467	0.6192
HERAS	2	0.2628	0.144	0.1982	0.3485
HERAS	3	0.1657	0.1756	0.1174	0.2337
HERAS	4	0.2162	0.0973	0.1787	0.2617
HERAS	5	0.2162	0.0973	0.1787	0.2617
HERAS	6	0.2162	0.0973	0.1787	0.2617
HERAS	7	0.3022	0.1206	0.2386	0.3828
HERAS	8	0.3022	0.1206	0.2386	0.3828
IBTS-Q1	1	0.4042	0.149	0.3018	0.5414
IBTS0	0	0.3889	0.1552	0.2869	0.5271
IBTS-Q3	0	0.5458	0.1275	0.4251	0.7008
IBTS-Q3	1	0.5458	0.1275	0.4251	0.7008
IBTS-Q3	2	0.3313	0.09474	0.2752	0.3989
IBTS-Q3	3	0.3313	0.09474	0.2752	0.3989
IBTS-Q3	4	0.3313	0.09474	0.2752	0.3989
IBTS-Q3	5	0.3313	0.09474	0.2752	0.3989
LAI-ORSH	0	1.191	0.0427	1.095	1.295
LAI-BUN	0	1.191	0.0427	1.095	1.295
LAI-CNS	0	1.191	0.0427	1.095	1.295
LAI-SNS	0	1.191	0.0427	1.095	1.295

Table 2.6.2.2 North Sea herring single fleet assessment. Catchabilities at age.

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.9824	0.06447	0.8658	1.115
HERAS	2	0.9824	0.06447	0.8658	1.115
HERAS	3	1.102	0.05514	0.9892	1.228
HERAS	4	1.102	0.05514	0.9892	1.228
HERAS	5	1.102	0.05514	0.9892	1.228
HERAS	6	1.102	0.05514	0.9892	1.228
HERAS	7	1.102	0.05514	0.9892	1.228
HERAS	8	1.102	0.05514	0.9892	1.228
IBTS-Q1	1	0.1113	0.08009	0.09512	0.1302
IBTS0	0	3.819e-06	0.09098	3.195e-06	4.564e-06
IBTS-Q3	0	0.1164	0.1257	0.09101	0.149
IBTS-Q3	1	0.05367	0.122	0.04225	0.06817
IBTS-Q3	2	0.04383	0.08491	0.03711	0.05177
IBTS-Q3	3	0.03878	0.08397	0.03289	0.04572
IBTS-Q3	4	0.03354	0.08515	0.02839	0.03964
IBTS-Q3	5	0.02566	0.08625	0.02167	0.03038
LAI-ORSH	0	0.01568	0.1029	0.01282	0.01919
LAI-BUN	0	0.01568	0.1029	0.01282	0.01919
LAI-CNS	0	0.01568	0.1029	0.01282	0.01919
LAI-SNS	0	0.01568	0.1029	0.01282	0.01919

Table 2.6.2.3 North Sea herring single fleet assessment. Numbers at age.

Year	0	1	2	3	4	5	6	7	8
1947	30621233	15433892	13813546	5198039	7029905	4277673	3710115	1959538	5979178
1948	29070933	15026013	9235656	8261857	3521215	4878968	2797094	2111080	4615432
1949	24273480	14377150	11141751	6992858	4095392	2206971	3082811	1772878	4036291
1950	34775849	11212830	8705233	9005681	5029624	2285011	1379416	1720534	3069877
1951	33693408	17655463	6315629	5860910	6595096	3489966	1416038	801768	2665686
1952	33632863	16366005	10100555	3779846	3487902	3668914	2065449	895590	2165630
1953	38329433	16143378	8928172	5564276	2567426	2049382	2125570	1172156	1685656
1954	35691660	18772430	8622541	5085396	3039772	1656829	1190941	1221750	1626740
1955	30473231	16922208	10245952	4958609	2606538	1735640	1002342	631320	1347996
1956	22419518	15051042	8334324	5886829	2810068	1428141	1e+06	554732	1316332
1957	52353447	10129671	7866990	3663517	3449096	1628125	890377	619438	1119609
1958	22070713	30975238	4632011	4404863	1851144	2164033	885690	517997	968691
1959	25456406	10379870	18753978	2125976	2291384	1073418	1115372	542383	1133874
1960	11005724	13515063	4855684	10309935	1047879	1127320	581226	592231	1034836
1961	48261947	3949257	7053684	2326118	6957858	655792	763996	331406	840209
1962	25396077	25881505	1588446	3116993	1349940	4264349	410236	493028	687980
1963	30919268	12332780	15689437	993355	1249457	669790	2176798	196877	667750
1964	31252492	14124084	6445097	9219978	656942	729838	492152	1496090	533497
1965	15467291	15769241	6135205	3357670	5345762	385542	417150	312617	1347759
1966	16690308	7545228	7403995	2131838	1363980	2296892	165872	185216	824653
1967	23323633	7481564	3564399	3118286	846624	649474	855798	98697	458892
1968	20084911	11144558	3083106	1826109	1149447	290653	243627	275054	162625
1969	11480464	9469753	4207680	659179	303006	348050	77557	64099	94382
1970	20166463	5558704	4091425	1505064	208912	99019	107764	16164	42310
1971	15749198	9749429	2314673	1204634	373025	51669	31238	29438	17348
1972	11593482	7389372	3251812	749454	312583	95403	13847	1037	6386
1973	6260827	5191224	2643291	1115573	290809	121018	46611	7321	4382
1974	10018862	2651556	1543796	729418	262568	96882	39524	11258	5159
1975	2313981	5162326	912121	431334	231276	80321	26704	11568	5798
1976	3004558	798778	1772090	208858	92160	60818	13407	6165	

									2437
1977	3915006	1309315	285332	599734	49985	24529	17874	4442	2061
1978	3771310	1728268	693735	220872	247517	30381	11200	9722	3082
1979	6965666	1544968	884707	400765	175708	121284	19954	6891	7077
1980	11231519	2953533	731879	465378	226997	152240	61535	16316	7973
1981	24635892	4289114	1563460	321365	219894	136638	115657	52997	19645
1982	41822432	7341135	1804101	997368	197760	120246	74850	68863	38333
1983	41830979	13635843	3141018	1033406	497512	124084	99654	51331	80540
1984	40185496	12577200	5967834	1751451	659634	267332	77272	65195	79059
1985	47896184	13519960	5601638	3477750	974915	349739	120969	45444	73043
1986	56160258	18547879	5289169	2923095	1523769	419047	163777	52921	58866
1987	50394206	23366843	8519493	2557482	1521462	760195	215803	74182	48952
1988	31174654	1.8e+07	9656575	4502576	1314782	788545	378766	108558	64961
1989	25843693	11396462	6775566	5455887	2618214	683394	392996	188688	88071
1990	23394636	9434121	4324870	3872304	3592936	1530896	366990	212598	158995
1991	25487061	9671868	4081597	2317239	2303788	2135931	866536	210986	196158
1992	45139614	9398591	4373488	1783005	1331793	1330942	1277577	514435	243229
1993	45885185	15285208	3634893	1986583	943476	729521	731844	629036	402405
1994	35615947	14427379	5672676	1444878	860834	405223	342152	335155	464891
1995	39223445	12017462	5792577	2588577	731209	369329	198387	171500	374593
1996	33239153	13309275	4960893	3024047	1106457	343050	150672	96860	265252
1997	25251470	13689685	6294056	2945134	1672317	667488	209036	88974	223364
1998	16900525	11007546	8832094	3211842	1505110	897176	432172	129264	175142
1999	48704107	7946242	5408329	5407583	1705260	758412	434068	225813	151844
2000	35316347	20726737	5424573	2923346	3206570	1030006	471953	268085	196741
2001	60379135	14699457	10788243	3578776	1709298	1775182	550680	279114	227557
2002	30988450	27357930	7794067	7966798	1915633	925291	1077902	321246	310620
2003	17195899	12613580	16804978	4496057	4948080	1061704	568298	648866	338507
2004	20195615	6800955	6036140	10789158	2963451	2979065	546180	362743	496451
2005	17414312	8749897	3648121	3777337	6484954	1751711	1604082	269638	406169
2006	17914382	6422316	4761415	2407758	2372811	4091807	860109	720884	284007
2007	21111160	6832924	3089257	2867650	1522048	1365995	2288940	445684	466183
2008	19373943	8080469	4168857	2064575	1686223	982431	858449	1452704	561935
2009	30298560	8130486	5153460	2561746	1395900	1117126	665245	620609	1579240

2010	23568051	11963978	5331385	3809678	1887963	1042804	977029	509259	1706936
2011	21112101	10082398	6457482	3513318	2423872	1223093	711723	641898	1458340
2012	20330007	8328226	5653798	4911456	2573881	1694764	792476	468156	1185102
2013	26882376	8278859	4378467	4018556	3365382	1929657	1170834	499236	1020086
2014	40757592	12548167	5220399	3069868	3230262	2252882	1225027	688627	751603
2015	11658757	17271981	9236335	2899796	1900050	2021401	1350141	710639	802747
2016	20260759	4678752	11197455	6709178	1808481	1195778	1148479	688406	710353
2017	12665478	7714491	2414689	8153031	4692744	1194984	622628	547472	590217
2018	22695846	5217182	3994398	1882231	5800825	3322508	792046	417745	685466
2019	20660977	9257576	2340652	2672009	1407087	3662812	2031420	430694	569521
2020	23073483	8491397	5607037	1600170	1844105	1040720	2246640	1074533	516021
2021	15893196	10443312	4713098	3049675	1115015	1276347	725627	1276577	892715
2022	24686032	6053006	6703718	3622497	2270525	785772	856194	473049	1206218
2023	12056085	11542254	3429422	3771392	2455186	1625232	504764	498106	958483
2024	15849920	3724604	6468517	2175237	2324239	1450535	949161	282566	730932

Table 2.6.2.4 North Sea herring single fleet assessment. Harvest at age.

Year	0	1	2	3	4	5	6	7	8
1947	0.0001311	0.001073	0.04057	0.09941	0.1154	0.1552	0.2573	0.286	0.286
1948	0.0001048	0.0008317	0.0343	0.09023	0.1095	0.1462	0.2216	0.2535	0.2535
1949	0.0002628	0.002371	0.05162	0.1131	0.1298	0.166	0.2699	0.3223	0.3223
1950	0.0006467	0.006618	0.0766	0.1406	0.153	0.1708	0.2296	0.2505	0.2505
1951	0.001987	0.0238	0.1344	0.2075	0.2192	0.2176	0.2462	0.2388	0.2388
1952	0.003427	0.04429	0.166	0.2168	0.2257	0.2343	0.296	0.322	0.322
1953	0.005129	0.07014	0.1967	0.2394	0.234	0.2426	0.296	0.3133	0.3133
1954	0.007245	0.107	0.2411	0.2824	0.2644	0.2823	0.3817	0.3976	0.3976
1955	0.00775	0.1277	0.2584	0.2735	0.2415	0.2492	0.2832	0.2465	0.2465
1956	0.007904	0.1429	0.2833	0.2757	0.2351	0.2397	0.2573	0.2505	0.2505
1957	0.008711	0.1564	0.2938	0.2835	0.2482	0.2706	0.2991	0.2851	0.2851
1958	0.009431	0.1571	0.3015	0.283	0.2363	0.2455	0.2135	0.1812	0.1812
1959	0.01602	0.2218	0.3569	0.3206	0.2757	0.2795	0.3036	0.3005	0.3005

1960	0.01847	0.2006	0.3159	0.2625	0.2189	0.2181	0.2483	0.2801	0.2801
1961	0.021	0.2046	0.3337	0.2989	0.2587	0.2469	0.2622	0.2468	0.2468
1962	0.01335	0.1351	0.2788	0.3198	0.3047	0.3135	0.3897	0.3615	0.3615
1963	0.01345	0.1213	0.2389	0.2281	0.1821	0.1726	0.1351	0.1486	0.1486
1964	0.02012	0.2021	0.3457	0.3434	0.2899	0.2772	0.2307	0.2223	0.2223
1965	0.02598	0.2974	0.5278	0.5861	0.5256	0.526	0.5135	0.5214	0.5214
1966	0.02642	0.2617	0.4972	0.5645	0.4982	0.5173	0.4205	0.5206	0.5206
1967	0.03152	0.2988	0.5748	0.7397	0.672	0.7143	0.7772	0.9669	0.9669
1968	0.05271	0.5481	0.9969	1.294	1.002	0.9713	1.166	1.232	1.232
1969	0.02969	0.3056	0.6995	0.8883	0.805	0.8573	1.206	1.083	1.083
1970	0.04977	0.4325	0.8201	1.024	0.9325	0.8589	1.19	0.9227	0.9227
1971	0.07343	0.582	0.8919	1.092	1.073	1.138	2.945	1.743	1.743
1972	0.074	0.4739	0.7047	0.733	0.6018	0.5343	0.5465	0.3242	0.3242
1973	0.1087	0.6526	0.9153	1.026	0.8648	0.8686	1.086	0.7139	0.7139
1974	0.1225	0.5567	0.8468	0.9463	0.8445	0.9467	0.968	0.8532	0.8532
1975	0.1893	0.6961	1.016	1.251	1.119	1.302	1.307	1.635	1.635
1976	0.1603	0.4545	0.7323	1.016	0.8818	0.9642	0.8277	1.173	1.173
1977	0.0749	0.132	0.2662	0.3923	0.3343	0.4101	0.2826	0.4721	0.4721
1978	0.08646	0.1187	0.2196	0.2852	0.2384	0.2723	0.1464	0.2635	0.2635
1979	0.1228	0.1371	0.2154	0.2533	0.197	0.2056	0.08641	0.1589	0.1589
1980	0.1812	0.1645	0.219	0.2375	0.1744	0.1596	0.05225	0.09368	0.09368
1981	0.3708	0.285	0.2571	0.285	0.2522	0.2694	0.2177	0.3854	0.3854
1982	0.336	0.2521	0.2261	0.2549	0.2068	0.1782	0.1097	0.1577	0.1577
1983	0.3413	0.2888	0.2487	0.2951	0.2898	0.2827	0.2626	0.3452	0.3452
1984	0.2487	0.2808	0.268	0.3509	0.3943	0.3952	0.4013	0.5058	0.5058
1985	0.2115	0.3487	0.3302	0.4437	0.5067	0.492	0.5388	0.604	0.604
1986	0.1649	0.3241	0.3162	0.3872	0.4445	0.4547	0.5345	0.6	0.6
1987	0.2024	0.407	0.3326	0.3639	0.4222	0.437	0.47	0.4719	0.4719
1988	0.1926	0.4218	0.3227	0.3341	0.4031	0.4317	0.4687	0.4823	0.4823
1989	0.1838	0.4095	0.3272	0.3273	0.394	0.411	0.4257	0.4325	0.4325
1990	0.1351	0.2988	0.2868	0.2689	0.3086	0.3176	0.292	0.3097	0.3097
1991	0.1798	0.3531	0.3495	0.3101	0.3234	0.3115	0.289	0.2623	0.2623
1992	0.2624	0.4318	0.4032	0.3627	0.3801	0.3608	0.3825	0.3604	0.3604
1993	0.3078	0.4732	0.4567	0.4494	0.4683	0.4088	0.4322	0.4132	

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0.4132
  1994     0.2451     0.3685    0.4241    0.4794    0.5051    0.4038    0.3772    0.3283
0.3283
  1995     0.2114      0.301    0.3526    0.4332    0.4491    0.4071    0.3989    0.3191
0.3191
  1996    0.07782     0.1105    0.1789     0.222    0.2215    0.2152    0.1707    0.1161
0.1161
  1997    0.03687     0.0609    0.1402    0.1943    0.2096    0.2129    0.1882    0.1358
0.1358
  1998    0.04152    0.07701    0.1628      0.23    0.2459    0.2536    0.2445    0.1494
0.1494
  1999    0.04238    0.06803    0.1468    0.2233    0.2337    0.2349    0.2006    0.1229
0.1229
  2000     0.0481    0.07094     0.139    0.2146    0.2487    0.2562    0.2197    0.1355
0.1355
  2001    0.03975    0.05126    0.1048    0.1691    0.2094     0.229    0.2016    0.1399
0.1399
  2002    0.03612    0.04346   0.09205    0.1485     0.193    0.2191    0.2028    0.1705
0.1705
  2003    0.04098    0.04731   0.09287    0.1508    0.2149    0.2698    0.2552    0.2124
0.2124
  2004     0.0502    0.05145   0.09713    0.1579    0.2402    0.3278    0.4029     0.345
0.345
  2005    0.07864    0.07562    0.1185    0.1781    0.2719    0.3706    0.5276     0.567
0.567
  2006    0.06564    0.05798     0.106    0.1642    0.2478    0.3214    0.4197    0.5027
0.5027
  2007    0.05736       0.05     0.101    0.1594    0.2318    0.2899    0.3638    0.4433
0.4433
  2008    0.05483    0.04316   0.08946    0.1112    0.1471    0.1757     0.169    0.2142
0.2142
  2009     0.0325    0.02289    0.0573   0.06133   0.07906   0.09562   0.06992   0.09705
0.09705
  2010    0.03803    0.02639   0.06405   0.07292   0.08523   0.09968   0.07164   0.08144
0.08144
  2011     0.0423    0.02841   0.07038   0.09296    0.1112      0.13    0.1036    0.1068
0.1068
  2012    0.06043    0.04599   0.09947    0.1527    0.1926    0.2275    0.2463    0.2568
0.2568
  2013    0.05045    0.03984   0.09186    0.1521    0.2153    0.2749    0.3529    0.3975
0.3975
  2014    0.05826    0.03767   0.08684    0.1494    0.2191    0.2744    0.3224    0.3898
0.3898
  2015    0.06061    0.02959    0.0698    0.1236    0.1965    0.2839    0.4155    0.5653
0.5653
  2016    0.07815    0.03183   0.07113    0.1438    0.2191    0.3017    0.4509    0.6789
0.6789
  2017    0.06434     0.0244   0.06259    0.1404    0.2104    0.2566    0.3156    0.4749
0.4749
  2018    0.06498    0.02221   0.06542    0.1436    0.2304    0.2942    0.3858    0.5516
0.5516
  2019    0.05334    0.01816     0.065    0.1328    0.1878    0.2406    0.3252    0.4755
0.4755
  2020     0.0798    0.02785    0.1018    0.1676    0.1991    0.2187    0.2819    0.4428
0.4428
  2021    0.05717    0.02286    0.1053    0.1688    0.2026    0.2257    0.2295    0.3584
0.3584
  2022    0.06919     0.0328    0.1374    0.2004    0.2361    0.2544    0.2795    0.3548
0.3548
  2023    0.06698    0.02914    0.1199    0.1821    0.2491     0.279    0.3279    0.4469
0.4469
  2024    0.06733    0.02933    0.1203    0.1826    0.2497    0.2796    0.3289    0.4481
0.4481
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Table 2.6.2.5 North Sea herring single fleet assessment. Analytical retrospective (Mohn's Rho).

year	ssb	fbar	rec
2013	20.25	-26.03	18.1
2014	12.89	-15.31	3.781
2015	11.07	-11.81	7.159
2016	9.713	-9.618	-22.7
2017	18.32	-25.18	-2.936
2018	11.59	-13.63	-5.99
2019	6.555	-8.682	-5.785
2020	4.381	-4.966	3.1
2021	10.64	-10.04	0.2572
2022	5.579	-6.618	-10.71
2023	0	0	0
av_5y	6.457	-7.323	-3.189

Table 2.6.2.6 North Sea herring single fleet assessment. Assessment summary.

Year	Rec	Rec_lo	Rec_hi	TSB	TSB_lo	TSB_hi	SSB	SSB_lo	SSB_hi	Catch	Catch_lo	Catch_hi	Fbar	Fbar_lo	Fbar_hi	Landings	SOP
1947	30621233	17476034	53654044	8114073	6256413	10523311	5043436	3700423	6873875	851417	729715	993417	0.1336	0.09514	0.1875	811852	1.047
1948	29070933	17477384	48355014	6999284	5432551	9017858	4305462	3186470	5817410	660002	574697	757970	0.1204	0.08691	0.1667	642519	1.041
1949	24273480	14738885	39976011	6469565	5085348	8230561	3908648	2921865	5228690	724137	631301	830625	0.1461	0.1066	0.2002	708914	1.04
1950	34775849	21536074	56155068	6115545	4877847	7667294	3675771	2797974	4828956	648214	576457	728904	0.1541	0.1152	0.2062	627280	1.025
1951	33693408	21030281	53981480	5982433	4849190	7380511	3256018	2509011	4225431	775367	694364	865819	0.205	0.1571	0.2675	784357	1.013
1952	33632863	21140199	53507987	5753376	4695501	7049586	3081452	2391083	3971148	835298	751059	928984	0.2278	0.1753	0.2959	834018	1.013
1953	38329433	24836155	59153497	5537599	4537466	6758178	2861065	2223326	3681733	836834	752234	930947	0.2417	0.1868	0.3128	830051	1.008
1954	35691660	23202096	54904288	5404266	4440225	6577616	2615097	2019253	3386763	949229	848262	1062214	0.2904	0.223	0.3781	946914	1.008
1955	30473231	19929268	46595681	5170829	4240892	6304681	2627773	2036611	3390530	845214	748620	954272	0.2612	0.201	0.3394	852139	1.003
1956	22419518	14647469	34315469	4835802	3975561	5882184	2538717	1970803	3270284	832816	738239	939510	0.2582	0.1997	0.3339	855412	1.003
1957	52353447	33894775	80864482	4724728	3896303	5729292	2303462	1787185	2968879	785455	700691	880473	0.279	0.2153	0.3616	788332	1.003
1958	22070713	14533179	33517536	4737265	3885829	5775263	1956200	1518600	2519898	734642	625393	862976	0.256	0.199	0.3292	781848	1.001
1959	25456406	16308255	39736233	5336921	4414269	6452421	2848808	2219480	3656580	1166245	1002831	1356287	0.3073	0.2393	0.3946	1189352	1.002
1960	11005724	7127879	16993267	4474161	3702544	5406585	2457492	1920044	3145381	808174	703464	928471	0.2527	0.1982	0.3223	823638	1
1961	48261947	31360388	74272536	4615285	3854096	5526810	2471470	1957178	3120903	765103	676357	865494	0.2801	0.2231	0.3517	790607	1
1962	25396077	16813009	38360814	4297551	3588955	5146051	1726645	1350984	2206765	726053	629461	837467	0.3213	0.2547	0.4054	734871	1
1963	30919268	20569874	46475791	5002948	4199135	5960630	2738677	2203017	3404580	596123	510334	696335	0.1914	0.1552	0.236	615876	1
1964	31252492	20927860	46670718	4967661	4310070	5725580	2486856	2065136	2994695	903680	784836	1040520	0.2974	0.2482	0.3563	928370	1

1965	15467291	10348956	23117025	4505872	3988297	5090614	1970172	1664765	2331607	1298433	1139853	1479075	0.5358	0.4542	0.632	1343637	1
1966	16690308	11232313	24800447	3384042	3007560	3807650	1576884	1342498	1852191	933127	828746	1050656	0.4995	0.4269	0.5846	958788	1
1967	23323633	15615639	34836350	2611557	2335564	2920164	951918	819132	1106230	837333	743534	942966	0.6956	0.6029	0.8025	817684	1
1968	20084911	13565041	29738477	2203753	1941323	2501658	519484	445941	605156	904968	773983	1058121	1.086	0.9583	1.231	900936	1
1969	11480464	7647018	17235616	1641629	1422078	1895076	474781	390681	576985	503263	427522	592422	0.8911	0.7792	1.019	528854	1
1970	20166463	13430366	30281097	1613954	1404998	1853986	453541	372915	551598	547518	468820	639427	0.9652	0.8489	1.097	543767	1
1971	15749198	10611468	23374450	1426119	1217663	1670261	285369	236464	344388	526749	426384	650738	1.428	1.266	1.61	558968	1
1972	11593482	7752024	17338547	1286153	1107465	1493673	326826	270447	394957	393974	319354	486030	0.624	0.5408	0.7201	457564	1
1973	6260827	4202670	9326918	1081972	947687	1235284	277562	232364	331550	444478	372772	529979	0.9522	0.8376	1.083	463442	1
1974	10018862	6619137	15164755	756122	660149	866047	190734	160618	226496	271470	232604	316829	0.9104	0.7984	1.038	266297	1
1975	2313981	1519169	3524630	598249	501716	713356	104811	86989	126284	269683	214682	338776	1.199	1.038	1.386	292243	1
1976	3004558	1911116	4723610	440118	368266	525988	142578	108716	186987	157729	132752	187406	0.8844	0.6963	1.123	166578	1
1977	3915006	2427775	6313302	304469	241476	383894	108813	79624	148703	51949	43919	61447	0.3371	0.2472	0.4597	55105	1
1978	3771310	2307766	6163008	361225	277693	469884	135431	1e+05	183384	45863	26609	79049	0.2324	0.1468	0.3679	13368	.
1979	6965666	4426293	10961884	471715	376541	590945	183613	141696	237930	59433	33869	104292	0.1915	0.1197	0.3066	25242	.
1980	11231519	7592590	16614491	627934	520234	757929	206352	165684	257001	80025	62918	101783	0.1685	0.1342	0.2116	77390	1
1981	24635892	16686610	36372108	1021917	842777	1239136	265559	213933	329643	148017	114080	192051	0.2563	0.2056	0.3195	176293	1
1982	41822432	28400972	61586476	1586408	1299597	1936517	376610	307175	461741	240204	175667	328452	0.1952	0.1591	0.2394	269180	1
1983	41830979	28783716	60792387	2197714	1834632	2632651	538518	442339	655610	386217	288490	517050	0.2758	0.2283	0.3332	417047	1
1984	40185496	27689136	58321577	2925530	2490358	3436745	884344	725176	1078447	482503	389872	597143	0.3619	0.3025	0.433	451919	1
1985	47896184	32936095	69651380	3321837	2856641	3862787	974543	806497	1177604	637830	542898	749363	0.4623	0.3871	0.5521	639487	1
1986	56160258	38501328	81918591	3682482	3146434	4309855	1012673	843201	1216205	724550	581139	903351	0.4274	0.3575	0.511	763655	1
1987	50394206	34577130	73446699	3686452	3171731	4284704	1191258	992885	1429264	760723	625603	925026	0.4051	0.3405			

```
0.4821    805789       1
  1988  31174654  21474190  45257076  3651167  3180054  4192074  1509394  1263534  1803093  894007  730200  1094561  0.3921  0.3314
0.4639   1033395       1
  1989  25843693  17814208  37492345  3318338  2948523  3734535  1583265  1361768  1840790  805180  695699  931891  0.377  0.3221
0.4413    814319       1
  1990  23394636  16066086  34066105  3339796  2967704  3758541  1724840  1488272  1999012  637765  553754  734521  0.2948  0.2507
0.3467    678463       1
  1991  25487061  17537154  37040803  3200259  2849147  3594640  1539063  1333949  1775716  682076  586777  792852  0.3167  0.2699
0.3717    670985       1
  1992  45139614  32190290  63298118  3140956  2789784  3536333  1167241  1008792  1350577  704495  602338  823978  0.3778  0.3217
0.4437    713182       1
  1993  45885185  32695087  64396531  2904526  2542788  3317724  828560  708561  968883  702197  592941  831583  0.4431  0.376
0.5221    686916       1
  1994  35615947  25270080  50197534  2742661  2383125  3156440  881590  753153  1031930  688063  562986  840929  0.4379  0.3717
0.516    596508       1
  1995  39223445  27667616  55605753  2616666  2274551  3010239  905373  767439  1068098  599798  511995  702658  0.4082  0.3433
0.4853    584264       1
  1996  33239153  23540969  46932702  2653226  2279221  3088604  1061422  899872  1251974  268233  233544  308075  0.2017  0.1681
0.2419    274740       1
  1997  25251470  17841740  35738486  2800151  2423690  3235087  1234946  1051330  1450630  276228  243471  313393  0.189  0.1579
0.2263    264467       1
  1998  16900525  12117500  23571508  3057040  2670432  3499618  1426692  1225917  1660348  376326  332849  425483  0.2274  0.1905
0.2714    392320       1
  1999  48704107  3.5e+07  67764654  3095271  2718049  3524846  1512251  1299878  1759322  352910  312396  398678  0.2079  0.175
0.2469    363147       1
  2000  35316347  25498249  48914901  3658066  3186572  4199323  1540798  1326852  1789241  380461  337219  429247  0.2157  0.1814
0.2563    388295       1
  2001  60379135  43179621  84429642  4085685  3561228  4687378  1915648  1649409  2224862  371989  330777  418336  0.1828  0.1536
0.2176    370371       1
  2002  30988450  22268324  43123319  4904616  4259577  5647335  2375250  2043542  2760800  394795  350689  444447  0.1711  0.1438
0.2035    393674       1
  2003  17195899  12393157  23859857  5195724  4533970  5954064  2348556  2034544  2711032  485299  434544  541982  0.1967  0.1659
0.2332    489667       1
  2004  20195615  14565452  2.8e+07  4560936  4026162  5166742  2313239  2008372  2664384  588859  528575  656018  0.2452  0.2064
0.2913    586841       1
  2005  17414312  12618999  24031880  3774100  3351659  4249786  2095051  1809378  2425826  664790  596345  741090  0.2933  0.2476
0.3475    665983       1
  2006  17914382  12936952  24806852  3158912  2804094  3558627  1707215  1476980  1973340  511708  459130  570308  0.2518  0.2122
0.2988    512037       1
  2007  21111160  15161373  29395825  2627364  2324234  2970028  1357448  1170653  1574049  398139  357181  443795  0.2292  0.1924
0.273    408766       1
  2008  19373943  13884300  27034106  2658907  2328956  3035602  1442678  1245136  1671561  257415  230144  287918  0.1385  0.1164
0.1648    258901       1
  2009  30298560  21729396  42247044  3098410  2698918  3557034  1788991  1540973  2076926  165736  148141  185420  0.07265  0.06075
0.08686    168824       1
```

2010	23568051	16952435	32765383	3716029	3241345	4260231	1901356	1634761	2211428	186725	167237	208484	0.0787	0.066	0.09385	188242	1
2011	21112101	15234292	29257729	3721112	3272648	4231031	2244944	1953340	2580080	228894	205964	254376	0.1016	0.08574	0.1204	225066	1
2012	20330007	14669314	28175087	3674665	3253598	4150223	2294310	1997130	2635713	431961	389047	479608	0.1837	0.1552	0.2174	439435	1
2013	26882376	19264404	37512823	3585138	3188995	4030491	2098364	1829969	2406124	5e+05	450877	554375	0.2174	0.1838	0.2572	512118	1
2014	40757592	29046564	57190286	3764153	3337455	4245404	2065880	1799681	2371454	508146	458321	563388	0.2104	0.1778	0.249	518832	1
2015	11658757	8328378	16320899	3926402	3445294	4474693	1912355	1661555	2201010	487519	438628	541859	0.2179	0.1831	0.2593	494924	1
2016	20260759	14611836	28093551	3912234	3430382	4461769	2195134	1895295	2542407	550799	496262	611330	0.2373	0.1993	0.2826	563596	1
2017	12665478	9082436	17662039	3406701	2995329	3874571	2043992	1758061	2376426	467124	416585	523794	0.1971	0.166	0.2341	499068	1
2018	22695846	16342487	31519156	3247182	2869280	3674856	1833544	1575385	2134007	550547	488638	620301	0.2239	0.1886	0.2659	604413	1
2019	20660977	14859124	28728208	2805053	2483114	3168731	1587379	1369015	1840572	427866	381970	479277	0.1903	0.1598	0.2266	443134	1
2020	23073483	16630263	32013060	2753068	2432726	3115592	1525521	1318877	1764541	415516	371398	464874	0.1938	0.1634	0.2299	428348	1
2021	15893196	11324431	22305198	2708591	2383148	3078476	1462333	1263450	1692522	355757	316979	399279	0.1864	0.1572	0.221	365446	1
2022	24686032	16736201	36412097	3049496	2673838	3477931	1675352	1440711	1948207	442838	397027	493935	0.2215	0.1861	0.2637	461759	1
2023	12056085	7239966	20075947	2882419	2466793	3368073	1519404	1272183	1814669	412396	370114	459509	0.2316	0.1885	0.2845	419377	1
2024	15849920	8108935	30980637	2590936	2021577	3320652	1467406	1107693	1943933	383506	217239	677030	0.2322	0.1195	0.4515	.	.

Table 2.6.2.7 North Sea herring single fleet assessment. SAM model control object.

```
An object of class "FLSAM.control"
Slot "name":
[1] "North Sea Herring"

Slot "desc":
[1] "Imported from a VPA file. ( ./bootstrap/data/index.txt ).  Sat Mar 16 16:26:25 2024"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2024         2         6

Slot "fleets":
catch unique        HERAS      IBTS-Q1        IBTS0      IBTS-Q3     LAI-ORSH
           0            2            2            2            2            6
     LAI-BUN      LAI-CNS      LAI-SNS
           6            6            6

Slot "plus.group":
[1] 1 1 0 0 0 1 1 1 1

Slot "states":
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique  0  1  2  3  4  5  6  7  7
  HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "logN.vars":
0 1 2 3 4 5 6 7 8
0 1 1 1 1 1 1 1 1

Slot "logP.vars":
[1] 0 1 2

Slot "catchabilities":
```

```
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique -1 -1 -1 -1 -1 -1 -1 -1 -1
  HERAS        -1  1  1  2  2  2  2  2  2
  IBTS-Q1      -1  3 -1 -1 -1 -1 -1 -1 -1
  IBTS0         0 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3       4  5  6  7  8  9 -1 -1 -1
  LAI-ORSH     10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      10 -1 -1 -1 -1 -1 -1 -1 -1

Slot "power.law.exps":
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique -1 -1 -1 -1 -1 -1 -1 -1 -1
  HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "f.vars":
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique  0  0  1  1  1  1  2  2  2
  HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "obs.vars":
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique  0  0  1  1  1  1  1  2  2
  HERAS        -1  3  4  5  6  6  6  7  7
  IBTS-Q1      -1  8 -1 -1 -1 -1 -1 -1 -1
  IBTS0         9 -1 -1 -1 -1 -1 -1 -1 -1
```

```
  IBTS-Q3      10 10 11 11 11 11 -1 -1 -1
  LAI-ORSH     12 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      12 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      12 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      12 -1 -1 -1 -1 -1 -1 -1 -1

Slot "srr":
[1] 0

Slot "scaleNoYears":
[1] 0

Slot "scaleYears":
[1] NA

Slot "scalePars":
      age
years  0 1 2 3 4 5 6 7 8

Slot "cor.F":
[1] 2

Slot "cor.obs":
              age
fleet          0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
  catch unique  NA  NA  NA  NA  NA  NA  NA  NA
  HERAS         -1  NA  NA  NA  NA  NA  NA  NA
  IBTS-Q1       -1  -1  -1  -1  -1  -1  -1  -1
  IBTS0         -1  -1  -1  -1  -1  -1  -1  -1
  IBTS-Q3        0   0   0   0   0  -1  -1  -1
  LAI-ORSH      -1  -1  -1  -1  -1  -1  -1  -1
  LAI-BUN       -1  -1  -1  -1  -1  -1  -1  -1
  LAI-CNS       -1  -1  -1  -1  -1  -1  -1  -1
  LAI-SNS       -1  -1  -1  -1  -1  -1  -1  -1

Slot "cor.obs.Flag":
[1] ID ID ID ID AR ID ID ID ID
Levels: ID AR US

Slot "biomassTreat":
[1] -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "timeout":
[1] 3600
```

```
Slot "likFlag":
[1] LN LN LN LN LN LN LN LN LN
Levels: LN ALN

Slot "fixVarToWeight":
[1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE

Slot "fracMixF":
[1] 0

Slot "fracMixN":
[1] 0 0 0 0 0 0 0 0 0

Slot "fracMixObs":
catch unique        HERAS      IBTS-Q1        IBTS0      IBTS-Q3     LAI-ORSH
           0            0            0            0            0            0
     LAI-BUN      LAI-CNS      LAI-SNS
           0            0            0

Slot "constRecBreaks":
numeric(0)

Slot "predVarObsLink":
              age
fleet           0  1  2  3  4  5  6  7  8
  catch unique -1 -1 -1 -1 -1 -1 -1 -1 -1
  HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "stockWeightModel":
[1] FALSE

Slot "stockWeightMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "stockWeightObsVar":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA
```

```
Slot "catchWeightModel":
[1] FALSE

Slot "catchWeightMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "catchWeightObsVar":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "maturityModel":
[1] FALSE

Slot "maturityMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "mortalityModel":
[1] FALSE

Slot "mortalityMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "mortalityObsVar":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "XtraSd":
     [,1] [,2] [,3] [,4]

Slot "logNMeanAssumption":
[1] 0 0

Slot "initState":
[1] 0

Slot "simulate":
[1] FALSE

Slot "residuals":
[1] TRUE
```

```
Slot "sumFleets":
logical(0)
```

Table 2.6.3.1 North Sea herring multi fleet assessment. observation variance per data source and at age.

fleet	age	value	CV	lbnd	ubnd
catch A	1	0.6229	0.1238	0.4886	0.794
catch A	2	0.1294	0.1372	0.09886	0.1693
catch A	3	0.1294	0.1372	0.09886	0.1693
catch A	4	0.1294	0.1372	0.09886	0.1693
catch A	5	0.1294	0.1372	0.09886	0.1693
catch A	6	0.1294	0.1372	0.09886	0.1693
catch A	7	0.1697	0.2675	0.1004	0.2866
catch A	8	0.1697	0.2675	0.1004	0.2866
catch BD	0	0.4273	0.1889	0.2951	0.6188
catch BD	1	0.3445	0.2517	0.2103	0.5642
catch BD	2	1.008	0.05002	0.9141	1.112
catch BD	3	1.008	0.05002	0.9141	1.112
catch BD	4	1.008	0.05002	0.9141	1.112
catch BD	5	1.008	0.05002	0.9141	1.112
catch C	1	0.6654	0.1272	0.5186	0.8537
catch C	2	0.331	0.1568	0.2434	0.4501
catch C	3	0.4281	0.05904	0.3813	0.4806
catch C	4	0.4281	0.05904	0.3813	0.4806
catch C	5	0.4281	0.05904	0.3813	0.4806
catch C	6	0.4281	0.05904	0.3813	0.4806
HERAS	1	0.4642	0.1485	0.347	0.621
HERAS	2	0.2537	0.1467	0.1903	0.3382
HERAS	3	0.1614	0.1788	0.1137	0.2292
HERAS	4	0.2257	0.09523	0.1873	0.272
HERAS	5	0.2257	0.09523	0.1873	0.272
HERAS	6	0.2257	0.09523	0.1873	0.272
HERAS	7	0.3178	0.1212	0.2506	0.4029
HERAS	8	0.3178	0.1212	0.2506	0.4029
IBTS-Q1	1	0.4088	0.1498	0.3048	0.5483
IBTS0	0	0.3884	0.1572	0.2854	0.5286
IBTS-Q3	0	0.5279	0.1264	0.412	0.6763
IBTS-Q3	1	0.5279	0.1264	0.412	0.6763
IBTS-Q3	2	0.3324	0.09381	0.2765	0.3994
IBTS-Q3	3	0.3324	0.09381	0.2765	0.3994

IBTS-Q3	4	0.3324	0.09381	0.2765	0.3994
IBTS-Q3	5	0.3324	0.09381	0.2765	0.3994
LAI-ORSH	0	1.192	0.04272	1.096	1.296
LAI-BUN	0	1.192	0.04272	1.096	1.296
LAI-CNS	0	1.192	0.04272	1.096	1.296
LAI-SNS	0	1.192	0.04272	1.096	1.296

Table 2.6.3.2 North Sea herring multi fleet assessment. Catchabilities at age.

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.99	0.0684	0.8658	1.132
HERAS	2	0.99	0.0684	0.8658	1.132
HERAS	3	1.107	0.06	0.9839	1.245
HERAS	4	1.107	0.06	0.9839	1.245
HERAS	5	1.107	0.06	0.9839	1.245
HERAS	6	1.107	0.06	0.9839	1.245
HERAS	7	1.107	0.06	0.9839	1.245
HERAS	8	1.107	0.06	0.9839	1.245
IBTS-Q1	1	0.1121	0.0838	0.0951	0.1321
IBTS0	0	3.878e-06	0.09528	3.217e-06	4.674e-06
IBTS-Q3	0	0.1183	0.1265	0.09229	0.1515
IBTS-Q3	1	0.0542	0.122	0.04268	0.06884
IBTS-Q3	2	0.0445	0.08873	0.03739	0.05295
IBTS-Q3	3	0.03909	0.0877	0.03291	0.04642
IBTS-Q3	4	0.03333	0.08913	0.02799	0.0397
IBTS-Q3	5	0.02575	0.09002	0.02159	0.03072
LAI-ORSH	0	0.01601	0.1049	0.01303	0.01966
LAI-BUN	0	0.01601	0.1049	0.01303	0.01966
LAI-CNS	0	0.01601	0.1049	0.01303	0.01966
LAI-SNS	0	0.01601	0.1049	0.01303	0.01966

Table 2.6.3.3 North Sea herring multi fleet assessment. Numbers at age.

Year	0	1	2	3	4	5	6	7	8
1947	18514003	12653156	12959464	5207598	7165062	5322730	5270667	2601567	7891250
1948	24752782	8708322	7565111	7843495	3470870	5635585	3769574	2986628	6375210
1949	24110250	12564531	8550471	6125407	3699738	2346530	3831384	2431679	5556781

1950	37065689	11101499	7797841	8042508	4591127	2279032	1586452	2174107	4085691
1951	36276904	19110355	6219324	5599999	6357200	3594032	1535697	938102	3270491
1952	35446174	17652429	10475112	3628209	3345555	3761786	2259304	1031145	2611620
1953	38059962	17021347	9227342	5533521	2489526	2117299	2320202	1325982	2002136
1954	37510660	18856928	8720287	5100583	2936691	1726299	1310586	1381825	1920088
1955	30891343	17957864	10277315	4932223	2523346	1788745	1116039	720935	1536665
1956	23570984	15096493	8488043	5782178	2719762	1442117	1071974	618854	1544954
1957	51917646	10487029	7702533	3541520	3313802	1670874	955458	687492	1276691
1958	22938466	31235982	4544139	4310363	1748719	2251854	930593	564524	1061238
1959	26309258	10744351	18657000	2033013	2179499	1080561	1173964	575286	1290546
1960	10538838	14463934	5019654	10023079	967641	1082968	605748	629125	1185551
1961	45520652	3514499	7453648	2296064	6746909	649234	793150	346518	897058
1962	24633929	24529398	1403697	3050664	1286914	4255222	432889	527229	724529
1963	30575770	12066039	15477017	934564	1124856	622037	2108988	203406	720919
1964	30650234	14562713	6344097	9007103	622675	694642	480582	1452864	538992
1965	15587126	15739568	6060459	3295110	5236047	380429	408130	305108	1328366
1966	16486272	7449964	7483834	2078039	1307145	2314762	160507	177731	825071
1967	21188898	7439948	3453528	3078033	821709	643338	842528	99134	448456
1968	20993542	9908693	3048231	1870041	1118739	284590	241678	258882	159975
1969	10848400	9892269	4141343	642514	292827	343799	77145	63318	89843
1970	21103412	5148329	4038075	1484239	204261	96015	105701	15414	41361
1971	17034465	10393443	2228874	1173850	358074	48887	31117	29295	16521
1972	11792392	8128726	3399822	736734	297710	89275	13210	1009	6135
1973	6294052	5335627	2642154	1132554	284410	116835	45879	7143	4245
1974	9539347	2631324	1569104	718698	256058	96440	39074	10639	5231
1975	2104899	5071235	903216	428831	227834	80470	26577	11305	5793
1976	2795511	680408	1780785	203782	91591	61201	13556	6243	2421
1977	3621459	1210576	247646	589086	44970	24359	18509	4604	2223
1978	4070472	1626171	625905	197500	228693	27140	10898	9836	3391
1979	7047511	1590167	840935	363968	165478	103323	18399	6405	7109
1980	11566323	2813962	743082	457347	210208	149061	49789	15351	7163
1981	24928037	4460415	1560091	306220	202544	131217	112782	48736	19153
1982	41034501	7336759	1879116	1041060	189922	111580	69350	63767	35728
1983	40084297	13045258	3160810	1038886	489460	122839	99974	47684	78354
1984	39623182	11514251	5755747	1738499	660396	273175	78466	65251	77551
1985	47579961	13217369	5238059	3435938	968646	358365	123138	46522	72861
1986	55618674	18807237	5012093	2781030	1456962	418646	169733	52895	62132
1987	52863231	23512550	8350289	2436674	1454196	761575	222647	75458	50802
1988	31674987	19341631	9447339	4338551	1250339	790451	387895	110925	68055
1989	27330996	11551854	6668394	5302220	2542388	678712	398412	190503	90558
1990	23183052	10211213	4254303	3789473	3480600	1537849	367054	216402	164525
1991	25459456	9670364	4149089	2267748	2216909	2118168	878757	206633	196748
1992	44420103	9408331	4519100	1761005	1291160	1319267	1296721	522477	241836
1993	44284070	15014380	3780605	2018471	930602	725284	734285	628620	410452
1994	35701291	13620512	5819242	1445115	875672	400662	338151	328407	467595

1995	40016880	12058284	5885820	2631741	734236	383618	198778	167399	371969
1996	30906172	13706222	5117602	3066304	1083750	346418	158649	96053	254370
1997	24496032	12503543	6059527	3135681	1618968	647727	203987	97281	207223
1998	16361215	10823371	8710036	3108809	1543033	852967	443936	131439	169580
1999	50062725	7740495	5295861	5375810	1700587	774029	413047	231928	144988
2000	33176513	21994943	5374065	2926840	3148927	993963	486783	257008	206512
2001	60879695	13045492	11026715	3709942	1701643	1592968	491148	269135	273397
2002	31220326	28506810	7637035	7963114	1957445	899245	973883	297707	297330
2003	15934416	12963640	16951718	4418071	5124087	1093207	570284	621064	308766
2004	19652154	6012883	5856176	10679820	2979732	3091737	583839	370243	458774
2005	17130130	9025744	3481931	3839695	6312448	1748463	1630118	284959	399047
2006	17548906	6219946	4817062	2446423	2470865	4033791	839994	725159	289414
2007	21655925	6637355	2944034	2792517	1492581	1404484	2066589	433729	462588
2008	19415656	8333694	4245035	2060097	1618190	933621	810160	1343163	569315
2009	29606418	8408081	5070383	2498390	1393658	1062947	640504	618384	1555180
2010	22519101	12038719	5604338	3767296	1916118	1072857	893778	501101	1692660
2011	20577793	9551666	6413126	3563610	2394988	1227841	728541	603828	1423843
2012	20519169	8304078	5485310	4826898	2643370	1659518	797676	479059	1113168
2013	26820020	8479960	4116769	3891545	3294049	1919859	1165066	500454	1011575
2014	40081230	12699934	5293497	3112372	3253618	2276721	1187244	684345	742808
2015	10981007	16806908	9411929	2886859	1903786	2098053	1378014	703295	816343
2016	20217276	4371815	11479460	6933613	1852043	1173592	1137478	694829	729760
2017	12542890	7846171	2289746	7911229	4877909	1246049	570197	533436	602220
2018	22346732	5265727	4069499	1802497	5803891	3382650	793056	396643	712473
2019	19490711	9129430	2185346	2759675	1377346	3460238	1982559	428304	583993
2020	22042468	8005922	5701148	1623724	1949688	1015323	2143333	1054464	520090
2021	15095047	9919587	4638904	2959818	1175829	1323678	719567	1234975	920844
2022	26185557	5437093	6517664	3431453	2195157	813091	894136	459934	1217853
2023	12547517	13050583	3019182	3685130	2396537	1630720	516134	508337	973365
2024	15968534	3593546	7352439	1887829	2230698	1404289	950842	289071	740398

Table 2.6.3.4 North Sea herring multi fleet assessment. Harvest at age fleet A.

Year	0	1	2	3	4	5	6	7	8
1947	0	8.724e-05	0.02938	0.08328	0.1063	0.115	0.1619	0.1919	0.1919
1948	0	8.142e-05	0.02811	0.08195	0.1065	0.1141	0.1463	0.1659	0.1659
1949	0	0.0001923	0.04293	0.1101	0.1367	0.1414	0.1953	0.2173	0.2173
1950	0	0.0003663	0.05711	0.132	0.1593	0.1511	0.18	0.1792	0.1792
1951	0	0.0008829	0.08837	0.1815	0.2155	0.1893	0.2033	0.1836	0.1836

1952	0	0.001382	0.1053	0.1897	0.224	0.2059	0.2469	0.2531	0.2531
1953	0	0.002027	0.1232	0.2045	0.2295	0.2114	0.2454	0.2486	0.2486
1954	0	0.003193	0.1546	0.2416	0.2607	0.246	0.3143	0.3176	0.3176
1955	0	0.003891	0.166	0.2335	0.237	0.2166	0.2305	0.1981	0.1981
1956	0	0.004847	0.1855	0.2396	0.2345	0.2133	0.2191	0.2058	0.2058
1957	0	0.005504	0.1969	0.2495	0.2486	0.238	0.2541	0.2368	0.2368
1958	0	0.005895	0.2047	0.2493	0.2368	0.2153	0.1839	0.154	0.154
1959	0	0.007349	0.2364	0.2837	0.2786	0.252	0.2645	0.257	0.257
1960	0	0.005557	0.198	0.2296	0.2249	0.2047	0.2192	0.2389	0.2389
1961	0	0.005678	0.2071	0.253	0.2547	0.2257	0.2285	0.2149	0.2149
1962	0	0.005542	0.2071	0.2927	0.3119	0.2903	0.3391	0.3176	0.3176
1963	0	0.003667	0.1578	0.2022	0.191	0.1686	0.1278	0.1343	0.1343
1964	0	0.006172	0.2242	0.2981	0.293	0.2618	0.217	0.2094	0.2094
1965	0	0.01184	0.3599	0.5156	0.5244	0.4831	0.4877	0.5053	0.5053
1966	0	0.009368	0.3235	0.4825	0.491	0.4657	0.405	0.5026	0.5026
1967	0	0.01141	0.3837	0.6344	0.6637	0.6468	0.7354	0.9303	0.9303
1968	0	0.02418	0.6508	1.068	0.984	0.8848	1.116	1.211	1.211
1969	0	0.01546	0.4878	0.7844	0.8112	0.7907	1.12	1.054	1.054
1970	0	0.01855	0.5415	0.8694	0.9052	0.8	1.132	0.9112	0.9112
1971	0	0.02415	0.6141	0.9869	1.103	1.107	2.738	1.75	1.75
1972	0	0.01485	0.4303	0.6162	0.595	0.5123	0.521	0.3174	0.3174
1973	0	0.02469	0.5916	0.8787	0.8604	0.8107	1.016	0.7054	0.7054
1974	0	0.0218	0.5444	0.8122	0.8285	0.8454	0.8999	0.8257	0.8257
1975	0	0.03166	0.6809	1.076	1.095	1.137	1.239	1.576	1.576
1976	0	0.02091	0.5074	0.8696	0.8618	0.8447	0.7629	1.086	1.086
1977	0	0.005353	0.1948	0.3493	0.3496	0.3705	0.2543	0.4123	0.4123
1978	0	0.00427	0.1562	0.2577	0.2545	0.2561	0.1444	0.2465	0.2465
1979	0	0.00417	0.1426	0.2183	0.2041	0.1919	0.08819	0.1524	0.1524
1980	0	0.004667	0.1421	0.2032	0.1805	0.153	0.05801	0.09695	0.09695
1981	0	0.006762	0.1659	0.2494	0.2623	0.2565	0.2145	0.3849	0.3849
1982	0	0.005605	0.1393	0.2082	0.2053	0.1715	0.1086	0.1595	0.1595
1983	0	0.007267	0.1597	0.2475	0.2826	0.2602	0.2428	0.3397	0.3397
1984	0	0.009223	0.1845	0.301	0.3778	0.3512	0.3633	0.4848	0.4848
1985	0	0.01398	0.2364	0.3851	0.4865	0.4353	0.4814	0.5681	0.5681
1986	0	0.01381	0.2289	0.3486	0.4445	0.4117	0.4748	0.55	0.55
1987	0	0.01398	0.2245	0.3201	0.4171	0.3908	0.4141	0.4279	0.4279
1988	0	0.01358	0.2162	0.2963	0.4009	0.3879	0.4182	0.4387	0.4387
1989	0	0.01327	0.2173	0.2881	0.3883	0.3704	0.3855	0.3988	0.3988
1990	0	0.01043	0.1913	0.2381	0.3068	0.2892	0.2677	0.2849	0.2849
1991	0	0.01239	0.2263	0.2706	0.3214	0.2857	0.2622	0.2439	0.2439
1992	0	0.01332	0.2493	0.3095	0.372	0.33	0.3459	0.3323	0.3323
1993	0	0.01479	0.2799	0.3751	0.4458	0.3717	0.3952	0.3786	0.3786
1994	0	0.01324	0.2715	0.4038	0.4721	0.3665	0.351	0.3064	0.3064
1995	0	0.009752	0.2205	0.3586	0.4166	0.3592	0.3622	0.3014	0.3014
1996	0	0.003609	0.1121	0.1852	0.2063	0.1904	0.1472	0.1083	0.1083

1997	0	0.002971	0.09842	0.1684	0.1852	0.1763	0.1406	0.1086	0.1086
1998	0	0.004795	0.1289	0.2186	0.2307	0.2306	0.2151	0.1397	0.1397
1999	0	0.004988	0.1205	0.2173	0.2248	0.2229	0.192	0.1186	0.1186
2000	0	0.004911	0.1107	0.2069	0.2298	0.2329	0.1934	0.1271	0.1271
2001	0	0.003358	0.0814	0.1608	0.197	0.2209	0.1939	0.1685	0.1685
2002	0	0.002852	0.06915	0.1393	0.1805	0.2106	0.1956	0.1764	0.1764
2003	0	0.003003	0.06865	0.1459	0.2036	0.2556	0.247	0.2163	0.2163
2004	0	0.002351	0.0595	0.141	0.2194	0.299	0.3641	0.3248	0.3248
2005	0	0.003743	0.07335	0.1646	0.2641	0.3619	0.5219	0.5522	0.5522
2006	0	0.004534	0.07898	0.165	0.2512	0.3286	0.4492	0.5144	0.5144
2007	0	0.004813	0.07584	0.157	0.232	0.2933	0.3958	0.4596	0.4596
2008	0	0.005027	0.07129	0.1135	0.1517	0.1825	0.1829	0.224	0.224
2009	0	0.002901	0.04904	0.06599	0.08381	0.1013	0.07682	0.1038	0.1038
2010	0	0.003066	0.05016	0.07085	0.08296	0.09704	0.07138	0.08311	0.08311
2011	0	0.00357	0.05691	0.09097	0.1095	0.1278	0.1015	0.1086	0.1086
2012	0	0.007291	0.08653	0.1552	0.193	0.2273	0.2429	0.2569	0.2569
2013	0	0.006598	0.07743	0.1546	0.217	0.2753	0.3546	0.3996	0.3996
2014	0	0.005084	0.07077	0.1473	0.215	0.27	0.3288	0.3927	0.3927
2015	0	0.002685	0.05436	0.1215	0.1927	0.2746	0.4074	0.5559	0.5559
2016	0	0.002258	0.05429	0.1391	0.215	0.2996	0.4641	0.6809	0.6809
2017	0	0.001748	0.0468	0.1343	0.2027	0.2549	0.3365	0.4858	0.4858
2018	0	0.002031	0.05268	0.1447	0.2286	0.2945	0.4008	0.5665	0.5665
2019	0	0.001668	0.04756	0.1218	0.182	0.2453	0.3412	0.4938	0.4938
2020	0	0.004479	0.08799	0.1646	0.196	0.2253	0.2937	0.4487	0.4487
2021	0	0.004847	0.09759	0.1682	0.1951	0.2196	0.2298	0.356	0.356
2022	0	0.009569	0.1442	0.2158	0.2428	0.254	0.2747	0.3577	0.3577
2023	0	0.008781	0.1328	0.1997	0.257	0.2803	0.3273	0.4511	0.4511
2024	0	0.008802	0.133	0.1999	0.2573	0.2806	0.3278	0.4517	0.4517

Table 2.6.3.5 North Sea herring multi fleet assessment. Harvest at age combined fleet B-D.

Year	0	1	2	3	4	5	6	7	8
1947	0.0007391	0.0004127	0.003943	0.001442	0.001442	0.001442	0	0	0
1948	0.0007257	0.0003964	0.003671	0.001388	0.001388	0.001388	0	0	0
1949	0.001226	0.001255	0.006279	0.001788	0.001788	0.001788	0	0	0
1950	0.002046	0.003872	0.01026	0.002224	0.002224	0.002224	0	0	0
1951	0.003445	0.01216	0.01732	0.002873	0.002873	0.002873	0	0	0
1952	0.004644	0.02344	0.02219	0.003088	0.003088	0.003088	0	0	0
1953	0.005678	0.03647	0.02605	0.003254	0.003254	0.003254	0	0	0
1954	0.006832	0.05159	0.02998	0.003446	0.003446	0.003446	0	0	0
1955	0.007275	0.06917	0.03363	0.003501	0.003501	0.003501	0	0	0

1956	0.006985	0.07443	0.03462	0.003451	0.003451	0.003451	0	0	0
1957	0.007956	0.08774	0.03717	0.003576	0.003576	0.003576	0	0	0
1958	0.008734	0.08597	0.03692	0.00357	0.00357	0.00357	0	0	0
1959	0.01316	0.09962	0.03965	0.003729	0.003729	0.003729	0	0	0
1960	0.01903	0.1043	0.03971	0.003602	0.003602	0.003602	0	0	0
1961	0.02001	0.08318	0.03613	0.003635	0.003635	0.003635	0	0	0
1962	0.01398	0.06288	0.03109	0.003604	0.003604	0.003604	0	0	0
1963	0.01711	0.07785	0.03319	0.003552	0.003552	0.003552	0	0	0
1964	0.02112	0.121	0.04589	0.004774	0.004774	0.004774	0	0	0
1965	0.02141	0.131	0.05581	0.006441	0.006441	0.006441	0	0	0
1966	0.02795	0.1418	0.06091	0.007503	0.007503	0.007503	0	0	0
1967	0.03527	0.1686	0.07158	0.009357	0.009357	0.009357	0	0	0
1968	0.03914	0.1926	0.08954	0.01198	0.01198	0.01198	0	0	0
1969	0.03142	0.1712	0.08102	0.01135	0.01135	0.01135	0	0	0
1970	0.04577	0.204	0.08836	0.01207	0.01207	0.01207	0	0	0
1971	0.06219	0.2892	0.1	0.01245	0.01245	0.01245	0	0	0
1972	0.08023	0.3199	0.1004	0.01126	0.01126	0.01126	0	0	0
1973	0.09325	0.3276	0.1068	0.01219	0.01219	0.01219	0	0	0
1974	0.1222	0.291	0.1034	0.01243	0.01243	0.01243	0	0	0
1975	0.1625	0.2991	0.107	0.01344	0.01344	0.01344	0	0	0
1976	0.134	0.1613	0.06797	0.009935	0.009935	0.009935	0	0	0
1977	0.1195	0.09281	0.03888	0.005988	0.005988	0.005988	0	0	0
1978	0.1461	0.08561	0.03288	0.004827	0.004827	0.004827	0	0	0
1979	0.1758	0.08021	0.02845	0.003975	0.003975	0.003975	0	0	0
1980	0.2105	0.07374	0.02449	0.003279	0.003279	0.003279	0	0	0
1981	0.3812	0.125	0.03007	0.003602	0.003602	0.003602	0	0	0
1982	0.3844	0.1218	0.02819	0.003458	0.003458	0.003458	0	0	0
1983	0.3782	0.1396	0.03111	0.00399	0.00399	0.00399	0	0	0
1984	0.2599	0.1338	0.03218	0.004622	0.004622	0.004622	0	0	0
1985	0.1865	0.1637	0.03772	0.005468	0.005468	0.005468	0	0	0
1986	0.1545	0.1745	0.03857	0.005424	0.005424	0.005424	0	0	0
1987	0.1828	0.2218	0.0422	0.005452	0.005452	0.005452	0	0	0
1988	0.1785	0.2599	0.04464	0.005354	0.005354	0.005354	0	0	0
1989	0.1615	0.22	0.04137	0.004947	0.004947	0.004947	0	0	0
1990	0.1409	0.187	0.03857	0.004487	0.004487	0.004487	0	0	0
1991	0.1719	0.1676	0.03918	0.004534	0.004534	0.004534	0	0	0
1992	0.2552	0.1898	0.04466	0.005077	0.005077	0.005077	0	0	0
1993	0.2833	0.1827	0.04702	0.00561	0.00561	0.00561	0	0	0
1994	0.2113	0.1182	0.0379	0.005289	0.005289	0.005289	0	0	0
1995	0.181	0.1044	0.0328	0.004789	0.004789	0.004789	0	0	0
1996	0.1004	0.06855	0.02215	0.003446	0.003446	0.003446	0	0	0
1997	0.04529	0.03272	0.01362	0.002619	0.002619	0.002619	0	0	0
1998	0.03785	0.03071	0.01186	0.002446	0.002446	0.002446	0	0	0
1999	0.03973	0.0234	0.0102	0.002419	0.002419	0.002419	0	0	0
2000	0.04448	0.02382	0.009553	0.002134	0.002134	0.002134	0	0	0

2001	0.03332	0.01094	0.006361	0.001679	0.001679	0.001679	0	0	0
2002	0.0419	0.02278	0.0095	0.001621	0.001621	0.001621	0	0	0
2003	0.04712	0.033	0.01011	0.001127	0.001127	0.001127	0	0	0
2004	0.05892	0.04203	0.0117	0.001012	0.001012	0.001012	0	0	0
2005	0.07714	0.05116	0.01103	0.0006395	0.0006395	0.0006395	0	0	0
2006	0.06425	0.02951	0.007943	0.0004987	0.0004987	0.0004987	0	0	0
2007	0.04625	0.01579	0.003703	0.0001487	0.0001487	0.0001487	0	0	0
2008	0.04572	0.01456	0.00245	7.138e-05	7.138e-05	7.138e-05	0	0	0
2009	0.04058	0.01423	0.002402	0.0001036	0.0001036	0.0001036	0	0	0
2010	0.04338	0.01479	0.002974	0.0002647	0.0002647	0.0002647	0	0	0
2011	0.04816	0.01678	0.002496	0.0002311	0.0002311	0.0002311	0	0	0
2012	0.05208	0.02311	0.003728	0.0003552	0.0003552	0.0003552	0	0	0
2013	0.04282	0.01994	0.00377	0.0003378	0.0003378	0.0003378	0	0	0
2014	0.05322	0.02162	0.003598	0.0003083	0.0003083	0.0003083	0	0	0
2015	0.06915	0.023	0.002443	0.0001403	0.0001403	0.0001403	0	0	0
2016	0.08818	0.02688	0.002462	0.0001475	0.0001475	0.0001475	0	0	0
2017	0.0717	0.01718	0.001211	5.583e-05	5.583e-05	5.583e-05	0	0	0
2018	0.06918	0.01154	0.00081	5.89e-05	5.89e-05	5.89e-05	0	0	0
2019	0.05748	0.007903	0.0006929	0.0001014	0.0001014	0.0001014	0	0	0
2020	0.06375	0.006644	0.0009089	0.0002546	0.0002546	0.0002546	0	0	0
2021	0.06242	0.01161	0.001211	0.0003611	0.0003611	0.0003611	0	0	0
2022	0.06141	0.01728	0.001134	0.0002512	0.0002512	0.0002512	0	0	0
2023	0.06404	0.01485	0.0009263	0.0002242	0.0002242	0.0002242	0	0	0
2024	0.06408	0.0149	0.0009278	0.0002244	0.0002244	0.0002244	0	0	0

Table 2.6.3.6 North Sea herring multi fleet assessment. Harvest at age fleet C.

Year	0	1	2	3	4	5	6	7	8
1947	0	0.001438	0.01	0.01316	0.007638	0.007638	0.007638	0	0
1948	0	0.00131	0.009111	0.01204	0.0072	0.0072	0.0072	0	0
1949	0	0.002898	0.01455	0.01729	0.009258	0.009258	0.009258	0	0
1950	0	0.005499	0.01992	0.02081	0.01017	0.01017	0.01017	0	0
1951	0	0.01163	0.03042	0.02872	0.01305	0.01305	0.01305	0	0
1952	0	0.0191	0.03765	0.03106	0.01359	0.01359	0.01359	0	0
1953	0	0.0287	0.04485	0.03391	0.01417	0.01417	0.01417	0	0
1954	0	0.04218	0.05494	0.03946	0.01585	0.01585	0.01585	0	0
1955	0	0.05417	0.06025	0.03866	0.0145	0.0145	0.0145	0	0
1956	0	0.06514	0.06581	0.03882	0.01379	0.01379	0.01379	0	0
1957	0	0.07588	0.07099	0.04116	0.01466	0.01466	0.01466	0	0
1958	0	0.079	0.07219	0.0403	0.01383	0.01383	0.01383	0	0
1959	0	0.09134	0.08085	0.04551	0.01581	0.01581	0.01581	0	0

1960	0	0.08116	0.07116	0.03773	0.01308	0.01308	0.01308	0	0
1961	0	0.08117	0.07324	0.04155	0.01496	0.01496	0.01496	0	0
1962	0	0.07633	0.07093	0.04555	0.01745	0.01745	0.01745	0	0
1963	0	0.0651	0.05766	0.03126	0.01057	0.01057	0.01057	0	0
1964	0	0.09632	0.08154	0.04766	0.01644	0.01644	0.01644	0	0
1965	0	0.1389	0.1213	0.08164	0.02951	0.02951	0.02951	0	0
1966	0	0.1298	0.1154	0.07785	0.02869	0.02869	0.02869	0	0
1967	0	0.1525	0.1368	0.1022	0.03977	0.03977	0.03977	0	0
1968	0	0.2245	0.2074	0.1671	0.06115	0.06115	0.06115	0	0
1969	0	0.1924	0.1728	0.1313	0.0537	0.0537	0.0537	0	0
1970	0	0.2131	0.1838	0.1404	0.05909	0.05909	0.05909	0	0
1971	0	0.2725	0.2112	0.1646	0.0735	0.0735	0.0735	0	0
1972	0	0.2252	0.1612	0.1023	0.03894	0.03894	0.03894	0	0
1973	0	0.2949	0.2081	0.1449	0.0545	0.0545	0.0545	0	0
1974	0	0.2677	0.196	0.139	0.05335	0.05335	0.05335	0	0
1975	0	0.2942	0.2228	0.1781	0.06681	0.06681	0.06681	0	0
1976	0	0.2188	0.1664	0.1383	0.04954	0.04954	0.04954	0	0
1977	0	0.09631	0.07235	0.054	0.01942	0.01942	0.01942	0	0
1978	0	0.08037	0.05705	0.03811	0.01299	0.01299	0.01299	0	0
1979	0	0.07845	0.0522	0.03277	0.01027	0.01027	0.01027	0	0
1980	0	0.07729	0.04861	0.02908	0.008422	0.008422	0.008422	0	0
1981	0	0.1049	0.05854	0.03895	0.01304	0.01304	0.01304	0	0
1982	0	0.09674	0.05037	0.0321	0.01068	0.01068	0.01068	0	0
1983	0	0.1155	0.05751	0.03967	0.01558	0.01558	0.01558	0	0
1984	0	0.1341	0.06517	0.04841	0.02152	0.02152	0.02152	0	0
1985	0	0.177	0.08109	0.06185	0.02832	0.02832	0.02832	0	0
1986	0	0.1785	0.07901	0.05614	0.02642	0.02642	0.02642	0	0
1987	0	0.1898	0.07905	0.05245	0.02529	0.02529	0.02529	0	0
1988	0	0.2012	0.07913	0.04953	0.02433	0.02433	0.02433	0	0
1989	0	0.1938	0.07824	0.04714	0.02287	0.02287	0.02287	0	0
1990	0	0.1645	0.07033	0.03889	0.01773	0.01773	0.01773	0	0
1991	0	0.1664	0.07864	0.04338	0.01833	0.01833	0.01833	0	0
1992	0	0.1754	0.08833	0.05098	0.02115	0.02115	0.02115	0	0
1993	0	0.1799	0.09778	0.06078	0.02447	0.02447	0.02447	0	0
1994	0	0.1516	0.09125	0.0614	0.02469	0.02469	0.02469	0	0
1995	0	0.1195	0.07553	0.05316	0.02234	0.02234	0.02234	0	0
1996	0	0.06534	0.04292	0.02693	0.01184	0.01184	0.01184	0	0
1997	0	0.04752	0.03381	0.02036	0.009944	0.009944	0.009944	0	0
1998	0	0.03954	0.02707	0.01358	0.007557	0.007557	0.007557	0	0
1999	0	0.0383	0.02869	0.01262	0.006882	0.006882	0.006882	0	0
2000	0	0.03693	0.02878	0.01099	0.005756	0.005756	0.005756	0	0
2001	0	0.01842	0.01441	0.002991	0.001008	0.001008	0.001008	0	0
2002	0	0.008219	0.007221	0.0009955	0.0003827	0.0003827	0.0003827	0	0
2003	0	0.01576	0.0158	0.003174	0.001941	0.001941	0.001941	0	0
2004	0	0.01638	0.01914	0.003195	0.002138	0.002138	0.002138	0	0

2005	0	0.02498	0.02672	0.003658	0.001599	0.001599	0.001599	0	0
2006	0	0.01908	0.0188	0.002201	0.0008217	0.0008217	0.0008217	0	0
2007	0	0.01808	0.0166	0.001228	0.0003735	0.0003735	0.0003735	0	0
2008	0	0.01125	0.01052	0.0006441	0.0001828	0.0001828	0.0001828	0	0
2009	0	0.004416	0.004067	0.0002138	8.521e-05	8.521e-05	8.521e-05	0	0
2010	0	0.005344	0.005319	0.0002159	7.039e-05	7.039e-05	7.039e-05	0	0
2011	0	0.007542	0.00947	0.0005803	0.0001728	0.0001728	0.0001728	0	0
2012	0	0.007796	0.01026	0.0007154	0.0002292	0.0002292	0.0002292	0	0
2013	0	0.00828	0.01213	0.0008799	0.0002126	0.0002126	0.0002126	0	0
2014	0	0.006964	0.01167	0.00124	0.0003007	0.0003007	0.0003007	0	0
2015	0	0.007515	0.0136	0.002471	0.0008856	0.0008856	0.0008856	0	0
2016	0	0.003792	0.006596	0.0009639	0.0003188	0.0003188	0.0003188	0	0
2017	0	0.006855	0.01109	0.001606	0.0004752	0.0004752	0.0004752	0	0
2018	0	0.005245	0.008791	0.001221	0.0002953	0.0002953	0.0002953	0	0
2019	0	0.004407	0.007404	0.0009418	0.0001337	0.0001337	0.0001337	0	0
2020	0	0.004707	0.009649	0.002259	0.0005352	0.0005352	0.0005352	0	0
2021	0	0.002444	0.005882	0.001692	0.0007283	0.0007283	0.0007283	0	0
2022	0	0.000249	0.0006727	0.000157	9.692e-05	9.692e-05	9.692e-05	0	0
2023	0	0.0002361	0.0004739	0.0001297	7.13e-05	7.13e-05	7.13e-05	0	0
2024	0	0.0002361	0.0004739	0.0001297	7.13e-05	7.13e-05	7.13e-05	0	0

Table 2.6.3.7 North Sea herring multi fleet assessment. Assessment summary.

Year	Rec	Rec_lo	Rec_hi	TSB	TSB_lo	TSB_hi	SSB	SSB_lo	SSB_hi	Catch	Catch_lo	Catch_hi	Fbar	Fbar_lo	Fbar_hi	Landings
1947	18514003	9934673	34502224	8807458	6058408	12803911	5920924	3819052	9179592	945594	829333	1078152	0.11	0.07241	0.1672	956473
1948	24752782	14179833	43209270	7292111	5088496	10450020	4896868	3205922	7479692	738483	654158	833678	0.1055	0.0715	0.1557	756926
1949	24110250	14022228	41455903	6564029	4743246	9083752	4101247	2750085	6116258	789669	698356	892921	0.1395	0.09698	0.2008	800920
1950	37065689	22154285	62013525	6216687	4664243	8285844	3757282	2639950	5347515	688744	618508	766956	0.1535	0.1105	0.2134	673478
1951	36276904	21872397	60167789	6233056	4821454	8057940	3384031	2447640	4678657	814608	733107	905171	0.2004	0.1483	0.271	807521
1952	35446174	21535809	58341491	6050828	4740713	7722999	3257253	2394754	4430391	854487	773084	944462	0.2225			

														0.1656	0.299	807213
1953	38059962	23824127	60802256	5772615	4560953	7306168	3028236	2240742	4092490	828497	748454	917101	0.2342	0.1754	0.3128	762456
1954	37510660	23630745	59543176	5589178	4444043	7029389	2749067	2026604	3729080	927494	832587	1033220	0.2799	0.2087	0.3753	847894
1955	30891343	19604345	48676714	5322373	4244164	6674497	2710045	2022888	3630621	829972	733245	939460	0.254	0.1907	0.3384	716313
1956	23570984	14961110	37135699	4939860	3958770	6164092	2606773	1954659	3476445	814898	721889	919891	0.2566	0.194	0.3394	718241
1957	51917646	32785757	82213807	4750318	3831493	5889485	2318639	1741280	3087432	762444	679748	855201	0.2782	0.2107	0.3673	670508
1958	22938466	14642601	35934409	4781405	3848425	5940568	1972985	1486000	2619562	815369	673865	986588	0.2583	0.1978	0.3373	632687
1959	26309258	16376210	42267231	5383554	4374222	6625785	2869045	2188313	3761536	1054429	912813	1218014	0.3079	0.2365	0.4009	931407
1960	10538838	6606919	16810725	4520627	3673305	5563400	2465123	1883341	3226622	783766	681126	901874	0.255	0.1971	0.33	672869
1961	45520652	28634803	72364032	4589453	3773690	5581559	2500841	1943964	3217244	697329	618755	785882	0.2751	0.2161	0.3503	683292
1962	24633929	15817163	38365316	4189010	3451706	5083807	1705600	1305313	2228639	748252	638262	877198	0.3304	0.2596	0.4204	626843
1963	30575770	19891482	4.7e+07	4901022	4062067	5913249	2666842	2111629	3368039	606041	514032	714519	0.2023	0.1626	0.2518	502852
1964	30650234	19991906	46990861	4894629	4199897	5704280	2424431	1983748	2963010	874749	755627	1012650	0.3066	0.2542	0.3698	746906
1965	15587126	10170365	23888869	4446526	3903926	5064541	1917206	1598911	2298864	1278212	1119293	1459695	0.5475	0.462	0.6488	1130909
1966	16486272	10844699	25062674	3366540	2965254	3822132	1571616	1321544	1869009	902919	799684	1019481	0.5061	0.4304	0.5952	814320
1967	21188898	13929385	32231817	2538953	2259378	2853123	928109	790054	1090287	803011	711339	906497	0.7044	0.6086	0.8152	687372
1968	20993542	13772363	3.2e+07	2143903	1884668	2438797	521464	441380	616079	847882	725867	990408	1.077	0.9465	1.226	739398
1969	10848400	7044080	16707332	1634840	1403974	1903668	455012	371213	557728	571430	469321	695755	0.9149	0.798	1.049	418690
1970	21103412	13832177	32196956	1592483	1374865	1844548	447749	364101	550613	524053	445948	615838	0.9749	0.8549	1.112	439985
1971	17034465	11273656	25739030	1454210	1233007	1715098	265927	217346	325366	602049	471036	769501	1.457	1.283	1.654	424716
1972	11792392	7797987	17832873	1341625	1145616	1571170	332787	271400	408058	477410	374624	608397	0.6379	0.55	0.7398	348147
1973	6294052	4155615	9532908	1089965	949912	1250668	276664	228535	334927	468848	384932	571058	0.9634	0.8437	1.1	362259
1974	9539347	6226873	14613939	747992	650291	860371	189460	157712	227600	267991	226050	317714	0.9132	0.7975	1.046	216518

1975	2104899	1364551	3246930	587862	495062	698058	103449	85078	125786	295991	229400	381913	1.195	1.032	1.385	221911
1976	2795511	1762832	4433142	431487	359618	517720	142126	107723	187517	145147	122965	171331	0.8795	0.6944	1.114	136564
1977	3621459	2196933	5969669	286410	228414	359131	102481	74551	140875	50561	42052	60792	0.352	0.2604	0.4758	45053
1978	4070472	2409027	6877774	340797	262654	442190	121296	88627	166009	47312	30403	73626	0.2501	0.1613	0.3876	.
1979	7047511	4353060	11409769	454399	358741	575563	169173	128382	222925	52072	33814	80187	0.2002	0.1292	0.3103	.
1980	11566323	7642035	17505784	617929	503421	758482	199551	157976	252069	63499	50929	79172	0.1748	0.1381	0.2213	65735
1981	24928037	16467603	37735124	1024127	829180	1264907	257587	204289	324790	127255	100932	160444	0.2652	0.2111	0.3332	233440
1982	41034501	27294811	61690490	1586506	1282537	1962518	384313	307906	479681	172047	132223	223866	0.1972	0.1591	0.2445	293709
1983	40084297	26911964	59703961	2142305	1768651	2594901	538306	435555	665297	331365	252049	435640	0.276	0.2263	0.3365	408217
1984	39623182	26765353	58657793	2822633	2378713	3349398	862078	698751	1063579	455345	371880	557541	0.3604	0.2985	0.435	418614
1985	47579961	31982891	70783243	3243392	2761058	3809984	941211	769608	1151077	686100	566140	831478	0.4613	0.383	0.5557	593451
1986	55618674	37316116	82898147	3615880	3057881	4275702	956533	786336	1163568	786579	628365	984627	0.4356	0.3609	0.5257	604115
1987	52863231	35590372	78519022	3663490	3125282	4294384	1152037	947762	1400339	1038166	818693	1316475	0.4065	0.3384	0.4883	827335
1988	31674987	21360366	46970394	3657854	3156628	4238667	1459549	1206869	1765133	1089590	877198	1353408	0.3964	0.3324	0.4726	858463
1989	27330996	18406657	40582237	3285467	2898682	3723863	1541153	1313287	1808554	897335	764800	1052837	0.3799	0.3229	0.447	756848
1990	23183052	15539205	34586964	3335002	2939497	3783722	1685522	1439408	1973717	725900	623587	845001	0.3015	0.2551	0.3563	612584
1991	25459456	17160373	37772135	3179698	2805922	3603266	1522096	1304174	1776432	676483	583970	783652	0.3192	0.2704	0.3768	582730
1992	44420103	31150905	63341517	3144954	2768157	3573040	1173446	1001761	1374556	691338	594927	803374	0.3739	0.3165	0.4417	709584
1993	44284070	30935171	63393179	2903604	2524200	3340035	845353	714315	1e+06	764399	628449	929760	0.4327	0.3649	0.513	718366
1994	35701291	24870996	51247735	2713326	2338886	3147710	898732	758761	1064523	636031	525853	769294	0.4291	0.3617	0.509	535636
1995	40016880	27689495	57832428	2645730	2276926	3074271	927553	778594	1105011	558874	472590	660911	0.392	0.3278	0.4687	548069
1996	30906172	21486130	44456189	2683415	2288802	3146063	1074813	904235	1277568	334348	279185	400410	0.1958	0.1627	0.2356	285856
1997	24496032	16915993	35472679	2723707	2343709	3165316	1235433	1044127	1461791	300335	260730	345957	0.1749			

														0.1457	0.21	248023
1998	16361215	11520238	23236443	3011518	2609434	3475558	1409407	1199688	1655787	381812	339547	429339	0.2213	0.1848	0.265	385577
1999	50062725	35257692	71084530	3071230	2675044	3526093	1494061	1271268	1755899	374890	335044	419476	0.2114	0.1771	0.2523	370877
2000	33176513	23470870	46895619	3687873	3175826	4282479	1529995	1302944	1796611	432176	379811	491761	0.2094	0.1751	0.2503	382794
2001	60879695	42533972	87138282	4007057	3459809	4640865	1914965	1630854	2248572	355332	317931	397133	0.1772	0.1478	0.2124	358657
2002	31220326	22037171	44230211	4906368	4216154	5709575	2346757	1998850	2755218	398114	354600	446969	0.1638	0.1367	0.1962	371955
2003	15934416	11279700	22509961	5235550	4524948	6057746	2368471	2028587	2765301	533489	479227	593894	0.1918	0.1607	0.2289	480107
2004	19652154	13925872	27733068	4513853	3946299	5163033	2338952	2008918	2723205	566402	510435	628506	0.2253	0.1881	0.2698	570865
2005	17130130	12187401	24077435	3748131	3299715	4257486	2083193	1780471	2437385	772999	684786	872576	0.2868	0.2403	0.3423	666404
2006	17548906	12439032	24757883	3165046	2785955	3595720	1708538	1462119	1996488	581989	522747	647945	0.2612	0.2186	0.3121	524366
2007	21655925	15239649	30773615	2539107	2227910	2893773	1299180	1109001	1521972	397748	359004	440674	0.2354	0.1962	0.2824	408528
2008	19415656	13626744	27663811	2627829	2279151	3029850	1404057	1198898	1644324	257400	232713	284707	0.1432	0.1194	0.1719	259031
2009	29606418	20841518	42057396	3063482	2641615	3552722	1749003	1489336	2053944	181064	162712	201486	0.07684	0.06377	0.09259	172685
2010	22519101	15919400	31854838	3730623	3221444	4320282	1900647	1616855	2234251	186746	168581	206867	0.07638	0.0635	0.09188	187508
2011	20577793	14583717	29035505	3678007	3204166	4221922	2232658	1921542	2594147	238635	215792	263896	0.1001	0.08384	0.1195	224148
2012	20519169	14521046	28994901	3628393	3184168	4134592	2259917	1946253	2624132	456109	412851	503898	0.1843	0.1546	0.2196	437236
2013	26820020	18874602	38110125	3514899	3098824	3986839	2043242	1761842	2369587	494815	448072	546435	0.2195	0.1842	0.2615	511733
2014	40081230	27992423	57390708	3781867	3322082	4305287	2077680	1789993	2411604	534568	484969	589239	0.21	0.1761	0.2505	517593
2015	10981007	7708321	15643161	3947558	3434420	4537363	1943748	1670741	2261365	512214	463512	566034	0.2144	0.1791	0.2568	494072
2016	20217276	14349777	28483944	3975758	3452151	4578783	2246433	1918464	2630470	555084	502160	613585	0.2367	0.1973	0.2839	564880
2017	12542890	8835839	17805224	3393089	2957285	3893115	2037998	1734936	2394000	465361	416525	519922	0.1981	0.1656	0.2371	499145
2018	22346732	15812707	31580705	3258298	2853464	3720568	1835553	1559250	2160817	555328	494264	623936	0.2266	0.1895	0.2711	604449
2019	19490711	13739462	27649395	2737309	2402213	3119150	1546571	1320003	1812028	425688	380625	476085	0.1895	0.1578	0.2276	451542

2020	22042468	15527437	31291086	2728896	2389978	3115875	1521327	1300854	1779167	419939	377922	466627	0.1965	0.1644	0.2351	434000
2021	15095047	10570227	21556817	2676960	2337473	3065753	1461389	1249136	1709707	361511	324455	402799	0.1845	0.1544	0.2204	373167
2022	26185557	17595107	38970118	2973507	2591734	3411518	1634048	1392524	1917463	446628	402159	496013	0.2269	0.1894	0.2718	462596
2023	12547517	7574555	20785403	2883305	2448895	3394775	1473474	1220693	1778600	418132	376710	464109	0.2399	0.1942	0.2965	421599
2024	15968534	8148601	31292989	2621410	1998387	3438668	1461138	1076207	1983747	396210	221328	709273	0.2402	0.1213	0.4758	.

Table 2.6.3.8 North Sea herring multi fleet assessment. SAM model control object.

```
An object of class "FLSAM.control"
Slot "name":
[1] "North Sea herring multifleet"

Slot "desc":
[1] "Imported from a VPA file. ( ./bootstrap/data/index.txt ).  Sat Mar 16 16:26:25 2024"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2024         2         6

Slot "fleets":
 catch A catch BD  catch C    HERAS  IBTS-Q1    IBTS0  IBTS-Q3 LAI-ORSH
       0        0        0        2        2        2        2        6
 LAI-BUN  LAI-CNS  LAI-SNS
       6        6        6

Slot "plus.group":
 [1] 1 1 1 1 0 0 0 1 1 1 1

Slot "states":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1  0  1  2  3  4  5  6  6
  catch BD  7  8  9 10 10 10 -1 -1 -1
  catch C  -1 11 12 13 14 14 14 -1 -1
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "logN.vars":
0 1 2 3 4 5 6 7 8
0 1 1 1 1 1 1 1 1

Slot "logP.vars":
[1] 0 1 2

Slot "catchabilities":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch BD -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch C  -1 -1 -1 -1 -1 -1 -1 -1 -1
  HERAS    -1  1  1  2  2  2  2  2  2
  IBTS-Q1  -1  3 -1 -1 -1 -1 -1 -1 -1
  IBTS0     0 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3   4  5  6  7  8  9 -1 -1 -1
  LAI-ORSH 10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  10 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  10 -1 -1 -1 -1 -1 -1 -1 -1

Slot "power.law.exps":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch BD -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch C  -1 -1 -1 -1 -1 -1 -1 -1 -1
```

```
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "f.vars":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1  0  1  1  1  1  2  2  2
  catch BD  3  4  4  4  4  4 -1 -1 -1
  catch C  -1  5  6  7  7  7  7 -1 -1
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "obs.vars":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1  0  1  1  1  1  1  2  2
  catch BD  3  4  5  5  5  5 -1 -1 -1
  catch C  -1  6  7  8  8  8  8 -1 -1
  HERAS    -1  9 10 11 12 12 12 13 13
  IBTS-Q1  -1 14 -1 -1 -1 -1 -1 -1 -1
  IBTS0    15 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  16 16 17 17 17 17 -1 -1 -1
  LAI-ORSH 18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  18 -1 -1 -1 -1 -1 -1 -1 -1

Slot "srr":
[1] 0

Slot "scaleNoYears":
[1] 0

Slot "scaleYears":
[1] NA

Slot "scalePars":
      age
years  0 1 2 3 4 5 6 7 8

Slot "cor.F":
[1] 2 2 2

Slot "cor.obs":
          age
fleet      0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
  catch A   NA  NA  NA  NA  NA  NA  NA  NA
  catch BD  NA  NA  NA  NA  NA  NA  NA  NA
  catch C   NA  NA  NA  NA  NA  NA  NA  NA
  HERAS     -1  NA  NA  NA  NA  NA  NA  NA
  IBTS-Q1   -1  -1  -1  -1  -1  -1  -1  -1
  IBTS0     -1  -1  -1  -1  -1  -1  -1  -1
  IBTS-Q3    0   0   0   0   0  -1  -1  -1
  LAI-ORSH  -1  -1  -1  -1  -1  -1  -1  -1
  LAI-BUN   -1  -1  -1  -1  -1  -1  -1  -1
```

```
  LAI-CNS   -1  -1  -1  -1  -1  -1  -1  -1
  LAI-SNS   -1  -1  -1  -1  -1  -1  -1  -1

Slot "cor.obs.Flag":
 [1] ID ID ID ID ID ID AR ID ID ID ID
Levels: ID AR US

Slot "biomassTreat":
 [1] -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "timeout":
[1] 3600

Slot "likFlag":
 [1] LN LN LN LN LN LN LN LN LN LN LN
Levels: LN ALN

Slot "fixVarToWeight":
 [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE

Slot "fracMixF":
[1] 0

Slot "fracMixN":
[1] 0 0 0 0 0 0 0 0 0

Slot "fracMixObs":
 catch A catch BD  catch C    HERAS  IBTS-Q1    IBTS0  IBTS-Q3 LAI-ORSH
       0        0        0        0        0        0        0        0
 LAI-BUN  LAI-CNS  LAI-SNS
       0        0        0

Slot "constRecBreaks":
numeric(0)

Slot "predVarObsLink":
          age
fleet       0  1  2  3  4  5  6  7  8
  catch A  -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch BD -1 -1 -1 -1 -1 -1 -1 -1 -1
  catch C  -1 -1 -1 -1 -1 -1 -1 -1 -1
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "stockWeightModel":
[1] FALSE

Slot "stockWeightMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "stockWeightObsVar":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA

Slot "catchWeightModel":
[1] FALSE

Slot "catchWeightMean":
 0  1  2  3  4  5  6  7  8
NA NA NA NA NA NA NA NA NA
```

```
Slot "catchWeightObsVar":
 0  1  2  3  4  5  6  7  8 
NA NA NA NA NA NA NA NA NA 

Slot "maturityModel":
[1] FALSE

Slot "maturityMean":
 0  1  2  3  4  5  6  7  8 
NA NA NA NA NA NA NA NA NA 

Slot "mortalityModel":
[1] FALSE

Slot "mortalityMean":
 0  1  2  3  4  5  6  7  8 
NA NA NA NA NA NA NA NA NA 

Slot "mortalityObsVar":
 0  1  2  3  4  5  6  7  8 
NA NA NA NA NA NA NA NA NA 

Slot "XtraSd":
     [,1] [,2] [,3] [,4]

Slot "logNMeanAssumption":
[1] 0 0

Slot "initState":
[1] 0

Slot "simulate":
[1] FALSE

Slot "residuals":
[1] TRUE

Slot "sumFleets":
logical(0)
```

Table 2.7.1. North Sea herring. Intermediate year (2024) assumptions for the stock.

Variable	Value	Notes
Fages (wr) 2–6 (2024)	0.332	Based on estimated catch 2023
SSB (2024)	1 386 241	Calculated based on catch constraint (in tonnes)
Rage (wr) 0 (2024)	15 849 920	Estimated by assessment model (in thousands)
Rage (wr) 0 (2025)	19 447 271	Weighted mean over 2012–2022 (in thousands)
Total catch (2024)	544 980	Estimated realized catch of autumn spawning herring derived from agreed TACs for A-D fleets, the proportion of NSAS herring in the catch (for A, C and D fleets), the transfer of TAC to the North Sea (C fleet) and the uptake of the by-catch quota (for B and D fleets).

Table 2.7.2. North Sea herring. Intermediate year (2024), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	510 323	
	B-fleet TAC	7716	
	C-fleet TAC	29 735	Total TAC in IIIa (including WBSS and NSAS)
	D-fleet TAC	6 659	Total TAC in IIIa (including WBSS and NSAS)
TACs to catches variables	C-fleet transfer FcY	0.979	Taken from ImY as % of C-fleet TAC
	C-fleet transfer ImY	29 123	Value for the Intermediate year in tonnes
	D-fleet transfer ImY	6101	Value for the Intermediate year in tonnes
	D-fleet transfer FcY	0.916	Taken from ImY as % of D-fleet TAC
	WBSS/NSAS split in the North Sea	0.009	Value from terminal year
	B-fleet uptake	0.70	Average over the last 3 years (2021-2023)
	C-fleet NSAS/WBSS split	0.56	Average over the last 3 years (2021-2023)
	D-fleet NSAS/WBSS split	0.78	Average over the last 3 years (2021-2023)
F by fleet and total	$F_{(wr)\ 2–6}$ A-fleet	0.332	
	$F_{(wr)\ 0–1}$ B-fleet	0.06	
	$F_{(wr)\ 1–3}$ C-fleet	0	
	$F_{(wr)\ 0–1}$ D-fleet	0.003	
	$F_{(wr)\ 2–6}$	0.332	
	$F_{(wr)\ 0–1}$	0.069	
NSAS catches by fleet	Catches A-fleet	534 546	Fleet TAC (510 323 t*) + C-fleet TAC transfer to the North Sea (29 124 t^), scaled by the 3-year average proportion of NSAS in A-fleet catch (99.1%, 2021–2023).
	Catches B-fleet	9 654	Fleet TAC (7 716 t*) + D-fleet TAC transfer to the North Sea (6 101 t^^), scaled with the fleet uptake in 2023 (69.9%).
	Catches C-fleet	342	Fleet catches in 3.a of 611 t (200 t agreed maximum Norwegian catch** and 42.5% (proportion of C-fleet EU catches in the total EU catches in 3.a in 2023) of 969 t agreed maximum EU catch*), scaled by the 3-year average proportion of NSAS in the C-fleet catch (56%, 2021–2023).

Field	Value	Note
Catches D-fleet	438	Fleet catches based on 57.5% (proportion of D-fleet catches in the total EU catches in 3.a in 2023) of 969 t agreed maximum EU catch*, scaled by the 3-year average proportion of NSAS in the D-fleet catch (78.5%, 2021–2023).

^ Estimated as the TAC of the C-fleet in 3.a (29 735 t*) reduced by the maximum EU and Norwegian agreed catches of the C-fleet in 3.a (42.5% of 969 t*+200 t**).

^^ Estimated as the TAC of the D-fleet in 3.a (6 659 t*) reduced by the maximum EU agreed catches of the D-fleet in 3.a (57.5% of 969 t*)

* Council Regulation (EU) 2024/257 (EU, 2024).

** Norwegian regulation (Norway, 2024).

Table 2.7.3. North Sea herring. reference points.

wg	fmsy	Fsq	Flim	Fpa	Blim	Bpa	msyBtrigger
HAWG2024	0.32	.	0.39	0.33	828874	903707	1131601
IBPNSherring2021	0.31	.	0.4	0.31	874198	956483	1232828
WKPELA2018	0.26	.	0.34	0.3	8e+05	9e+05	1400000

Table 2.7.4. North Sea herring. All scenarios following WBSS TAC advice.

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
intermediate year	0.3317	0.05972	0.0003636	0.002707	0.3324	0.06867	534546	9654	342.3	437.5	1386241	.
fmsyAR	0.3127	0.05939	1.813e-09	4.915e-07	0.3131	0.06513	400909	12084	0.001151	0.1	1106359	923412
fmsyAR_Btarget	0.3127	0.04426	1.812e-09	1.319e-08	0.3131	0.05	401028	9082	0.001151	0.002706	1106363	924716
fmsyAR_TACrule_transfer	0.3125	0.05258	0.0004033	3.217e-08	0.3131	0.05849	400674	10739	256.1	0.006571	1106409	923928
fmsyAR_TACrule_notransfer	0.3014	0.0542	0.02014	3.852e-07	0.3136	0.06823	387362	11040	12726	0.07846	1108215	919605
fmsyAR_notransfer	0.3126	0.05629	8.819e-08	1.328e-08	0.3131	0.06203	400909	11474	0.056	0.002706	1106378	923708
fmsyAR_Btarget_notransfer	0.3127	0.04426	8.814e-08	1.319e-08	0.3131	0.05	401027	9082	0.056	0.002706	1106363	924716
fmsy	0.3195	0.05753	8.836e-08	1.329e-08	0.32	0.0634	408288	11717	0.056	0.002706	1100994	914385
nf	0	0	0	0	0	0	0	0	0	0	1384953	1506455
tacro	0.4203	0.07568	9.091e-08	1.344e-08	0.4209	0.0834	510323	15240	0.056	0.002706	1025464	790563
-15%	0.3437	0.06189	8.897e-08	1.332e-08	0.3442	0.0682	433775	12570	0.056	0.002706	1082320	882567
+15%	0.5037	0.09069	9.303e-08	1.356e-08	0.5044	0.09993	586871	18092	0.056	0.002706	967392	703863
fsq	0.3319	0.05976	8.867e-08	1.331e-08	0.3324	0.06585	421401	12154	0.056	0.002706	1091402	897940
fpa	0.3295	0.05933	8.861e-08	1.33e-08	0.33	0.06538	418892	12070	0.056	0.002706	1093240	901075
flim	0.3894	0.07012	9.013e-08	1.339e-08	0.39	0.07727	480196	14168	0.056	0.002706	1047981	826137
bpa	0.3873	0.06974	9.007e-08	1.339e-08	0.3879	0.07685	478127	14096	0.056	0.002706	1049521	828610
blim	0.7274	0.131	9.873e-08	1.39e-08	0.7284	0.1443	762724	25491	0.056	0.002706	828874	524474
MSYBtrigger	0.2819	0.05076	8.741e-08	1.323e-08	0.2823	0.05594	367331	10383	0.056	0.002706	1130747	966766

Table 2.7.5. North Sea herring. Final scenario table.

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	total_catch	SSB1	SSB2	SSB_change	TAC_change

advice_change

fmsyAR_notransfer	0.313	0.056	0	0	0.313	0.062	400909	11474	0	0	412383	1106378	923708	-20.2	-21.4	-22.5
fmsy	0.32	0.058	0	0	0.32	0.063	408288	11717	0	0	420005	1100994	914385	-20.6	-20	-21.1
nf	0	0	0	0	0	0	0	0	0	0	0	1384953	1506455	-0.1	-100	-100
tacro	0.423	0.076	0.027	0.001	0.44	0.096	510323	15282	16651	180	542436	1014685	764140	-26.8	0	1.9
fsq	0.332	0.06	0	0	0.332	0.066	421401	12154	0	0	433555	1091402	897940	-21.3	-17.4	-18.5
fpa	0.33	0.059	0	0	0.33	0.065	418892	12070	0	0	430962	1093240	901075	-21.1	-17.9	-19
flim	0.389	0.07	0	0	0.39	0.077	480196	14168	0	0	494364	1047981	826137	-24.4	-5.9	-7.1
bpa	0.387	0.07	0	0	0.388	0.077	478127	14096	0	0	492223	1049521	828610	-24.3	-6.3	-7.5
blim	0.727	0.131	0	0	0.728	0.144	762724	25491	0	0	788215	828874	524474	-40.2	49.5	48.1
MSYBtrigger	0.282	0.051	0	0	0.282	0.056	367331	10383	0	0	377714	1130747	966766	-18.4	-28	-29
fmsyAR_Btarget_notransfer	0.313	0.044	0	0	0.313	0.05	401027	9082	0	0	410109	1106363	924716	-20.2	-21.4	-22.9
fmsyAR_TACrule_transfer	0.312	0.084	0	0.002	0.313	0.092	400344	16830	256	438	417868	1106451	921141	-20.2	-21.6	-21.5
fmsyAR_TACrule_notransfer	0.301	0.055	0.02	0.026	0.314	0.095	387092	11031	12717	5225	416065	1108250	917457	-20.1	-24.1	-21.8

Table 2.9.1. North Sea herring. Old and new reference points following HAWG 2024.

metric	IBP2021	HAWG2024	deviation
Flim	0.4	0.39	-2.5
Fpa	0.31	0.33	6.5
Fmsy	0.31	0.32	3.2
Blim	874198	828874	-5.2
Bpa	956483	1049521	-5.5
MSYBtrigger	1232828	1130747	-8.2

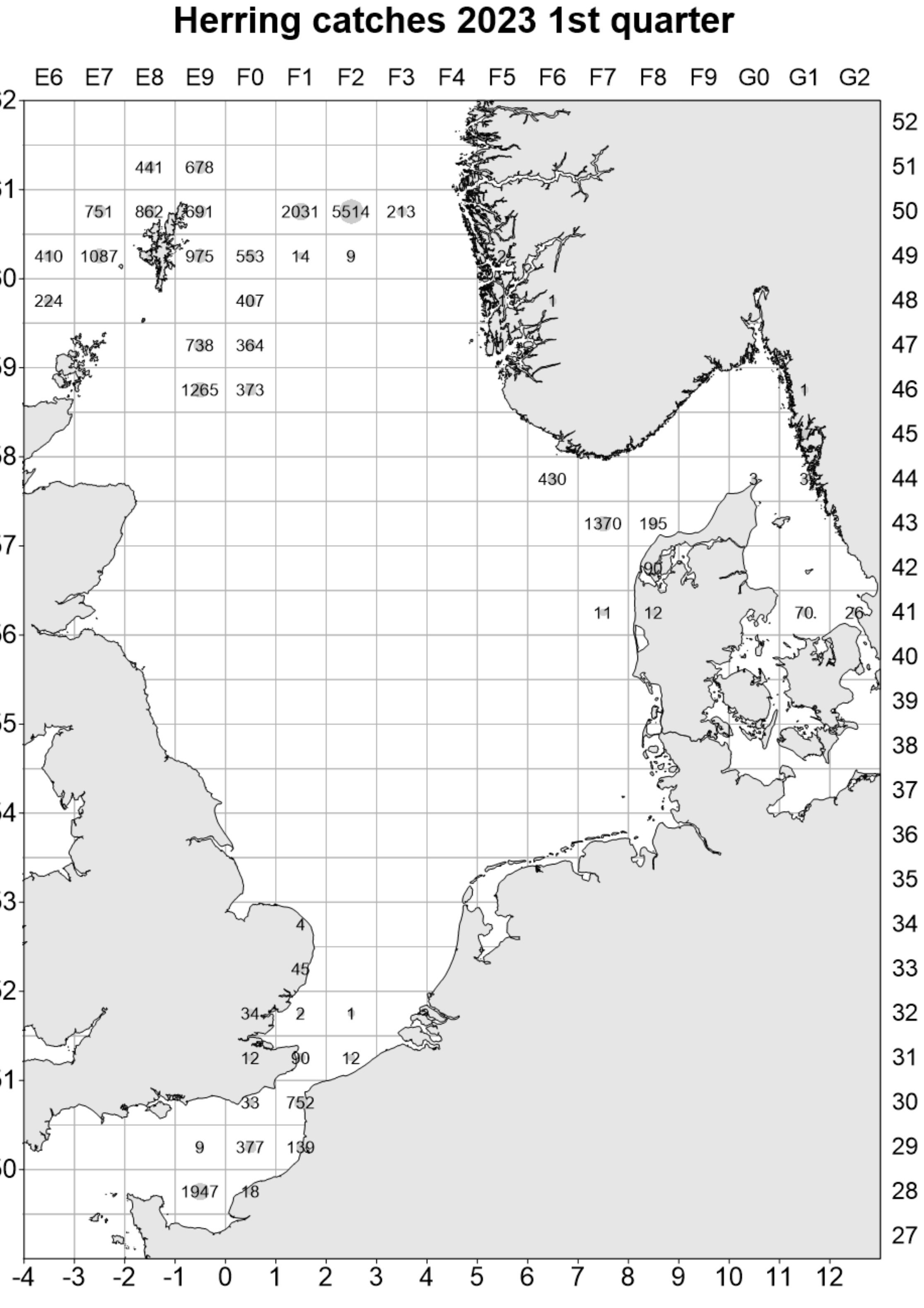


Figure 2.1.1a. Herring catches in the North Sea in the 1st quarter of 2023 (in tonnes) by statistical rectangle.

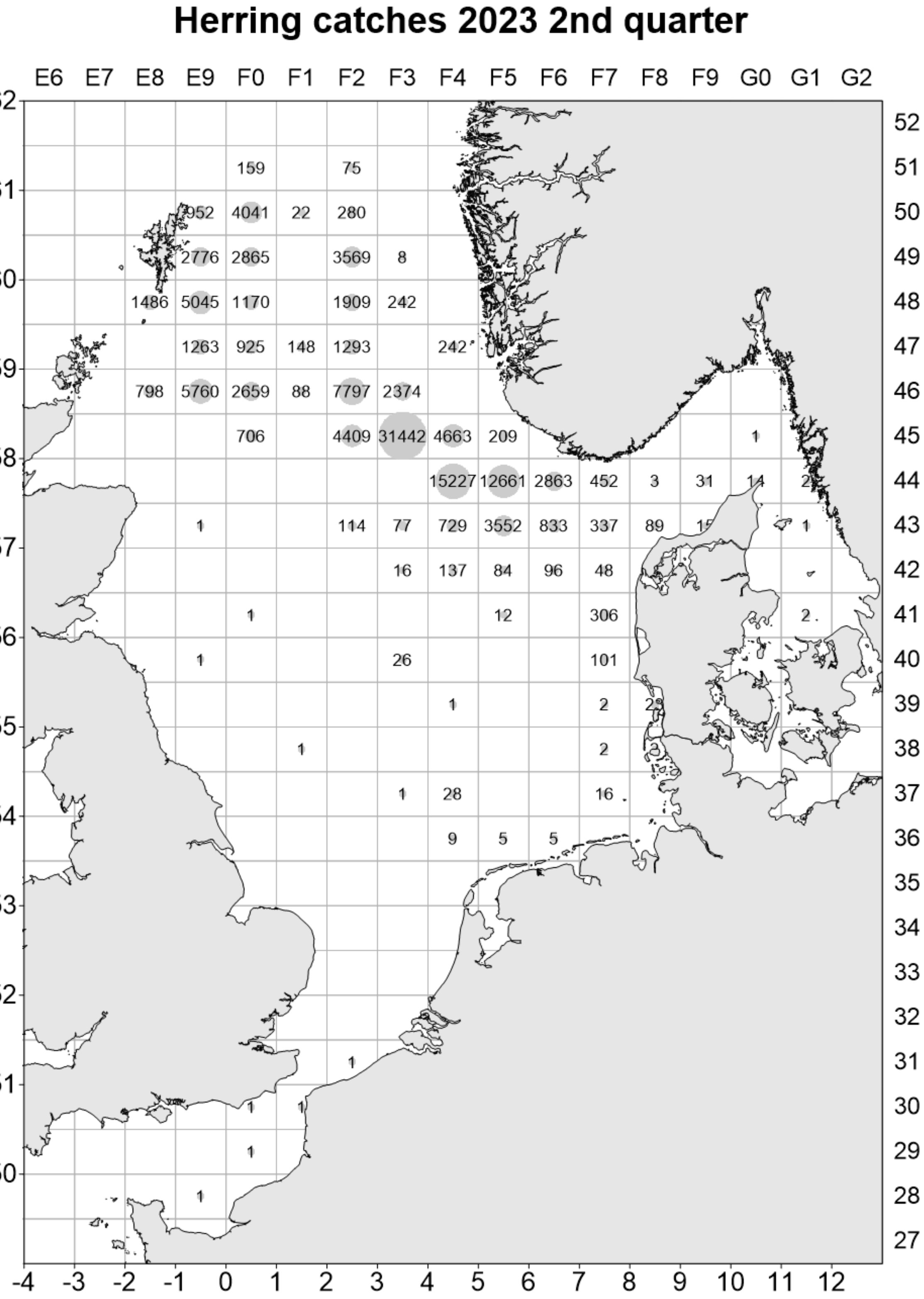


Figure 2.1.1b. Herring catches in the North Sea in the second quarter of 2023 (in tonnes) by statistical rectangle.

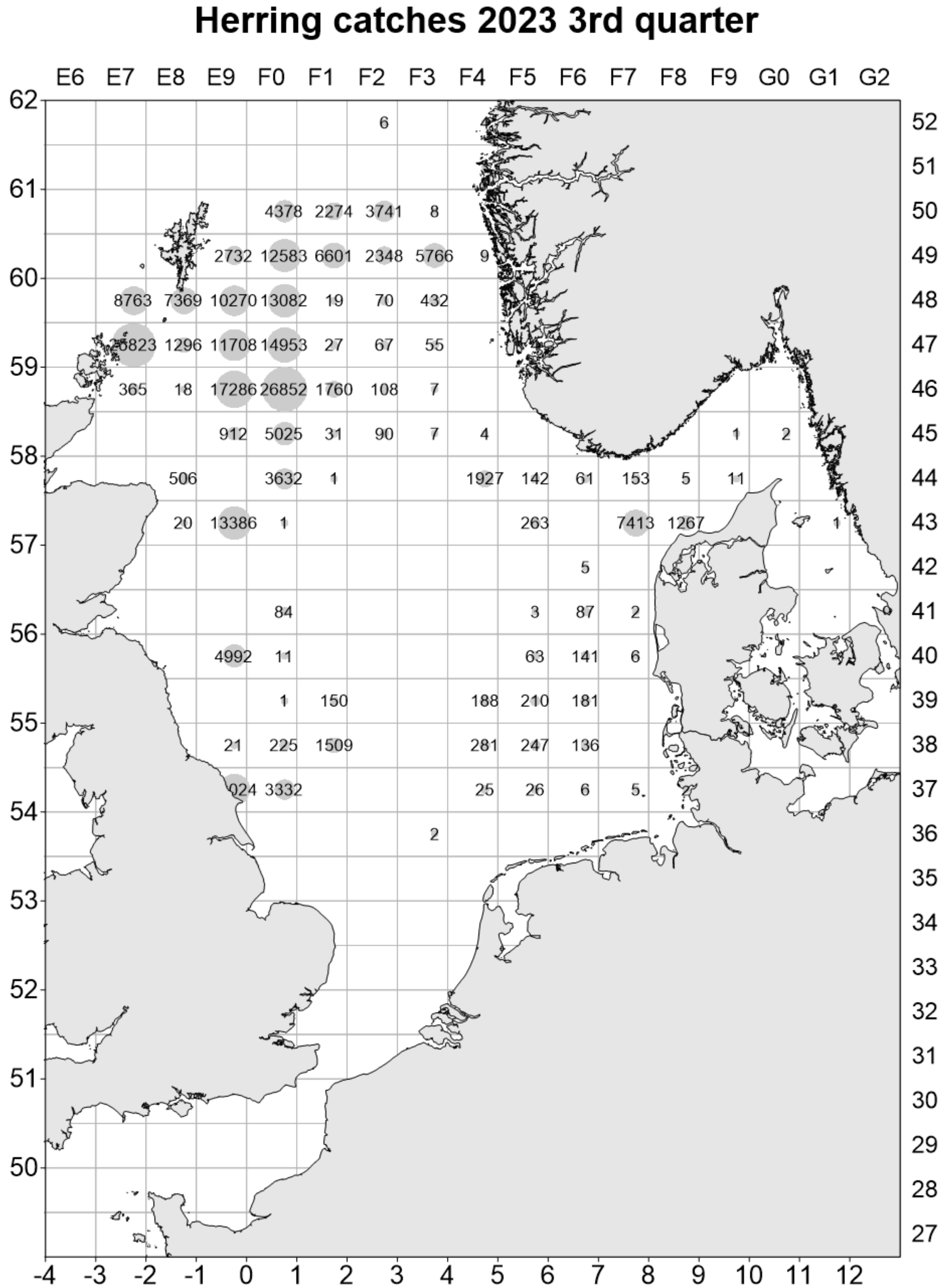


Figure 2.1.1c. Herring catches in the North Sea in the 3rd quarter of 2023 (in tonnes) by statistical rectangle.

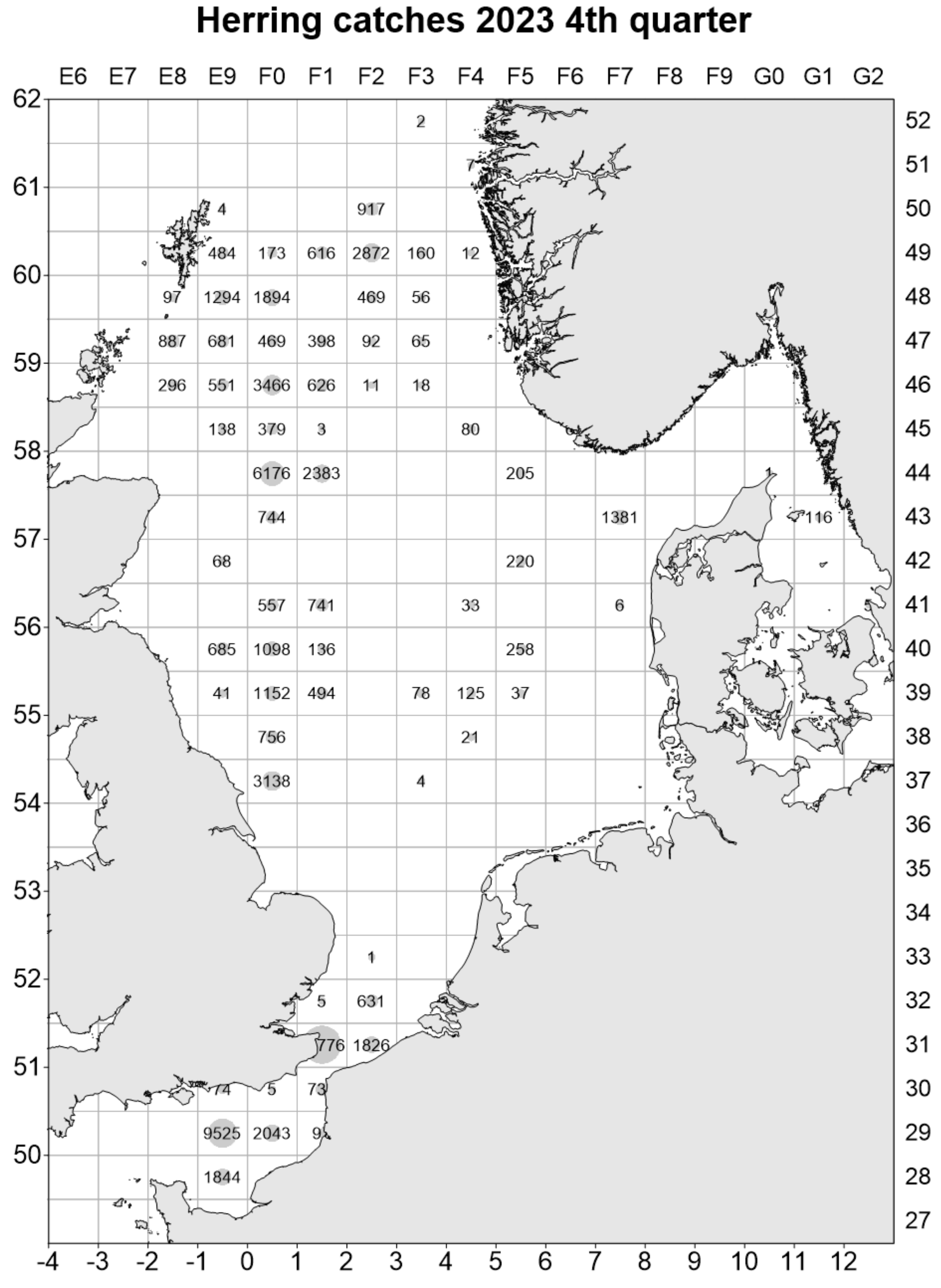


Figure 2.1.1d. Herring catches in the North Sea in the 4th quarter of 2023 (in tonnes) by statistical rectangle.

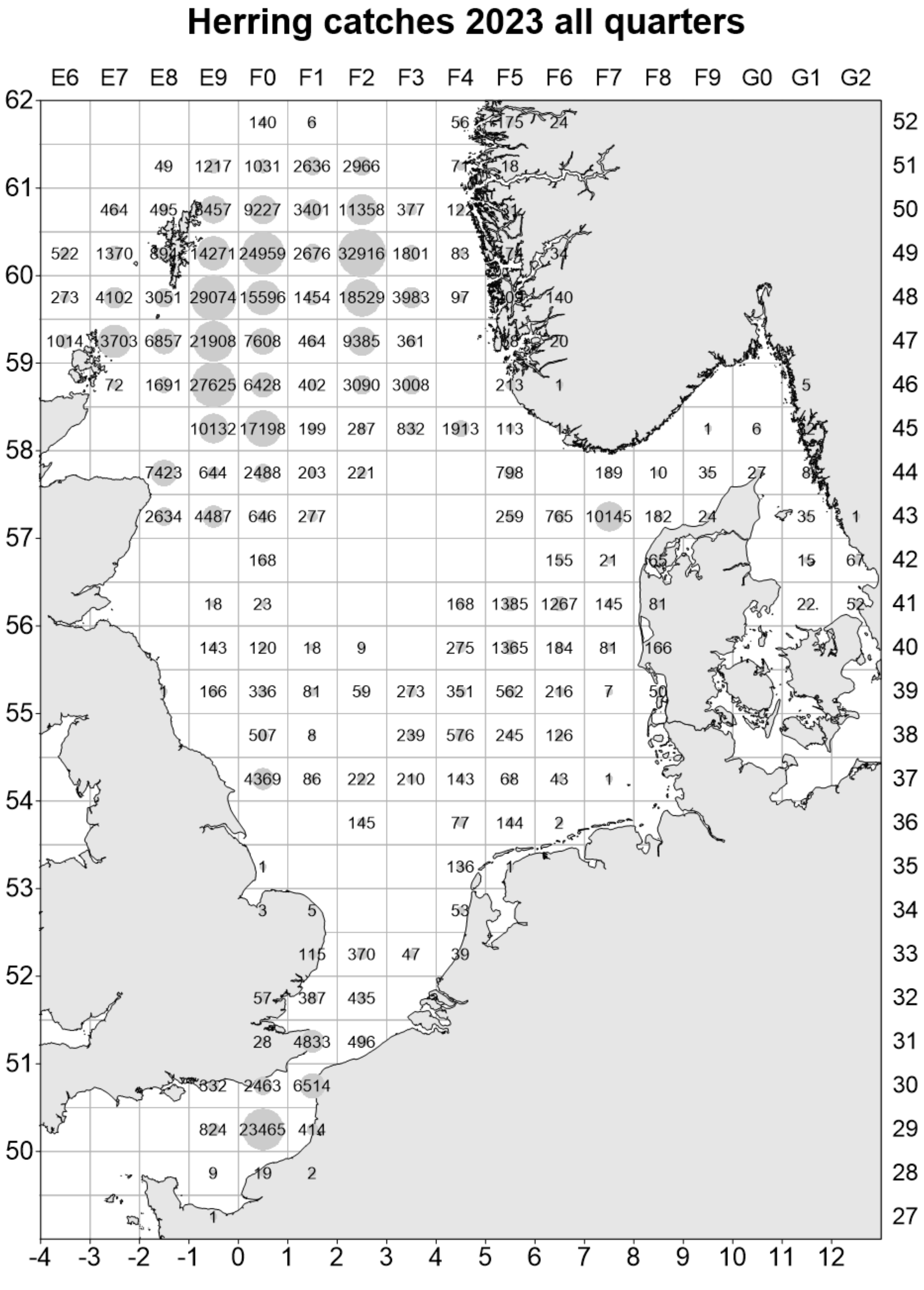


Figure 2.1.1e. Herring catches in the North Sea in all quarters of 2023 (in tonnes) by statistical rectangle.

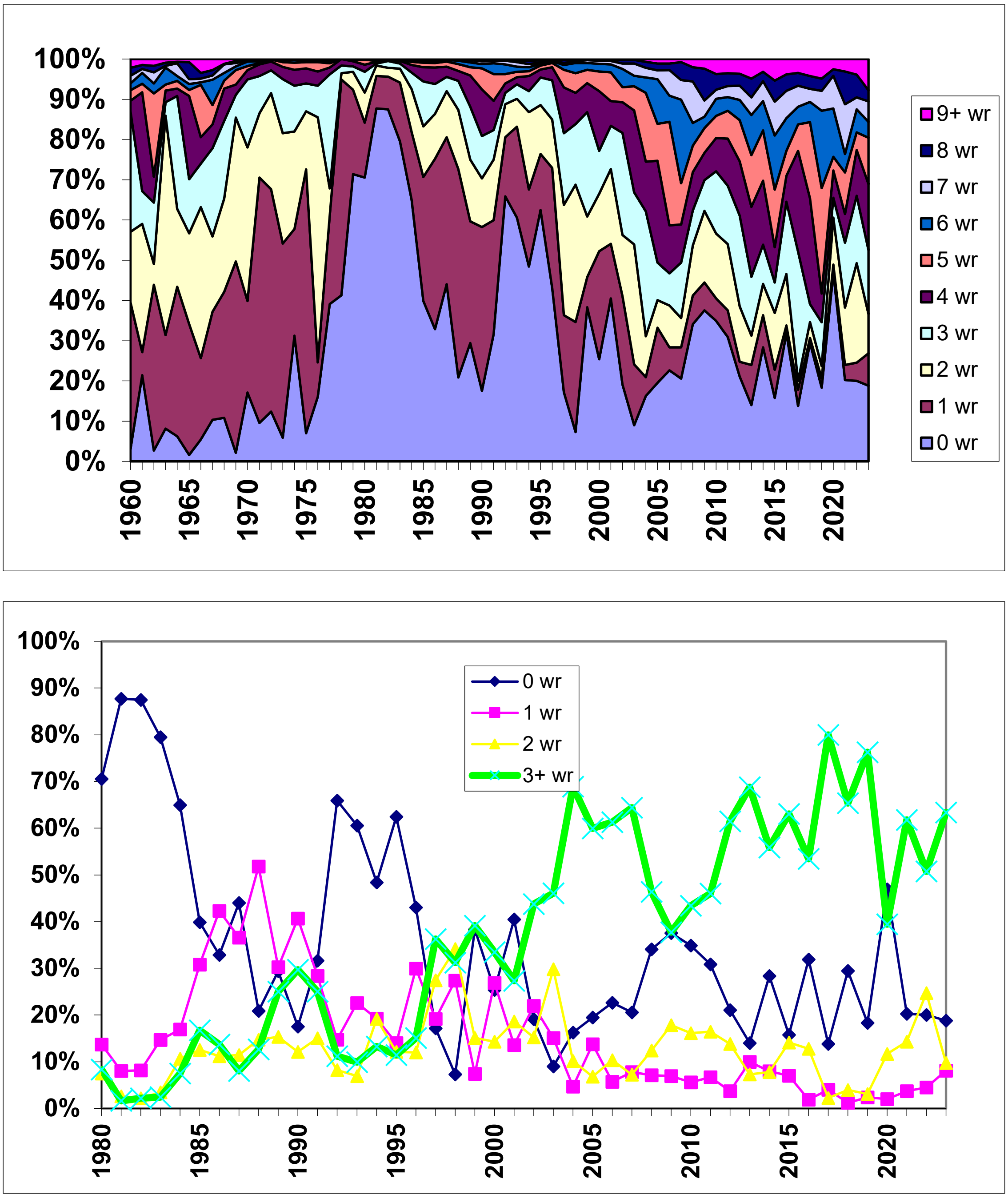


Figure 2.2.1. Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2023, and lower panel, 1980–2023).

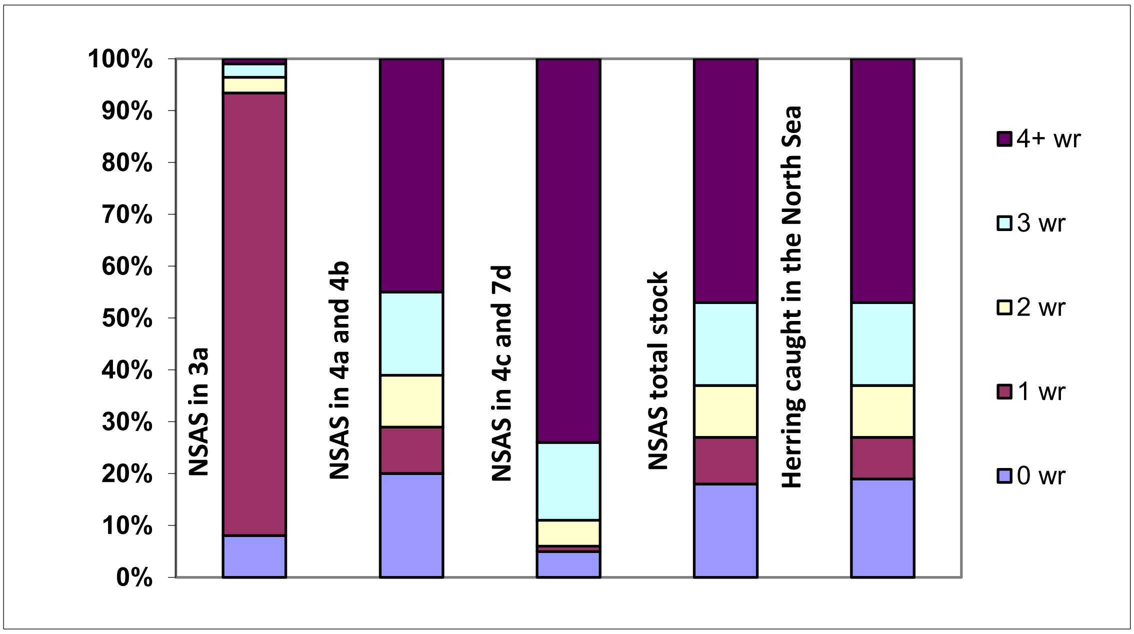


Figure 2.2.2. Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2023.

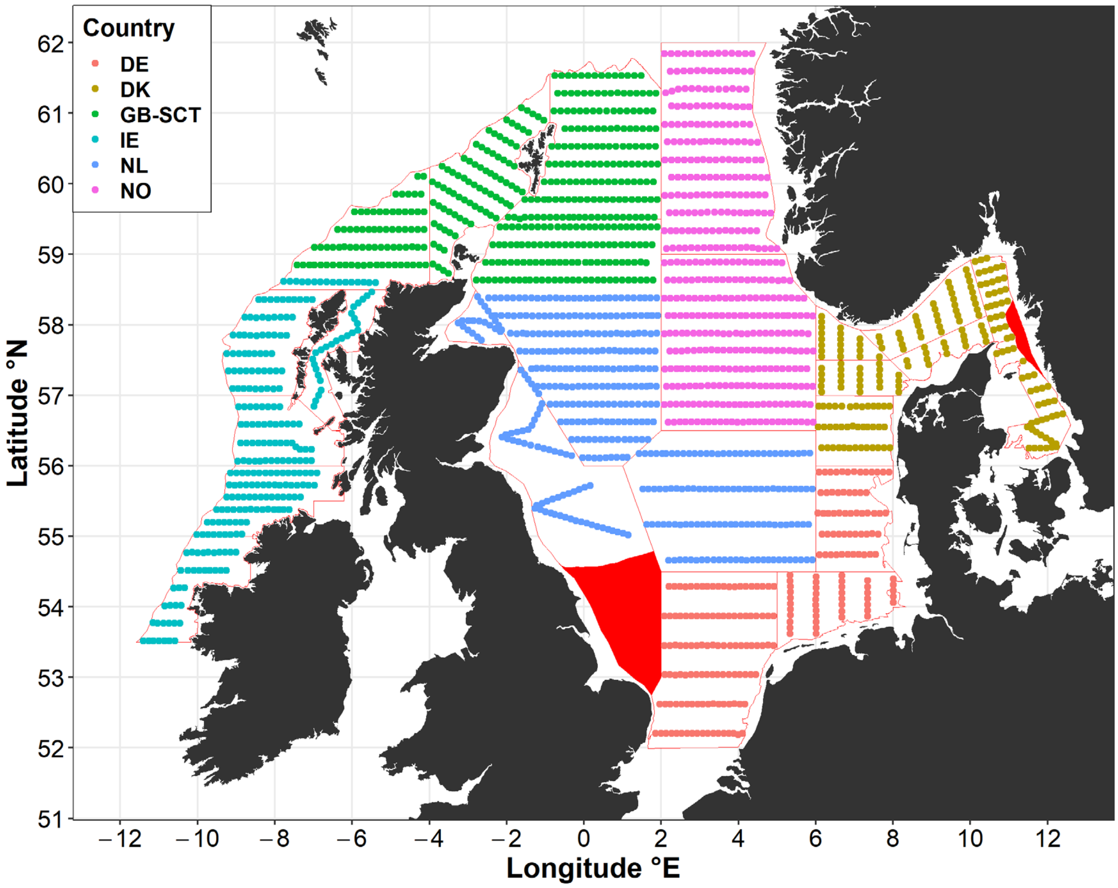


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2023 by nation. Red shaded areas were planned but not covered.

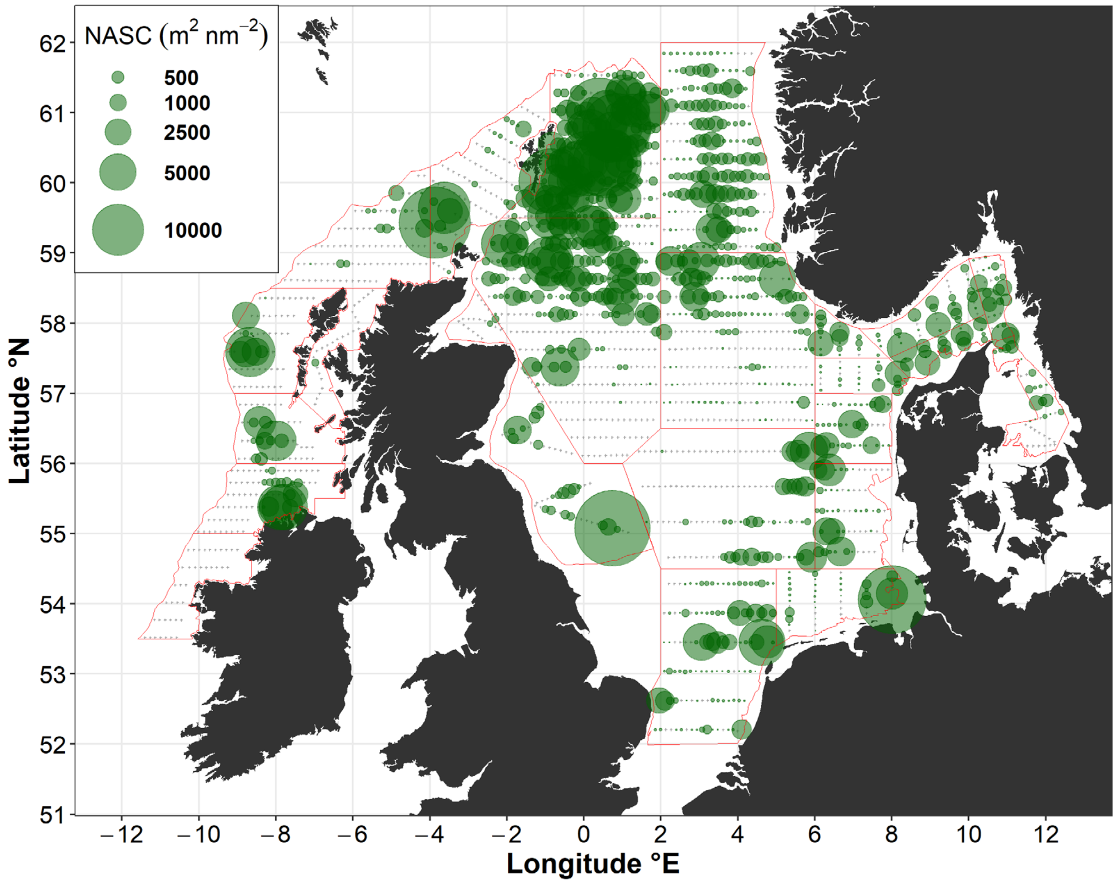


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2023. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

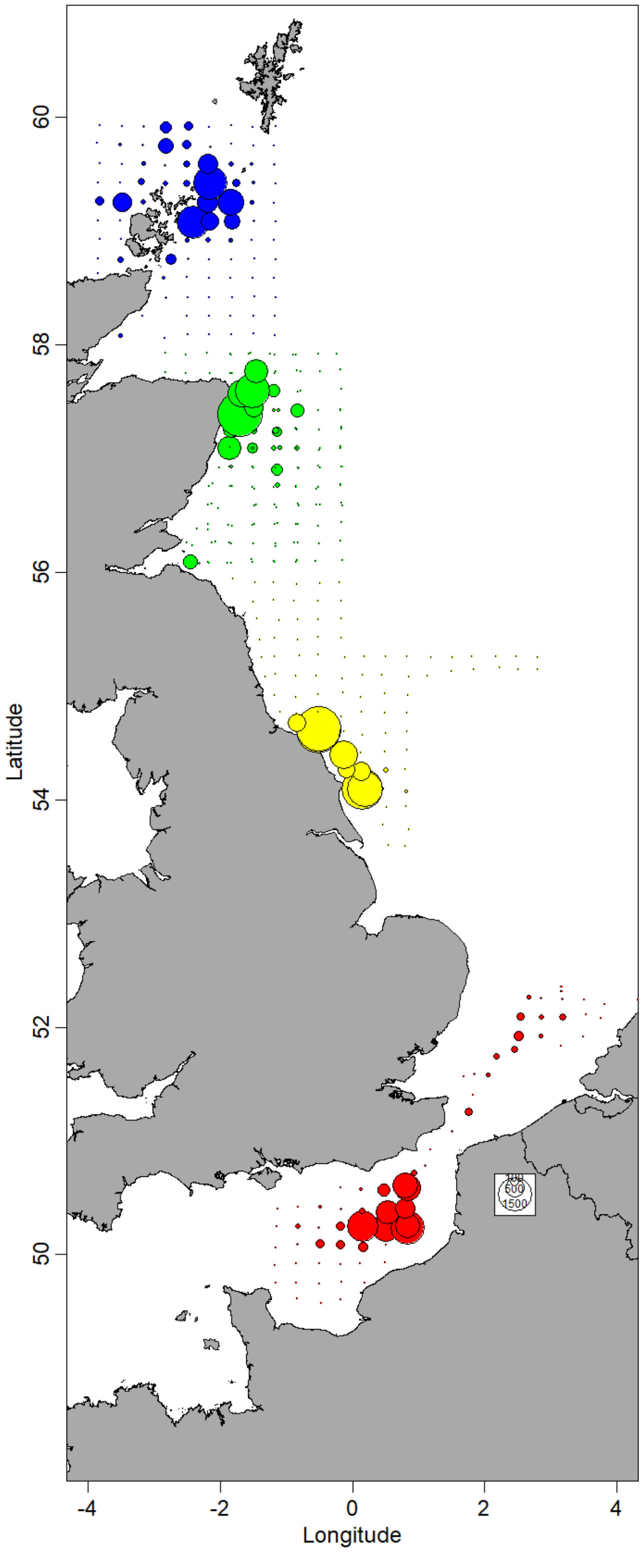


Figure 2.3.2.1. North Sea herring - Abundance of herring larvae < 10 mm (n/m²) at the main spawning grounds (Orkney/Shetlands = blue circles, Buchan area = green circles, central Banks = yellow circles and Downs = red circles, maximum circle size = 1 500 n/m²). The three northern areas were monitored in September 2023 and the southern North Sea in December 2023.

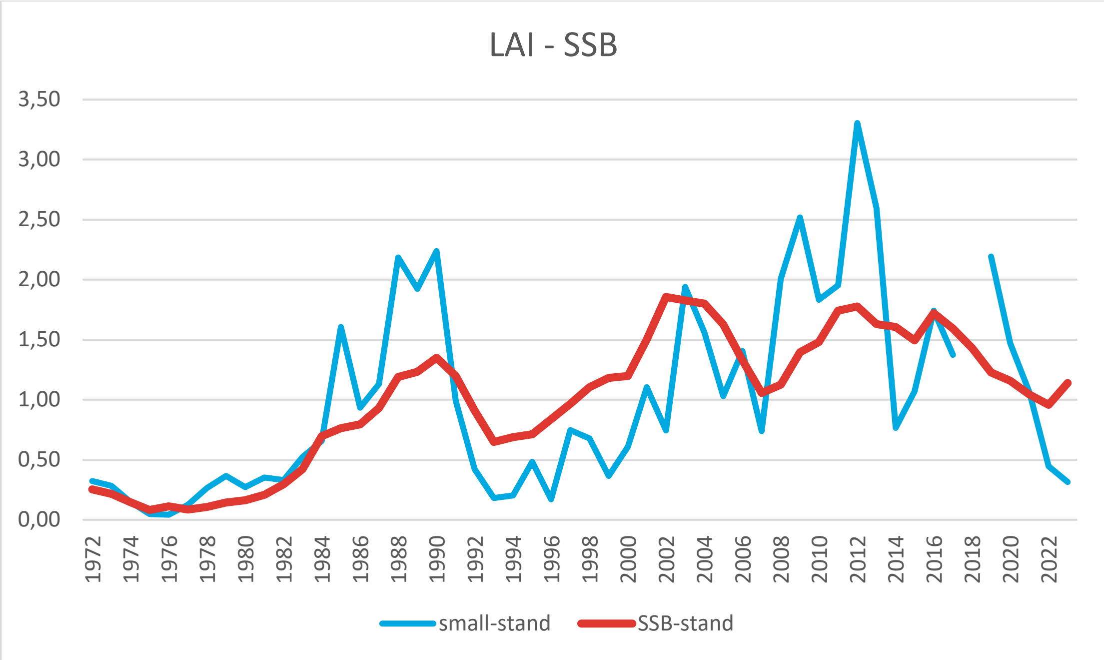


Figure 2.3.2.2. North Sea herring – Comparison of standardised LAI-time-series and SSB in the North Sea. Note there is no LAI estimate for 2018.

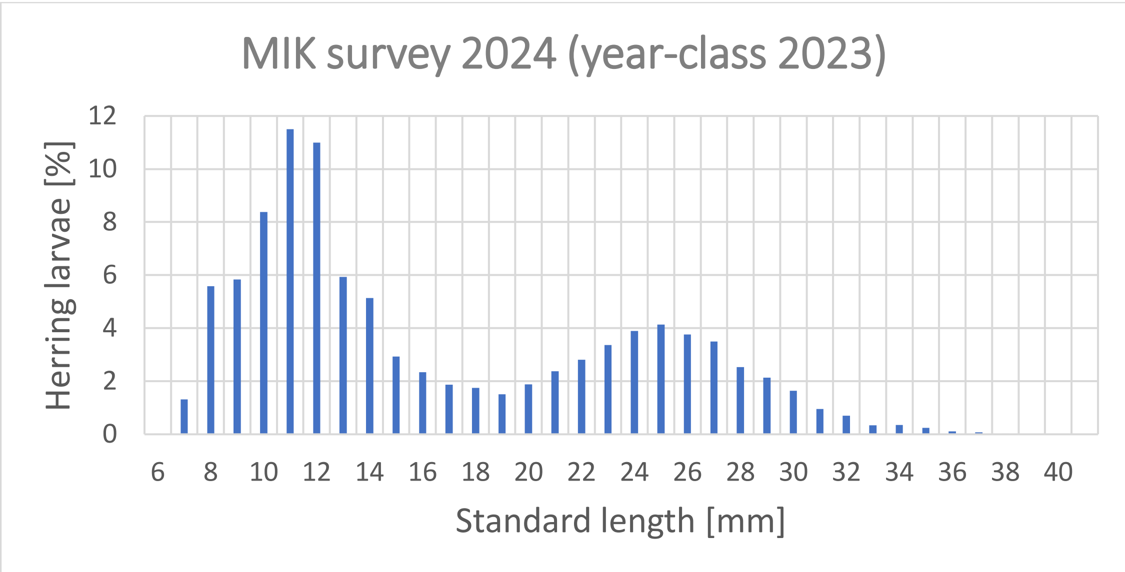


Figure 2.3.3.1.1 North Sea herring. Length distribution of all herring larvae caught in the MIK during the 2024 Q1 IBTS.

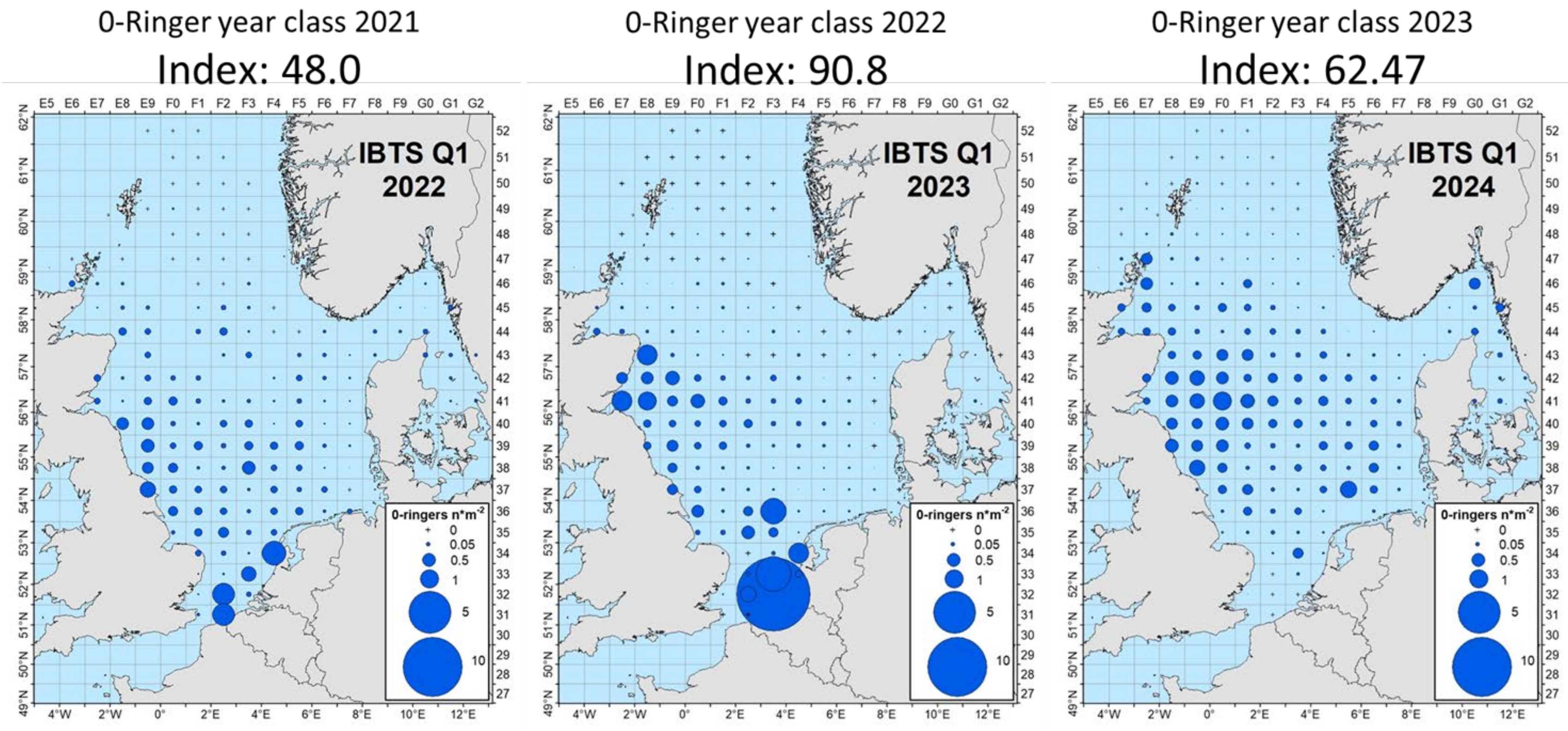


Figure 2.3.3.1.2 North Sea herring. Distribution of 0-ringer herring, year classes 2021–2023. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2022–2024. Areas of filled circles illustrate densities in no m-2.

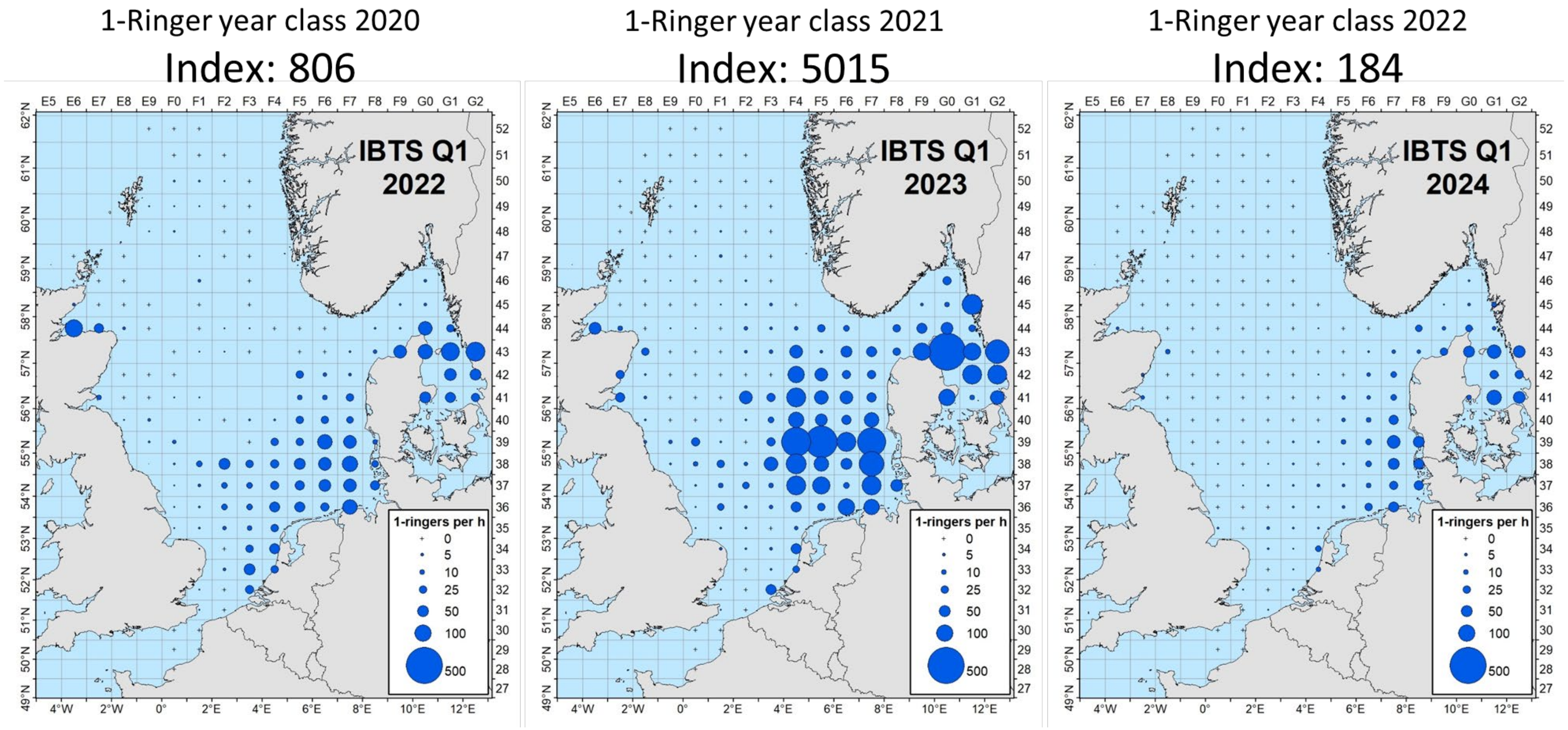


Figure 2.3.3.2.1 North Sea herring. Distribution of 1-ringer herring, year classes 2020–2022. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2022–2024. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data.

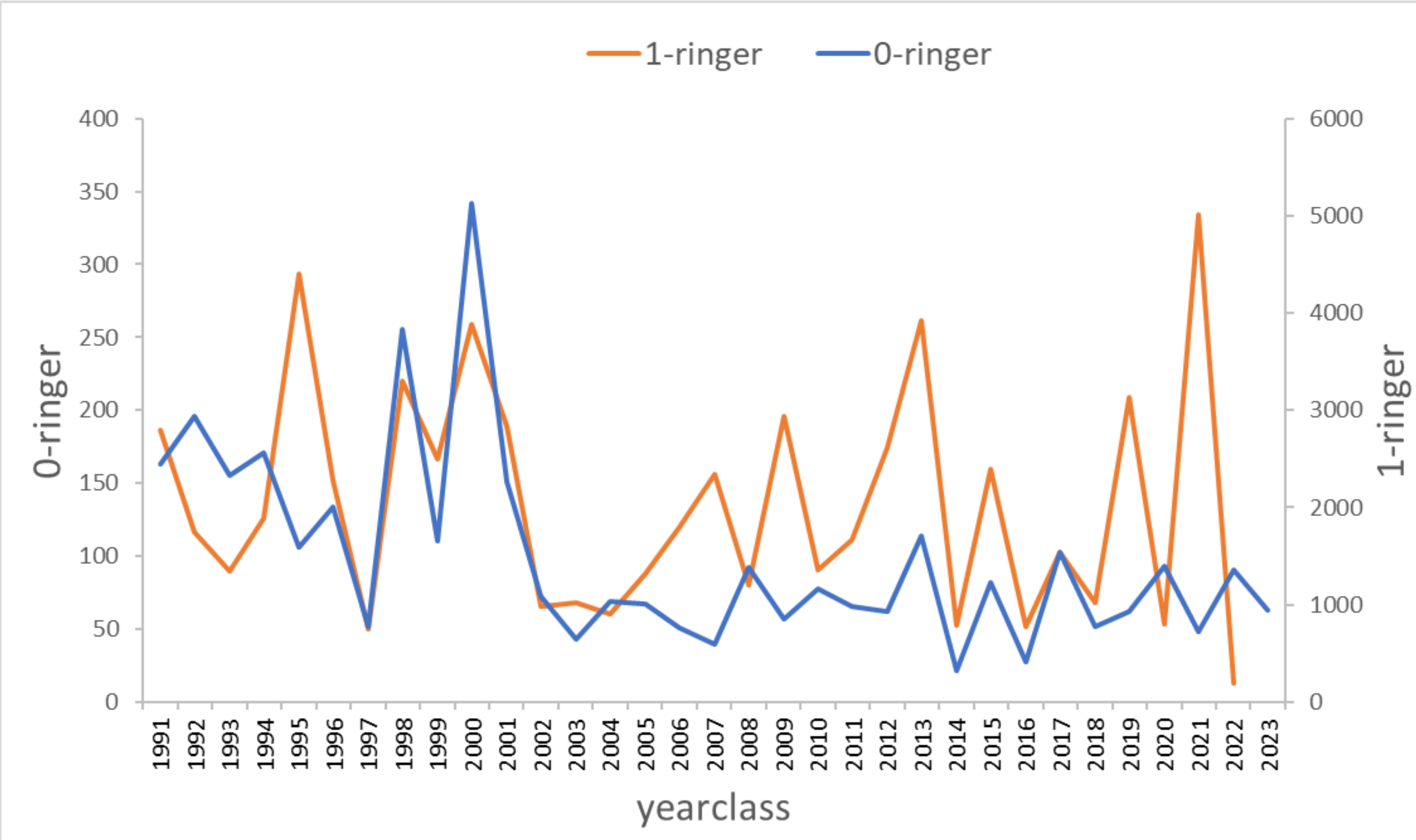


Figure 2.3.3.2.2 North Sea herring. Time series of 0-ringer (blue) and 1-ringer indices (orange). Year-classes 1991 to 2023 for 0-ringers, year-classes 1991–2022 for 1-ringers.

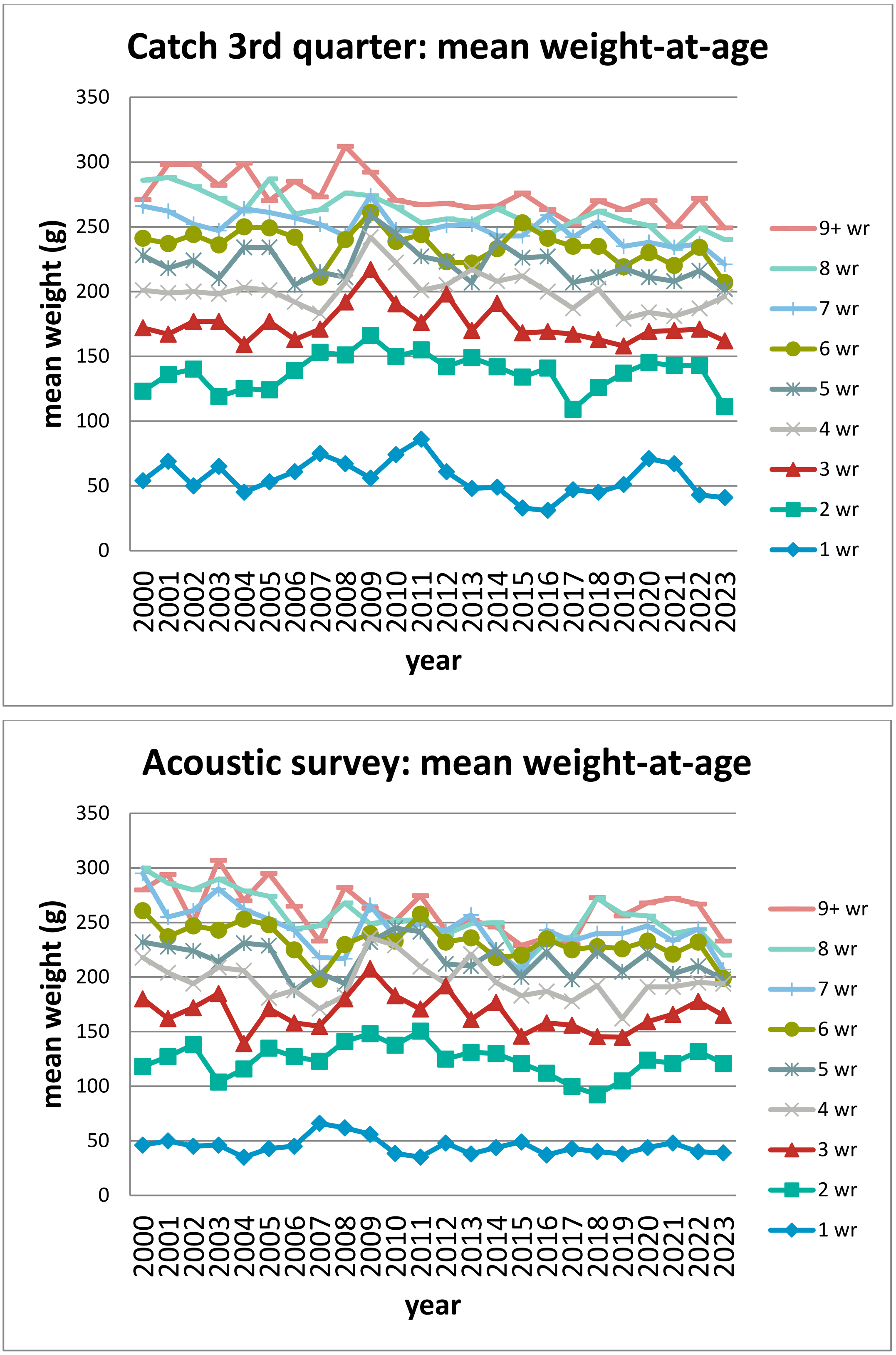


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age in Divisions 4 and 3.a in the 3rd quarter from the catch (upper panel) and from the acoustic survey (lower panel) for comparison

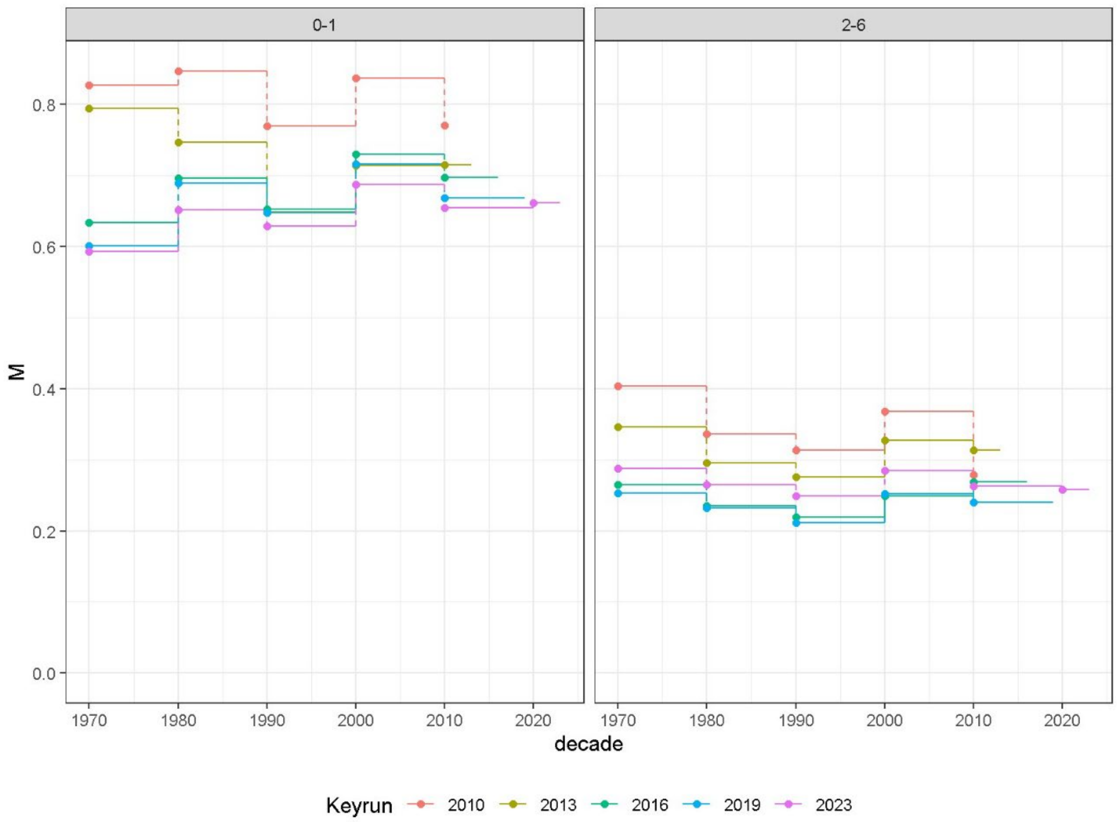


Figure 2.4.2.1. North Sea Herring. Natural mortality per decade for the different SMS keyruns ICES WGSAM, 2014; 2016, 2021, 2024). Results are presented as M averaged over ages 0-1 and 2-6.

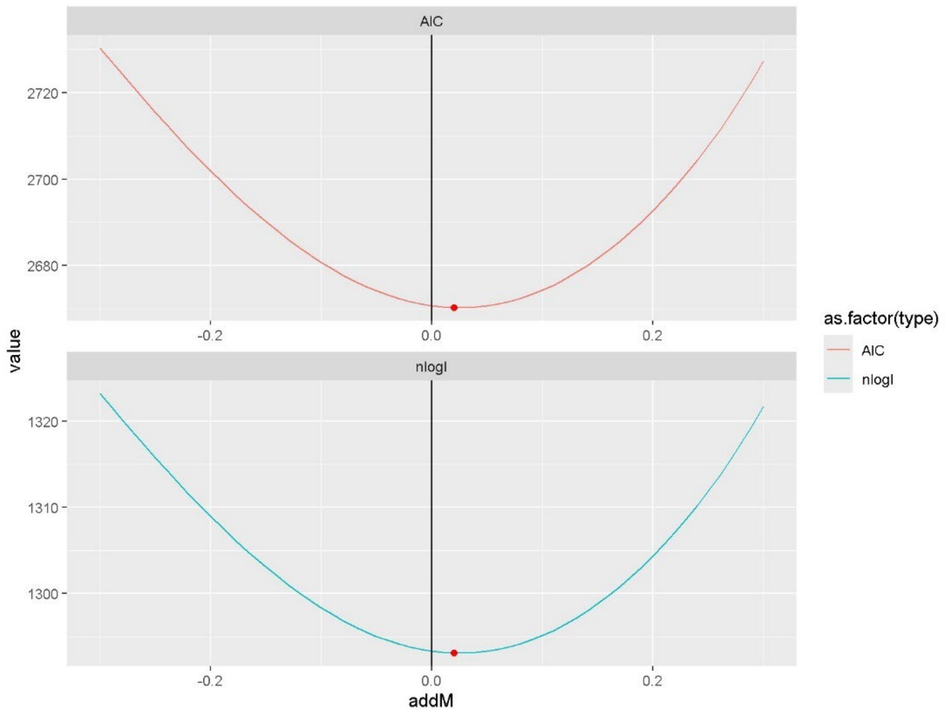


Figure 2.4.2.2. North Sea Herring. Assessment profiling for natural mortality offset. An age and year independent offset is applied when new natural mortality time series is available. The offset (addM) is determined from the profiling of the

assessment, based on the negative likelihood (bottom panel). The profiling of the assessment using the 2023 keyruns leads to addM=0.02.

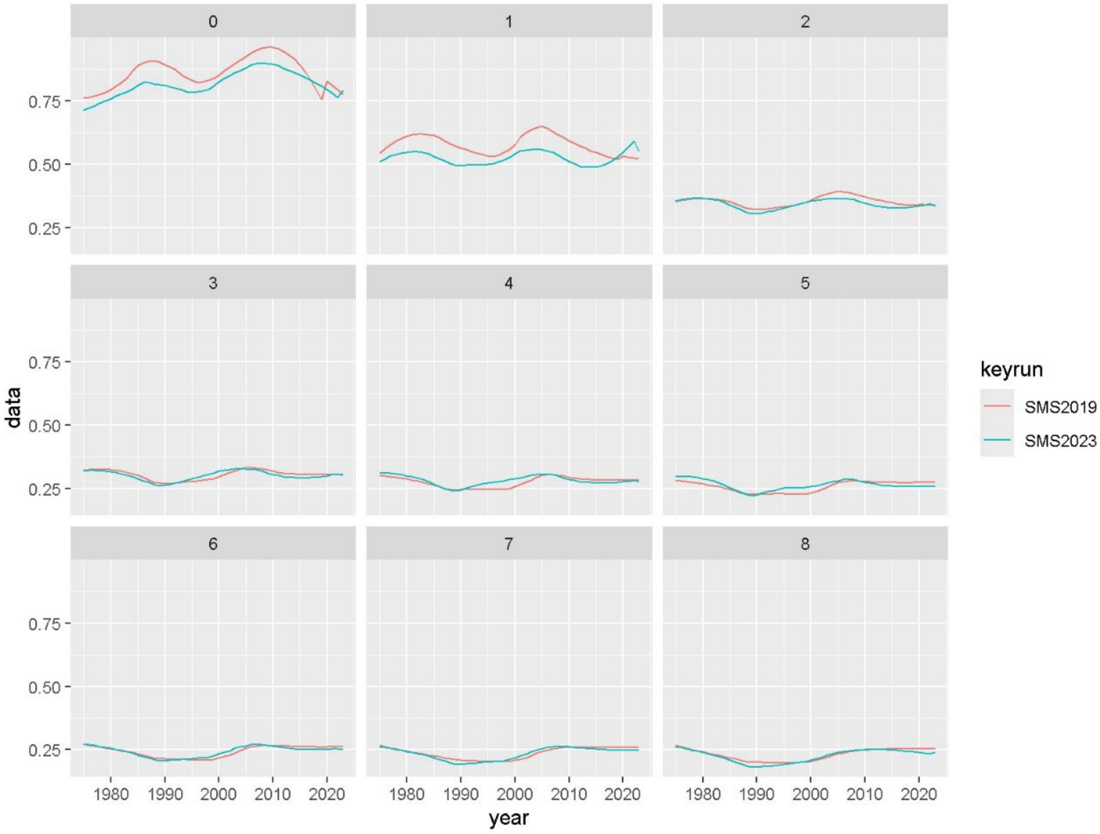


Figure 2.4.2.3. North Sea Herring. Input natural mortality to the assessment based on 2019 and 2023 SMS keyruns. Prior to inputting the assessment, the raw natural mortality vector is smoothed and offset.

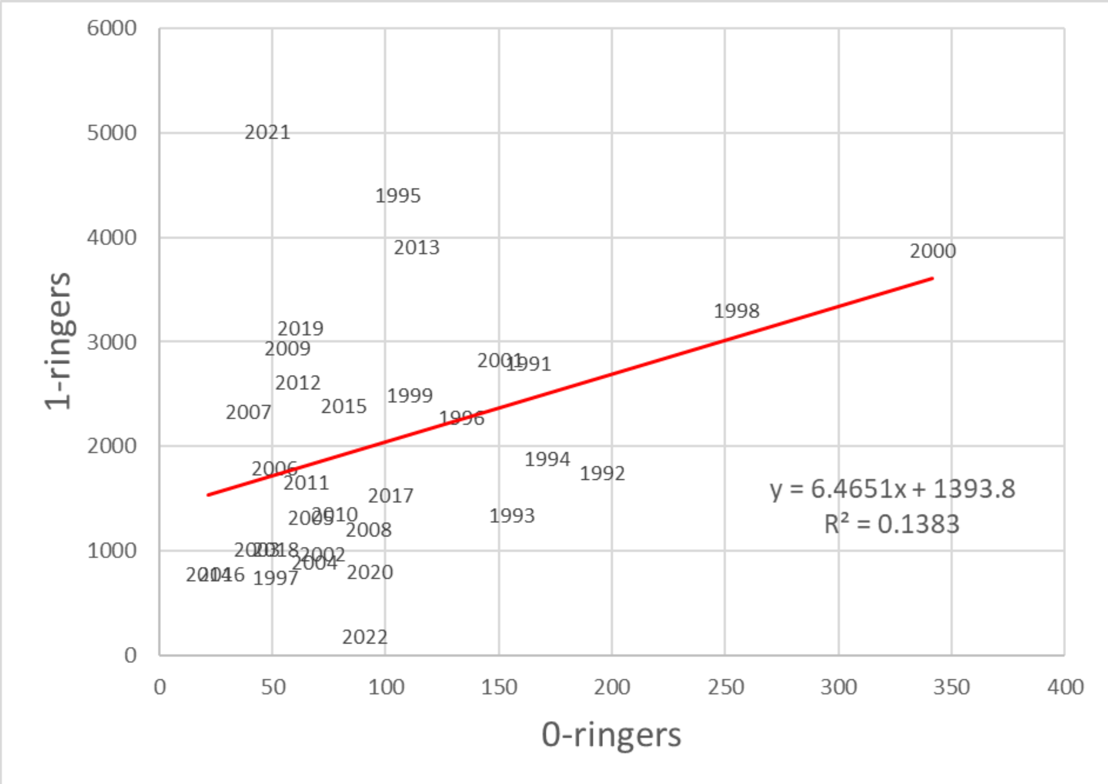


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers, calculated with the new algorithm, and 1-ringers for year-classes 1991 to 2022.

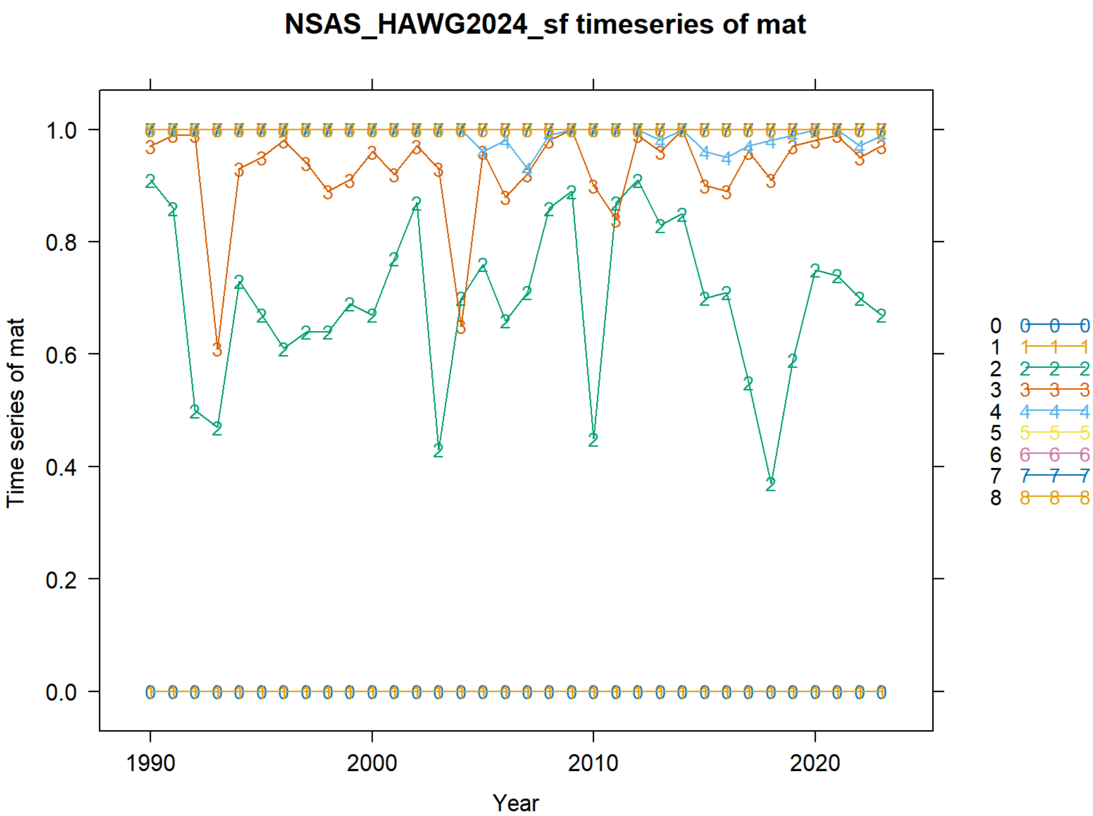


Figure 2.6.1.1. North Sea Herring. Time-series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

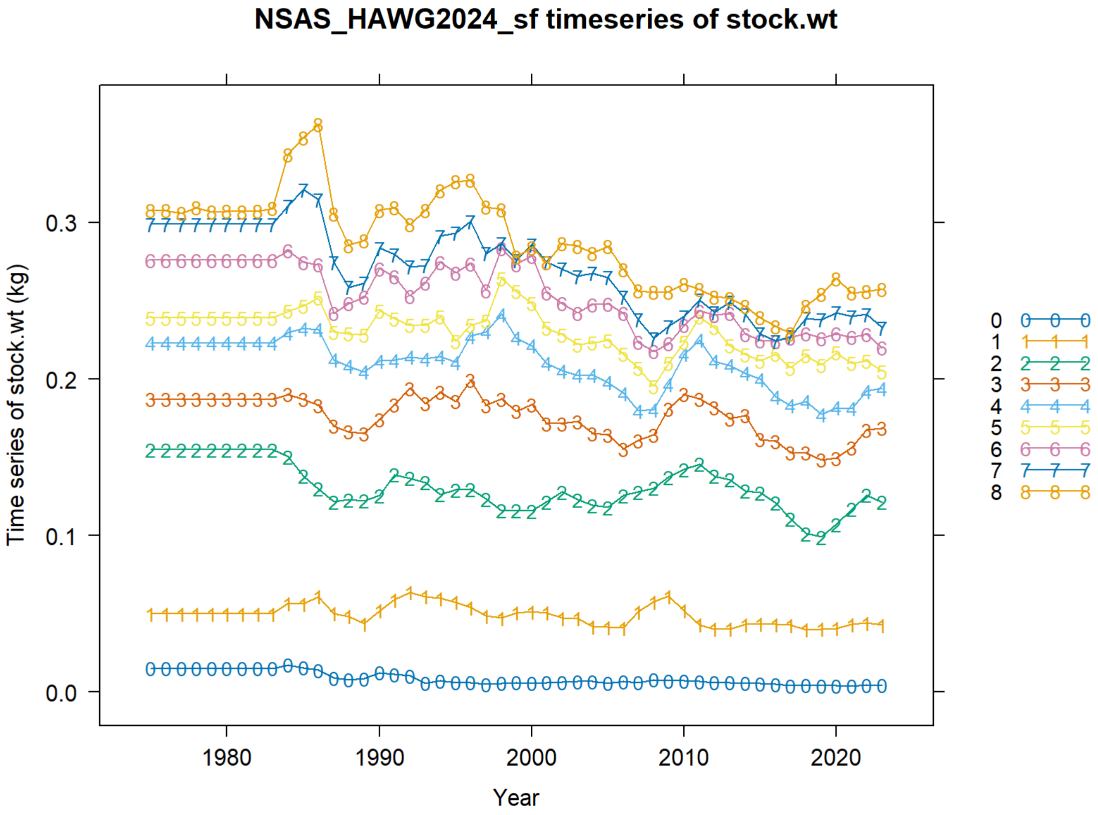


Figure 2.6.1.2. North Sea Herring. Time-series of stock weight at ages 0 to 8+ as used in the North Sea herring assessment.

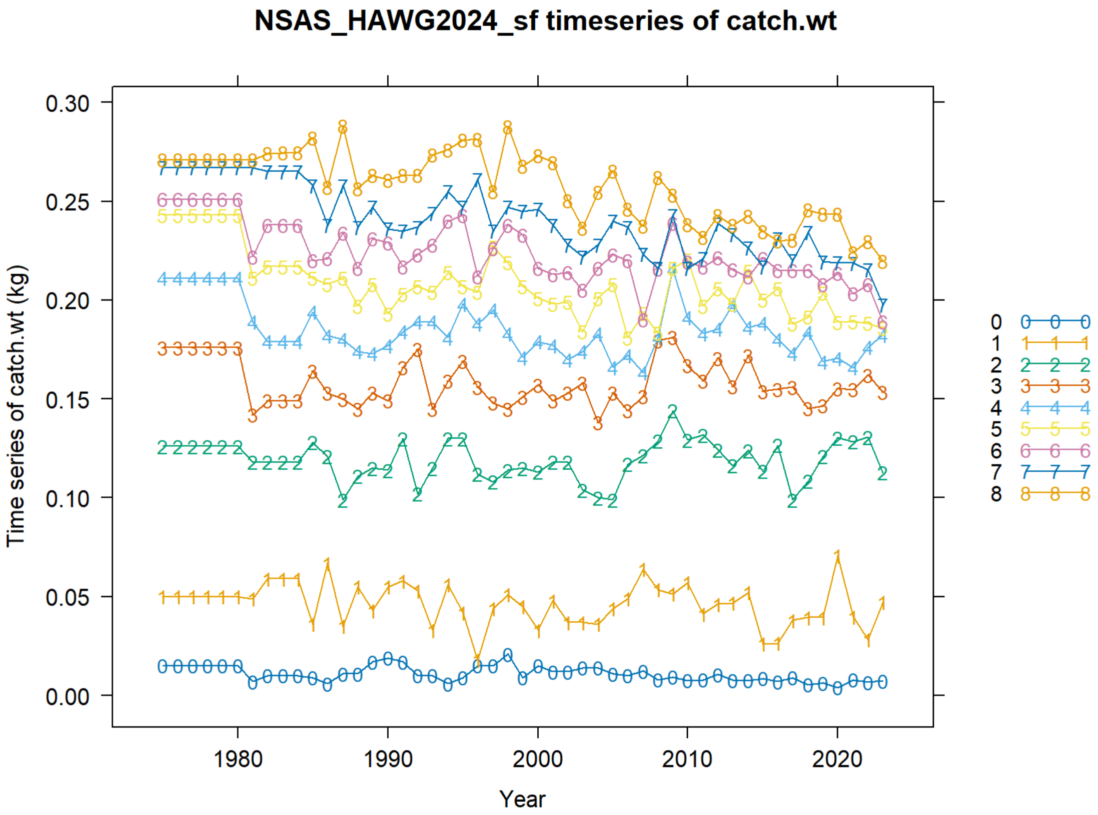


Figure 2.6.1.3. North Sea Herring. Time-series of catch weight at ages 0 to 8+ as used in the North Sea herring assessment.

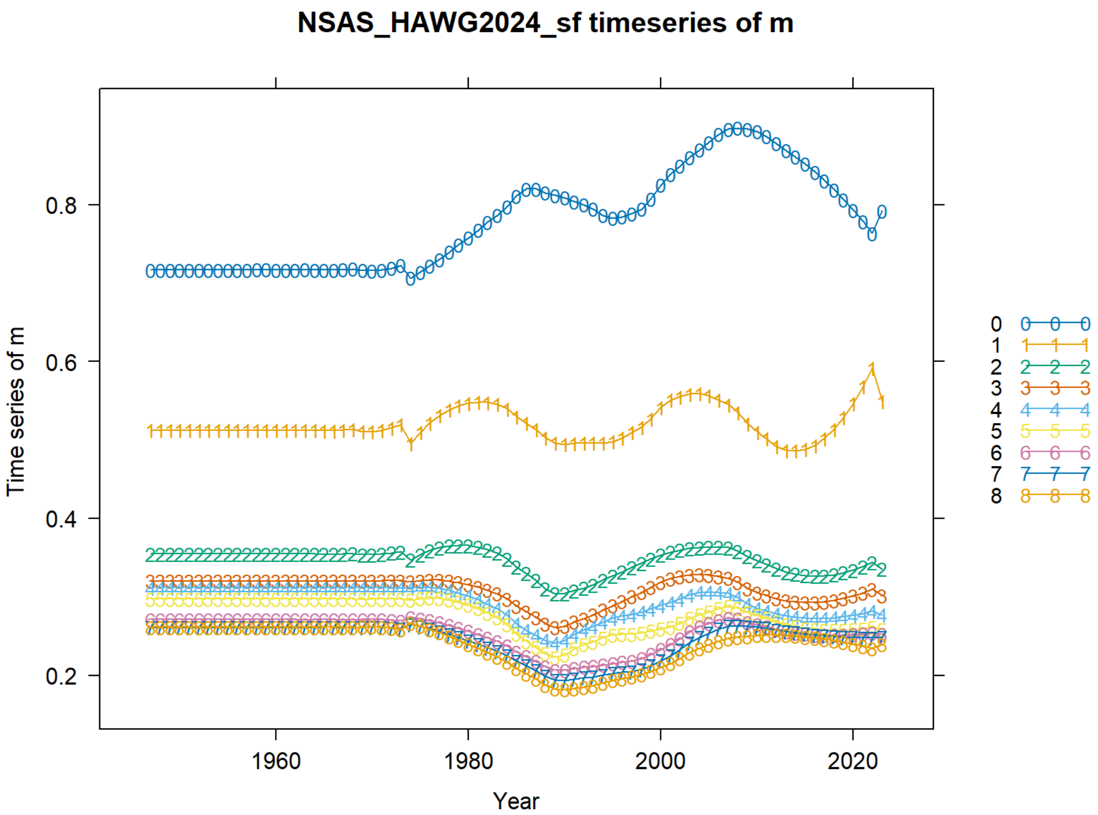


Figure 2.6.1.4. North Sea Herring. Time-series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2023 North Sea key-run (ICES WGSAM, 2024)

Figure 2.6.1.5. North Sea Herring. Proportion of catch at age since 2000.

Figure 2.6.1.6. North Sea Herring. Proportion of HERAS index at age since 2000.

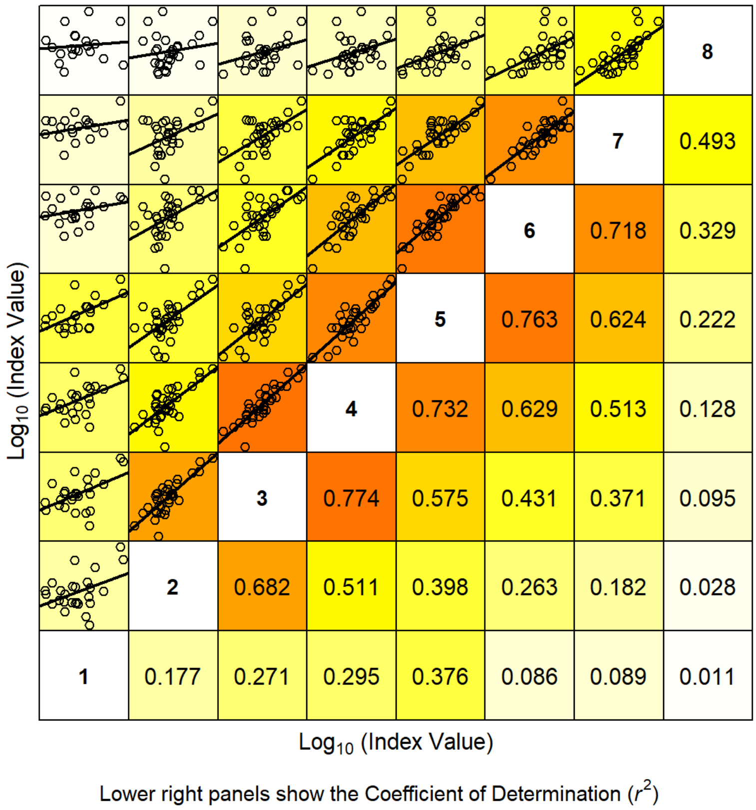


Figure 2.6.1.7. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r² value that is associated with the linear regression is given.

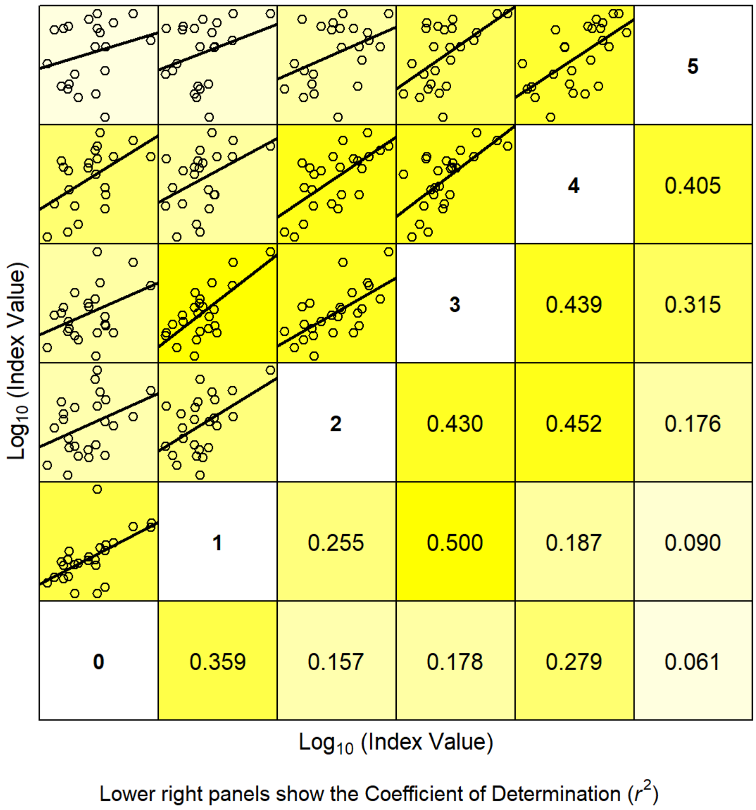


Figure 2.6.1.8. North Sea herring. Internal consistency plot of the IBTS in quarter 3. Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r² value that is associated with the linear regression is given.

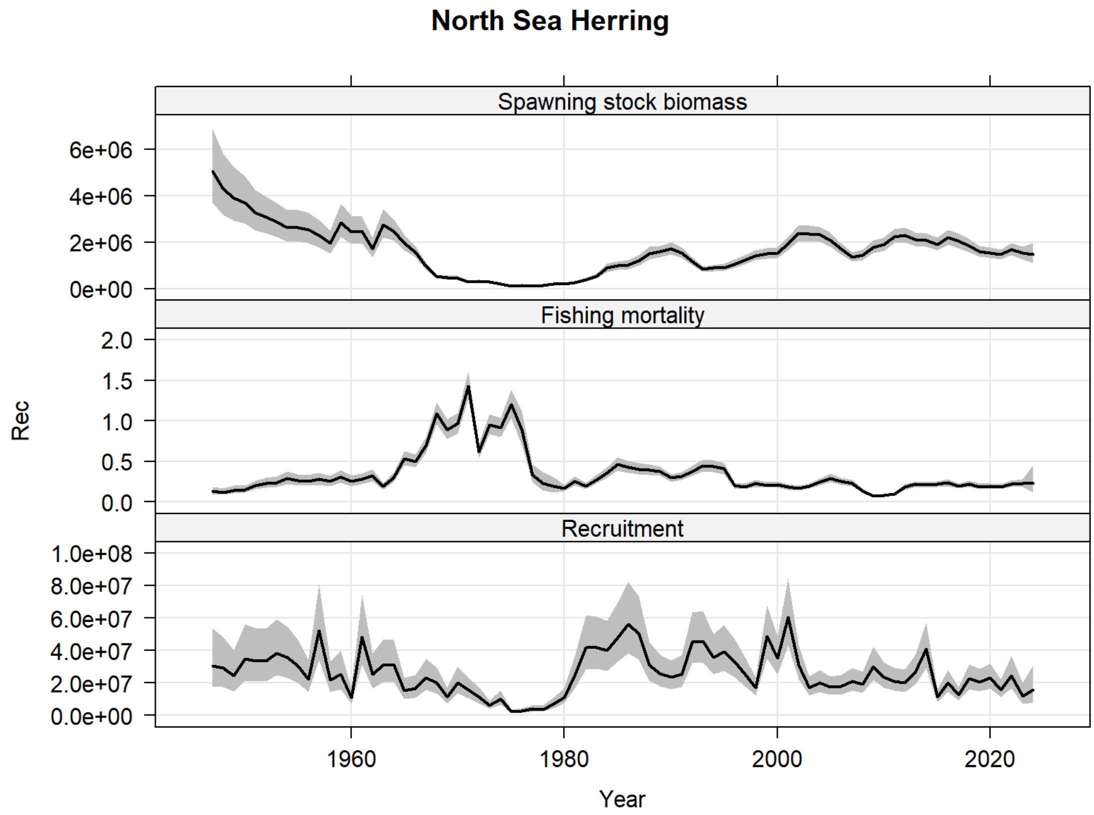


Figure 2.6.2.1. North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

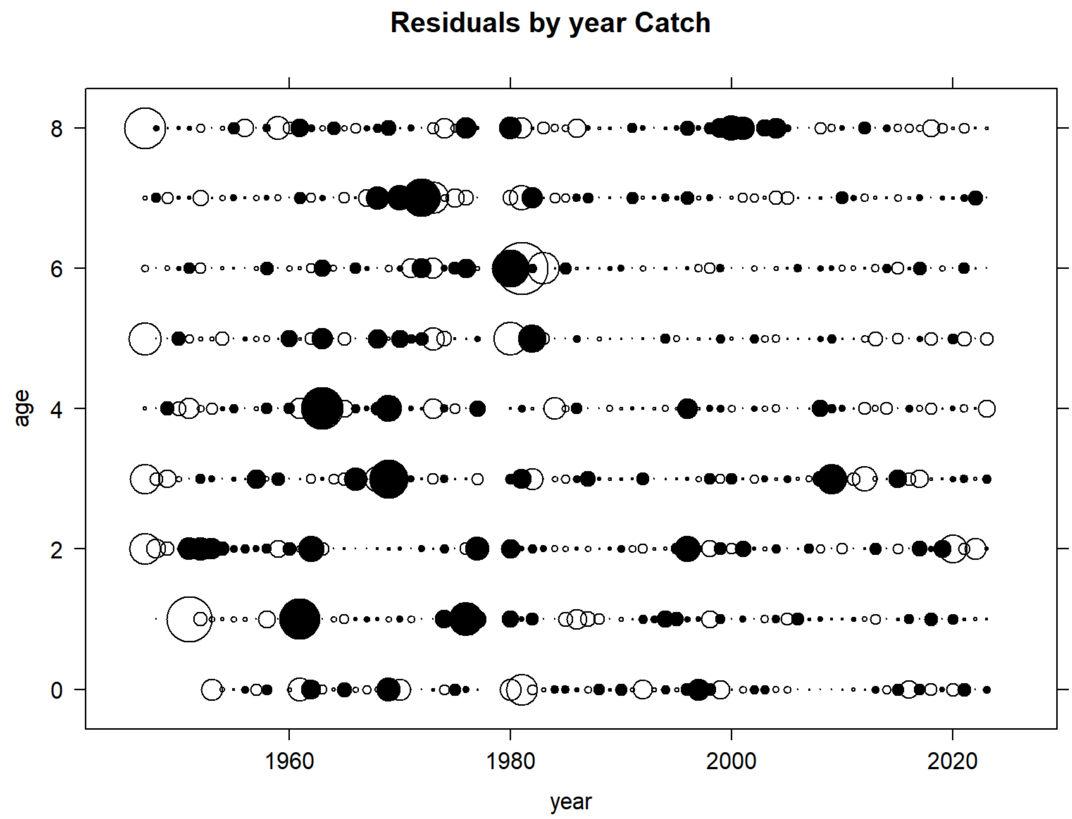


Figure 2.6.2.2. North Sea herring. Bubble plot of standardized catch residual at age.

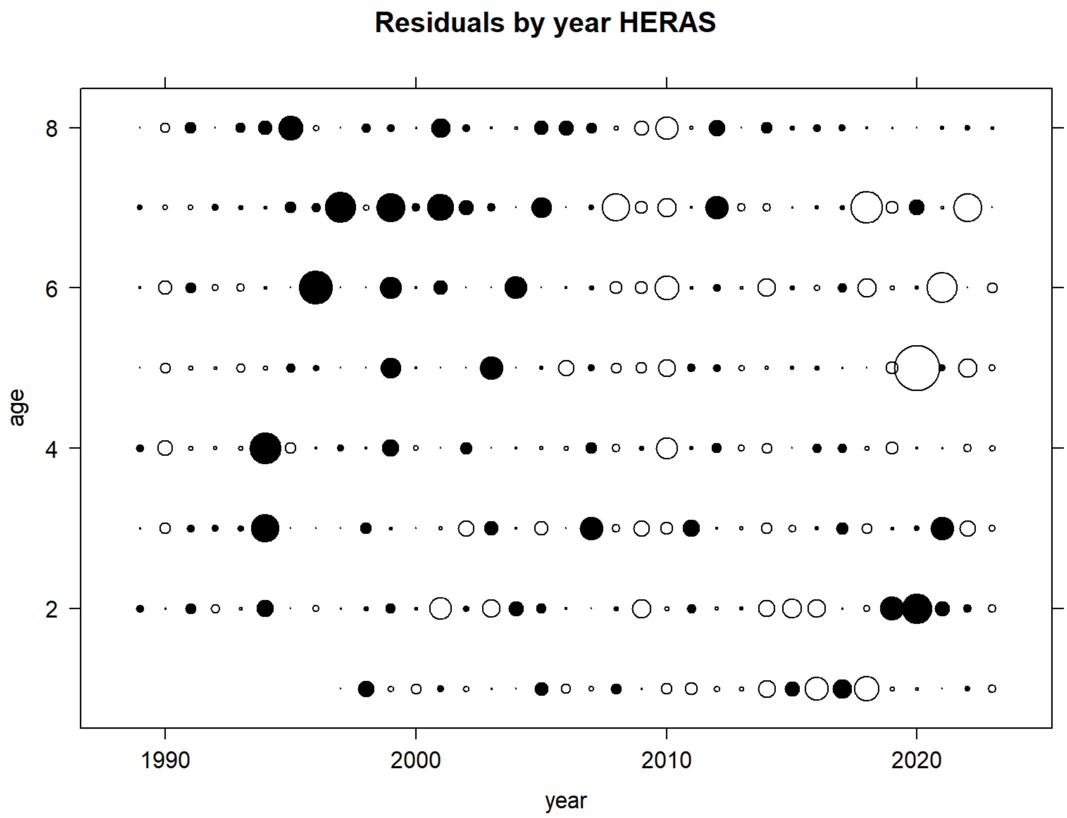


Figure 2.6.2.3. North Sea herring. Bubble plot of standardized acoustic survey residuals at age.

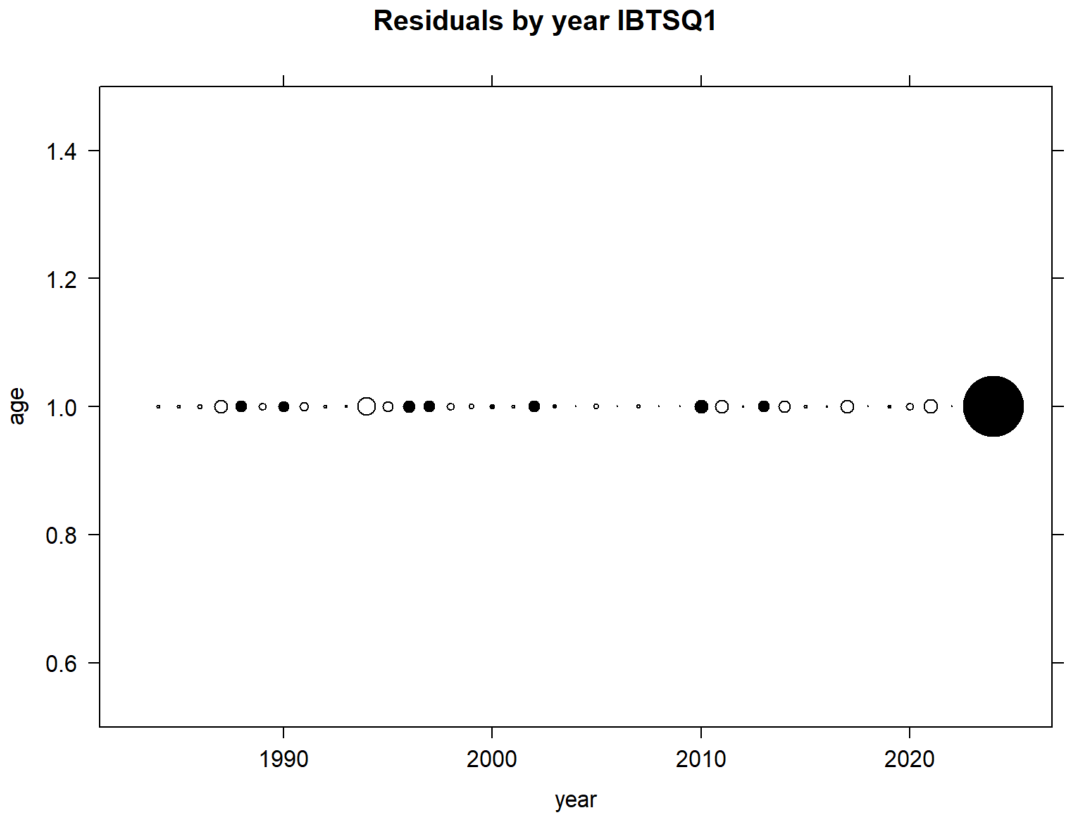


Figure 2.6.2.4. North Sea herring. Bubble plot of standardized IBTSQ1 residuals at age.

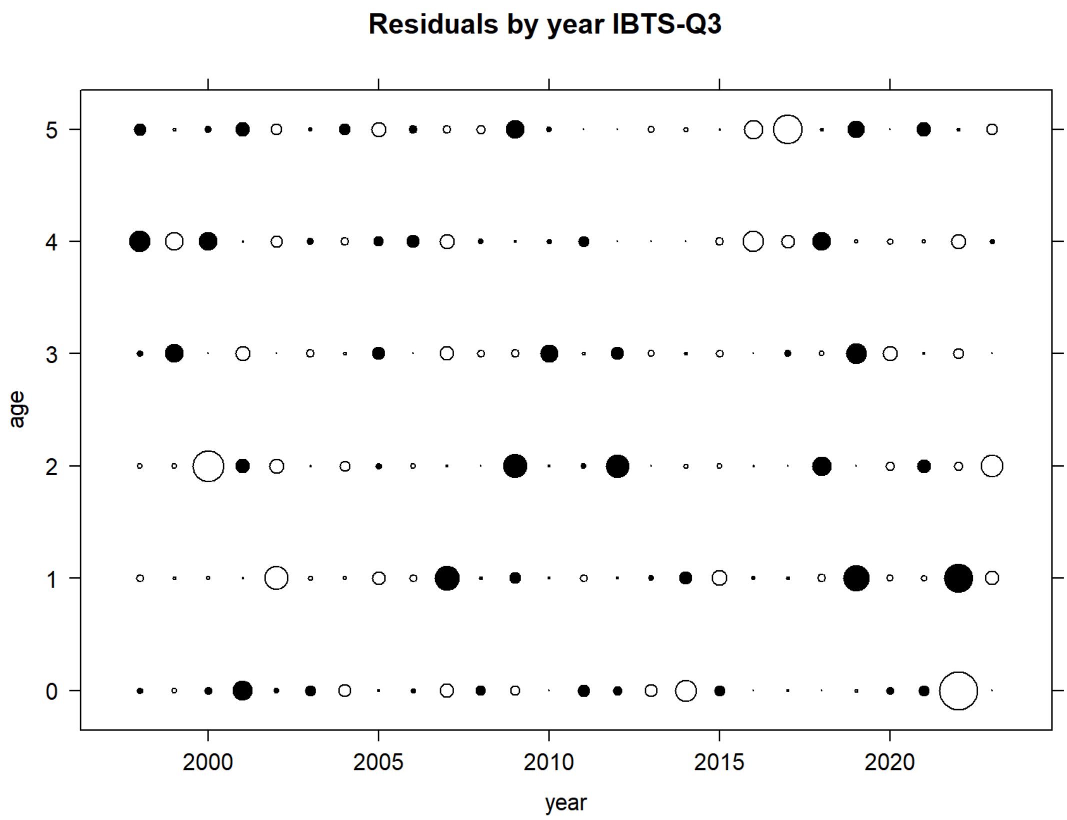


Figure 2.6.2.5. North Sea herring. Bubble plot of standardized IBTSQ3 residuals at age.

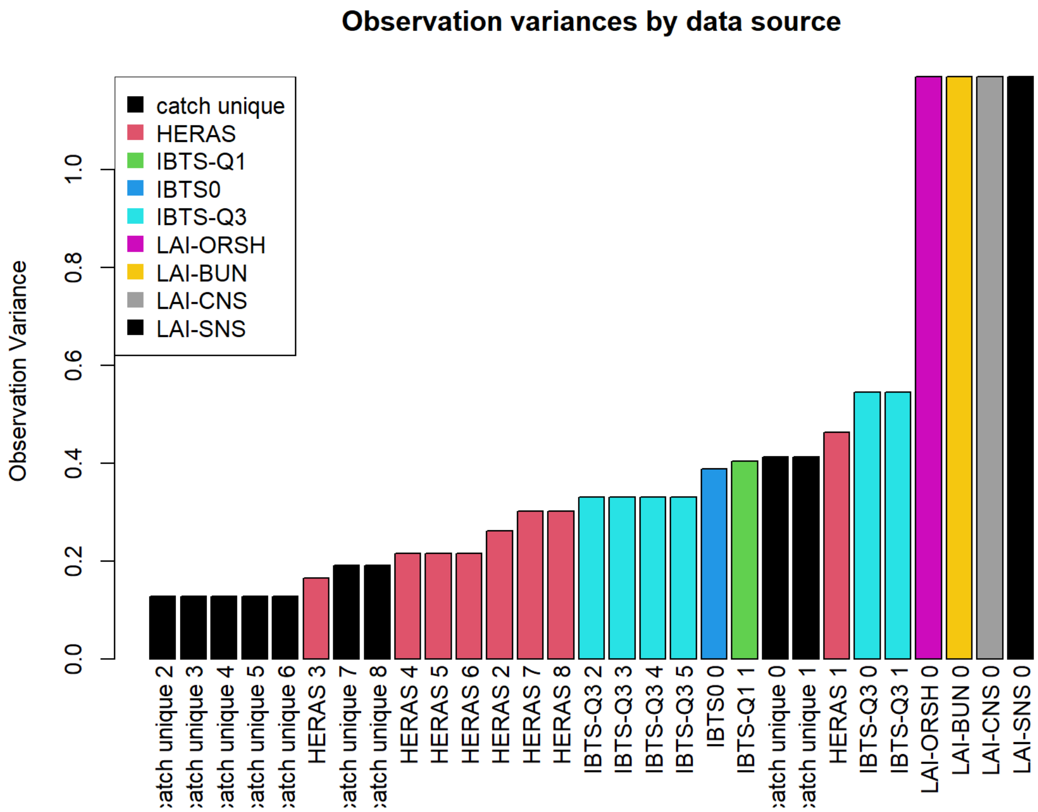


Figure 2.6.2.6. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

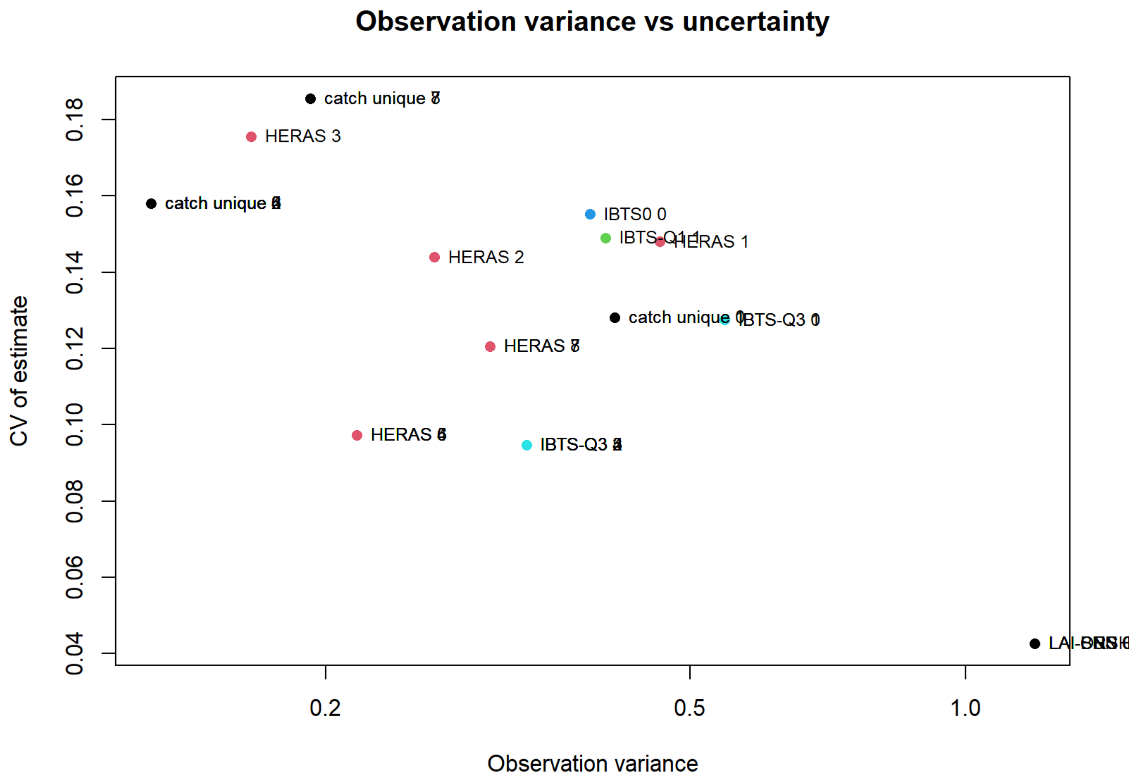


Figure 2.6.2.7. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

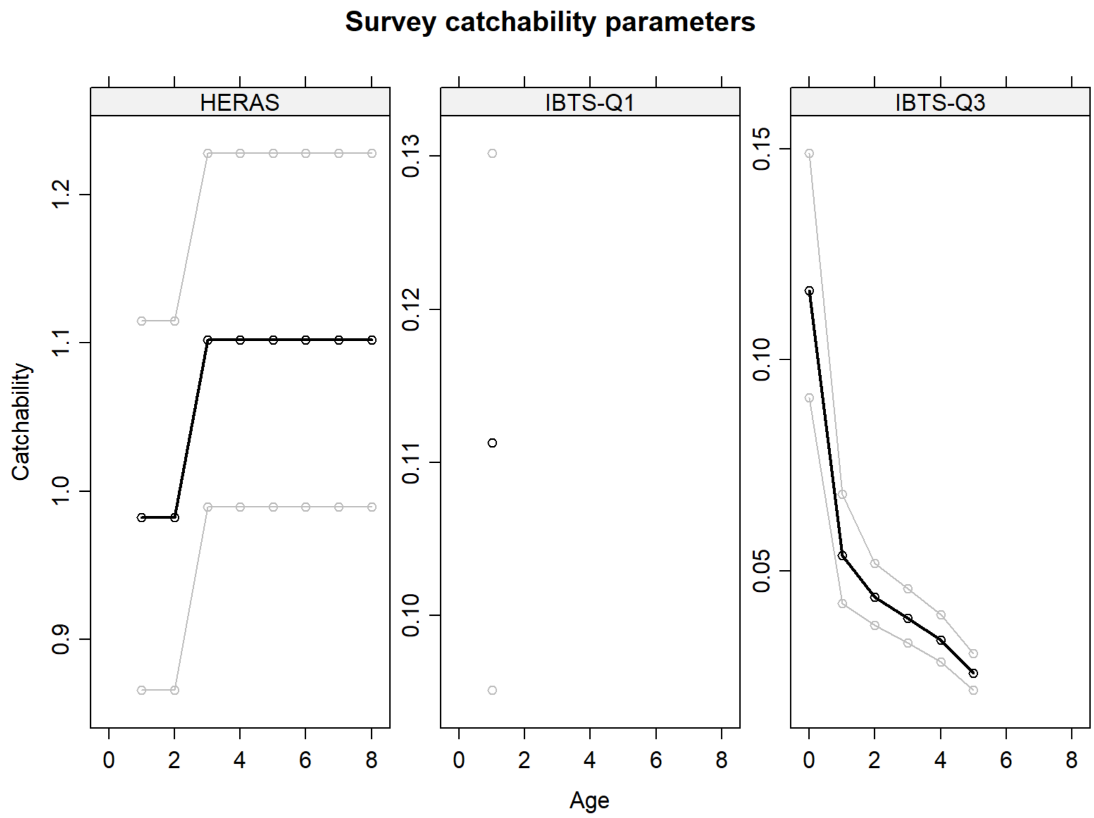


Figure 2.6.2.8. North Sea herring. Catchability at age for the HERAS, IBTSQ1 and IBTSQ3 surveys.

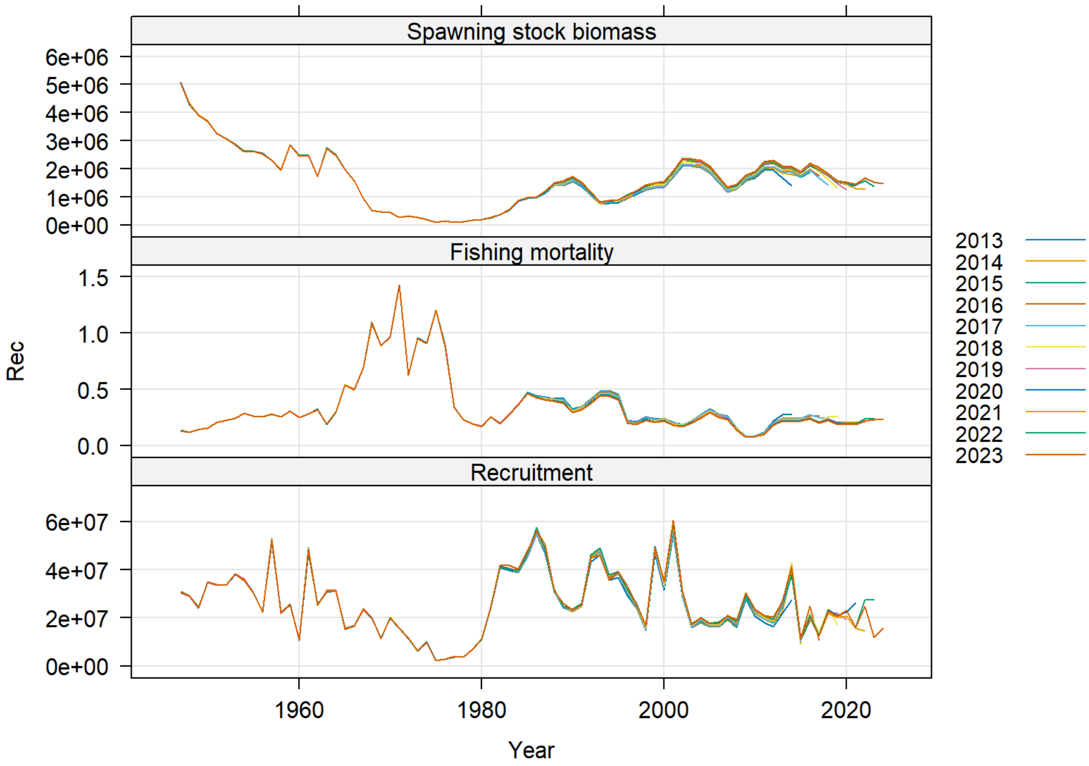


Figure 2.6.2.9. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

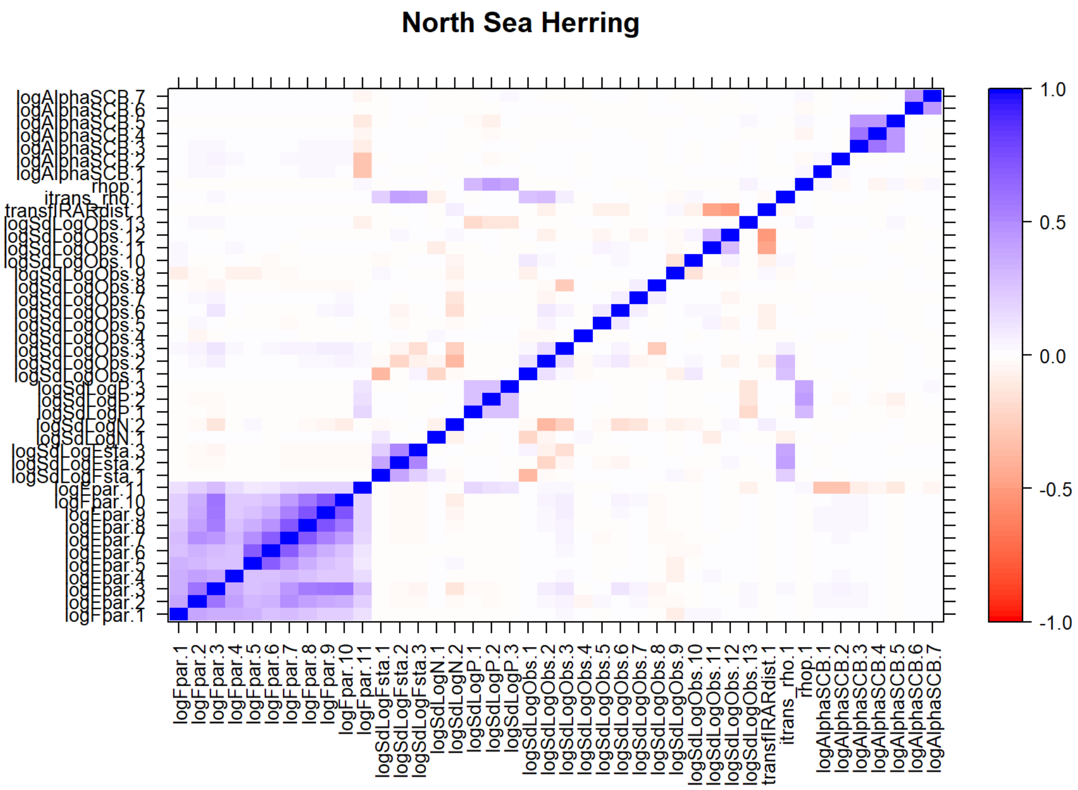


Figure 2.6.2.10. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

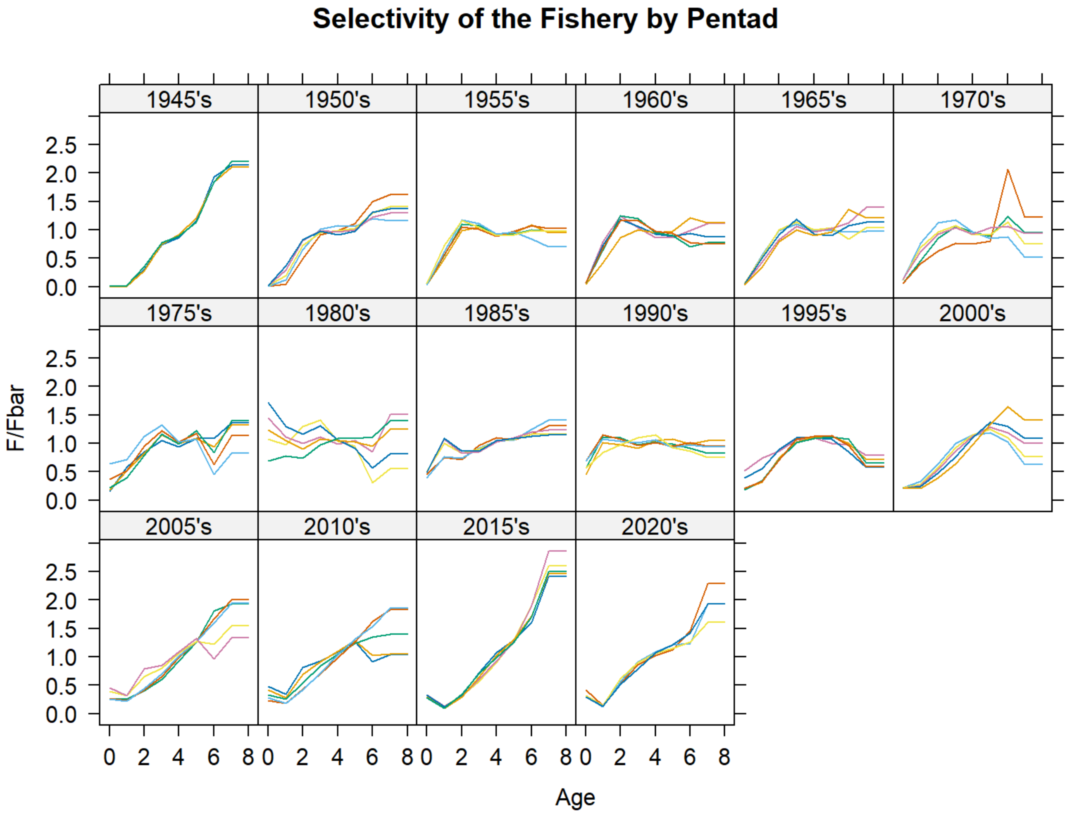


Figure 2.6.2.11. North Sea herring. Fishing selectivity by pentad.

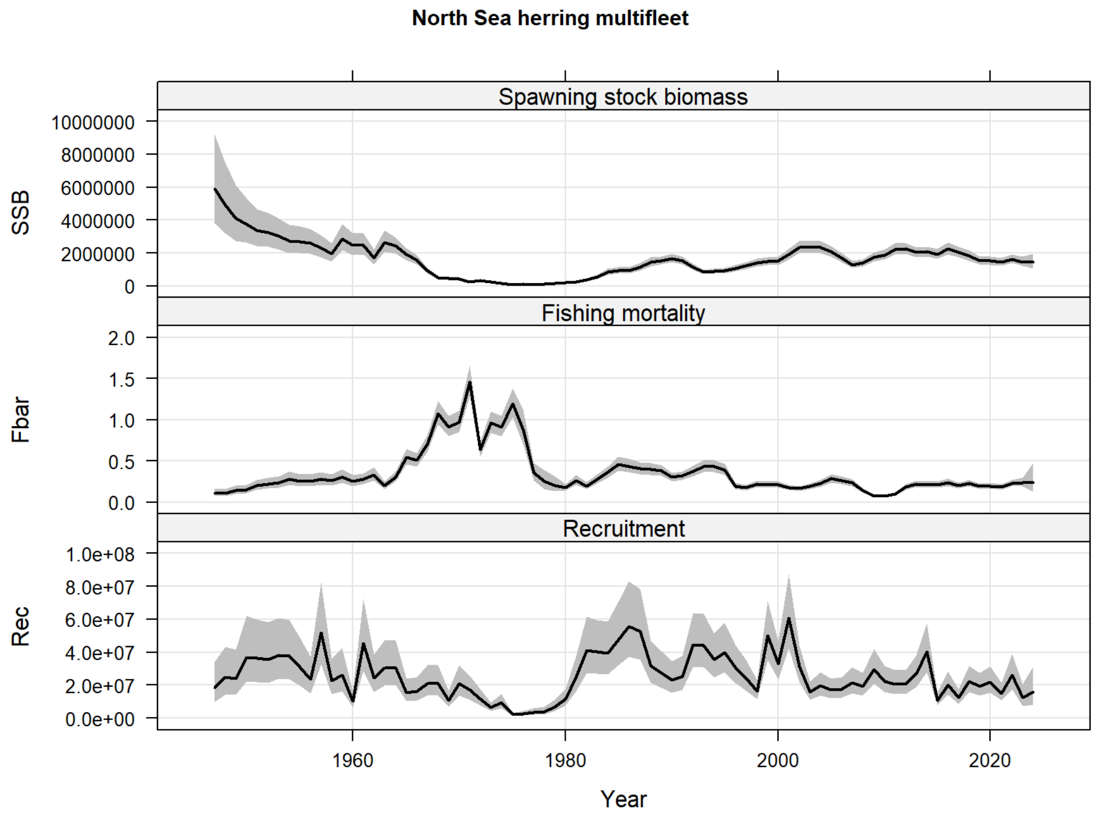


Figure 2.6.3.1 North Sea herring multi-fleet model. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

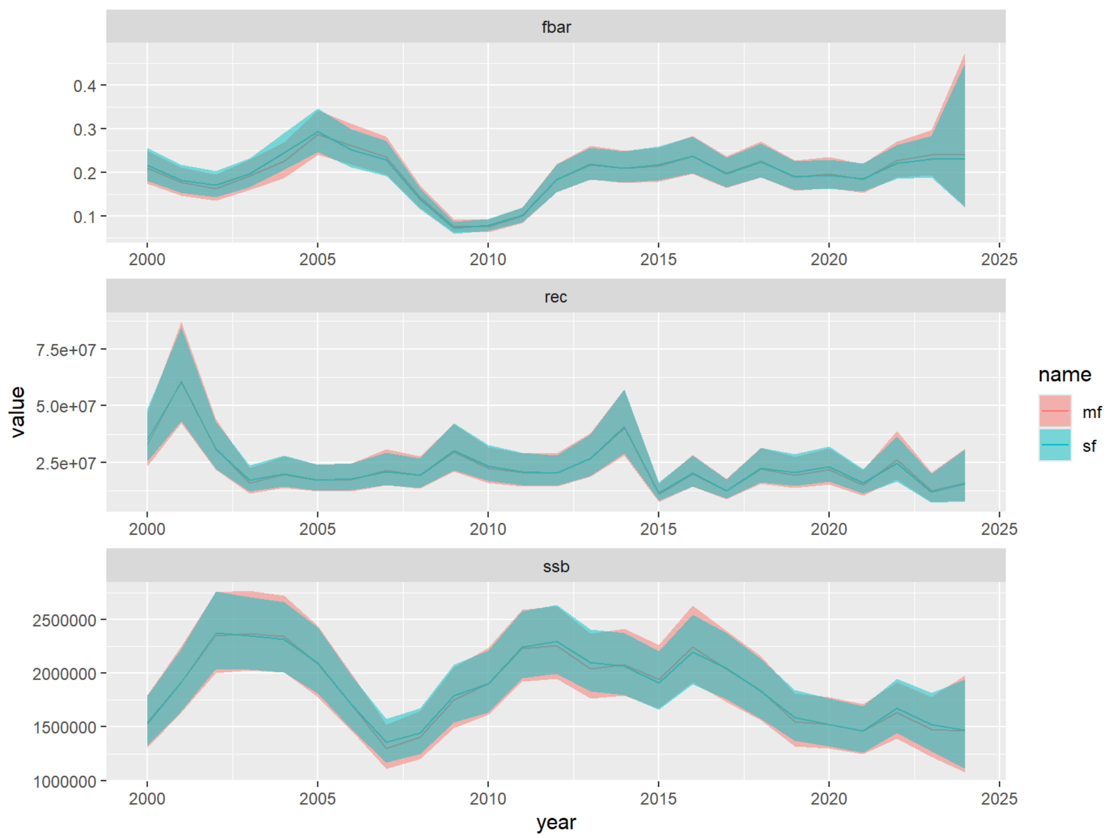


Figure 2.6.3.2 North Sea herring multi-fleet model. Comparison between single fleet and multi-fleet assessment models for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

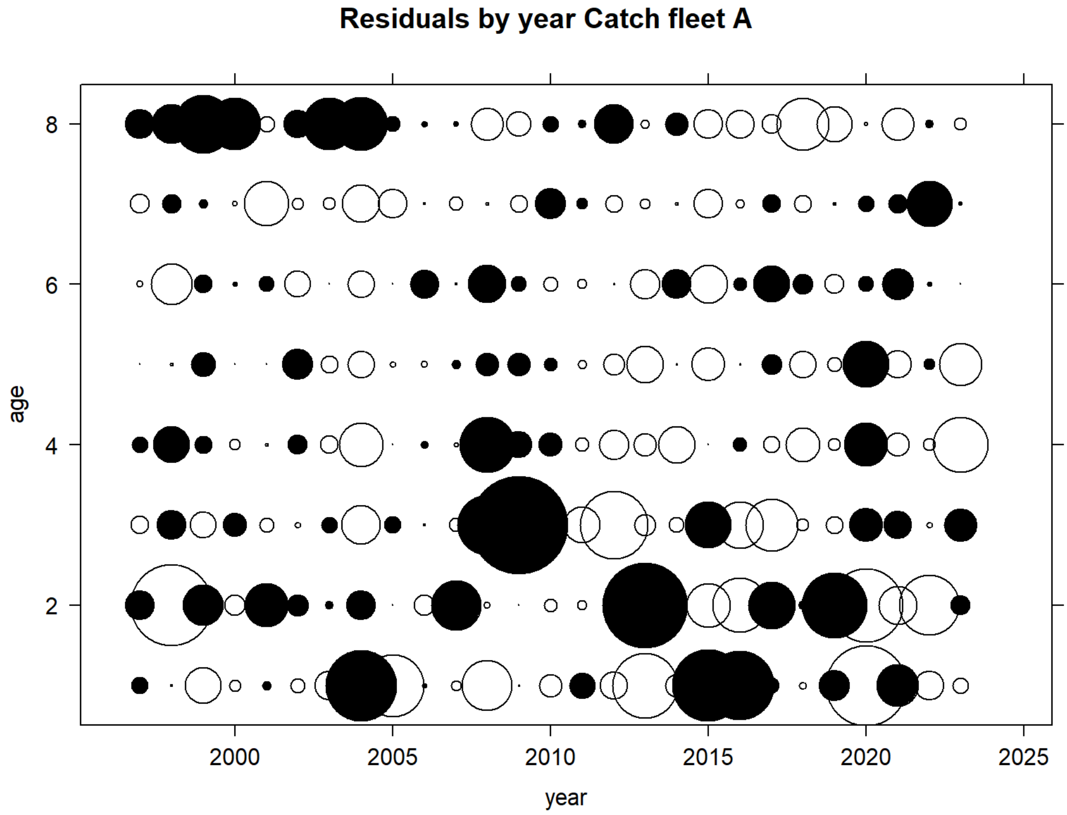


Figure 2.6.3.3. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet A.

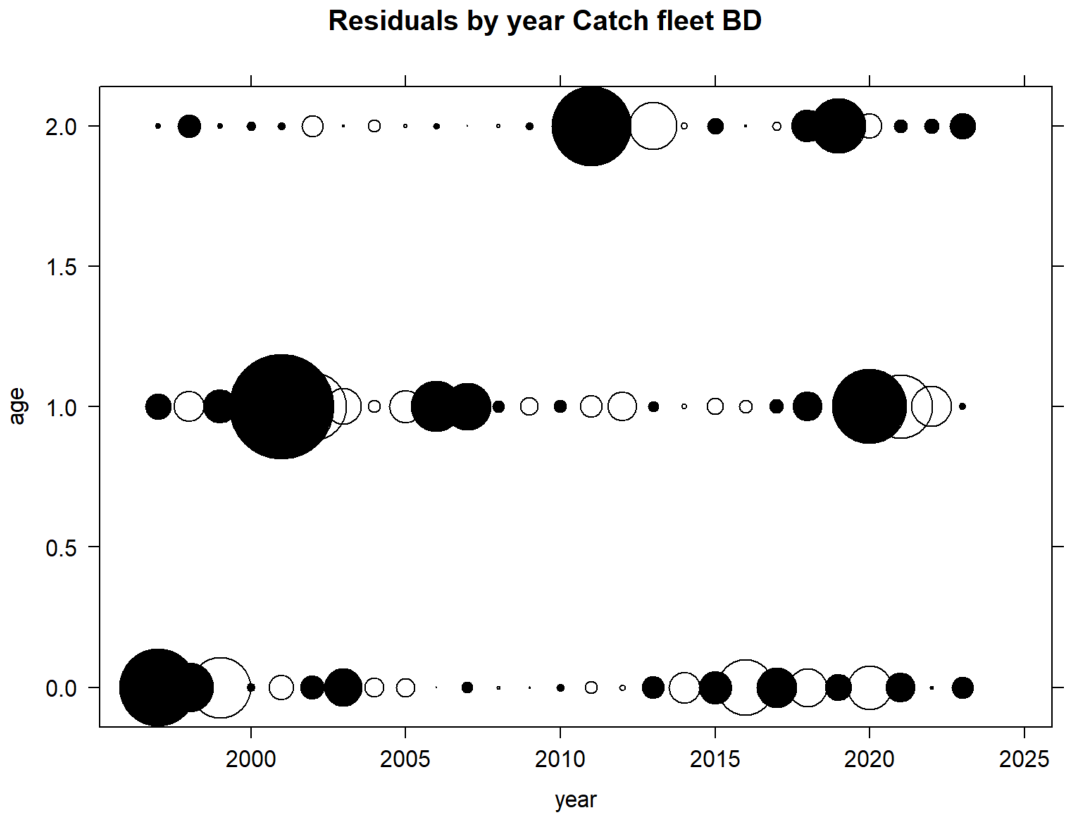


Figure 2.6.3.4. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet B&D.

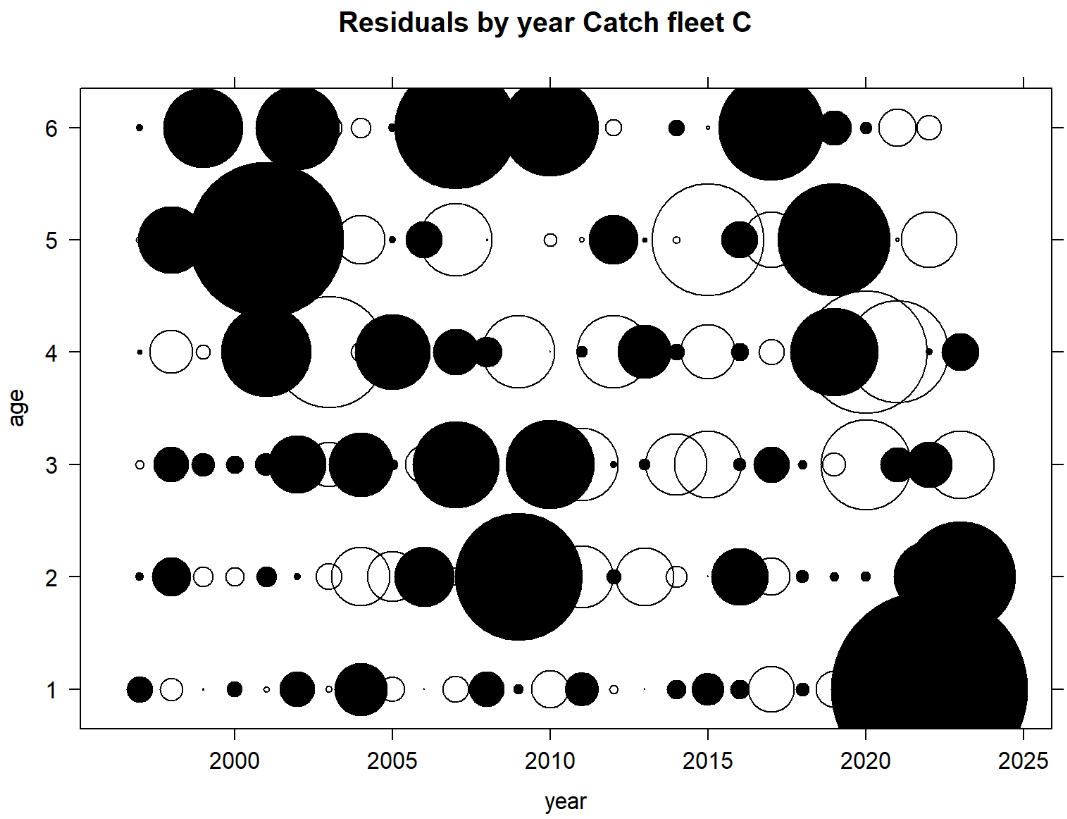


Figure 2.6.3.5. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet C.

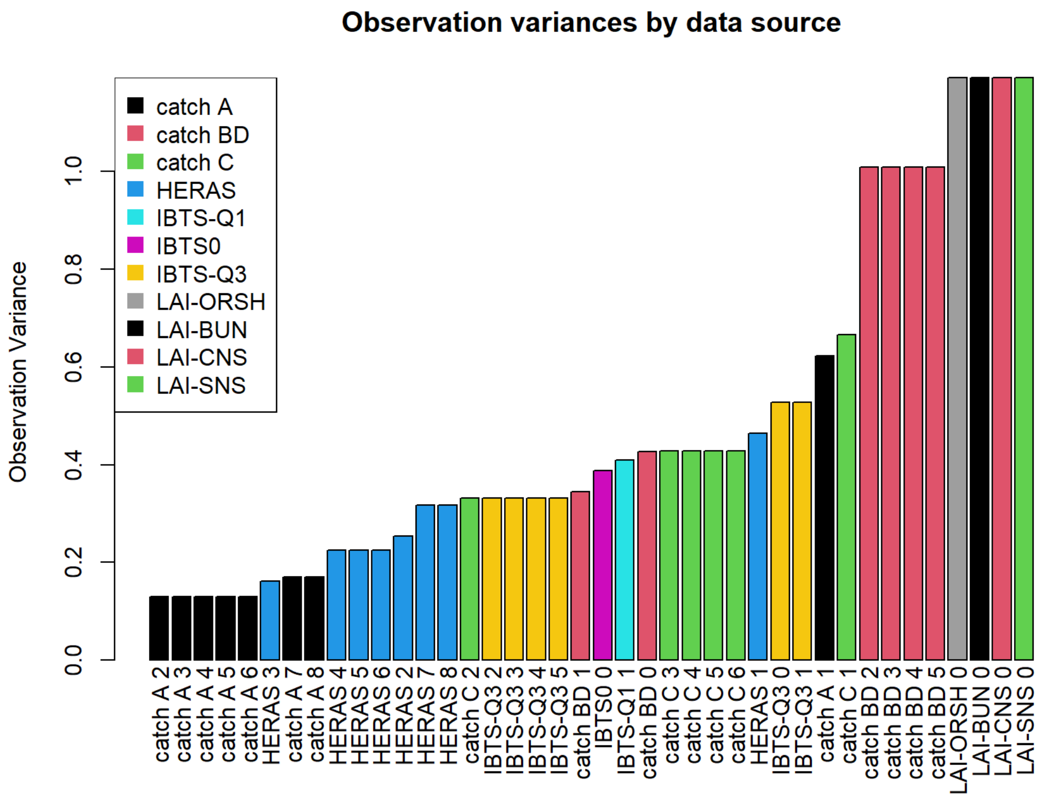


Figure 2.6.3.6. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

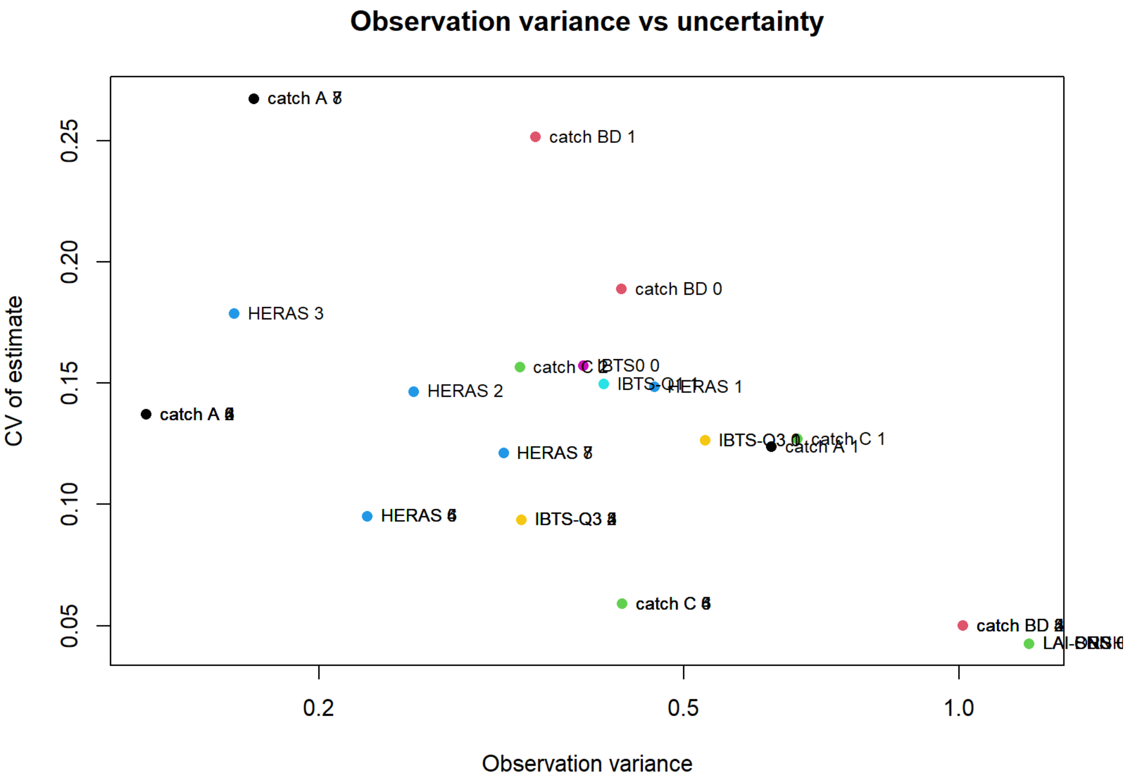


Figure 2.6.3.7. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

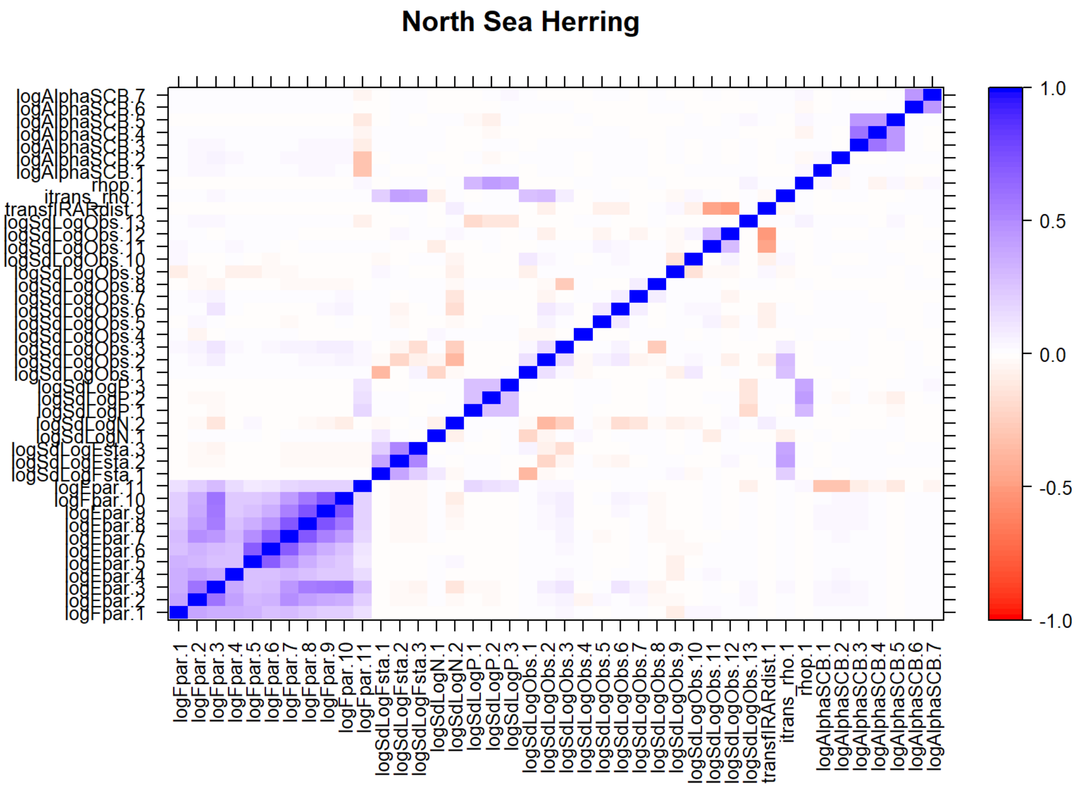


Figure 2.6.3.8. North Sea multifleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

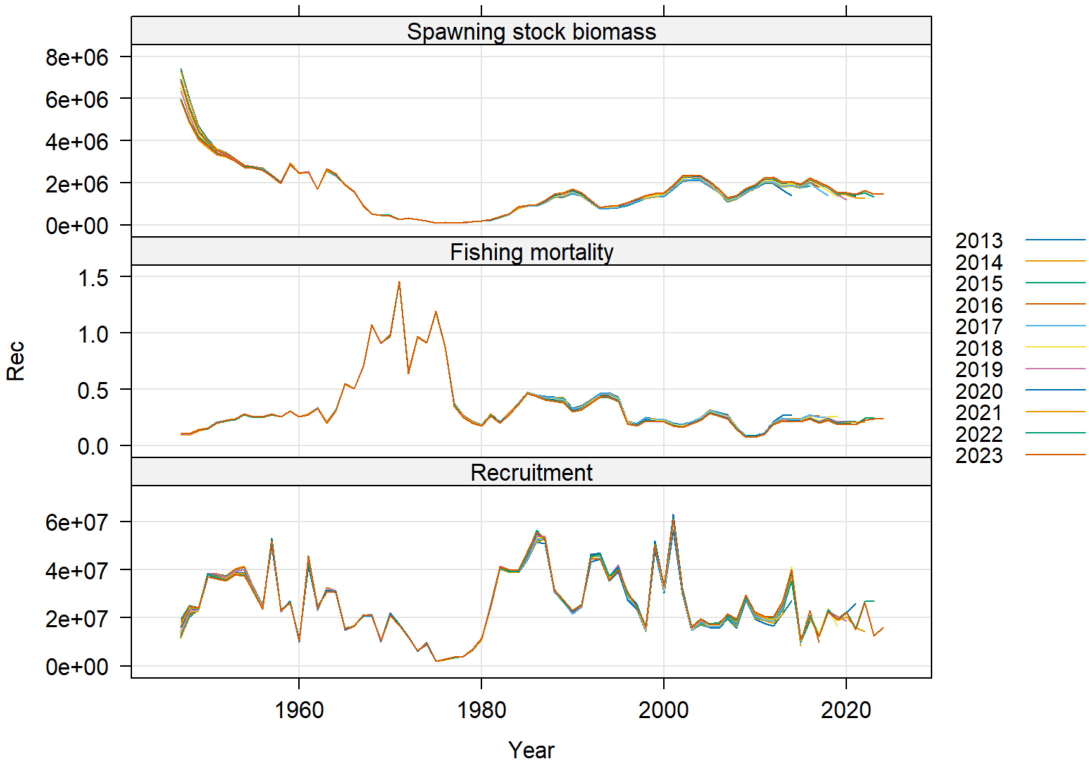


Figure 2.6.3.9. North Sea herring multifleet assessment model. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

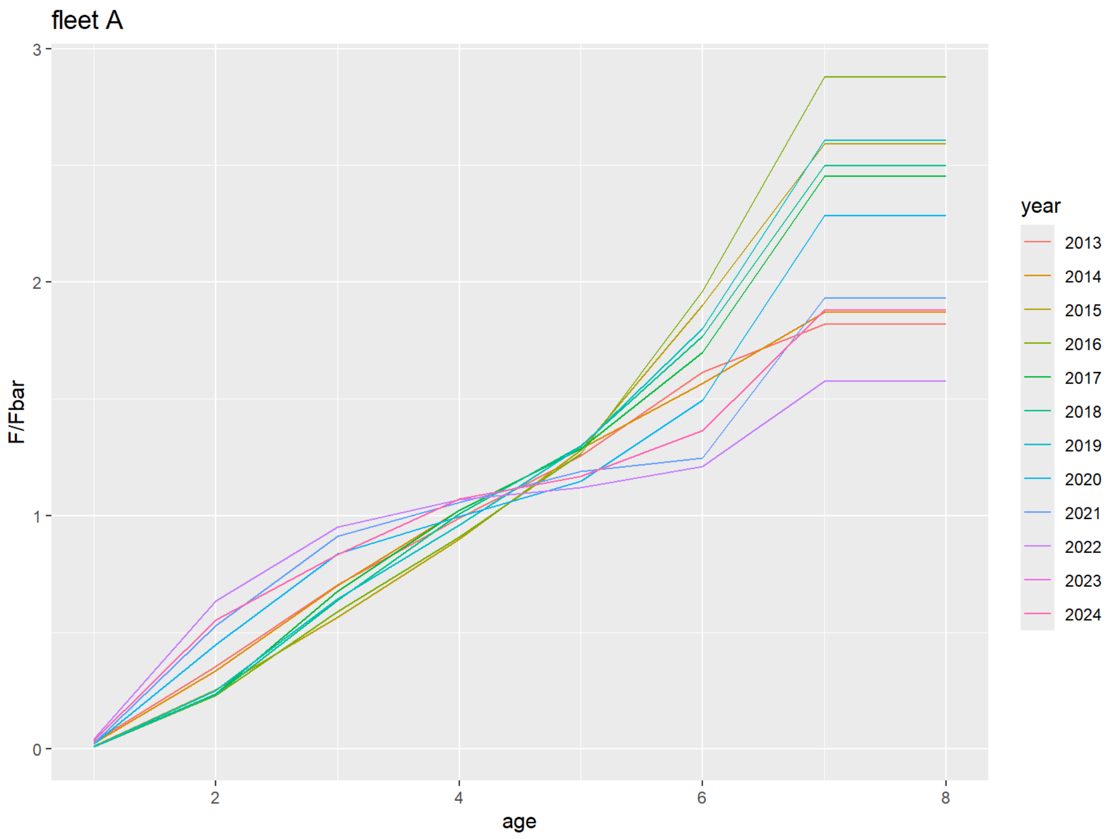


Figure 2.6.3.10. North Sea herring multifleet assessment model. Fishing selectivity fleet A. 2024 is assumed equal to 2023.

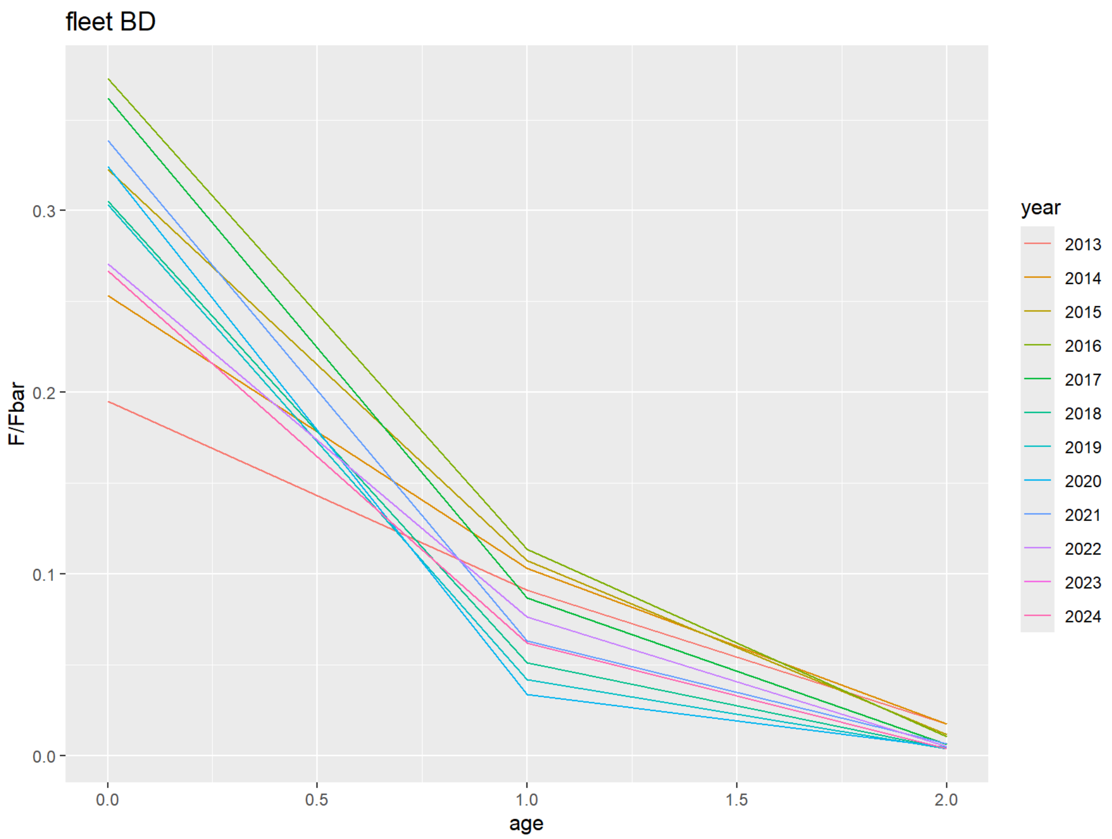


Figure 2.6.3.11. North Sea herring multifleet assessment model. Fishing selectivity fleet B and D combined. 2024 is assumed equal to 2023.

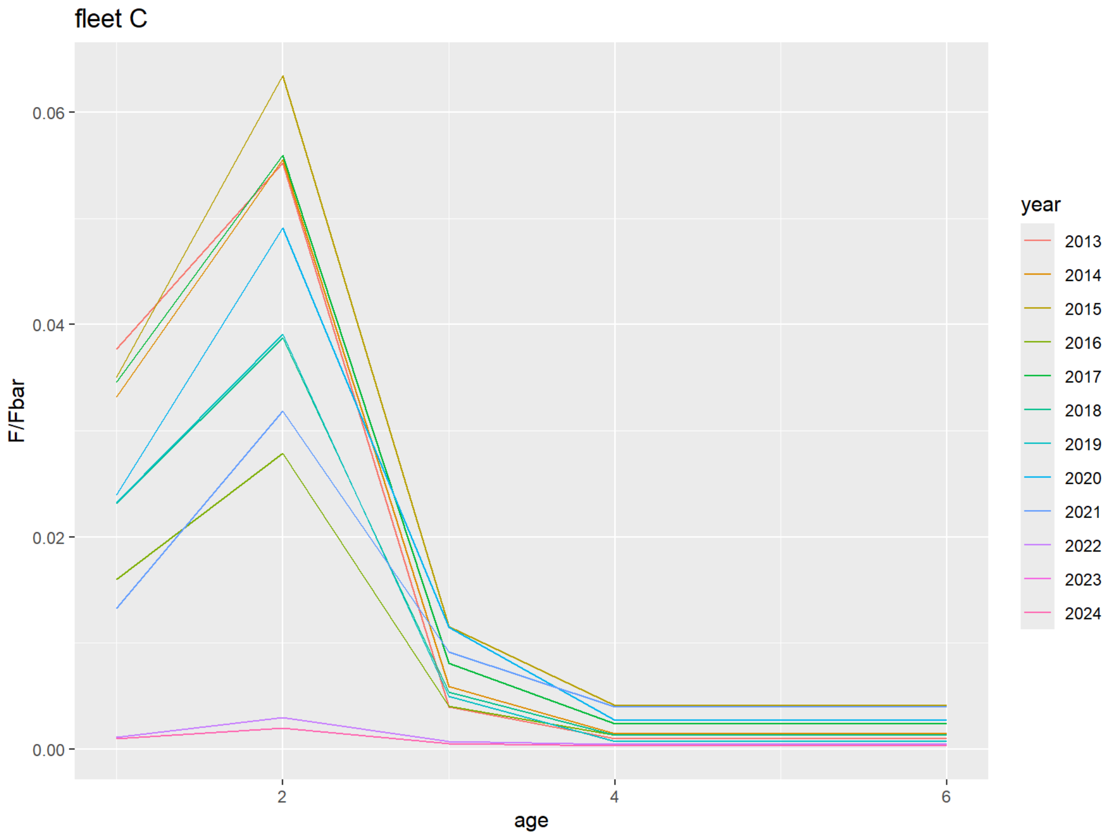


Figure 2.6.3.12. North Sea herring multifleet assessment model. Fishing selectivity fleet C. 2024 is assumed equal to 2023.

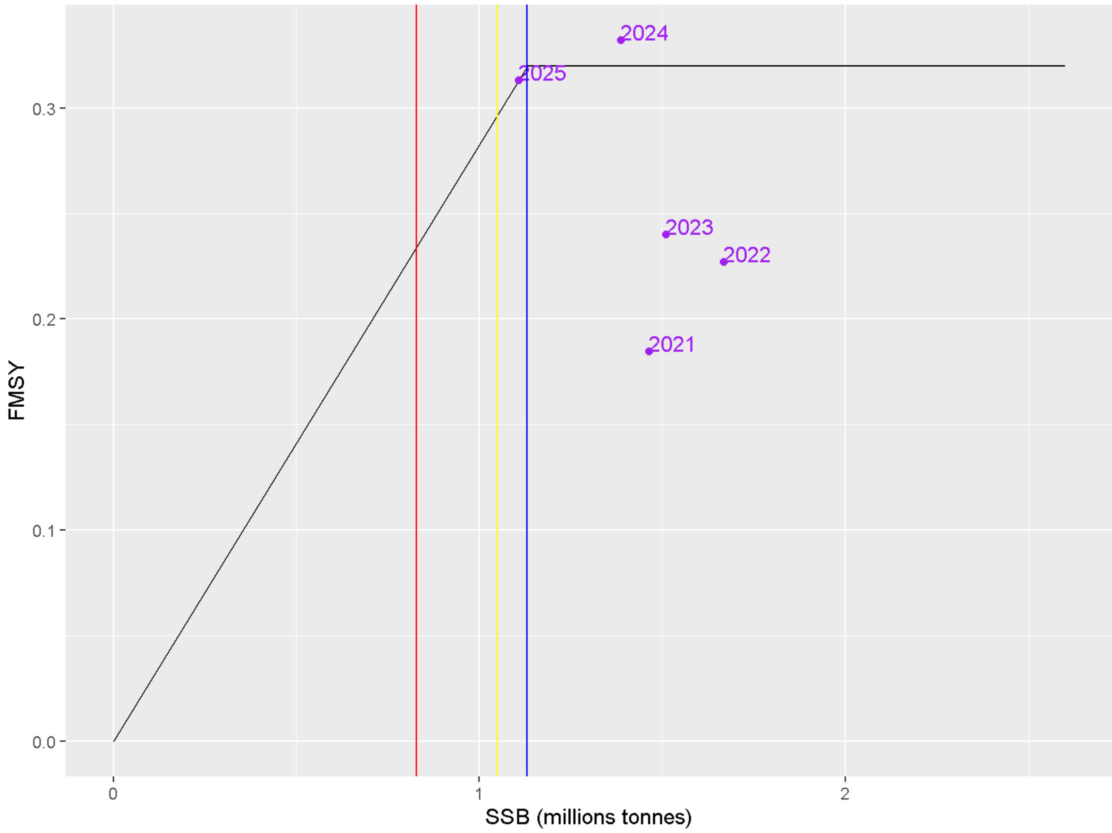


Figure 2.7.1.1. North Sea herring. FMSY advice rule and SSB/Fbar data point since 2021.

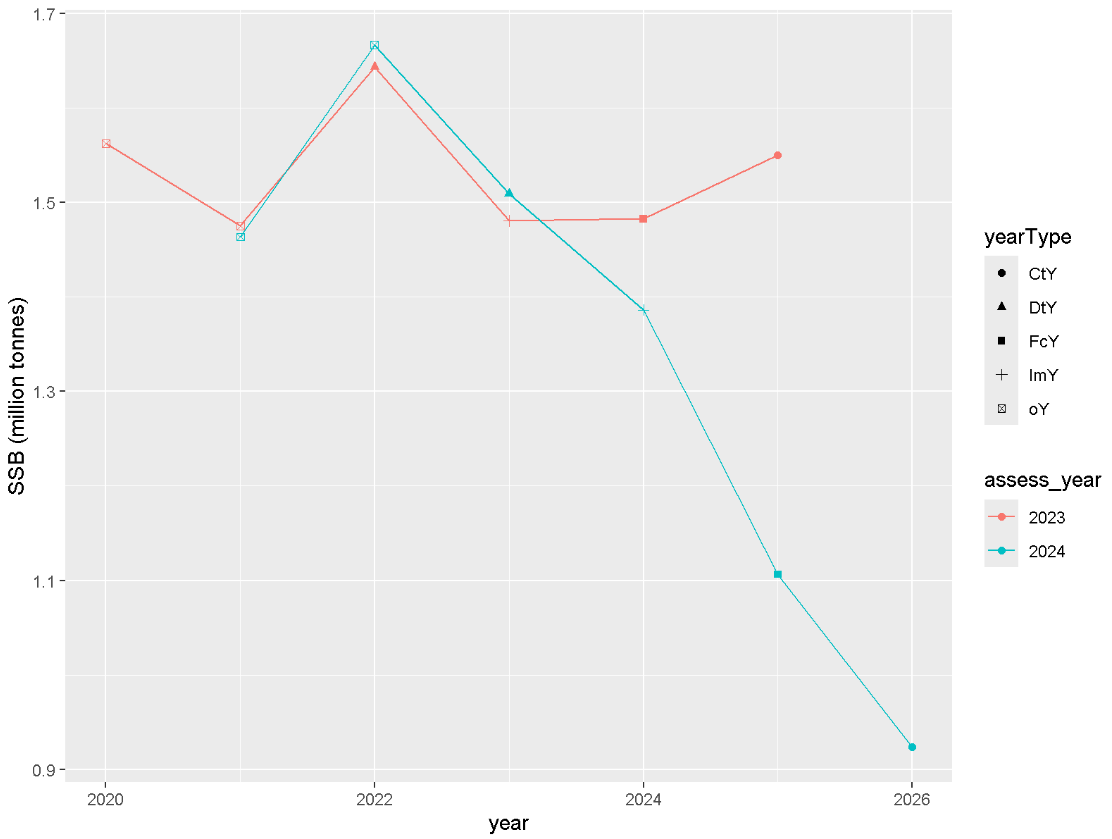


Figure 2.7.2.1. North Sea herring. Comparison of SSB trajectory between short term forecasts applied to HAWG2023 and HAWG2024 data. oY: old years (prior to data year). DtY: data year. ImY: intermediate year. FcY: forecast year. CtY: continuation year.

Figure 2.7.2.2. North Sea Herring. Realized and projected catch (in weight) by age (wr) between 2022 assessment (2023 as forecast year), 2023 assessment (2024 as forecast year) and 2024 assessment (2025 as forecast year).

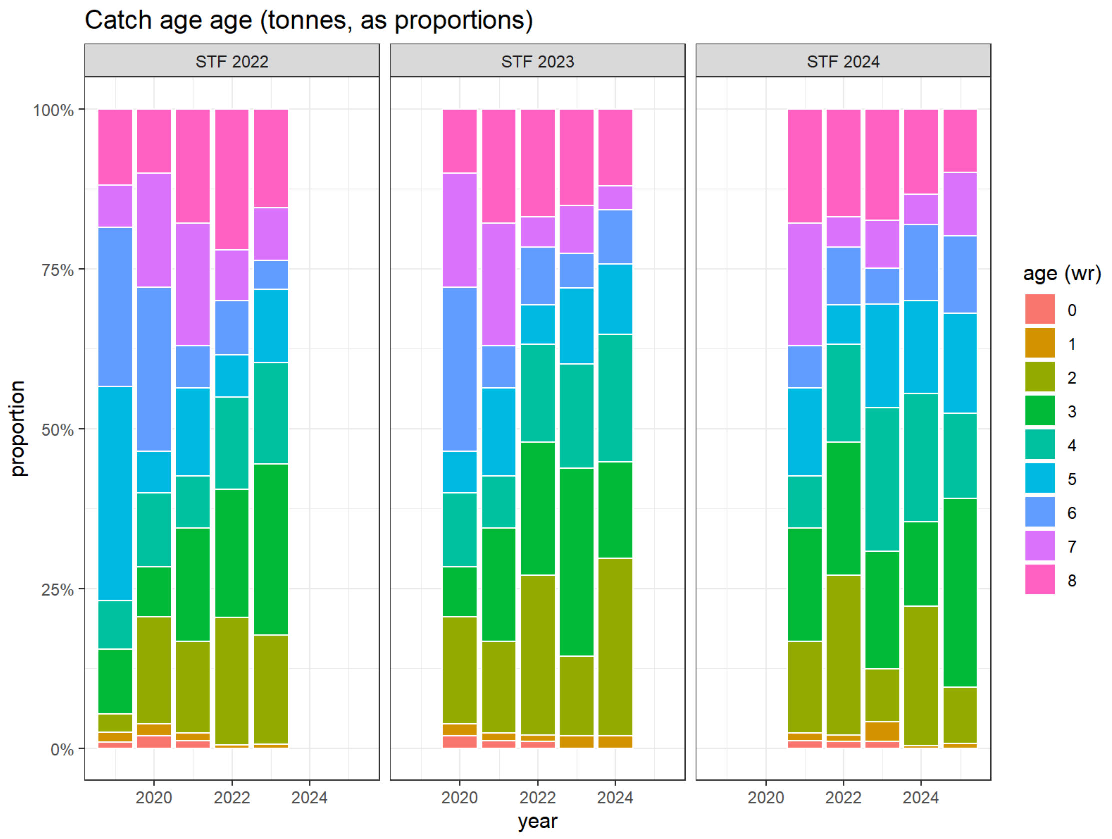
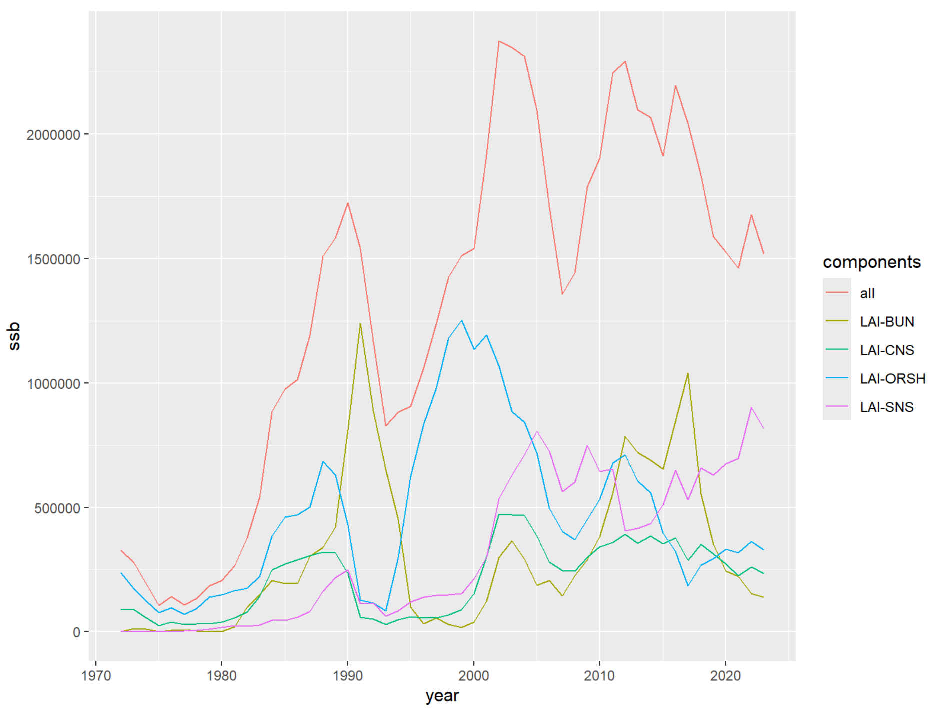


Figure 2.7.2.3. North Sea Herring. Catch proportions for the different ages between the 2022 short-term forecast (2023 as forecast year), 2023 short-term forecast (2024 as forecast year) and 2024 short term forecast (2025 as forecast year).



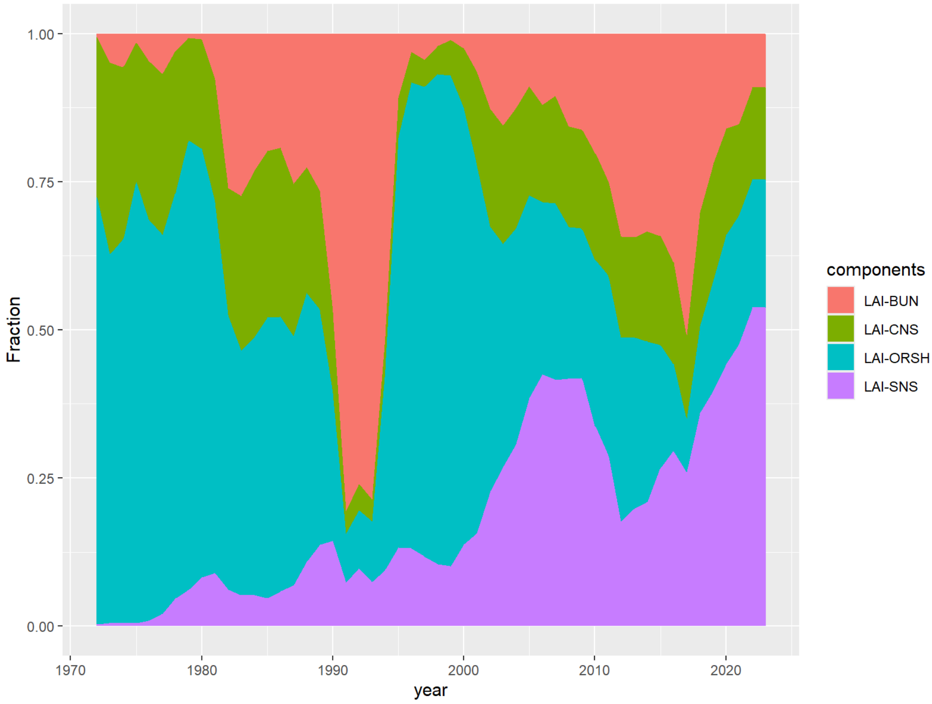


Figure 2.11.1. North Sea herring. Time-series of spawning-stock biomass of each component (top), and contribution of each component to the total stock (bottom; Payne, 2010) as estimated from the LAI index Areas are arranged from top to bottom according to the south-to-north arrangement of the components.

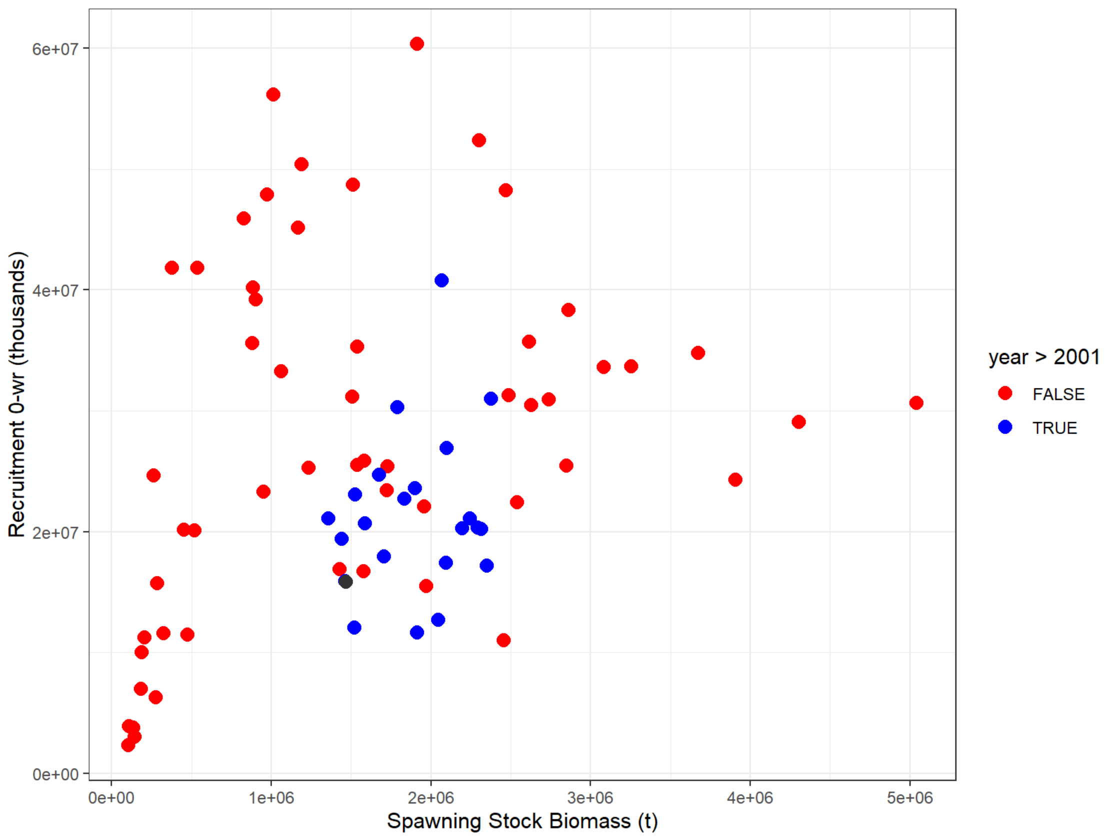


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning-stock biomass against the resulting recruitment. Year classes spawned after 2001 (blue) highlight the years of recent low recruitment. The most recent year class is plotted in grey.

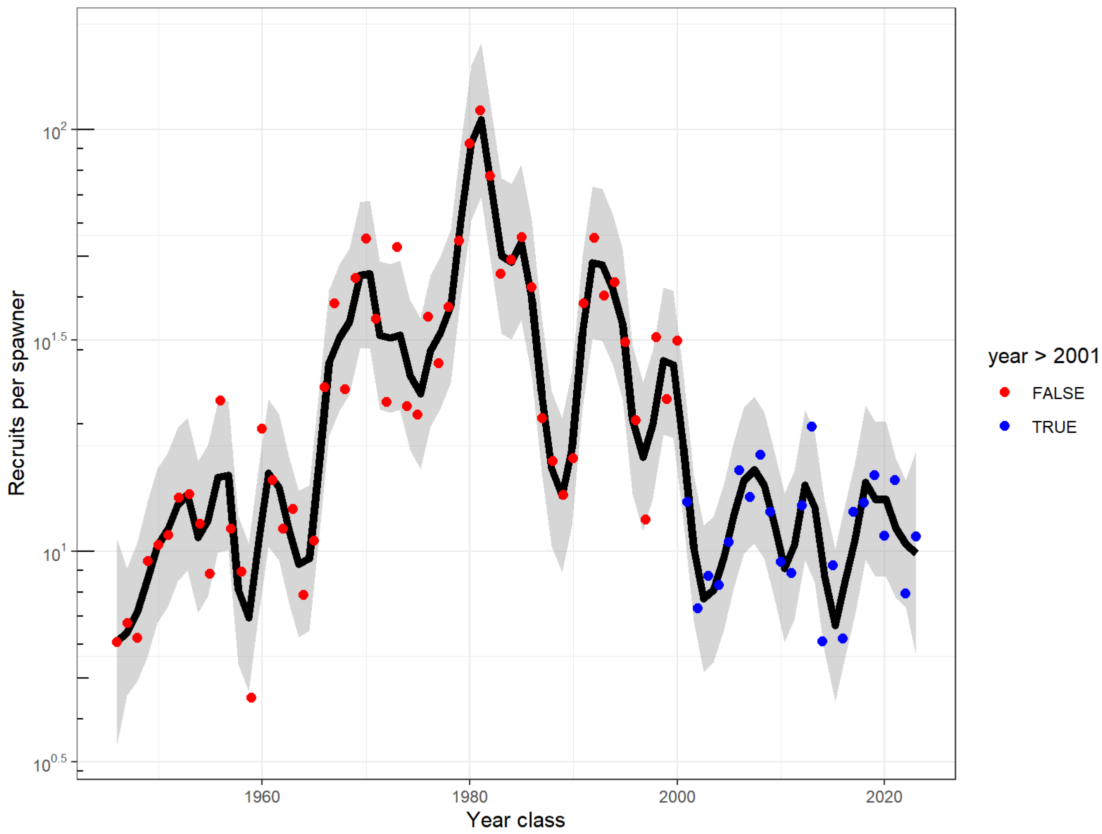


Figure 2.13.2. North Sea Autumn Spawning Herring time-series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Year classes spawned after 2001 (blue) highlight the years of recent low recruitment. Black line: Smoother to aid visual interpretation. Note the logarithmic scale on the vertical axis.

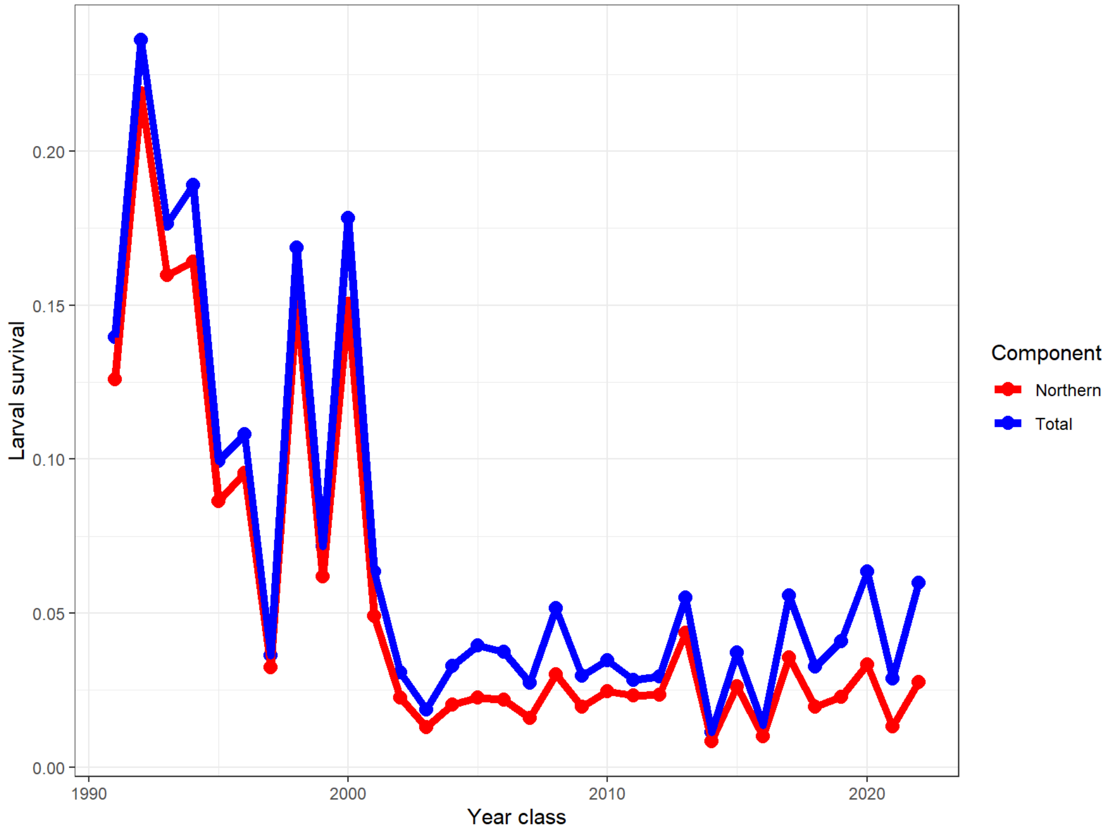


Figure 2.13.3. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the all (blue) and for the northern-most spawning components (Banks, Buchan, Orkney-Shetland; red), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is plotted against the year in which the larvae are spawned.

2.15 Reference list

ICES. 2023. Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 5:74. 122 pp. https://doi.org/10.17895/ices.pub.23607303

ICES. 2021. Inter-Benchmark Protocol of North Sea Herring (IBPNSHerring). ICES Scientific Reports. 3:98. 168 pp. http://doi.org/10.17895/ices.pub.8398

Contents

3 Herring in Division 3.a and subdivisions 22–24, spring spawners [Update Assessment]

3.1 The fishery

3.1.1 Advice and management applicable to 2023 and 2024

ICES advised in 2023 on the basis of the MSY approach and precautionary considerations. This corresponds to zero catch in 2024 (ICES 2023c).

Since 2022, the EU, UK, and Norway agreement on herring TAC for human consumption in Division 3.a is based on agreement on maximum catches taken in 3.a with transfer of the remaining TAC (estimated from the 3.a TAC rule) to the North Sea. Since 2021, the agreement states that the possibility to transfer up to 100% of the human consumption TAC from 3.a to the North Sea. In 2022-2023, the agreement states the possibility to transfer up to 50% for the bycatch small mesh fishery (see Council Regulation (EU) 2023/194 + amendment on 17 March 2023, EU 2023 for more specifics on area limitations on the transfer within the North Sea), and this was increased to 100% in 2024 (see Council Regulation (EU) 2024/257, EU 2024).

For 2024, maximum catches in Division 3.a for both the human consumption and the industrial fishery are set to 969 t for EU countries (EU 2024) and 200 t for Norway (Norway 2024).

Prior to 2006, no separate TAC for subdivisions 22–24 was set. In 2022, a TAC of 788 t was set on the Western Baltic stock component in subdivisions 22–24. The TAC for 2023-2024 was kept constant and set at 788 t.

3.1.2 Landings in 2023

Herring caught in Division 3.a are a mixture of mainly North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). This section gives the landings of both NSAS and WBSS, but the stock assessment applies only to WBSS.

Landings from 1989 to 2023 are given in Table 3.1.1 and Figure 3.1.1. In 2023, the total landings in Division 3.a and subdivisions 22–24 have decreased to 1 709 t. Landings in 2023 increased by 65% in the Skagerrak, by 12% in subdivisions 22–24 and decreased by 80% in the Kattegat compared to 2022. As in previous years the 2023 landing data are calculated by fleet according to the fleet definitions used by the working group (see section 3.1.3).

3.1.3 Fleets

One of the unresolved issues from the benchmark in 2018 was the definition of the fleets, which differs between years and countries (ICES WKPELA, 2018).

The definition of the fleets in the EU TAC and quota regulation, since 1998 (e.g., EU 2017/127 and 2016/1903)

Fleet C: Catches of herring in Kattegat and Skagerrak taken in fisheries using nets with mesh sizes equal to or larger than 32 mm.

Fleet D: Exclusively for catches of herring in Kattegat and Skagerrak taken as bycatch in fisheries using nets with mesh sizes smaller than 32 mm.

Fleet F: Not defined directly in the regulation, but landings from subdivisions 22–24. Most of the catches are taken in a directed fishery for herring and some as bycatch in a directed sprat fishery.

The definition used by HAWG, since 2010.

Fleet C: Directed fishery for herring in Kattegat and Skagerrak in which trawlers (with 32 mm minimum mesh size) and purse seiners participate. Since 2010 *(with the exception of 2022 and 2023)* this fleet also includes the Swedish trawl fishery with mesh sizes less than 32 mm, since an earlier change in the Swedish industrial fishery implies that there is no difference in age structure of the landings between vessels using different mesh sizes since both are basically targeting herring for human consumption.

Fleet D: By-catch of herring in Kattegat and Skagerrak in the industrial fleet and only including Danish landings (except 2022 and 2023 when it includes also the Swedish small-meshed trawl industrial fishery). Covering all fisheries with mesh sizes less than 32 mm, except purse seiners, e.g. the sprat, Norway pout and sandeel fishery, where herring is landed as by-catch.

Fleet F: Landings from subdivisions 22–24. Most of the catches are taken in a directed fishery for herring and some as bycatch in a directed sprat fishery.

Following changes in the management of fishing opportunities of herring in 3a in 2022, the fishery had the possibility to transfer up to 100% of the EU human consumption TAC and 50% of the by catch small mesh fishery TAC to the North Sea. This resulted in a decrease of herring catches in all the main fisheries conducted in 3a, but also altered the relative contribution of the small and large mesh size fisheries to the herring catches in the area. In 2022, the relative importance of small and large mesh size fisheries in 3a became more comparable, with 35% of herring catches as bycatches in the small mesh fishery (48% in the Swedish fishery). To reflect this emerging pattern, since 2022 catches by the Swedish fishery with mesh sizes less than 32 mm have been included in the D-fleet catches together with the Danish landings. The pattern in 2023 is similar to 2022 and it was decided to include the Swedish small mesh trawl fishery in the D fleet as in 2022.

In Table 3.1.2 the landings are given for 2004 to 2023 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

The text table below gives the TACs (t) for the fishery by the C- and D-fleets in Division 3.a and for the F-fleet in subdivisions 22–24.

	TAC	DK	GER	FI	PL	SWE	EC	NOR
2023								
C-fleet total	23 250	9 771	156			10 221	20 148	
To be taken in Div. 3.a	1 279	559	7			403	969	310
D-fleet total	6 659	5 692	51			916	6 659	
To be taken in Div. 3.a	1 279	559	7			403	969	
SD 22–24 F-fleet	788	110	435	0	103	140	788	
% of 3.a C-fleet can be taken in 4.b EU waters							50%	
% of 3.a C-fleet can be taken in 4 UK waters							50%	
% of 3.a D-fleet can be taken in 4 EU waters	50%							

	TAC	DK	GER	FI	PL	SWE	EC	NOR
2024								
C-fleet total	29 735	12 498	200			13 073	25 771	3 964
To be taken in Div. 3.a	1 169	554	8			407	969	200
D-fleet total	6 659	5 692	51			916	6 659	
To be taken in Div. 3.a	1 279	554	8			407	969	
SD 22–24 F-fleet	788	110	435	0	103	140	788	
% of 3.a C-fleet can be taken in 4.b EU waters							50%	
% of 3.a C-fleet can be taken in 4 UK waters							50%	
% of 3.a D-fleet can be taken in 4 EU waters	100%							

3.1.4 Regulations and their effects

Before 2009, HAWG has calculated that a substantial part of the catch reported as taken in Division 3.a in fleet C actually was taken in Subarea 4. These catches have been allocated to the North Sea stock and accounted for under the A-fleet at earlier HAWG meetings. Misreported catches have been moved to the appropriate stock for the assessment. However, from 2009 and on onwards, information from both the industry and VMS estimates suggests that this pattern of misreporting does no longer occur. Therefore, no catches were reallocated from Division 3.a to the North Sea for catches taken in 2023.

Since 2011 the EU-Norway agreement allowed 50% of the Division 3.a quotas for human consumption (Fleet C) to be taken in the North Sea. The optional transfer of quotas from one management area to another introduces uncertainty for catch predictions and thus influence the quality of the stock projections. To decrease the uncertainty industry agreed in the 2013 benchmark to inform HAWG prior to the meeting of the assumed transfer in the intermediate year. In the last few years this information has proved to be highly valuable and consistent with the realized distribution of the catches.

In 2021-2024, following the agreed record from the bilateral consultations between the EU and Norway for Skagerrak, the C-fleet inter-area flexibility from Division 3.a to Subarea 4 has been increased to 100%, and a flexibility of 100% has been given in 2024 to the D-fleet, in order to protect WBSS herring. In addition, in 2022-2024, EU committed to limit overall herring catches in Division 3.a to 969 t and Norway to limit those to 167 t in 2022, 310 t in 2023, and 200 t in 2024.

The quota for the C fleet and the bycatch TAC for the D fleet are set for the NSAS and the WBSS stocks together. The implication for the catch of NSAS must also be considered when setting herring quotas for these fleets in 3a.

3.1.5 Winter rings vs. ages

To avoid confusion and facilitate comparability among herring stocks with different “spawning style” (i.e., NSAS) the age of WBSS, as well as other HAWG herring stocks, is specified in terms of winter rings (wr) throughout the entire assessment and advice. In the case of WBSS perfect correspondence exists between wr and age with no actual risk of confusion, so that a wr 1 is also an age 1 WBSS herring.

3.2 Biological composition of the landings

The 1 709 t of landed herring were submitted stratified by area, fleet, and quarter, resulting in 41 strata with landings. 19 of these strata were sampled – accounting for 54% of the landings. Some strata with relatively large amounts of landings were unsampled and only 11 out of 77 samples were from Skagerrak and Kattegat (Table 3.2.1). Unsampled strata accounted in total for 780 t and samples from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 3.2.2).

Table 3.2.3 show the total catch in numbers and mean weight-at-age in the catch for herring by area, quarter and fleet.

Based on the proportions of spring- and autumn-spawners in the landings, catches were split between NSAS and WBSS (Table 3.2.4 and the stock annex for more details).

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat and Skagerrak were then estimated by quarter and fleet (NSAS in Table 3.2.5 and WBSS in Table 3.2.6).

In 2023, the age composition for the A-fleet in the transfer area was taken directly from the transfer area rather than from the entire Division 4aE given that samples were available in the Norwegian catches.

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Division 3.a in 2023 was estimated to be 2 616 t, which represents a decrease of 47% compared to 2022 (Table 3.2.7).

Total catches of WBSS from the North Sea, Division 3.a, and subdivisions 22–24 by quarter, were estimated to be 3 338 for 2023 (Table 3.2.6). Additionally, the total catches of WBSS in numbers and tonnes, divided between the North Sea and Division 3.a and subdivisions 22–24 respectively for 1993–2023, are presented in table 3.2.7.

The total catch of NSAS in Division 3.a amounted to 732 t in 2023, which represents the second lowest value in the 28-year time-series (Table 3.2.8).

The catches of WBSS and NSAS from Subdivision 4.aE and Division 3.a in 2023 were reallocated to the appropriate stocks as shown in the text table below:

Area	WBSS (tonnes)		NSAS (tonnes)	
Subdivision 4.aE (A-fleet)	2 361		16 365	
Division 3.a	C-fleet	D-fleet	C-fleet	D-fleet
	194	61	563	169

Catches of WBSS and NSAS from the 4.aE transfer area since 2021 are shown in text table below:

Year	NSAS (t)	WBSS (t)
2021	7 906	3 505
2022	85 521	5 402
2023	16 365	2 361

3.2.1 Quality of Catch Data and Biological Sampling Data

No quantitative estimates of discards were available to the Working Group from all countries, but the overall amount of discards for 2022 is assumed to be insignificant, as in previous years.

Table 3.2.1 shows the number of fishes aged by country, area, fishery, and quarter. The overall sampling in 2023 meets the recommended level of one sample per 1000 t landed per quarter, but the coverage of areas, times of the year and gear (mesh size) is problematic, since landings from Kattegat and Skagerrak are poorly covered.

Splitting of 2023 catches into WBSS (Spring spawners) and NSAS (Autumn spawners) in Division 3.a was based on genetic analyses for both Swedish and Danish catches. The use of genetic methods (Sweden used otolith microstructure (OM) until 2021) provides higher resolution in the separation of the main spawning components and a more consistent method of stock assignment now that it is implemented by all the countries with catches in this division. In particular, the winter spawning component from the Downs can be specifically identified and allocated to the catches of the NSAS herring stock while the previous method based on OM was unable to partition this spawning component from other winter spawners which are likely to occur in 3.a (Rosenberg and Palmen 1981).

For Danish data, a genetic stock identification method was used to classify individual fish to genetic stock origin. The total sample size for hatch type was 2516 (1595 Danish and 921 Swedish) with 62% of the samples in Subdivision 20 (Skagerrak) and 38% in Subdivision 21 (Kattegat). Sampling from the Danish fishery had a lower coverage of quarters and subdivisions than sampling of the Swedish fishery. Proportions of WBSS in sampled age classes were weighted by the national catches in the respective quarters and subdivisions. The sampling did not cover all age classes and thus proportions were estimated using information from relevant adjacent age classes, or from cruises in the same quarter and subdivision. Proportions were estimated for commercial catch by country, wr, quarter, and subdivision by a logistic mixed effects regression model. The default model included wr, subdivision, quarter, and cruise as fixed effects and had a random intercept varying by trip/haul[1]. Both commercial and survey samples from both countries were used in the analysis. Total composition estimates per wr, quarter, and subdivision were calculated as a weighted average of the country-wise estimates. Total estimates were only calculated for combinations of wr, quarter, and subdivision with catches. For combinations with Danish or Swedish catches, the country-wise estimates were weighted by the catches. For combinations without Danish and Swedish catches, country-wise estimates were weighted by the sum of catches for the relevant quarter and subdivision.

Random samples of 496 individual herring from Norwegian, Danish and Swedish commercial catches in the "transfer area" in 4.aE are analysed for size at age distribution and stock affiliation based on a genetic stock identification method using an extended SNP panel comparable to Bekkevold et al. 2023. In addition, Norwegian and Danish samples from HERAS and Swedish IBTS samples are included (882 individuals). A common baseline with small deviations was used for stock identification for Danish/Swedish and Norwegian samples. Based on expected OM/vertebral series counts, genetic stock origin was converted to NSAS/WBSS to continue the historical time series. Catches from the so called "transfer area" are split into proportions of NSAS and WBSS by quarter and wr based on a logistic mixed effects regression model.

A total of 18 728 tonnes of herring was caught in the transfer area in 2022, with catches constituting 50% in quarter 3 and 33% in quarter 4. Compare to 2022 the catches in the transfer area decreased by 486% in 2023.

For quarter 2 and 3, the same split was applied based on the combined samples from surveys and the fishery in the transfer area (1196 fish). This was done under the assumption that the

[1] In the R formula syntax, the regression model is ~ bs(wr,3) + bs(wr,3) * SubDivision + bs(wr,3) * Cruise + bs(wr,3) * Quarter + wr0Quarter + (1|TripID), where bs(-,3) is a B-spline with 3 knots, and wr0Quarter is a factor with a level per quarter for 0 wr and a combined level for 1+ wr. Winter rings were capped at 8 in the analysis.

fishery is restricted to the same period as HERAS/IBTS in June and July and would catch similar proportions of the two stocks in this period. The default regression model included a B-spline on wr with 5 knots and additional dummy variables for commercial samples wr 1, 2, and 3 to account for different selectivities. Finally, a random intercept varying by trip/haul was included. Due to the properties of the specific samples available for 2023, it was necessary to reduce the number of spline knots to 3 to ensure the model was identifiable and converged properly.

Due to lack of sampling data in 2023 the split for quarters 1 and 4 were handled differently. For quarter 4, raw proportions from 108 individuals were used as composition estimates, without accounting for within-sample correlation. For quarter 1, raw proportions were used for ages 1-3, based on 74 individuals, while the split had to be carried over from 2021 for other ages. Quarter 1 and 4 estimates from 2021 were based on data from the time-series of samples from the commercial fishery with respectively 48 (from 2016 Q1) and 342 herring (from Q4 in 2008, 2012 and 2014) available for the analysis.

Based on the splitting method, 2 361 tonnes of WBSS herring were caught in the transfer area in 2023.

There are clear indications from weight at age of mixing with Central Baltic herring in catches from SD 24 throughout the year from most of the countries. However, the catches are dominated by the German directed fishery in the spawning areas where mixing is likely to be minimum.

Catch data were not corrected for this mixing neither for potential catches of Western Baltic Spring-spawning herring in SD 25–26.

3.3 Fishery-independent Information

3.3.1 German Autumn Acoustic Survey (GERAS) in subdivisions 21-24

As a part of Baltic International Acoustic Survey (BIAS); the German autumn acoustic survey (GERAS) was carried out with R/V "SOLEA" between 4–24 October 2023 in the Western Baltic, covering subdivisions 21, 22, 23 and 24. A survey report is given in the report of the 'ICES Working Group of International Pelagic Surveys' (ICES WGIPS, 2022). In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning (WBSS) herring and the Central Baltic herring (CBH) overlap. Survey results indicated that in SD 24, which is part of the WBSS herring management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSS stock indices (ICES 2013/ACOM:46). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSS herring in the area (Gröhsler et al., 2013; Gröhsler et al., 2016). The estimates of the growth parameters from baseline samples of WBSS and CBH in 2011-2018 and 2020-2023 support the applicability of the SF (Oeberst et al., 2013; WD/WGIPS Oeberst et al., 2014, 2015; WD/WGBIFS Oeberst et al., 2016, 2017; WD/WGBIFS Gröhsler and Schaber, 2018, 2019; WD/WGIPS Gröhsler and Schaber 2021, WD/WGIPS Gröhsler and Schaber 2022, WD/WGIPS Haase and Schaber 2023, 2024). The applicability of the SF could not be tested in 2019 due some higher degree of mixing of CBH/WBSS in the baseline area of WBSS herring in SDs 21 and 23. In 2023, genetic samples were taken on all aged fish so that the applicability of the SF can be re-tested. The data were not readily analysed before HAWG 2024.

As in the previous two years, there was again a large aggregation of herring in rectangle 41G2 (SD23) recorded with the echosounder. Biological information could not be collected this year, however haul information from previous years yielded a substantial sample of almost exclusively large herring with a high proportion of individuals that were preparing to spawning (maturity 4-6), and already spent (maturity 8). Genetic samples confirmed that the majority of that whole was not of WBSSH origin. Since the herring could not be allocated to WBSS, both the hydroacoustic data from that aggregation as well as the biological data from that haul were removed from the further analysis for producing a biomass and abundance estimate for WBSS.

Individual mean weight, total numbers and biomass by age as estimated from the GERAS-Index (covering the standard survey area, which generally excludes 43G1/43G2 in SD 21 and 37G3/37G4 in SD 24) are presented in Table 3.3.1. The Western Baltic spring spawning herring GERAS-Index including age classes 1-4 in 2023 was estimated to be 0.66 x 10^9 fish or about 31.41 x 10^3 tonnes in subdivisions 21–24.

The years 1991–1993 were excluded from the assessment due to different recording method and 2001 was also excluded from the assessment since SD 23 was not covered during that year (ICES 2008/ACOM:02).

Age (wr) classes (1–4) are included in the assessment.

3.3.2 Herring Summer Acoustic Survey (HERAS) in Division 3.a and the North Sea

The Herring acoustic survey (HERAS) was conducted from 28 June to 20 July 2023 and covered the Skagerrak and the Kattegat and the North Sea. The 2023 estimate of Western Baltic Spring Spawning herring 3+ group is 45 000 tonnes and 319 million. Compared to the 2022 estimates of 77 000 tonnes and 483 million fish, this equals a decrease of 42% in biomass. In 2022 the fish of age 2-wr was the single largest component of the stock (32% of overall abundance). In 2023 this year class, now at 3-wr still account for 21% of the total stock. The single largest age component in 2023 however was 1-wr fish that accounted for 35% in contrast to the almost complete lack of 1 winter ring fish in both 2021 and 2022. The numbers of older herring (3+ group) accounted for 49% of the total stock in 2023. The results from the HERAS index are summarised in Table 3.3.2.

The 1999 survey was excluded from the assessment due to different survey area coverage.

Ages (wr) 3–6 are used in the assessment.

3.3.3 Larvae Surveys (N20)

Herring larvae surveys (Greifswalder Bodden and adjacent waters; SD 24) were conducted in the western Baltic Sea at weekly intervals during the 2023 spawning season (March–June). The larval index was defined as the total number of larvae that reach the length of 20 mm (N20; Table 3.3.3; Oeberst et al., 2009). With an estimated product of **1 516 million** larvae, the 2023 N20 recruitment index is > 4 times lower than in 2022 (6 603 million) when the index exceeded the time series mean (1992-2022: 6 137 million) for the first time after 11 years. Thus, after two years of increasing larval production, the N20 index is smaller again in 2023 and is noticeably below the long-term average (1992-2023: 5 992). For further details see WD Polte, Haase and Kotterba, HAWG 2024.

The larval index is used as recruitment index age (wr) 0) in the assessment.

3.3.4 IBTS/BITS Q1 and Q3-Q4

Since the recent benchmark (ICES, WKPELA 2018), the IBTS and the BITS data are combined according to the standardization methodology proposed by Berg et al., (2014) (hauls showed in Figures 3.3.1-3.3.2). In addition to the standardization model, two extra modelling steps are included, which consist of splitting the survey length and age data by stock using subsamples of stock- identified individuals (limited to the IBTS and not for the BITS). First, the length distributions are split by haul into WBSS / non-WBSS. Next the individual age samples are split into WBSS / non-WBSS. This gives a stock-specific ALK, which is used to convert the split length distributions from the first step into numbers-at-age by haul. Stock proportions for splitting are based on otolith microstructure (OM) until 2021 and genetics since 2022 from the IBTS samples. The genetic assignment (7 spawning components) was harmonised to the spawning type (3 spawning types) inferred by the OM which assume that only OM4 (Spring-spawning) contribute to the WBSS fraction, while OM9 and OM12 (Autumn and Winter spawning) are considered non-WBSS as follows:

Genetic component	OM spawning type	stock
Baltic Autumn	Autumn (OM9)	NSAS
Central Baltic Spring	Spring (OM4)	WBSS
Downs	Winter (OM12)	NSAS
North Sea Autumn	Autumn (OM9)	NSAS
Norwegian Spring	Spring (OM4)	WBSS
Western Baltic Spring	Spring (OM4)	WBSS

The same formulation was used for the presence/absence and positive parts of the Delta-Lognormal model:

g(μi) =Year(i) + Gear(i) + f1(loni; lati) + f2(Depthi) + f3(timei) + log(HaulDuri)

where Gear(i) and Year(i) maps the ith haul to categorical gear/year effects for each age group.

Age (wr) classes (1–3) and (2-3) from the surveys in Q1 and Q3-4 are included in the assessment.

3.4 Mean weights-at-age and maturity-at-age

Mean weights at age in the catch in the 1st quarter were used as estimates of mean weight-at-age in the stock (Table 3.2.6).

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and has been the same since 1991 (ICES 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). Maturity ogive has been investigated in the recent benchmark assessment of WBSS (ICES 2013/ACOM:46). WKPELA in 2013 decided to carry on with the application of the constant maturity ogive vector for WBSS.

The same maturity ogive was used as in the last year assessment (ICES CM 2018/ACOM:07):

W-rings	0	1	2	3	4	5	6	7	8+
Maturity	0.00	0.00	0.20	0.75	0.90	1.00	1.00	1.00	1.00

3.5 Recruitment

Indices of recruitment of 0-ringer WBSS for 2023 were available from the N20 larval surveys (see Section 3.3.3).

The strong correlation of the N20 with the 1-wr group of the GERAS ($R2 = 0.72$, Figure 3.5.1), which also shows a good internal consistency with the GERAS 2-wr group, indicates that the N20 is a good proxy for the strength of the new incoming year class. Apart from 2022 (N20 of 6 603 million), the N20 index has been below the long-term average since 2011 (1992-2023: 5 992 million). The N20 for 2023 is less than a quarter of the previous year's value and is again one of the lower values of the time series (Table 3.3.3).

3.6 Assessment of Western Baltic spring spawners in Division 3.a and subdivisions 22–24

3.6.1 Input data

All input data can be found in Tables 3.6.1–3.6.8.

Only the input landings and weights data differ between the single and multi-fleet model, the rest of the input files are the same for both models.

3.6.1.1 Landings data

Catch in numbers-at-age from 1991 to 2023 were available for Subdivision 27.4.aEast (fleet A), Division 27.3.a (fleet C and D, respectively) and subdivisions 27.3.c–27.3.d.24 (fleet F) (Table 3.6.1.a–d). Years before 1991 are excluded due to lack of reliable data for splitting spawning type and due to a large change in fishing pattern caused by changes in the German fishing fleets (ICES 2008/ACOM:02).

Mean weights-at-age in the catch vary annually and are available for the same period as the catch in numbers (Table 3.6.2.a–d; Figure 3.6.1.1). Proportions at age thus reflect the combined variation in weight at age and numbers-at-age (Figures 3.6.1.2 and 3.6.1.3).

3.6.1.2 Biological data

Estimates of the mean weight of individuals in the stock (Table 3.6.3 (taken from weights in catches in Q1) and Figure 3.6.1.4) are available for all years considered. Since 2019, the mean weight at age in the stock has increased. It is believed to be an artefact of the increase proportion of NSAS herring in the samples and increased proportion of catches from the eastern part of the North Sea which biased positively these values. An attempt to correct this will be performed at the next benchmark.

Natural mortality was assumed constant over time and equal to 0.3, 0.5, and 0.2 for 0-ringers, 1-ringers, and 2+ -ringers respectively (Table 3.6.4). The estimates of natural mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2) as no new values were available as confirmed in the recent benchmark.

The percentage of individuals that are mature is assumed constant over time (Table 3.6.5): ages (wr) 0–1 are assumed to be all immature, ages (wr) 2–4 are 20%, 75% and 90% mature respectively, and all older ages are 100% mature.

The proportions of fishing mortality and natural mortality before spawning are 0.1 and 0.25 respectively and are assumed to be constant over time (Table 3.6.6–7). The difference between these two values is due to differences in the seasonal patterns of fishing and natural mortality.

3.6.1.3 Surveys

Surveys indices used in both the model runs can be found in Tables 3.6.8a–e.

According to the last benchmark of WBSS (ICES WKPELA, 2018), the following age (w-rings) classes (in grey) are used from each survey to tune the assessment of this stock:

Survey	0	1	2	3	4	5	6	7	8+
HERAS									
GERAS									
N20									
IBTS/BITS Q1									
IBTS/BITS Q3-4									

3.6.2 Assessment method

Since the 2018 benchmark (ICES WKPELA, 2018), the WBSS assessment is based on the state-space multi-fleet assessment model SAM. The assessment model presents one fishing mortality matrix for each of the four fleets fishing WBSS herring (A, C, D, and F). The model is designed to handle fleet disaggregated catches, which are available only from year 2000 while the model is run over the time period 1991–2023. The current implementation is an R-package based on Template Model Builder (TMB) and can be found at https://github.com/fishfollower/SAM (branch "multi"), more details in Nielsen et al. 2021.

The benchmark found consistent estimates of SSB, F and Recruitment as well as combined age selections between the multi- and the single-fleet SAM using comparable model settings.

The disaggregation of the fishing catches in the multi-fleet SAM can bring problems of convergence due to the increase of zeros in the fleet observed catches, which are ignored by the model since zeros cannot be fitted with a lognormal distribution. It is therefore important to compare the outputs of both the single and the multi-fleet models every year and check that the results are consistent between the models. For this year update assessment, the corresponding single fleet version is available with a configuration as close as possible to the multi-fleet model. The single fleet model output is represented as an overlay in the SSB, F, recruitment, and total catch plots in the multi-fleet output. Both the multi-fleet (WBSS_HAWG_2024) and the single fleet (WBSS_HAWG_2024_sf) outputs are available at www.stockassessment.org.

Details of the software version employed are given in Table 3.6.9.

3.6.3 Assessment configuration

The model configuration was set as specified in Table 3.6.10.

During the 2020 assessment, problems of convergence occurred with the multifleet model when adding the 2019 data due to difficulties estimating the variance parameter of the F process for the C-fleet (logSdLogFsta). Coupling the variance parameters for all fleets so only one logSdLogFsta parameter is estimated as a first run and then running the model with the original configuration removed the problem of convergence since 2020.

During the 2018 benchmark it was chosen to replace missing data in catches at age for all fleets by a small value (1 tonne). In addition to the method described in the previous paragraph, removing this constraint for the C-fleet and letting the model handling the zeros as missing data enabled the convergence of the 2021 assessment model.

There was no problem of convergence in 2022-2023 in the multifleet model. There was a convergence problem in an intermediate fitting step for the 2024 multifleet model. This was solved by removing the extra fitting step and instead use 0 as initial value for the catchability parameters (logFpar).

3.6.4 Final run

The results of the assessment are given in Tables 3.6.11–3.6.14. The estimated SSB for 2023 is 66 152 [45 334, 96 529 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.053 [0.021, 0.135 (95% CI)] yr-1. This means that the $F_{3\text{-}6}$ is estimated to be below F_{MSY} and F_{pa}, and below F_{lim}.

After a marked decline from almost 300 000 t in the early 1990s to a low of about 120 000 t in the late 1990s, the SSB of this stock was above 120 000 t in the early 2000s (Figure 3.6.4.1). After a small peak in 2006 coinciding with the maturing of the last major year-class, the SSB has declined up to 2011 with a SSB of 67.2 kt. SSB has only slightly increased in the following period up to around 84-70 kt in 2015-2017 and then has declined to 41.9 kt in 2020, which is the lowest SSB of the time-series. A slight increase in SSB was then estimated since 2021 to around 66.2 kt in 2023.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of 0.67 yr-1 in 1996. In 1999–2009, $F_{3\text{-}6}$ stabilized between 0.45 and 0.60. In 2010 and 2011, $F_{3\text{-}6}$ decreased significantly to a value of 0.43 and 0.30 yr-1, respectively. It stabilized between 0.32 and 0.41 yr-1 for few years until it increased again above 0.53 yr-1 from 2016 to 2018. $F_{3\text{-}6}$ then decreased to 0.3-0.36 yr-1 in 2019-2020, 0.17 yr-1 in 2021, 0.07 in 2022 and finally 0.05 in 2023, which is the lowest estimated $F_{3\text{-}6}$ of the entire time series (Table 3.6.11, Figure 3.6.4.2). This coincides with a change in regulation in Division 3.a that allows since 2021 100% transfer of the human consumption quota and 50-100% transfer of the industrial fishery bycatch quota to the North Sea.

Recruitment was the highest (~3-5 billion) at the beginning of the time-series (1991-1999) and has been decreasing overall since 1999. The 2022 estimate of 475 494 thousand is the lowest on record and the estimate in 2023 has slightly increased to 512 582 thousand (Tables 3.6.11, Figure 3.6.4.3). However, this keeps being revised downwards every year. The stock-recruitment plot for the WBSS stock (Figure 3.6.4.4) shows three distinct periods of recruitment with an early period of high recruitments varying between 3 and 5 billion coinciding with a declining SSB from 300 kt to 120 kt in the years 1991–1999 and no signs of density-dependence. This is followed by a distinct decline in recruitment to values below 3 billion at a relatively constant spawning-stock biomass between 120 and 160 kt over the period from 2000–2006. In the most recent period, from 2007 to 2023 recruitment has varied from about 1.5 billion to less than 0.9 billion at SSB between 54 kt and 111 kt, with a trend of declining recruitment in 2017-2022 and some slight increased recruitment in 2023.

The total catch is well fitted (Figure 3.6.4.5) as well as the catch per fleet (Figure 3.6.4.6) except for the fleet A where some observations are outside the confidence interval of the estimated catch. In 2021, the model started to accommodate the large catches of the A-fleet in 2019 and 2020 by an increase in the upper limit of the confidence interval on the catches for this fleet. The catch of the A-fleet in 2021-2022 was relatively well fitted, however catches for the A-fleet in 2023 decreased substantially (-56% compared to 2022) and the model does not accommodate this decrease and predicted a larger catch than observed. The A-fleet being now the largest fleet catching WBSS herring, the total catch is overestimated in 2023 compared to the observed catch.

The estimated partial fishing mortalities show remarkable differences between the four fleets reflecting the targeted ages of the individual fisheries, increasing with age for the A-fleet and the F-fleet, whereas distinct peaks are found for the C-fleet and the D-fleet at ages 2 and 1-2 (wr) respectively (Figure 3.6.4.7). The fishing mortality increases in the recent years for the A-fleet but has been decreasing for the other fleets following the ICES zero catch advice since 2018 and the subsequent decrease in quotas and increase in transferable quotas to the North Sea. The selectivity pattern for the D-fleet has a tendency of increasing selectivity at age 2 (wr) in later years. Total fishing mortality on the WBSS stock increased with herring age and is variable over time (Figure 3.6.4.8). A clear decrease in fishing mortality at age is seen since 2019 with F well below F_{MSY} since 2020.

The model was constrained to have the same selectivity for the two oldest ages (wr) 7+ in all fleets. The fishing mortality was assumed to be independent across ages for the A-fleet (see $corFlag in Table 3.6.10). The estimated correlation parameter in the F random walk for the C-fleet was estimated to a very high value, which caused convergence problems in initial runs during the benchmark, and it was therefore assigned a fixed high value in the subsequent assessment runs resulting in parallel selection patterns.

The estimated survey catchability is rather different among the surveys (Figure 3.6.4.9). The HERAS and the GERAS surveys are relatively constant over the applied ages (wr) 3–6 and 1–4 respectively. Whereas both IBTS+BITS-Q1 and -Q3.4 surveys show, sharp declines with increasing ages 1–3 and 2–3, respectively. Interpretation of the different catchability patterns is complex, and likely, several reasons including ontogenetic differences in the spatial distribution and behaviour of the different age classes at the time of the surveys may affect their relative availability to the different samplings.

The surveys present some strong correlations notably between the older ages (Figure 3.6.4.10). The same is observed for fleets C and F. The tracking of each cohort can be observed in Figure 3.6.4.11.

The F-fleet (ages 1-8+) has a lower observation variance than the GERAS and the HERAS, the C-fleet (ages 2-8+) is lower than the IBTS+BITS-Q1 surveys variance, the IBTS+BITS- Q3.4 and the N20. Both the D-fleet and the A-fleet have very high observation variances, as well as the age 0 for all fishing fleets and the age 1 for the C-fleet (Figure 3.6.4.12).

Residuals for catch in different fleets generally show poorer fit to the youngest year-classes 0–1 wr (Figure 3.6.4.13). The A-fleet shows large positive residuals in 2019-2020 showing that the model underestimates the catches-at-age in those years. The inverse is observed for the C-fleet with large negative residuals in 2019 for ages 3-8+, showing an overestimation of the catches for these ages. The F-fleet presents large negative residuals for ages 0-1 over the entire time-series. Further, the fit by fleet to some degree follows the catches in the fleets with increasingly better fit from A-fleet, D-fleet, C-fleet to the F-fleet (Figures 3.6.4.14–3.6.4.17). This has becoming progressively more worrisome considering that the A-fleet is now contributing to >50% of the WBSS catches. The fit to the combined fleets at the beginning of the time-series follows the observations to some degree except for the two youngest age classes 0–1 wr, which exhibit a rather poor fit. (Figure 3.6.4.18).

Inspection of model diagnostics shows the occurrence of high residuals in some years for the surveys (e.g., 2018-2023 in the GERAS and 1991 and 2013–2014 in HERAS; Figure 3.6.4.13). Overall, the agreement between the data and the fitted model appears acceptable throughout the data sources, which are most influential in the model. The individual survey diagnostics show some differences in how the model fit the different survey data, and the level of fitting is widely in agreement with the estimated observation variance for each data component (Figures 3.6.4.19–23). In general, a similar fit is found for all included ages (wr) 3–6 of the HERAS index (Figure 3.6.4.19). In recent years, GERAS shows a clear drop in observed indices for ages (wr) 3–4 that are poorly fitted and show therefore large negative residuals (Figures 3.6.4.13 and 3.6.4.20). The model picks up the overall negative trend of the recruitment index (N20) and is conservative on the high index value estimated in 2021-2022 which are the largest observed since 2013 (Figure 3.6.4.21). Poorer fit is observed for the IBTS+BITS-Q1 for all ages (wr) 1–3, over the entire time-series (Figure 3.6.4.22) and likewise to the IBTS+BITS-Q3.4 for the two ages (wr) 2–3 (Figure 3.6.4.23) with large positive residuals for age (wr) 2 in recent years (Figure 3.6.4.13).

Retrospective patterns have largely increased compared to last year assessment (Figure 3.6.4.24-27). The SSB has a 5 years Mohn's rho of 40% (compared to 16% in 2023) with only the 1-year peel remaining inside the confidence intervals of the SSB estimates. Average fishing mortality retrospective estimates are also outside the confidence bounds for F for the 4 to 5-year peels

(Mohn's rho = -24% compared to -4% in the 2023 assessment, Figure 3.6.4.25). The retrospective for recruitment is acceptable having a Mohn's rho = 11% (6% in 2023, Figure 3.6.4.26). Retrospective is small for total catch (Figure 3.6.4.27).

Since the 2019 assessment, the GERAS survey indices have been the most influential of all surveys on the estimated decrease in the stock. While the GERAS indices are still low in 2023 and continue to show the largest contribution to the estimated SSB level, the small SSB increase in 2022-2023 appear independent from any individual specific survey (Figures 3.6.4.28–31) and likely due to the decrease in catches in the recent years.

A haul with spawning fish in SD23 has been seen for a few years during the GERAS survey in Autumn. The consideration of the haul with spawning fish (SD23) was discussed in depth in 2023. In 2021, the haul was removed because most of the fish were mature (stage>=6), but the year before only the mature fish were removed. This 2021 sample was genetically analysed in 2023 and showed mainly a NSAS genotype. Two indices were created for 2022 in 2023, one excluding the haul and the other one including it and sensitivity analyses were run with both indices. However, there was no index available using the usual assumption of only removing the mature fish (stage >=6) since some of these fish could still be WBSS. Both runs give very similar outputs but the number at age 2 are larger for the run including the haul so the differences might increase in future years when the ages enter the SSB. It was therefore agreed in 2023 to use the 2022 indices with exclusion of the haul, and the same method was applied in 2024 for the 2023 indices. The GERAS time series will be evaluated at the next benchmark (planned for 2025) and a method to handle this haul in the acoustic data will be agreed then.

Since assessment in 2022, the age composition for the A-fleet is taken directly from the transfer area rather than from the entire Division 4aE given that samples are available in the Norwegian catches. Sensitivity runs were performed in 2022 and the same method was used ever since without repeating the sensitivity.

3.7 State of the stock

The stock was benchmarked in 2018 with a substantial increase in the chosen value of B_{lim} and a slight downwards revision of the SSB levels. The stock has decreased consistently from mid 2000s to a historical low in 2020 (Tables 3.6.11, Figure 3.6.4.1). With the new B_{lim} (120 kt) the stock has been in a state of impaired recruitment since 2007 but since 2022 is showing a small sign of recovery. This recovery is however revised downwards and delayed compared to the assessment in 2023.

The 2018 benchmark calculated a new F_{MSY} of 0.31. Fishing mortality ($F_{3\text{–}6}$) was reduced between 2008 and 2011 from 0.57 to 0.30 (Tables 3.6.11, Figure 3.6.4.2). $F_{3\text{–}6}$ has then remained stable above F_{MSY} until 2019 (0.32-0.65). $F_{3\text{–}6}$ has decreased since 2020 from 0.30 to 0.05 in 2023, which is the lowest $F_{3\text{–}6}$ on records.

Recruitment has been declining since 2014 with a historical low value in 2022 of 475 494 thousand (Tables 3.6.11, Figure 3.6.4.3). Recruitment increased to 512 582 thousand in 2023. Despite the increase in 2023, recruitment is still low compared to the average of the time series and the final recruitment was revised downwards in 2023 and 2024. Low fishing mortality should continue to support a slow rebuilding of the stock given the present levels of low recruitment.

3.8 Comparison with previous years perceptions of the stock

The table below summarizes the differences between the current and the previous year assessment. The addition of the 2023 data resulted in a large negative change in the perception of the stock back in time compared to the last year assessment of 28%. The recent estimates of recruitment have however increased by 5.3% for 2021 in the current assessment but decreased by 12% for 2022. F appears to be larger than previously estimated (32-55%).

Parameter	Assessment in 2023	Assessment in 2024	Difference (2024/2023-1)
SSB (t) 2021	62 343	45 107	-28 %
$F_{(3–6)}$ 2021	0.111	0.172	55 %
Recr. (‘000) 2021	454 304	478 283	5.3 %
SSB (t) 2022	75 548	54 162	-28 %
$F_{(3–6)}$ 2022	0.050	0.066	32 %
Recr. (‘000) 2022	537 470	475 494	-12 %

3.9 Short-term predictions

Short-term projections are possible both as stochastic and deterministic forecasts. While SAM runs with parameter values represented by percentiles, forecasts in multi-fleet SAM have to switch to a representation by means and standard deviations in order for catches in the individual fleets to add up the totals predicted. However, to be in line with the median representation, all values would have to be recalculated back from the representation by means. Although statistically correct, the HAWG did not want to perform these operations without a prior scrutinizing of the effects on the presentation of the advice. Therefore, HAWG in line with all other assessments of the working group calculated deterministic predictions using that forecast option of the multi-fleet SAM and following the settings in the stock annex.

3.9.1 Input data

In the short-term predictions recruitment (0-winter ring, wr) is assumed to be constant, and it is calculated as the mean of the last five years prior the last year model estimate (i.e., for the 2024 assessment, recruitment for the forecasts was calculated on the period 2018–2022, see Table 3.9.1). For all older ages, the stock numbers are projected forward from the last data year to the intermediate year according to the estimated total mortalities based on fleet wise expected catches and natural mortalities. The mean weight-at-age in the catch and in the stock as well as the maturity ogive were calculated as the arithmetic averages over the last five years of the assessment (2019–2023). Based on earlier considerations in HAWG, the different periods were chosen to reflect recent levels in recruitment and weights.

3.9.2 Intermediate year 2023

A catch constraint was assumed for the intermediate year (2024). Predicted 2024 catch by fleet is summarized in the table below and depends on two main assumptions:

- Both NSAS and WBSS herring stocks are caught in the Division 3.a (C and D-fleets) and subdivisions 4.aE and 4.bE (A-fleet) whereas the subdivision 22–24 catch (F-fleet) is assumed to only be WBSS herring.
- The F-fleet utilizes its entire TAC in Subdivision 22-24.

Fleets	TAC 2024 NSAS+WBSS (t)	Predicted 2024 WBSS catch (t)	Predicted 2024 WBSS catch explained (t)
A	510 323	4 900	(510 323+29 735-(0.425x969+200))x0.009
C	29 735	269	(0.425x969+200)x0.44
D	6 659	120	(0.575x969)x0.215
F	788	788	100% 2024 TAC
Total	547 505	6 078	

Since the benchmark, the amount of WBSS taken in the transfer area by the A-fleet in the intermediate year was assumed equal to the observed average A-fleet catch over the last 3 years. From 2022, it was chosen to make the assumption for the A-fleet consistent with what is usually assumed for the NSAS herring advice. This year's assumption results in a total catch of WBSS herring of 4 900 t corresponding to the sum of the A-fleet TAC (510 323 t, EU 2024) and what is transferred from the C-fleet in Division 3.a to the North Sea (29 123 t), scaled by the 3-year average proportion of WBSS in A-fleet catch (0.9%, 2020-2022).

Similarly to in 2023, the observed catch in the data year was used to predict the split of catches in Division 3.a between the C- and D-fleets. Norwegian catches count against catches by the C-fleet, so the 969 t of EU share of the 2024 quota in 3.a (EU 2024) are split by the proportion of each fleet in the total EU catches in 2023 (42.5% and 57.5% for C- and D-fleets, respectively). Additionally, the C-fleet catches also include the maximum agreed Norway catch of 200 t (Norway 2024). Both catches in the C- and D-fleets are scaled by the 3-year average proportion of WBSS in the C-fleet catch (44.0%, 2021-2023) and D-fleet catch (21.5%, 2021-2023), respectively.

The catch by the F-fleet fishing for human consumption in Subdivisions 22–24 is usually very close to the TAC and a utilization of 100% is assumed for the intermediate year, hence 788 t (EU 2024).

Misreporting of catches from the North Sea into Division 3.a is no longer assumed to occur after 2008. Therefore, no account was taken in the compilations.

These assumptions give the expected catch by fleet summing up to 6 078 t of WBSS herring in 2024.

3.9.3 Catch scenarios for 2025–2027

The inputs and outputs of the short-term predictions are based on a catch constraint in the intermediate year of 6 077 t and are given in Tables 3.9.1–3.9.17.

Different catch options for the years after the intermediate year were explored with fleet-wise selection patterns and deterministic forecasts. Before 2022, to most closely resemble current WBSS management, a constraint was added to the forecasts so that, after the intermediate year, for all scenarios (except for the constant intermediate year TAC, the F = 0 and the catch for bycatch fleets only scenarios) the F-fleet is assumed to get 50% of the total catch of WBSS herring. Since 2022, this constraint was removed since it is considered now not representative of the WBSS management where most of the catch in Division 3.a can now be transferred to the North Sea and now most catches of WBSS herring are from the A-fleet, while the F-fleet catch keeps decreasing due to the decrease in TAC in Subdivisions 22–24.

3.9.4 Exploring a range of total WBSS catches for 2025 (advice year) to 2027

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because the forecasted SSB in 2026 is below B_{lim} (120 000 t) even when F=0, ICES advises a zero catch for 2025.

None of the catch scenarios for 2025, including zero catch, is expected to bring SSB above B_{lim} in 2026. For the past 3 years, besides requested standard scenarios HAWG also calculated the potential development of the stock projections for an extra year (2027) with different low F scenarios, where F2026 = F2025. None of these scenarios, even when F = 0, can bring the SSB above B_{lim} in 2027.

Since 2020, two new scenarios were requested by ACOM for zero catch advice stocks: (1) the "Catch for bycatch fleets only" scenario that was renamed in 2023 to "Catch of WBSS by A- and D-fleets only" to avoid the confusion due to the fact that the A-fleet is not a bycatch fishery but a directed fishery for herring in the North Sea, and (2) a scenario where the biomass is constant between the advice year and the year after that. The first scenario is given in the Table below. Similarly, to the previous years the latter scenario was not run for the following reasons. For a stock with SSB calculated on the 1st of January (and the final year of assessment being 2023), this can be easily done because SSB in 2025 only depends on F in 2024 and F is estimated given a TAC constraint so is the same for all forecast scenarios. As a result, all scenarios tested in the short-term forecast would have the same SSB in 2025 and the F in 2025 can be estimated to obtain a SSB in 2026 equal to 2025. For WBSS, there are complications to this calculation because the advice is annual (Jan-Dec) but the SSB is calculated and reported at spawning time (spring). This means that SSB in 2025 is in fact the result of catches assumed (agreed TACs) for the intermediate year (2024) and some catches in the first months of 2025. In other words, the SSB in 2025 depends on F in 2024 but also on a fraction of the F in 2025, which is the advice year. What to assume for the first months of 2025 is the real issue here. For instance, if a zero catch is assumed in 2025 according to the advice, it will be uninformative because the table of advice would still only show the average F in 2025 (so F = 0). If an F that makes SSB 2025 = SSB 2024 is assumed for 2025, it will be an unrealistic high F needed to compensate for the low catches assumed in 2024. Given the reasons described above, the constant SSB between 2025 and 2026 scenario could not be meaningfully run for WBSS herring and is not included among the catch scenarios presented by the EG.

Table number	Basis	Total catch (2025)	$F_{3–6}$ (2025)	SSB* (2025)	SSB* (2026)	% SSB change **	% advice change ***
ICES advice basis							
3.9.2	MSY approach: zero catch	0	0	79 917	91 000	14	0
Other scenarios							
3.9.3	EU Baltic Sea multiannual plan (MAP): F = F_{MSY} × SSB_{2024}/MSY $B_{trigger}$ ^	24 741	0.149	77 112	68 886	-11	
3.9.4	MAP: F = $F_{MSY\ lower}$ × SSB_{2024}/MSY $B_{trigger}$ ^	18 656	0.104	77 940	74 124	-4.9	
3.9.5	F = F_{MSY}	40 880	0.310	74 310	55 747	-25	
3.9.6	F = F_{pa}	48 341	0.410	72 678	49 870	-31	
3.9.7	F = F_{lim}	50 989	0.450	72 046	47 828	-34	
	SSB (2026) = B_{lim} ^^						
	SSB (2026) = B_{pa} ^^						
	SSB (2026) = MSY $B_{trigger}$ ^^						
3.9.8	F = F_{2024}	7 389	0.036	79 220	84 256	6.4	
3.9.9	Catch of WBSS by A- and D-fleets only^^^	5 021	0.020	79 456	86 631	9.0	

* For spring-spawning stocks, the SSB is influenced by fisheries and natural mortality between 1 January and spawning time (April).
** SSB (2026) relative to SSB (2025).
*** The advised catch for 2024 was 0 tonnes.
^ Because SSB_{2024} is below MSY $B_{trigger}$, the F_{MSY} and $F_{MSY\ lower}$ values in the MAP are adjusted by the SSB_{2024}/MSY $B_{trigger}$ ratio.
^^ B_{lim} and B_{pa} cannot be achieved in 2026, even with zero catch.
^^^ Only the A-fleet that targets North Sea autumn-spawning (NSAS) herring but also catches WBSS herring in the eastern part of the North Sea, and the D-fleet that targets fish for reduction in Division 3.a, assuming the same catch as in the intermediate year 2024 (C- and F-fleets are directed WBSS fisheries so have zero catch in this scenario).

Table number	Basis	Total catch (2025)	Total catch (2026)	$F_{3–6}$ (2025)	SSB* (2025)	SSB* (2026)	SSB* (2027)	% SSB change (2025–2026)	% SSB change (2026–2027)
Medium-term catch scenarios									
3.9.10	F = 0	0	0	0	79 917	91 000	101 998	14	12
3.9.11	F = 0.010	2 171	2 846	0.010	79 722	89 003	97 869	12	10
3.9.12	F = 0.025	5 253	6 545	0.025	79 432	86 190	92 341	8.5	7.1
3.9.13	F = 0.050	9 969	11 487	0.050	78 952	81 938	84 580	3.8	3.2
3.9.14	F = 0.100	18 093	18 222	0.100	78 012	74 769	72 925	-4.2	-2.5
3.9.15	F = 0.150	24 860	22 453	0.150	77 095	68 950	64 540	-11	-6.4
3.9.16	Constant catch 2024–2026 **	6 078	6 078	0.029	79 353	85 585	92 280	7.9	7.8

* For spring-spawning stocks, the SSB is influenced by fisheries and natural mortality between 1 January and spawning time (April).
** It is assumed that the fleets’ 2024 catches (as defined in Table 1) are kept constant for 2025–2026

3.10 Reference points

The WBSS stock was benchmarked in 2018 (ICES WKPELA, 2018) with subsequent changes of reference points. B_{lim} was revised from 90 000 to 120 000 t to take account of the new perception that recruitment is impaired when the spawning-stock biomass (SSB) is below 120 000 t. B_{pa} and MSY $B_{trigger}$ were subsequently set to 150 000 t. Using the EqSim software F_{MSY} was estimated to 0.31, F_{lim} 0.45 (5% risk to B_{lim}) and F_{pa} 0.41 (since 2020, F_{pa}=F_{p05}; ICES, 2021). The values were based on stochastic simulation of recruitment generated on a combination of Beverton & Holt, Ricker and segmented regression (ICES 2014/ACOM:64).

3.11 Quality of the Assessment

The stock was benchmarked in 2018 (ICES, 2018), which led to a change in perception for the entire time-series. Despite the assessment estimates being consistent during the past three years, this year, a large downwards revision in SSB and upward revision in F are visible. The reason for this retrospective is unknow but the 2023 catches are largely overestimated by the model compared to observed catches. This comes from difficulty for the model to fit the catches for the A-fleet. While this was not a problem in the past, it’s becoming more problematic now that the A-fleet is the largest fleet catching WBSS herring.

The herring assessed in subdivisions 20–24 is a mixture of several genetically distinct populations predominantly spawning in spring, but with local components spawning also in autumn and winter. The population dynamics and the relative contribution of these components are likely to affect the precision of the assessment. Moreover, mixing between WBSS and central Baltic herring in subdivisions 22–24 may contribute to uncertainty in the assessment.

Inter-annual variability of the herring migration patterns and the distribution of the fisheries (including the optional transfer of quotas between Division 3.a and Subarea 4) certainly add uncertainty to the assessment and forecasts of this meta-population. Since these cannot be predicted, recent average proportions between stocks are assumed in projections. It is expected that the implementation of genetic stock separation (which allows for identifying these smaller stock components) will improve data on their contributions to subdivisions 20-22 in years to come.

3.12 Considerations on the 2024 advice

This year assessment shows an SSB revised downwards compared to last year’s assessment. Recruitment is still very low. Despite a slightly increase in R is estimated in 2023 (512 582 thousands) withis well within the uncertainty of the recruitment estimates during the record low recent period. Moreover, an increase in recruitment has been systematically delayed in the past few years after updating the data. For example, the increase in recruitment was in 2021 in the 2022 assessment but was shifted to 2022 in the 2023 assessment. This year, the increase is in 2023, so the increase in recruitment has always been estimated in the last data year in the past three assessments. Under these conditions the stock is not expected to increase above B_{lim} in the short-term (2026) nor in the medium-term (2027) for any level of fishing mortality (SSB_{2027} = 101 998 t assuming F = 0).

To explore the potential development of the stock, projections until 2027 with different low F scenarios are provided in the Table in section 3.9.4. The development of a rebuilding plan for this stock remains a high priority and it is recommended by HAWG, however, this should now wait for the next benchmark planned for 2025.

The EU–Norway TAC-setting procedure used for herring in Division 3.a (EU–Norway, 2013) calculates the TAC for the combined WBSS and NSAS stocks in the C-fleet as 41% of the ICES MSY advice for WBSS plus 5.7% of the TAC for the A-fleet (see section 3.13 for more details). However, according to a safety clause in the procedure, the method should not apply if serious concerns exist about the status of one of the two stocks, which is the case given the severe over-exploitation of the WBSS stock. Recently, this has been considered by the managers by increasing the possibility to transfer the quotas from Division 3.a to the North Sea up to 100%. This can however create an overshoot of the advice for NSAS herring if not accounted in the quota set for the North Sea. Catch scenarios where an extra optimization is done to avoid the overshoot are available since 2023 in the NSAS herring advice sheet and should be given attention when fishing opportunities are set by managers.

WBSS is caught across three different management areas, and recovery will be impaired if catches of this stock are not avoided in all areas. Based on agreed catches for 2024 and assumptions on stock mixing, it is predicted that around 81% of the total WBSS catches in 2024 will be taken in the eastern parts of divisions 4.a and 4.b. The remaining 19% is assumed to be shared between the two management areas, subdivisions 20–21 and subdivisions 22–24.

The catch of WBSS in the North Sea in recent years has been estimated at 3 756 t (based on the average over the 2021–2023 period). The catches of WBSS in 2024 are expected to continue to be larger in the North Sea than in subdivisions 20–24. Without additional area and seasonal restrictions on herring fishery in the North Sea in 2025, catches of WBSS in the North Sea will be unavoidable, delaying the recovery of the WBSS stock.

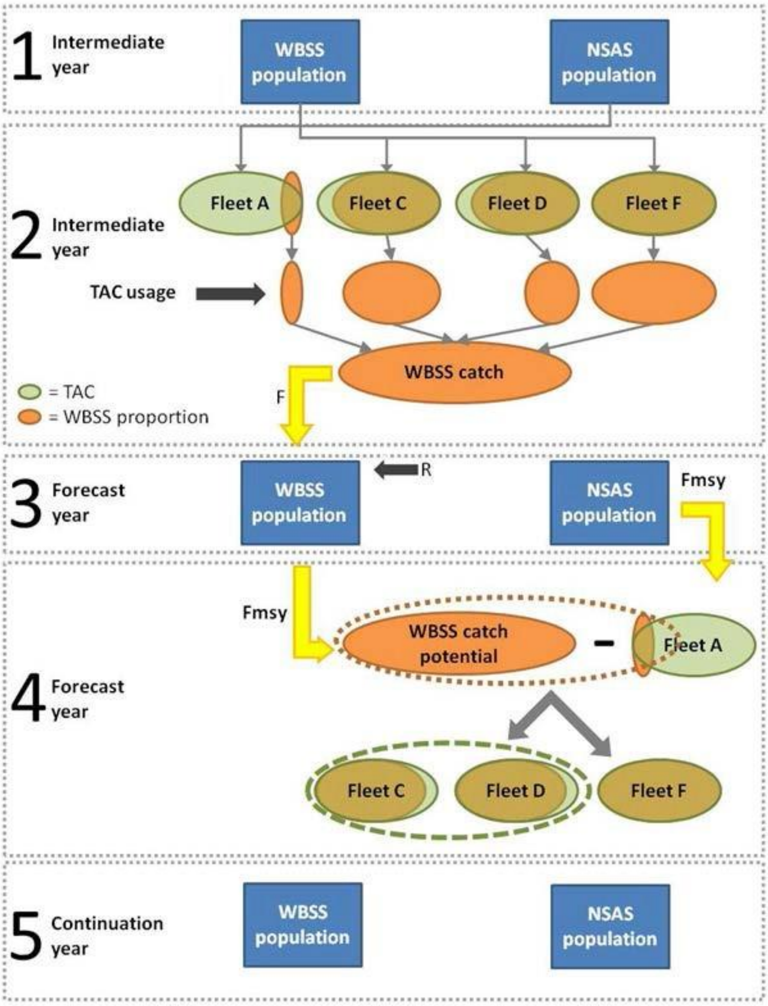
3.13 Management Considerations

3.13.1 Quotas in Division 3.a

The quota for the C-fleet and the bycatch quota for the D-fleet are set for both stocks of NSAS and WBSS herring together (see Section 2.7). Since 2011, 50% of the EU and Norwegian quotas for human consumption (C-fleet) can optionally be transferred from Division 3.a and taken in Subarea 4. In 2021, the transfer was increased to 100%, effective in 2022. This year, 100% of the quotas for the industrial fishery in 3.a can also be transferred to the North Sea (50% previously), effective in 2024. Since the increase in inter-area flexibility, ICES assumes that most of the quotas in Division 3.a will be transferred to the North Sea resulting in a maximum catch of NSAS and WBSS herring of 1 169 t (969 t of EU catches + 200 t of Norwegian catches) in Division 3.a (cf. part 3.1.1).

3.13.2 ICES catch predictions vs. management TAC

ICES gives advice on catch scenarios for the entire distribution of the NSAS and WBSS herring stocks separately whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES Division 3.a and SD 22–24 takes into account the occurrence of different fleet's catches of both WBSS and NSAS herring, utilization of TACs and the proportion of NSAS and WBSS that mix in the areas. In the flowchart below, a schematic of the general procedure is presented, although for the present advice it should be interpreted in the light of the zero catch advice and specific agreements for the management of fleets in Division 3.a in 2024:



Box 1: Each year estimations of the WBSS and NSAS stock size are made using a stock assessment model. Stock size estimation together with the estimated pattern of harvesting is used as the starting point for the short-term forecast.

Box 2: To derive at a TAC proposal in the forecast year, first the intermediate year (the year where the TAC has already been agreed on) catches need to be resolved. Four different fleets catch WBSS: the A-fleet (within the transfer area where they take it as a mixture of mainly NSAS and partly WBSS), the C- and D-fleet (within the Division 3.a where they take it as a mixture of mainly WBSS and NSAS), and the F-fleet (within SDs 22–24 where they only take WBSS). Each of these fleets target herring with a specific TAC. Only part of this TAC is WBSS catches and not all fleets utilize their full TAC fleet share, or have the possibility to transfer their quotas to another area. This results in an estimate of the intermediate year WBSS catches. Given WBSS stock size and these intermediate year catches, the fishing mortality that the WBSS stock is exploited at can be estimated.

Box 3: Based on the estimated fishing mortality we can now calculate the survivors from the intermediate year to the forecast year assuming an incoming constant recruitment.

Box 4: The management rule for the C-fleet TAC uses the potential WBSS catches calculated from the F_{MSY} advice plus a fraction of the NSAS TAC to define the total TAC in ICES Division 3.a as well as SD22–24 (see Application of the management rule below). Dependent on the relative development of the NSAS and WBSS stocks and the quota transfer from Division 3.a to the North Sea the realized WBSS catches may deviate from the predictions based on F_{MSY}.

Box 5: The TAC advice from box 4 is taken into the political arena. The result of this will be taken into account to calculate the WBSS population again the year after. Hence box 5 is similar to box 1.

3.13.3 Application of the management rule for the herring fishery for human consumption in Division 3.a

ICES has not evaluated the agreed management rule after revision of reference points in the 2018 benchmark.

The agreed management rule has since 2014 been the basis for setting the C-fleet TAC in Division 3.a and is calculated as the sum of 41% of the WBSS MSY advised catch and 5.7% of the North Sea herring TAC for the A-fleet.

However, given the new B_{lim}, the stock has been below B_{lim} since 2018 raising serious concerns about the status of the WBSS stock. According to a safety clause, which was part of the TAC-setting procedure evaluation, the procedure itself therefore should not be applied and it should be re-evaluated.

Since 2022, the TAC rule is used to predict the transfer of catches from Division 3.a to the North Sea but catches in Division 3.a are predicted following the agreed maximum catches negotiated for Norway and EU in the EU-Norway-UK regulation (see sections 3.1.1, 3.11.2 and updated stock annex).

3.14 Ecosystem and Conservation considerations

3.14.1 Migration

Herring in Division 3.a and subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic Sea into the more saline waters of Division 3.a and to the eastern parts of Division 4.a. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations (Podolska et al., 2006), and this notion is corroborated with genetic data. Herring in Division 3.a and subdivisions 22–24 migrate back to the Rügen area (SD 24) and other spawning areas at the beginning of winter. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24 (Gröhsler et al., 2013; Bekkevold et al., 2023).

Overwintering is considered to take place in the Öresund (Nielsen et al., 2001). However, recent observations on the acoustic surveys (Gröhsler and Schaber, 2018) indicate changes in distribution and it is currently unclear whether fish still aggregate in the shallow parts of the Sound or whether the density of herring accumulating in the area has changed overall. Whatever the temporal limitation of this survey is and whatever the cause for this observation might be, it may underline the need to validate the multiple-decade-old information on WBSS herring migration patterns.

Similar to the NSAS, the WBSS has produced a series of poor year classes in the last one and a half decade and the declining trend continues. An earlier analysis on different Baltic herring stocks showed that the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for the recruitment of WBSS (Cardinale et al., 2009). A recent study demonstrated that the later onset and shorter duration of cold periods (below 4°C water temperatures on spawning sites) resulted in reduced reproductive success (Polte et al. 2021). The mechanisms driving this relationship is hypothesized as a mismatch of the initial hatching peaks of larvae in Greifswald Bay and the prey field at the time of first feeding.

A recent review paper on WBSS herring covers the present knowledge on environmental drivers and stressors of early life stage herring productivity (Moyano et al. 2022).

3.14.2 Predation

Predation on larval herring by gelatinous plankton (*Aurelia aurita*) in the Western Baltic Sea was described to a be a major impact on recruitment strength of the population in the 1980s (Möller, 1984). Currently, in the inshore nursery grounds around Rügen the bloom of *A. aurita* is rather seasonally decoupled from major larval production periods as the jelly fish occur in large quantities during summer (July-Sept.). The same is true for the invading ctenophore *Mnemiopsis leidyi*, that appears from August on (Polte and Kotterba, pers. obs.). The seasonal peaks of jelly fish blooms, however, might be subjected to change and should be kept under close surveillance as in the past two years *A. aurita* became more abundant during June therefore increasing the temporal overlap with WBSS larvae (Polte, pers. obs. RHLS).

Besides this potential predator, in Greifswald Bay there is evidently significant predation pressure on herring eggs by three-spined sticklebacks and- to a lower percentage by juv. Perch (*Perca fluviliatis*) and 9-spined stickleback, *Pungitius pungitius* (Kotterba *et al.*, 2014; Kotterba *et al.*, 2017a). Since predation pressure has been shown to increase with increasing concentrations of herring eggs (Kotterba et al., 2014), eutrophication-related shrinkage of spawning grounds (see below) could also indirectly increase egg mortality. In contrast the predation on larvae by the sticklebacks was found rather minor (Kotterba *et al.*, 2017b). Unfortunately, there are no historical baseline data available on stickleback densities in the system, but they are considered to have increased speculatively by a trophic cascade including overfishing of predators (Bergstrom *et al.*, 2015).

The non-indigenous goby (*Neogobius melanostomus*) has reached extremely high abundances in the coastal Baltic Sea during recent years (Kornis *et al.*, 2012). It has been suspected to significantly increase predation pressure on herring eggs. However, a recent study revealed a minor effect by juvenile gobies that would ingest eggs when encountered but *N. melanostomus* in general is rather specialized on mollusc-prey and additionally there is a temporal mismatch among the juvenile gobies and the herring spawning period (Wiegleb *et al.*, 2018).

3.14.3 Eutrophication

Estuarine WBSS herring spawning grounds in the Western Baltic Sea are still subject of increased nutrient levels and steady input of agricultural discharge. The resulting increased turbidity leads to a strict vertical limitation of perennial macrophytes in Greifswald Bay to the very littoral zone with a growth limit of about 3.5 m (Kanstinger et al., 2018). The major spawning zone in the system is considered to be located in a range of 1-2 m water depth (Moll, 2018). Besides a potential reduction in spawning beds fostering increased mortalities of eggs laid in multiple layers (Finke et al., 2022), the depth limitation evidently results in increased exposure against storm-induced turbulence and consequently increased herring egg mortality (Moll et al., 2018).

Although spring-spawning herring facultative selects other spawning substrates for egg deposition (e.g., stones), the complexity of spawning substrate as provided by macrophytes promotes egg survival by unknown mechanisms (von Nordheim *et al.*, 2018). Additionally, increased blooms of filamentous algae (*Pilayella littoralis*) promoted by elevated nutrient levels in synergy with warming spring temperatures cause significant herring egg mortality (von Nordheim *et al.*, 2020)

3.14.4 Climate drivers

There is ample indication that prevailing winter temperature- as expressed by the Baltic Sea Index (BSI) - significantly affect recruitment strength of WBSS herring (Cardinale et al., 2009; Gröger et al., 2014). The exact ecological mechanisms causing this link remains widely unknown. However, for larval herring production in Greifswald Bay it could be shown that the optimal temperature window for embryonic development (Peck et al., 2012) is very important for reproduction success and tends to have contracted in recent years (Dodson et al., 2019). There are strong indications that according to recent mild winter regimes the seasonal timing of spawning migration and reproduction has shifted, and those phenology changes are responsible for limited reproduction success as expressed by larval productivity in Greifswald Bay reflected by the abundance of 1-year juveniles in the outer Western Baltic Sea as expressed by the GERAS 1-wr abundance index (Polte et al., 2021). As currently the initial hatching cohorts are not resulting in significant numbers of larval survivors beyond the critical period after yolk-sac consumption, later cohorts are contributing most to recent recruitment patterns (Polte et al., 2014). However, this might overall result in low recruitment compared to earlier years when the larvae of initial cohorts drove the numbers of survivors. Additionally, those later cohorts (hatching mid-April-early May) are exposed to a suite of different stressors: If the seasonal SST curve is steep and the shallow water heats fast during spring, those larvae are increasingly encountering physiological limits. Moyano et al. (2020) could recently show that WBSS larvae develop cardiac arrhythmia beyond an SST threshold of 16°C and that the number of days above this threshold increased in Greifswald Bay during past decades. Besides those direct temperature effects, synergistic effects of eutrophication and warming (see Eutrophication above) lead to multiple cascades affecting egg survival of those later cohorts in particular.

3.14.5 Conservation considerations

Ongoing eutrophication and advancing climate change have in several studies been identified as the main stressors associated with declining herring recruitment in the Western Baltic Sea (well summarized in Moyano et al., 2022). Long-term, large-scale efforts to reduce anthropogenic emissions (greenhouse gas and nutrients) are essential for the preservation of Baltic Sea ecosystems. However, neither climate change nor eutrophication can be significantly mitigated in the short or medium-term perspective relevant to the reconstruction of the spring-spawning herring stock in the Western Baltic Sea. It is therefore advisable to avoid all other stressors that could act additionally or even in synergy with climate change and eutrophication. In particular, coastal modifications that result in a further decline in important spawning and nursery areas (e.g. due to port and pipeline construction) should be avoided in order to enable the stock to recover beyond the safe biological limit. Given the genetic differences of the different subpopulations contributing to the overall stock (Bekkevold et al., 2023), protective measures should be taken for all spawning areas, as further losses could reduce genetic diversity and thus affect the resilience of the stock in a changing environment.

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3.16 Tables and Figures

Table 3.1.1 WESTERN BALTIC HERRING. Both WBSS and NSAS. Total catch in 1989-2023 (1000 tonnes) by year, area and country. Data provided by working group members

year	area	Denmark	Faroe Islands	Finland	Germany	Lithuania	Netherlands	Norway	Poland	Sweden	Total
1989	27.3.a.20	47.40	-	-	-	-	-	1.60	-	47.90	96.90
1989	27.3.a.21	57.10	-	-	-	-	-	-	-	37.90	95.00
1989	27.3.b.23	1.50	-	-	-	-	-	-	-	0.10	1.60
1989	27.3.c.22, 27.3.d.24	21.70	-	-	56.40	-	-	-	8.50	6.30	92.90
1989	Total	127.70	-	-	56.40	-	-	1.60	8.50	92.20	286.40
1990	27.3.a.20	62.30	-	-	-	-	-	5.60	-	56.50	124.40
1990	27.3.a.21	32.20	-	-	-	-	-	-	-	45.20	77.40
1990	27.3.b.23	1.10	-	-	-	-	-	-	-	0.10	1.20
1990	27.3.c.22, 27.3.d.24	13.60	-	-	45.50	-	-	-	9.70	8.10	76.90
1990	Total	109.20	-	-	45.50	-	-	5.60	9.70	109.90	279.90
1991	27.3.a.20	58.70	-	-	-	-	-	8.10	-	54.70	121.50
1991	27.3.a.21	29.70	-	-	-	-	-	-	-	36.70	66.40
1991	27.3.b.23	1.70	-	-	-	-	-	-	-	2.30	4.00
1991	27.3.c.22, 27.3.d.24	25.20	-	-	15.80	-	-	-	5.60	19.30	65.90
1991	Total	115.30	-	-	15.80	-	-	8.10	5.60	113.00	257.80
1992	27.3.a.20	64.70	-	-	-	-	-	13.90	-	88.00	166.60
1992	27.3.a.21	33.50	-	-	-	-	-	-	-	26.40	59.90
1992	27.3.b.23	2.90	-	-	-	-	-	-	-	1.70	4.60
1992	27.3.c.22, 27.3.d.24	26.90	-	-	15.60	-	-	-	15.50	22.30	80.30
1992	Total	128.00	-	-	15.60	-	-	13.90	15.50	138.40	311.40
1993	27.3.a.20	87.80	-	-	-	-	-	24.20	-	56.40	168.40
1993	27.3.a.21	28.70	-	-	-	-	-	-	-	16.70	45.40
1993	27.3.b.23	3.30	-	-	-	-	-	-	-	0.70	4.00

year	area	Den-mark	Faroe Islands	Fin-land	Ger-many	Lithu-ania	Neth-er-lands	Nor-way	Poland	Swe-den	Total
1993	27.3.c.22, 27.3.d.24	38.00	-	-	11.10	-	-	-	11.80	16.20	77.10
1993	Total	157.80	-	-	11.10	-	-	24.20	11.80	90.00	294.90
1994	27.3.a.20	44.90	-	-	-	-	-	17.70	-	66.40	129.00
1994	27.3.a.21	23.60	-	-	-	-	-	-	-	15.40	39.00
1994	27.3.b.23	1.50	-	-	-	-	-	-	-	0.30	1.80
1994	27.3.c.22, 27.3.d.24	39.50	-	-	11.40	-	-	-	6.30	7.40	64.60
1994	Total	109.50	-	-	11.40	-	-	17.70	6.30	89.50	234.40
1995	27.3.a.20	43.70	-	-	-	-	-	16.70	-	48.50	108.90
1995	27.3.a.21	16.90	-	-	-	-	-	-	-	30.80	47.70
1995	27.3.b.23	0.90	-	-	-	-	-	-	-	0.20	1.10
1995	27.3.c.22, 27.3.d.24	36.80	-	-	13.40	-	-	-	7.30	15.80	73.30
1995	Total	98.30	-	-	13.40	-	-	16.70	7.30	95.30	231.00
1996	27.3.a.20	28.70	-	-	-	-	-	9.40	-	32.70	70.80
1996	27.3.a.21	17.20	-	-	-	-	-	-	-	27.00	44.20
1996	27.3.b.23	0.70	-	-	-	-	-	-	-	0.30	1.00
1996	27.3.c.22, 27.3.d.24	34.40	-	-	7.30	-	-	-	6.00	9.00	56.70
1996	Total	81.00	-	-	7.30	-	-	9.40	6.00	69.00	172.70
1997	27.3.a.20	14.30	-	-	-	-	-	8.80	-	32.90	56.00
1997	27.3.a.21	8.80	-	-	-	-	-	-	-	18.00	26.80
1997	27.3.b.23	2.20	-	-	-	-	-	-	-	0.10	2.30
1997	27.3.c.22, 27.3.d.24	30.50	-	-	12.80	-	-	-	6.90	14.50	64.70
1997	Total	55.80	-	-	12.80	-	-	8.80	6.90	65.50	149.80
1998	27.3.a.20	10.30	-	-	-	-	-	8.00	-	46.90	65.20
1998	27.3.a.21	23.70	-	-	-	-	-	-	-	29.90	53.60
1998	27.3.b.23	0.40	-	-	-	-	-	-	-	0.30	0.70
1998	27.3.c.22, 27.3.d.24	30.10	-	-	9.00	-	-	-	6.50	4.30	49.90

year	area	Den-mark	Faroe Islands	Fin-land	Ger-many	Lithu-ania	Neth-er-lands	Nor-way	Poland	Swe-den	Total
1998	Total	64.50	-	-	9.00	-	-	8.00	6.50	81.40	169.40
1999	27.3.a.20	10.10	-	-	-	-	-	7.40	-	36.40	53.90
1999	27.3.a.21	17.90	-	-	-	-	-	-	-	14.60	32.50
1999	27.3.b.23	0.50	-	-	-	-	-	-	-	0.10	0.60
1999	27.3.c.22, 27.3.d.24	32.50	-	-	9.80	-	-	-	5.30	2.60	50.20
1999	Total	61.00	-	-	9.80	-	-	7.40	5.30	53.70	137.20
2000	27.3.a.20	16.00	-	-	-	-	-	9.70	-	45.80	71.50
2000	27.3.a.21	18.90	-	-	-	-	-	-	-	17.30	36.20
2000	27.3.b.23	0.90	-	-	-	-	-	-	-	0.10	1.00
2000	27.3.c.22, 27.3.d.24	32.60	-	-	9.30	-	-	-	6.60	4.80	53.30
2000	Total	68.40	-	-	9.30	-	-	9.70	6.60	68.00	162.00
2001	27.3.a.20	16.20	-	-	-	-	-	-	-	30.80	47.00
2001	27.3.a.21	18.80	-	-	-	-	-	-	-	16.20	35.00
2001	27.3.b.23	0.60	-	-	-	-	-	-	-	0.20	0.80
2001	27.3.c.22, 27.3.d.24	28.30	-	-	11.40	-	-	-	9.30	13.90	62.90
2001	Total	63.90	-	-	11.40	-	-	-	9.30	61.10	145.70
2002	27.3.a.20	25.97	-	-	-	-	-	-	-	26.35	52.32
2002	27.3.a.21	18.61	-	-	-	-	-	-	-	7.25	25.85
2002	27.3.b.23	4.57	-	-	-	-	-	-	-	-	4.57
2002	27.3.c.22, 27.3.d.24	13.07	-	-	22.40	-	-	-	-	10.72	46.18
2002	Total	62.22	-	-	22.40	-	-	-	-	44.32	128.93
2003	27.3.a.20	15.48	-	-	0.72	-	-	-	-	25.83	42.03
2003	27.3.a.21	15.95	-	-	-	-	-	-	-	10.24	26.19
2003	27.3.b.23	2.32	-	-	-	-	-	-	-	0.24	2.56
2003	27.3.c.22, 27.3.d.24	6.14	-	-	18.78	-	-	-	4.40	9.38	38.70
2003	Total	39.89	-	-	19.50	-	-	-	4.40	45.69	109.47

year	area	Denmark	Faroe Islands	Finland	Germany	Lithuania	Netherlands	Norway	Poland	Sweden	Total
2004	27.3.a.20	11.78	-	-	0.48	-	-	-	-	21.81	34.07
2004	27.3.a.21	7.56	-	-	-	-	-	-	-	9.63	17.19
2004	27.3.b.23	0.09	-	-	-	-	-	-	-	0.32	0.41
2004	27.3.c.22, 27.3.d.24	7.31	-	-	18.49	-	-	-	5.51	9.87	41.18
2004	Total	26.74	-	-	18.98	-	-	-	5.51	41.61	92.85
2005	27.3.a.20	14.77	0.44	-	0.75	-	-	-	-	32.55	48.50
2005	27.3.a.21	11.11	-	-	-	-	-	-	-	9.99	21.09
2005	27.3.b.23	1.78	-	-	-	-	-	-	-	0.38	2.16
2005	27.3.c.22, 27.3.d.24	5.31	-	-	21.04	-	-	-	6.29	9.17	41.81
2005	Total	32.97	0.44	-	21.79	-	-	-	6.29	52.09	113.58
2006**	27.3.a.20	5.16	-	-	0.60	-	-	-	-	26.00	31.76
2006**	27.3.a.21	8.62	-	-	-	-	-	-	-	10.80	19.42
2006**	27.3.b.23	1.83	-	-	-	-	-	-	-	0.65	2.48
2006**	27.3.c.22, 27.3.d.24	1.41	-	-	22.87	-	-	-	5.50	9.60	39.38
2006**	Total	17.00	-	-	23.47	-	-	-	5.50	47.06	93.03
2007	27.3.a.20	3.59	-	-	0.45	-	-	3.47	-	19.42	26.94
2007	27.3.a.21	9.18	-	-	-	-	-	-	-	11.15	20.33
2007	27.3.b.23	2.87	-	-	-	-	-	-	-	-	2.87
2007	27.3.c.22, 27.3.d.24	2.84	-	-	24.58	-	-	-	2.94	7.22	37.59
2007	Total	18.49	-	-	25.04	-	-	3.47	2.94	37.80	87.73
2008	27.3.a.20	3.87	-	-	1.57	-	-	4.02	-	16.50	25.96
2008	27.3.a.21	7.02	-	-	-	-	-	-	-	5.21	12.23
2008	27.3.b.23	5.32	-	-	-	-	-	-	-	0.33	5.65
2008	27.3.c.22, 27.3.d.24	3.07	-	-	22.82	-	-	-	5.54	7.02	38.46
2008	Total	19.28	-	-	24.39	-	-	4.02	5.54	29.07	82.30
2009	27.3.a.20	12.72	0.55	-	0.26	-	-	3.30	-	12.87	29.69

year	area	Den-mark	Faroe Islands	Fin-land	Ger-many	Lithu-ania	Neth-er-lands	Nor-way	Poland	Swe-den	Total
2009	27.3.a.21	4.90	-	-	0.63	-	-	-	-	3.61	9.14
2009	27.3.b.23	2.82	-	-	-	-	-	-	-	0.81	3.62
2009	27.3.c.22, 27.3.d.24	2.15	-	-	15.98	-	-	-	5.23	4.05	27.41
2009	Total	22.58	0.55	-	16.87	-	-	3.30	5.23	21.34	69.86
2010	27.3.a.20	5.31	0.45	-	0.15	0.4	-	3.28	-	17.44	27.02
2010	27.3.a.21	7.57	-	-	-	-	-	-	-	2.69	10.26
2010	27.3.b.23***	0.10	-	-	-	-	-	-	-	0.93	1.03
2010	27.3.c.22, 27.3.d.24	0.76	-	-	12.24	-	-	-	1.80	2.03	16.83
2010	Total	13.74	0.45	-	12.38	0.4	-	3.28	1.80	23.11	55.15
2011	27.3.a.20	3.58	-	-	0.05	-	-	0.12	-	9.46	13.20
2011	27.3.a.21	5.16	-	-	-	-	-	-	-	1.66	6.82
2011	27.3.b.23	0.03	-	-	-	-	-	-	-	0.54	0.57
2011	27.3.c.22, 27.3.d.24	3.09	-	-	8.19	-	-	-	1.80	2.18	15.26
2011	Total	11.85	-	-	8.24	-	-	0.12	1.80	13.84	35.85
2012	27.3.a.20	3.24	-	-	0.63	-	-	0.45	-	16.21	20.53
2012	27.3.a.21	6.33	-	-	-	-	-	-	-	0.80	7.13
2012	27.3.b.23	0.04	-	-	-	-	-	-	-	0.68	0.72
2012	27.3.c.22, 27.3.d.24	4.11	-	-	11.17	-	-	-	2.39	2.71	20.38
2012	Total	13.71	-	-	11.80	-	-	0.45	2.39	20.40	48.75
2013	27.3.a.20	4.89	-	-	0.19	-	-	3.02	-	16.68	24.78
2013	27.3.a.21	3.88	-	-	-	-	-	-	-	2.59	6.46
2013	27.3.b.23	0.04	-	-	-	-	-	-	-	0.63	0.68
2013	27.3.c.22, 27.3.d.24	5.06	-	-	14.59	-	-	-	3.11	2.07	24.83
2013	Total	13.87	-	-	14.78	-	-	3.02	3.11	21.96	56.74
2014	27.3.a.20	6.45	-	-	0.08	-	-	2.05	-	12.59	21.17
2014	27.3.a.21	4.27	-	-	-	-	-	-	-	3.41	7.68

year	area	Den-mark	Faroe Islands	Fin-land	Ger-many	Lithu-ania	Neth-er-lands	Nor-way	Poland	Swe-den	Total
2014	27.3.b.23	0.05	-	-	-	-	-	-	-	0.32	0.37
2014	27.3.c.22, 27.3.d.24	4.28	-	-	10.24	-	-	-	2.38	1.08	17.98
2014	Total	15.04	-	-	10.33	-	-	2.05	2.38	17.40	47.20
2015	27.3.a.20	4.14	0.48	-	0.13	-	0.03	2.48	-	12.86	20.11
2015	27.3.a.21	3.98	-	-	-	-	-	-	-	3.75	7.73
2015	27.3.b.23	0.03	-	-	-	-	-	-	-	0.19	0.22
2015	27.3.c.22, 27.3.d.24	4.49	-	-	13.29	-	-	-	2.65	1.50	21.92
2015	Total	12.63	0.48	-	13.42	-	0.03	2.48	2.65	18.30	49.98
2016	27.3.a.20	3.55	0.32	-	0.12	-	-	3.92	-	13.32	21.24
2016	27.3.a.21	2.45	-	-	-	-	-	-	-	6.21	8.65
2016	27.3.b.23	0.03	-	-	-	-	-	-	-	0.33	0.36
2016	27.3.c.22, 27.3.d.24	5.71	-	-	14.43	-	-	-	2.92	1.66	24.72
2016	Total	11.74	0.32	-	14.55	-	-	3.92	2.92	21.52	54.97
2017	27.3.a.20	2.70	0.40	-	0.09	-	-	3.34	-	11.94	18.46
2017	27.3.a.21	0.91	-	-	-	-	-	-	-	7.43	8.34
2017	27.3.b.23	0.26	-	-	-	-	-	-	-	0.36	0.62
2017	27.3.c.22, 27.3.d.24	5.59	-	-	14.69	-	-	-	3.33	2.29	25.90
2017	Total	9.46	0.40	-	14.78	-	-	3.34	3.33	22.01	53.31
2018	27.3.a.20	0.86	0.15	-	0.21	-	-	3.41	-	11.33	15.96
2018	27.3.a.21	1.26	-	-	-	-	-	-	-	6.04	7.30
2018	27.3.b.23	0.07	-	-	-	-	-	-	-	0.42	0.49
2018	27.3.c.22, 27.3.d.24	4.49	-	-	11.30	-	-	-	1.77	0.94	18.51
2018	Total	6.67	0.15	-	11.51	-	-	3.41	1.77	18.73	42.25
2019	27.3.a.20	0.59	-	-	0.12	-	-	2.47	-	8.51	11.69
2019	27.3.a.21	1.50	-	-	-	-	-	-	-	1.73	3.22
2019	27.3.b.23	0.01	-	-	-	-	-	-	-	0.35	0.36

year	area	Den-mark	Faroe Islands	Fin-land	Ger-many	Lithu-ania	Neth-er-lands	Nor-way	Poland	Swe-den	Total
2019	27.3.c.22, 27.3.d.24	2.04	-	-	5.57	-	-	-	1.13	0.73	9.47
2019	Total	4.14	-	-	5.69	-	-	2.47	1.13	11.31	24.75
2020	27.3.a.20	3.19	-	-	0.16	-	-	2.12	-	9.07	14.54
2020	27.3.a.21	0.67	-	-	-	-	-	-	-	2.57	3.24
2020	27.3.b.23	-	-	-	-	-	-	-	-	0.48	0.48
2020	27.3.c.22, 27.3.d.24	0.59	-	-	2.07	-	-	-	0.60	0.23	3.48
2020	Total	4.45	-	-	2.22	-	-	2.12	0.60	12.36	21.74
2021	27.3.a.20	2.87	-	-	0.14	-	-	1.12	-	6.13	10.26
2021	27.3.a.21	0.21	-	-	-	-	-	-	-	2.84	3.05
2021	27.3.b.23	0.01	-	-	-	-	-	-	-	0.28	0.29
2021	27.3.c.22, 27.3.d.24	0.15	-	-	0.84	-	-	-	0.25	0.08	1.31
2021	Total	3.23	-	-	0.99	-	-	1.12	0.25	9.33	14.92
2022	27.3.a.20	0.13	-	-	-	-	-	0.25	-	0.10	0.48
2022	27.3.a.21	0.11	-	-	-	-	-	-	-	0.14	0.25
2022	27.3.b.23	-	-	-	-	-	-	-	-	0.24	0.25
2022	27.3.c.22, 27.3.d.24	0.01	-	-	0.23	-	-	-	0.15	0.01	0.39
2022	Total	0.25	-	-	0.23	-	-	0.25	0.15	0.49	1.36
2023*	27.3.a.20	0.09	-	-	-	-	-	0.59	-	0.12	0.79
2023*	27.3.a.21	0.08	-	-	-	-	-	-	-	0.12	0.20
2023*	27.3.b.23	-	-	-	-	-	-	-	-	0.28	0.28
2023*	27.3.c.22, 27.3.d.24	0.01	-	-	0.24	-	-	-	0.20	-	0.45
2023*	Total	0.17	-	-	0.24	-	-	0.59	0.20	0.51	1.71

*Preliminary

**2,000 t of Danish catches are missing (HAWG 2007)

***Danmark has officially reported 3,103 t of catches (HAWG 2011)

Table 3.1.2 WESTERN BALTIC HERRING. Both WBSS and NSAS. Catch (SOP, 1000 tonnes) in 2004-2023 by year, area, fleet and quarter

year	area	fleet	1	2	3	4	Total
2004	27.3.a	C	13.45	2.76	8.18	5.86	30.26
2004	27.3.a	D	2.84	3.31	10.82	4.97	21.95
2004	27.3.b, 27.3.c, 27.3.d.24	F	20.36	10.45	2.36	8.57	41.74
2004	Total	Total	36.66	16.51	21.37	19.41	93.95
2005	27.3.a	C	16.56	3.41	23.42	12.03	55.42
2005	27.3.a	D	6.14	1.94	3.42	2.65	14.15
2005	27.3.b, 27.3.c, 27.3.d.24	F	20.42	15.59	1.87	5.84	43.72
2005	Total	Total	43.12	20.94	28.71	20.52	113.29
2006	27.3.a	C	15.30	2.57	15.67	8.33	41.87
2006	27.3.a	D	5.86	0.14	0.85	2.42	9.26
2006	27.3.b, 27.3.c, 27.3.d.24	F	15.06	17.24	3.03	6.53	41.86
2006	Total	Total	36.22	19.95	19.55	17.28	92.99
2007	27.3.a	C	7.75	3.80	22.38	7.67	41.60
2007	27.3.a	D	2.96	0.14	0.80	1.76	5.67
2007	27.3.b, 27.3.c, 27.3.d.24	F	18.78	10.49	1.71	9.48	40.46
2007	Total	Total	29.49	14.44	24.89	18.91	87.73
2008	27.3.a	C	8.17	2.69	14.88	6.54	32.28
2008	27.3.a	D	3.91	0.31	0.64	1.04	5.91
2008	27.3.b, 27.3.c, 27.3.d.24	F	18.42	11.28	6.02	8.40	44.12
2008	Total	Total	30.49	14.29	21.54	15.98	82.31
2009	27.3.a	C	11.07	3.14	14.28	5.99	34.48
2009	27.3.a	D	2.70	0.12	0.85	0.67	4.35
2009	27.3.b, 27.3.c, 27.3.d.24	F	19.46	6.82	1.43	3.32	31.03
2009	Total	Total	33.24	10.08	16.56	9.98	69.86
2010	27.3.a	C	8.43	3.93	13.44	9.16	34.95
2010	27.3.a	D	1.14	0.71	0.41	0.07	2.33
2010	27.3.b, 27.3.c, 27.3.d.24	F	10.23	5.43	0.43	1.83	17.92
2010	Total	Total	19.80	10.07	14.28	11.06	55.20

year	area	fleet	1	2	3	4	Total
2011	27.3.a	C	7.01	0.53	6.49	3.39	17.42
2011	27.3.a	D	0.54	0.19	0.97	0.90	2.60
2011	27.3.b, 27.3.c, 27.3.d.24	F	7.76	4.07	0.85	3.16	15.83
2011	Total	Total	15.31	4.79	8.31	7.44	35.85
2012	27.3.a	C	4.52	0.27	12.30	5.17	22.27
2012	27.3.a	D	1.82	0.73	1.69	1.14	5.39
2012	27.3.b, 27.3.c, 27.3.d.24	F	13.98	2.51	1.06	3.55	21.09
2012	Total	Total	20.32	3.51	15.05	9.86	48.75
2013	27.3.a	C	8.50	1.65	8.37	9.84	28.36
2013	27.3.a	D	0.75	0.62	0.98	0.53	2.88
2013	27.3.b, 27.3.c, 27.3.d.24	F	11.66	8.50	1.07	4.28	25.50
2013	Total	Total	20.90	10.77	10.42	14.65	56.74
2014	27.3.a	C	6.23	2.27	10.74	5.68	24.93
2014	27.3.a	D	0.24	0.52	2.38	0.82	3.96
2014	27.3.b, 27.3.c, 27.3.d.24	F	10.81	2.30	0.84	4.39	18.34
2014	Total	Total	17.28	5.09	13.97	10.89	47.23
2015	27.3.a	C	8.99	0.97	7.54	4.05	21.56
2015	27.3.a	D	1.88	0.15	1.47	2.77	6.28
2015	27.3.b, 27.3.c, 27.3.d.24	F	14.21	2.76	0.90	4.27	22.14
2015	Total	Total	25.08	3.88	9.92	11.10	49.98
2016	27.3.a	C	7.85	0.36	15.75	3.40	27.37
2016	27.3.a	D	0.69	0.25	1.33	0.25	2.53
2016	27.3.b, 27.3.c, 27.3.d.24	F	15.48	3.51	1.39	4.69	25.07
2016	Total	Total	24.02	4.12	18.47	8.35	54.96
2017	27.3.a	C	7.51	0.19	12.13	6.59	26.43
2017	27.3.a	D	-	0.05	0.05	0.26	0.37
2017	27.3.b, 27.3.c, 27.3.d.24	F	16.83	3.38	0.97	5.33	26.51
2017	Total	Total	24.34	3.63	13.16	12.18	53.31
2018	27.3.a	C	9.95	0.22	10.23	2.49	22.89

year	area	fleet	1	2	3	4	Total
2018	27.3.a	D	-	0.11	0.11	0.14	0.36
2018	27.3.b, 27.3.c, 27.3.d.24	F	11.96	3.43	0.21	3.40	18.99
2018	Total	Total	21.92	3.76	10.55	6.03	42.25
2019	27.3.a	C	4.38	0.54	6.49	3.15	14.56
2019	27.3.a	D	0.09	0.02	0.21	0.04	0.36
2019	27.3.b, 27.3.c, 27.3.d.24	F	6.05	0.43	0.28	3.07	9.83
2019	Total	Total	10.52	0.99	6.98	6.26	24.75
2020	27.3.a	C	4.31	0.35	9.52	2.69	16.86
2020	27.3.a	D	-	0.07	0.60	0.24	0.91
2020	27.3.b, 27.3.c, 27.3.d.24	F	1.96	0.19	0.37	1.44	3.97
2020	Total	Total	6.27	0.61	10.50	4.37	21.74
2021	27.3.a	C	4.38	1.15	6.53	1.12	13.18
2021	27.3.a	D	-	0.02	0.05	0.06	0.14
2021	27.3.b, 27.3.c, 27.3.d.24	F	0.49	0.17	0.08	0.85	1.60
2021	Total	Total	4.88	1.34	6.66	2.03	14.92
2022	27.3.a	C	0.19	0.03	0.15	0.11	0.48
2022	27.3.a	D	0.01	0.11	0.02	0.12	0.25
2022	27.3.b, 27.3.c, 27.3.d.24	F	0.25	0.07	0.02	0.31	0.64
2022	Total	Total	0.45	0.21	0.18	0.53	1.36
2023*	27.3.a	C	0.27	0.01	0.35	0.13	0.76
2023*	27.3.a	D	-	0.06	0.03	0.14	0.23
2023*	27.3.b, 27.3.c, 27.3.d.24	F	0.30	0.13	0.07	0.22	0.72
2023*	Total	Total	0.57	0.20	0.45	0.50	1.71

*Preliminary

Table 3.2.1 WESTERN BALTIC HERRING. Both WBSS and NSAS. Samples of commercial catch available to the Working Group by area, quarter, country and fleet for 2023

year	area	quarter	country	fleet	catch (t)	number of samples	number of fish measured	number of fish aged
2023	27.3.a.20	1	Denmark	C	0.0	-	-	-
2023	27.3.a.20	2	Denmark	C	0.0	-	-	-
2023	27.3.a.20	3	Denmark	C	0.1	-	-	-
2023	27.3.a.20	4	Denmark	C	0.0	-	-	-
2023	27.3.a.20	1	Germany	C	0.0	-	-	-
2023	27.3.a.20	2	Germany	C	0.0	-	-	-
2023	27.3.a.20	3	Germany	C	0.0	-	-	-
2023	27.3.a.20	4	Germany	C	0.0	-	-	-
2023	27.3.a.20	1	Norway	C	215.4	-	-	-
2023	27.3.a.20	2	Norway	C	0.4	-	-	-
2023	27.3.a.20	3	Norway	C	300.9	-	-	-
2023	27.3.a.20	4	Norway	C	71.2	-	-	-
2023	27.3.a.20	1	Sweden	C	20.3	1	75	75
2023	27.3.a.20	2	Sweden	C	6.0	-	-	-
2023	27.3.a.20	3	Sweden	C	6.2	1	50	50
2023	27.3.a.20	4	Sweden	C	60.7	1	75	75
2023	27.3.a.20	1	Denmark	D	0.0	-	-	-
2023	27.3.a.20	2	Denmark	D	59.2	-	-	-
2023	27.3.a.20	3	Denmark	D	26.9	-	-	-
2023	27.3.a.20	4	Denmark	D	0.0	-	-	-
2023	27.3.a.20	1	Germany	D	0.0	-	-	-
2023	27.3.a.20	2	Germany	D	0.0	-	-	-
2023	27.3.a.20	3	Germany	D	0.0	-	-	-
2023	27.3.a.20	4	Germany	D	0.0	-	-	-
2023	27.3.a.20	1	Norway	D	0.0	-	-	-
2023	27.3.a.20	2	Norway	D	0.0	-	-	-
2023	27.3.a.20	3	Norway	D	0.0	-	-	-
2023	27.3.a.20	4	Norway	D	0.0	-	-	-

year	area	quarter	country	fleet	catch (t)	number of samples	number of fish measured	number of fish aged
2023	27.3.a.20	1	Sweden	D	0.0	-	-	-
2023	27.3.a.20	2	Sweden	D	0.0	-	-	-
2023	27.3.a.20	3	Sweden	D	0.0	-	-	-
2023	27.3.a.20	4	Sweden	D	21.9	-	-	-
2023	27.3.a.21	1	Denmark	C	30.6	2	588	220
2023	27.3.a.21	2	Denmark	C	0.1	-	-	-
2023	27.3.a.21	3	Denmark	C	41.3	-	-	-
2023	27.3.a.21	4	Denmark	C	0.7	-	-	-
2023	27.3.a.21	1	Germany	C	0.0	-	-	-
2023	27.3.a.21	2	Germany	C	0.0	-	-	-
2023	27.3.a.21	3	Germany	C	0.0	-	-	-
2023	27.3.a.21	4	Germany	C	0.0	-	-	-
2023	27.3.a.21	1	Sweden	C	1.0	-	-	-
2023	27.3.a.21	2	Sweden	C	0.1	-	-	-
2023	27.3.a.21	3	Sweden	C	2.1	-	-	-
2023	27.3.a.21	4	Sweden	C	0.1	1	51	51
2023	27.3.a.21	1	Denmark	D	0.0	-	-	-
2023	27.3.a.21	2	Denmark	D	1.8	-	-	-
2023	27.3.a.21	3	Denmark	D	4.0	-	-	-
2023	27.3.a.21	4	Denmark	D	0.0	-	-	-
2023	27.3.a.21	1	Germany	D	0.0	-	-	-
2023	27.3.a.21	2	Germany	D	0.0	-	-	-
2023	27.3.a.21	3	Germany	D	0.0	-	-	-
2023	27.3.a.21	4	Germany	D	0.0	-	-	-
2023	27.3.a.21	1	Sweden	D	0.0	-	-	-
2023	27.3.a.21	2	Sweden	D	0.0	-	-	-
2023	27.3.a.21	3	Sweden	D	0.0	-	-	-
2023	27.3.a.21	4	Sweden	D	116.0	5	375	375
2023	27.3.b.23	1	Denmark	F	0.0	-	-	-

year	area	quarter	country	fleet	catch (t)	number of samples	number of fish measured	number of fish aged
2023	27.3.b.23	2	Denmark	F	0.0	-	-	-
2023	27.3.b.23	3	Denmark	F	0.0	-	-	-
2023	27.3.b.23	4	Denmark	F	0.0	-	-	-
2023	27.3.b.23	1	Sweden	F	46.1	3	184	184
2023	27.3.b.23	2	Sweden	F	0.0	-	-	-
2023	27.3.b.23	3	Sweden	F	54.1	6	395	394
2023	27.3.b.23	4	Sweden	F	175.4	17	1099	1097
2023	27.3.c.22	1	Denmark	F	0.3	-	-	-
2023	27.3.c.22	2	Denmark	F	2.5	2	270	150
2023	27.3.c.22	3	Denmark	F	0.0	-	-	-
2023	27.3.c.22	4	Denmark	F	0.1	-	-	-
2023	27.3.c.22	1	Germany	F	5.6	7	1900	412
2023	27.3.c.22	2	Germany	F	3.4	1	216	51
2023	27.3.c.22	3	Germany	F	0.0	-	-	-
2023	27.3.c.22	4	Germany	F	2.3	-	-	-
2023	27.3.c.22	1	Poland	F	0.0	-	-	-
2023	27.3.c.22	2	Poland	F	0.0	-	-	-
2023	27.3.c.22	3	Poland	F	0.0	-	-	-
2023	27.3.c.22	4	Poland	F	0.0	-	-	-
2023	27.3.c.22	1	Sweden	F	0.0	-	-	-
2023	27.3.c.22	2	Sweden	F	0.0	-	-	-
2023	27.3.c.22	3	Sweden	F	0.0	-	-	-
2023	27.3.c.22	4	Sweden	F	0.0	-	-	-
2023	27.3.d.24	1	Denmark	F	0.0	-	-	-
2023	27.3.d.24	2	Denmark	F	3.7	-	-	-
2023	27.3.d.24	3	Denmark	F	0.0	-	-	-
2023	27.3.d.24	4	Denmark	F	0.0	-	-	-
2023	27.3.d.24	1	Germany	F	157.9	19	3961	968
2023	27.3.d.24	2	Germany	F	43.3	1	207	50

year	area	quarter	country	fleet	catch (t)	number of samples	number of fish measured	number of fish aged
2023	27.3.d.24	3	Germany	F	0.0	-	-	-
2023	27.3.d.24	4	Germany	F	26.4	2	327	113
2023	27.3.d.24	1	Poland	F	88.5	4	640	226
2023	27.3.d.24	2	Poland	F	78.0	3	551	171
2023	27.3.d.24	3	Poland	F	13.5	1	171	48
2023	27.3.d.24	4	Poland	F	20.2	-	-	-
2023	27.3.d.24	1	Sweden	F	0.0	-	-	-
2023	27.3.d.24	2	Sweden	F	0.3	-	-	-
2023	27.3.d.24	3	Sweden	F	0.0	-	-	-
2023	27.3.d.24	4	Sweden	F	0.0	-	-	-
2023	Total	Total	Total	Total	1708.6	77	11135	4710

Table 3.2.2 WESTERN BALTIC HERRING. Both WBSS and NSAS. Samples of commercial catch by quarter, fleet and area for 2023 used to estimate catch in numbers and mean weight at age as W-ringers for 2023

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.a.20	1	Denmark	C	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	2	Denmark	C	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	3	Denmark	C	0.1	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	4	Denmark	C	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	1	Denmark	D	0.0	No landings
2023	27.3.a.20	2	Denmark	D	59.2	2023 Sweden 27.3.a.21 fleetD Q4
2023	27.3.a.20	3	Denmark	D	26.8	2023 Sweden 27.3.a.21 fleetD Q4
2023	27.3.a.20	4	Denmark	D	0.0	No landings
2023	27.3.a.20	1	Germany	C	0.0	No landings
2023	27.3.a.20	2	Germany	C	0.0	No landings
2023	27.3.a.20	3	Germany	C	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	4	Germany	C	0.0	No landings

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.a.20	1	Germany	D	0.0	No landings
2023	27.3.a.20	2	Germany	D	0.0	No landings
2023	27.3.a.20	3	Germany	D	0.0	No landings
2023	27.3.a.20	4	Germany	D	0.0	No landings
2023	27.3.a.20	1	Norway	C	215.4	2023 Sweden 27.3.a.20 fleetC - purse seine Q1
2023	27.3.a.20	2	Norway	C	0.4	2023 Sweden 27.3.a.20 fleetC - purse seine Q1
2023	27.3.a.20	3	Norway	C	300.8	National imputation
2023	27.3.a.20	4	Norway	C	71.2	2023 Sweden 27.3.a.20 fleetC - purse seine Q4
2023	27.3.a.20	1	Norway	D	0.0	No landings
2023	27.3.a.20	2	Norway	D	0.0	No landings
2023	27.3.a.20	3	Norway	D	0.0	No landings
2023	27.3.a.20	4	Norway	D	0.0	No landings
2023	27.3.a.20	1	Sweden	C - other	0.2	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	2	Sweden	C - other	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	3	Sweden	C - other	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	4	Sweden	C - other	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.20	1	Sweden	C - passive	7.2	2023 Sweden 27.3.a.21 fleetC - passive Q4
2023	27.3.a.20	2	Sweden	C - passive	0.0	No landings
2023	27.3.a.20	3	Sweden	C - passive	0.0	No landings
2023	27.3.a.20	4	Sweden	C - passive	0.2	2023 Sweden 27.3.a.21 fleetC - passive Q4
2023	27.3.a.20	1	Sweden	C - purse seine	13.0	Sampling
2023	27.3.a.20	2	Sweden	C - purse seine	5.9	2023 Sweden 27.3.a.20 fleetC - purse seine Q1
2023	27.3.a.20	3	Sweden	C - purse seine	6.2	Sampling
2023	27.3.a.20	4	Sweden	C - purse seine	60.6	Sampling
2023	27.3.a.20	1	Sweden	D	0.0	No landings

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.a.20	2	Sweden	D	0.0	No landings
2023	27.3.a.20	3	Sweden	D	0.0	No landings
2023	27.3.a.20	4	Sweden	D	21.8	2023 Sweden 27.3.a.21 fleetD Q4
2023	27.3.a.21	1	Denmark	C - trawl	30.5	Sampling
2023	27.3.a.21	2	Denmark	C - trawl	0.1	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	3	Denmark	C - trawl	41.2	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	4	Denmark	C - trawl	0.7	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	1	Denmark	D	0.0	No landings
2023	27.3.a.21	2	Denmark	D	1.9	2023 Sweden 27.3.a.21 fleetD Q4
2023	27.3.a.21	3	Denmark	D	4.0	2023 Sweden 27.3.a.21 fleetD Q4
2023	27.3.a.21	4	Denmark	D	0.0	No landings
2023	27.3.a.21	1	Germany	C	0.0	No landings
2023	27.3.a.21	2	Germany	C	0.0	No landings
2023	27.3.a.21	3	Germany	C	0.0	No landings
2023	27.3.a.21	4	Germany	C	0.0	No landings
2023	27.3.a.21	1	Germany	D	0.0	No landings
2023	27.3.a.21	2	Germany	D	0.0	No landings
2023	27.3.a.21	3	Germany	D	0.0	No landings
2023	27.3.a.21	4	Germany	D	0.0	No landings
2023	27.3.a.21	1	Sweden	C - other	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	2	Sweden	C - other	0.1	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	3	Sweden	C - other	2.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	4	Sweden	C - other	0.0	2023 Denmark 27.3.a.21 fleetC - trawl Q1
2023	27.3.a.21	1	Sweden	C - passive	0.9	2023 Sweden 27.3.a.21 fleetC - passive Q4
2023	27.3.a.21	2	Sweden	C - passive	0.0	No landings
2023	27.3.a.21	3	Sweden	C - passive	0.0	No landings

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.a.21	4	Sweden	C - passive	0.2	Sampling
2023	27.3.a.21	1	Sweden	D	0.0	No landings
2023	27.3.a.21	2	Sweden	D	0.0	No landings
2023	27.3.a.21	3	Sweden	D	0.0	No landings
2023	27.3.a.21	4	Sweden	D	116.0	Sampling
2023	27.3.b.23	1	Denmark	F - active	0.0	No landings
2023	27.3.b.23	2	Denmark	F - active	0.0	No landings
2023	27.3.b.23	3	Denmark	F - active	0.0	No landings
2023	27.3.b.23	4	Denmark	F - active	0.0	No landings
2023	27.3.b.23	1	Denmark	F - passive	0.0	No landings
2023	27.3.b.23	2	Denmark	F - passive	0.0	No landings
2023	27.3.b.23	3	Denmark	F - passive	0.0	No landings
2023	27.3.b.23	4	Denmark	F - passive	0.2	2023 Sweden 27.3.b.23 fleetF - passive Q1
2023	27.3.b.23	1	Sweden	F - active	0.0	No landings
2023	27.3.b.23	2	Sweden	F - active	0.0	No landings
2023	27.3.b.23	3	Sweden	F - active	0.0	No landings
2023	27.3.b.23	4	Sweden	F - active	0.0	No landings
2023	27.3.b.23	1	Sweden	F - passive	46.1	Sampling
2023	27.3.b.23	2	Sweden	F - passive	0.0	No landings
2023	27.3.b.23	3	Sweden	F - passive	54.0	Sampling
2023	27.3.b.23	4	Sweden	F - passive	175.3	Sampling
2023	27.3.c.22	1	Denmark	F - active	0.0	No landings
2023	27.3.c.22	2	Denmark	F - active	0.0	No landings
2023	27.3.c.22	3	Denmark	F - active	0.0	No landings
2023	27.3.c.22	4	Denmark	F - active	0.0	No landings
2023	27.3.c.22	1	Denmark	F - passive	0.3	2023 Germany 27.3.c.22 fleetF - passive Q1
2023	27.3.c.22	2	Denmark	F - passive	2.5	Sampling
2023	27.3.c.22	3	Denmark	F - passive	0.0	2023 Denmark 27.3.c.22 fleetF - passive Q2

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.c.22	4	Denmark	F - passive	0.2	2023 Denmark 27.3.c.22 fleetF - passive Q2
2023	27.3.c.22	1	Germany	F - active	0.0	No landings
2023	27.3.c.22	2	Germany	F - active	0.0	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.c.22	3	Germany	F - active	0.0	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.c.22	4	Germany	F - active	0.0	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.c.22	1	Germany	F - passive	5.7	Sampling
2023	27.3.c.22	2	Germany	F - passive	3.3	Sampling
2023	27.3.c.22	3	Germany	F - passive	0.0	2023 Germany 27.3.c.22 fleetF - passive Q2
2023	27.3.c.22	4	Germany	F - passive	2.3	2023 Germany 27.3.c.22 fleetF - passive Q2
2023	27.3.c.22	1	Poland	F	0.0	No landings
2023	27.3.c.22	2	Poland	F	0.0	No landings
2023	27.3.c.22	3	Poland	F	0.0	No landings
2023	27.3.c.22	4	Poland	F	0.0	No landings
2023	27.3.c.22	1	Sweden	F - active	0.0	No landings
2023	27.3.c.22	2	Sweden	F - active	0.0	No landings
2023	27.3.c.22	3	Sweden	F - active	0.0	No landings
2023	27.3.c.22	4	Sweden	F - active	0.0	No landings
2023	27.3.c.22	1	Sweden	F - passive	0.0	No landings
2023	27.3.c.22	2	Sweden	F - passive	0.0	No landings
2023	27.3.c.22	3	Sweden	F - passive	0.0	No landings
2023	27.3.c.22	4	Sweden	F - passive	0.0	No landings
2023	27.3.d.24	1	Denmark	F - active	0.0	No landings
2023	27.3.d.24	2	Denmark	F - active	3.6	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.d.24	3	Denmark	F - active	0.0	No landings
2023	27.3.d.24	4	Denmark	F - active	0.0	No landings
2023	27.3.d.24	1	Denmark	F - passive	0.0	No landings

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.d.24	2	Denmark	F - passive	0.0	No landings
2023	27.3.d.24	3	Denmark	F - passive	0.0	No landings
2023	27.3.d.24	4	Denmark	F - passive	0.0	No landings
2023	27.3.d.24	1	Germany	F - active	0.5	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.d.24	2	Germany	F - active	20.4	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.d.24	3	Germany	F - active	0.0	No landings
2023	27.3.d.24	4	Germany	F - active	6.0	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.d.24	1	Germany	F - passive	157.4	Sampling
2023	27.3.d.24	2	Germany	F - passive	22.9	Sampling
2023	27.3.d.24	3	Germany	F - passive	0.0	2023 Germany 27.3.d.24 fleetF - passive Q4
2023	27.3.d.24	4	Germany	F - passive	20.3	Sampling
2023	27.3.d.24	1	Poland	F - active	0.0	No landings
2023	27.3.d.24	2	Poland	F - active	0.0	No landings
2023	27.3.d.24	3	Poland	F - active	13.6	Sampling
2023	27.3.d.24	4	Poland	F - active	20.2	2023 Poland 27.3.d.24 fleetF - active Q3
2023	27.3.d.24	1	Poland	F - passive	88.6	Sampling
2023	27.3.d.24	2	Poland	F - passive	77.9	Sampling
2023	27.3.d.24	3	Poland	F - passive	0.0	No landings
2023	27.3.d.24	4	Poland	F - passive	0.0	No landings
2023	27.3.d.24	1	Sweden	F - active	0.0	No landings
2023	27.3.d.24	2	Sweden	F - active	0.0	No landings
2023	27.3.d.24	3	Sweden	F - active	0.0	No landings
2023	27.3.d.24	4	Sweden	F - active	0.0	No landings
2023	27.3.d.24	1	Sweden	F - passive	0.0	No landings
2023	27.3.d.24	2	Sweden	F - passive	0.3	2023 Poland 27.3.d.24 fleetF - passive Q2
2023	27.3.d.24	3	Sweden	F - passive	0.0	2023 Germany 27.3.d.24 fleetF - passive Q4

year	area	quarter	ctry	fleet	catch (t)	sampling
2023	27.3.d.24	4	Sweden	F - passive	0.1	2023 Germany 27.3.d.24 fleetF - passive Q4

Table 3.2.3 WESTERN BALTIC HERRING. Both WBSS and NSAS. CANUM: Catch in numbers (mill), WECA: mean weight (g) and SOP (t) by age as W-ringers, area, fleet and quarter in 2023

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.20	C	1	CANUM	-	8.98	0.12	0.01	0.01	0.01	0.01	0.00	0.00	9.15
2023	27.3.a.20	C	2	CANUM	-	0.25	0.00	0.00	0.00	0.00	-	-	-	0.25
2023	27.3.a.20	C	3	CANUM	0.55	0.00	0.27	0.90	0.28	0.15	0.07	0.02	-	2.25
2023	27.3.a.20	C	4	CANUM	0.90	2.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74
2023	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	CANUM	0.06	1.40	0.02	0.00	-	-	-	-	-	1.48
2023	27.3.a.20	D	3	CANUM	0.03	0.63	0.01	0.00	-	-	-	-	-	0.67
2023	27.3.a.20	D	4	CANUM	0.02	0.52	0.01	0.00	-	-	-	-	-	0.55
2023	27.3.a.21	C	1	CANUM	-	0.92	0.13	0.04	0.01	0.01	0.00	0.00	0.00	1.12
2023	27.3.a.21	C	2	CANUM	-	0.01	0.00	0.00	0.00	0.00	-	-	-	0.01
2023	27.3.a.21	C	3	CANUM	-	1.30	0.18	0.06	0.01	0.02	-	-	-	1.57
2023	27.3.a.21	C	4	CANUM	-	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
2023	27.3.a.21	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	CANUM	0.00	0.04	0.00	0.00	-	-	-	-	-	0.05
2023	27.3.a.21	D	3	CANUM	0.00	0.09	0.00	0.00	-	-	-	-	-	0.10
2023	27.3.a.21	D	4	CANUM	0.11	2.74	0.05	0.01	-	-	-	-	-	2.90
2023	27.3.b.23	F	1	CANUM	-	-	-	0.03	0.05	0.07	0.06	0.03	0.03	0.28

2023	27.3.b.23	F	2	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	CANUM	-	-	0.00	0.11	0.08	0.05	0.04	0.02	0.01	0.30
2023	27.3.b.23	F	4	CANUM	-	-	0.03	0.31	0.27	0.23	0.13	0.06	0.04	1.06
2023	27.3.c.22	F	1	CANUM	-	-	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.04
2023	27.3.c.22	F	2	CANUM	-	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.05
2023	27.3.c.22	F	3	CANUM	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023	27.3.c.22	F	4	CANUM	-	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02
2023	27.3.d.24	F	1	CANUM	-	0.00	0.00	0.51	0.32	0.22	0.38	0.16	0.21	1.81
2023	27.3.d.24	F	2	CANUM	-	0.00	0.07	0.56	0.37	0.12	0.09	0.06	0.08	1.35
2023	27.3.d.24	F	3	CANUM	-	0.00	0.04	0.01	0.07	0.04	0.01	0.00	0.01	0.19
2023	27.3.d.24	F	4	CANUM	-	0.00	0.08	0.03	0.16	0.09	0.05	0.02	0.04	0.48
2023	27.3.a.20	C	1	SOP	-	224.92	3.68	1.31	1.55	1.39	2.02	0.79	0.16	235.83
2023	27.3.a.20	C	2	SOP	-	6.27	0.10	0.00	0.00	0.00	-	-	-	6.37
2023	27.3.a.20	C	3	SOP	6.23	0.09	38.34	164.38	53.78	28.41	12.68	3.30	-	307.22
2023	27.3.a.20	C	4	SOP	20.41	111.42	0.01	0.05	0.05	0.04	0.06	0.02	0.00	132.08
2023	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	SOP	1.25	56.20	1.50	0.20	-	-	-	-	-	59.16
2023	27.3.a.20	D	3	SOP	0.57	25.50	0.68	0.09	-	-	-	-	-	26.85
2023	27.3.a.20	D	4	SOP	0.46	20.71	0.55	0.07	-	-	-	-	-	21.80
2023	27.3.a.21	C	1	SOP	-	19.37	5.60	3.67	1.29	1.14	0.25	0.10	0.02	31.44
2023	27.3.a.21	C	2	SOP	-	0.14	0.04	0.03	0.01	0.01	-	-	-	0.22

2023	27.3.a.21	C	3	SOP	-	27.45	7.93	4.96	1.56	1.37	-	-	-	43.27
2023	27.3.a.21	C	4	SOP	-	0.50	0.14	0.12	0.07	0.06	0.05	0.02	0.00	0.98
2023	27.3.a.21	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	SOP	0.04	1.80	0.05	0.01	-	-	-	-	-	1.90
2023	27.3.a.21	D	3	SOP	0.08	3.79	0.10	0.01	-	-	-	-	-	3.99
2023	27.3.a.21	D	4	SOP	2.46	110.17	2.95	0.39	-	-	-	-	-	115.97
2023	27.3.b.23	F	1	SOP	-	-	-	4.29	8.11	11.42	10.74	5.46	6.11	46.12
2023	27.3.b.23	F	2	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	SOP	-	-	0.26	18.98	12.97	9.11	6.82	3.29	2.58	54.00
2023	27.3.b.23	F	4	SOP	-	-	3.10	45.07	43.45	41.01	23.51	11.98	7.35	175.47
2023	27.3.c.22	F	1	SOP	-	-	0.03	0.22	0.60	1.10	1.81	1.71	0.54	6.00
2023	27.3.c.22	F	2	SOP	-	0.00	0.26	0.71	0.51	0.75	1.66	0.97	0.97	5.84
2023	27.3.c.22	F	3	SOP	-	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.08
2023	27.3.c.22	F	4	SOP	-	0.00	0.02	0.06	0.06	0.23	1.01	0.48	0.64	2.50
2023	27.3.d.24	F	1	SOP	-	0.00	0.20	40.99	34.04	35.37	65.89	30.06	39.84	246.39
2023	27.3.d.24	F	2	SOP	-	0.21	5.03	44.36	31.16	12.28	11.83	9.40	10.79	125.08
2023	27.3.d.24	F	3	SOP	-	0.12	2.85	1.00	5.29	2.44	0.97	0.20	0.76	13.62
2023	27.3.d.24	F	4	SOP	-	0.23	5.65	2.94	14.48	7.75	6.63	4.11	4.83	46.63
2023	27.3.a.20	C	1	WECA	-	25.04	30.05	162.23	179.57	177.03	185.57	204.12	208.33	25.78
2023	27.3.a.20	C	2	WECA	-	25.03	30.17	86.11	106.94	86.42	-	-	-	25.11
2023	27.3.a.20	C	3	WECA	11.28	21.05	141.93	183.02	192.27	185.49	177.25	197.00	-	136.78

2023	27.3.a.20	C	4	WECA	22.78	39.24	43.27	143.57	174.37	169.42	185.57	204.12	208.33	35.34
2023	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.a.20	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.a.20	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.a.21	C	1	WECA	-	21.05	43.27	87.96	113.84	93.77	185.57	204.12	208.33	28.16
2023	27.3.a.21	C	2	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	27.47
2023	27.3.a.21	C	3	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	27.47
2023	27.3.a.21	C	4	WECA	-	21.05	43.27	99.05	140.57	124.51	185.57	204.12	208.33	32.88
2023	27.3.a.21	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.a.21	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.a.21	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.92
2023	27.3.b.23	F	1	WECA	-	-	-	141.01	148.14	163.32	176.54	179.69	182.55	164.88
2023	27.3.b.23	F	2	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	WECA	-	-	113.09	175.31	171.10	178.39	183.61	193.50	195.97	177.22
2023	27.3.b.23	F	4	WECA	-	-	118.63	144.46	162.43	176.25	183.59	199.19	198.96	165.00
2023	27.3.c.22	F	1	WECA	-	-	66.38	125.44	132.59	142.78	148.43	155.35	168.33	147.10
2023	27.3.c.22	F	2	WECA	-	57.50	59.83	72.26	87.33	111.34	144.65	142.60	159.37	114.08
2023	27.3.c.22	F	3	WECA	-	57.50	64.73	72.66	82.05	95.75	137.36	141.39	143.39	103.82
2023	27.3.c.22	F	4	WECA	-	57.50	61.52	72.35	89.27	135.27	150.08	158.95	160.54	144.66

2023	27.3.d.24	F	1	WECA	-	57.50	95.67	79.71	106.31	161.61	172.22	183.17	190.56	136.04
2023	27.3.d.24	F	2	WECA	-	57.50	70.03	78.79	84.58	102.94	131.87	163.92	142.12	92.69
2023	27.3.d.24	F	3	WECA	-	57.50	70.09	75.77	77.47	65.14	69.18	81.47	59.31	71.38
2023	27.3.d.24	F	4	WECA	-	57.50	71.02	93.06	92.52	86.54	125.90	170.73	116.40	97.24

Table 3.2.4 WESTERN BALTIC HERRING. Proportion of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) in Skagerrak (27.3.a.20) and Kattegat (27.3.a.21) by age as W-ringers and quarter. n: number of individuals sampled for stock. The samples can come from both commercial and scientific survey samping schemes

year	area	quarter	type	0	1	2	3	4	5	6	7	8+
2023	27.3.a.20	1	n	0	104	63	37	5	5	2	2	1
2023	27.3.a.20	1	NSAS	-	0.9497	0.9152	0.7214	0.2993	0.0736	0.0265	0.0275	0.1272
2023	27.3.a.20	1	WBSS	-	0.0503	0.0848	0.2786	0.7007	0.9264	0.9735	0.9725	0.8728
2023	27.3.a.20	2	n	0	0	0	0	0	0	0	0	0
2023	27.3.a.20	2	NSAS	0.8458	0.7965	0.7829	0.6599	0.4350	0.2216	-	-	-
2023	27.3.a.20	2	WBSS	0.1542	0.2035	0.2171	0.3401	0.5650	0.7784	-	-	-
2023	27.3.a.20	3	n	69	541	214	259	94	42	28	17	15
2023	27.3.a.20	3	NSAS	0.8458	0.7965	0.7829	0.6599	0.4350	0.2216	0.1102	0.0741	-
2023	27.3.a.20	3	WBSS	0.1542	0.2035	0.2171	0.3401	0.5650	0.7784	0.8898	0.9259	-
2023	27.3.a.20	4	n	10	40	0	0	0	0	0	0	0
2023	27.3.a.20	4	NSAS	0.9715	0.8670	0.6147	0.2774	0.1634	0.3107	0.9103	0.9998	1.0000
2023	27.3.a.20	4	WBSS	0.0285	0.1330	0.3853	0.7226	0.8366	0.6893	0.0897	0.0002	0.0000
2023	27.3.a.21	1	n	0	236	44	24	6	7	1	0	0
2023	27.3.a.21	1	NSAS	-	0.8585	0.8019	0.5999	0.2938	0.1044	0.0426	0.0302	0.0514
2023	27.3.a.21	1	WBSS	-	0.1415	0.1981	0.4001	0.7062	0.8956	0.9574	0.9698	0.9486
2023	27.3.a.21	2	n	0	0	0	0	0	0	0	0	0
2023	27.3.a.21	2	NSAS	0.7084	0.5573	0.5751	0.5292	0.4285	0.2946	-	-	-
2023	27.3.a.21	2	WBSS	0.2916	0.4427	0.4249	0.4708	0.5715	0.7054	-	-	-
2023	27.3.a.21	3	n	25	98	50	92	63	34	23	15	15
2023	27.3.a.21	3	NSAS	0.7084	0.5573	0.5751	0.5292	0.4285	0.2946	-	-	-

year	area	quar-ter	type	0	1	2	3	4	5	6	7	8+
2023	27.3.a.21	3	WBSS	0.2916	0.4427	0.4249	0.4708	0.5715	0.7054	-	-	-
2023	27.3.a.21	4	n	7	223	4	1	0	0	0	0	0
2023	27.3.a.21	4	NSAS	0.9378	0.6770	0.3744	0.1819	0.1598	0.3982	0.9431	0.9998	1.0000
2023	27.3.a.21	4	WBSS	0.0622	0.3230	0.6256	0.8181	0.8402	0.6018	0.0569	0.0002	0.0000

Table 3.2.5 WESTERN BALTIC HERRING. NSAS in Skagerrak (27.3.a.20) and Kattegat (27.3.a.21). CANUM: Catch in numbers (mill), WECA: mean weight (g) and SOP (t) by age as W-ringers, area, fleet and quarter in 2023

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.20	C	1	CANUM	-	8.53	0.11	0.01	0.00	0.00	0.00	0.00	0.00	8.65
2023	27.3.a.20	C	2	CANUM	-	0.20	0.00	0.00	0.00	0.00	-	-	-	0.20
2023	27.3.a.20	C	3	CANUM	0.47	0.00	0.21	0.59	0.12	0.03	0.01	0.00	-	1.44
2023	27.3.a.20	C	4	CANUM	0.87	2.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33
2023	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	CANUM	0.05	1.11	0.02	0.00	-	-	-	-	-	1.18
2023	27.3.a.20	D	3	CANUM	0.02	0.51	0.01	0.00	-	-	-	-	-	0.54
2023	27.3.a.20	D	4	CANUM	0.02	0.45	0.01	0.00	-	-	-	-	-	0.47
2023	27.3.a.21	C	1	CANUM	-	0.79	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.92
2023	27.3.a.21	C	2	CANUM	-	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00
2023	27.3.a.21	C	3	CANUM	-	0.73	0.11	0.03	0.01	0.00	-	-	-	0.87
2023	27.3.a.21	C	4	CANUM	-	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
2023	27.3.a.21	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	CANUM	0.00	0.03	0.00	0.00	-	-	-	-	-	0.03

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.21	D	3	CANUM	0.00	0.05	0.00	0.00	-	-	-	-	-	0.06
2023	27.3.a.21	D	4	CANUM	0.10	1.86	0.02	0.00	-	-	-	-	-	1.98
2023	27.3.a.20	C	1	SOP	-	213.60	3.36	0.95	0.46	0.10	0.05	0.02	0.02	218.58
2023	27.3.a.20	C	2	SOP	-	4.99	0.08	0.00	0.00	0.00	-	-	-	5.08
2023	27.3.a.20	C	3	SOP	5.27	0.07	30.02	108.48	23.40	6.29	1.40	0.24	-	175.17
2023	27.3.a.20	C	4	SOP	19.83	96.60	0.01	0.01	0.01	0.01	0.06	0.02	0.00	116.56
2023	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	SOP	1.06	44.76	1.18	0.13	-	-	-	-	-	47.13
2023	27.3.a.20	D	3	SOP	0.48	20.31	0.53	0.06	-	-	-	-	-	21.39
2023	27.3.a.20	D	4	SOP	0.45	17.96	0.34	0.02	-	-	-	-	-	18.77
2023	27.3.a.21	C	1	SOP	-	16.63	4.49	2.20	0.38	0.12	0.01	0.00	0.00	23.84
2023	27.3.a.21	C	2	SOP	-	0.08	0.02	0.01	0.00	0.00	-	-	-	0.12
2023	27.3.a.21	C	3	SOP	-	15.30	4.56	2.63	0.67	0.40	-	-	-	23.56
2023	27.3.a.21	C	4	SOP	-	0.34	0.05	0.02	0.01	0.02	0.05	0.02	0.00	0.53
2023	27.3.a.21	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	SOP	0.03	1.01	0.03	0.00	-	-	-	-	-	1.07
2023	27.3.a.21	D	3	SOP	0.06	2.11	0.06	0.01	-	-	-	-	-	2.24
2023	27.3.a.21	D	4	SOP	2.31	74.58	1.10	0.07	-	-	-	-	-	78.07
2023	27.3.a.20	C	1	WECA	-	25.04	30.05	162.23	179.57	177.03	185.57	204.12	208.33	25.26
2023	27.3.a.20	C	2	WECA	-	25.03	30.17	86.11	106.94	86.42	-	-	-	25.11

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.20	C	3	WECA	11.28	21.05	141.93	183.02	192.27	185.49	177.25	197.00	-	121.69
2023	27.3.a.20	C	4	WECA	22.78	39.24	43.27	143.57	174.37	169.42	185.57	204.12	208.33	34.97
2023	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.87
2023	27.3.a.20	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.87
2023	27.3.a.20	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.71
2023	27.3.a.21	C	1	WECA	-	21.05	43.27	87.96	113.84	93.77	185.57	204.12	208.33	25.81
2023	27.3.a.21	C	2	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	26.97
2023	27.3.a.21	C	3	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	26.97
2023	27.3.a.21	C	4	WECA	-	21.05	43.27	99.05	140.57	124.51	185.57	204.12	208.33	28.87
2023	27.3.a.21	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.76
2023	27.3.a.21	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.76
2023	27.3.a.21	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	39.49

Table 3.2.6 WESTERN BALTIC HERRING. WBSS. CANUM: Catch in numbers (mill), WECA: mean weight (g) and SOP (t) by age as W-ringers, area, fleet and quarter in 2023

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.20	C	1	CANUM	-	0.45	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.49
2023	27.3.a.20	C	2	CANUM	-	0.05	0.00	0.00	0.00	0.00	-	-	-	0.05
2023	27.3.a.20	C	3	CANUM	0.09	0.00	0.06	0.31	0.16	0.12	0.06	0.02	-	0.81

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.20	C	4	CANUM	0.03	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
2023	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	CANUM	0.01	0.28	0.01	0.00	-	-	-	-	-	0.30
2023	27.3.a.20	D	3	CANUM	0.00	0.13	0.00	0.00	-	-	-	-	-	0.14
2023	27.3.a.20	D	4	CANUM	0.00	0.07	0.00	0.00	-	-	-	-	-	0.07
2023	27.3.a.21	C	1	CANUM	-	0.13	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.19
2023	27.3.a.21	C	2	CANUM	-	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00
2023	27.3.a.21	C	3	CANUM	-	0.58	0.08	0.03	0.01	0.01	-	-	-	0.70
2023	27.3.a.21	C	4	CANUM	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
2023	27.3.a.21	D	1	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	CANUM	0.00	0.02	0.00	0.00	-	-	-	-	-	0.02
2023	27.3.a.21	D	3	CANUM	0.00	0.04	0.00	0.00	-	-	-	-	-	0.04
2023	27.3.a.21	D	4	CANUM	0.01	0.89	0.03	0.01	-	-	-	-	-	0.93
2023	27.3.b.23	F	1	CANUM	-	-	-	0.03	0.05	0.07	0.06	0.03	0.03	0.28
2023	27.3.b.23	F	2	CANUM	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	CANUM	-	-	0.00	0.11	0.08	0.05	0.04	0.02	0.01	0.30
2023	27.3.b.23	F	4	CANUM	-	-	0.03	0.31	0.27	0.23	0.13	0.06	0.04	1.06
2023	27.3.c.22	F	1	CANUM	-	-	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.04
2023	27.3.c.22	F	2	CANUM	-	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.05
2023	27.3.c.22	F	3	CANUM	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.c.22	F	4	CANUM	-	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02
2023	27.3.d.24	F	1	CANUM	-	0.00	0.00	0.51	0.32	0.22	0.38	0.16	0.21	1.81
2023	27.3.d.24	F	2	CANUM	-	0.00	0.07	0.56	0.37	0.12	0.09	0.06	0.08	1.35
2023	27.3.d.24	F	3	CANUM	-	0.00	0.04	0.01	0.07	0.04	0.01	0.00	0.01	0.19
2023	27.3.d.24	F	4	CANUM	-	0.00	0.08	0.03	0.16	0.09	0.05	0.02	0.04	0.48
2023	27.4.a.e	A	1	CANUM	-	-	0.55	0.07	0.00	0.04	0.00	-	0.00	0.67
2023	27.4.a.e	A	2	CANUM	-	0.22	1.06	0.23	0.25	0.18	0.10	0.03	0.02	2.09
2023	27.4.a.e	A	3	CANUM	-	0.37	1.00	1.92	2.55	1.90	1.15	1.16	0.86	10.89
2023	27.4.a.e	A	4	CANUM	-	-	-	0.40	0.33	-	-	-	-	0.73
2023	27.3.a.20	C	1	SOP	-	11.32	0.31	0.37	1.09	1.29	1.97	0.77	0.14	17.25
2023	27.3.a.20	C	2	SOP	-	1.28	0.02	0.00	0.00	0.00	-	-	-	1.30
2023	27.3.a.20	C	3	SOP	0.96	0.02	8.32	55.90	30.38	22.12	11.29	3.06	-	132.05
2023	27.3.a.20	C	4	SOP	0.58	14.82	0.00	0.03	0.04	0.03	0.01	0.00	0.00	15.52
2023	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	SOP	0.19	11.43	0.33	0.07	-	-	-	-	-	12.02
2023	27.3.a.20	D	3	SOP	0.09	5.19	0.15	0.03	-	-	-	-	-	5.46
2023	27.3.a.20	D	4	SOP	0.01	2.75	0.21	0.05	-	-	-	-	-	3.03
2023	27.3.a.21	C	1	SOP	-	2.74	1.11	1.47	0.91	1.02	0.24	0.10	0.02	7.61
2023	27.3.a.21	C	2	SOP	-	0.06	0.02	0.01	0.00	0.00	-	-	-	0.10
2023	27.3.a.21	C	3	SOP	-	12.15	3.37	2.34	0.89	0.96	-	-	-	19.72

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.a.21	C	4	SOP	-	0.16	0.09	0.10	0.06	0.04	0.00	0.00	0.00	0.45
2023	27.3.a.21	D	1	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	SOP	0.01	0.80	0.02	0.00	-	-	-	-	-	0.83
2023	27.3.a.21	D	3	SOP	0.02	1.68	0.04	0.01	-	-	-	-	-	1.75
2023	27.3.a.21	D	4	SOP	0.15	35.58	1.84	0.32	-	-	-	-	-	37.90
2023	27.3.b.23	F	1	SOP	-	-	-	4.29	8.11	11.42	10.74	5.46	6.11	46.12
2023	27.3.b.23	F	2	SOP	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	SOP	-	-	0.26	18.98	12.97	9.11	6.82	3.29	2.58	54.00
2023	27.3.b.23	F	4	SOP	-	-	3.10	45.07	43.45	41.01	23.51	11.98	7.35	175.47
2023	27.3.c.22	F	1	SOP	-	-	0.03	0.22	0.60	1.10	1.81	1.71	0.54	6.00
2023	27.3.c.22	F	2	SOP	-	0.00	0.26	0.71	0.51	0.75	1.66	0.97	0.97	5.84
2023	27.3.c.22	F	3	SOP	-	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.08
2023	27.3.c.22	F	4	SOP	-	0.00	0.02	0.06	0.06	0.23	1.01	0.48	0.64	2.50
2023	27.3.d.24	F	1	SOP	-	0.00	0.20	40.99	34.04	35.37	65.89	30.06	39.84	246.39
2023	27.3.d.24	F	2	SOP	-	0.21	5.03	44.36	31.16	12.28	11.83	9.40	10.79	125.08
2023	27.3.d.24	F	3	SOP	-	0.12	2.85	1.00	5.29	2.44	0.97	0.20	0.76	13.62
2023	27.3.d.24	F	4	SOP	-	0.23	5.65	2.94	14.48	7.75	6.63	4.11	4.83	46.63
2023	27.4.a.e	A	1	SOP	-	-	31.32	6.51	0.07	5.07	0.04	-	0.03	43.04
2023	27.4.a.e	A	2	SOP	-	4.96	69.25	41.48	47.28	33.37	17.71	5.49	5.34	224.87
2023	27.4.a.e	A	3	SOP	-	26.02	135.92	354.75	498.27	353.22	210.05	226.87	167.28	1972.38

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.4.a.e	A	4	SOP	-	-	-	61.09	60.07	-	-	-	-	121.16
2023	27.3.a.20	C	1	WECA	-	25.04	30.05	162.23	179.57	177.03	185.57	204.12	208.33	34.99
2023	27.3.a.20	C	2	WECA	-	25.03	30.17	86.11	106.94	86.42	-	-	-	25.12
2023	27.3.a.20	C	3	WECA	11.28	21.05	141.93	183.02	192.27	185.49	177.25	197.00	-	163.71
2023	27.3.a.20	C	4	WECA	22.78	39.24	43.27	143.57	174.37	169.42	185.57	204.12	208.33	38.41
2023	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.20	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	40.12
2023	27.3.a.20	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	40.12
2023	27.3.a.20	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	41.25
2023	27.3.a.21	C	1	WECA	-	21.05	43.27	87.96	113.84	93.77	185.57	204.12	208.33	39.36
2023	27.3.a.21	C	2	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	28.10
2023	27.3.a.21	C	3	WECA	-	21.05	43.27	86.11	106.94	86.42	-	-	-	28.10
2023	27.3.a.21	C	4	WECA	-	21.05	43.27	99.05	140.57	124.51	185.57	204.12	208.33	39.23
2023	27.3.a.21	D	1	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.a.21	D	2	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	40.13
2023	27.3.a.21	D	3	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	40.13
2023	27.3.a.21	D	4	WECA	22.68	40.17	63.43	50.87	-	-	-	-	-	40.85
2023	27.3.b.23	F	1	WECA	-	-	-	141.01	148.14	163.32	176.54	179.69	182.55	164.88
2023	27.3.b.23	F	2	WECA	-	-	-	-	-	-	-	-	-	-
2023	27.3.b.23	F	3	WECA	-	-	113.09	175.31	171.10	178.39	183.61	193.50	195.97	177.22

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2023	27.3.b.23	F	4	WECA	-	-	118.63	144.46	162.43	176.25	183.59	199.19	198.96	165.00
2023	27.3.c.22	F	1	WECA	-	-	66.38	125.44	132.59	142.78	148.43	155.35	168.33	147.10
2023	27.3.c.22	F	2	WECA	-	57.50	59.83	72.26	87.33	111.34	144.65	142.60	159.37	114.08
2023	27.3.c.22	F	3	WECA	-	57.50	64.73	72.66	82.05	95.75	137.36	141.39	143.39	103.82
2023	27.3.c.22	F	4	WECA	-	57.50	61.52	72.35	89.27	135.27	150.08	158.95	160.54	144.66
2023	27.3.d.24	F	1	WECA	-	57.50	95.67	79.71	106.31	161.61	172.22	183.17	190.56	136.04
2023	27.3.d.24	F	2	WECA	-	57.50	70.03	78.79	84.58	102.94	131.87	163.92	142.12	92.69
2023	27.3.d.24	F	3	WECA	-	57.50	70.09	75.77	77.47	65.14	69.18	81.47	59.31	71.38
2023	27.3.d.24	F	4	WECA	-	57.50	71.02	93.06	92.52	86.54	125.90	170.73	116.40	97.24
2023	27.4.a.e	A	1	WECA	-	-	56.60	89.20	166.00	126.00	174.00	-	179.00	64.49
2023	27.4.a.e	A	2	WECA	-	22.20	65.50	179.80	191.90	185.70	177.00	196.70	215.45	107.59
2023	27.4.a.e	A	3	WECA	-	70.80	136.30	185.00	195.70	186.20	182.30	196.40	194.59	181.08
2023	27.4.a.e	A	4	WECA	-	-	-	152.80	180.50	-	-	-	-	165.38

Table 3.2.7 WESTERN BALTIC HERRING. WBSS. CANUM: Catch in numbers (mill), WECA: mean weight (g) and SOP (t) by age as W-ringers in 1993-2023

year	area	type	0	1	2	3	4	5	6	7	8+	Total
1993	27.3.a, 27.4.a.e	CANUM	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1292.03
1993	27.3.b, 27.3.c, 27.3.d.24	CANUM	44.85	159.21	180.13	196.06	166.87	151.07	61.80	42.21	16.31	1018.51
1994	27.3.a, 27.4.a.e	CANUM	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
1994	27.3.b, 27.3.c, 27.3.d.24	CANUM	202.58	96.29	103.84	161.01	136.06	90.84	74.02	35.11	24.47	924.22

year	area	type	0	1	2	3	4	5	6	7	8+	Total
1995	27.3.a, 27.4.a.e	CANUM	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
1995	27.3.b, 27.3.c, 27.3.d.24	CANUM	490.99	1358.18	233.95	128.88	104.01	53.57	38.82	20.87	13.22	2442.49
1996	27.3.a, 27.4.a.e	CANUM	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
1996	27.3.b, 27.3.c, 27.3.d.24	CANUM	4.91	410.82	82.84	124.08	103.75	99.46	52.69	23.98	19.48	922.02
1997	27.3.a, 27.4.a.e	CANUM	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
1997	27.3.b, 27.3.c, 27.3.d.24	CANUM	350.83	595.19	130.62	96.86	45.13	28.96	35.15	19.46	21.83	1324.02
1998	27.3.a, 27.4.a.e	CANUM	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
1998	27.3.b, 27.3.c, 27.3.d.24	CANUM	513.51	447.93	115.75	88.33	91.97	34.13	15.04	13.21	12.02	1331.90
1999	27.3.a, 27.4.a.e	CANUM	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
1999	27.3.b, 27.3.c, 27.3.d.24	CANUM	528.26	425.84	178.67	123.95	47.10	33.71	11.07	6.46	3.68	1358.73
2000	27.3.a, 27.4.a.e	CANUM	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
2000	27.3.b, 27.3.c, 27.3.d.24	CANUM	37.75	616.32	194.30	86.73	77.78	52.96	30.06	12.43	9.29	1117.62
2001	27.3.a, 27.4.a.e	CANUM	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
2001	27.3.b, 27.3.c, 27.3.d.24	CANUM	634.60	486.53	280.71	146.76	76.04	48.71	29.25	14.14	4.27	1721.02
2002	27.3.a, 27.4.a.e	CANUM	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1027.26
2002	27.3.b, 27.3.c, 27.3.d.24	CANUM	80.64	81.44	113.58	186.71	119.19	45.11	31.05	11.41	6.31	675.44
2003	27.3.a, 27.4.a.e	CANUM	52.11	63.02	182.52	63.99	62.23	20.31	5.87	3.84	1.62	455.52

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2003	27.3.b, 27.3.c, 27.3.d.24	CANUM	1.37	63.86	82.33	95.80	125.06	82.18	22.86	13.10	7.01	493.56
2004	27.3.a, 27.4.a.e	CANUM	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
2004	27.3.b, 27.3.c, 27.3.d.24	CANUM	217.88	248.41	101.79	70.79	74.97	74.40	44.45	13.36	10.42	856.48
2005	27.3.a, 27.4.a.e	CANUM	95.32	96.87	203.33	75.35	46.93	9.33	11.50	3.46	1.41	543.51
2005	27.3.b, 27.3.c, 27.3.d.24	CANUM	11.59	207.56	115.89	102.48	83.46	51.30	54.19	27.77	11.21	665.46
2006	27.3.a, 27.4.a.e	CANUM	7.30	104.15	115.60	114.22	48.92	55.75	11.09	10.31	5.15	472.49
2006	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.65	44.76	72.07	119.00	101.73	43.00	31.36	22.11	12.16	446.84
2007	27.3.a, 27.4.a.e	CANUM	1.63	103.86	90.88	36.91	30.81	12.78	9.45	6.24	2.68	295.22
2007	27.3.b, 27.3.c, 27.3.d.24	CANUM	18.96	668.54	158.33	169.66	112.79	65.14	24.63	5.91	1.78	1225.74
2008	27.3.a, 27.4.a.e	CANUM	4.90	101.76	71.07	38.92	13.48	15.13	7.73	4.50	1.30	258.80
2008	27.3.b, 27.3.c, 27.3.d.24	CANUM	18.96	668.54	158.33	169.66	112.79	65.14	24.63	5.91	1.78	1225.74
2009	27.3.a, 27.4.a.e	CANUM	14.80	149.60	132.29	45.85	24.44	10.88	7.80	7.68	5.28	398.63
2009	27.3.b, 27.3.c, 27.3.d.24	CANUM	5.93	31.48	110.72	55.48	45.50	37.21	31.95	13.23	7.24	338.74
2010	27.3.a, 27.4.a.e	CANUM	9.11	48.57	106.09	45.22	20.77	8.59	5.91	7.24	5.88	257.38
2010	27.3.b, 27.3.c, 27.3.d.24	CANUM	3.29	26.49	31.31	39.31	28.45	22.42	13.89	7.96	7.51	180.63
2011	27.3.a, 27.4.a.e	CANUM	6.17	83.06	29.87	20.96	13.39	5.99	2.98	1.02	1.12	164.56
2011	27.3.b, 27.3.c,	CANUM	5.64	15.46	16.41	17.83	35.93	21.64	19.65	11.21	8.21	151.99

year	area	type	0	1	2	3	4	5	6	7	8+	Total
	27.3.d.24											
2012	27.3.a, 27.4.a.e	CANUM	1.52	30.54	94.31	20.71	9.51	7.09	4.21	2.23	8.56	178.68
2012	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.48	46.31	36.50	43.76	37.81	28.35	13.96	9.01	8.44	224.62
2013	27.3.a, 27.4.a.e	CANUM	-	12.03	51.73	71.36	11.26	4.35	1.40	0.48	1.02	153.62
2013	27.3.b, 27.3.c, 27.3.d.24	CANUM	1.03	60.58	37.10	43.31	55.92	28.72	25.32	11.50	10.99	274.46
2014	27.3.a, 27.4.a.e	CANUM	25.32	31.53	22.38	24.24	44.58	7.60	4.55	2.33	2.90	165.42
2014	27.3.b, 27.3.c, 27.3.d.24	CANUM	5.84	35.27	37.73	42.12	37.50	19.02	11.20	6.54	6.19	201.41
2015	27.3.a, 27.4.a.e	CANUM	3.31	57.75	59.94	20.98	14.10	14.59	4.85	2.68	3.90	182.10
2015	27.3.b, 27.3.c, 27.3.d.24	CANUM	26.67	46.24	72.78	38.51	48.44	29.85	14.86	7.86	9.12	294.32
2016	27.3.a, 27.4.a.e	CANUM	23.88	27.18	161.73	43.03	13.33	12.10	13.25	3.60	6.55	304.65
2016	27.3.b, 27.3.c, 27.3.d.24	CANUM	20.01	22.34	37.25	93.86	45.68	30.54	17.42	10.46	8.26	285.82
2017	27.3.a, 27.4.a.e	CANUM	1.43	48.42	42.18	42.82	34.17	10.25	10.88	7.35	2.90	200.41
2017	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.07	9.41	32.84	38.54	78.33	38.50	26.94	13.46	10.17	248.26
2018	27.3.a, 27.4.a.e	CANUM	0.29	20.47	179.14	17.62	15.19	22.30	6.84	3.90	3.13	268.88
2018	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.37	48.38	18.46	34.64	23.06	51.27	16.26	8.84	4.51	205.79
2019	27.3.a, 27.4.a.e	CANUM	5.31	38.23	59.24	21.05	8.22	9.74	11.10	2.98	2.64	158.51
2019	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.27	6.88	20.67	15.56	13.30	10.33	15.87	6.03	3.52	92.44

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2020	27.3.a, 27.4.a.e	CANUM	10.78	36.61	54.90	23.35	17.13	7.78	13.62	8.35	5.67	178.18
2020	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.03	1.69	2.49	4.58	4.67	6.71	4.15	5.33	1.58	31.22
2021	27.3.a, 27.4.a.e	CANUM	1.48	2.20	63.75	17.33	15.57	9.41	5.79	2.69	4.06	122.29
2021	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.04	0.59	1.77	3.19	2.53	1.50	1.33	0.93	0.92	12.81
2022	27.3.a, 27.4.a.e	CANUM	0.06	0.47	7.30	7.05	7.44	5.24	4.54	2.54	3.28	37.93
2022	27.3.b, 27.3.c, 27.3.d.24	CANUM	0.00	0.08	0.35	0.95	0.94	0.90	0.64	0.44	0.34	4.65
2023	27.3.a, 27.4.a.e	CANUM	0.13	3.62	2.82	2.98	3.31	2.27	1.33	1.20	0.89	18.55
2023	27.3.b, 27.3.c, 27.3.d.24	CANUM	-	0.01	0.23	1.59	1.32	0.84	0.80	0.38	0.44	5.59
1993	27.3.a, 27.4.a.e	SOP	2434.91	9611.56	25695.54	27935.64	14120.14	10166.57	8026.96	4540.63	1966.03	104497.98
1993	27.3.b, 27.3.c, 27.3.d.24	SOP	728.16	3895.79	8015.32	14420.93	15700.81	18492.58	9233.18	7111.29	2913.86	80511.93
1994	27.3.a, 27.4.a.e	SOP	1224.56	6524.31	24766.99	27206.25	19686.09	13043.26	8642.46	3021.51	1897.96	106013.39
1994	27.3.b, 27.3.c, 27.3.d.24	SOP	2613.28	2712.82	5627.67	12296.13	12926.14	10689.44	9887.47	5416.74	4255.09	66424.79
1995	27.3.a, 27.4.a.e	SOP	901.66	12551.14	19969.61	13517.04	14822.87	6065.33	4404.12	2746.64	1695.68	76674.09
1995	27.3.b, 27.3.c, 27.3.d.24	SOP	4567.55	22198.52	10012.98	8802.55	9242.52	6717.94	5836.94	4034.62	2743.17	74156.79
1996	27.3.a, 27.4.a.e	SOP	1747.94	6296.43	28617.71	10196.93	6664.61	5714.08	2567.57	1402.34	1241.02	64448.62
1996	27.3.b, 27.3.c, 27.3.d.24	SOP	59.46	9410.34	3790.35	9176.81	9559.06	11565.13	6366.55	3333.98	3555.17	56816.85
1997	27.3.a, 27.4.a.e	SOP	497.94	3648.03	12175.61	22912.70	4655.67	2488.87	879.10	336.83	480.33	48075.08

year	area	type	0	1	2	3	4	5	6	7	8+	Total
1997	27.3.b, 27.3.c, 27.3.d.24	SOP	10664.28	14726.68	7629.60	9782.77	5447.57	4495.70	6373.70	3835.46	4557.05	67512.81
1998	27.3.a, 27.4.a.e	SOP	1008.50	8979.66	22541.57	10286.89	7804.06	1921.99	1694.74	402.61	481.46	55121.49
1998	27.3.b, 27.3.c, 27.3.d.24	SOP	6831.86	11784.54	6046.07	6943.75	9474.35	4274.81	2255.97	2142.02	2157.56	51910.94
1999	27.3.a, 27.4.a.e	SOP	476.52	9697.90	13011.90	14047.56	5231.70	3225.44	748.67	373.38	366.22	47179.29
1999	27.3.b, 27.3.c, 27.3.d.24	SOP	5860.25	11455.16	8998.16	10115.52	5276.56	5001.96	1675.65	1084.60	592.39	50060.25
2000	27.3.a, 27.4.a.e	SOP	2600.55	10145.19	20357.05	10755.90	7131.34	3188.81	1287.93	249.46	293.63	56009.87
2000	27.3.b, 27.3.c, 27.3.d.24	SOP	623.62	13687.78	8309.07	6974.41	9606.20	7053.69	4310.81	1931.33	1406.79	53903.71
2001	27.3.a, 27.4.a.e	SOP	1095.59	1875.17	15863.43	12092.68	4657.21	3370.83	1852.00	780.09	492.37	42079.37
2001	27.3.b, 27.3.c, 27.3.d.24	SOP	8198.11	10845.78	13128.16	10128.55	7110.63	7345.74	4245.14	2068.45	653.26	63723.84
2002	27.3.a, 27.4.a.e	SOP	708.74	11795.44	13161.97	15848.04	7632.35	2045.85	1435.18	481.39	434.97	53543.92
2002	27.3.b, 27.3.c, 27.3.d.24	SOP	873.98	2221.32	6561.21	15246.91	12965.46	5958.22	5794.80	2029.69	995.11	52646.70
2003	27.3.a, 27.4.a.e	SOP	677.85	2355.21	13956.34	7211.41	8222.76	2859.91	892.23	643.30	256.11	37075.13
2003	27.3.b, 27.3.c, 27.3.d.24	SOP	30.80	1644.48	3816.60	7217.62	11902.70	9627.35	2878.73	2057.67	1139.04	40314.98
2004	27.3.a, 27.4.a.e	SOP	694.94	9047.40	7868.58	11004.82	2652.45	2651.17	769.31	278.96	110.63	35078.25
2004	27.3.b, 27.3.c, 27.3.d.24	SOP	810.64	3560.14	4829.01	5500.15	7224.46	9336.75	6686.03	2215.45	1573.88	41736.50
2005	27.3.a, 27.4.a.e	SOP	1341.03	5318.72	17414.88	9163.28	6960.95	1518.52	2027.61	617.71	282.14	44644.85
2005	27.3.b, 27.3.c,	SOP	157.26	2943.82	5595.72	7513.20	7456.75	5928.01	7782.71	4439.22	1908.12	43724.81

year	area	type	0	1	2	3	4	5	6	7	8+	Total
	27.3.d.24											
2006	27.3.a, 27.4.a.e	SOP	121.25	3846.70	9584.17	12906.53	6971.55	9765.29	2199.10	2159.24	1133.90	48687.73
2006	27.3.b, 27.3.c, 27.3.d.24	SOP	13.80	1520.98	4084.76	9991.37	10393.89	5388.28	4513.86	3887.99	2066.24	41861.19
2007	27.3.a, 27.4.a.e	SOP	40.92	6815.63	7723.10	4269.33	4265.11	2035.14	1802.16	1113.94	567.07	28632.40
2007	27.3.b, 27.3.c, 27.3.d.24	SOP	225.20	18564.43	9073.47	12713.07	11988.06	7903.51	3466.99	961.09	330.68	65226.50
2008	27.3.a, 27.4.a.e	SOP	94.08	7280.71	6471.59	4456.26	1916.81	2590.50	1401.67	899.93	256.26	25367.80
2008	27.3.b, 27.3.c, 27.3.d.24	SOP	308.89	33104.93	10325.89	14953.38	12465.51	8677.35	3456.01	925.59	307.00	84524.54
2009	27.3.a, 27.4.a.e	SOP	198.86	7783.27	11946.08	5436.40	4093.60	1974.15	1668.64	1757.36	1371.35	36229.71
2009	27.3.b, 27.3.c, 27.3.d.24	SOP	62.50	889.91	5320.36	5020.17	5629.96	5403.84	5123.78	2264.46	1317.23	31032.20
2010	27.3.a, 27.4.a.e	SOP	74.92	2878.22	8990.76	5870.44	3444.74	1685.52	1311.02	1696.32	1512.86	27464.80
2010	27.3.b, 27.3.c, 27.3.d.24	SOP	40.13	587.84	1633.42	3421.88	3409.42	3470.59	2370.19	1526.80	1456.84	17917.11
2011	27.3.a, 27.4.a.e	SOP	51.84	2796.70	2659.53	2522.41	1877.76	1019.75	554.48	221.56	237.44	11941.47
2011	27.3.b, 27.3.c, 27.3.d.24	SOP	70.24	354.90	903.73	1392.34	4066.39	2955.12	2899.87	1807.71	1380.02	15830.32
2012	27.3.a, 27.4.a.e	SOP	14.16	1434.28	7179.64	2779.88	1570.23	1290.26	858.19	495.08	1931.43	17553.16
2012	27.3.b, 27.3.c, 27.3.d.24	SOP	8.67	734.99	2008.00	4176.64	4351.34	4262.55	2340.68	1598.25	1613.51	21094.64
2013	27.3.a, 27.4.a.e	SOP	-	715.86	4872.03	9408.78	1829.78	848.33	290.16	117.96	242.34	18325.24
2013	27.3.b, 27.3.c, 27.3.d.24	SOP	14.08	1075.75	2005.51	3757.67	7237.17	3930.39	3678.24	1829.39	1975.48	25503.69

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2014	27.3.a, 27.4.a.e	SOP	235.80	1647.16	2203.35	3331.52	7942.09	1513.29	964.34	523.91	658.87	19020.33
2014	27.3.b, 27.3.c, 27.3.d.24	SOP	96.11	1058.94	2226.96	3466.04	4577.57	3013.91	1746.33	1066.42	1085.68	18337.95
2015	27.3.a, 27.4.a.e	SOP	52.94	1838.42	4066.94	2418.05	2150.04	2520.89	938.61	531.95	829.76	15347.59
2015	27.3.b, 27.3.c, 27.3.d.24	SOP	190.21	736.65	3670.80	3053.25	5211.20	4318.47	2535.06	1065.74	1362.20	22143.57
2016	27.3.a, 27.4.a.e	SOP	170.21	1090.64	10312.47	5425.51	2141.77	2118.68	2660.61	765.08	1539.43	26224.40
2016	27.3.b, 27.3.c, 27.3.d.24	SOP	206.30	761.56	1924.56	7937.46	4340.07	3955.54	2793.91	1757.05	1396.74	25073.19
2017	27.3.a, 27.4.a.e	SOP	43.52	2136.90	2585.40	4847.99	4844.08	1668.42	1863.33	1344.92	492.58	19827.13
2017	27.3.b, 27.3.c, 27.3.d.24	SOP	1.30	322.47	1895.29	3191.57	9235.11	4752.94	3706.40	1985.92	1421.77	26512.76
2018	27.3.a, 27.4.a.e	SOP	2.97	1139.59	9901.98	1926.62	2345.95	4007.33	1333.55	760.67	647.02	22065.66
2018	27.3.b, 27.3.c, 27.3.d.24	SOP	5.85	700.74	955.67	3021.46	2500.97	7315.11	2331.65	1394.26	766.47	18992.17
2019	27.3.a, 27.4.a.e	SOP	106.18	2018.98	5035.94	2502.42	1137.80	1618.61	2034.84	577.20	557.41	15589.37
2019	27.3.b, 27.3.c, 27.3.d.24	SOP	4.51	211.26	1176.85	1303.11	1644.24	1442.18	2628.03	834.62	586.15	9830.96
2020	27.3.a, 27.4.a.e	SOP	146.33	1723.30	3680.94	3093.83	2753.00	1406.15	2536.16	1663.22	1160.40	18163.34
2020	27.3.b, 27.3.c, 27.3.d.24	SOP	0.57	64.80	171.86	399.61	520.01	976.02	646.85	916.51	270.10	3966.32
2021	27.3.a, 27.4.a.e	SOP	16.01	132.43	4138.44	1855.90	2436.11	1597.39	1081.93	524.80	796.42	12579.44
2021	27.3.b, 27.3.c, 27.3.d.24	SOP	0.81	13.62	127.90	332.27	350.75	219.89	228.42	163.33	163.53	1600.53
2022	27.3.a, 27.4.a.e	SOP	1.61	25.96	758.58	915.39	1065.94	892.22	798.68	487.94	667.35	5613.66

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.b, 27.3.c, 27.3.d.24	SOP	0.08	1.87	32.88	89.69	124.38	134.81	109.87	80.11	63.90	637.60
2023	27.3.a, 27.4.a.e	SOP	2.03	130.96	252.33	524.53	639.07	417.12	241.30	236.29	172.82	2616.45
2023	27.3.b, 27.3.c, 27.3.d.24	SOP	-	0.57	17.42	158.63	150.67	121.48	130.88	67.69	74.40	721.73
1993	27.3.a, 27.4.a.e	WECA	15.10	25.87	81.36	127.53	150.09	171.08	195.93	209.13	239.04	80.88
1993	27.3.b, 27.3.c, 27.3.d.24	WECA	16.24	24.47	44.50	73.55	94.09	122.41	149.40	168.47	178.65	79.05
1994	27.3.a, 27.4.a.e	WECA	20.20	42.61	94.84	122.75	150.31	168.73	194.67	209.92	220.24	109.05
1994	27.3.b, 27.3.c, 27.3.d.24	WECA	12.90	28.17	54.20	76.37	95.00	117.67	133.58	154.28	173.89	71.87
1995	27.3.a, 27.4.a.e	WECA	17.92	41.49	97.80	138.03	163.14	198.51	206.99	228.79	234.35	93.86
1995	27.3.b, 27.3.c, 27.3.d.24	WECA	9.30	16.34	42.80	68.30	88.86	125.41	150.37	193.30	207.45	30.36
1996	27.3.a, 27.4.a.e	WECA	10.52	27.61	90.07	134.89	164.94	186.57	204.05	208.47	220.25	72.94
1996	27.3.b, 27.3.c, 27.3.d.24	WECA	12.10	22.91	45.75	73.96	92.14	116.28	120.83	139.04	182.54	61.62
1997	27.3.a, 27.4.a.e	WECA	19.18	49.68	76.71	127.25	154.39	175.83	184.37	192.04	208.02	97.85
1997	27.3.b, 27.3.c, 27.3.d.24	WECA	30.40	24.74	58.41	101.00	120.71	155.22	181.34	197.13	208.80	50.99
1998	27.3.a, 27.4.a.e	WECA	27.81	51.27	71.53	108.82	142.63	171.74	194.44	184.16	230.00	78.75
1998	27.3.b, 27.3.c, 27.3.d.24	WECA	13.30	26.31	52.23	78.61	103.02	125.25	149.97	162.10	179.52	38.97
1999	27.3.a, 27.4.a.e	WECA	11.53	50.96	83.59	114.90	121.21	145.24	169.57	123.84	152.32	80.68
1999	27.3.b, 27.3.c,	WECA	11.09	26.90	50.36	81.61	112.04	148.38	151.43	167.81	160.98	36.84

year	area	type	0	1	2	3	4	5	6	7	8+	Total
	27.3.d.24											
2000	27.3.a, 27.4.a.e	WECA	22.65	31.88	67.39	107.68	140.25	169.95	156.95	184.97	210.10	61.17
2000	27.3.b, 27.3.c, 27.3.d.24	WECA	16.52	22.21	42.76	80.41	123.51	133.18	143.42	155.40	151.41	48.23
2001	27.3.a, 27.4.a.e	WECA	9.00	51.20	76.23	108.87	145.27	171.37	188.21	187.25	203.34	77.12
2001	27.3.b, 27.3.c, 27.3.d.24	WECA	12.92	22.29	46.77	69.01	93.51	150.82	145.12	146.27	153.14	37.03
2002	27.3.a, 27.4.a.e	WECA	10.18	20.42	78.22	117.74	143.76	169.78	191.89	198.25	215.45	52.12
2002	27.3.b, 27.3.c, 27.3.d.24	WECA	10.84	27.28	57.77	81.66	108.78	132.08	186.61	177.82	157.70	77.94
2003	27.3.a, 27.4.a.e	WECA	13.01	37.37	76.46	112.69	132.13	140.84	151.90	167.36	158.21	81.39
2003	27.3.b, 27.3.c, 27.3.d.24	WECA	22.41	25.75	46.36	75.34	95.18	117.15	125.94	157.10	162.59	81.68
2004	27.3.a, 27.4.a.e	WECA	27.07	43.22	81.94	117.10	145.41	157.41	170.71	184.38	187.07	75.16
2004	27.3.b, 27.3.c, 27.3.d.24	WECA	3.72	14.33	47.44	77.70	96.36	125.49	150.42	165.78	151.01	48.73
2005	27.3.a, 27.4.a.e	WECA	14.07	54.91	85.65	121.61	148.32	162.67	176.31	178.31	200.61	82.14
2005	27.3.b, 27.3.c, 27.3.d.24	WECA	13.57	14.18	48.28	73.31	89.34	115.55	143.61	159.87	170.16	65.71
2006	27.3.a, 27.4.a.e	WECA	16.62	36.94	82.91	113.00	142.50	175.17	198.21	209.46	219.96	103.04
2006	27.3.b, 27.3.c, 27.3.d.24	WECA	21.24	33.98	56.68	83.96	102.17	125.30	143.92	175.85	169.96	93.68
2007	27.3.a, 27.4.a.e	WECA	25.17	65.63	84.98	115.67	138.44	159.24	190.77	178.55	211.88	96.99
2007	27.3.b, 27.3.c, 27.3.d.24	WECA	11.88	27.77	57.31	74.93	106.28	121.34	140.75	162.69	185.52	53.21

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2008	27.3.a, 27.4.a.e	WECA	19.19	71.54	91.06	114.48	142.21	171.24	181.39	200.04	196.43	98.02
2008	27.3.b, 27.3.c, 27.3.d.24	WECA	16.29	49.52	65.22	88.14	110.52	133.22	140.31	156.68	172.24	68.96
2009	27.3.a, 27.4.a.e	WECA	13.44	52.03	90.30	118.57	167.49	181.45	213.89	228.91	259.49	90.89
2009	27.3.b, 27.3.c, 27.3.d.24	WECA	10.53	28.27	48.05	90.49	123.75	145.22	160.38	171.16	181.84	91.61
2010	27.3.a, 27.4.a.e	WECA	8.23	59.26	84.75	129.82	165.86	196.16	221.83	234.34	257.16	106.71
2010	27.3.b, 27.3.c, 27.3.d.24	WECA	12.22	22.19	52.16	87.06	119.82	154.80	170.59	191.86	194.10	99.19
2011	27.3.a, 27.4.a.e	WECA	8.40	33.67	89.04	120.37	140.24	170.21	185.92	216.34	211.85	72.57
2011	27.3.b, 27.3.c, 27.3.d.24	WECA	12.45	22.96	55.06	78.08	113.16	136.56	147.58	161.24	168.00	104.15
2012	27.3.a, 27.4.a.e	WECA	9.31	46.96	76.13	134.24	165.08	181.96	204.08	222.01	225.61	98.24
2012	27.3.b, 27.3.c, 27.3.d.24	WECA	18.12	15.87	55.02	95.44	115.08	150.34	167.62	177.42	191.18	93.91
2013	27.3.a, 27.4.a.e	WECA	-	59.50	94.18	131.84	162.56	194.96	207.80	247.92	238.12	119.29
2013	27.3.b, 27.3.c, 27.3.d.24	WECA	13.69	17.76	54.06	86.76	129.42	136.87	145.26	159.10	179.80	92.92
2014	27.3.a, 27.4.a.e	WECA	9.31	52.25	98.47	137.42	178.17	199.21	211.71	225.10	227.05	114.98
2014	27.3.b, 27.3.c, 27.3.d.24	WECA	16.46	30.02	59.02	82.29	122.07	158.43	155.98	163.02	175.51	91.05
2015	27.3.a, 27.4.a.e	WECA	16.00	31.83	67.85	115.24	152.44	172.83	193.40	198.66	212.90	84.28
2015	27.3.b, 27.3.c, 27.3.d.24	WECA	7.13	15.93	50.44	79.29	107.58	144.69	170.59	135.65	149.36	75.24
2016	27.3.a, 27.4.a.e	WECA	7.13	40.13	63.76	126.09	160.66	175.09	200.82	212.82	235.02	86.08

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2016	27.3.b, 27.3.c, 27.3.d.24	WECA	10.31	34.09	51.67	84.56	95.01	129.54	160.36	168.06	169.17	87.73
2017	27.3.a, 27.4.a.e	WECA	30.50	44.13	61.29	113.21	141.77	162.84	171.23	182.87	169.95	98.93
2017	27.3.b, 27.3.c, 27.3.d.24	WECA	18.12	34.25	57.71	82.81	117.90	123.46	137.60	147.50	139.80	106.79
2018	27.3.a, 27.4.a.e	WECA	10.31	55.68	55.28	109.34	154.45	179.69	194.97	194.95	206.43	82.07
2018	27.3.b, 27.3.c, 27.3.d.24	WECA	15.90	14.48	51.77	87.24	108.43	142.67	143.41	157.66	170.05	92.29
2019	27.3.a, 27.4.a.e	WECA	20.01	52.81	85.01	118.91	138.37	166.10	183.29	193.95	211.38	98.35
2019	27.3.b, 27.3.c, 27.3.d.24	WECA	16.69	30.70	56.94	83.72	123.62	139.58	165.62	138.32	166.67	106.35
2020	27.3.a, 27.4.a.e	WECA	13.58	47.08	67.05	132.51	160.71	180.81	186.14	199.26	204.83	101.94
2020	27.3.b, 27.3.c, 27.3.d.24	WECA	18.46	38.34	69.11	87.25	111.28	145.53	155.94	172.08	171.04	127.04
2021	27.3.a, 27.4.a.e	WECA	10.80	60.24	64.91	107.10	156.43	169.78	186.75	194.86	196.11	102.87
2021	27.3.b, 27.3.c, 27.3.d.24	WECA	19.10	23.02	72.19	104.11	138.56	146.52	171.64	176.35	177.14	124.95
2022	27.3.a, 27.4.a.e	WECA	25.94	55.62	103.92	129.89	143.19	170.29	175.87	192.07	203.16	148.02
2022	27.3.b, 27.3.c, 27.3.d.24	WECA	20.04	24.42	92.68	94.90	132.63	149.31	170.85	181.45	185.81	137.13
2023	27.3.a, 27.4.a.e	WECA	15.35	36.18	89.33	175.81	193.26	184.08	181.69	196.44	195.19	141.05
2023	27.3.b, 27.3.c, 27.3.d.24	WECA	-	57.50	76.42	100.06	113.93	145.45	164.53	179.77	170.62	129.14

Table 3.2.8 WESTERN BALTIC HERRING. NSAS. CANUM: Catch in numbers (mill), WECA: mean weight (g) and SOP (t) by age as W-ringers in 1993-2023

year	area	type	0	1	2	3	4	5	6	7	8+	Total
1993	27.3.a	CANUM	2795.45	2032.52	237.62	26.51	7.68	3.64	2.71	2.16	0.66	5108.95
1994	27.3.a	CANUM	481.61	1086.54	201.41	26.91	6.01	2.90	1.55	0.38	0.17	1807.48
1995	27.3.a	CANUM	1144.54	1189.25	161.51	13.31	3.46	1.10	0.62	0.36	0.27	2514.43
1996	27.3.a	CANUM	516.09	961.10	161.37	16.99	3.42	1.65	0.67	0.35	0.28	1661.92
1997	27.3.a	CANUM	67.64	305.28	131.70	21.24	1.66	0.79	0.21	0.09	0.13	528.75
1998	27.3.a	CANUM	51.34	745.14	161.51	26.63	19.25	3.04	3.08	1.18	0.48	1011.65
1999	27.3.a	CANUM	598.78	303.03	148.62	47.21	13.40	6.23	1.23	0.48	0.46	1119.42
2000	27.3.a	CANUM	235.33	984.26	115.97	21.86	22.88	7.54	3.27	0.60	0.07	1391.78
2001	27.3.a	CANUM	807.75	563.64	150.03	17.16	1.36	0.29	0.50	0.04	0.03	1540.80
2002	27.3.a	CANUM	478.50	362.57	56.69	5.63	0.74	0.16	0.12	0.05	0.02	904.47
2003	27.3.a	CANUM	21.58	444.99	182.31	13.04	16.21	1.79	1.12	1.23	0.18	682.44
2004	27.3.a	CANUM	88.42	70.87	179.94	20.72	6.04	9.75	1.83	1.96	0.87	380.39
2005	27.3.a	CANUM	96.44	307.46	159.17	16.17	5.36	2.38	2.27	0.48	0.16	589.88
2006	27.3.a	CANUM	35.09	150.13	50.18	10.20	3.26	3.34	0.56	0.38	0.18	253.31
2007	27.3.a	CANUM	67.65	189.31	76.90	2.07	0.45	1.44	0.26	0.63	0.02	338.72
2008	27.3.a	CANUM	85.66	86.60	72.00	1.88	0.25	0.15	0.06	0.33	0.07	246.99
2009	27.3.a	CANUM	116.75	77.52	7.03	0.35	0.22	-	-	-	0.10	201.98
2010	27.3.a	CANUM	48.60	197.00	43.30	0.30	0.10	0.10	-	0.10	-	289.50
2011	27.3.a	CANUM	203.80	35.43	61.46	3.22	0.28	0.17	0.12	0.09	0.02	304.58
2012	27.3.a	CANUM	145.83	174.74	43.05	1.85	1.14	0.19	0.20	0.11	0.03	367.14

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2013	27.3.a	CANUM	0.90	86.19	85.82	2.39	0.36	0.28	-	-	-	175.93
2014	27.3.a	CANUM	284.74	61.13	80.21	5.90	0.54	0.50	0.17	0.03	0.06	433.28
2015	27.3.a	CANUM	30.71	169.58	97.57	6.96	1.25	4.89	1.11	1.20	0.35	313.63
2016	27.3.a	CANUM	133.30	23.33	47.56	5.95	0.53	0.30	0.22	0.03	0.06	211.30
2017	27.3.a	CANUM	0.15	75.99	34.43	6.91	2.97	1.20	0.07	0.05	0.03	121.80
2018	27.3.a	CANUM	14.51	19.17	28.49	1.13	1.79	1.04	0.18	0.12	0.09	66.52
2019	27.3.a	CANUM	23.72	101.32	19.84	4.56	0.10	0.13	0.07	0.01	0.00	149.75
2020	27.3.a	CANUM	79.43	26.58	44.16	5.27	2.18	0.30	0.61	0.80	0.00	159.33
2021	27.3.a	CANUM	6.91	15.69	36.34	2.79	1.51	0.79	0.46	0.15	0.14	64.78
2022	27.3.a	CANUM	1.18	3.29	3.78	0.23	0.14	0.07	0.06	0.03	0.04	8.79
2023	27.3.a	CANUM	1.53	16.73	0.59	0.66	0.13	0.04	0.01	0.00	0.00	19.70
1993	27.3.a	SOP	34903.11	58106.61	18939.29	3749.22	1016.25	850.14	646.94	389.84	133.08	118734.49
1994	27.3.a	SOP	7722.84	46630.15	16789.90	2979.53	830.85	459.57	286.84	74.94	36.82	75811.44
1995	27.3.a	SOP	12836.74	46555.17	14266.53	1939.87	572.98	224.93	132.55	85.96	65.49	76680.21
1996	27.3.a	SOP	5696.90	22448.28	12946.67	2151.39	564.81	307.10	144.65	76.73	66.36	44402.89
1997	27.3.a	SOP	1304.36	14571.21	9025.33	2643.29	285.19	145.85	40.18	16.33	24.85	28056.57
1998	27.3.a	SOP	1408.88	41993.78	12895.90	3137.24	3136.38	546.61	607.87	211.01	107.72	64045.37
1999	27.3.a	SOP	6255.48	15297.03	13037.30	5368.64	1840.84	974.42	230.49	90.23	91.69	43186.13
2000	27.3.a	SOP	5004.98	28011.84	8825.12	2377.46	3730.67	1436.04	600.96	114.18	13.39	50114.64
2001	27.3.a	SOP	7029.00	27848.95	11299.75	1856.44	177.45	42.57	109.07	7.89	5.24	48376.36

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2002	27.3.a	SOP	5858.67	13790.27	5705.23	684.17	105.57	26.00	21.40	8.46	5.32	26205.10
2003	27.3.a	SOP	441.56	14992.46	12218.68	1605.67	2435.66	292.78	213.07	264.41	33.39	32497.68
2004	27.3.a	SOP	1993.35	3920.77	12638.28	2498.27	850.51	1479.09	312.27	366.55	154.49	24213.59
2005	27.3.a	SOP	1595.05	15527.28	11303.61	1711.89	828.18	412.21	419.59	95.15	33.57	31926.51
2006	27.3.a	SOP	503.45	8034.66	3974.80	1199.64	456.33	620.45	107.43	81.46	37.07	15015.30
2007	27.3.a	SOP	1807.38	11857.46	5464.09	224.04	55.37	218.75	48.01	110.46	2.86	19788.42
2008	27.3.a	SOP	1385.63	4986.26	6222.26	204.96	34.78	24.68	9.89	67.26	12.91	12948.64
2009	27.3.a	SOP	1095.33	4634.68	710.24	28.57	45.73	-	-	-	27.55	6542.09
2010	27.3.a	SOP	364.50	9968.20	3325.44	36.69	14.93	19.13	-	21.63	-	13750.52
2011	27.3.a	SOP	1524.02	1243.86	5136.69	364.38	37.18	32.79	22.66	21.96	4.71	8388.25
2012	27.3.a	SOP	1792.18	6937.44	2873.20	229.20	192.92	33.05	39.04	24.43	6.34	12127.79
2013	27.3.a	SOP	30.26	6497.88	6405.35	320.40	56.94	55.94	-	-	-	13366.78
2014	27.3.a	SOP	2556.85	3482.13	5904.69	640.69	88.40	95.08	36.29	5.80	12.66	12822.58
2015	27.3.a	SOP	484.77	5039.71	6635.56	924.60	196.92	879.97	217.75	237.52	75.04	14691.84
2016	27.3.a	SOP	899.04	873.19	2806.67	733.03	79.27	47.04	46.14	7.21	14.85	5506.43
2017	27.3.a	SOP	4.57	3689.57	2327.96	708.64	411.51	207.80	12.33	8.38	4.60	7375.38
2018	27.3.a	SOP	145.80	933.08	1637.53	115.71	278.95	187.12	34.79	22.05	17.28	3372.31
2019	27.3.a	SOP	276.56	4154.39	1230.43	385.12	11.62	15.00	11.03	1.93	0.43	6086.51
2020	27.3.a	SOP	1071.90	969.96	2901.59	729.82	367.16	52.94	121.73	172.67	0.07	6387.85
2021	27.3.a	SOP	74.63	741.51	2584.86	322.94	240.54	137.03	88.61	30.83	25.09	4246.05

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a	SOP	30.52	170.93	230.19	26.64	21.82	11.24	11.21	5.33	7.21	515.07
2023	27.3.a	SOP	29.48	508.35	45.85	114.60	24.93	6.96	1.57	0.31	0.03	732.08
1993	27.3.a	WECA	12.49	28.59	79.70	141.41	132.32	233.37	238.53	180.61	203.09	23.24
1994	27.3.a	WECA	16.04	42.92	83.36	110.72	138.31	158.58	184.61	199.05	213.90	41.94
1995	27.3.a	WECA	11.22	39.15	88.33	145.70	165.54	204.53	212.20	236.38	244.27	30.50
1996	27.3.a	WECA	11.04	23.36	80.23	126.64	165.02	186.50	216.05	216.29	239.11	26.72
1997	27.3.a	WECA	19.28	47.73	68.53	124.44	171.49	184.72	188.68	188.66	192.37	53.06
1998	27.3.a	WECA	27.44	56.36	79.85	117.80	162.93	179.71	197.21	178.94	226.27	63.31
1999	27.3.a	WECA	10.45	50.48	87.73	113.72	137.40	156.47	188.10	187.35	198.80	38.58
2000	27.3.a	WECA	21.27	28.46	76.10	108.77	163.08	190.33	183.91	189.41	200.18	36.01
2001	27.3.a	WECA	8.70	49.41	75.31	108.21	130.09	147.09	219.10	175.76	198.05	31.40
2002	27.3.a	WECA	12.24	38.04	100.64	121.55	142.65	160.88	178.71	177.37	218.58	28.97
2003	27.3.a	WECA	20.47	33.69	67.02	123.16	150.28	163.48	190.17	214.62	186.83	47.62
2004	27.3.a	WECA	22.54	55.32	70.24	120.60	140.87	151.72	170.58	186.55	178.46	63.65
2005	27.3.a	WECA	16.54	50.50	71.01	105.86	154.64	173.46	184.53	200.23	208.91	54.12
2006	27.3.a	WECA	14.35	53.52	79.22	117.63	140.16	185.51	190.40	215.63	206.91	59.28
2007	27.3.a	WECA	26.72	62.64	71.06	108.14	124.38	151.73	183.74	174.65	153.77	58.42
2008	27.3.a	WECA	16.18	57.58	86.42	109.14	138.75	167.67	175.37	203.06	197.69	52.43
2009	27.3.a	WECA	9.38	59.79	101.00	81.30	206.35	0.00	0.00	0.00	268.53	32.39
2010	27.3.a	WECA	7.50	50.60	76.80	122.30	149.30	191.30	221.50	216.30	204.50	47.50

year	area	type	0	1	2	3	4	5	6	7	8+	Total
2011	27.3.a	WECA	7.48	35.11	83.57	113.32	133.86	191.47	193.17	234.32	248.25	27.54
2012	27.3.a	WECA	12.29	39.70	66.75	123.69	169.16	174.56	199.39	219.78	215.93	33.03
2013	27.3.a	WECA	33.66	75.39	74.64	133.88	160.14	200.37	-	-	-	75.98
2014	27.3.a	WECA	8.98	56.96	73.62	108.56	162.38	190.94	209.02	221.12	227.82	29.59
2015	27.3.a	WECA	15.79	29.72	68.01	132.87	157.09	179.85	195.87	197.22	214.93	46.84
2016	27.3.a	WECA	6.74	37.42	59.01	123.13	149.08	156.65	207.97	209.50	234.59	26.06
2017	27.3.a	WECA	30.81	48.55	67.62	102.48	138.67	172.88	170.96	184.78	161.99	60.55
2018	27.3.a	WECA	10.05	48.67	57.48	102.82	155.48	179.69	189.49	186.69	202.12	50.70
2019	27.3.a	WECA	11.66	41.00	62.01	84.37	116.20	118.10	164.56	202.20	158.50	40.64
2020	27.3.a	WECA	13.49	36.49	65.71	138.58	168.38	174.62	199.24	216.74	137.84	40.09
2021	27.3.a	WECA	10.80	47.26	71.13	115.75	159.30	173.46	192.63	205.52	185.88	65.55
2022	27.3.a	WECA	25.94	52.03	60.93	117.62	157.34	169.84	193.14	197.60	204.54	58.59
2023	27.3.a	WECA	19.26	30.38	77.91	173.54	186.03	170.81	178.12	198.54	208.33	37.16

Table 3.3.1 Western Baltic spring spawning herring. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0–42G2) – 24 in autumn 1993–2022 (September/October).

								*	**			***	***	***	***
Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
W-rings/Numbers in millions															
0	5,474.540	5,107.780	1,833.130	2,859.220	2,490.090	5,993.820	1,008.910	2,477.972	4,102.595	3,776.780	2,554.680	3,055.595	4,159.311	2,588.922	2,150.306
1	415.730	1,675.340	1,439.460	1,955.400	801.350	1,338.710	1,429.880	1,125.716	837.557	1,238.480	968.860	750.199	940.892	558.851	392.737
2	883.810	328.610	590.010	738.180	678.530	287.240	453.980	1,226.932	421.396	222.530	592.360	590.756	226.959	260.402	165.347
3	559.720	357.960	434.090	394.530	394.070	232.510	328.960	844.088	575.358	217.270	346.230	295.659	279.618	117.412	166.301
4	443.73	353.85	295.17	162.43	236.83	155.95	201.59	366.84	341.12	260.35	163.15	142.77	212.20	76.782	102.01

	0	0	0	0	0	0	0	1	0	0	0	8	1		8
5	189.420	253.510	305.550	118.910	100.190	51.940	78.930	131.430	63.678	96.960	143.320	78.541	139.813	43.919	82.174
6	60.400	126.760	119.260	99.290	50.980	8.130	38.610	85.690	24.520	38.040	79.030	79.018	97.261	12.144	29.727
7	23.510	46.430	46.980	33.280	23.640	1.470	5.920	19.471	9.690	8.580	22.600	25.564	66.937	9.262	11.443
8+	2.330	27.240	18.910	47.850	9.330	2.100	4.190	9.683	13.380	9.890	11.770	15.013	27.789	8.839	9.262
Total	8,053.190	8,277.480	5,082.560	6,409.090	4,785.010	8,071.870	3,550.970	6,287.823	6,389.293	5,868.880	4,882.000	5,033.123	6,150.781	3,676.532	3,109.314
3+ group	1,279.110	1,165.750	1,219.960	856.290	815.040	452.100	658.200	1,457.203	1,027.746	631.090	766.100	636.573	823.619	268.357	400.924
W-rings/Biomass ('000 tonnnes)															
0	66.889	58.540	16.564	28.497	23.760	71.814	13.784	31.163	38.209	33.928	23.074	32.794	42.958	25.202	23.699
1	14.466	58.620	46.643	76.396	39.899	51.117	57.530	48.177	34.165	44.791	35.885	29.790	38.230	22.782	17.602
2	40.972	20.939	29.127	43.461	50.085	22.016	28.431	75.879	29.957	16.089	34.542	46.478	18.013	20.202	10.446
3	40.749	30.091	31.035	35.942	35.280	27.484	27.740	77.137	56.769	22.008	27.726	31.876	31.946	11.366	15.297
4	43.038	40.104	21.174	22.291	28.049	16.664	24.065	37.936	40.360	34.167	18.364	20.414	31.253	9.679	11.077
5	24.198	27.268	37.141	16.743	11.430	6.768	9.259	18.458	9.029	14.561	17.348	12.772	24.876	6.724	11.584
6	12.313	14.915	16.056	13.998	6.157	0.867	5.620	13.267	3.497	5.715	12.225	13.820	17.959	2.001	4.823
7	5.294	9.269	6.101	5.333	3.716	0.350	1.210	3.866	1.075	1.343	3.413	5.111	13.431	1.703	1.756
8+	0.627	6.570	2.930	10.636	2.170	0.458	0.757	2.101	1.908	1.615	1.991	3.447	6.344	1.798	1.303
Total	248.545	266.316	206.771	253.297	200.547	197.537	168.395	307.984	214.967	174.218	174.568	196.503	225.010	101.456	97.588
3+ group	126.218	128.217	114.438	104.943	86.802	52.590	68.651	152.765	112.637	79.410	81.067	87.441	125.809	33.270	45.840
W-rings/Mean weight (g)															
0	12.2	11.5	9.0	10.0	9.5	12.0	13.7	12.6	9.3	9.0	9.0	10.7	10.3	9.7	11.0
1	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	39.7	40.6	40.8	44.8
2	46.4	63.7	49.4	58.9	73.8	76.6	62.6	61.8	71.1	72.3	58.3	78.7	79.4	77.6	63.2
3	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	107.8	114.2	96.8	92.0
4	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	143.0	147.3	126.1	108.6
5	127.7	107.6	121.6	140.8	114.1	130.3	117.3	140.4	141.8	150.2	121.0	162.6	177.9	153.1	141.0
6	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	174.9	184.6	164.8	162.2
7	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.6	110.9	156.6	151.0	199.9	200.6	183.8	153.5
8+	269.1	241.2	154.9	222.3	232.6	217.9	180.7	217.0	142.6	163.3	169.2	229.6	228.3	203.4	140.7
Total	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.0	36.6	27.6	31.4

Year	*** 2009	*** 2010	*** 2011	*** 2012	*** 2013	*** 2014	**** 2015	***** 2016	*** 2017	*** 2018	& 2019	&& 2020	&&& 2021	&&&& 2022	&&&& 2023
W-rings/Numbers in millions															
0	2,821.022	4,561.405	2,929.434	4,103.180	8,996.225	5,473.400	888.081	2,638.277	1,290.650	2,635.830	1,816.647	1,028.745	439.285	2,469.980	2,424.320
1	270.959	534.633	1,206.762	755.034	893.837	769.320	440.738	493.366	463.940	428.530	247.870	185.814	158.368	118.050	466.310
2	95.866	305.54	360.35	294.24	456.20	242.59	509.76	155.41	145.36	89.280	122.94	82.236	144.63	75.870	114.26

		0	4	2	4	0	9	7	0		8		8		0
3	43.553	214.539	210.455	193.974	307.567	279.650	221.344	196.061	123.230	41.160	47.727	66.046	49.942	39.610	55.710
4	17.761	107.364	115.984	124.548	262.908	332.660	129.795	60.953	137.500	20.240	24.244	21.600	22.420	18.400	23.170
5	9.016	85.635	57.840	70.135	87.114	317.240	95.579	30.490	46.550	17.570	17.488	15.890	9.390	11.140	6.170
6	3.227	47.140	50.844	45.017	32.684	211.600	86.150	14.980	21.230	4.940	16.802	7.590	2.780	9.010	4.300
7	1.947	25.021	29.234	22.520	22.565	85.630	47.093	3.300	2.130	1.060	1.540	3.210	3.180	2.100	1.700
8+	1.704	15.309	14.774	21.404	11.300	56.590	37.886	0.000	1.790	1.100	0.600	1.370	0.240	0.730	1.260
Total	3,265.055	5,896.586	4,975.682	5,630.054	11,070.405	7,768.680	2,456.435	3,592.844	2,232.380	3,239.710	2,295.867	1,412.500	830.243	2,744.890	3,097.200
3+ group	77.208	495.007	479.131	477.597	724.139	1,283.370	617.846	305.784	332.430	86.070	108.402	115.706	87.952	80.990	92.310
W-rings/Biomass ('000 tonnes)															
0	29.449	36.791	35.064	46.955	85.185	61.640	8.179	24.072	13.623	32.010	23.081	12.550	4.784	39.025	25.341
1	10.473	21.336	46.384	29.825	38.404	30.369	16.822	18.553	18.296	18.825	9.767	7.617	6.855	4.698	18.730
2	7.069	24.593	29.560	20.380	30.587	21.490	38.573	10.579	10.159	5.797	6.761	5.313	9.002	5.514	6.215
3	4.433	23.540	24.382	22.068	27.349	32.448	22.841	18.068	11.511	3.323	3.630	5.413	4.337	3.628	4.198
4	1.961	15.193	16.361	18.653	27.350	58.819	15.196	5.859	17.427	1.785	2.700	2.207	2.454	1.954	2.262
5	1.385	15.433	9.867	11.450	10.934	63.755	14.581	3.417	6.711	2.239	2.625	2.009	1.186	1.327	0.571
6	0.616	9.018	8.391	7.985	4.849	45.705	14.304	1.723	3.175	0.719	2.673	1.134	0.336	1.492	0.606
7	0.384	4.728	5.295	4.448	3.751	18.709	8.433	0.450	0.257	0.182	0.260	0.497	0.350	0.369	0.159
8+	0.284	3.013	3.015	3.876	1.821	13.498	7.108	0.000	0.190	0.203	0.060	0.230	0.038	0.134	0.256
Total	56.055	153.646	178.320	165.640	230.231	346.433	146.035	82.722	81.349	65.083	51.557	36.969	29.342	58.141	58.338
3+ group	9.064	70.926	67.312	68.480	76.055	232.933	82.462	29.518	39.271	8.451	11.948	11.490	8.701	8.904	8.052
W-rings/Mean weight (g)															
0	10.4	8.1	12.0	11.4	9.5	11.3	9.2	9.1	10.6	12.1	12.7	12.2	10.9	15.8	11.9
1	38.7	39.9	38.4	39.5	43.0	39.5	38.2	37.6	39.4	43.9	39.4	41.0	43.3	39.8	40.2
2	73.7	80.5	82.0	69.3	67.0	88.6	75.7	68.1	69.9	64.9	55.0	64.6	62.2	72.7	54.4
3	101.8	109.7	115.9	113.8	88.9	116.0	103.2	92.2	93.4	80.7	76.1	82.0	86.8	91.6	75.4
4	110.4	141.5	141.1	149.8	104.0	176.8	117.1	96.1	126.7	88.2	111.4	102.2	109.5	106.2	97.6
5	153.6	180.2	170.6	163.3	125.5	201.0	152.5	112.1	144.2	127.4	150.1	126.4	126.4	119.1	92.5
6	190.9	191.3	165.0	177.4	148.4	216.0	166.0	115.0	149.5	145.6	159.1	149.4	120.7	165.6	140.9
7	197.4	189.0	181.1	197.5	166.2	218.5	179.1	136.4	120.5	172.0	168.7	154.9	110.0	175.9	93.5
8+	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-	106.4	184.2	100.3	167.9	156.7	183.2	203.2
Total	17.2	26.1	35.8	29.4	20.8	44.6	59.5	23.0	36.4	20.1	22.5	26.2	35.3	21.2	18.8

small revision in 2015

small revision in 2017 (<0.5 %)

small revision in 2018

*incl. mean for Sub-division 23, which was not covered by RV SOLEA

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

*** excl. Central Baltic Herring in SD 24 (SD 23) based on SF (Gröhsler et al. 2013)

**** excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF & excl. mature herring in SD 23 (stages>=6)

***** excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF

& excl. Central Baltic Herring in SDs 21-24 based on SF

&& excl. Central Baltic Herring in SDs 21 and SD 24 (SD 23) based on SF

&&&excl. Central Baltic Herring in SDs 21-22 and SD 24 (SD 23) based on SF

&&&&excl. Central Baltic Herring in SD 24 based on SF and large herring accumulation in in rectangle 41G2/SD 23

Table 3.3.2 Western Baltic spring spawning herring. Acoustic surveys (HERAS) on the Western Baltic Spring Spawning Herring in the North Sea/Division 3.a in 1991–2023 (July).

		*	*	*	*	*			**						
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
W-rings/Numbers in millions															
0		3,853	372	964											
1		277	103	5	2,199	1,091	128	138	1,367	1,509	66	3,346	1,833	1,669	2,687
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21
Total	5,177	10,509	5,779	3,339	6,867	2,673	2,088	3,248	3,201	4,696	1,481	7,002	3,807	3,926	4,939
3+ group	5,177	4,287	2,536	1,957	2,781	577	1,245	1,428	691	1,295	774	2,079	864	1,328	910
W-rings/Biomass ('000 tonnnes)															
0		34.3	1	8.7											
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3
W-rings/Mean weight (g)															
0		8.9	4.0	9.0											
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
W-rings/Numbers in millions															
0			112				1		314	2	203	1		2	9
1	2,081	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106	418	815
2	2,217	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224	591	274
3	1,780	933	843	205	254	259	236	525	176	446	381	661	271	315	225
4	490	499	333	161	115	163	87	53	248	224	99	401	175	109	180
5	180	154	274	82	65	70	76	30	28	171	40	94	169	67	74
6	27	34	176	86	24	53	33	12	37	82	40	53	50	52	77
7	10	26	45	39	28	22	14	8	26	89	12	52	35	19	64
8+	0.1	14	44	65	34	46	60	15	42	115	28	92	44	13	46
Total	6,786	9,199	8,839	1,601	2,030	4,066	2,606	1,319	1,799	4,322	1,483	2,474	1,074	1,586	1,764
3+ group	2,487	1,660	1,715	638	520	613	506	643	557	1,127	600	1,353	744	575	666
W-rings/Biomass ('000 tonnnes)															
0							0.0		1.0	0.03	1.0	0.0		0.0	0.0
1	112.6	193.2	284.4	26.8	53.0	90.0	44.0	3.0	26.0	61.5	16.0	31.0	4.0	15.0	35.0
2	160.5	273.4	100.9	48.8	34.0	47.0	87.0	51.0	48.0	106.2	20.0	41.0	19.0	49.0	23.0
3	158.6	90.9	101.8	30.6	28.0	31.0	26.0	59.0	21.0	54.7	51.0	101.0	28.0	32.0	29.0
4	56.3	59.6	47.1	29.4	17.0	25.0	12.0	7.0	43.0	33.8	15.0	63.0	25.0	15.0	26.0
5	23.7	18.5	45.3	17.5	11.0	12.0	13.0	4.0	6.0	30.3	7.0	16.0	28.0	12.0	13.0
6	4.1	4.6	30.9	21.4	5.0	10.0	6.0	2.0	8.0	16.7	8.0	10.0	9.0	9.0	13.0
7	1.6	2.6	9.4	10.6	6.0	5.0	3.0	1.0	6.0	17.7	3.0	11.0	7.0	3.0	13.0
8+	0.0	1.9	8.7	19.8	8.0	10.0	14.0	3.0	11.0	25.2	6.0	20.0	10.0	3.0	9.0
Total	517.5	644.7	628.5	204.9	162.0	230.0	205.0	130.0	169.0	346.0	126.0	293.0	130.0	138.0	161.0
3+ group	244.4	178.2	243.2	129.3	75.0	93.0	74.0	76.0	95.0	178.3	90.0	221.0	107.0	74.0	103.0
W-rings/Mean weight (g)															
0			6.3				3.0		4.3	14.2	4.0	23.0		4.0	4.6
1	54.1	49.3	48.6	47.5	52.7	30.2	42.9	58.1	51.6	31.5	37.0	45.0	42.0	35.8	43.2
2	72.4	75.5	87.0	122.7	65.8	98.8	80.4	80.8	114.9	85.4	79.0	97.1	82.9	82.7	85.2
3	89.1	97.4	120.8	149.1	111.4	121.2	110.6	111.7	122.4	122.7	134.0	153.4	104.6	102.1	127.0
4	114.8	119.5	141.4	182.9	150.9	150.6	142.9	128.5	175.0	150.9	151.0	157.3	145.4	139.6	145.2
5	131.6	120.0	165.5	213.3	175.6	168.7	170.8	138.3	210.6	177.1	173.0	173.4	164.9	170.8	178.5
6	153.2	136.6	175.6	248.3	198.0	190.8	182.0	157.2	220.2	202.3	194.0	182.0	172.6	178.6	171.9
7	169.2	101.5	208.5	272.1	215.9	211.0	194.0	155.5	213.3	198.9	214.0	202.7	187.3	187.5	201.0
8+	178.0	138.3	196.7	304.7	234.8	228.5	228.6	198.5	244.1	218.9	215.0	221.2	236.4	221.8	198.7
Total	76.3	70.1	71.1	128.0	79.8	56.6	78.5	97.9	94.6	80.1	50.0	118.8	121.3	87.2	91.7

Year	2021	2022	2023

W-rings/Numbers in millions			
0	0	0	0
1	26	45	229
2	245	246	98
3	275	129	133
4	203	124	76
5	52	100	42
6	49	58	28
7	22	36	25
8+	39	37	15
Total	911	775	646
3+ group	640	484	319

W-rings/Biomass ('000 tonnnes)			
0	0.0	0.0	0.00
1	1.0	2.0	11.0
2	21.0	28.0	9.0
3	30.0	17.0	15.0
4	23.0	17.0	11.0
5	9.0	16.0	7.0
6	8.0	11.0	5.0
7	5.0	7.0	4.0
8+	8.0	9.0	3.0
Total	105.0	107.0	65.0
3+ group	83.0	77.0	45.0

W-rings/Mean weight (g)			
0			
1	54.4	40.2	17.8
2	86.9	115.6	22.3
3	107.4	132.6	24.1
4	112.5	137.2	26.0
5	168.8	163.1	27.0
6	169.1	183.2	27.5
7	212.0	198.5	27.6
8+	209.0	230.2	28.2
Total	115.3	138.1	100.6

* revised in 1997

**the survey only covered the Skagerrak area by Norway. Additional estimates for the Kattegat area were added (see ICES 2000/ACFM:10, Table 3.5.8)

Table 3.3.3. Western Baltic spring-spawning herring.

N20 Larval Abundance Index.

Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)

1992	660
1993	4542
1994	15158
1995	9327
1996	24540
1997	5290
1998	18782
1999	22342
2000	3404
2001	5670
2002	12452
2003	4775
2004	6818
2005	5118
2006	4173
2007	1986
2008	1903
2009	7989
2010	8004
2011	4493
2012	1340
2013	3588
2014	681
2015	3001
2016	482
2017	1247
2018	1563
2019	1317
2020	239
2021	2751
2022	6603
2023	1516

Table 3.6.1.a - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet A. Catch in number (CANUM, thousands) per year and age as W-ringers

	0	1	2	3	4	5	6	7	8
2000	0	0	8161	9752	10223	5660	2466	605	778
2001	0	454	11344	10224	6123	7151	2664	1556	410
2002	0	0	7589	14825	10583	3349	2877	969	620
2003	0	0	30	3130	5992	3502	1167	1305	605
2004	0	0	15140	27898	3520	4110	1002	456	146
2005	0	0	6569	17434	12680	2573	3787	1084	714
2006	0	129	3514	8783	13962	22370	5102	5258	3055
2007	0	0	74	2627	1253	596	806	377	613

	0	1	2	3	4	5	6	7	8
2008	0	0	70	87	167	77	81	182	35
2009	0	0	1017	2075	3375	1423	1733	4471	3144
2010	0	26	32	518	985	389	518	270	1018
2011	0	0	63	442	400	235	69	109	298
2012	0	0	16	214	359	0	1432	0	7395
2013	0	0	53	409	172	494	312	67	645
2014	0	34	2451	3369	5406	802	2116	1045	1573
2015	0	20	95	868	1404	3872	1837	1446	2170
2016	0	20	1209	4109	1033	1137	1182	689	1210
2017	0	3	47	2368	1013	245	90	108	136
2018	0	29	330	901	2277	4270	1744	861	623
2019	0	7599	6239	4857	2750	7257	9687	2650	2583
2020	0	1812	3204	5845	7536	1219	10720	5325	4587
2021	0	394	1096	2794	7339	4469	1887	1100	2250
2022	0	100	6245	6705	7203	5132	4464	2510	3244
2023	0	591	2608	2621	3126	2117	1253	1183	885

Table 3.6.1.b - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet C. Catch in number (CANUM, thousands) per year and age as W-ringers

	0	1	2	3	4	5	6	7	8
2000	59181	209579	294752	99060	55666	20361	7311	978	772.0
2001	2924	22479	184831	97597	25224	12059	5979	1672	882.0
2002	1207	108742	133960	118066	40768	8532	4442	1459	1345.0
2003	4704	27998	155177	57513	54639	16425	4427	2786	1051.0
2004	6559	78442	56286	42645	9927	7987	2586	671	290.0
2005	5318	62322	175515	53573	30534	6613	7336	2142	692.0
2006	2105	41760	91008	86554	29334	26306	4849	4390	1833.0
2007	230	90083	79527	31939	26596	11189	7371	5701	1931.0
2008	824	92818	60484	34255	12424	14454	7281	4175	1121.0
2009	442	91310	119936	41373	20153	9000	5845	3043	1921.0

	0	1	2	3	4	5	6	7	8
2010	230	41741	96890	42943	17084	7087	4177	2768	2739.0
2011	89	41858	28489	19924	12990	5756	2913	915	822.0
2012	0	15350	81497	20357	9152	7091	2774	2230	1166.0
2013	0	6260	40605	68642	10640	3858	1085	409	372.0
2014	49	23096	16886	18895	39169	6795	2439	1283	1329.0
2015	115	17357	47337	19590	12579	10401	3016	1232	1727.0
2016	0	13761	146136	38528	12298	10290	12066	2906	5340.0
2017	1427	47128	36117	40438	33155	10000	10792	7246	2762.1
2018	2	18967	176762	16634	12912	18031	5096	3041	2511.2
2019	5231	29648	52720	16127	5473	2488	1414	326	54.2
2020	10315	32689	49813	16558	9210	6368	2864	3022	1071.0
2021	1482	1370	62429	14535	8234	4939	3907	1594	1811.2
2022	0	8	920	333	239	107	77	31	40.7
2023	111	1599	176	353	181	149	76	20	0.8

Table 3.6.1.c - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet D. Catch in number (CANUM, thousands) per year and age as W-ringers

	0	1	2	3	4	5	6	7	8
2000	58480	109337	13888	5033	555	156.0	87	18	10
2001	118759	13695	11926	3256	711	460.0	1197	938	1130
2002	68427	468952	26715	1707	1742	169.0	160	0	53
2003	47410	35021	27318	4810	3741	1543.0	665	263	158
2004	19111	130900	24598	23435	4794	4746.0	918	387	156
2005	90002	35287	21250	4344	3718	149.0	377	238	0
2006	1551	47777	17551	14152	3926	5720.0	652	428	234
2007	1395	13772	11277	2346	2960	997.0	1270	161	133
2008	4079	8946	10511	4583	888	598.0	366	141	148
2009	14358	58292	11338	2404	913	457.0	224	164	219
2010	8879	6826	8183	202	310	83.0	0	0	0
2011	6080	41200	1317	590	0	0.0	0	0	0
2012	1521	15193	12792	138	0	0.0	0	0	0

	0	1	2	3	4	5	6	7	8
2013	0	5770	11071	2313	444	0.0	0	0	0
2014	25267	8397	3039	1979	0	0.0	0	0	0
2015	3195	40377	12506	526	121	313.0	0	0	0
2016	23879	13397	14390	391	0	674.0	0	0	0
2017	0	1294	6017	18	0	0.0	0	0	0
2018	285	1471	2047	85	0	0.0	0	0	0
2019	75	986	280	61	0	0.0	0	0	0
2020	463	2107	1881	944	385	190.1	41	0	7
2021	0	435	227	0	0	0.0	0	0	0
2022	62	359	134	10	2	0.3	0	0	0
2023	21	1430	41	10	0	0.0	0	0	0

Table 3.6.1.d - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet F. Catch in number (CANUM, thousands) per year and age as W-ringers

	0	1	2	3	4	5	6	7	8
2000	37749	616321	194300	86731	77777	52964	30056	12428	9291
2001	634631	498179	283245	147601	75897	47807	28743	13928	4188
2002	80637	81436	113576	186714	119192	45110	31053	11414	6310
2003	1374	63857	82330	95798	125060	82178	22858	13098	7006
2004	217885	248412	101789	70788	74972	74400	44450	13363	10422
2005	11586	207562	115890	102482	83461	51304	54195	27767	11214
2006	650	44762	72070	118995	101731	43005	31364	22110	12157
2007	9095	68189	93857	106993	96054	52215	20752	15017	12082
2008	4707	73668	68438	98131	75655	70738	37572	13260	18475
2009	5934	31481	110715	55478	45495	37211	31948	13230	7244
2010	3285	26490	31314	39307	28455	22420	13894	7958	7505
2011	5643	15458	16413	17831	35934	21639	19649	11212	8214
2012	479	46311	36497	43760	37810	28353	13964	9008	8440
2013	1029	60576	37098	43312	55919	28716	25322	11498	10987
2014	5840	35272	37735	42119	37499	19023	11196	6541	6186

	0	1	2	3	4	5	6	7	8
2015	26670	46242	72781	38506	48439	29846	14860	7857	9120
2016	20012	22342	37247	93863	45681	30535	17423	10455	8256
2017	52	9435	32839	38541	78328	38496	26936	13463	10170
2018	368	48383	18459	34635	23065	51273	16259	8843	4507
2019	270	6881	20667	15565	13301	10333	15868	6034	3517
2020	31	1690	2487	4580	4673	6707	4148	5326	1579
2021	43	592	1772	3192	2531	1501	1331	926	923
2022	4	77	355	945	938	903	643	442	344
2023	0	10	228	1585	1323	835	796	377	436

Table 3.6.2.a - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet A. Weight at age as W-ringers in the catch (WECA, kg)

	0	1	2	3	4	5	6	7	8
2000	0.0000	0.0000	0.1407	0.1652	0.1839	0.2070	0.2024	0.2176	0.2663
2001	0.0000	0.0790	0.1275	0.1514	0.1784	0.1884	0.1982	0.2208	0.2666
2002	0.0000	0.0000	0.1431	0.1542	0.1652	0.1864	0.1976	0.2075	0.2235
2003	0.0000	0.0000	0.1014	0.1356	0.1414	0.1632	0.1752	0.1846	0.1923
2004	0.0000	0.0000	0.1206	0.1328	0.1639	0.1659	0.1748	0.1843	0.2079
2005	0.0000	0.0000	0.1071	0.1539	0.1676	0.1793	0.1887	0.1864	0.2084
2006	0.0000	0.0247	0.1246	0.1488	0.1641	0.1752	0.2140	0.2243	0.2367
2007	0.0000	0.0000	0.1566	0.1482	0.1565	0.1850	0.1858	0.1993	0.2248
2008	0.0000	0.0000	0.1418	0.1647	0.1657	0.1680	0.1922	0.1994	0.2158
2009	0.0000	0.0000	0.1381	0.1701	0.2111	0.2110	0.2481	0.2484	0.2845
2010	0.0000	0.0678	0.1323	0.1573	0.2003	0.2056	0.2109	0.2190	0.2352
2011	0.0000	0.0000	0.1497	0.1670	0.1828	0.2078	0.2130	0.2106	0.2188
2012	0.0000	0.0000	0.1396	0.1846	0.2053	0.0000	0.2131	0.0000	0.2264
2013	0.0000	0.0000	0.1350	0.1542	0.2143	0.1956	0.2206	0.2433	0.2530
2014	0.0000	0.1037	0.1478	0.1595	0.1666	0.1957	0.1997	0.2116	0.2215
2015	0.0000	0.1147	0.1367	0.1436	0.1625	0.1809	0.2028	0.2040	0.2161
2016	0.0000	0.1218	0.1213	0.1537	0.1742	0.1819	0.2099	0.2198	0.2247

	0	1	2	3	4	5	6	7	8
2017	0.0000	0.1013	0.1231	0.1460	0.1660	0.1801	0.2001	0.1973	0.2109
2018	0.0000	0.0964	0.1275	0.1626	0.1827	0.1974	0.2134	0.2236	0.2387
2019	0.0000	0.0722	0.1309	0.1582	0.1599	0.1792	0.1873	0.1959	0.2124
2020	0.0000	0.1050	0.1275	0.1457	0.1597	0.1698	0.1829	0.1934	0.2072
2021	0.0000	0.1193	0.1380	0.1493	0.1596	0.1677	0.1738	0.1810	0.1965
2022	0.0000	0.0688	0.1101	0.1312	0.1429	0.1704	0.1756	0.1920	0.2031
2023	0.0000	0.0524	0.0907	0.1770	0.1938	0.1850	0.1819	0.1964	0.1952

Table 3.6.2.b - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet C. Weight at age as W-ringers in the catch (WECA, kg)

	0	1	2	3	4	5	6	7	8
2000	0.0216	0.0402	0.0685	0.1072	0.1390	0.1600	0.1463	0.1767	0.1554
2001	0.0244	0.0644	0.0744	0.1049	0.1377	0.1623	0.1906	0.1682	0.1987
2002	0.0095	0.0453	0.0856	0.1129	0.1382	0.1633	0.1887	0.1921	0.2132
2003	0.0130	0.0554	0.0808	0.1136	0.1327	0.1407	0.1553	0.1652	0.1473
2004	0.0237	0.0569	0.0736	0.1133	0.1392	0.1546	0.1677	0.1870	0.1774
2005	0.0230	0.0667	0.0863	0.1121	0.1413	0.1565	0.1711	0.1748	0.1926
2006	0.0262	0.0560	0.0842	0.1103	0.1343	0.1744	0.1816	0.1922	0.1962
2007	0.0472	0.0708	0.0881	0.1142	0.1379	0.1587	0.1912	0.1775	0.2078
2008	0.0362	0.0740	0.0925	0.1149	0.1421	0.1712	0.1809	0.1999	0.1967
2009	0.0227	0.0740	0.0902	0.1153	0.1605	0.1772	0.2039	0.2015	0.2247
2010	0.0279	0.0663	0.0880	0.1280	0.1592	0.1942	0.2109	0.2117	0.2257
2011	0.0215	0.0509	0.0910	0.1208	0.1389	0.1687	0.1853	0.2170	0.2093
2012	0.0000	0.0662	0.0818	0.1340	0.1635	0.1820	0.1994	0.2220	0.2206
2013	0.0000	0.0937	0.0994	0.1324	0.1628	0.1949	0.2041	0.2487	0.2123
2014	0.0141	0.0633	0.1046	0.1411	0.1798	0.1996	0.2221	0.2361	0.2336
2015	0.0175	0.0409	0.0747	0.1145	0.1500	0.1706	0.1877	0.1924	0.2089
2016	0.0000	0.0563	0.0659	0.1236	0.1595	0.1807	0.1999	0.2112	0.2374
2017	0.0305	0.0449	0.0673	0.1113	0.1410	0.1624	0.1710	0.1827	0.1679
2018	0.0216	0.0570	0.0553	0.1068	0.1495	0.1755	0.1887	0.1868	0.1984

	0	1	2	3	4	5	6	7	8
2019	0.0201	0.0487	0.0798	0.1073	0.1275	0.1277	0.1556	0.1784	0.1616
2020	0.0138	0.0435	0.0620	0.1289	0.1634	0.1848	0.1994	0.2095	0.1949
2021	0.0108	0.0480	0.0636	0.0990	0.1536	0.1717	0.1930	0.2044	0.1957
2022	0.0000	0.0361	0.0656	0.1061	0.1532	0.1671	0.1931	0.1976	0.2045
2023	0.0139	0.0266	0.0753	0.1706	0.1843	0.1708	0.1786	0.1985	0.2083

Table 3.6.2.c - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet D. Weight at age as W-ringers in the catch (WECA, kg)

	0	1	2	3	4	5	6	7	8
2000	0.0236	0.0161	0.0658	0.1304	0.1549	0.1669	0.1937	0.0804	0.1499
2001	0.0086	0.0287	0.0564	0.0940	0.1276	0.1440	0.1540	0.1655	0.1840
2002	0.0102	0.0146	0.0230	0.1363	0.1427	0.1700	0.1797	0.0000	0.1790
2003	0.0130	0.0229	0.0516	0.0951	0.1184	0.1101	0.1043	0.1469	0.1469
2004	0.0282	0.0350	0.0772	0.1053	0.1448	0.1548	0.1746	0.1800	0.1855
2005	0.0135	0.0340	0.0738	0.1093	0.1402	0.1490	0.1531	0.1727	0.0000
2006	0.0142	0.0245	0.0721	0.1123	0.1368	0.1824	0.1961	0.2195	0.2047
2007	0.0215	0.0316	0.0624	0.0997	0.1355	0.1502	0.1915	0.1682	0.2107
2008	0.0158	0.0465	0.0826	0.1101	0.1396	0.1717	0.1884	0.2042	0.1896
2009	0.0132	0.0176	0.0871	0.1296	0.1607	0.1728	0.2103	0.2068	0.2058
2010	0.0077	0.0166	0.0399	0.0940	0.0410	0.1110	0.0000	0.0000	0.0000
2011	0.0082	0.0162	0.0448	0.0711	0.0000	0.0000	0.0000	0.0000	0.0000
2012	0.0093	0.0275	0.0398	0.0852	0.0000	0.0000	0.0000	0.0000	0.0000
2013	0.0000	0.0224	0.0748	0.1114	0.1378	0.0000	0.0000	0.0000	0.0000
2014	0.0093	0.0216	0.0244	0.0643	0.0000	0.0000	0.0000	0.0000	0.0000
2015	0.0159	0.0279	0.0415	0.0971	0.2840	0.1470	0.0000	0.0000	0.0000
2016	0.0071	0.0234	0.0375	0.0805	0.0000	0.0780	0.0000	0.0000	0.0000
2017	0.0000	0.0150	0.0250	0.0750	0.0000	0.0000	0.0000	0.0000	0.0000
2018	0.0102	0.0385	0.0427	0.0480	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0120	0.0279	0.0397	0.0645	0.0000	0.0000	0.0000	0.0000	0.0000
2020	0.0095	0.0531	0.0979	0.1147	0.1164	0.1168	0.1158	0.0000	0.1300

	0	1	2	3	4	5	6	7	8
2021	0.0000	0.0453	0.0673	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2022	0.0259	0.0523	0.0806	0.0734	0.1129	0.0811	0.0000	0.0000	0.0000
2023	0.0227	0.0402	0.0634	0.0509	0.0000	0.0000	0.0000	0.0000	0.0000

Table 3.6.2.d - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet - Fleet F. Weight at age as W-ringers in the catch (WECA, kg)

	0	1	2	3	4	5	6	7	8
2000	0.0165	0.0222	0.0428	0.0804	0.1235	0.1332	0.1434	0.1554	0.1514
2001	0.0129	0.0221	0.0467	0.0689	0.0933	0.1504	0.1445	0.1455	0.1522
2002	0.0108	0.0273	0.0578	0.0817	0.1088	0.1321	0.1866	0.1778	0.1577
2003	0.0224	0.0257	0.0464	0.0753	0.0952	0.1172	0.1259	0.1571	0.1626
2004	0.0037	0.0143	0.0474	0.0777	0.0964	0.1255	0.1504	0.1658	0.1510
2005	0.0136	0.0142	0.0483	0.0733	0.0893	0.1156	0.1436	0.1599	0.1702
2006	0.0212	0.0340	0.0567	0.0840	0.1022	0.1253	0.1439	0.1758	0.1700
2007	0.0119	0.0278	0.0573	0.0749	0.1063	0.1213	0.1407	0.1627	0.1855
2008	0.0163	0.0369	0.0649	0.0877	0.1103	0.1332	0.1406	0.1583	0.1747
2009	0.0105	0.0283	0.0481	0.0905	0.1238	0.1452	0.1604	0.1712	0.1818
2010	0.0122	0.0222	0.0522	0.0871	0.1198	0.1548	0.1706	0.1919	0.1941
2011	0.0124	0.0230	0.0551	0.0781	0.1132	0.1366	0.1476	0.1612	0.1680
2012	0.0181	0.0159	0.0550	0.0954	0.1151	0.1503	0.1676	0.1774	0.1912
2013	0.0137	0.0178	0.0541	0.0868	0.1294	0.1369	0.1453	0.1591	0.1798
2014	0.0165	0.0300	0.0590	0.0823	0.1221	0.1584	0.1560	0.1630	0.1755
2015	0.0071	0.0159	0.0504	0.0793	0.1076	0.1447	0.1706	0.1356	0.1494
2016	0.0103	0.0341	0.0517	0.0846	0.0950	0.1295	0.1604	0.1681	0.1692
2017	0.0220	0.0342	0.0577	0.0828	0.1179	0.1235	0.1376	0.1475	0.1398
2018	0.0159	0.0145	0.0518	0.0872	0.1084	0.1427	0.1434	0.1577	0.1701
2019	0.0167	0.0307	0.0569	0.0837	0.1236	0.1396	0.1656	0.1383	0.1667
2020	0.0185	0.0383	0.0691	0.0873	0.1113	0.1455	0.1559	0.1721	0.1710
2021	0.0191	0.0230	0.0722	0.1041	0.1386	0.1465	0.1716	0.1763	0.1771
2022	0.0200	0.0244	0.0927	0.0949	0.1326	0.1493	0.1709	0.1814	0.1858

	0	1	2	3	4	5	6	7	8
2023	0.0000	0.0575	0.0764	0.1001	0.1139	0.1455	0.1645	0.1798	0.1706

Table 3.6.3 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Weight at age as W-ringers in the stock (WEST, kg)

	0	1	2	3	4	5	6	7	8
1991	0.0001	0.0308	0.0528	0.0787	0.1041	0.1245	0.1449	0.1594	0.1640
1992	0.0001	0.0203	0.0451	0.0818	0.1075	0.1313	0.1593	0.1710	0.1869
1993	0.0001	0.0156	0.0402	0.0967	0.1079	0.1409	0.1672	0.1827	0.1891
1994	0.0001	0.0186	0.0529	0.0836	0.1077	0.1392	0.1566	0.1768	0.2028
1995	0.0001	0.0131	0.0459	0.0708	0.1327	0.1674	0.1892	0.2097	0.2338
1996	0.0001	0.0181	0.0546	0.0905	0.1170	0.1197	0.1538	0.1467	0.1280
1997	0.0001	0.0131	0.0515	0.1063	0.1333	0.1662	0.1943	0.2090	0.2264
1998	0.0001	0.0221	0.0558	0.0829	0.1128	0.1338	0.1678	0.1683	0.1843
1999	0.0001	0.0211	0.0567	0.0871	0.1081	0.1480	0.1601	0.1439	0.1504
2000	0.0001	0.0140	0.0431	0.0837	0.1250	0.1436	0.1629	0.1650	0.1831
2001	0.0001	0.0169	0.0509	0.0783	0.1159	0.1690	0.1763	0.1681	0.1805
2002	0.0001	0.0164	0.0637	0.0905	0.1239	0.1736	0.1983	0.1980	0.2036
2003	0.0001	0.0144	0.0445	0.0793	0.1051	0.1268	0.1506	0.1729	0.1847
2004	0.0001	0.0131	0.0456	0.0811	0.1092	0.1440	0.1628	0.1932	0.2076
2005	0.0001	0.0126	0.0514	0.0800	0.1066	0.1322	0.1573	0.1677	0.1820
2006	0.0001	0.0185	0.0621	0.0953	0.1174	0.1659	0.1710	0.1858	0.1871
2007	0.0001	0.0150	0.0550	0.0800	0.1140	0.1430	0.1710	0.1750	0.1880
2008	0.0001	0.0180	0.0680	0.0860	0.1100	0.1390	0.1430	0.1410	0.1580
2009	0.0001	0.0230	0.0520	0.0900	0.1300	0.1560	0.1740	0.1850	0.1990
2010	0.0001	0.0140	0.0626	0.0974	0.1283	0.1618	0.1813	0.2023	0.2045
2011	0.0001	0.0090	0.0580	0.0950	0.1260	0.1560	0.1730	0.1850	0.1920
2012	0.0001	0.0120	0.0500	0.0920	0.1140	0.1580	0.1780	0.1910	0.2010
2013	0.0001	0.0140	0.0560	0.0950	0.1290	0.1430	0.1610	0.1790	0.1990
2014	0.0001	0.0160	0.0520	0.0810	0.1300	0.1650	0.1740	0.1900	0.2050
2015	0.0001	0.0150	0.0490	0.0880	0.1160	0.1570	0.1800	0.1690	0.1940

	0	1	2	3	4	5	6	7	8
2016	0.0001	0.0138	0.0415	0.0811	0.1057	0.1366	0.1735	0.1824	0.1903
2017	0.0001	0.0177	0.0479	0.0815	0.1181	0.1324	0.1558	0.1731	0.1751
2018	0.0001	0.0125	0.0491	0.0828	0.1091	0.1432	0.1544	0.1696	0.1853
2019	0.0001	0.0256	0.0568	0.0771	0.1190	0.1481	0.1705	0.1778	0.1910
2020	0.0001	0.0238	0.0484	0.0781	0.1039	0.1465	0.1644	0.1686	0.1809
2021	0.0001	0.0192	0.0544	0.0745	0.1170	0.1293	0.1773	0.1814	0.1781
2022	0.0001	0.0178	0.0749	0.0865	0.1127	0.1304	0.1650	0.1810	0.1872
2023	0.0001	0.0242	0.0557	0.0843	0.1138	0.1557	0.1725	0.1816	0.1892

Table 3.6.4 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Natural mortality (NATMOR)

	0	1	2	3	4	5	6	7	8
1991	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2

	0	1	2	3	4	5	6	7	8
2009	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2019	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2020	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2021	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2022	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2023	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.6.5 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Proportion mature (MATPROP)

	0	1	2	3	4	5	6	7	8
1991	0	0	0.2	0.8	0.9	1	1	1	1
1992	0	0	0.2	0.8	0.9	1	1	1	1
1993	0	0	0.2	0.8	0.9	1	1	1	1
1994	0	0	0.2	0.8	0.9	1	1	1	1
1995	0	0	0.2	0.8	0.9	1	1	1	1
1996	0	0	0.2	0.8	0.9	1	1	1	1
1997	0	0	0.2	0.8	0.9	1	1	1	1
1998	0	0	0.2	0.8	0.9	1	1	1	1
1999	0	0	0.2	0.8	0.9	1	1	1	1
2000	0	0	0.2	0.8	0.9	1	1	1	1
2001	0	0	0.2	0.8	0.9	1	1	1	1

	0	1	2	3	4	5	6	7	8
2002	0	0	0.2	0.8	0.9	1	1	1	1
2003	0	0	0.2	0.8	0.9	1	1	1	1
2004	0	0	0.2	0.8	0.9	1	1	1	1
2005	0	0	0.2	0.8	0.9	1	1	1	1
2006	0	0	0.2	0.8	0.9	1	1	1	1
2007	0	0	0.2	0.8	0.9	1	1	1	1
2008	0	0	0.2	0.8	0.9	1	1	1	1
2009	0	0	0.2	0.8	0.9	1	1	1	1
2010	0	0	0.2	0.8	0.9	1	1	1	1
2011	0	0	0.2	0.8	0.9	1	1	1	1
2012	0	0	0.2	0.8	0.9	1	1	1	1
2013	0	0	0.2	0.8	0.9	1	1	1	1
2014	0	0	0.2	0.8	0.9	1	1	1	1
2015	0	0	0.2	0.8	0.9	1	1	1	1
2016	0	0	0.2	0.8	0.9	1	1	1	1
2017	0	0	0.2	0.8	0.9	1	1	1	1
2018	0	0	0.2	0.8	0.9	1	1	1	1
2019	0	0	0.2	0.8	0.9	1	1	1	1
2020	0	0	0.2	0.8	0.9	1	1	1	1
2021	0	0	0.2	0.8	0.9	1	1	1	1
2022	0	0	0.2	0.8	0.9	1	1	1	1
2023	0	0	0.2	0.8	0.9	1	1	1	1

Table 3.6.6 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Fraction of harvest before spawning (FPROP)

	0	1	2	3	4	5	6	7	8
1991	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1992	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1993	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1994	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	0	1	2	3	4	5	6	7	8
1995	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1996	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1997	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1998	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1999	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2001	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2002	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2003	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2004	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2005	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2006	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2007	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2008	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2009	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2010	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2011	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2012	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2013	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2014	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2017	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2018	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2019	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2020	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2021	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2022	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2023	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 3.6.7 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Fraction of natural mortality before spawning (MPROP)

	0	1	2	3	4	5	6	7	8
1991	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

	0	1	2	3	4	5	6	7	8
2019	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2020	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2021	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2022	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2023	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.6.8.a - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Survey indices: HERAS (number in thousands)

	3	4	5	6
1991	1927000	866000	350000	88000
1992	1799000	1593000	556000	197000
1993	1274000	598000	434000	154000
1994	935000	501000	239000	186000
1995	1022000	1270000	255000	174000
1996	247000	141000	119000	37000
1997	787000	166000	67000	69000
1998	901000	282000	111000	51000
1999	-	-	-	-
2000	673600	363900	185700	55600
2001	452300	153100	96400	37600
2002	1392800	524300	87500	39500
2003	394600	323400	103400	25200
2004	726000	306900	183700	72100
2005	463500	201300	102500	83600
2006	1780400	490000	180400	27000
2007	933000	499000	154000	34000
2008	843000	333000	274000	176000
2009	205000	161000	82000	86000
2010	254000	115000	65000	24000
2011	259000	163000	70000	53000

	3	4	5	6
2012	236000	87000	76000	33000
2013	525000	53000	30000	12000
2014	176000	248000	28000	37000
2015	446000	224000	171000	82000
2016	381000	99000	40000	40000
2017	661000	401000	94000	53000
2018	271000	175000	169000	50000
2019	315000	109000	67000	52000
2020	225000	180000	74000	77000
2021	275000	203000	52000	49000
2022	129000	124000	100000	58000
2023	133000	76000	42000	28000

Table 3.6.8.b - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Survey indices: GerAS (number in thousands)

	1	2	3	4
1994	415730	883810	559720	443730
1995	1675340	328610	357960	353850
1996	1439460	590010	434090	295170
1997	1955400	738180	394530	162430
1998	801350	678530	394070	236830
1999	1338710	287240	232510	155950
2000	1429880	453980	328960	201590
2001	-	-	-	-
2002	837549	421393	575356	341119
2003	1238480	222530	217270	260350
2004	968860	592360	346230	163150
2005	750199	590756	295659	142778
2006	940892	226959	279618	212201
2007	558851	260402	117412	76782

	1	2	3	4
2008	392737	165347	166301	102018
2009	270959	95866	43553	17761
2010	534633	305540	214539	107364
2011	1206762	360354	210455	115984
2012	755034	294242	193974	124548
2013	893837	456204	307567	262908
2014	769320	242590	279650	332660
2015	440738	509769	221344	129795
2016	493366	155417	196061	60953
2017	463940	145360	123230	137500
2018	428530	89280	41160	20240
2019	247870	122948	47727	24244
2020	185814	82236	66046	21600
2021	158368	144638	49942	22420
2022	118050	75870	39610	18400
2023	466310	114260	55710	23140

Table 3.6.8.c - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Survey indices: N20 (number in thousands)

	0
1992	1060000
1993	3044000
1994	12515000
1995	7930000
1996	21012000
1997	4872000
1998	16743000
1999	20364000
2000	3026000
2001	4845000

	0
2002	11324000
2003	5507000
2004	5640000
2005	3887000
2006	3774000
2007	1829000
2008	1622000
2009	6464000
2010	7037000
2011	4444000
2012	1140000
2013	3021000
2014	539000
2015	2478000
2016	442000
2017	1247000
2018	1563000
2019	1317000
2020	239000
2021	2751000
2022	6603000
2023	1516000

Table 3.6.8.d - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Survey indices: IBTS Q1 + BITS Q1 (number in thousands)

	1	2	3
2002	974418	56760	11829
2003	687514	138009	3578
2004	290357	74979	13549
2005	173838	116306	7372

	1	2	3
2006	141507	33565	6727
2007	240314	38239	3426
2008	163055	33555	4184
2009	519381	38697	1135
2010	295999	80628	9650
2011	163034	70852	13607
2012	270009	75828	3872
2013	162468	73979	13661
2014	146054	21665	2836
2015	264168	64196	2122
2016	190978	93956	5606
2017	452583	72226	11269
2018	106606	70835	2867
2019	439963	40565	5888
2020	334842	83517	5294
2021	305014	128757	6627
2022	177567	73218	8219
2023	369005	31092	7170

Table 3.6.8.e - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Survey indices: IBTS Q3 + BITS Q4 (number in thousands)

	2	3
2002	3367	1482
2003	7220	1520
2004	3533	1263
2005	3626	627
2006	2835	1148
2007	3997	696
2008	2406	1264
2009	3367	612

	2	3
2010	4433	1252
2011	2939	689
2012	5424	805
2013	4861	1453
2014	1270	1436
2015	10219	1398
2016	8666	2119
2017	5831	1684
2018	6840	1149
2019	10044	3316
2020	8528	1981
2021	8853	1699
2022	2340	1166
2023	823	382

Table 3.6.9 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. SAM software version

SAM software version
Model version: [0.5.4 , 0.5.4 , 0.5.4] Model SHA: [3c872568b9d7 , 3c872568b9d7 , 3c872568b9d7]

Table 3.6.10 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. SAM configuration settings

SAM configuration settings

```
# Configuration saved: Tue Feb 13 12:34:28 2018
#
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
#
$minAge
# The minimium age class in the assessment
 0

$maxAge
# The maximum age class in the assessment
 8

$maxAgePlusGroup
```

SAM configuration settings

Is last age group considered a plus group (1 yes, or 0 no).

1

$keyLogFsta

Coupling of the fishing mortality states (nomally only first row is used).

-1 0 1 2 3 4 5 6 6
7 8 9 10 11 12 13 14 14
15 16 17 18 19 20 21 22 22
23 24 25 26 27 28 29 30 30
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

$corFlag

Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

0 2 2 2

$keyLogFpar

Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	0	1	2	3
	-1	-1				
-1	4	5	6	7	-1	-1
	-1	-1				
8	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	9	10	11	-1	-1	-1
	-1	-1				
-1	-1	12	13	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				

$keyQpow

Density dependent catchability power parameters (if any).

-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

SAM configuration settings

-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarF
Coupling of process variance parameters for log(F)-process (nomally only first row is used)
-1 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN
Coupling of process variance parameters for log(N)-process
0 1 1 1 1 1 1 1 1

$keyVarObs
Coupling of the variance parameters for the observations.

-1	0	1	1	1	1
1	1	1			
2	3	4	4	4	4
4	4	4			
5	6	6	6	6	6
6	6	6			
7	8	8	8	8	8
8	8	8			
-1	-1	-1	9	9	9
9	-1	-1			
-1	10	10	10	10	-1
-1	-1	-1			
11	-1	-1	-1	-1	-1
-1	-1	-1			
-1	12	12	12	-1	-1
-1	-1	-1			
-1	-1	13	13	-1	-1
-1	-1	-1			
-1	-1	-1	-1	-1	-1
-1	-1	-1			

$obsCorStruct
Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
"ID" "AR" "ID" "AR" "AR" "AR" "ID" "AR" "US" "NA"

$keyCorObs

```
SAM configuration settings
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
 NA NA NA NA NA NA NA NA
 3 3 3 3 4 4 4 4
 NA NA NA NA NA NA NA NA
 3 3 3 3 4 4 4 4
 -1 -1 -1 0 0 1 -1 -1
 -1 2 1 0 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 2 1 -1 -1 -1 -1 -1
 -1 -1 NA -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 0

$keyScaledYears
# A vector of the years where catch scaling is applied.


$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
# lowest and higest age included in Fbar
 3 6

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0
```

Table 3.6.11 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Stock summary - Estimated recruitment (1000), spawning stock biomass (SSB) (tons), average fishing mortality and total stock biomass (TSB) (tons)

year	R(age 0)	R low	R high	SSB	SSB low	SSB high	Fbar(3-6)	Fbar low	Fbar high	TSB	TSB low	TSB High
1991	5292337	4128731	6783883	293155	236016	364126	0.427	0.301	0.606	587206	490078	703584
1992	3686445	2944481	4615373	302630	244319	374859	0.505	0.373	0.682	522163	435453	626140
1993	3075567	2432552	3888555	286049	231403	353600	0.577	0.427	0.779	455109	377248	549041
1994	4537102	3579501	5750884	228160	184950	281465	0.601	0.448	0.804	375996	312689	452121
1995	4135074	3308026	5168896	195933	157476	243782	0.602	0.439	0.825	316834	262434	382511
1996	4215270	3390018	5241417	133988	108738	165100	0.669	0.499	0.896	277364	233722	329155
1997	3495958	2751371	4442048	146067	119311	178823	0.630	0.469	0.845	275644	231557	328126
1998	4851054	3839039	6129847	118410	97745	143445	0.629	0.471	0.840	262891	222827	310158
1999	5030092	4067316	6220767	118414	97708	143509	0.503	0.375	0.676	269458	228995	317071
2000	3004706	2416484	3736114	124533	102719	150979	0.569	0.434	0.745	261035	221341	307846
2001	2733098	2224332	3358233	136829	114026	164192	0.600	0.456	0.790	277853	236108	326980
2002	2768579	2265771	3382968	159429	133093	190976	0.507	0.383	0.670	285440	242176	336434
2003	2958715	2413153	3627618	127226	106007	152691	0.455	0.343	0.603	219578	187396	257285
2004	2049633	1666147	2521383	132152	110155	158540	0.461	0.348	0.610	225311	192503	263711
2005	1782942	1457994	2180313	125091	104922	149136	0.520	0.397	0.683	217763	185808	255214
2006	1329507	1085014	1629094	136710	114494	163237	0.482	0.366	0.635	231564	197209	271904
2007	1432198	1162218	1764894	111352	92598	133906	0.529	0.401	0.699	179859	152381	212291
2008	1166101	941695	1443983	90467	75338	108634	0.573	0.439	0.748	157288	133724	185003
2009	1091780	886684	1344315	80978	67698	96863	0.540	0.409	0.713	140948	120133	165371

year	R(age 0)	R low	R high	SSB	SSB low	SSB high	Fbar(3-6)	Fbar low	Fbar high	TSB	TSB low	TSB High
2010	1480858	1205800	1818662	73443	61759	87337	0.433	0.322	0.582	122483	104397	143701
2011	1318089	1087212	1597995	67247	56525	80003	0.299	0.218	0.410	110465	94567	129035
2012	1161406	951090	1418229	71808	60406	85363	0.375	0.278	0.507	123114	105562	143584
2013	1805794	1350513	2414557	80400	67682	95509	0.397	0.293	0.537	135879	116319	158729
2014	1162920	909738	1486562	83974	70118	100569	0.323	0.237	0.440	142595	121906	166795
2015	947668	740485	1212818	87504	73017	104865	0.410	0.302	0.558	148101	125835	174307
2016	822668	630427	1073532	83610	69468	100631	0.533	0.400	0.711	129906	109129	154638
2017	815008	629933	1054457	70608	58157	85724	0.606	0.459	0.799	112450	93573	135134
2018	729716	548544	970727	53449	43526	65634	0.648	0.488	0.860	86043	70924	104385
2019	731454	536818	996661	42554	33856	53487	0.359	0.252	0.511	79312	64496	97531
2020	631262	441039	903528	41929	32345	54353	0.301	0.171	0.533	75583	59597	95855
2021	478283	313434	729833	45107	32569	62473	0.172	0.091	0.324	75489	56101	101578
2022	475494	282700	799770	54162	37581	78058	0.066	0.029	0.148	86428	61651	121162
2023	512582	258477	1016491	66152	45334	96529	0.053	0.021	0.135	94873	66887	134569

Table 3.6.12.a - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated fishing mortality per year and age as W-ringers. Sum all fleets

	0	1	2	3	4	5	6	7	8
1991	0.030	0.215	0.313	0.356	0.407	0.452	0.493	0.525	0.525
1992	0.031	0.229	0.345	0.398	0.469	0.536	0.616	0.682	0.682
1993	0.039	0.269	0.365	0.439	0.532	0.614	0.723	0.803	0.803
1994	0.045	0.295	0.407	0.464	0.560	0.632	0.747	0.822	0.822

	0	1	2	3	4	5	6	7	8
1995	0.066	0.368	0.457	0.488	0.561	0.627	0.731	0.789	0.789
1996	0.052	0.344	0.428	0.501	0.616	0.714	0.845	0.918	0.918
1997	0.051	0.327	0.393	0.461	0.569	0.669	0.820	0.944	0.944
1998	0.053	0.341	0.430	0.477	0.573	0.668	0.798	0.964	0.964
1999	0.037	0.257	0.398	0.411	0.462	0.528	0.611	0.740	0.740
2000	0.031	0.256	0.431	0.449	0.520	0.601	0.706	0.858	0.858
2001	0.035	0.263	0.407	0.442	0.546	0.638	0.775	0.908	0.908
2002	0.027	0.205	0.377	0.388	0.457	0.537	0.646	0.759	0.759
2003	0.024	0.185	0.335	0.347	0.411	0.480	0.581	0.691	0.691
2004	0.025	0.188	0.278	0.323	0.416	0.491	0.612	0.738	0.738
2005	0.017	0.174	0.321	0.374	0.481	0.547	0.680	0.816	0.816
2006	0.016	0.173	0.367	0.383	0.452	0.498	0.595	0.703	0.703
2007	0.013	0.164	0.364	0.411	0.503	0.552	0.652	0.744	0.744
2008	0.013	0.168	0.384	0.435	0.540	0.606	0.710	0.785	0.785
2009	0.014	0.185	0.418	0.424	0.503	0.564	0.671	0.730	0.730
2010	0.007	0.125	0.350	0.349	0.405	0.445	0.532	0.584	0.584
2011	0.004	0.076	0.207	0.222	0.278	0.312	0.384	0.429	0.429
2012	0.005	0.088	0.225	0.266	0.354	0.396	0.485	0.531	0.531
2013	0.005	0.094	0.225	0.274	0.375	0.421	0.518	0.569	0.569
2014	0.004	0.077	0.204	0.236	0.303	0.340	0.413	0.467	0.467
2015	0.006	0.105	0.245	0.288	0.378	0.441	0.534	0.639	0.639
2016	0.005	0.125	0.388	0.412	0.480	0.562	0.680	0.850	0.850
2017	0.004	0.119	0.436	0.472	0.527	0.635	0.788	1.037	1.037
2018	0.004	0.125	0.468	0.510	0.565	0.679	0.837	1.163	1.163
2019	0.002	0.058	0.223	0.262	0.308	0.375	0.490	0.756	0.756
2020	0.002	0.085	0.324	0.279	0.285	0.280	0.361	0.554	0.554
2021	0.001	0.037	0.159	0.147	0.172	0.159	0.209	0.456	0.456
2022	0.000	0.003	0.017	0.034	0.072	0.060	0.097	0.551	0.551
2023	0.000	0.002	0.013	0.026	0.063	0.049	0.074	0.436	0.436

Table 3.6.12.b - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated fishing mortality per year and age as W-ringers. Fleet A

	0	1	2	3	4	5	6	7	8
1991	0.000	0.000	0.005	0.022	0.018	0.021	0.019	0.019	0.019
1992	0.000	0.000	0.005	0.022	0.018	0.020	0.021	0.021	0.021
1993	0.000	0.000	0.005	0.022	0.019	0.020	0.022	0.022	0.022
1994	0.000	0.000	0.005	0.021	0.021	0.020	0.023	0.024	0.024
1995	0.000	0.000	0.005	0.022	0.020	0.021	0.025	0.025	0.025
1996	0.000	0.000	0.005	0.021	0.021	0.023	0.026	0.028	0.028
1997	0.000	0.000	0.005	0.021	0.021	0.023	0.027	0.033	0.033
1998	0.000	0.000	0.005	0.020	0.021	0.026	0.026	0.040	0.040
1999	0.000	0.000	0.005	0.021	0.022	0.029	0.028	0.044	0.044
2000	0.000	0.000	0.004	0.020	0.024	0.032	0.032	0.048	0.048
2001	0.000	0.000	0.004	0.017	0.025	0.032	0.035	0.049	0.049
2002	0.000	0.000	0.003	0.017	0.022	0.030	0.033	0.048	0.048
2003	0.000	0.000	0.002	0.016	0.020	0.025	0.028	0.043	0.043
2004	0.000	0.000	0.003	0.017	0.019	0.022	0.025	0.035	0.035
2005	0.000	0.000	0.002	0.014	0.019	0.020	0.025	0.039	0.039
2006	0.000	0.000	0.002	0.010	0.015	0.018	0.023	0.044	0.044
2007	0.000	0.000	0.001	0.006	0.010	0.009	0.017	0.028	0.028
2008	0.000	0.000	0.001	0.004	0.007	0.006	0.012	0.021	0.021
2009	0.000	0.000	0.001	0.004	0.008	0.005	0.014	0.032	0.032
2010	0.000	0.000	0.000	0.003	0.007	0.004	0.013	0.024	0.024
2011	0.000	0.000	0.000	0.003	0.006	0.003	0.012	0.016	0.016
2012	0.000	0.000	0.000	0.003	0.005	0.002	0.016	0.014	0.014
2013	0.000	0.000	0.000	0.003	0.006	0.004	0.018	0.019	0.019
2014	0.000	0.000	0.001	0.005	0.008	0.007	0.024	0.033	0.033
2015	0.000	0.000	0.001	0.006	0.009	0.011	0.026	0.045	0.045
2016	0.000	0.000	0.001	0.008	0.011	0.013	0.027	0.049	0.049
2017	0.000	0.000	0.001	0.011	0.014	0.015	0.026	0.053	0.053
2018	0.000	0.000	0.002	0.013	0.023	0.023	0.041	0.104	0.104

	0	1	2	3	4	5	6	7	8
2019	0.000	0.000	0.004	0.019	0.035	0.035	0.064	0.170	0.170
2020	0.000	0.000	0.006	0.023	0.056	0.037	0.090	0.222	0.222
2021	0.000	0.000	0.007	0.023	0.062	0.046	0.083	0.304	0.304
2022	0.000	0.000	0.009	0.025	0.060	0.045	0.076	0.521	0.521
2023	0.000	0.001	0.010	0.022	0.056	0.040	0.061	0.417	0.417

Table 3.6.12.c - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated fishing mortality per year and age as W-ringers. Fleet C

	0	1	2	3	4	5	6	7	8
1991	0.001	0.030	0.125	0.093	0.072	0.065	0.062	0.061	0.061
1992	0.001	0.033	0.138	0.102	0.080	0.072	0.068	0.067	0.067
1993	0.001	0.028	0.119	0.088	0.069	0.062	0.059	0.058	0.058
1994	0.001	0.036	0.154	0.114	0.089	0.080	0.076	0.075	0.075
1995	0.001	0.042	0.179	0.133	0.104	0.093	0.089	0.087	0.087
1996	0.001	0.031	0.129	0.096	0.075	0.067	0.064	0.063	0.063
1997	0.001	0.026	0.108	0.080	0.063	0.056	0.054	0.053	0.053
1998	0.001	0.034	0.143	0.106	0.083	0.074	0.071	0.070	0.070
1999	0.001	0.046	0.195	0.145	0.113	0.101	0.097	0.095	0.095
2000	0.001	0.053	0.222	0.165	0.129	0.115	0.110	0.108	0.108
2001	0.001	0.042	0.178	0.132	0.103	0.092	0.088	0.086	0.086
2002	0.001	0.051	0.215	0.159	0.125	0.111	0.106	0.105	0.105
2003	0.001	0.044	0.184	0.136	0.107	0.095	0.091	0.089	0.089
2004	0.000	0.022	0.091	0.067	0.053	0.047	0.045	0.044	0.044
2005	0.001	0.033	0.138	0.102	0.080	0.071	0.068	0.067	0.067
2006	0.001	0.046	0.195	0.144	0.113	0.101	0.097	0.095	0.095
2007	0.001	0.041	0.175	0.129	0.101	0.091	0.087	0.085	0.085
2008	0.001	0.043	0.181	0.134	0.105	0.094	0.090	0.088	0.088
2009	0.001	0.054	0.229	0.169	0.132	0.118	0.113	0.112	0.112
2010	0.001	0.057	0.242	0.179	0.140	0.125	0.120	0.118	0.118
2011	0.001	0.032	0.134	0.099	0.077	0.069	0.066	0.065	0.065

	0	1	2	3	4	5	6	7	8
2012	0.001	0.029	0.122	0.090	0.071	0.063	0.061	0.060	0.060
2013	0.000	0.024	0.101	0.075	0.058	0.052	0.050	0.049	0.049
2014	0.001	0.026	0.111	0.082	0.064	0.057	0.055	0.054	0.054
2015	0.001	0.027	0.113	0.083	0.065	0.058	0.056	0.055	0.055
2016	0.001	0.062	0.264	0.194	0.152	0.136	0.131	0.129	0.129
2017	0.002	0.077	0.328	0.241	0.189	0.169	0.162	0.160	0.160
2018	0.002	0.084	0.356	0.262	0.205	0.183	0.176	0.173	0.173
2019	0.001	0.039	0.164	0.121	0.094	0.085	0.081	0.080	0.080
2020	0.001	0.069	0.292	0.215	0.168	0.151	0.144	0.142	0.142
2021	0.001	0.034	0.145	0.107	0.083	0.075	0.072	0.070	0.070
2022	0.000	0.001	0.005	0.004	0.003	0.003	0.002	0.002	0.002
2023	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 3.6.12.d - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated fishing mortality per year and age as W-ringers. Fleet D

	0	1	2	3	4	5	6	7	8
1991	0.013	0.037	0.017	0.009	0.005	0.004	0.005	0.004	0.004
1992	0.012	0.032	0.015	0.008	0.004	0.003	0.005	0.004	0.004
1993	0.017	0.044	0.020	0.010	0.005	0.004	0.006	0.005	0.005
1994	0.023	0.061	0.027	0.013	0.007	0.005	0.007	0.006	0.006
1995	0.044	0.122	0.049	0.023	0.011	0.007	0.010	0.008	0.008
1996	0.025	0.066	0.026	0.012	0.006	0.004	0.006	0.005	0.005
1997	0.026	0.064	0.025	0.011	0.005	0.004	0.006	0.005	0.005
1998	0.028	0.069	0.026	0.011	0.005	0.004	0.005	0.005	0.005
1999	0.019	0.046	0.018	0.008	0.004	0.003	0.004	0.003	0.003
2000	0.013	0.032	0.013	0.005	0.002	0.002	0.003	0.003	0.003
2001	0.017	0.047	0.020	0.009	0.005	0.005	0.009	0.010	0.010
2002	0.016	0.048	0.020	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.057	0.032	0.015	0.009	0.008	0.009	0.008	0.008
2004	0.016	0.066	0.044	0.023	0.014	0.012	0.012	0.009	0.009

	0	1	2	3	4	5	6	7	8
2005	0.007	0.034	0.023	0.011	0.006	0.005	0.004	0.003	0.003
2006	0.008	0.049	0.042	0.022	0.013	0.013	0.011	0.009	0.009
2007	0.005	0.031	0.029	0.014	0.007	0.008	0.008	0.007	0.007
2008	0.005	0.033	0.031	0.013	0.005	0.006	0.005	0.005	0.005
2009	0.007	0.061	0.050	0.015	0.004	0.004	0.003	0.003	0.003
2010	0.002	0.021	0.014	0.003	0.000	0.000	0.000	0.000	0.000
2011	0.001	0.012	0.007	0.001	0.000	0.000	0.000	0.000	0.000
2012	0.001	0.012	0.008	0.001	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.016	0.015	0.002	0.000	0.000	0.000	0.000	0.000
2014	0.001	0.013	0.011	0.001	0.000	0.000	0.000	0.000	0.000
2015	0.002	0.033	0.028	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.022	0.019	0.001	0.000	0.000	0.000	0.000	0.000
2017	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2018	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2019	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.000	0.011	0.010	0.001	0.000	0.000	0.000	0.001	0.001
2021	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2022	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2023	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000

Table 3.6.12.e - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated fishing mortality per year and age as W-ringers. Fleet F

	0	1	2	3	4	5	6	7	8
1991	0.016	0.149	0.166	0.232	0.311	0.363	0.406	0.441	0.441
1992	0.018	0.165	0.187	0.266	0.366	0.441	0.523	0.590	0.590
1993	0.021	0.197	0.222	0.318	0.439	0.528	0.636	0.718	0.718
1994	0.021	0.198	0.222	0.315	0.444	0.527	0.640	0.717	0.717
1995	0.022	0.203	0.224	0.310	0.426	0.505	0.607	0.668	0.668
1996	0.026	0.247	0.268	0.371	0.514	0.620	0.748	0.822	0.822

	0	1	2	3	4	5	6	7	8
1997	0.025	0.238	0.256	0.348	0.480	0.586	0.734	0.853	0.853
1998	0.024	0.239	0.256	0.339	0.463	0.565	0.695	0.850	0.850
1999	0.017	0.165	0.180	0.238	0.323	0.395	0.483	0.597	0.597
2000	0.017	0.171	0.192	0.259	0.364	0.452	0.562	0.699	0.699
2001	0.017	0.174	0.205	0.284	0.413	0.508	0.643	0.763	0.763
2002	0.010	0.106	0.139	0.205	0.307	0.393	0.503	0.604	0.604
2003	0.008	0.084	0.117	0.180	0.275	0.352	0.452	0.551	0.551
2004	0.009	0.100	0.141	0.215	0.331	0.410	0.531	0.649	0.649
2005	0.009	0.108	0.158	0.247	0.377	0.451	0.583	0.707	0.707
2006	0.006	0.079	0.128	0.206	0.311	0.366	0.464	0.555	0.555
2007	0.007	0.092	0.159	0.261	0.385	0.444	0.541	0.624	0.624
2008	0.007	0.092	0.171	0.284	0.423	0.501	0.604	0.670	0.670
2009	0.005	0.070	0.139	0.236	0.359	0.436	0.541	0.583	0.583
2010	0.003	0.047	0.093	0.164	0.258	0.315	0.399	0.442	0.442
2011	0.002	0.032	0.065	0.119	0.195	0.239	0.306	0.347	0.347
2012	0.003	0.047	0.094	0.172	0.278	0.331	0.409	0.457	0.457
2013	0.004	0.053	0.108	0.194	0.311	0.365	0.450	0.501	0.501
2014	0.003	0.037	0.081	0.148	0.230	0.276	0.334	0.381	0.381
2015	0.003	0.045	0.104	0.196	0.303	0.371	0.452	0.538	0.538
2016	0.003	0.041	0.104	0.208	0.317	0.412	0.522	0.672	0.672
2017	0.002	0.038	0.103	0.219	0.325	0.451	0.600	0.824	0.824
2018	0.002	0.037	0.106	0.234	0.338	0.472	0.620	0.886	0.886
2019	0.001	0.016	0.051	0.122	0.179	0.255	0.345	0.506	0.506
2020	0.000	0.004	0.015	0.040	0.062	0.092	0.127	0.190	0.190
2021	0.000	0.001	0.006	0.017	0.027	0.039	0.055	0.082	0.082
2022	0.000	0.000	0.002	0.005	0.009	0.013	0.019	0.028	0.028
2023	0.000	0.000	0.001	0.004	0.006	0.008	0.013	0.019	0.019

Table 3.6.13 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Estimated stock numbers (1000) per year and age as W-ringers

	0	1	2	3	4	5	6	7	8
1991	5292337	4031708	2256018	1869165	907568	543938	160753	48586	17362
1992	3686445	3816146	1969108	1351826	1071871	494198	283113	80530	31991
1993	3075567	2647800	1849574	1139182	745126	548673	236294	125163	46614
1994	4537102	2182043	1226633	1056405	599123	359719	242572	93865	62959
1995	4135074	3224980	986491	665502	548205	278012	157215	93954	56399
1996	4215270	2863325	1355021	512450	333786	256020	121466	62020	55931
1997	3495958	2967957	1230345	725398	254464	147259	102325	42711	38658
1998	4851054	2450377	1298424	679977	375305	117969	61858	36744	25934
1999	5030092	3414685	1053021	690790	345734	173627	49419	22872	19503
2000	3004706	3604954	1604584	577798	374300	178565	83867	21960	16561
2001	2733098	2150579	1695282	858063	300678	182287	79934	33968	13371
2002	2768579	1952257	997498	925574	454883	141968	78986	30013	15672
2003	2958715	1993772	964538	558404	514211	236553	67766	33924	17504
2004	2049633	2147305	1005282	565467	323381	278660	120056	31026	21078
2005	1782942	1476719	1083280	625162	334276	174670	139507	53392	20384
2006	1329507	1299665	749785	644172	354502	168439	83067	57747	26738
2007	1432198	966771	663904	425084	358681	185699	83096	37807	34161
2008	1166101	1050468	495826	378210	230667	177301	87985	35377	28051
2009	1091780	852426	540922	276534	199824	110384	78959	35504	23683
2010	1480858	794560	429811	291546	148576	99106	51531	32852	23389
2011	1318089	1092442	423783	247693	168316	81109	52100	24852	25621
2012	1161406	971742	617014	281523	162174	104308	48651	29057	26903
2013	1805794	853096	537805	405864	176306	93326	57330	24571	26953
2014	1162920	1342321	468071	350936	253683	98752	50214	27980	23951
2015	947668	857109	761370	312099	226624	152412	57691	27169	26727
2016	822668	697433	467012	492223	191677	127091	79717	27712	23344
2017	815008	605724	372916	257684	269803	97349	59388	32891	17882
2018	729716	602550	325902	197392	130234	131714	42424	22067	14690

	0	1	2	3	4	5	6	7	8
2019	731454	538411	321335	166591	97357	60407	54891	15103	9371
2020	631262	541536	307843	209576	104108	58910	33943	27599	9417
2021	478283	467740	302022	181941	129487	63728	36466	19333	17434
2022	475494	352954	274415	209558	128514	89126	44496	24148	19076
2023	512582	351470	213251	221828	165223	97945	68713	33003	20330

Table 3.6.14.a - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Predicted catch in numbers (1000) per year and age as W-ringers. Sum fleets

	0	1	2	3	4	5	6	7	8
1991	136399.33	649368.51	598510.69	554736.72	297449.19	193846.30	61291.29	19446.22	6949.00
1992	97192.30	649130.81	570993.86	442688.79	396297.64	202440.16	128797.29	39368.38	15639.36
1993	102401.09	523228.80	563731.71	403263.92	302934.21	247663.86	120019.84	68266.83	25424.05
1994	173885.97	473999.48	415690.03	396416.74	257087.54	167799.77	127801.80	52706.07	35352.17
1995	233362.77	870617.22	374038.11	263499.12	238064.80	130307.30	82571.91	51884.27	31145.58
1996	186368.91	710424.27	476837.87	202897.54	152578.50	129552.61	69089.34	37191.68	33539.93
1997	152700.46	702709.26	399305.51	266190.05	108627.80	70635.29	56625.65	25971.48	23507.34
1998	218507.87	606553.70	460124.40	259626.08	163205.60	57339.03	34004.11	23036.81	16259.30
1999	158097.87	654002.18	348893.43	235412.11	128456.00	71818.25	22832.68	12261.37	10455.39
2000	80664.19	686149.78	569827.89	212721.97	154220.67	82358.21	43503.92	13157.01	9922.42
2001	81931.51	420198.61	574285.86	309500.83	127565.71	87062.84	43998.77	20950.24	8247.01
2002	63887.06	304536.35	314041.95	299688.09	168393.22	59784.05	38350.45	16513.80	8623.04
2003	61950.69	281618.66	273662.88	163474.17	173232.85	90402.30	30166.43	17314.72	8934.09
2004	44156.09	306167.14	240775.54	153620.29	107649.65	105623.74	53938.19	16024.48	10886.43
2005	26348.38	194797.95	295321.80	193519.08	126452.37	72637.68	68350.16	29959.14	11438.05
2006	18131.41	172513.04	231720.43	206710.82	129592.04	66436.67	37633.73	29974.01	13878.80
2007	15972.62	121082.78	203116.28	143552.78	141409.24	78271.76	39819.07	20052.60	18118.77
2008	12693.71	134492.40	159449.81	134053.88	96007.01	80036.96	44692.45	19392.40	15376.52
2009	13017.02	120597.93	188367.06	96642.01	79596.08	47724.91	39032.51	18887.46	12599.07
2010	9076.69	76337.36	124562.35	85075.80	49380.88	35392.40	21343.14	14743.60	10496.56
2011	4873.79	64595.25	75463.22	47249.90	39368.93	20863.94	16099.95	8441.10	8702.26
2012	4912.27	66286.59	119768.33	63426.86	46632.49	32791.10	18178.53	11626.33	10764.71
2013	8070.86	61724.36	104528.03	93513.19	52950.87	30660.74	22421.55	10337.71	11339.56
2014	4027.90	80465.81	82837.19	70856.76	63644.12	27298.01	16506.52	10233.02	8759.59
2015	4508.04	69457.80	161230.84	75585.77	68859.18	52458.52	23357.79	12757.54	12549.89
2016	3674.27	67233.62	148765.06	167244.78	73864.06	55366.91	40440.94	16675.83	14047.03
2017	2924.08	55200.03	130008.27	99070.33	113739.77	47312.84	33999.81	22916.95	12459.75
2018	2637.41	57484.23	120481.62	81308.71	58638.65	68097.70	25705.17	17088.44	11375.53
2019	1203.48	24087.89	60836.69	37503.45	25467.64	18710.28	21579.99	8678.48	5384.64
2020	1166.82	35101.67	79840.59	48885.97	25409.90	14157.46	10456.84	12661.27	4320.12
2021	352.07	13504.52	40856.94	23359.39	19559.70	8941.65	6678.50	7180.17	6475.10
2022	41.98	888.92	4094.07	6349.28	8182.53	4784.48	3798.06	9621.00	7600.25
2023	35.08	658.51	2455.87	5252.30	9233.24	4321.27	4522.86	10844.95	6680.44

Table 3.6.14.b - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Predicted catch in numbers (1000) per year and age as W-ringers. Fleet A

	0	1	2	3	4	5	6	7	8
1991	0.00	9.53	9936.83	37343.56	15060.85	10203.75	2808.29	816.78	291.87
1992	0.00	9.02	8696.46	26385.05	17812.32	9002.42	5216.43	1484.84	589.86
1993	0.00	6.26	8009.23	22882.78	12731.29	9935.01	4616.76	2481.01	923.98
1994	0.00	5.16	5300.06	20090.16	11079.58	6480.99	5069.19	1980.28	1328.26
1995	0.00	7.63	4211.63	12920.73	10080.63	5263.86	3497.97	2091.61	1255.57
1996	0.00	6.77	5678.52	9807.75	6231.24	5179.92	2848.55	1534.95	1384.24
1997	0.00	7.02	5097.21	13729.37	4756.51	3064.54	2462.45	1268.08	1147.77
1998	0.00	5.79	5382.96	12384.66	7207.70	2721.24	1452.91	1304.15	920.46
1999	0.00	8.07	4335.62	12817.90	6753.72	4493.43	1227.69	902.44	769.52

	0	1	2	3	4	5	6	7	8
2000	0.00	8.52	6471.36	10210.11	8159.14	5087.29	2384.46	941.88	710.32
2001	0.00	6.01	6188.19	13463.73	6600.14	5244.15	2514.43	1469.33	578.40
2002	0.00	4.47	2819.01	14060.49	8966.85	3764.80	2319.99	1281.77	669.30
2003	0.00	4.20	1650.04	7948.51	9224.90	5207.69	1722.42	1303.57	672.62
2004	0.00	4.66	2284.25	8760.65	5527.51	5497.26	2637.54	970.79	659.52
2005	0.00	3.71	2170.99	8043.15	5769.33	3063.65	3142.30	1860.89	710.47
2006	0.00	4.19	1029.48	5937.58	4811.75	2673.79	1689.67	2251.58	1042.54
2007	0.00	3.00	467.81	2492.58	3154.77	1536.76	1252.01	943.31	852.34
2008	0.00	3.41	252.71	1336.61	1489.87	909.33	950.18	675.26	535.42
2009	0.00	3.18	249.68	986.39	1416.61	543.59	977.69	1016.60	678.13
2010	0.00	3.72	129.66	870.88	916.88	368.52	587.54	710.98	506.17
2011	0.00	5.44	107.54	665.43	863.61	217.20	543.10	367.11	378.47
2012	0.00	5.91	143.95	720.83	786.89	192.29	686.42	363.48	336.54
2013	0.00	7.29	177.00	1232.29	917.22	333.33	915.43	418.30	458.84
2014	0.00	18.95	271.91	1557.48	1900.03	608.22	1061.07	817.85	700.09
2015	0.00	18.98	487.19	1683.49	1923.56	1469.98	1358.78	1093.29	1075.49
2016	0.00	24.03	451.21	3600.38	1879.60	1434.79	1947.77	1206.74	1016.51
2017	0.00	32.81	426.98	2533.85	3328.28	1276.16	1395.20	1542.73	838.77
2018	0.00	62.43	666.45	2369.72	2707.71	2728.87	1535.79	1974.94	1314.69
2019	0.00	113.20	1291.42	2880.71	2999.43	1890.95	3109.94	2148.96	1333.34
2020	0.00	163.21	1706.21	4264.06	5112.21	1958.39	2643.56	4993.50	1703.82
2021	0.00	165.35	1955.66	3789.45	7028.96	2584.57	2631.49	4610.79	4158.02
2022	0.00	136.21	2275.46	4602.65	6813.54	3554.86	2957.04	8963.11	7080.55
2023	0.00	151.70	1885.22	4326.92	8223.84	3511.62	3704.41	10266.81	6324.31

Table 3.6.14.c - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Predicted catch in numbers (1000) per year and age as W-ringers. Fleet C

	0	1	2	3	4	5	6	7	8
1991	2807.07	92380.06	240177.78	149910.50	57581.60	30986.11	8754.12	2600.78	929.37
1992	2159.38	96435.81	230114.43	119193.03	74837.64	30993.14	16977.06	4747.31	1885.90
1993	1555.45	57885.13	188265.78	87292.86	45148.24	29844.81	12287.81	6398.36	2382.89
1994	2965.87	61433.59	158769.09	103352.41	46467.04	25068.48	16167.01	6150.50	4125.40
1995	3151.43	105575.42	147098.19	75224.86	49208.43	22437.25	12137.17	7131.42	4280.92
1996	2313.44	67858.76	148947.14	42443.15	21869.69	15059.78	6830.75	3428.51	3091.87
1997	1607.47	59060.33	114423.90	50695.38	14043.51	7291.20	4842.35	1986.79	1798.29
1998	2949.70	64247.18	157094.31	62066.94	27118.24	7654.02	3836.97	2240.71	1581.48
1999	4175.75	121567.20	169760.60	84526.45	33611.95	15177.54	4131.81	1880.27	1603.32
2000	2837.94	145609.93	290661.14	79683.63	41092.82	17638.53	7925.74	2040.69	1539.00
2001	2066.01	69852.78	250903.96	96155.25	26734.41	14565.29	6108.70	2553.09	1005.02
2002	2531.69	76417.54	175540.84	123827.13	48407.95	13591.51	7235.15	2705.67	1412.82
2003	2314.34	66982.03	147320.45	64583.33	47190.94	19513.91	5346.65	2635.23	1359.73
2004	792.88	36030.81	79320.56	33400.40	15048.20	11627.39	4785.98	1217.84	827.35
2005	1044.58	37349.77	126661.00	55014.17	23256.88	10914.70	8333.83	3142.34	1199.71
2006	1103.23	46287.55	120925.23	78713.51	34392.93	14711.83	6939.96	4756.95	2202.60
2007	1064.51	30913.65	96850.04	46858.69	31345.75	14605.59	6253.22	2806.14	2535.52
2008	896.85	34740.65	74658.26	43052.77	20824.53	14412.35	6844.19	2714.59	2152.44
2009	1059.81	35409.76	100598.86	39092.24	22482.92	11197.83	7670.01	3402.29	2269.53

	0	1	2	3	4	5	6	7	8
2010	1519.83	34852.55	84036.08	43387.54	17614.82	10598.19	5277.85	3318.99	2362.92
2011	748.42	26814.72	48219.86	21174.00	11371.19	4928.80	3028.45	1424.02	1468.08
2012	603.00	21836.10	64562.03	22094.83	10050.42	5814.25	2593.85	1527.01	1413.84
2013	774.45	15870.33	46965.62	26506.94	9077.29	4319.49	2537.60	1071.72	1175.58
2014	546.82	27350.74	44622.41	25040.86	14283.42	5001.96	2434.19	1336.64	1144.18
2015	452.52	17731.07	73660.81	22591.01	12944.19	7837.41	2841.44	1318.75	1297.29
2016	918.42	33200.24	98497.05	79016.06	24543.52	14715.88	8861.11	3037.02	2558.26
2017	1131.47	35614.70	94987.16	50308.78	42185.68	13784.90	8078.53	4411.78	2398.65
2018	1099.05	38320.37	88940.19	41393.59	21907.89	20073.19	6208.92	3183.49	2119.20
2019	508.99	16135.53	44228.65	17219.54	7956.23	4447.23	3870.52	1048.14	650.33
2020	781.59	28487.31	71062.23	36887.88	14626.67	7482.78	4134.84	3308.90	1129.02
2021	294.30	12415.88	37087.11	16737.77	9405.56	4168.80	2284.46	1190.66	1073.74
2022	10.18	330.56	1251.69	703.63	337.04	209.66	100.09	53.35	42.14
2023	3.06	91.91	271.87	208.08	120.99	64.32	43.13	20.33	12.52

Table 3.6.14.d - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Predicted catch in numbers (1000) per year and age as W-ringers. Fleet D

	0	1	2	3	4	5	6	7	8
1991	59428.84	115198.68	34962.25	15702.89	3924.70	1795.48	762.24	197.56	70.60
1992	38105.31	94001.97	26676.82	9949.11	4109.55	1467.91	1232.91	305.32	121.29
1993	44476.90	90139.61	32823.51	10692.08	3561.19	1993.35	1244.51	566.98	211.16
1994	88024.58	102179.83	29094.90	12588.24	3555.51	1583.56	1525.39	500.21	335.51
1995	153127.78	293798.14	42804.10	13538.04	5208.27	1868.68	1447.81	707.12	424.47
1996	90388.62	144344.31	32002.38	5724.67	1803.05	1021.95	691.35	300.87	271.33
1997	77194.38	144600.89	27256.40	7283.41	1217.63	520.92	518.82	187.72	169.91
1998	114473.84	128775.05	30729.45	6853.33	1758.81	404.36	300.27	155.95	110.07
1999	82255.28	121420.74	17236.01	4748.39	1110.24	415.97	170.64	71.01	60.55
2000	34373.80	90659.93	18360.98	2717.76	833.40	302.74	209.36	50.65	38.20
2001	40496.38	77423.44	30908.97	6921.04	1463.46	853.18	663.11	293.19	115.41
2002	37507.28	72722.91	18008.80	5968.04	1516.46	360.58	252.33	75.85	39.61
2003	40030.56	87117.77	27725.73	7418.22	4143.26	1660.14	575.95	233.28	120.37
2004	27863.73	108929.04	39461.59	11762.90	4079.94	3015.27	1319.03	260.77	177.16
2005	11378.79	38425.01	22211.68	6104.68	1754.34	716.27	497.11	135.79	51.84
2006	9658.15	48719.98	27987.07	12830.17	4038.69	1931.17	830.60	462.65	214.22
2007	5944.93	23327.50	16975.97	5395.90	2389.20	1366.00	565.60	237.39	214.49
2008	4698.69	27093.64	13860.14	4436.12	1079.57	897.22	380.01	169.18	134.14
2009	6959.45	39519.13	23792.08	3765.98	744.65	394.77	198.67	109.80	73.25
2010	3137.49	12875.17	5570.24	718.09	54.25	25.78	6.76	5.38	3.83
2011	1465.28	10473.93	2828.09	218.73	11.48	3.77	1.40	1.06	1.09
2012	1012.94	9043.35	4633.66	238.69	8.04	3.49	0.94	0.99	0.92
2013	1668.18	10874.82	7380.31	722.20	17.65	6.00	1.76	1.27	1.39
2014	949.04	14166.14	4821.84	395.23	13.66	4.74	1.09	1.04	0.89
2015	1623.04	21863.89	18944.00	777.80	32.40	26.53	3.45	2.39	2.35
2016	866.24	11721.33	7880.82	656.91	14.57	16.47	4.09	2.30	1.94
2017	151.69	1975.19	1311.69	68.22	4.59	3.07	1.20	1.40	0.76
2018	127.67	1911.29	1092.08	57.01	2.80	4.93	1.26	1.44	0.96
2019	90.43	1257.65	756.52	42.83	2.63	2.88	2.30	1.31	0.82

	0	1	2	3	4	5	6	7	8
2020	244.96	4696.67	2871.53	270.31	21.58	21.31	10.36	13.21	4.51
2021	20.55	403.06	194.18	12.36	1.57	1.46	1.01	1.16	1.05
2022	22.33	324.39	147.11	10.85	1.10	1.28	0.87	1.15	0.91
2023	26.69	364.87	107.18	10.32	1.23	1.21	1.18	1.43	0.88

Table 3.6.14.e - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Predicted catch in numbers (1000) per year and age as W-ringers. Fleet F

	0	1	2	3	4	5	6	7	8
1991	59428.84	115198.68	34962.25	15702.89	3924.70	1795.48	762.24	197.56	70.60
1992	38105.31	94001.97	26676.82	9949.11	4109.55	1467.91	1232.91	305.32	121.29
1993	44476.90	90139.61	32823.51	10692.08	3561.19	1993.35	1244.51	566.98	211.16
1994	88024.58	102179.83	29094.90	12588.24	3555.51	1583.56	1525.39	500.21	335.51
1995	153127.78	293798.14	42804.10	13538.04	5208.27	1868.68	1447.81	707.12	424.47
1996	90388.62	144344.31	32002.38	5724.67	1803.05	1021.95	691.35	300.87	271.33
1997	77194.38	144600.89	27256.40	7283.41	1217.63	520.92	518.82	187.72	169.91
1998	114473.84	128775.05	30729.45	6853.33	1758.81	404.36	300.27	155.95	110.07
1999	82255.28	121420.74	17236.01	4748.39	1110.24	415.97	170.64	71.01	60.55
2000	34373.80	90659.93	18360.98	2717.76	833.40	302.74	209.36	50.65	38.20
2001	40496.38	77423.44	30908.97	6921.04	1463.46	853.18	663.11	293.19	115.41
2002	37507.28	72722.91	18008.80	5968.04	1516.46	360.58	252.33	75.85	39.61
2003	40030.56	87117.77	27725.73	7418.22	4143.26	1660.14	575.95	233.28	120.37
2004	27863.73	108929.04	39461.59	11762.90	4079.94	3015.27	1319.03	260.77	177.16
2005	11378.79	38425.01	22211.68	6104.68	1754.34	716.27	497.11	135.79	51.84
2006	9658.15	48719.98	27987.07	12830.17	4038.69	1931.17	830.60	462.65	214.22
2007	5944.93	23327.50	16975.97	5395.90	2389.20	1366.00	565.60	237.39	214.49
2008	4698.69	27093.64	13860.14	4436.12	1079.57	897.22	380.01	169.18	134.14
2009	6959.45	39519.13	23792.08	3765.98	744.65	394.77	198.67	109.80	73.25
2010	3137.49	12875.17	5570.24	718.09	54.25	25.78	6.76	5.38	3.83
2011	1465.28	10473.93	2828.09	218.73	11.48	3.77	1.40	1.06	1.09
2012	1012.94	9043.35	4633.66	238.69	8.04	3.49	0.94	0.99	0.92
2013	1668.18	10874.82	7380.31	722.20	17.65	6.00	1.76	1.27	1.39
2014	949.04	14166.14	4821.84	395.23	13.66	4.74	1.09	1.04	0.89
2015	1623.04	21863.89	18944.00	777.80	32.40	26.53	3.45	2.39	2.35
2016	866.24	11721.33	7880.82	656.91	14.57	16.47	4.09	2.30	1.94
2017	151.69	1975.19	1311.69	68.22	4.59	3.07	1.20	1.40	0.76
2018	127.67	1911.29	1092.08	57.01	2.80	4.93	1.26	1.44	0.96
2019	90.43	1257.65	756.52	42.83	2.63	2.88	2.30	1.31	0.82
2020	244.96	4696.67	2871.53	270.31	21.58	21.31	10.36	13.21	4.51
2021	20.55	403.06	194.18	12.36	1.57	1.46	1.01	1.16	1.05
2022	22.33	324.39	147.11	10.85	1.10	1.28	0.87	1.15	0.91
2023	26.69	364.87	107.18	10.32	1.23	1.21	1.18	1.43	0.88

TABLE 3.9.1 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Input table for short term predictions

2023						
wr	N	M	Mat	PM	PF	SWt
0	512582	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0242
2		0.2	0.20	0.25	0.1	0.0557
3		0.2	0.75	0.25	0.1	0.0843
4		0.2	0.90	0.25	0.1	0.1138
5		0.2	1.00	0.25	0.1	0.1557
6		0.2	1.00	0.25	0.1	0.1725
7		0.2	1.00	0.25	0.1	0.1816
8+		0.2	1.00	0.25	0.1	0.1892

2024						
wr	N	M	Mat	PM	PF	SWt
0	609242	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0221
2		0.2	0.20	0.25	0.1	0.0580
3		0.2	0.75	0.25	0.1	0.0801
4		0.2	0.90	0.25	0.1	0.1133
5		0.2	1.00	0.25	0.1	0.1420
6		0.2	1.00	0.25	0.1	0.1699
7		0.2	1.00	0.25	0.1	0.1781
8+		0.2	1.00	0.25	0.1	0.1853

2025						
wr	N	M	Mat	PM	PF	SWt
0	609242	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0221
2		0.2	0.20	0.25	0.1	0.0580

3	0.2	0.75	0.25	0.1	0.0801
4	0.2	0.90	0.25	0.1	0.1133
5	0.2	1.00	0.25	0.1	0.1420
6	0.2	1.00	0.25	0.1	0.1699
7	0.2	1.00	0.25	0.1	0.1781
8+	0.2	1.00	0.25	0.1	0.1853

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)

N_{2023} wr 0-8+:	Populations numbers from the assessment
$N_{2024/2025}$ wr 0:	Average of wr 0 for the years 2018-2022
Natural Mortality (M):	Constant
Weight in the Stock 2024-2025 (SWt):	Average for 2019-2023

TABLE 3.9.2 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. MSY approach (zero catch, F=0)

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.000	0.000	0.000
fbar:low	0.053	0.036	0.000	0.000	0.000
fbar:high	0.053	0.036	0.000	0.000	0.000
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79917	91000	101998
ssb:low	66152	72116	79917	91000	101998
ssb:high	66152	72116	79917	91000	101998
catch:Estimate	7742	6078	0	0	0
catch:low	7742	6078	0	0	0
catch:high	7742	6078	0	0	0

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	0	0	0
Fleet C	103	269	0	0	0
Fleet D	23	120	0	0	0
Fleet F	546	788	0	0	0

TABLE 3.9.3 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. MAP 2018: F=FMSY(0.31)*SSBy-1/MSYBtrigger

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.149	0.159	0.142
fbar:low	0.053	0.036	0.149	0.159	0.142
fbar:high	0.053	0.036	0.149	0.159	0.142
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	77112	68886	63955

value	2023	2024	2025	2026	2027
ssb:low	66152	72116	77112	68886	63955
ssb:high	66152	72116	77112	68886	63955
catch:Estimate	7742	6078	24741	23540	20042
catch:low	7742	6078	24741	23540	20042
catch:high	7742	6078	24741	23540	20042

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	19790	18675	15946
Fleet C	103	269	1097	1133	1007
Fleet D	23	120	566	629	564
Fleet F	546	788	3288	3103	2525

TABLE 3.9.4 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. MAP 2018: F=FMSYlower(0.216)*SSBy-1/MSYBtrigger

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.104	0.112	0.107
fbar:low	0.053	0.036	0.104	0.112	0.107
fbar:high	0.053	0.036	0.104	0.112	0.107
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	77940	74124	71257
ssb:low	66152	72116	77940	74124	71257
ssb:high	66152	72116	77940	74124	71257
catch:Estimate	7742	6078	18656	19808	18627
catch:low	7742	6078	18656	19808	18627
catch:high	7742	6078	18656	19808	18627

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	15050	16015	15145
Fleet C	103	269	785	849	813

fleet	2023	2024	2025	2026	2027
Fleet D	23	120	396	448	427
Fleet F	546	788	2425	2498	2242

TABLE 3.9.5 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=FMSY=0.31

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.310	0.310	0.310
fbar:low	0.053	0.036	0.310	0.310	0.310
fbar:high	0.053	0.036	0.310	0.310	0.310
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	74310	55747	47771
ssb:low	66152	72116	74310	55747	47771
ssb:high	66152	72116	74310	55747	47771
catch:Estimate	7742	6078	40880	29334	25071
catch:low	7742	6078	40880	29334	25071
catch:high	7742	6078	40880	29334	25071

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	31845	22032	18646
Fleet C	103	269	2097	1860	1776
Fleet D	23	120	1154	1186	1187
Fleet F	546	788	5784	4256	3462

TABLE 3.9.6 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=Fpa=0.41

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.410	0.410	0.410
fbar:low	0.053	0.036	0.410	0.410	0.410
fbar:high	0.053	0.036	0.410	0.410	0.410
rec:Estimate	512582	609242	609242	609242	609242

value	2023	2024	2025	2026	2027
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	72678	49870	40914
ssb:low	66152	72116	72678	49870	40914
ssb:high	66152	72116	72678	49870	40914
catch:Estimate	7742	6078	48341	31654	26070
catch:low	7742	6078	48341	31654	26070
catch:high	7742	6078	48341	31654	26070

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	37149	23141	18765
Fleet C	103	269	2652	2247	2108
Fleet D	23	120	1508	1538	1538
Fleet F	546	788	7032	4727	3659

TABLE 3.9.7 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=Flim=0.45

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.450	0.450	0.450
fbar:low	0.053	0.036	0.450	0.450	0.450
fbar:high	0.053	0.036	0.450	0.450	0.450
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	72046	47828	38602
ssb:low	66152	72116	72046	47828	38602
ssb:high	66152	72116	72046	47828	38602
catch:Estimate	7742	6078	50989	32374	26322
catch:low	7742	6078	50989	32374	26322
catch:high	7742	6078	50989	32374	26322

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	38994	23447	18726
Fleet C	103	269	2863	2384	2222
Fleet D	23	120	1647	1675	1674
Fleet F	546	788	7485	4868	3699

TABLE 3.9.8 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=F2024=0.036

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.036	0.036	0.036
fbar:low	0.053	0.036	0.036	0.036	0.036
fbar:high	0.053	0.036	0.036	0.036	0.036
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79220	84256	88725
ssb:low	66152	72116	79220	84256	88725
ssb:high	66152	72116	79220	84256	88725
catch:Estimate	7742	6078	7389	8887	10104
catch:low	7742	6078	7389	8887	10104
catch:high	7742	6078	7389	8887	10104

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	6041	7405	8539
Fleet C	103	269	285	306	322
Fleet D	23	120	139	146	146
Fleet F	546	788	925	1031	1097

TABLE 3.9.9 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. Catch for bycatch fleets only

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.020	0.015	0.012
fbar:low	0.053	0.036	0.020	0.015	0.012

value	2023	2024	2025	2026	2027
fbar:high	0.053	0.036	0.020	0.015	0.012
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79456	86631	94196
ssb:low	66152	72116	79456	86631	94196
ssb:high	66152	72116	79456	86631	94196
catch:Estimate	7742	6078	5021	5021	5021
catch:low	7742	6078	5021	5021	5021
catch:high	7742	6078	5021	5021	5021

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	4900	4900	4900
Fleet C	103	269	0	0	0
Fleet D	23	120	120	120	120
Fleet F	546	788	0	0	0

TABLE 3.9.10 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.000	0.000	0.000
fbar:low	0.053	0.036	0.000	0.000	0.000
fbar:high	0.053	0.036	0.000	0.000	0.000
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79917	91000	101998
ssb:low	66152	72116	79917	91000	101998
ssb:high	66152	72116	79917	91000	101998
catch:Estimate	7742	6078	0	0	0
catch:low	7742	6078	0	0	0

value	2023	2024	2025	2026	2027
catch:high	7742	6078	0	0	0

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	0	0	0
Fleet C	103	269	0	0	0
Fleet D	23	120	0	0	0
Fleet F	546	788	0	0	0

TABLE 3.9.11 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0.01

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.010	0.010	0.010
fbar:low	0.053	0.036	0.010	0.010	0.010
fbar:high	0.053	0.036	0.010	0.010	0.010
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79722	89003	97869
ssb:low	66152	72116	79722	89003	97869
ssb:high	66152	72116	79722	89003	97869
catch:Estimate	7742	6078	2171	2846	3472
catch:low	7742	6078	2171	2846	3472
catch:high	7742	6078	2171	2846	3472

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	1784	2397	2974
Fleet C	103	269	81	89	97
Fleet D	23	120	39	41	41
Fleet F	546	788	268	319	361

TABLE 3.9.12 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0.025

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.025	0.025	0.025
fbar:low	0.053	0.036	0.025	0.025	0.025
fbar:high	0.053	0.036	0.025	0.025	0.025
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79432	86190	92341
ssb:low	66152	72116	79432	86190	92341
ssb:high	66152	72116	79432	86190	92341
catch:Estimate	7742	6078	5253	6545	7655
catch:low	7742	6078	5253	6545	7655
catch:high	7742	6078	5253	6545	7655

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	4304	5478	6506
Fleet C	103	269	199	217	231
Fleet D	23	120	96	102	102
Fleet F	546	788	653	749	816

TABLE 3.9.13 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0.05

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.050	0.050	0.050
fbar:low	0.053	0.036	0.050	0.050	0.050
fbar:high	0.053	0.036	0.050	0.050	0.050
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	78952	81938	84580
ssb:low	66152	72116	78952	81938	84580

value	2023	2024	2025	2026	2027
ssb:high	66152	72116	78952	81938	84580
catch:Estimate	7742	6078	9969	11487	12639
catch:low	7742	6078	9969	11487	12639
catch:high	7742	6078	9969	11487	12639

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	8127	9515	10602
Fleet C	103	269	392	414	432
Fleet D	23	120	192	202	203
Fleet F	546	788	1258	1356	1403

TABLE 3.9.14 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0.1

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.100	0.100	0.100
fbar:low	0.053	0.036	0.100	0.100	0.100
fbar:high	0.053	0.036	0.100	0.100	0.100
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	78012	74769	72925
ssb:low	66152	72116	78012	74769	72925
ssb:high	66152	72116	78012	74769	72925
catch:Estimate	7742	6078	18093	18222	18294
catch:low	7742	6078	18093	18222	18294
catch:high	7742	6078	18093	18222	18294

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	14606	14779	14941
Fleet C	103	269	758	764	774
Fleet D	23	120	382	400	400

fleet	2023	2024	2025	2026	2027
Fleet F	546	788	2347	2279	2179

TABLE 3.9.15 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F=0.15

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.150	0.150	0.150
fbar:low	0.053	0.036	0.150	0.150	0.150
fbar:high	0.053	0.036	0.150	0.150	0.150
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	77095	68950	64540
ssb:low	66152	72116	77095	68950	64540
ssb:high	66152	72116	77095	68950	64540
catch:Estimate	7742	6078	24860	22453	21206
catch:low	7742	6078	24860	22453	21206
catch:high	7742	6078	24860	22453	21206

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	19882	17840	16879
Fleet C	103	269	1103	1071	1063
Fleet D	23	120	569	593	594
Fleet F	546	788	3305	2948	2670

TABLE 3.9.16 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. Constant 2024 TAC

value	2023	2024	2025	2026	2027
fbar:Estimate	0.053	0.036	0.029	0.024	0.021
fbar:low	0.053	0.036	0.029	0.024	0.021
fbar:high	0.053	0.036	0.029	0.024	0.021
rec:Estimate	512582	609242	609242	609242	609242
rec:low	512582	609242	609242	609242	609242

value	2023	2024	2025	2026	2027
rec:high	512582	609242	609242	609242	609242
ssb:Estimate	66152	72116	79353	85585	92280
ssb:low	66152	72116	79353	85585	92280
ssb:high	66152	72116	79353	85585	92280
catch:Estimate	7742	6078	6078	6078	6078
catch:low	7742	6078	6078	6078	6078
catch:high	7742	6078	6078	6078	6078

Catch per fleet

fleet	2023	2024	2025	2026	2027
Fleet A	7070	4900	4900	4900	4900
Fleet C	103	269	269	269	269
Fleet D	23	120	120	120	120
Fleet F	546	788	788	788	788

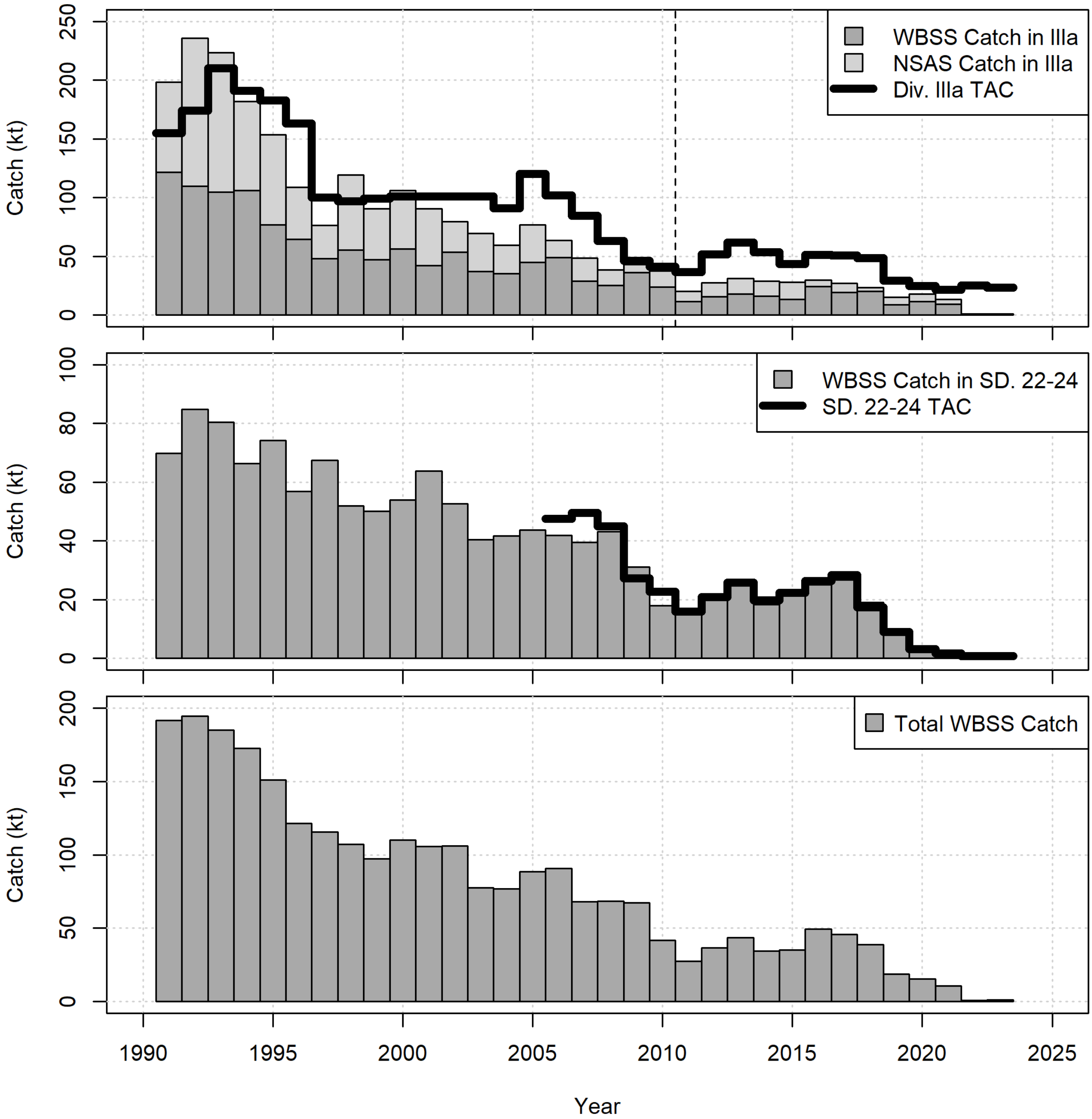


Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for IIIa excludes the by-catch TAC, while the CATCH includes the by-catch

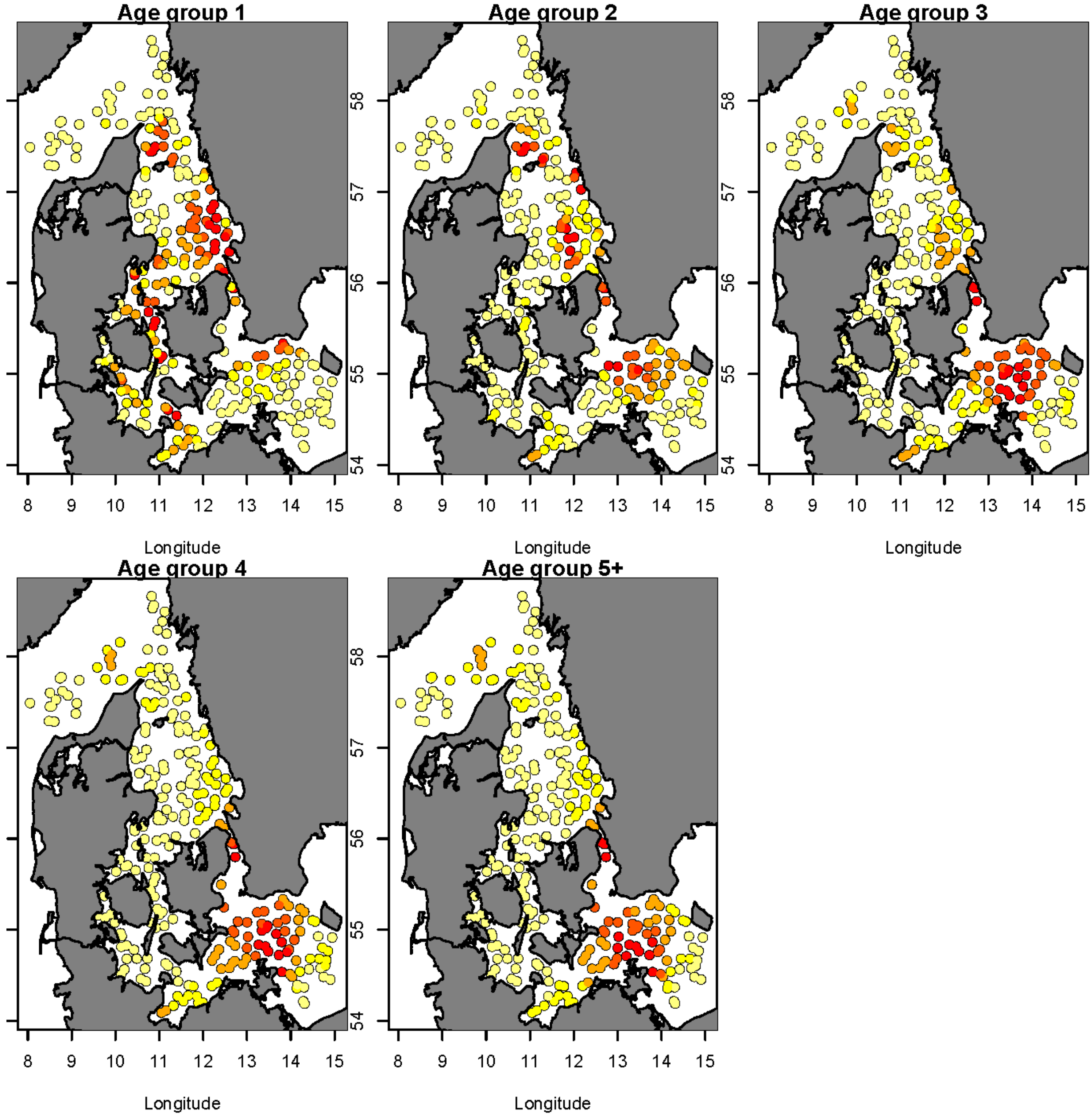


Figure 3.3.1 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distibution of hauls and the density of fish per age in the IBTS+BITS-Q1 survey.

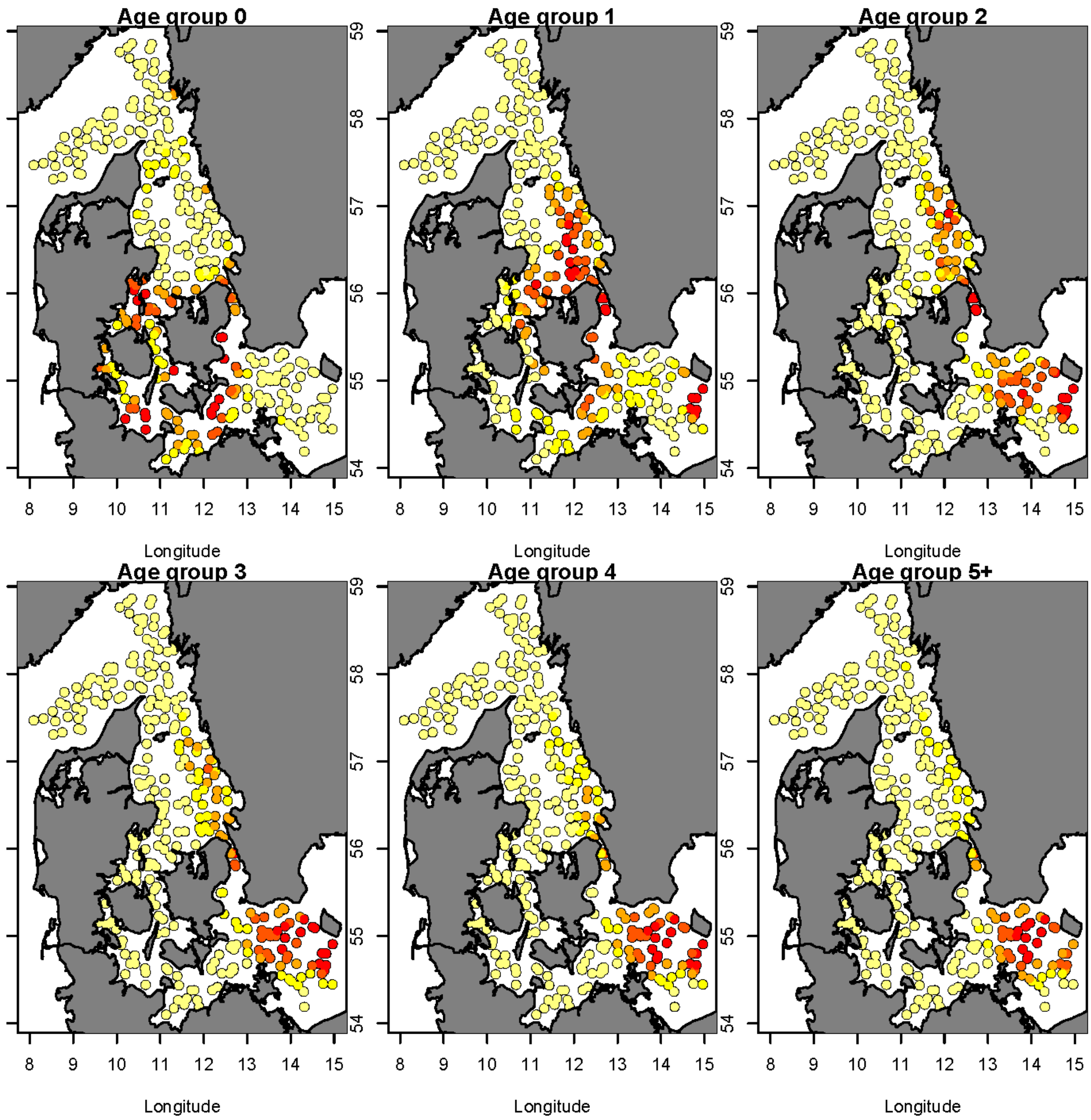


Figure 3.3.2 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distibution of hauls and the density of fish per age in the IBTS+BITS-Q3.4 survey.

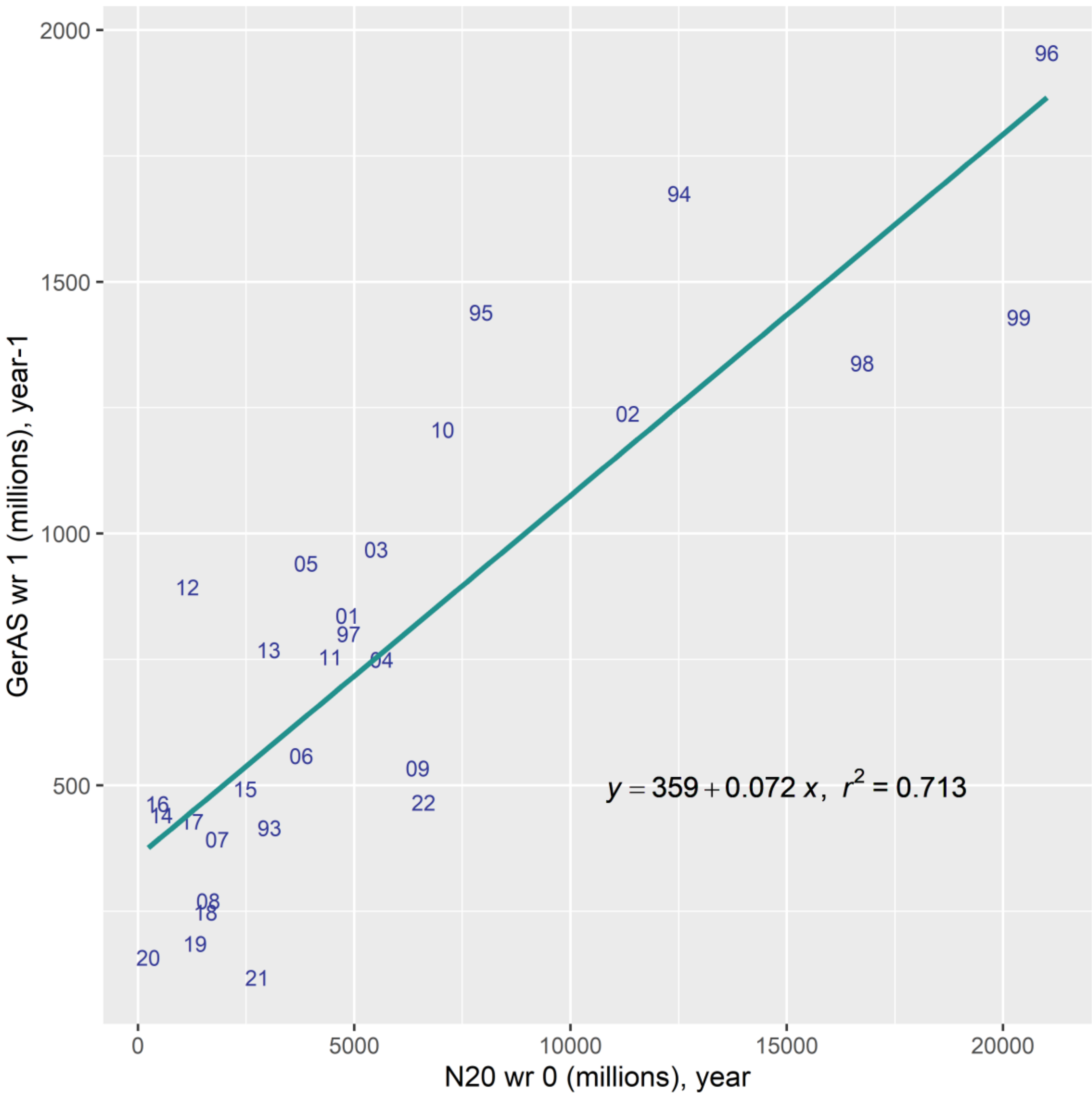


Figure 3.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N20.

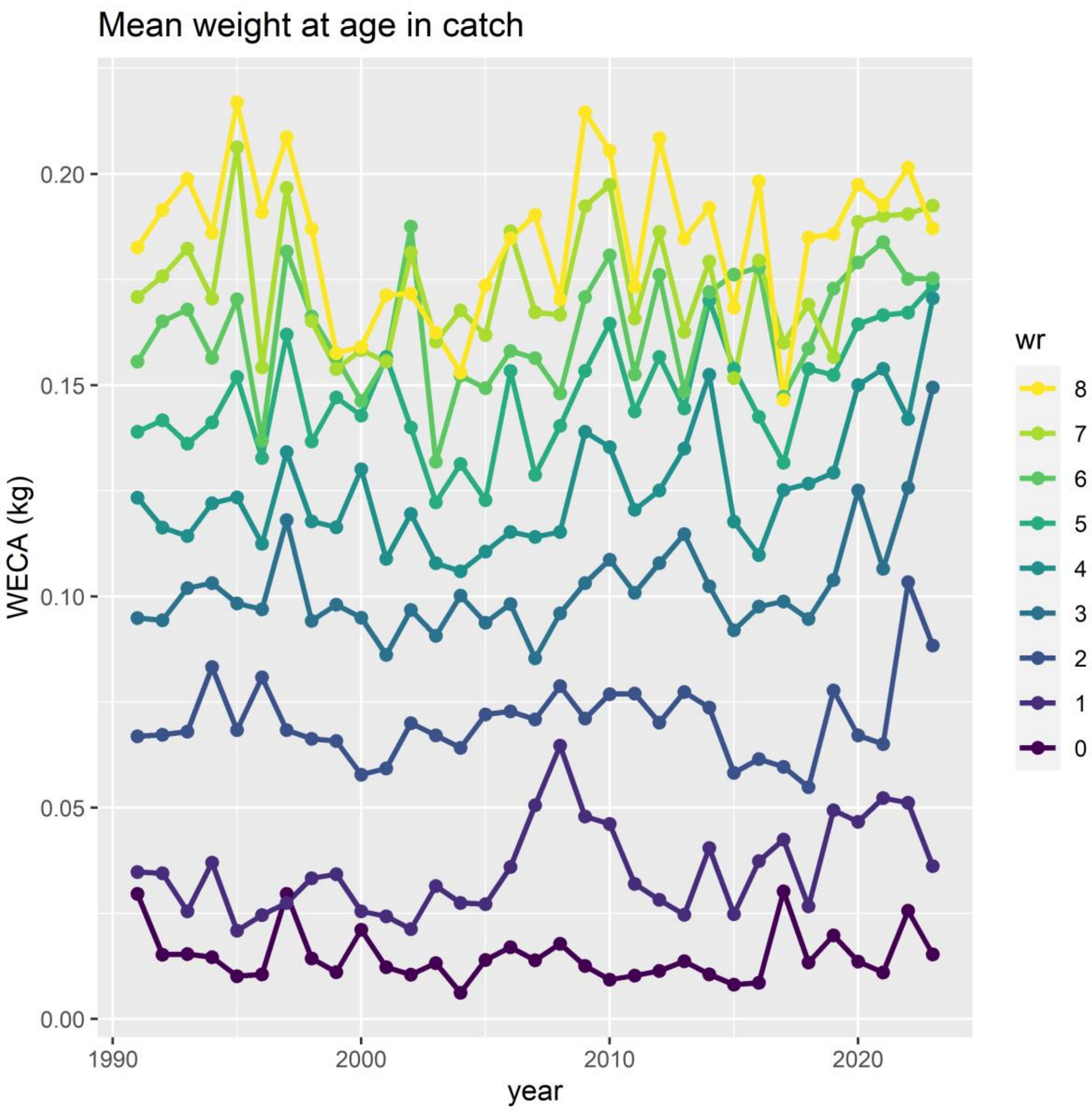
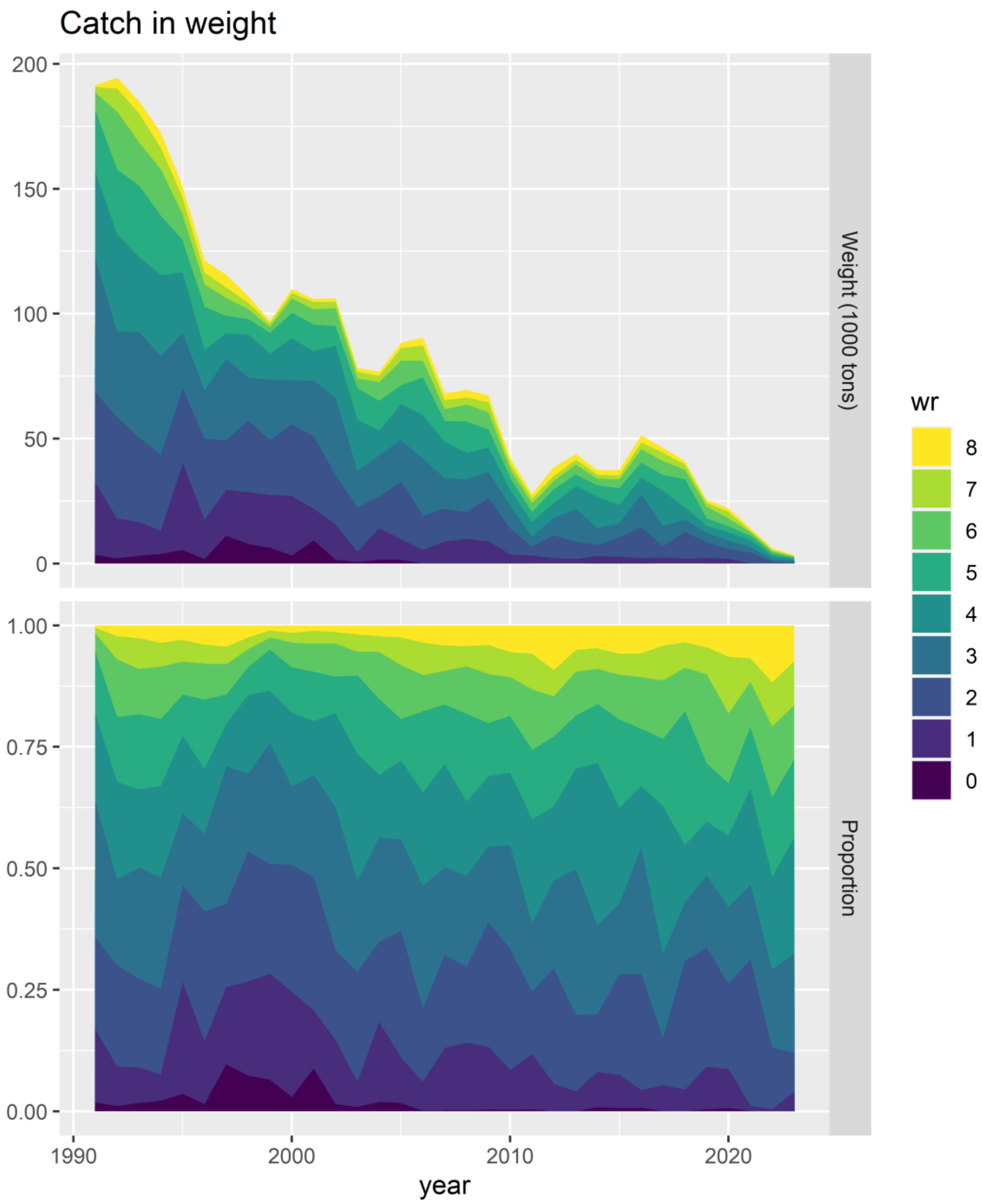


Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WECA).



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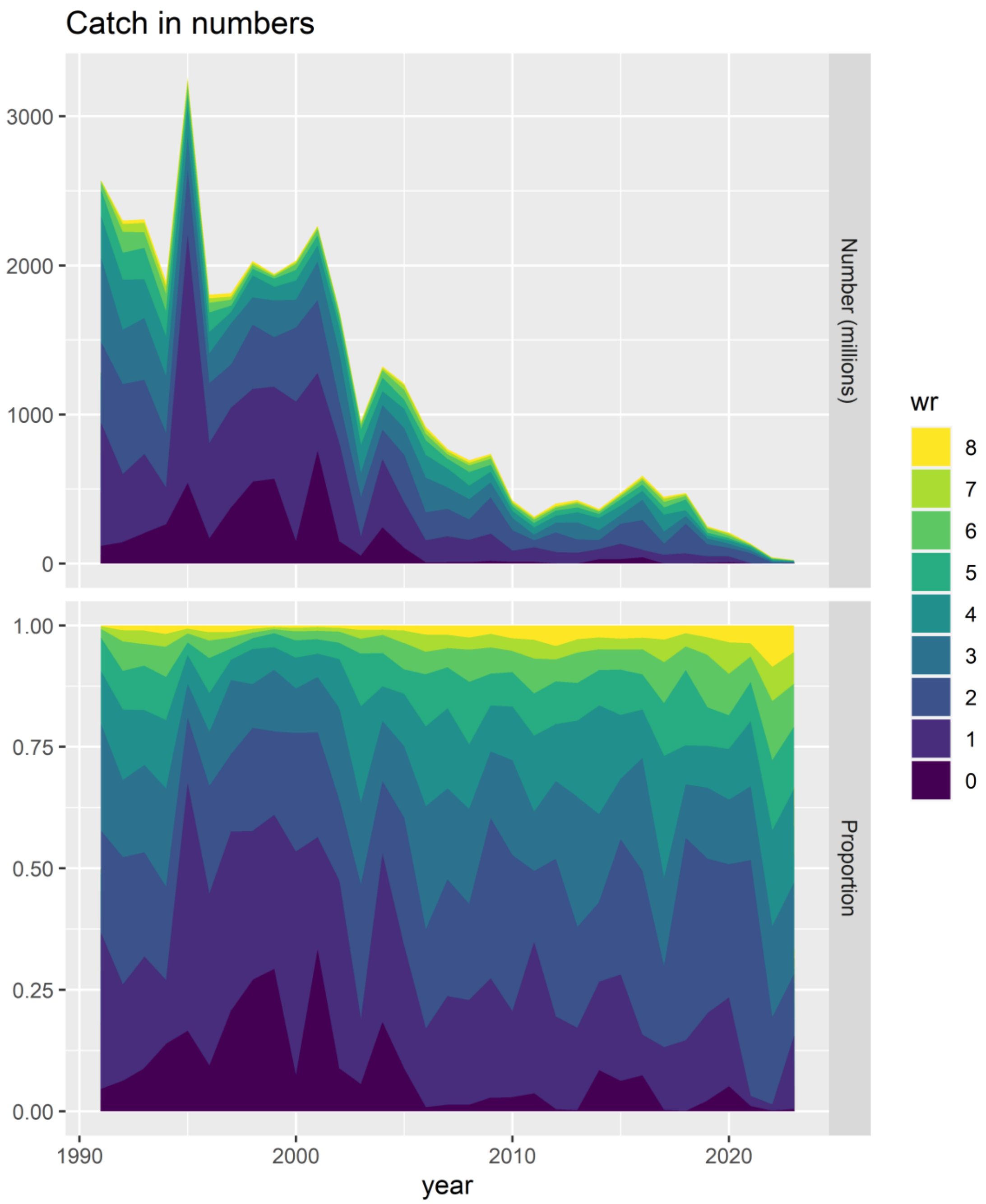

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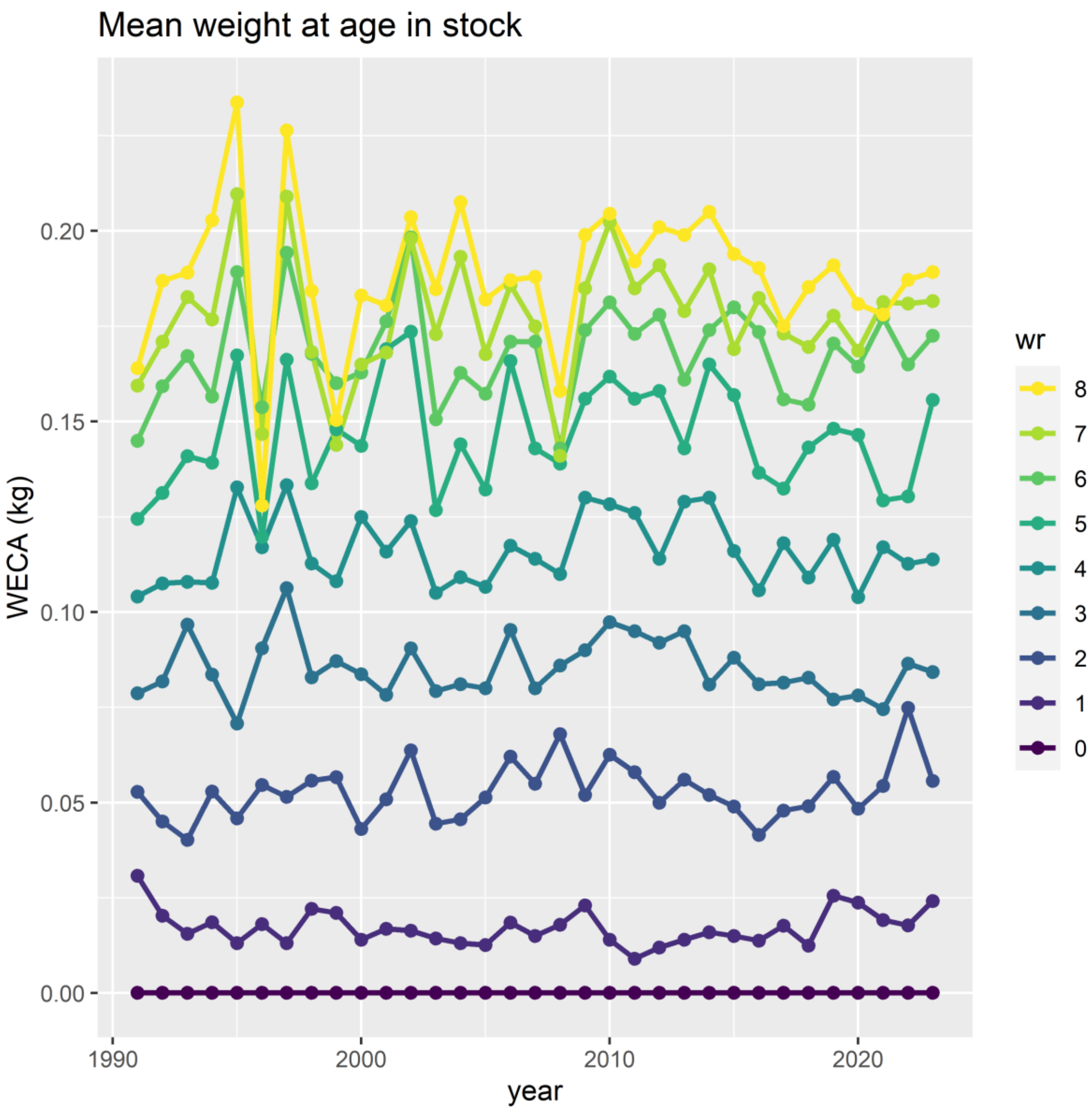
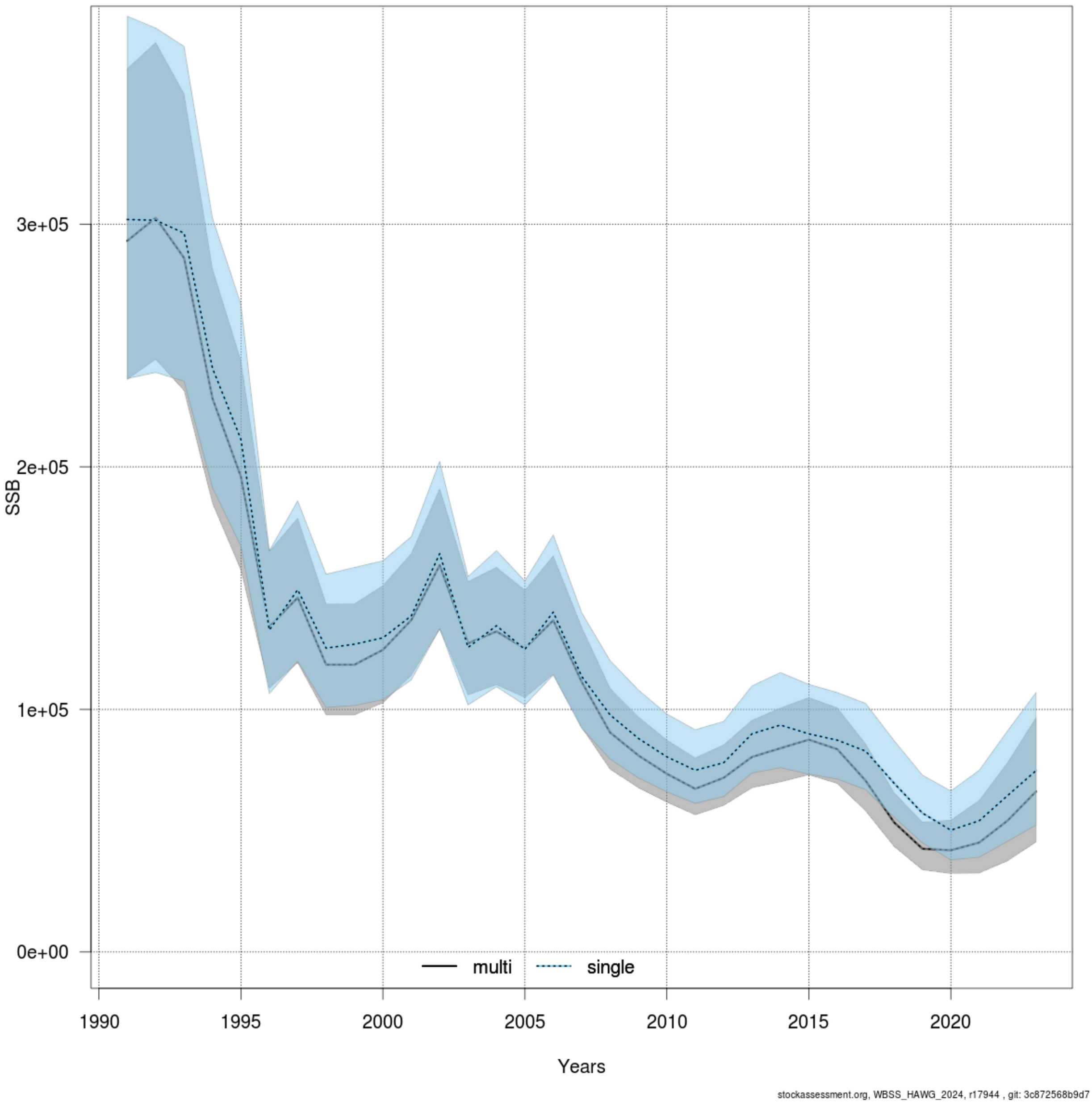


Figure 3.6.1.4 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WEST).



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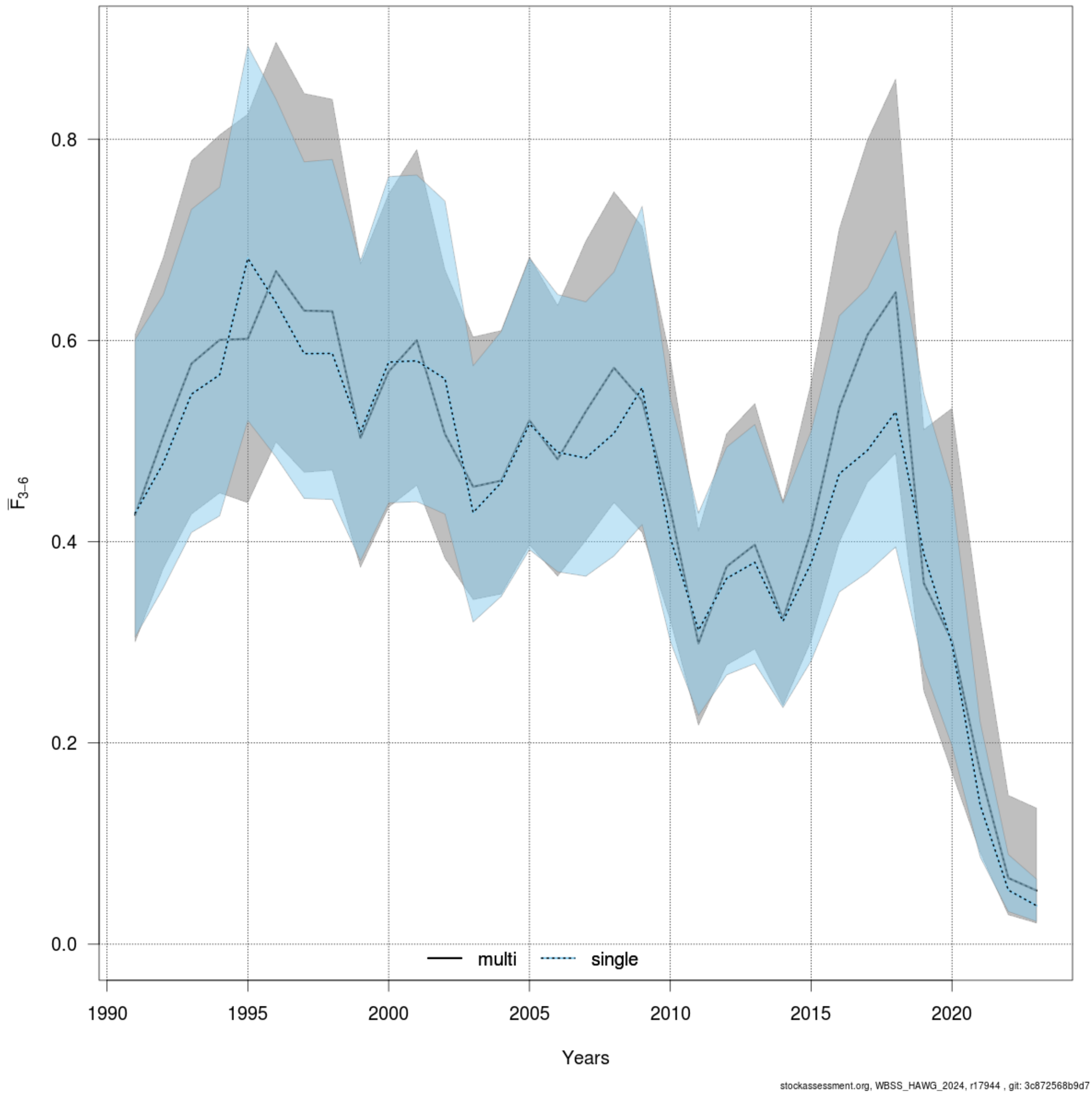

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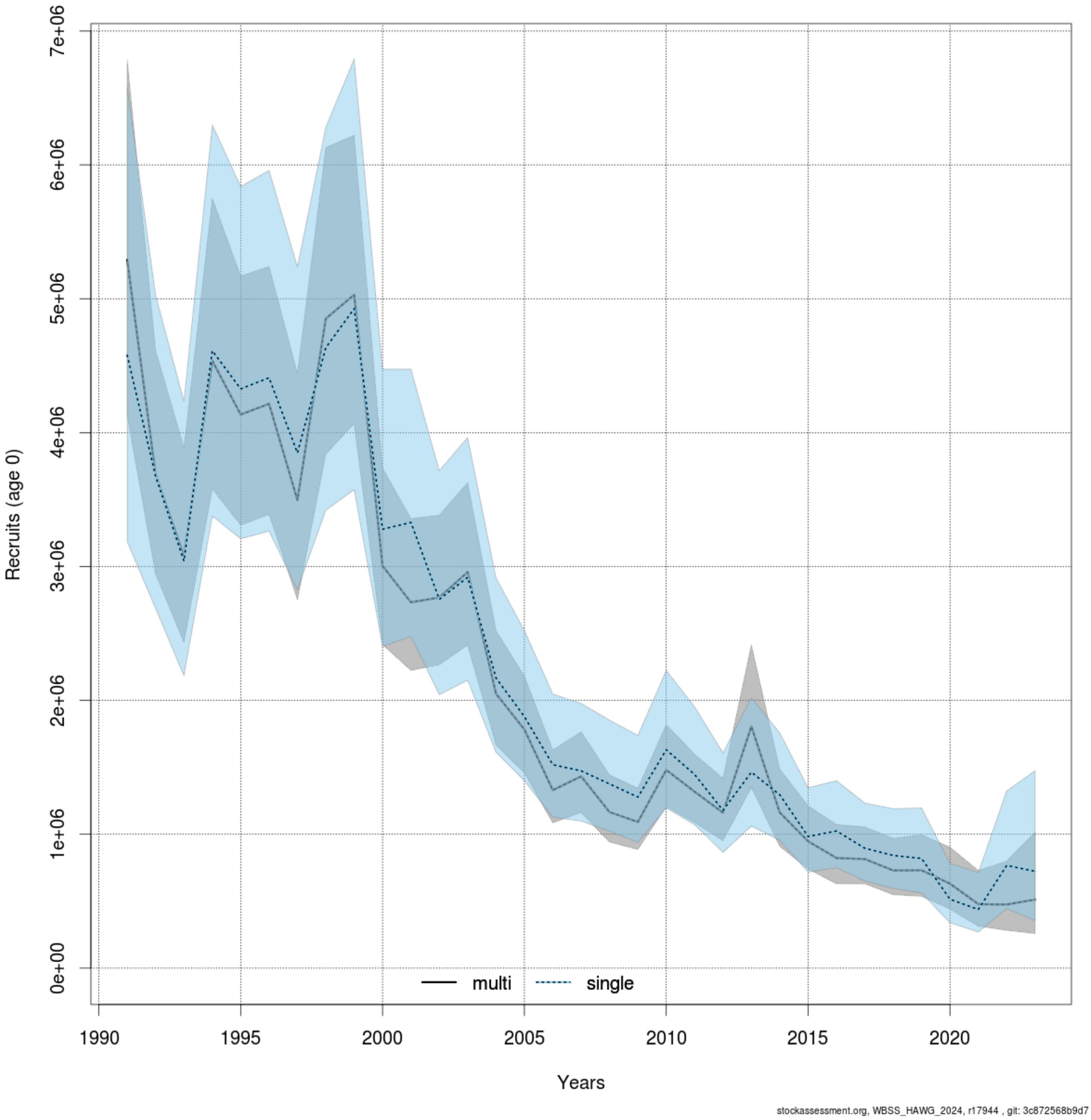
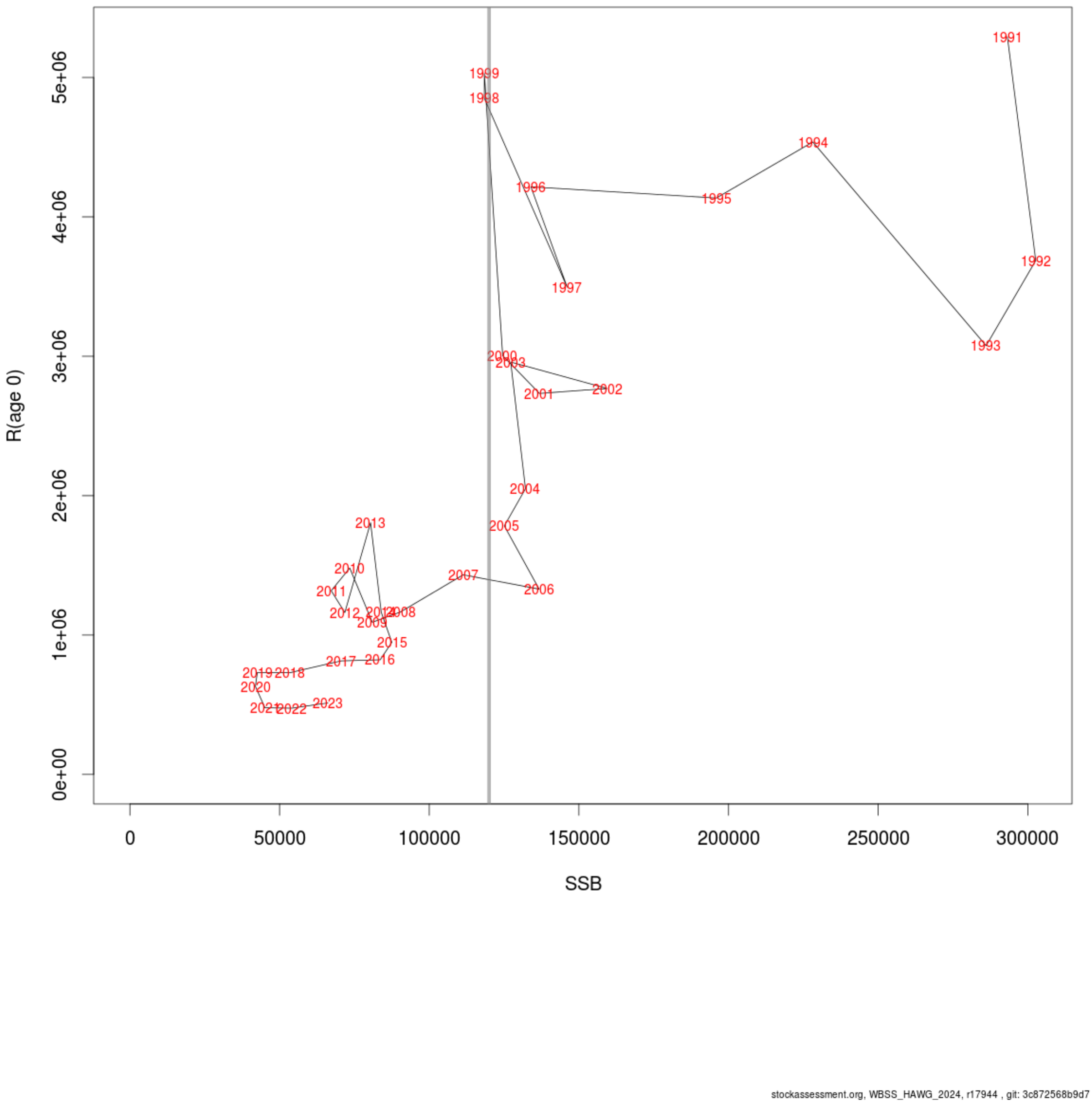


Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.



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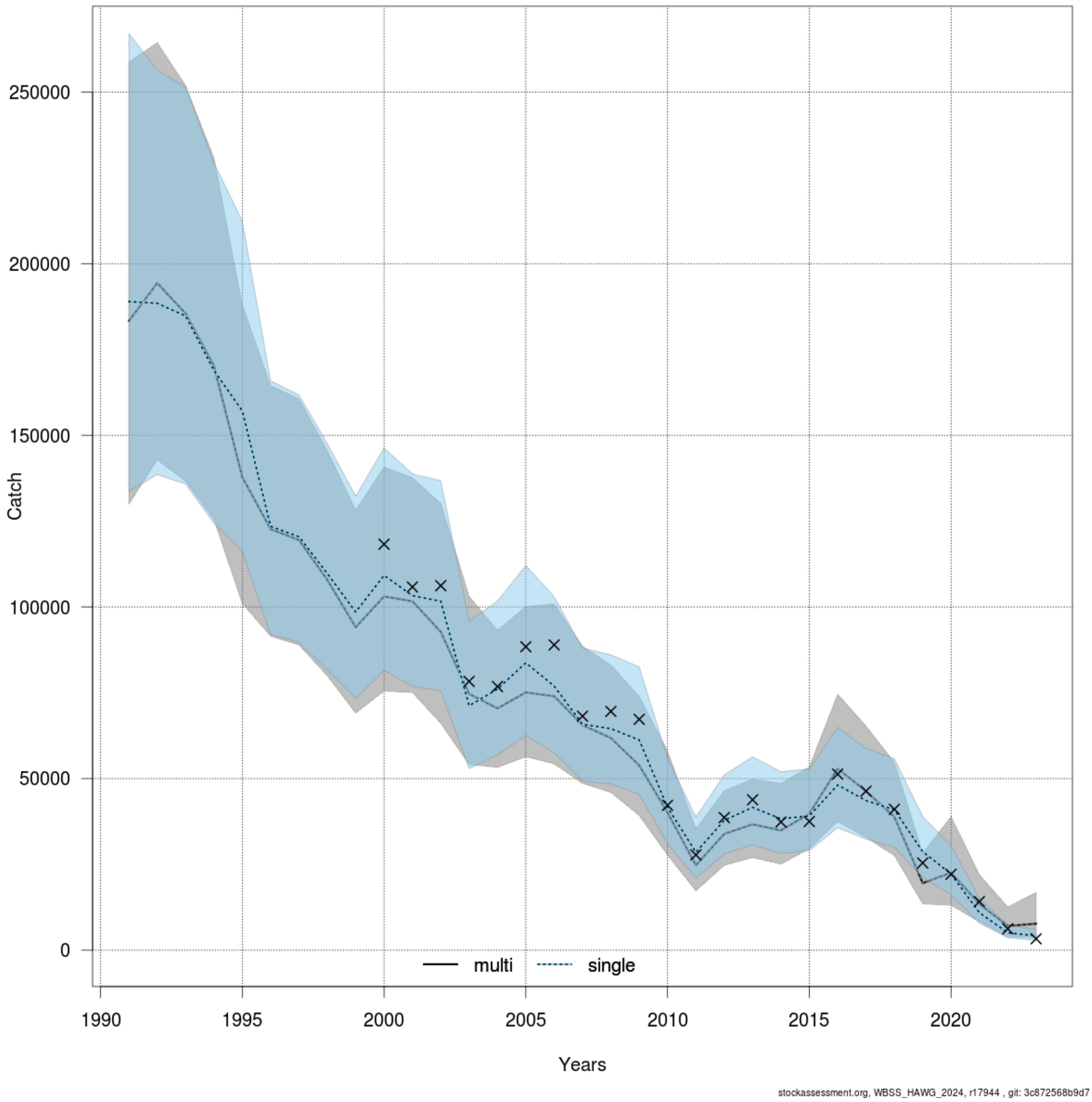

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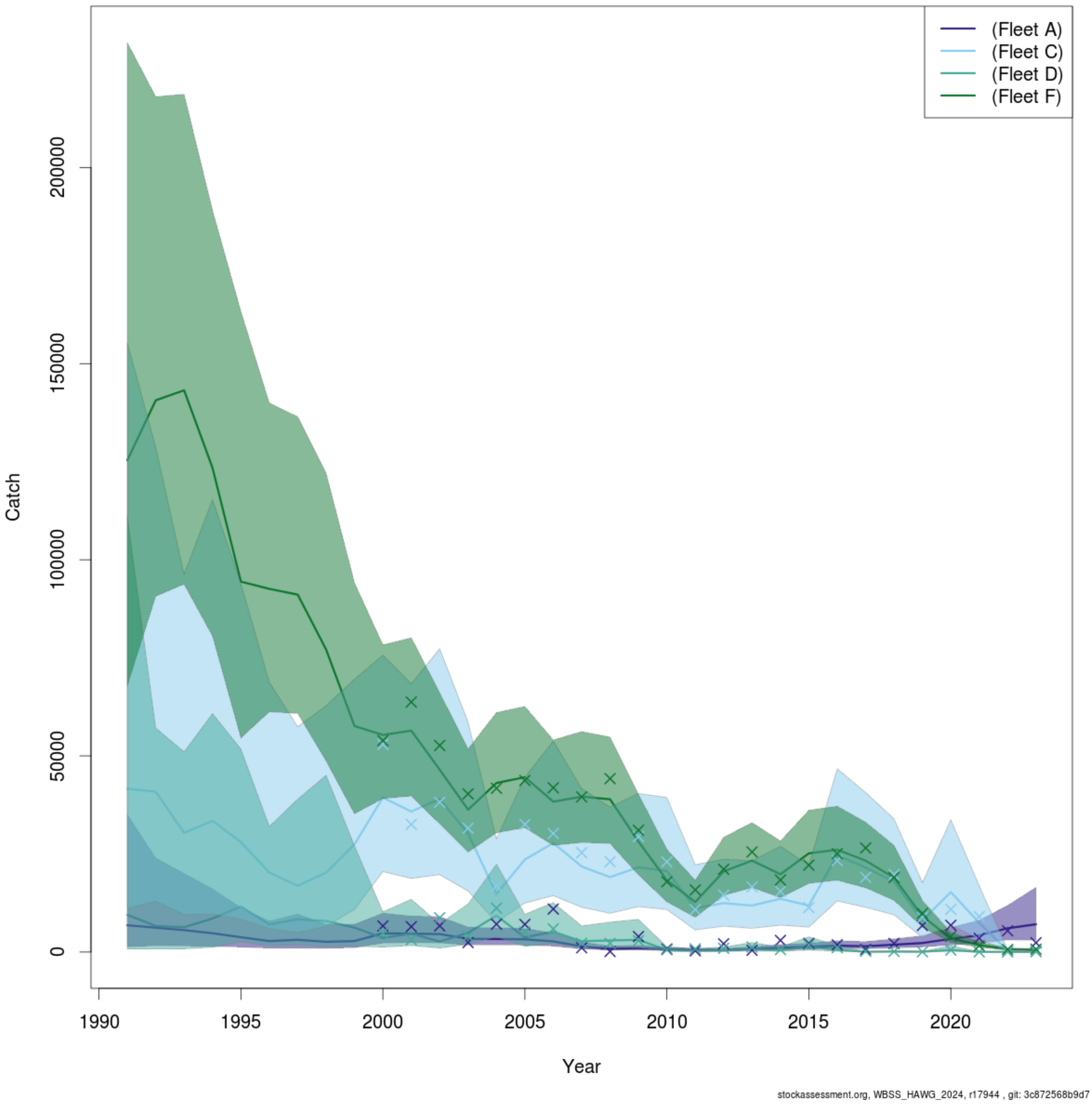

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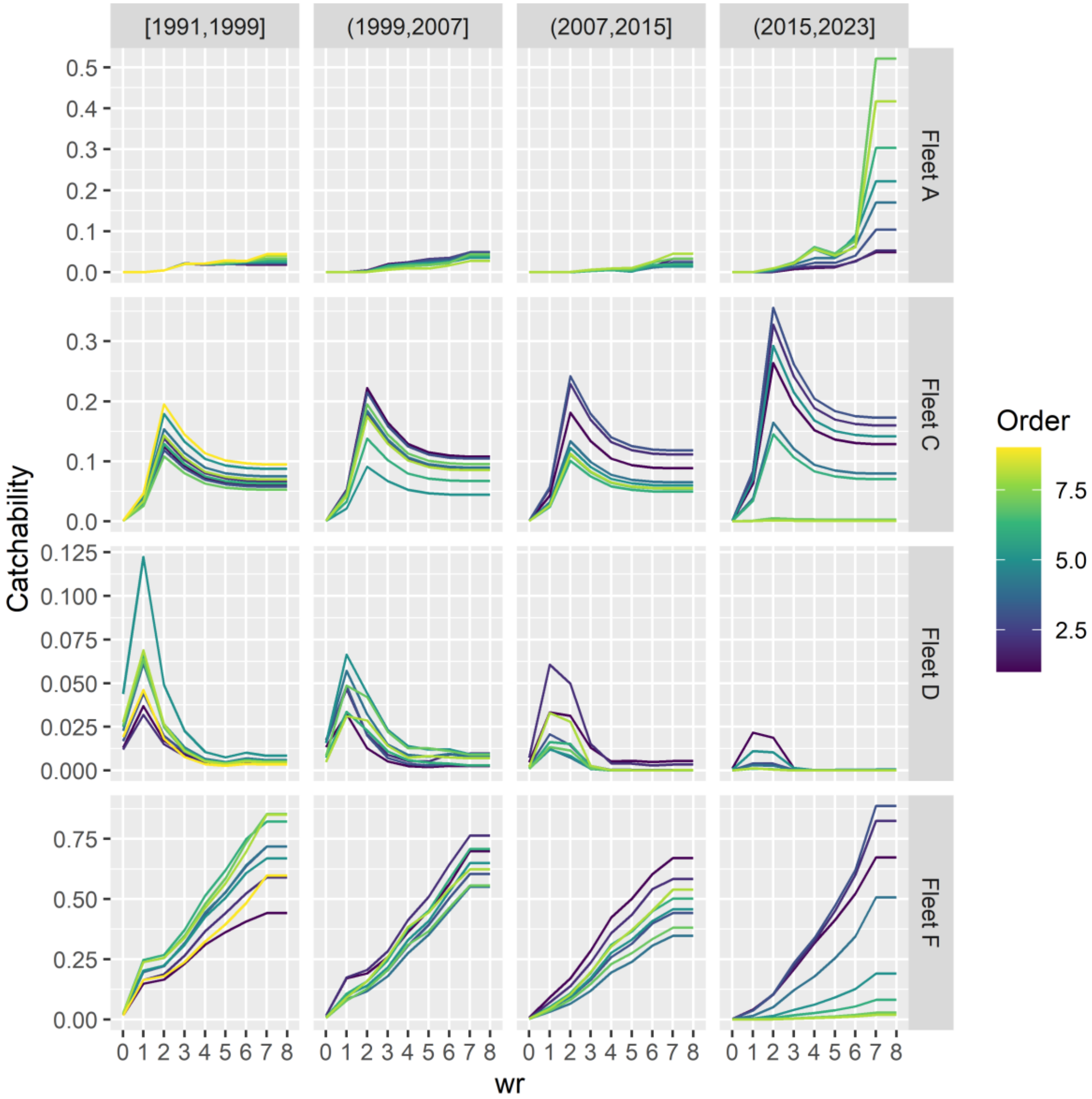

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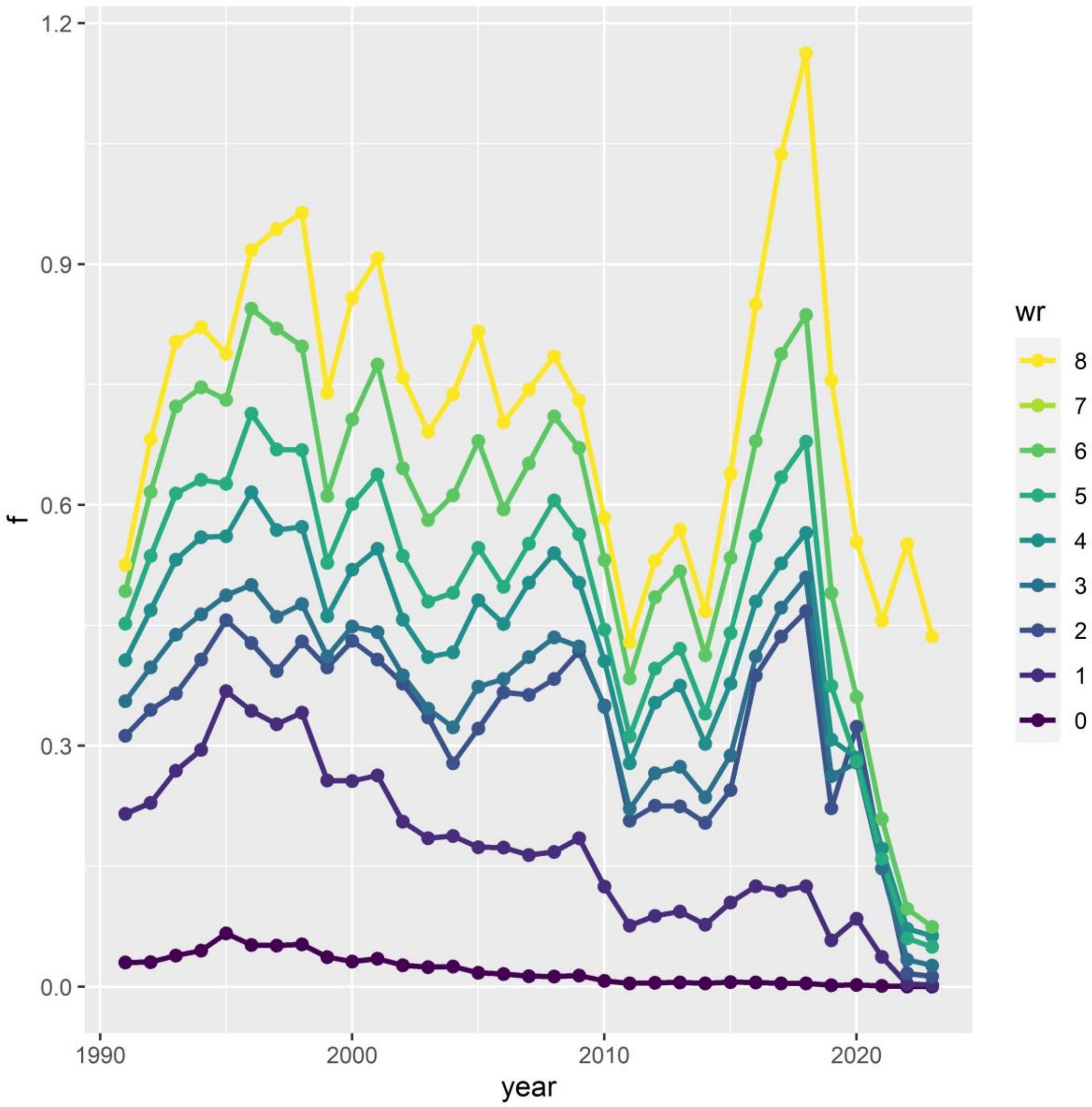


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr)

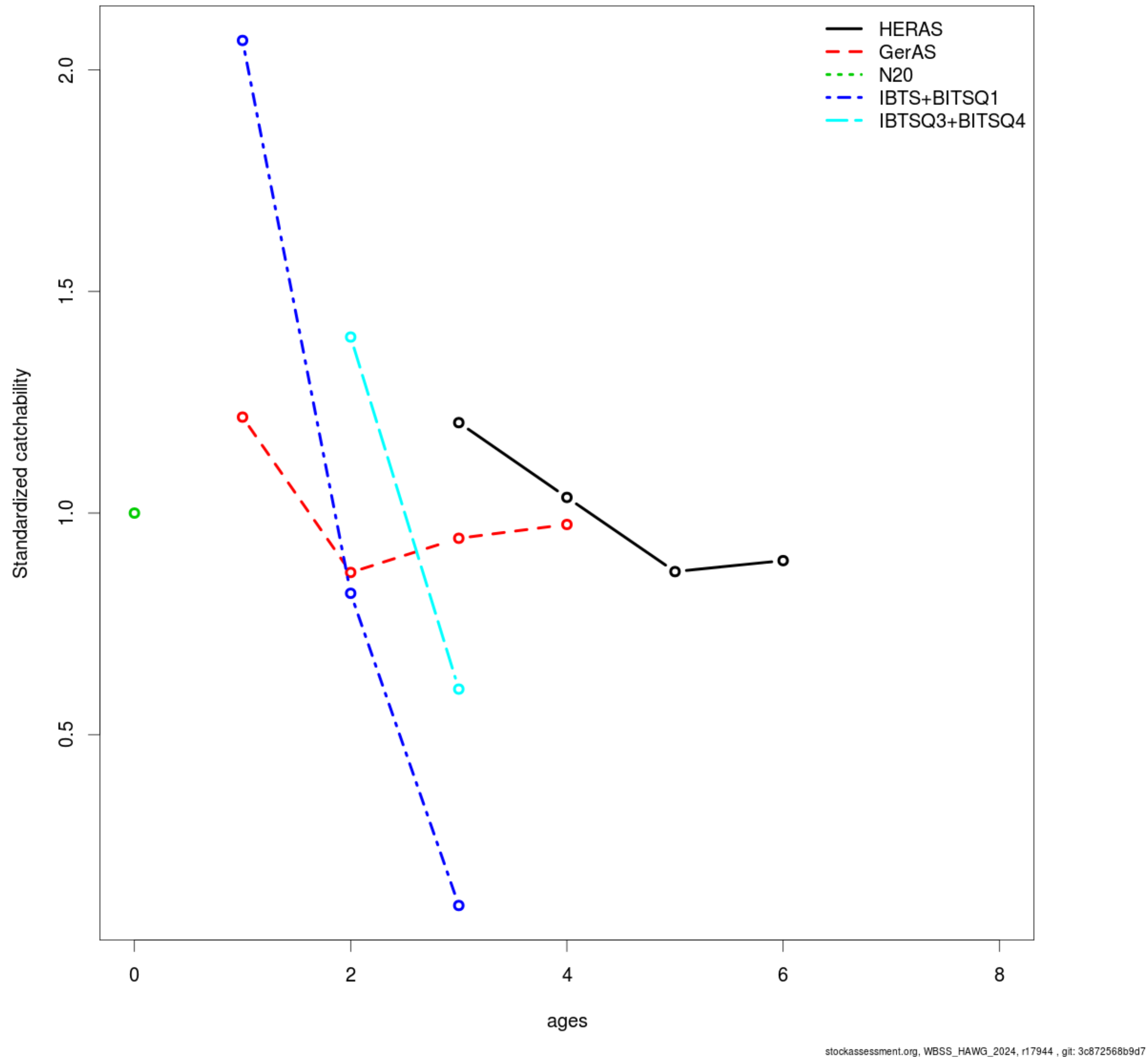
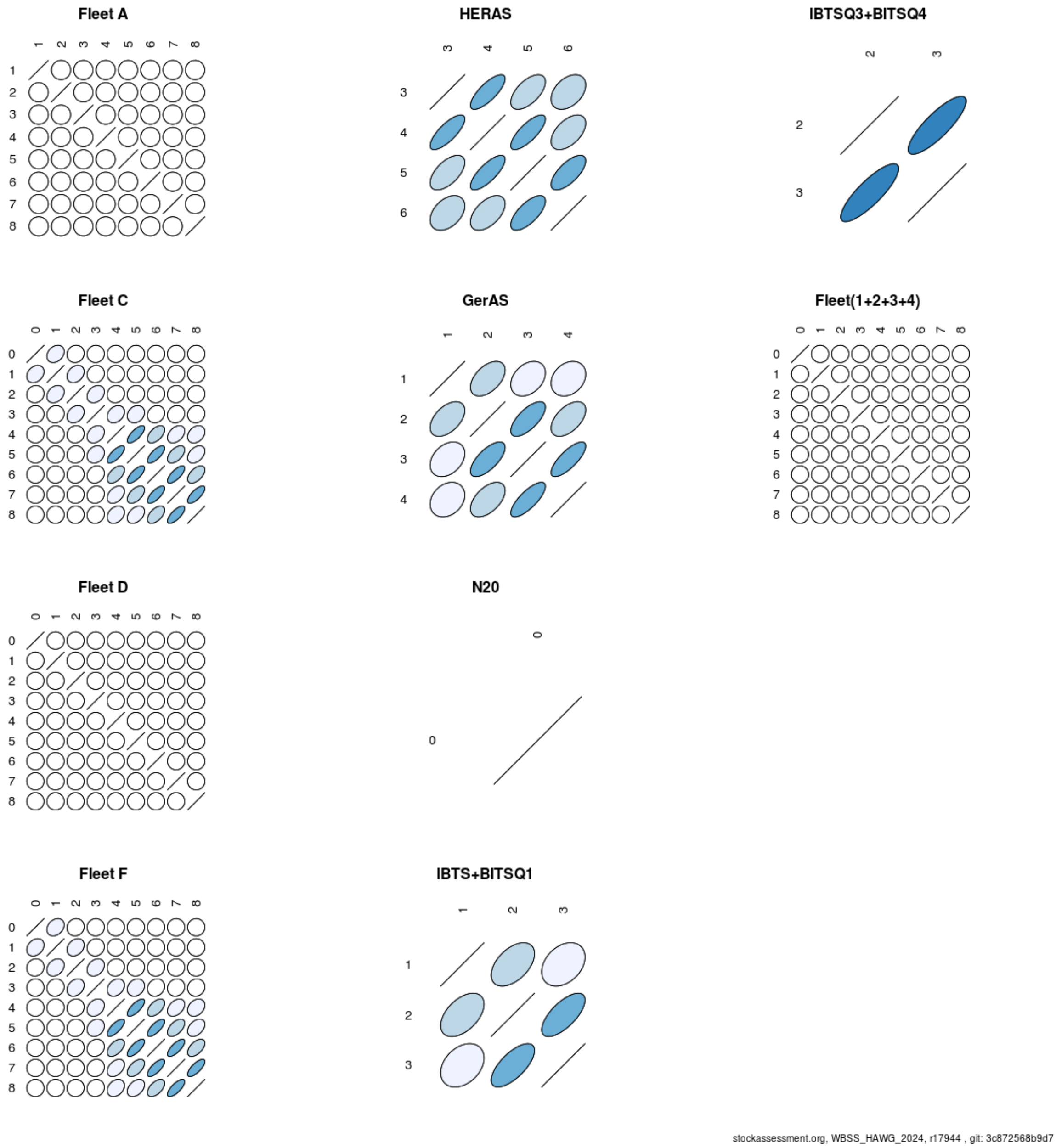


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Estimated survey catchabilities. N20 only covers a age 0 and therefore no line



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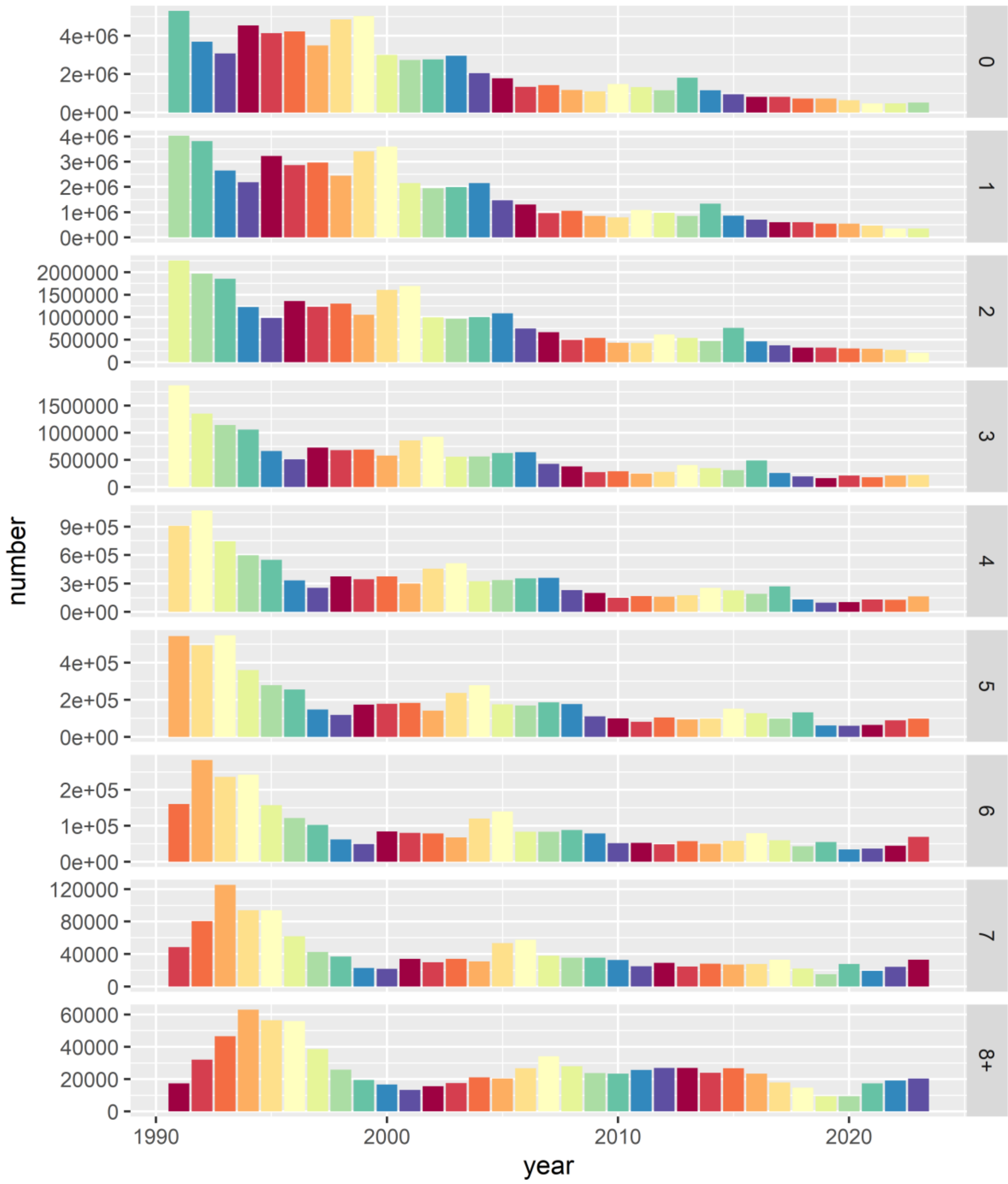

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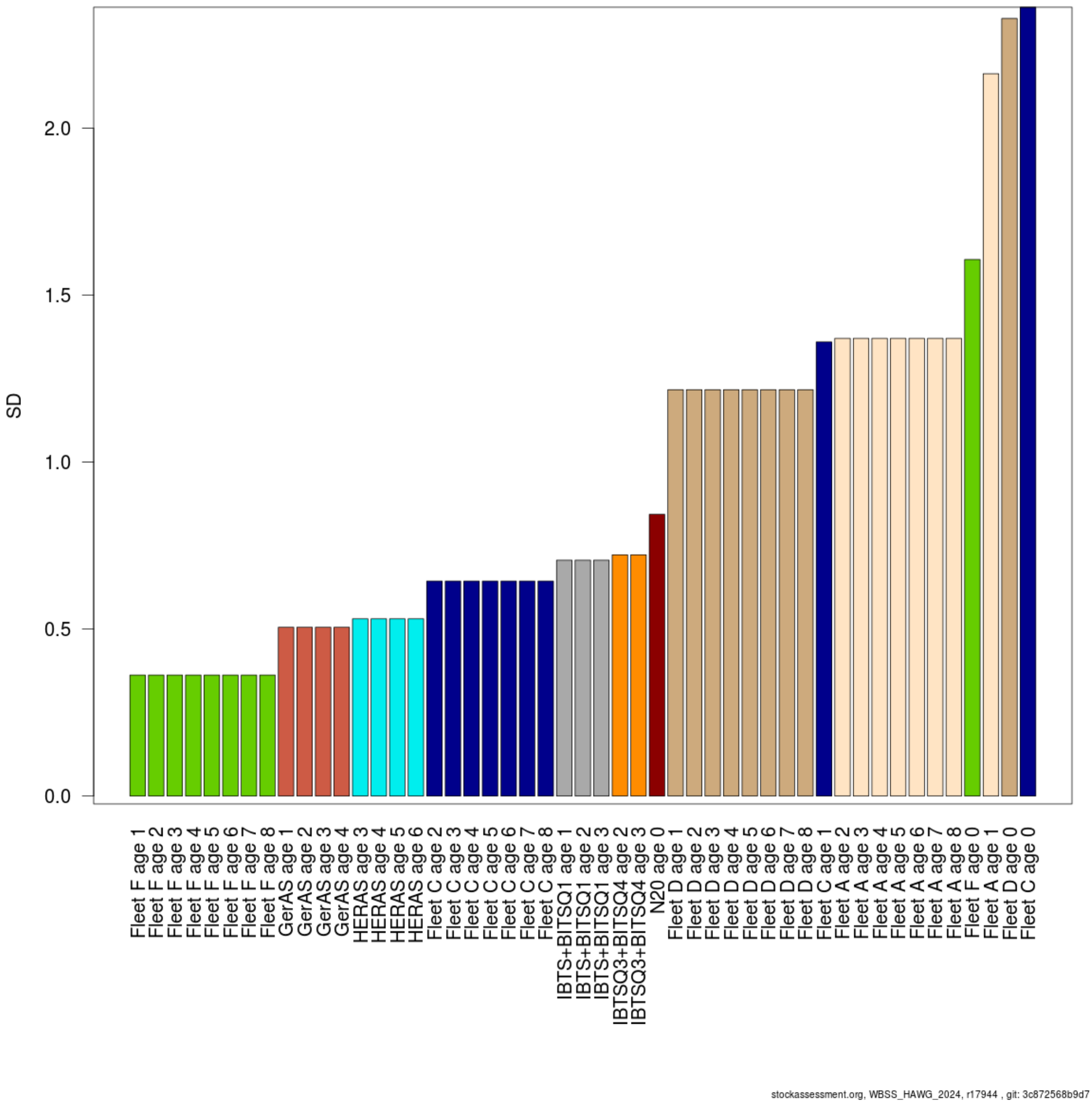

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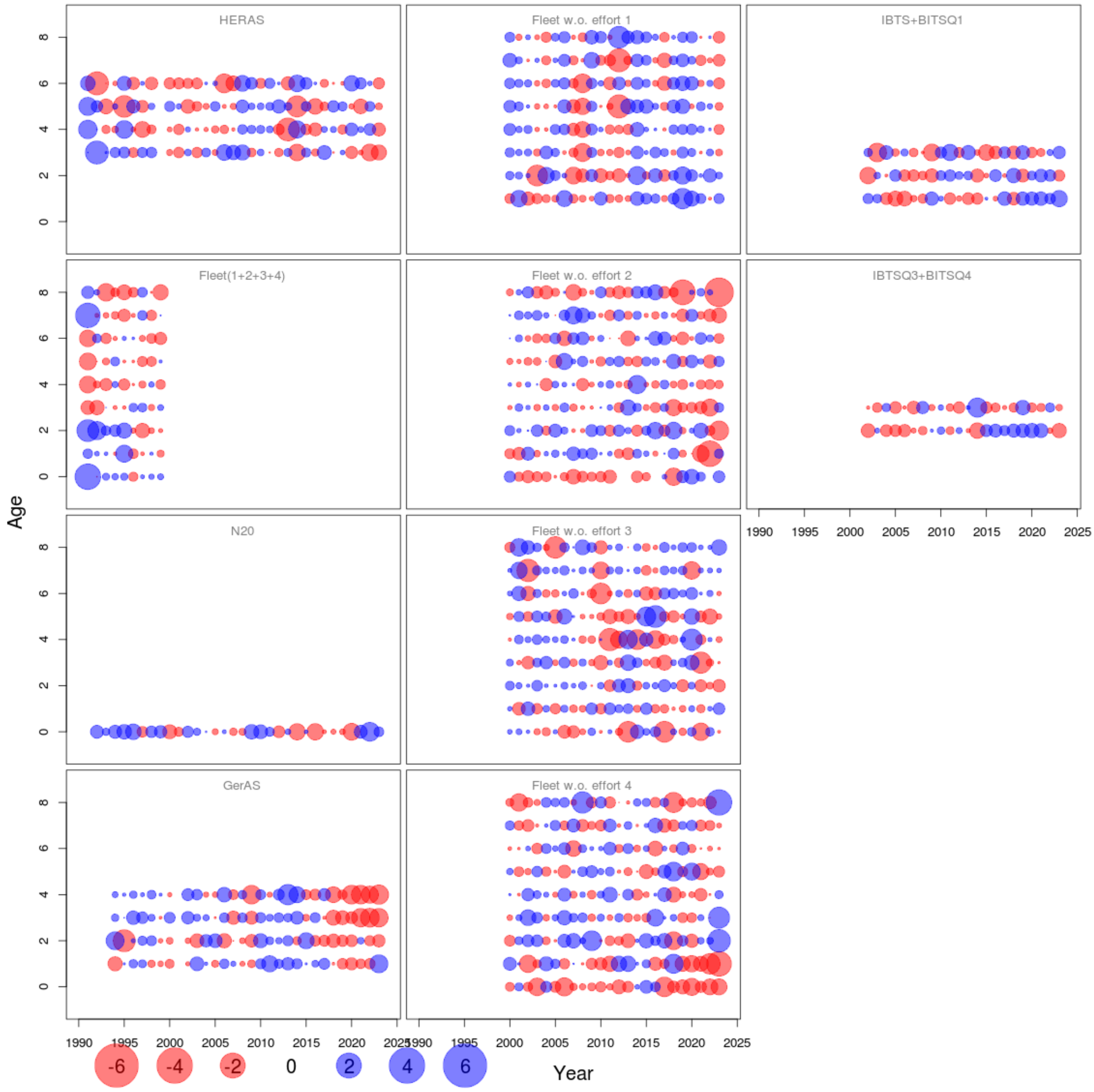

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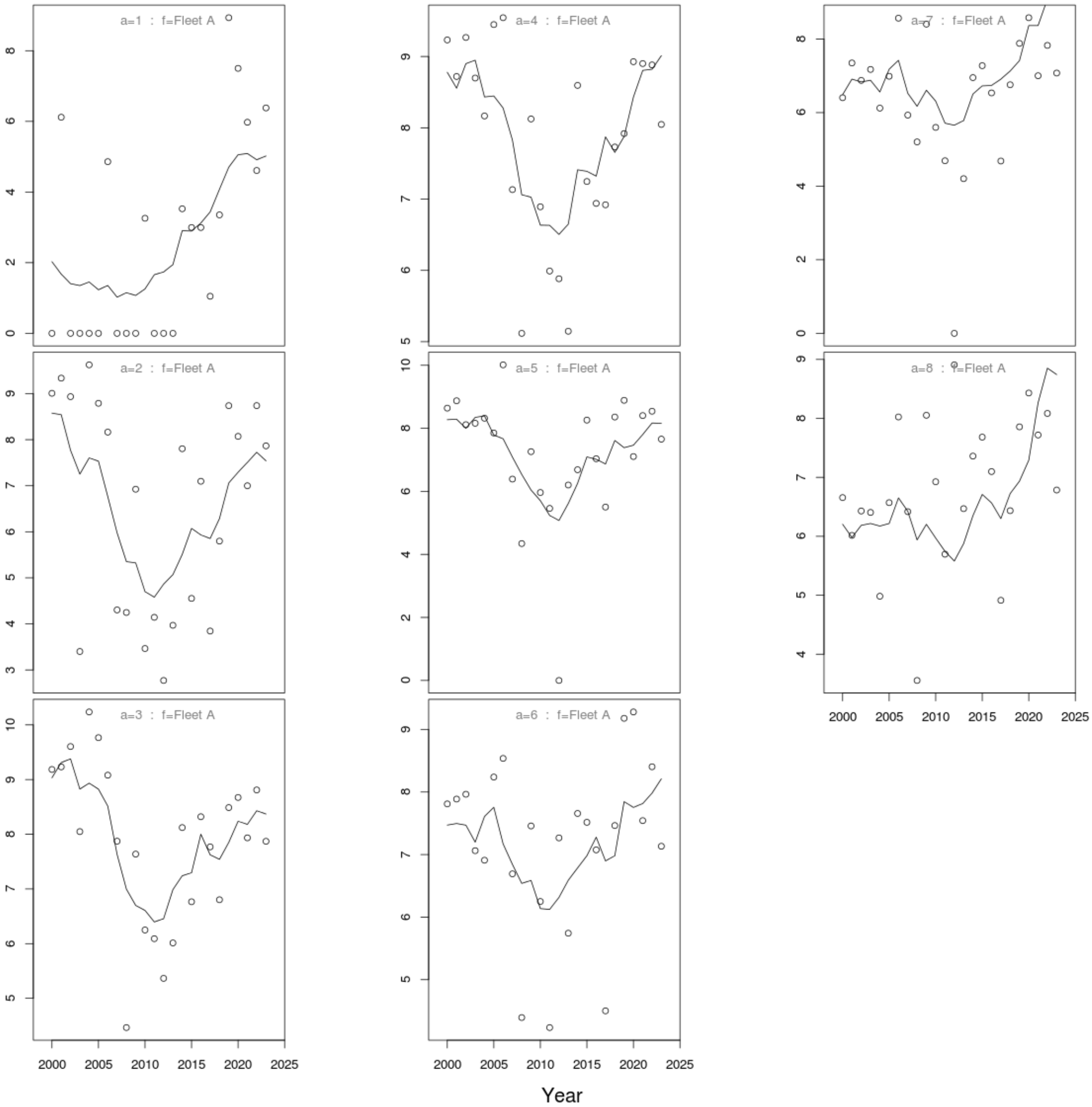

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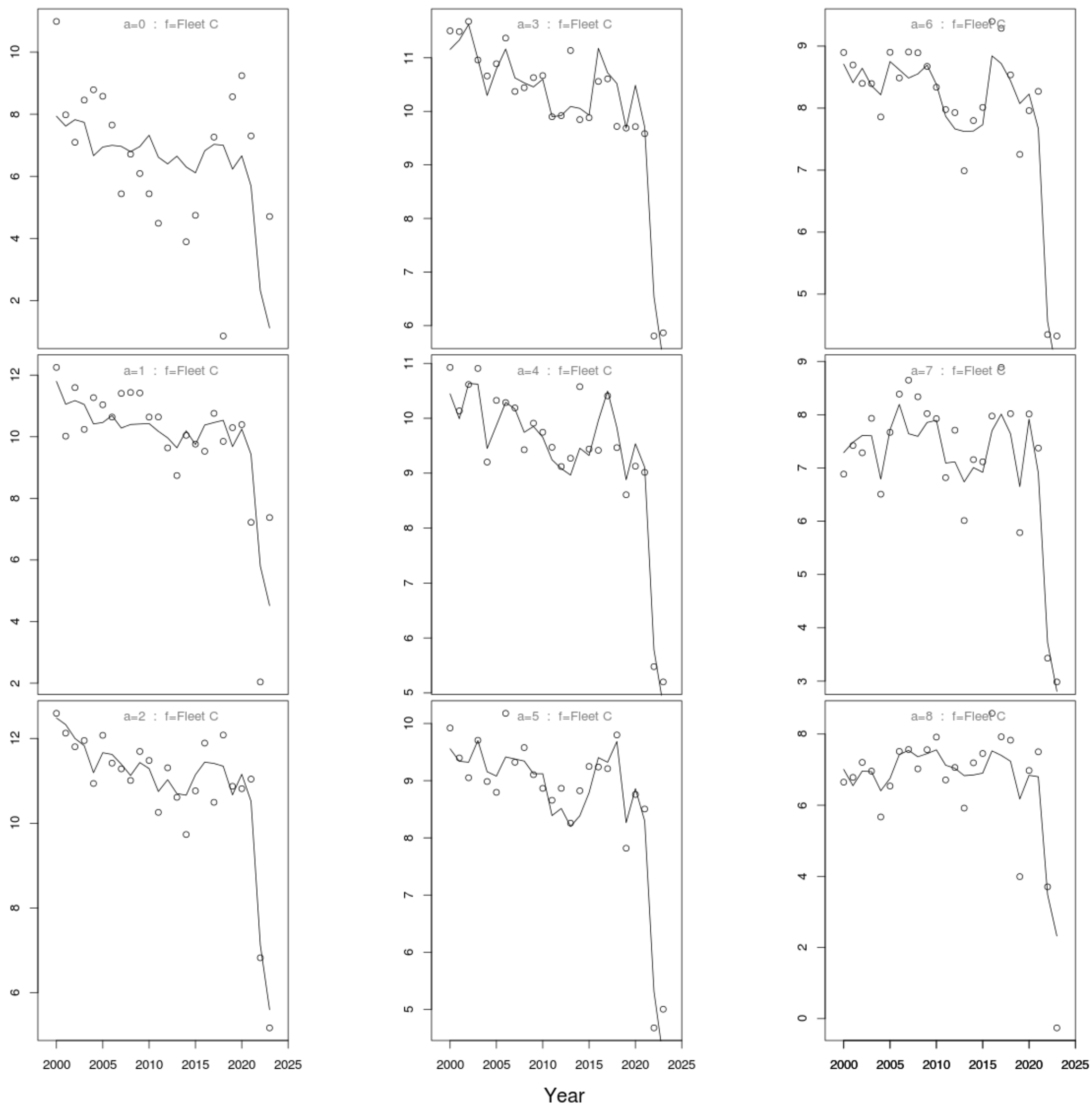


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

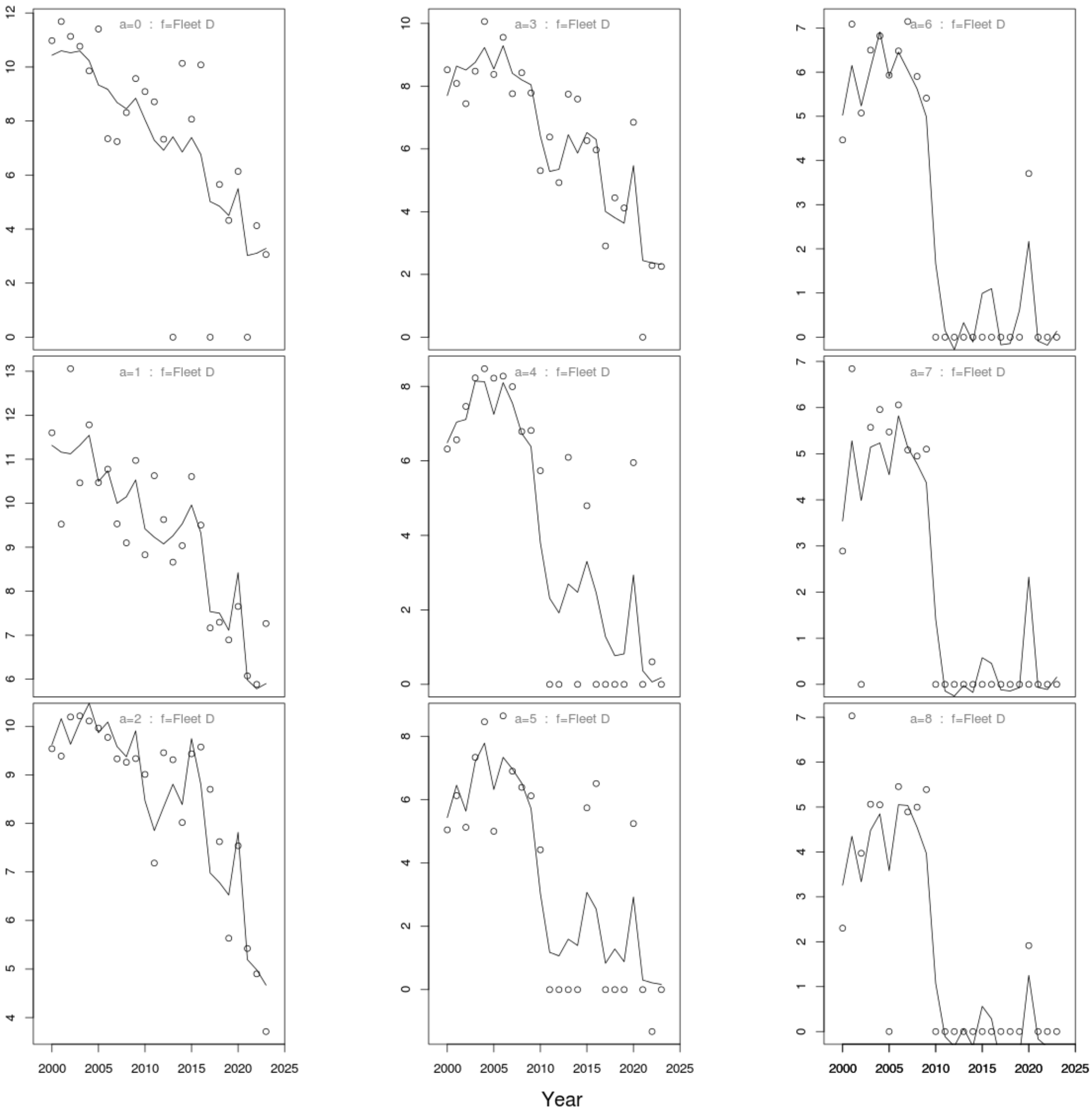
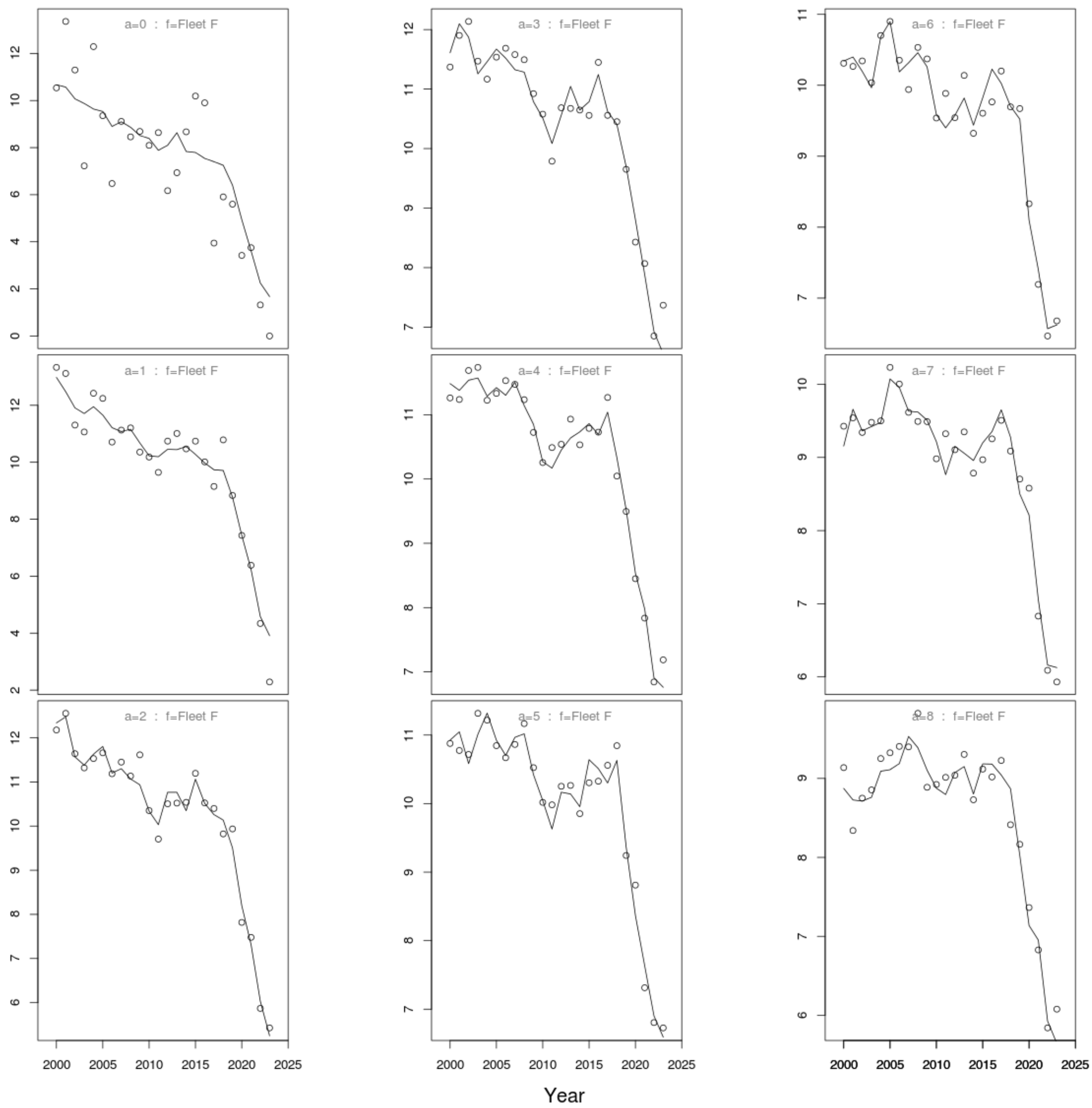


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.



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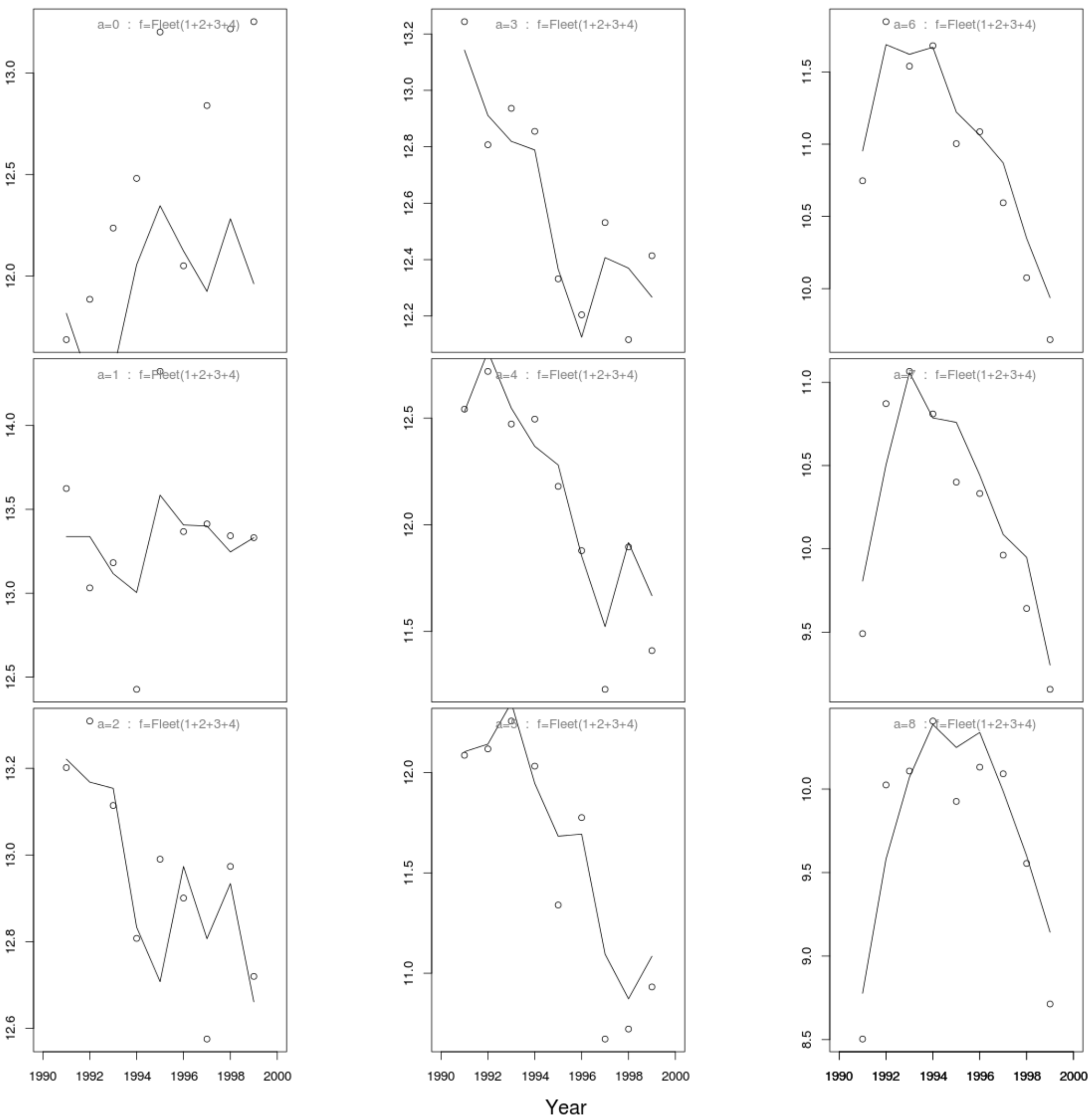

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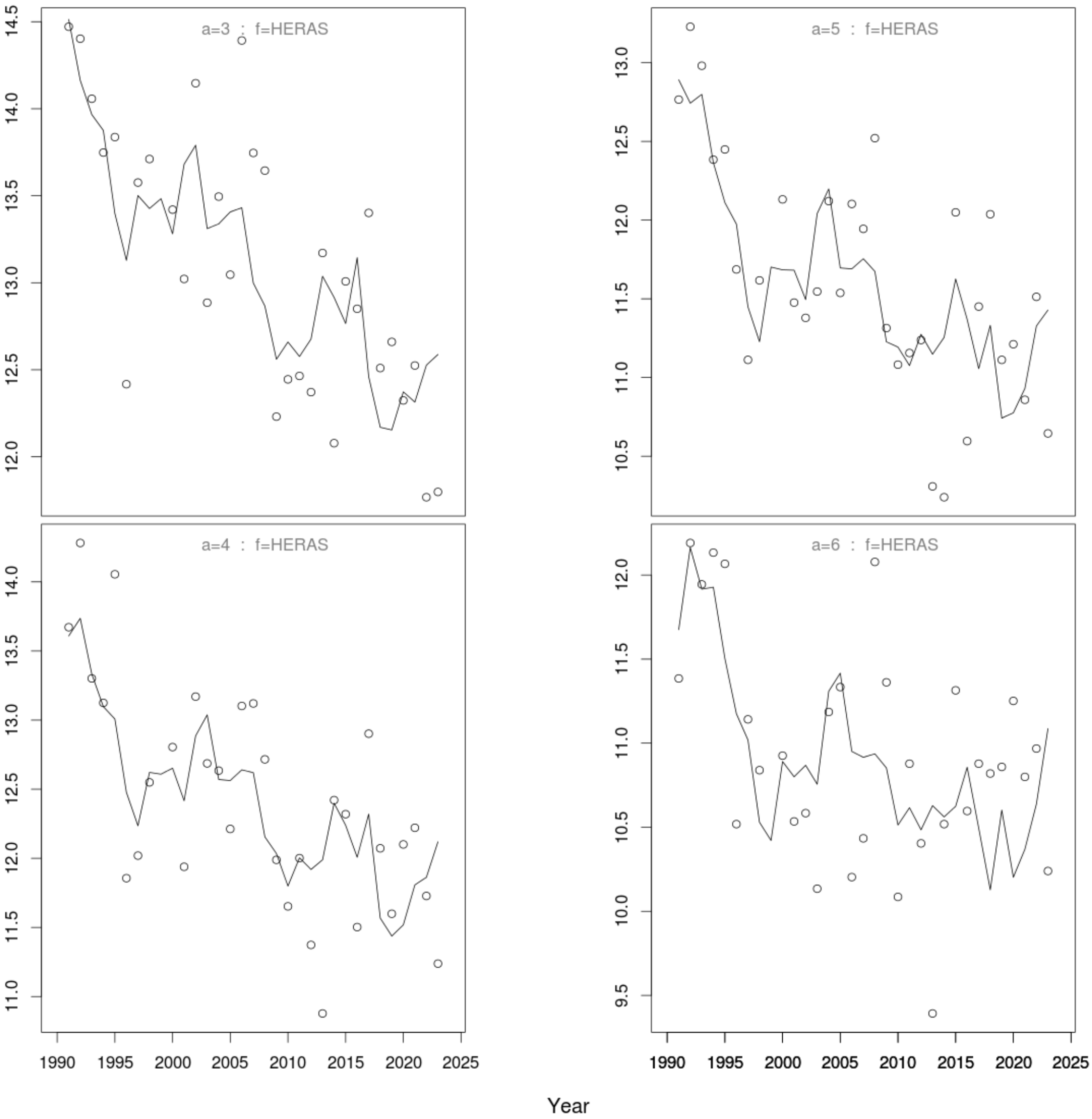

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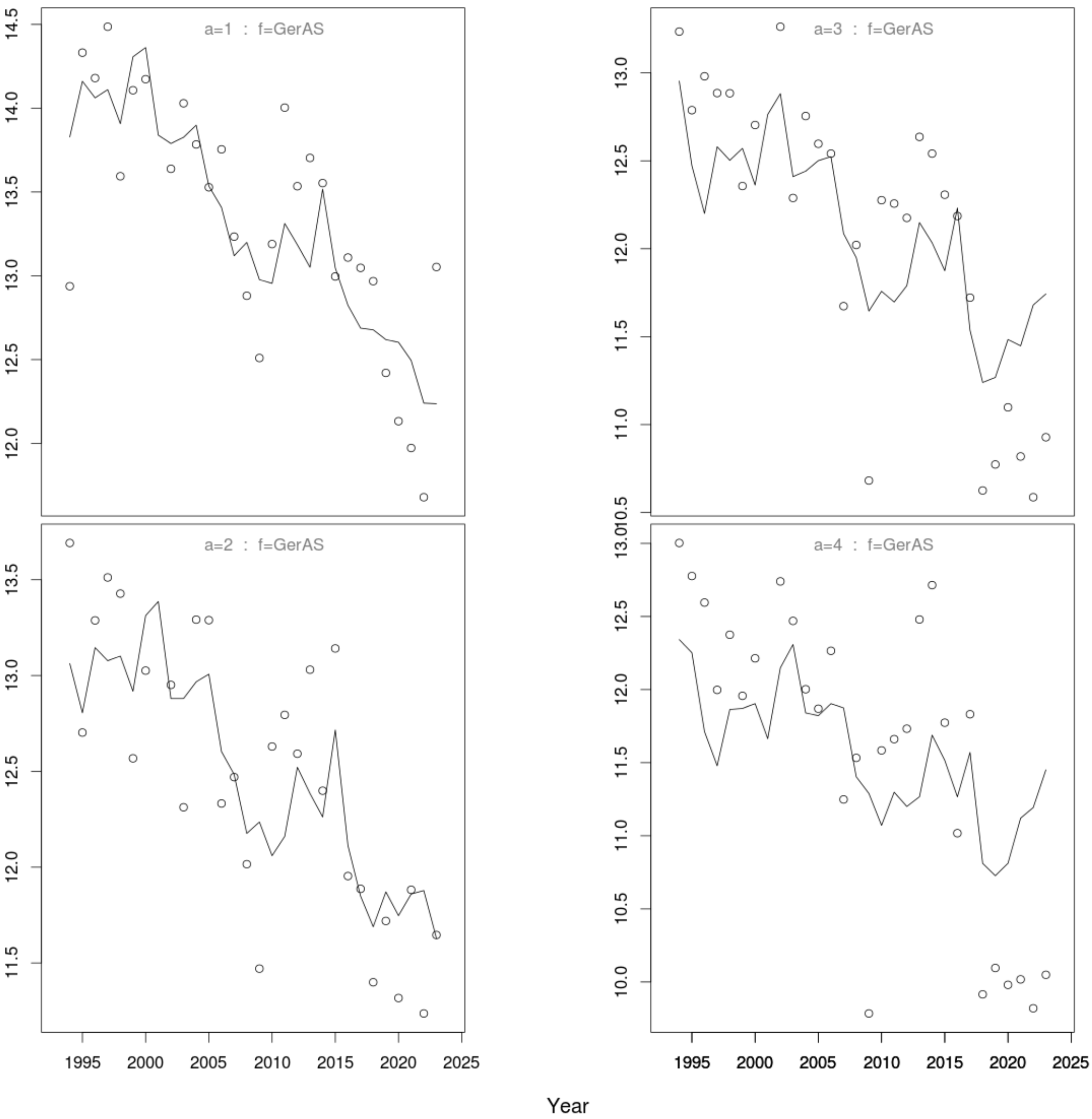

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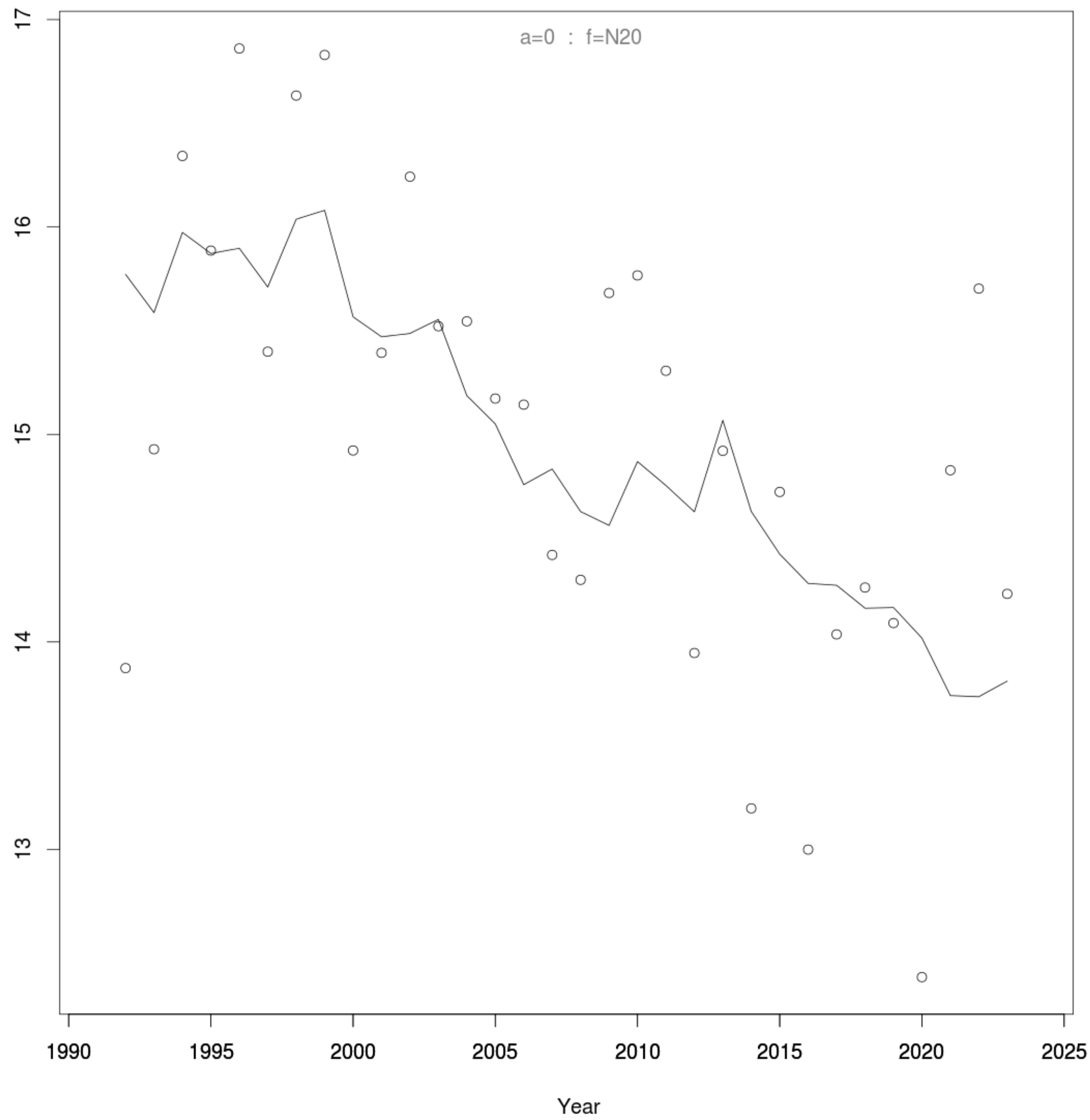

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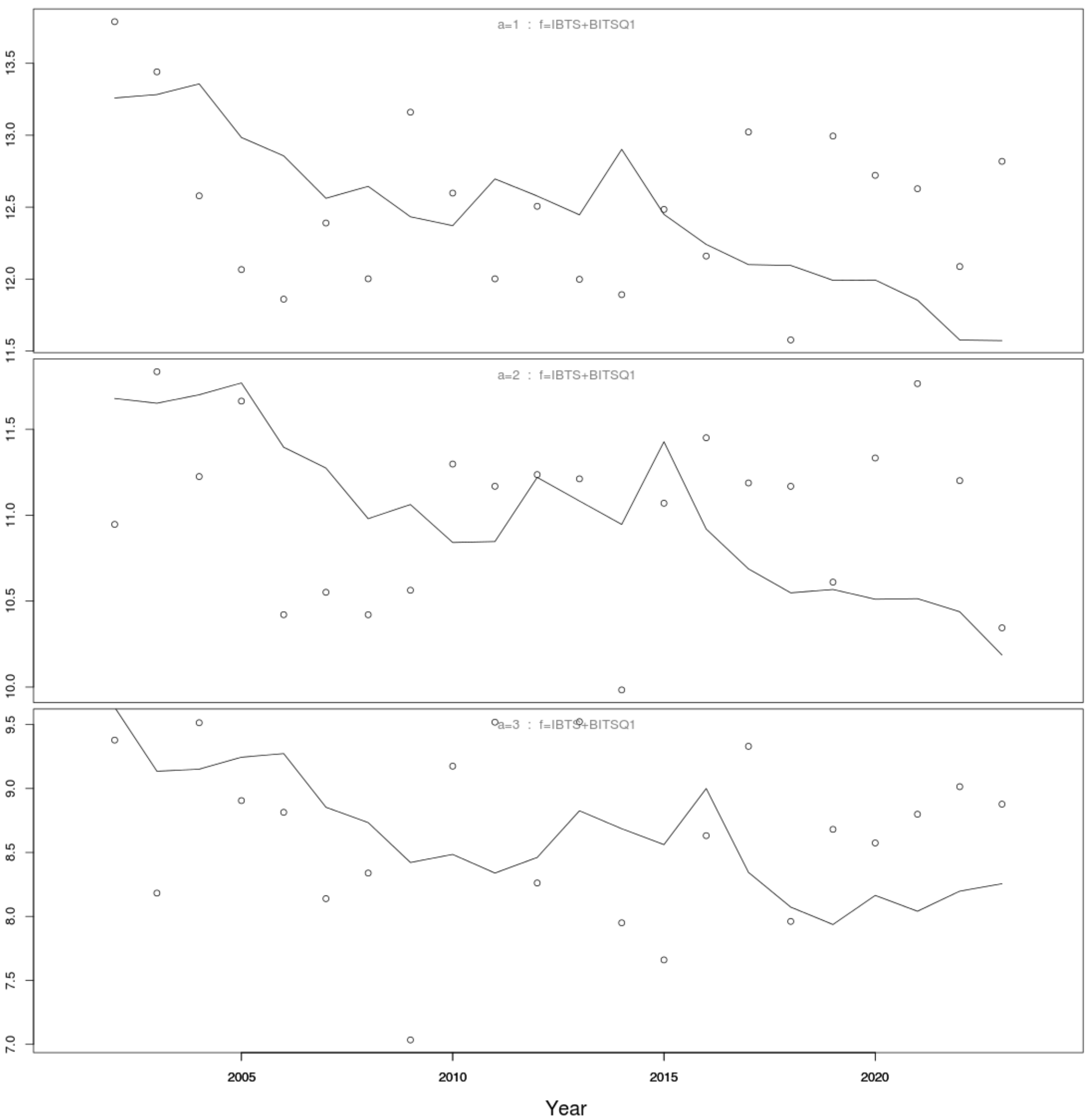

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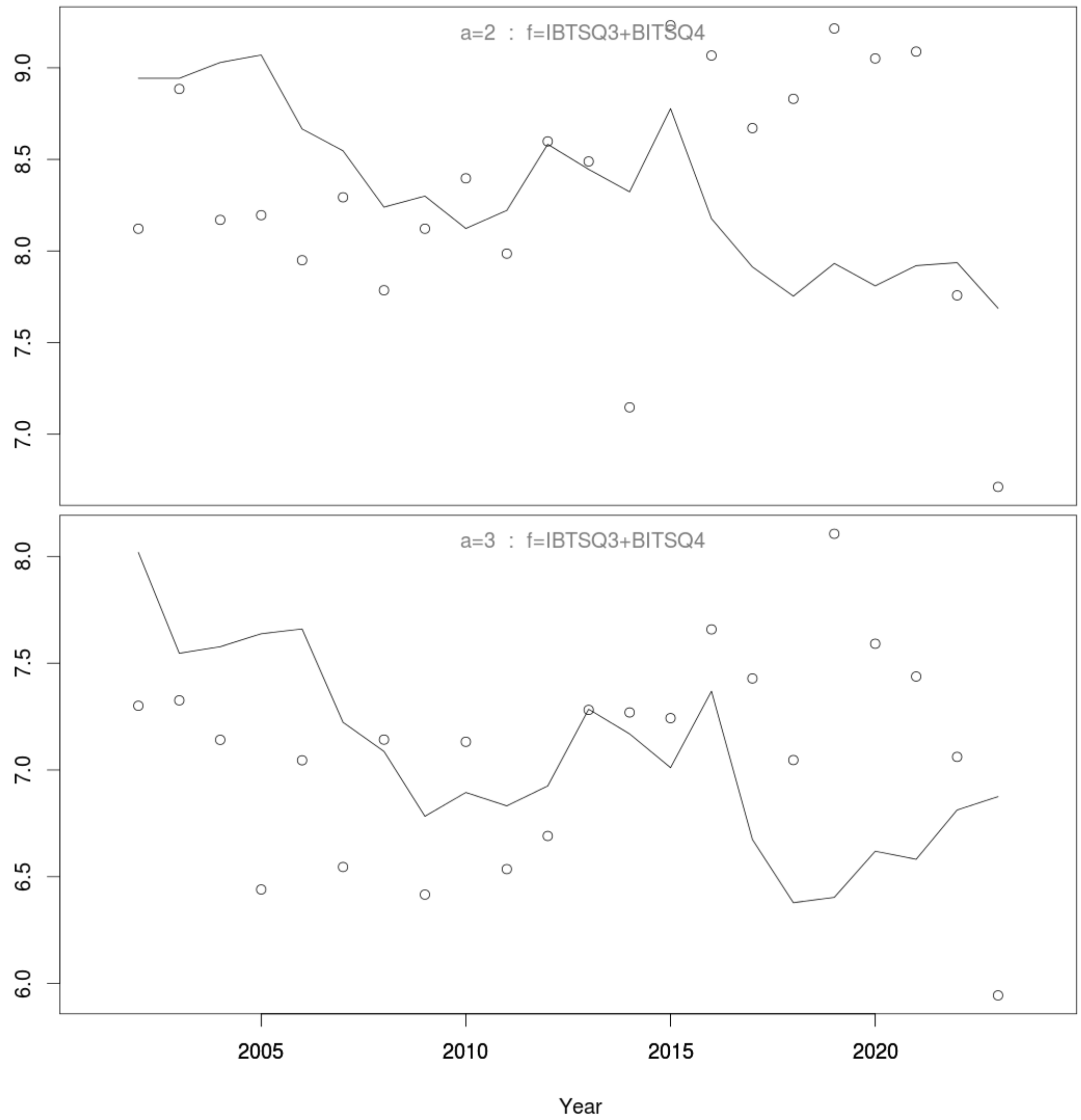

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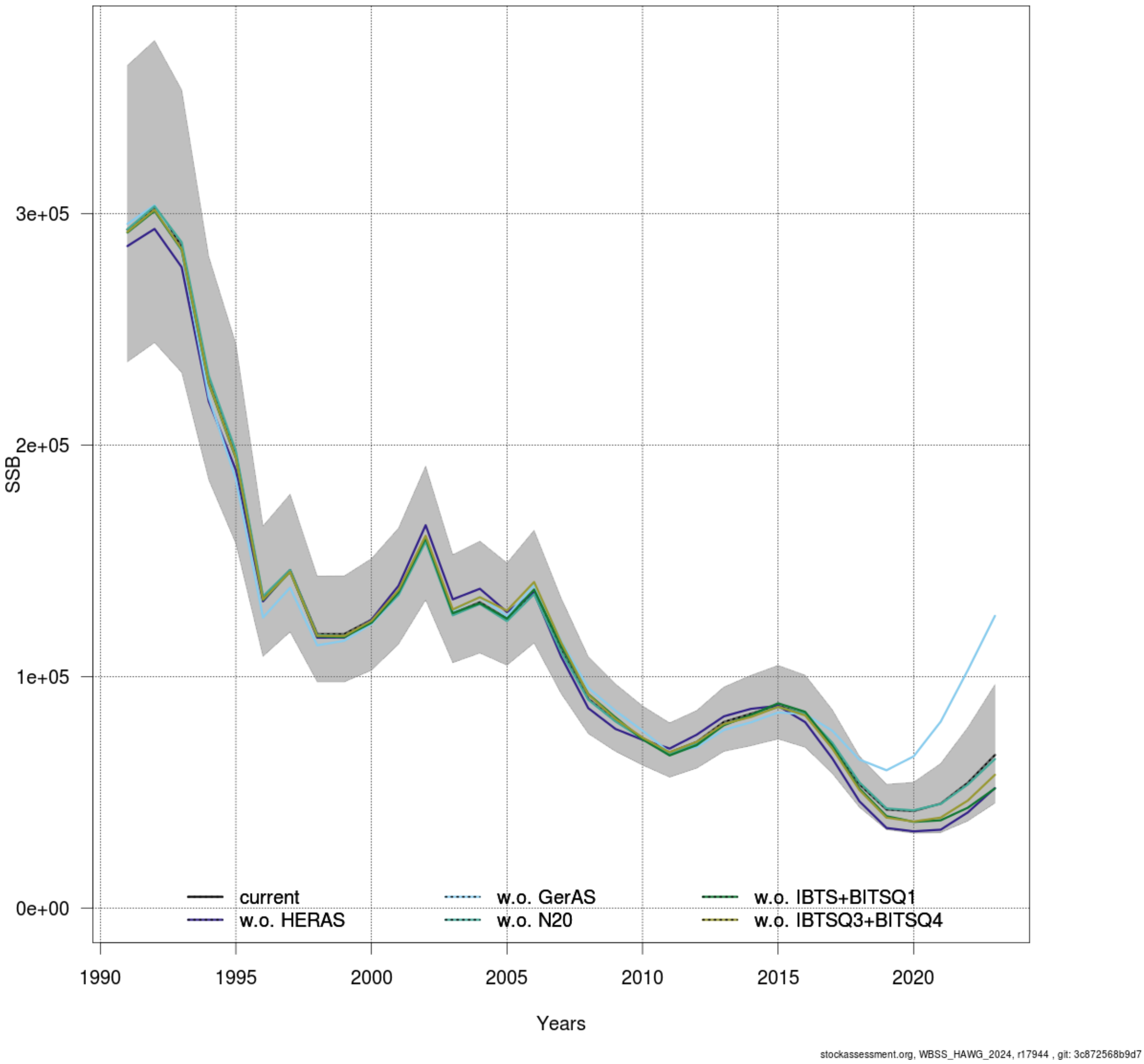
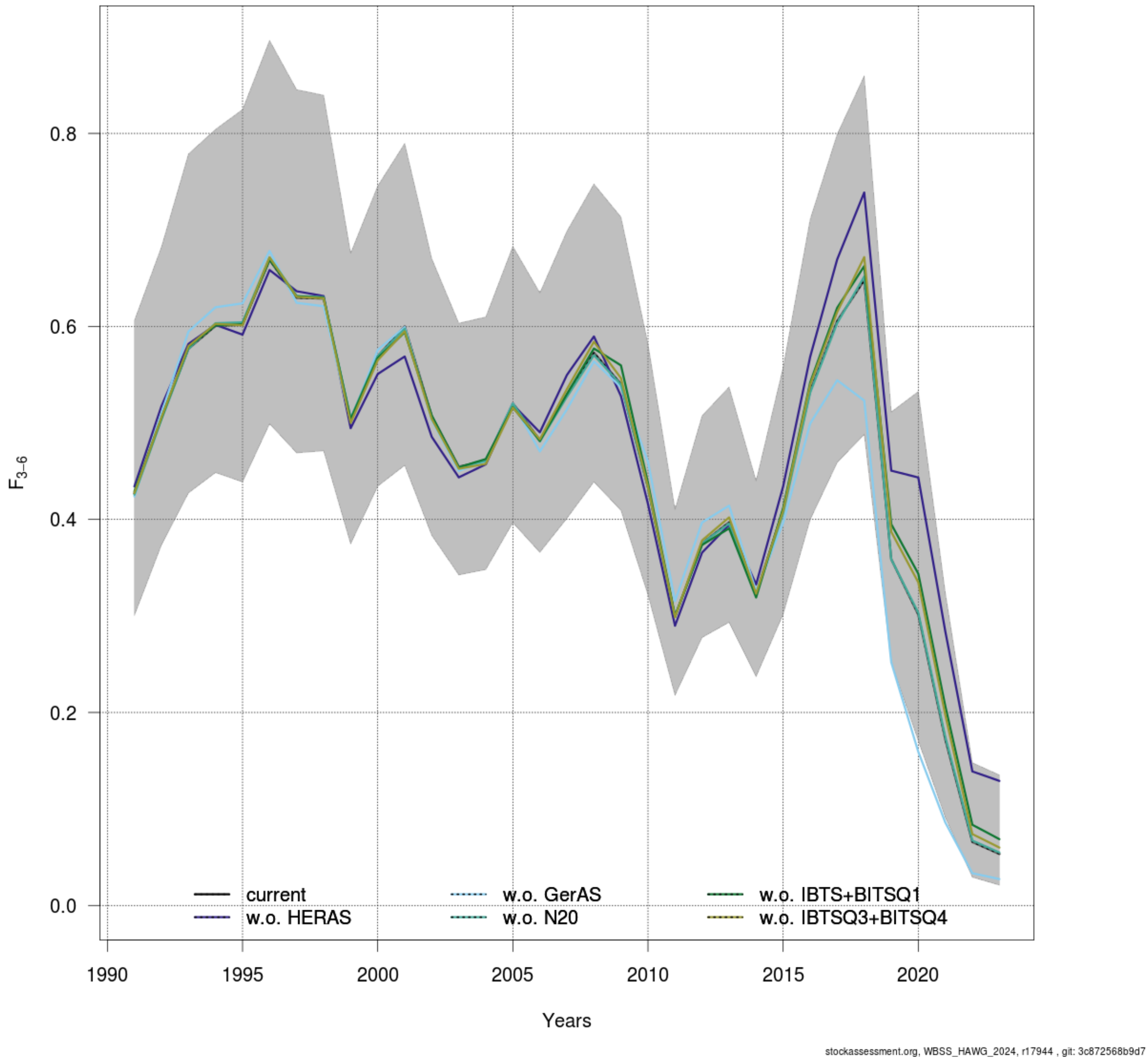


Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Spawning stock biomass.



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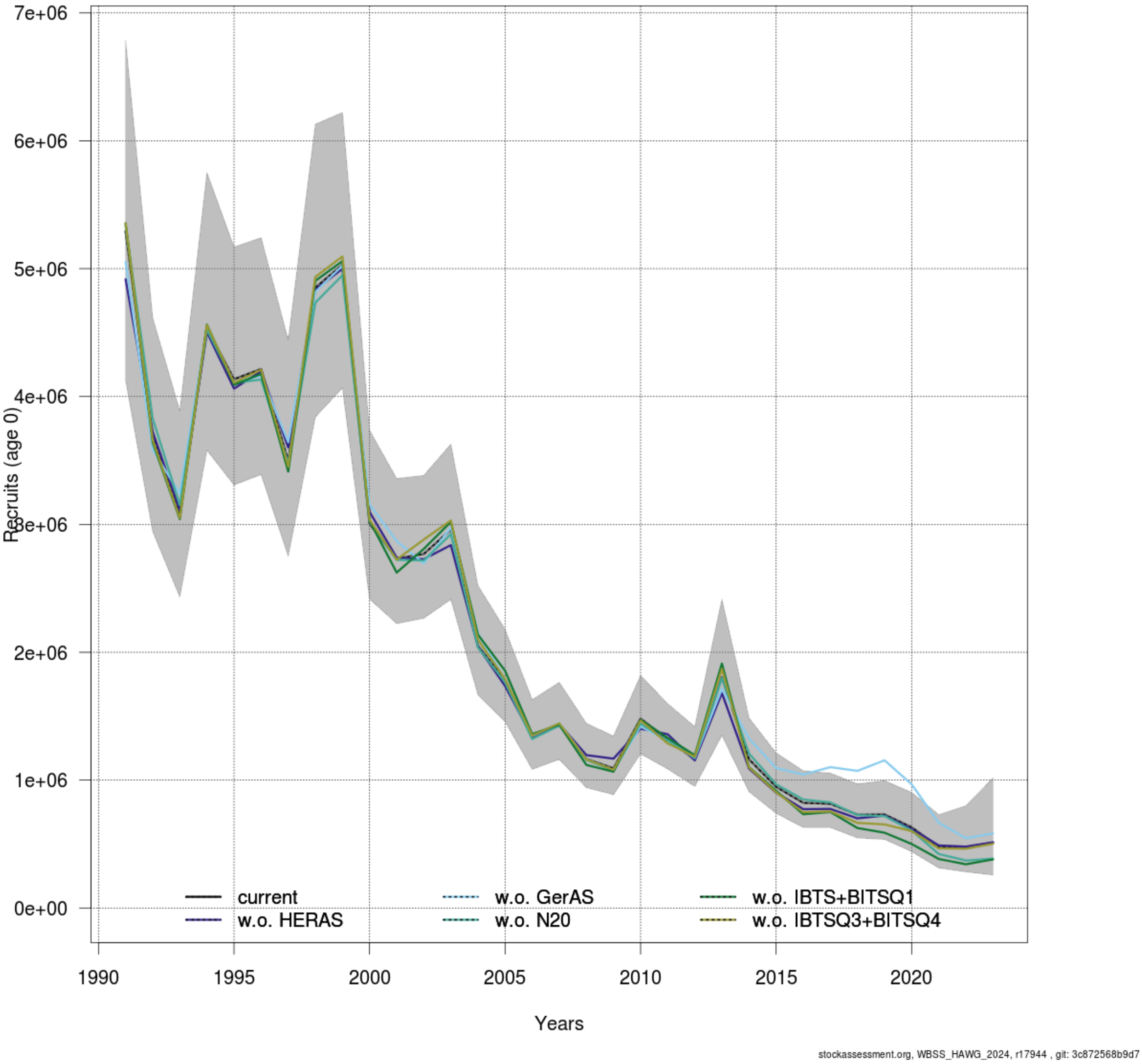


Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

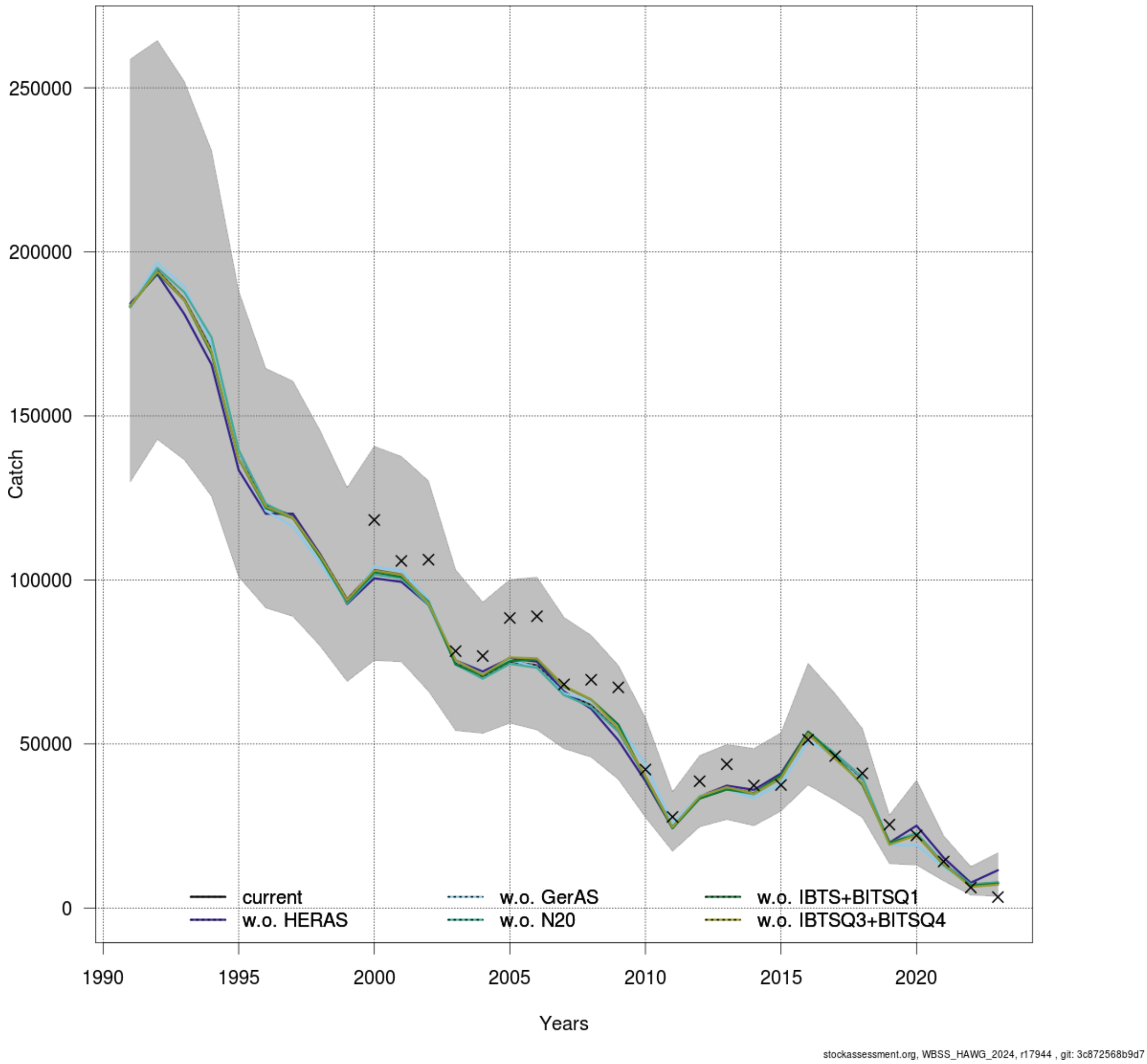
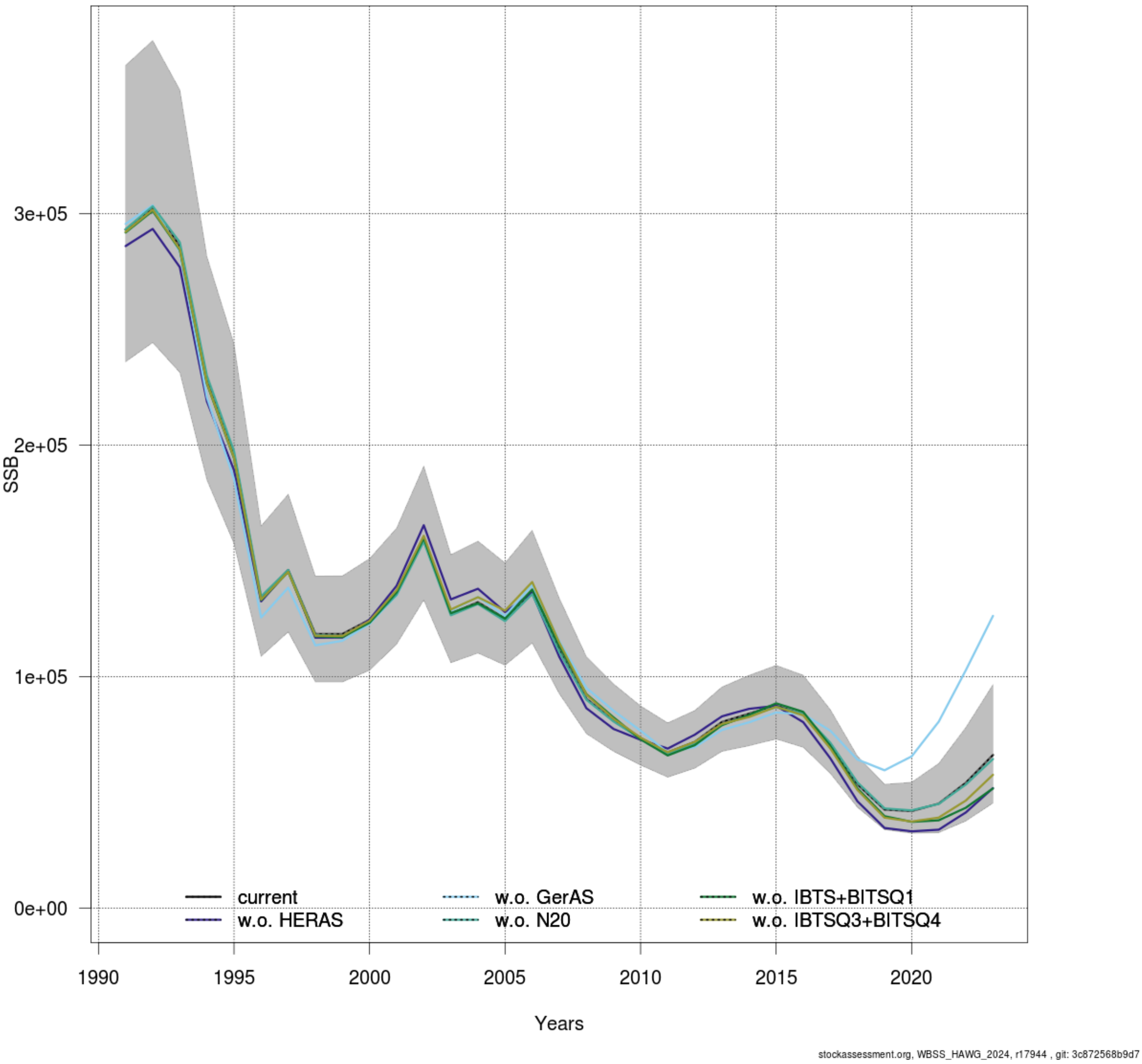


Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Catch.



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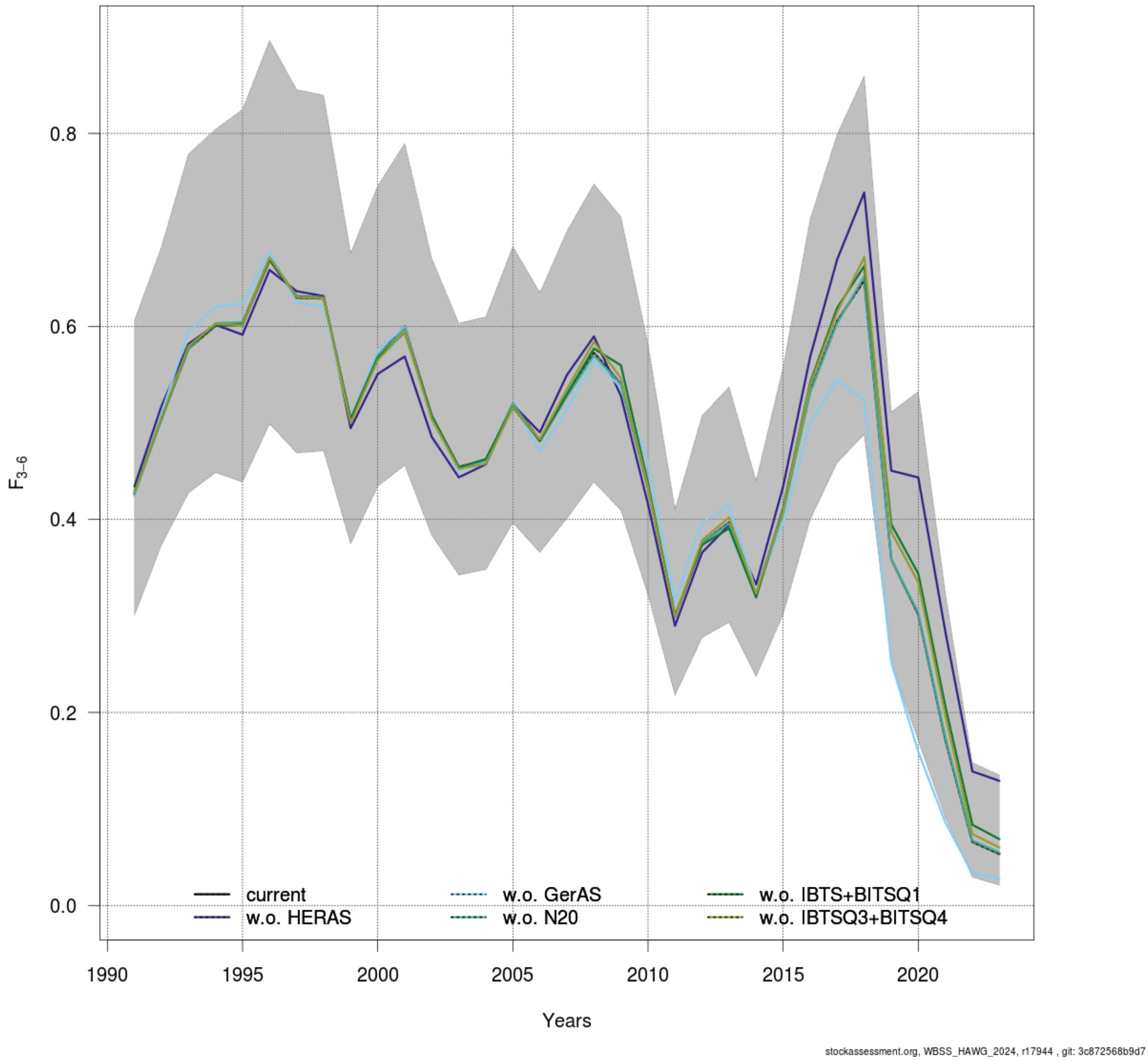


Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

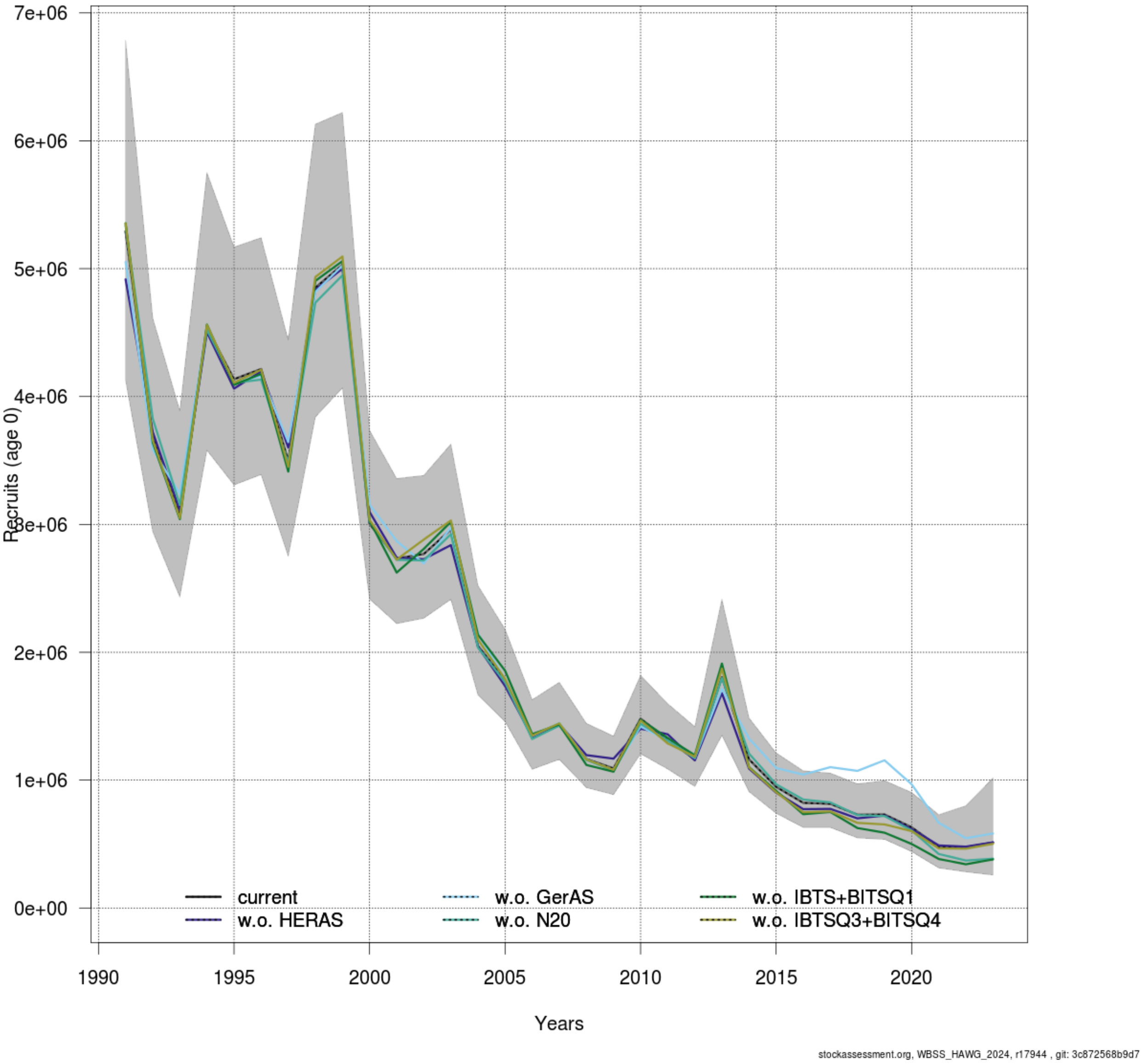
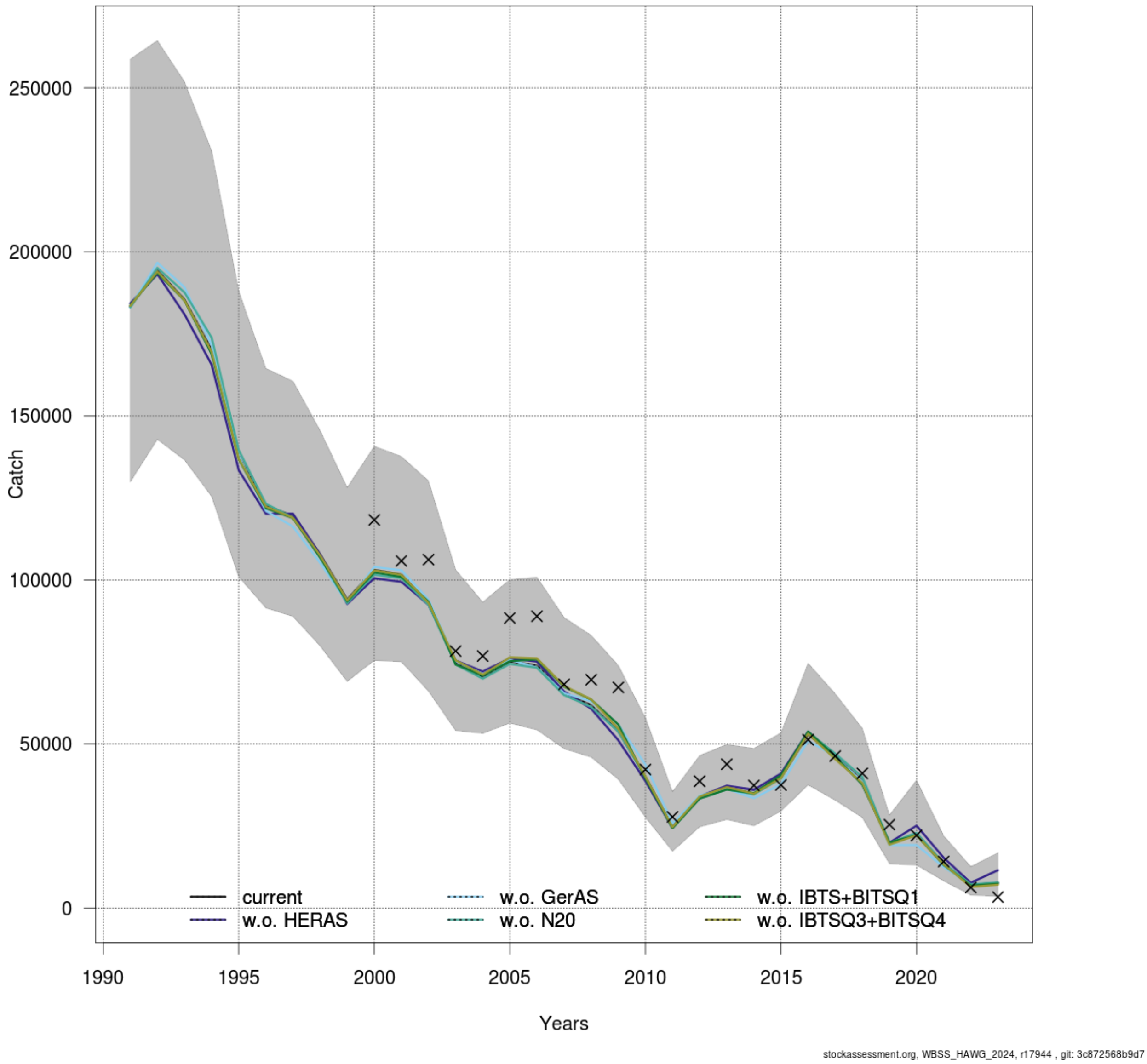


Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Recruitment.



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Contents

4 Herring (*Clupea harengus*) in Division 6.a (North), autumn spawners (West of Scotland)

Herring in Division 6.aN existed as a distinct management unit from 1982 to 2014. Following the WKWEST benchmark meeting (ICES, 2015a), this stock was combined with herring in 6.aS7.b-c, as the survey indices could not be successfully split between the two areas. From 2015 to 2021 the two stocks were assessed together as a meta-population (ICES, 2021b) despite continuing to be considered by HAWG as discrete stocks. Following recent genetic work (Farrell, *et al.*, 2021, Farrell, *et al.*, 2022), the survey indices have been successfully split, and the combined stock was separated back into its northern and southern components at the WKNSCS benchmark in 2022 (ICES, 2023a).

The location of the area occupied by the stock is shown in Figure 4.1. For assessment purposes this stock is considered as an autumn spawning stock only despite spring-spawning populations occurring in the area.

The Working Group (WG) noted that the use of the terms "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used, it is qualified in brackets with one of the ring designations. It should be noted that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for the spring spawners. Further elaboration on the rationale behind this can be found in the relevant Stock Annex. It is the responsibility of any user utilising age-based data for any of these herring stocks to consult the Stock Annex and, if still in doubt, a relevant member of the WG.

4.1 The Fishery

4.1.1 Advice and management applicable to 2016–2024

ICES gave separate advice for herring in 6.aN up to 2015, and advice for the combined stocks between 2016 and 2022. After the WKWEST benchmarking process in early 2015 (ICES 2015a), the stocks (6.aN and 6.aS7.bc) were assessed together. The management plans in place for either stock were no longer applicable for the combined stocks. Considering both the low SSB and recruitment estimated for the combined stocks in recent years, ICES advised in 2016 that it was not possible to identify any non-zero catch that would be compatible with the MSY and precautionary approaches. Specifically, there were no catch options consistent with the combined stocks recovering to above B_{lim}, and consequently, ICES advised that the TAC be set at zero tonnes. In February 2016, the European Commission asked ICES to provide advice on a TAC of sufficiently small size to enable the ongoing collection of fisheries-dependent data and to continue the long-term catch-at-age dataset. ICES advised on a scientific monitoring TAC of 4840 t (with a TAC split of 3480 t to be taken in 6.aN and 1360 t in 6.aS7.bc; ICES, 2016g). Furthermore, the data should be collected in a way that (i) satisfied standard length, age, and reproductive monitoring purposes by EU Member States for ICES, and (ii) ensured that sufficient spawning-specific samples were available for morphometric and genetic analyses as agreed by the Pelagic Advisory Council monitoring scheme 2016 (Pelagic Advisory Council, 2016).

The European Commission set a monitoring TAC slightly higher than this advice, at 5800 t (TAC split of 4170 t in 6.aN and 1630 t in 6.aS7.bc (EU, 2016), and the same for 2017, 2018 and 2019 (EU, 2017; 2018; 2019). This was reduced for 2020 and 2021 to 4840 t, split of 3480 t in 6.aN and 1360 t in 6.aS7.bc (EU 2020; 2021).

Following the WKNSCS benchmark meeting in early 2022 (ICES 2023a), ICES returned to providing separate advice for herring in 6.aN, although now this advice only covers the autumn spawning population. In 2022 the ICES herring assessment working group used a category 3 *chr* rule for the first time to provide advice for catches in 2023 of 1,212 t (ICES 2022a).

4.1.2 Changes in the fishery

There have been no significant changes in the fishing technology of the fleets in this area in recent years. In 6.aN, the fishery has become restricted to the northern part of the area since 2006, focusing on the autumn spawning population. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially. In 6.aN there were three fisheries categories prior to 2016: (i) a Scottish domestic pair trawl fleet and the Northern Irish fleet; (ii) the Scottish single boat trawl and purse-seine fleets; and (iii) an international freezer-trawler fishery.

Since 2016 the fishery has been restricted to a monitoring fishery, with a TAC of 4170 t between 2016 – 2019, 3480 t between 2020 – 2022, 1212 t in 2023, and 1454 t in 2024. These are all significantly lower than the 2015 TAC of 22 690 t for 6.aN.

4.1.3 The monitoring fishery

In 2020, following a proposal from the pelagic fishing industry to ensure that commercial catches in 6.aN in 2020 were reduced to a minimum, the commercial fishing of herring was limited to sample hauls during the 6aSPAWN acoustic survey (see Section 4.3.11 in ICES 2021a; Mackinson *et al*. 2021). In total only 177 tonnes of herring were caught in 6.aN during 2020. Following continued concern over the poor state of the stock, the industry reiterated their wish to minimise commercial catches in 6.aN in 2021, proposing again that the only removal of herring from 6.aN should be limited to sample hauls during the 6aSPAWN survey (Mackinson *et al*. 2022). In 2021 1115 tonnes of herring were caught in division 6.aN. The low uptake of the monitoring TAC in 2020 and 2021 was due to a combination of the industry taking pro-active measures to avoid commercial catch when the stock is low, a change in management measures and difficulties in catching allocated monitoring quotas. In 2022 the results of the monitoring survey report suggested a near complete absence of herring in the survey area (see Section 4.3.11). Despite concerted searching, efforts to obtain a commercial catch of 6.aN herring as compensation for the monitoring survey were unsuccessful, so no commercial samples from fisheries directed at herring in 6.aN were available for use in assessment for 2020 or 2022. In 2023, combined catches of scientific sample hauls and catch of monitoring quota were 406 t.

4.1.4 Stock recovery plan

In 2018, the Pelagic Advisory Council submitted a revised proposed rebuilding plan for both 6.aN and 6.aS7.bc stocks combined which was reviewed by HAWG (ICES 2018a, Annex 9). However, the ICES ACOM considered that further quantitative evaluation would be required for this to be used as the basis for advice. ICES advice in 2019 stated *'ICES still considers it important to develop a stock recovery plan for herring in divisions 6.a and 7.b–c, but given the large changes in perception of the stock, fishing pressure and recruitment together with the continued uncertainty in the quality of the assessment, the requirement for a rebuilding plan (or plans) are considered to be better addressed during a full benchmark, anticipated for 2021'*. There is currently no specific stock recovery or other management plan in place for herring in 6.aN, although UK fisheries management plans are currently in development (as of spring 2024).

The provision of catch advice raises questions regarding how this quota will be utilised in relation to ongoing needs for scientific monitoring. In particular, whether and what kind of 'advice rule' (i.e. harvest control rule) could be established to support any plans for ongoing monitoring and the development of a rebuilding plan.

The rebuilding plan and development work previously undertaken under the auspices of the PELAC focus group and reviewed by ICES remains relevant, and could provide a starting place for future considerations for the 6.aN stock.

4.1.5 Regulations and their effects

The 4° meridian notionally divides the 6.aN stock from the North Sea stock. It is not clear if this boundary is appropriate, as it bisects some of the spawning grounds and genetic results show that 6.aN autumn spawning herring are genetically identical to North Sea autumn spawning herring (NSAS; Farrell *et al*. 2022). Historically, area misreporting is known to have occurred across the 4° boundary. The north–south boundary between 6.aN and 6.aS (the 56° parallel) is also unlikely to be appropriate, because it traverses the spawning and feeding grounds of 6.aS herring. Transboundary catches have occurred along this line in the past, although this has been less of an issue recently. A holistic stock structure workshop for herring in European waters would be required to address these issues.

With 6.aN quota being used to support industry-science survey work and monitoring fisheries, decisions regarding the limitations on quota allocation from available TAC have a bearing on the opportunities and extent of possible survey work and commercial catch sampling.

4.1.6 Catches in 2023

The WG's estimate of commercial removals from the stock is shown in Table 4.1.6.

4.1.7 Length frequency information

Length frequency information is available from commercial market sampling from 2014 to 2015 before the introduction of the monitoring TAC, and from commercial hauls under the monitoring TAC from 2016 to 2023 (Figure 4.1.7.1). In 2018, length frequency data from Dutch vessels were only collected to 1 cm bins, so all data were binned to this resolution for this year. In 2020 catches in 6.aN were reduced to a minimum and removals were limited to survey hauls only, therefore commercial length frequency data are not available for this year. In 2021 the length frequency data come from commercial hauls by the one vessel (*Chris Andra*) allocated monitoring quota. During 2022 there were no commercial hauls from the fishery and therefore commercial length data are not available for that year. Finally, in 2023 the length frequency data again came from commercial hauls by the one vessel (*Challenge*) allocated monitoring quota.

4.2 Biological composition of the catch

Catch and sample data by country and by period (quarter) in 2022 are detailed in Table 4.2.1. There were no further commercial samples made available to the WG from 2022 or 2023. Although the current assessment does not require data on numbers or weights at age in the catch, these data (where available) are detailed in Tables 4.2.2 and 4.2.3 and summarised in Figures 4.2.1 and 4.2.2. The allocation of age distributions to unsampled catches and the calculation of total international catch-at-age and mean weight-at-age in the catches were done following established raising methods. A detailed description of the process can be found in WD02 of HAWG

(ICES, 2017a). The principles described in that document were followed in 2023 as far as possible. The number of samples in recent years does not meet the requirements of the monitoring fishery as advised by ICES (ICES, 2016g), and caution should be applied when comparing trends in biological composition of the catch with other years when sampling was more comprehensive.

4.3 Fishery-independent Information

4.3.1 Acoustic surveys (A9481)

An acoustic survey has been carried out in Division 6.aN by Marine Scotland Science (now the Marine Directorate of the Scottish Government) during June and July each year since 1991. It originally covered an area bounded by the 200 m depth contour in the north and west, 4°W in the east and 56°N in the south, and it had provided an age-disaggregated index of abundance as the sole tuning index for the analytical assessment of 6.aN herring since 2002. In 2008, it was decided that this survey should be expanded into a larger coordinated summer survey on the recommendation of the ICES WESTHER, HAWG and SGHERWAY groups (Hatfield *et al.*, 2005; ICES 2007; ICES, 2010). The Scottish 6.aN survey was augmented with the participation of the Irish Marine Institute and the area was expanded to cover all of ICES Divisions 6.a and 7.b. The Malin Shelf Herring Acoustic Survey (MSHAS), as it is now known, has covered this increased geographical area in the period 2008 to 2023 as well as maintaining coverage of the original survey area in 6.aN. Genetic work (Farrell *et al*., 2021, 2022) has allowed estimates from this survey to be split between populations (ICES, 2023b), but these splits only go back to 2014.

The Malin Shelf herring estimate of SSB for autumn spawning herring in 6.aN in 2023 is 22 463 tonnes and 160 million mature individuals (Table 4.3.1, Figure 4.3.1.1), both decreasing from the estimates in 2022. Although SSB and abundance appear to be greater than the minimum values in 2019, it should be noted that numbers of herring to the West of Scotland are very low compared to historical estimates prior to the 2014 genetic split (ICES, 2021a).

Herring has in the past been found in high densities to the east of the 4°W line in association with a specific bathymetric feature. The occurrence of these herring west of the line in some years has the ability to strongly influence the annual estimate of abundance of the Malin Shelf/West of Scotland estimates. There is some evidence that this was the case in 2019. It appears that the increase in the 2017 and 2018 estimates compared to 2016 were a result of a greater spread in the distribution of herring rather than distributions occurring around the 4°W line. The stock in 2023 is dominated by 2-winter ringers (41.93% of the abundance from the 2021 year class). Age disaggregated survey abundance indices for 6.aN autumn spawning herring since 2014 are given in Table 4.3.2 and displayed in Figure 4.3.1.2.

The stock is highly transient in its spatial distribution, which explains some of the high variability in the time-series. The survey covers the area at the time of year when aggregations of herring from both the 6.aN and 6.aS7.b–c stocks are feeding offshore (i.e. not at spawning time). These distributions of offshore herring aggregations are considered to be more available to the survey compared to surveying spawning aggregations, which aggregate close to the seabed and are generally found inshore in areas unsuitable for the large vessels carrying out acoustic surveys. Genetic analyses outlined in Farrell *et al.*, 2021 split these indices into 6.aN autumn spawning herring and 6.aS7b-c winter spawning herring for use in assessments.

4.3.1.1 Industry–Science Acoustic survey (6aSPAWN)

Since 2016, an industry-science acoustic survey (6aSPAWN) of herring during the autumn spawning season has been undertaken in conjunction with the monitoring fishery (see Section

4.1.3). The aim of the survey and sampling undertaken from the monitoring fishery is to maintain and improve the knowledge base of the genetic identity of herring stock components in 6.aN, and to provide an age-disaggregated acoustic abundance index to assist in assessing the herring stocks and establishing a rebuilding plan.

Following the guidance arising from WKHASS (ICES, 2020c), from 2020 onwards the survey area has focused on two principal spawning areas (Figure 4.1.3.1), with the timing planned to coincide with the known spawning period. Strata 1 and 2 correspond to regions that have been covered consistently since 2016. Refocusing the survey to these new strata has resulted in a more consistent survey time-series (Mackinson and Berges, 2022).

In 2023, the survey was limited to one Scottish vessel. Marks of herring were considerably more abundant than in the previous two years, particularly in Strata 1 where they are typically seen in greater numbers. Mackerel were present throughout the survey area and some sprat marks were also detected. Herring marks were successfully sampled although none were determined to be spawning or likely to spawn within a few days. Genetic samples were taken for later analysis, but because no spawning ready or spawning fish were present in samples, no genetic identity baseline samples are available from 2023. Two commercial catches of 6aN herring were taken by the vessel a few days after the survey, with one catch in each strata, providing two commercial samples for use in assessment. Full details of the survey can be found in the ICES WGIPS 2024 report (in prep) and Mackinson *et al.* (2024), who conclude that the 2023 survey:

(i) Contained a significant part of the area where herring spawn in 6aN during autumn. Limited searching indicated that herring may also have been present slightly NW of the survey area.

(ii) Was limited in the period of observation in relation to the extended period that herring may potentially spawn, but the timing of the survey was consistent with previous observations of herring aggregating in this area and in condition for spawning.

(iii) Provides a reliable estimate of the minimum biomass of mature herring at age observed in survey areas during the survey period.

4.4 Mean weight-at-age, maturity-at-age and natural mortality

4.4.1 Mean weight-at-age

Weight-at-age in the stock are obtained from the genetically split acoustic survey and are given in Table 4.3.1 (for the current year) and Table 4.4.1.1 (for the time-series). The weights-at-age in the stock have shown a slight overall decrease since 2014 (Figure 4.4.1.1). Weights-at-age in the catches are presented in Table 4.2.3, although these were not available to the WG for 2022 and 2023. There have been fluctuations in catch weights over time. In several years no one-winter ring fish have been taken in the 6.aN fishery.

4.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 4.4.2.1). The genetically split MSHAS provides estimated values for the period 2014 to 2023, but in some years no estimates are available at younger ages.

4.4.3 Natural mortality

The natural mortality (M) used in previous assessments of several herring stocks to the West of Scotland, including 6.aN, was based on the results of a multispecies VPA for North Sea herring calculated by the ICES multispecies working group in 1987 (ICES, 1987). From 2012 onwards the assessment of North Sea herring has used variable estimates of M-at-age derived from a new multispecies stock assessment model (SMS), used in WGSAM (Lewy and Vinther, 2004).

The 2015 benchmark meeting for herring in Division 6.a and 7.b–c (ICES 2015a) agreed to use the natural mortalities for North Sea herring from the current North Sea multispecies model, as these were deemed the best available proxy for natural mortality of herring in 6.a and 7.b–c. The input data to the assessment of herring in divisions 6.a and 7.b–c were averaged annual M values from the 2011 SMS key run (period 1974–2010) for each age. This approach was similar to the pre-benchmarked assessment in that it was time-invariant and age-variant. This time-series reflected the most recent period of stability in terms of M from the North Sea SMS, as it excluded the gadoid outburst of the 1960 which was thought to be of little relevance to present day conditions.

In 2020, the SMS model from the North Sea was updated (ICES, 2021e), and new values for natural mortality became available (Table 4.4.3.1). At the latest WKNSCS benchmark (ICES, 2023a) it was agreed that these values were the most suitable for herring in 6.aN. For the Category 3 advice method, the value of M was taken from ages 3-6.

A more detailed explanation regarding the natural mortality estimates can be found in the Stock Annex.

4.5 Recruitment

There are no specific recruitment indices for this stock. Although both the catch and the surveys generally have some catches at 1-wr, both the fishery and survey encounter this age group only incidentally. The first reliable appearances of all cohorts occurs at 2-wr in both the catch and the surveys.

4.6 Assessment of 6.aN autumn spawning herring

The assessment presented here follows the procedure agreed by the benchmark in 2022 (ICES, 2023a) supplemented with stock-specific simulation work to update $F_{\text{proxy MSY}}$.

4.6.1 Data Exploration

For Category 3 stocks, advice is provided using biomass or abundance trends-based assessments. The latest ICES guidance on applying these methods recommends that a Surplus Production in Continuous Time model (SPiCT, Pedersen and Berg, 2017) should be attempted first. If an acceptable SPiCT model is not possible, other data-limited approaches should be attempted, based on the von Bertalanffy growth parameter *k* for the population being assessed (ICES, 2021g).

A SPiCT model using various model settings was attempted for herring in 6.aN at the 2022 benchmark, but no suitable model could be developed for this stock (ICES, 2023a). Correspondingly, following the recommendations of WKLIFE, (ICES, 2021g), the growth parameter *k* was calculated and used in the relevant Category 3 calculation (see below).

At the benchmark meeting in 2022, length-at-age data from the commercial fishery were not available for the calculation of growth parameters, and the calculations were done using the biological data from the acoustic survey. Biological data from the 6.aN genetically split acoustic survey were extracted from DATRAS and analysed to calculate k and asymptotic length (ICES, 2023a). These fish are 6.aN autumn spawning herring (compared to catch/IBTS data where genetic samples are not available). Guidelines indicate that calculations of growth parameters should come from commercial data (ICES, 2021g), and this calculation was updated for HAWG in 2022 (ICES, 2022a).

Von Bertalanffy growth parameters were calculated from the combined commercial data for autumn spawning herring in 6.aN from 2000-2021 (Figure 4.6.1), and gives an estimated L_∞ value of 30.51cm and an associated k value of 0.335. Given that $0.32 \le k \le 0.45$, the Constant Harvest Rate (*chr*) rule was used to provide advice.

4.6.2 Assessment

The *chr* rule applies a constant harvest rate ($F_{MSY\ proxy}$ calculated from catch length frequency data) that is considered a proxy for the MSY harvest rate and applies this to the biomass index. This rule is being applied using the genetically split acoustic survey index, so runs from 2014 onwards. The F_{MSY} proxy used in applying this rule is calculated from the length frequency data. Therefore, this value remains constant after the initial implementation year (ICES, 2022a) and should not change unless there are significant changes to the fishery.

The F_{MSY} proxy is calculated as the average of the ratio of catch C to the biomass index I, calculated across all years for which mean length/target reference length > 1. The target reference length is usually calculated using the following equation:

$$L_{F=M} = \left(0.75 \times L_{C(y)}\right) + (0.25 \times L_\infty).$$

This calculation assumes that the M/k ratio is equal to 1.5. When the actual M/k ratio is calculated for 6.aN herring the value comes to 0.65, which is considerably different to the assumed value. Using the assumed method with an M/k ratio of 1.5 would suggest a natural mortality estimate of 0.51 for herring in 6.aN. This value contrasts with the values taken from the 2020 SMS key run. ICES technical guidelines (ICES, 2018a) state that stock specific M/k values can be applied by using an alternative $L_{F=M}$ calculation from Jardim *et al*. (2015). Utilising this alternative method for calculating the target reference length was approved at the benchmark meeting in 2022 (ICES, 2023a), and the following equation is therefore applied:

$$L_{F=\gamma M, K=\theta M} = \theta L_\infty + \frac{1}{\theta} L_c(\gamma + 1) + \gamma + 1.$$

4.6.2.1 Calculation of Constant Harvest Rate (*chr*)

The *chr* rule applies a constant harvest rate ($F_{MSY\ proxy}$) that is considered a proxy for an MSY harvest rate and applies this to the biomass index (genetically split MSHAS). As per the WKLIFEX (ICES, 2021g) report, advised catch (C_{y+1}) is calculated as follows:

$$C_{y+1} = I_{y-1} F_{MSY\ proxy} bm$$

Definitions of the components are presented in Table 4.6.2.1.

4.6.2.2 Target Harvest Rate

Prior to this year, $F_{proxy\ MSY}$ was calculated as per the WKLIFEX methodology (but using an alternative LF=M equation, as per Jardim et al. (2015), to account for the specific M/k value of the stock). However, due to the relatively short time-series available for the split survey index and the fact that catches were constrained by the monitoring TAC in most of those years, the resulting $F_{proxy\ MSY}$ was unusually low and led to apparently inconsistent advice with the neighbouring 6.a North stock. Stock-specific simulation work was therefore undertaken to estimate a more appropriate proxy harvest rate for the stock. The methods followed were largely informed by Fischer et al. (2022), who used a simulation-based approach "as an optimisation procedure to tune the parameters of the control rule to meet maximum sustainable yield and precautionary management objectives." The FLife R package was used to condition operating models (OMs) for both herring stocks in ICES Area 6.a (i.e. 6.aN and 6.aS), simulating FLBRP (equilibrium biological reference point) objects based on life-history parameters. The majority of the life-history parameters used for this simulation exercise were empirically derived, using stock-specific data, or, where appropriate parameters were already available, from stock annexes. Full details of the methodology and results were presented to HAWG in a WD (see report annexes) and were favourably reviewed by two external reviewers.

On the basis of the simulation work, $F_{proxy\ MSY}$ is now set at 0.28 (as opposed to 0.335 previously).

4.6.2.3 *chr* results

Using these estimates the formula gives:

$$C_{y+1} = 22463 \times 0.335 \times 1 \times 0.5 = 3768 \text{ tonnes.}$$

Under WKLIFE guidelines (ICES, 2021g), a stability clause of +20% and -30% is recommended relative to the previous year's advised catch. When the stability clause is applied, the advised catch for herring in 6.aN under the *chr* rule is **1745 tonnes**.

4.6.3 Final Assessment for 6.aN autumn spawning herring

In accordance with the method set out in the Stock Annex, the final assessment of 6.aN autumn spawning herring was carried out using the Constant Harvest Rate (*chr*) rule. This corresponds to the approach agreed at the 2022 benchmark (ICES, 2023a).

4.6.4 State of the stock

Fishing mortality has been reduced since the introduction of zero-targeted catch advice and the monitoring TAC in 2016. SSB remains at very low levels relative to the long term trend, despite some overall improvement since 2019. Recruitment has been low, with no big cohorts evident in recent years. Recent catches have been among the lowest in the time-series.

4.7 Quality of the Assessment

This assessment is for herring in 6.aN only, following seven years of a combined assessment with herring in 6.aS and 7.b-c. Unlike prior assessments for 6.aN herring, this assessment only includes the Cape Wrath autumn spawning component, as the spring spawning component in the Minch and elsewhere in 6.aNcannot currently be separated in the acoustic index using genetic information. Further information on this population of herring is detailed in Section 8.2 of this report.

Herring in 6.aN had been under zero advice and a monitoring TAC during 2016-2022 under the combined assessment. Despite an increasing trend in recent biomass estimates, the survey biomass for this stock remains at low levels compared to historical values.

Work on genetic stock identity and spawning distributions of herring conducted under the EASME project was used in the ICES Benchmark Workshop on North Sea and Celtic Sea stocks (WKNSCS, ICES 2023a) to split 6a.N autumn spawning herring and 6a.S,7bc winter spawning stocks based on their genetic identity determined from 'baseline' samples taken during spawning periods (Farrell et al. 2021, 2022). Results also showed that 6aN autumn spawning herring are genetically indistinguishable from North Sea autumn spawning herring and that uncertainties remain about the genetic composition of stocks in 6a.N during autumn. In particular, results from the EASME project were not able to differentiate 6a.N spring spawning fish from late-spawning 6a.S fish. The consequence of this is that these genetically distinct components currently sit outside of the assessment and are not accounted for in the estimation of herring abundance West of Scotland (WoS). Analysis of acoustic data undertaken as part of the international HERAS survey, and used in herring stock assessment, quantifies that this population may be of a similar size to the 6aN autumn spawning component (see 'her-67bc' in Figure 1) (O'Malley et al. 2022).

4.8 Management Considerations

The assessment for herring in 6.aN includes only the autumn spawning component around Cape Wrath. The spring-spawning herring in the Minch area and elsewhere in 6a.N have not yet been split out from the acoustic survey and are therefore not currently assessed by HAWG.

Recruitment of the autumn spawning component in 6.aN has been at a low level since 1998, and even lower since 2013. There is almost complete absence in the stock of 7, 8, and 9+ winter-ring fish in both the catches and the acoustic survey in recent years

The survey index across the whole MSHAS has been steadily decreasing since 2008 (ICES, 2023b). Although the estimates in recent years for autumn spawning 6.aN herring indicate increases compared to 2019, the stock remains at very low levels compared to long term trends.

A monitoring TAC of 4170 t was implemented from 2016-2019, and reduced to 3480 t during 2020 and 2021. In 2022 the TAC level was reduced to 1212 t following the implementation of the ICES Category 3 *chr* rule. In 2023 the TAC was increased again to 1454 tonnes, although this was capped at +20%.

4.9 Ecosystem Considerations

Herring constitute one of the highest biomasses of forage fish to the west of Scotland and Ireland, and are thus an integral part of the ecosystem. As a dominant planktivore, herring link zooplankton production with higher trophic level predators, including fish, sea mammals and birds. Ecosystem models of the West of Scotland (Bailey *et al*., 2011; Alexander *et al*., 2015) show herring to be an important mid-trophic level species, along with sprat, sandeel, and horse mackerel. They can also predate on other fish species through consumption of fish eggs at certain times of year (ICES, 2014a). For example, work using length-based ecosystem modelling suggests a link between herring and cod biomass in the North Sea (Speirs *et al.*, 2010), via the predation of cod eggs by herring.

As herring constitute an important part of the overall biomass of planktivorous and forage fish in the west of Scotland and Ireland ecosystem, impacts from changes in productivity from environmental drivers are likely to be widely felt.

4.10 Changes in the Environment

Temperatures in this area have been increasing over the last number of decades, and there are indications that salinity is also increasing (ICES, 2006) which may have implications for herring. For example, temperature increases and a positive AMO (Atlantic Multi-decadal Oscillation) index are thought to be related to drops in weight-at-age in Celtic Sea herring (Lyashevska *et al*, 2020). However, the potential impacts on herring in 6.aN are uncertain.

4.11 Tables and Figures

Table 4.1.6. Autumn-spawning herring in Division 6.aN. ICES estimated landings by country and total catches. Units: tonnes

Year	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Lithuania	Norway	UK	Unallocated	Discards*	Total	Area misreported	ICES estimate
1992	0	0	119	5640	7985	8000	0	2389	32730	-5485	200	51578	-22593	28985
1993	0	0	818	4693	8236	6132	0	7447	32602	-3735	0	56175	-24397	31778
1994	0	274	5087	7938	6093	8183	0	30676	-4287	700	0	54664	-30234	24430
1995	0	0	3672	3733	3548	7808	0	4840	42661	-4541	0	61271	-32146	29575
1996	0	0	2297	7836	9721	9396	0	6223	46639	-17753	0	64359	-38254	26105
1997	0	0	3093	8873	1875	9873	0	4962	44273	-8015	62	64995	-29766	35233
1998	0	0	1903	8253	11199	8483	0	5317	42302	-11748	90	65799	-32446	33353
1999	0	0	463	6752	7915	7244	0	2695	36446	-8155	0	61514	-23623	29736
2000	0	0	870	4615	4841	4647	0	0	22816	0	0	37789	-14627	23162
2001	0	0	760	3944	4311	4534	0	0	21862	277	0	35688	-10437	25251
2002	0	800	1340	3810	4239	4612	0	0	20604	6244	0	41649	-8735	32914
2003	0	400	1370	2935	3581	3609	0	0	16947	2820	0	31622	-3581	28081
2004	0	228	625	1046	1894	8232	0	0	17706	3490	123	33344	-6885	26459
2005	0	1810	613	2691	2880	5132	0	0	17494	0	772	31392	-17263	14129
2006	0	570	701	3152	4352	7008	0	0	18284	0	163	34230	-6884	27346
2007	0	484	703	1749	5129	8052	0	0	17618	0	0	33735	-4119	29616
2008	0	927	564	2526	3103	4133	0	0	13963	0	0	25216	-9162	16054
2009	0	1544	1049	27	1935	5675	0	0	11076	0	0	21306	-2798	18508
2010	0	70	511	3583	2728	3600	0	0	12018	0	95	22510	-2728	19877
2011	0	0	504	3518	3956	1684	0	0	11696	0	0	21358	-3599	17759
2012	0	0	244	1829	3451	3523	0	0	12249	0	0	21296	-2780	18516
2013	0	0	586	4025	3124	1775	0	0	15906	0	30	25446	-2468	22978
2014	0	360	589	3354	2632	1641	770	0	16769	0	0	26115	-4088	22027
2015	0	0	0	3292	1799	956	0	1	15260	0	0	21307	-2506	18801
2016	23	0	0	1028	569	300	0	0	3254	0	0	5174	-450	4724
2017	0	0	0	0	10	835	0	0	3356	0	0	4200	0	4201
2018	39	0	7	17	84	1000	0	4	2911	0	0	4063	0	4063
2019	71	0	46	2	37	653	0	3	928	0	0	1739	0	1739
2020	0	4	0	0	116	85	0	0	51	0	0	256	-79	177
2021	0	0	0	0	242	5	0	0	974	0	0	1221	-106	1115
2022	8	0	0	0	66	0	0	0	7	0	0	81	-31	51
2023	0	0	0	46	152	0	0	0	406	0	0	488	-116	488

***unraised discards**

Table 4.2.1. Autumn-spawning herring in Division 6.aN. Catch and sampling effort by nation in the fishery in 2022

Country	Quarter	Sampled catch (t)	Official Catch (t)	No. Hauls	No. of samples	No. measured	No.aged	SOP
UK (SCO)	1	0	7	-	-	-	-	0%
Ireland	1	0	36	-	-	-	-	0%
Denmark	1	0	8	-	-	-	-	0%
Total		0	51	-	-	-	-	0%

Table 4.2.2. Autumn-spawning herring in Division 6.aN. Catch in number. Units: Thousands

Year	1	2	3	4	5	6	7	8	9+
1957	6496	74622	58086	25762	33979	19890	8885	1427	4423
1958	15616	30980	145394	39070	24908	27630	17405	9857	7159
1959	53092	67972	35263	116390	24946	17332	16999	7372	8595
1960	3561	102124	60290	22781	48881	11631	10347	6346	4617
1961	13081	45195	61619	33125	22501	12412	5345	4814	2582
1962	55048	92805	22278	67454	44357	19759	24139	6147	7082
1963	11796	78247	53455	11859	40517	26170	8687	13662	6088
1964	26546	82611	70076	26680	7283	24227	18637	8797	15103
1965	299483	19767	62642	59375	22265	5120	22891	18925	19531
1966	211675	500853	33456	60502	40908	19344	5563	17811	27083
1967	207947	27416	218689	37069	39246	29793	11770	5533	25799
1968	220255	94438	20998	159122	13988	23582	15677	6377	10814
1969	37706	92561	71907	23314	211243	21011	42762	26031	26207
1970	238226	99014	253719	111897	27741	142399	21609	27073	24082
1971	207711	335083	412816	302208	101957	25557	154424	16818	31999
1972	534963	621496	175137	54205	66714	25716	10342	55763	16631
1973	51170	235627	808267	131484	63071	54642	18242	6506	32223
1974	309016	124944	151025	519178	82466	49683	34629	22470	21042
1975	172879	202087	89066	63701	188202	30601	12297	13121	13698
1976	69053	319604	101548	35502	25195	76289	10918	3914	12014
1977	34836	47739	95834	22117	10083	12211	20992	2758	1486
1978	22525	46284	20587	40692	6879	3833	2100	6278	1544
1979	247	142	77	19	13	8	4	1	0
1980	2692	279	95	51	13	9	8	1	0
1981	36740	77961	105600	61341	21473	12623	11583	1309	1326
1982	13304	250010	72179	93544	58452	23580	11516	13814	4027
1983	81923	77810	92743	29262	42535	27318	14709	8437	8484
1984	2207	188778	49828	35001	14948	11366	9300	4427	1959
1985	40794	68845	148399	17214	15211	6631	6907	3323	2189
1986	33768	154963	86072	118860	18836	18000	2578	1427	1971
1987	19463	65954	45463	32025	50119	8429	7307	3508	5983
1988	1708	119376	41735	28421	19761	28555	3252	2222	2360
1989	6216	36763	109501	18923	18109	7589	15012	1622	3505
1990	14294	40867	40779	74279	26520	13305	9878	21456	5522
1991	26396	23013	25229	28212	37517	13533	7581	6892	4456
1992	5253	24469	24922	23733	21817	33869	6351	4317	5511
1993	17719	95288	18710	10978	13269	14801	19186	4711	3740
1994	1728	36554	40193	6007	7433	8101	10515	12158	10206
1995	266	82176	30398	21272	5376	4205	8805	7971	9787
1996	1952	37854	30899	9219	7508	2501	4700	8458	31108
1997	1193	55810	34966	31657	23118	17500	10331	5213	9883
1998	9092	74167	34571	31905	22872	14372	8641	2825	3327
1999	7635	35252	93910	25078	13364	7529	3251	1257	1089
2000	4511	22960	21825	51420	15504	9002	3897	1835	576
2001	147	83318	15368	9569	25175	9544	6813	4741	1028
2002	992	38481	93975	9014	18113	28016	9040	1547	1422
2003	56	33331	46865	53766	7462	4344	12818	9187	1407
2004	0	7235	23483	29421	48394	4151	8100	9023	4265
2005	182	9632	23236	20602	10237	9783	1014	1194	1430
2006	132	6691	9186	13644	41067	27781	20972	3041	5088
2007	130	34326	17754	6555	14264	30566	21517	13585	4242

Year	1	2	3	4	5	6	7	8	9+
2008	0	7898	13039	5427	3219	5688	14832	8142	8968
2009	1923	11508	10475	16586	8332	5688	7514	11793	9443
2010	10074	20339	16331	9957	14608	6322	4322	5388	13199
2011	1667	40587	15782	10333	7190	5071	3164	2611	7225
2012	979	14952	46647	9704	8097	6311	3873	1129	4013
2013	0	13681	18181	53116	11681	7093	5098	4324	5031
2014	0	8705	15144	21063	42229	7130	2944	2854	3511
2015	231	10854	13937	15716	19386	21621	6397	1932	1250
2016	12	8148	3341	3197	2791	2821	3148	739	431
2017	0	1122	11929	4082	2075	1443	1416	767	273
2018	0	1508	3215	6873	5253	3068	844	852	680
2019	1504	1333	1035	2007	3100	1003	214	79	42
2020	145	110	206	234	156	191	118	11	20
2021	0	3188	1748	378	378	449	295	35	83
2022*	-	-	-	-	-	-	-	-	-
2023*	-	-	-	-	-	-	-	-	-

* Data not currently available to the WG.

Table 4.2.3. Autumn-spawning herring in Division 6.aN. Weights at age in the catch. Units: kilograms

Year	1	2	3	4	5	6	7	8	9+
1957	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1958	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1959	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1960	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1961	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1962	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1963	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1964	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1965	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1966	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1967	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1968	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1969	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1970	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1971	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1972	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1973	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1974	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1975	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1976	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1977	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1978	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1979	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1980	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1981	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1982	0.08	0.14	0.175	0.205	0.231	0.253	0.270	0.284	0.295
1983	0.08	0.14	0.175	0.205	0.231	0.253	0.270	0.284	0.295
1984	0.08	0.14	0.175	0.205	0.231	0.253	0.270	0.284	0.295
1985	0.069	0.103	0.134	0.161	0.182	0.199	0.213	0.223	0.231
1986	0.113	0.103	0.173	0.196	0.215	0.23	0.242	0.251	0.258
1987	0.073	0.143	0.183	0.211	0.22	0.238	0.241	0.253	0.256
1988	0.08	0.112	0.157	0.177	0.203	0.194	0.24	0.213	0.228
1989	0.082	0.142	0.145	0.191	0.19	0.213	0.216	0.204	0.243
1990	0.079	0.129	0.173	0.182	0.209	0.224	0.228	0.237	0.247
1991	0.084	0.118	0.16	0.203	0.211	0.229	0.236	0.261	0.271
1992	0.091	0.119	0.183	0.196	0.227	0.219	0.244	0.256	0.256
1993	0.089	0.128	0.158	0.197	0.206	0.228	0.223	0.262	0.263
1994	0.083	0.142	0.167	0.19	0.195	0.201	0.244	0.234	0.266
1995	0.106	0.142	0.181	0.191	0.198	0.214	0.208	0.277	0.277
1996	0.081	0.134	0.178	0.21	0.23	0.233	0.262	0.247	0.291
1997	0.089	0.136	0.177	0.205	0.222	0.223	0.219	0.238	0.263
1998	0.097	0.138	0.159	0.182	0.199	0.218	0.227	0.212	0.199
1999	0.076	0.13	0.158	0.175	0.191	0.21	0.225	0.223	0.226

Year	1	2	3	4	5	6	7	8	9+
2000	0.0834	0.1373	0.1637	0.1829	0.2014	0.2147	0.2394	0.2812	0.2526
2001	0.0490	0.1398	0.1628	0.1828	0.1922	0.1959	0.2047	0.2245	0.2716
2002	0.1066	0.1464	0.1625	0.1728	0.1595	0.1780	0.1863	0.2449	0.2802
2003	0.0609	0.1448	0.1593	0.1690	0.1852	0.1997	0.1942	0.1854	0.2938
2004	0	0.1541	0.1732	0.1948	0.2160	0.2197	0.1986	0.1885	0.3030
2005	0.1084	0.1327	0.1632	0.1845	0.2108	0.2258	0.2341	0.2556	0.2496
2006	0.0908	0.158	0.1676	0.1929	0.2076	0.2251	0.2443	0.2615	0.275
2007	0.1152	0.1667	0.1881	0.1968	0.2105	0.2214	0.2161	0.2618	0.303
2008	0	0.1705	0.206	0.231	0.2309	0.2489	0.2529	0.284	0.2877
2009	0.1121	0.1726	0.2141	0.2379	0.2457	0.2535	0.2599	0.2549	0.273
2010	0.0818	0.1549	0.1883	0.2129	0.2337	0.2394	0.2369	0.2400	0.2549
2011	0.0613	0.155	0.1894	0.2178	0.234	0.2388	0.247	0.2463	0.2522
2012	0.0725	0.1469	0.1894	0.2076	0.2161	0.2261	0.2408	0.2817	0.2467
2013	0	0.1441	0.1746	0.1965	0.202	0.2124	0.2304	0.2343	0.2476
2014	0	0.1451	0.1877	0.203	0.2279	0.2449	0.2608	0.2614	0.2835
2015	0.0769	0.1425	0.1795	0.2059	0.2136	0.2307	0.2386	0.2454	0.2685
2016	0.1	0.144	0.178	0.204	0.219	0.229	0.237	0.251	0.257
2017	0	0.137	0.167	0.187	0.204	0.213	0.221	0.233	0.249
2018	0	0.126	0.151	0.174	0.190	0.208	0.218	0.238	0.246
2019	0.089	0.129	0.148	0.182	0.199	0.210	0.220	0.257	0.244
2020	0.074	0.125	0.115	0.147	0.180	0.192	0.210	0.140	0.222
2021	0	0.137	0.158	0.178	0.202	0.201	0.214	0.278	0.238
2022*	-	-	-	-	-	-	-	-	-
2023*	-	-	-	-	-	-	-	-	-

* Data not available to the WG.

Table 4.3.1. Autumn-spawning herring in Division 6.aN. Total numbers (millions) and biomass (thousands of tonnes) of 6.aN autumn spawning herring from the Malin Shelf Survey (MSHAS) June-July 2023. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0.00	0.00	0.00	0.00	0.00
1	46.86	3.33	0.00	71.10	20.57
2	101.95	10.08	0.64	98.92	22.34
3	30.91	4.76	1.00	154.09	26.08
4	41.30	7.16	1.00	173.37	26.77
5	16.26	2.89	1.00	177.65	27.25
6	3.89	0.78	1.00	199.97	27.74
7	1.15	0.25	1.00	213.94	29.19
8	0.31	0.07	1.00	225.31	29.34
9+	0.52	0.10	1.00	198.77	28.50
Immature	83.6	6.96		83.32	21.35
Mature	159.6	22.463		140.76	24.92
Total	243.1	29.43		121.02	23.70

Table 4.3.2. Autumn-spawning herring in Division 6.aN. Numbers-at-age (millions) and SSB (thousands of tonnes) of 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey time-series. Age (rings) from acoustic surveys 2014 to 2023.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9	SSB
2014	0.00	2.75	13.50	21.36	85.13	20.39	5.35	2.41	6.65	32.46
2015	0.00	35.56	139.03	127.40	97.37	106.38	24.68	3.81	5.76	107.11
2016	0.00	5.81	15.50	13.62	11.15	8.83	5.22	0.06	0.73	10.87
2017	0.00	0.71	35.75	25.40	26.44	11.41	9.93	2.48	1.86	21.86
2018	92.96	41.07	14.27	48.31	16.67	3.34	10.05	5.49	2.28	20.66
2019	0.00	17.17	17.32	15.80	20.17	4.64	0.16	0.00	0.51	10.51
2020	59.05	103.81	49.51	14.96	12.44	28.21	11.01	0.00	0.00	26.07
2021	20.48	140.01	57.44	41.87	13.98	14.57	33.73	10.25	9.07	43.89
2022	8.47	37.00	41.53	57.76	20.30	8.49	11.63	5.38	0.88	33.283
2023	46.86	101.95	30.91	41.30	16.26	3.89	1.15	0.31	0.52	22.463

Table 4.4.1.1. Autumn-spawning herring in Division 6.aN. Mean weights-at-age (kg) of 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey time-series. Age (rings) from acoustic surveys 2014 to 2023.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
2014		0.142	0.179	0.182	0.212	0.216	0.229	0.226	0.255
2015		0.159	0.184	0.198	0.214	0.220	0.219	0.198	0.220
2016		0.147	0.154	0.174	0.195	0.209	0.201	0.219	0.225
2017		0.130	0.175	0.184	0.197	0.207	0.211	0.238	0.221
2018	0.051	0.103	0.164	0.181	0.203	0.206	0.200	0.232	0.217
2019		0.121	0.140	0.175	0.208	0.214	0.204		0.212
2020	0.050	0.112	0.149	0.168	0.198	0.199	0.220		
2021	0.063	0.110	0.161	0.166	0.198	0.272	0.249	0.270	0.239
2022	0.069	0.128	0.159	0.174	0.193	0.199	0.253	0.223	0.252
2023	0.071	0.099	0.154	0.173	0.178	0.200	0.214	0.225	0.199

Table 4.4.2.1. Autumn-spawning herring in Division 6.aN. Maturity at age of 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey time-series. Age (rings) from acoustic surveys 2014 to 2023.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
2014		0.98	1.00	0.95	1.00	1.00	1.00	1.00	1.00
2015		0.88	0.99	0.99	1.00	1.00	1.00	1.00	1.00
2016		1.00	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2017		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018	0.00	0.37	0.97	1.00	1.00	1.00	1.00	1.00	1.00
2019		0.51	0.48	1.00	1.00	1.00	1.00		1.00
2020	0.00	0.47	0.97	1.00	1.00	1.00	1.00		
2021	0.00	0.45	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2022	0.00	0.99	1.00	0.97	1.00	1.00	1.00	1.00	1.00
2023	0.00	0.64	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.4.3.1. Autumn-spawning herring in Division 6.aN. Natural mortality estimates.

Age (Rings)	1	2	3	4	5	6	7	8	9	Mean 3 to 6
	0.528	0.303	0.255	0.225	0.207	0.193	0.186	0.180	0.180	0.220

Table 4.6.1. Autumn-spawning herring in Division 6.aN. F_{MSY} proxy calculations under the constant harvest rate (*chr*) rule.

Year	Survey Index	ICES landings	Modal Catch	Lc	Mean>Lc	LF=M	F ($L_{mean}/L_{F = \gamma M, K = \theta M}$)	Inverse of F ($L_{F = \gamma M, K = \theta M} / L_{mean}$)	Cy/Iy	F_{MSY} proxy
2014	32460	22027	28.5	27.5	29.448	28.801	1.022	0.987	0.679	0.335
2015	107113	18801	29	27.5	29.208	28.801	1.014	0.986	0.176	0.335
2016	10870	4724	29.5	25.5	28.691	27.666	1.037	0.963	0.435	0.335
2017	21863	4200	27	25.5	27.702	27.666	1.001	0.999	0.192	0.335
2018	20663	4063	27	25	27.595	27.382	1.008	0.992	0.197	0.335
2019	10508	1739	23.5	20	23.982	24.543	0.977	1.023	0.165	0.335
2020	26070	177	NA	NA	NA	NA	NA	NA	0.007	0.335
2021	43886	1115	25.5	24	26.084	26.814	0.973	1.027	0.025	0.335
2022	33283	51	NA	NA	NA	NA	NA	NA	0.002	0.335
2023	22463	488	27.5	25.5	27.677	27	27.666	1.000	0.022	0.335

Table 4.6.2.1. Herring in divisions 6.aN. Definitions of the components used to calculate *chr* from WKLIFEX (note $F_{proxy\ MSY}$ has now been estimated using stock-specific simulations described in section 4.6.2.2 of this report).

Component	Definition	Description and use
I_{y-1}		The index in year *y*−1.
$F_{proxy,MSY}$	$\frac{1}{u}\sum_{y\in U} C_y/I_y$	Is the mean of the ratio C_y/I_y for the set of historical years U for which the quantity *f* > 1, and u is the number of years in the set U. The quantity *f* is the ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2018b).
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that *b* is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, *b* is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock.
m	$[0,1]$	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	$min\{max(0.7C_y, C_{y+1}), 1.2C_y\}$	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%; i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year’s advised catch. The stability clause does not apply when *b* < 1.

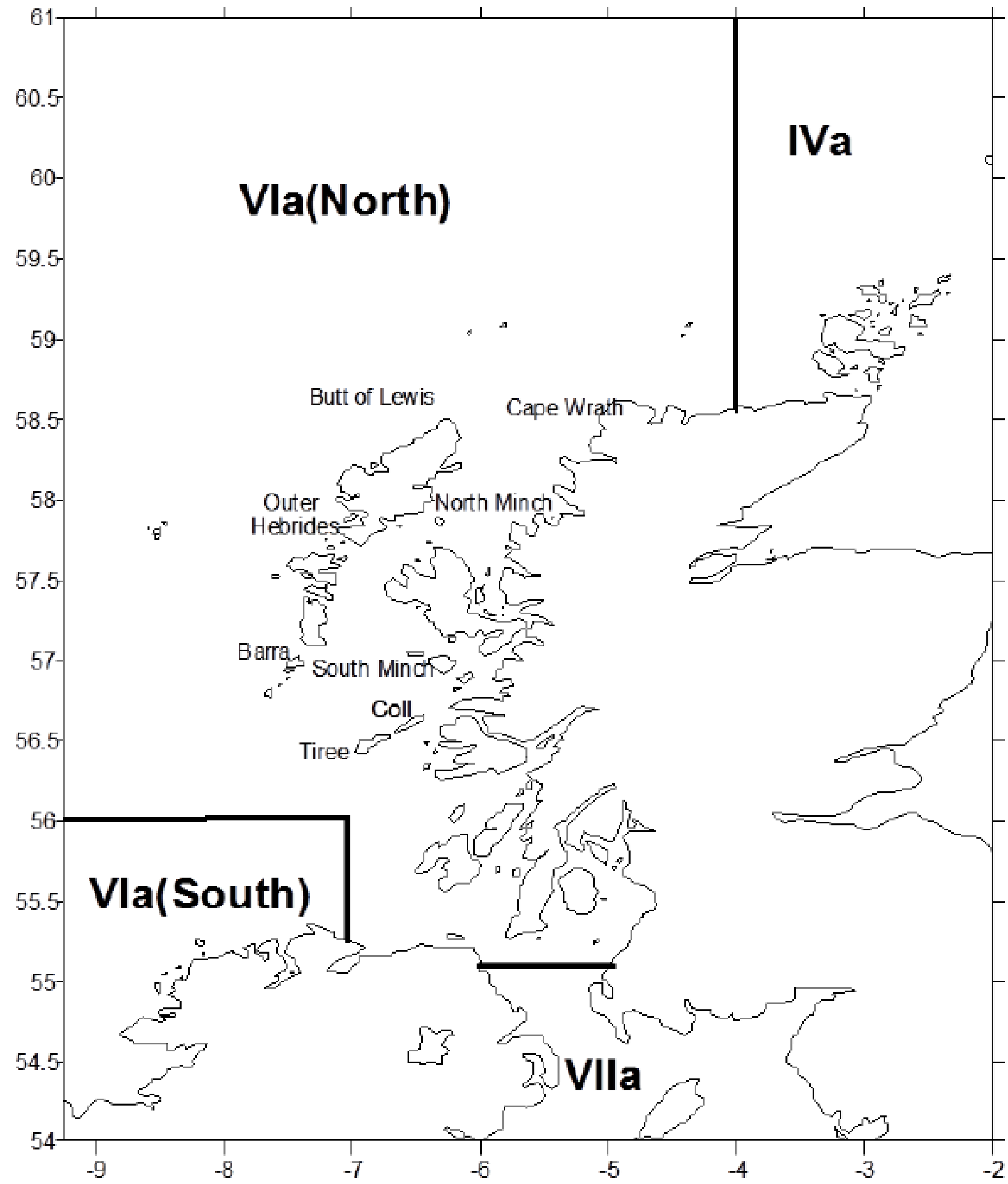


Figure 4.1. Location of ICES area 6.a (North) and adjacent areas.

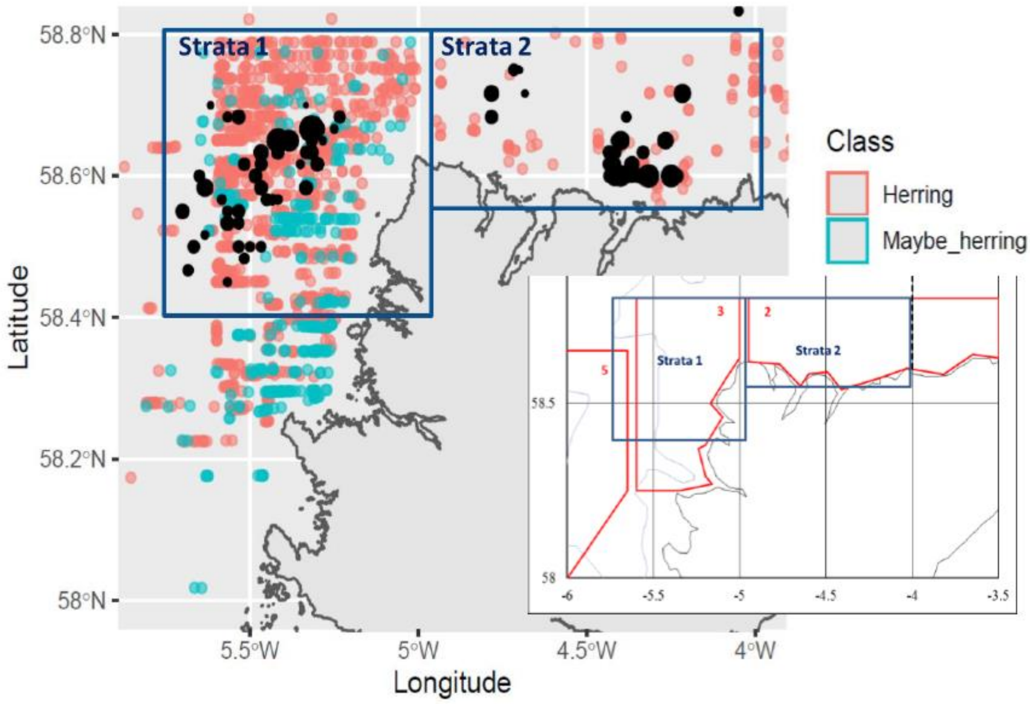


Figure 4.1.3.1. Acoustic survey recordings of herring and 'maybe herring' marks and locations of commercial catches 2016-2019 in defined Strata 1 and 2, showing overlap with previous survey Areas 2,3,5 (inset) and noting that the distribution of catches reflect spawning grounds. Catches (black dots) scaled proportionally. Acoustic marks are not scaled and denote location only.

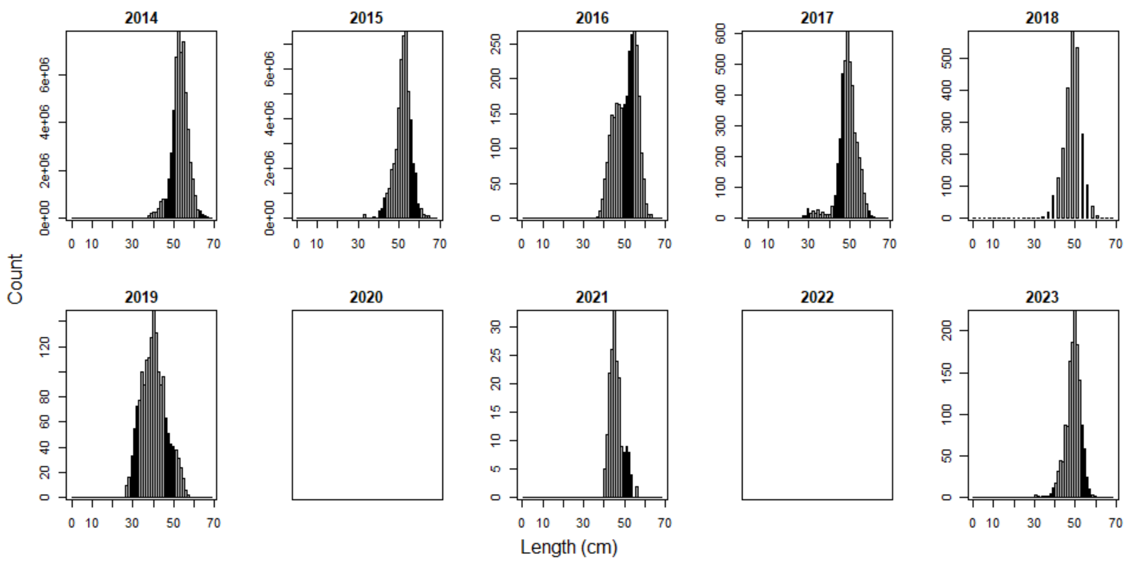


Figure 4.1.7.1. Length-frequency of commercial catches in Division 6.aN. Since 2016 a monitoring TAC has been in place for this area. Some data in 2018 were reported to a 1cm resolution, and therefore all data in this year have been binned to this level in this year. No length data from commercial hauls are available for 2020 or 2022.

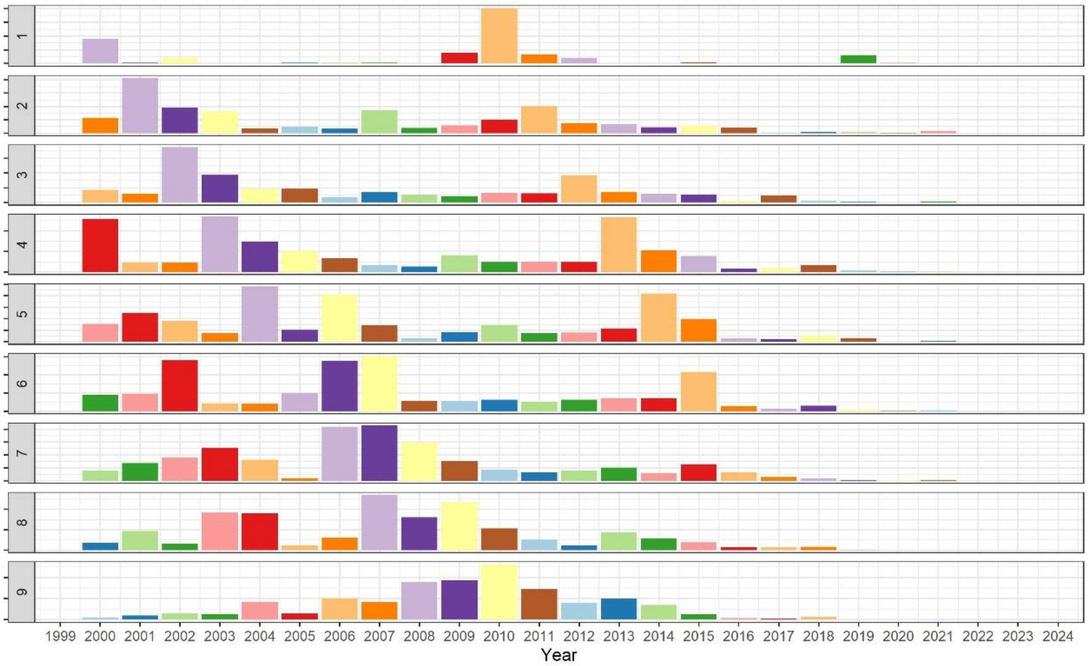


Figure 4.2.1. Catch numbers at age for herring in division 6.aN 2000-2023. Note no commercial samples available for 2022 or 2023.

Figure 4.2.2. Weights at age in the catch for herring in 6.aN 2000 – 2023. Note no commercial samples available for 2022 or 2023.

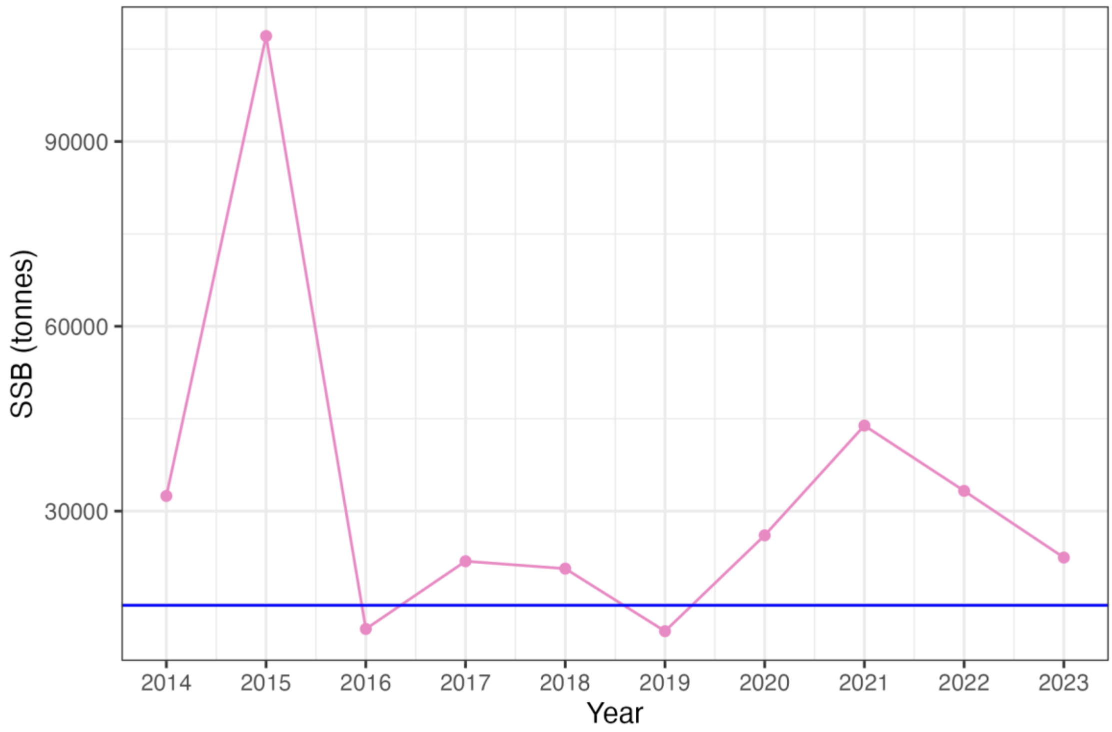


Figure 4.3.1.1. Estimated SSB for 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey 2014-2023. The blue line gives the estimated value of $I_{trigger}$.

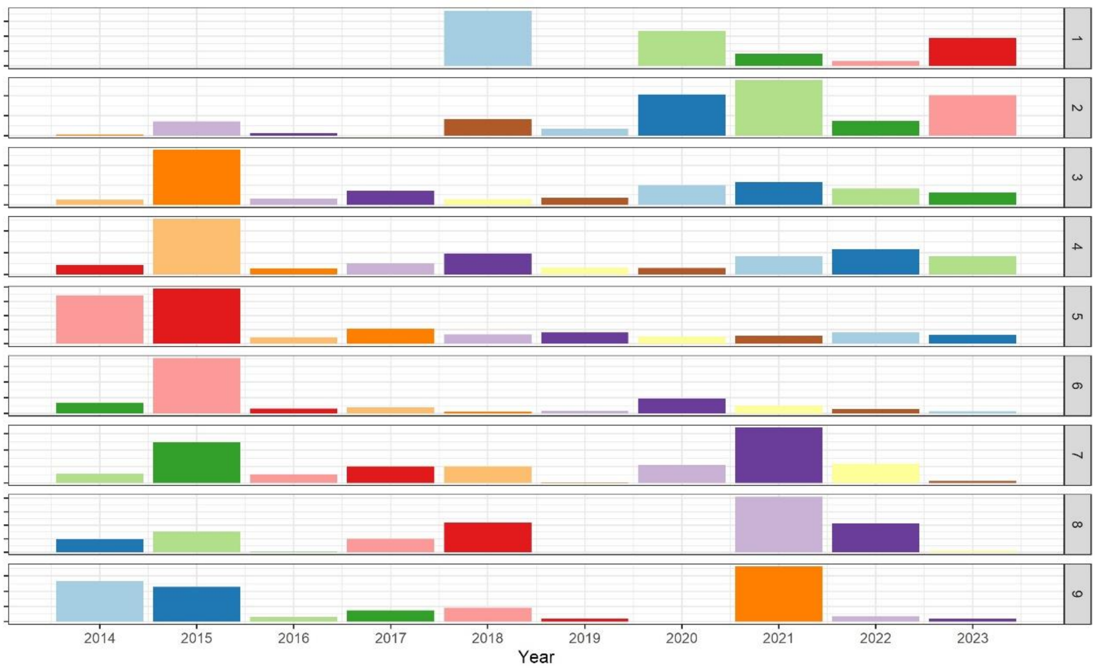


Figure 4.3.1.2. Catch numbers at age for 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey 2014-2023.

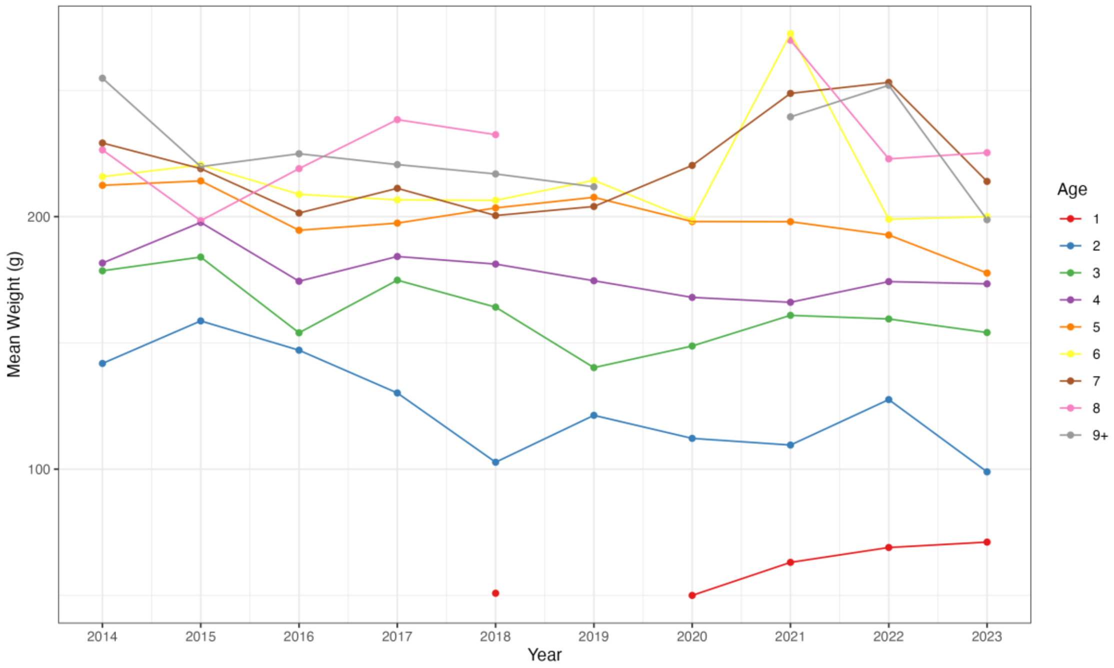


Figure 4.4.1.1. Weights-at-age for 6.aN autumn spawning herring from the genetically split Malin Shelf Herring acoustic survey 2014-2023.

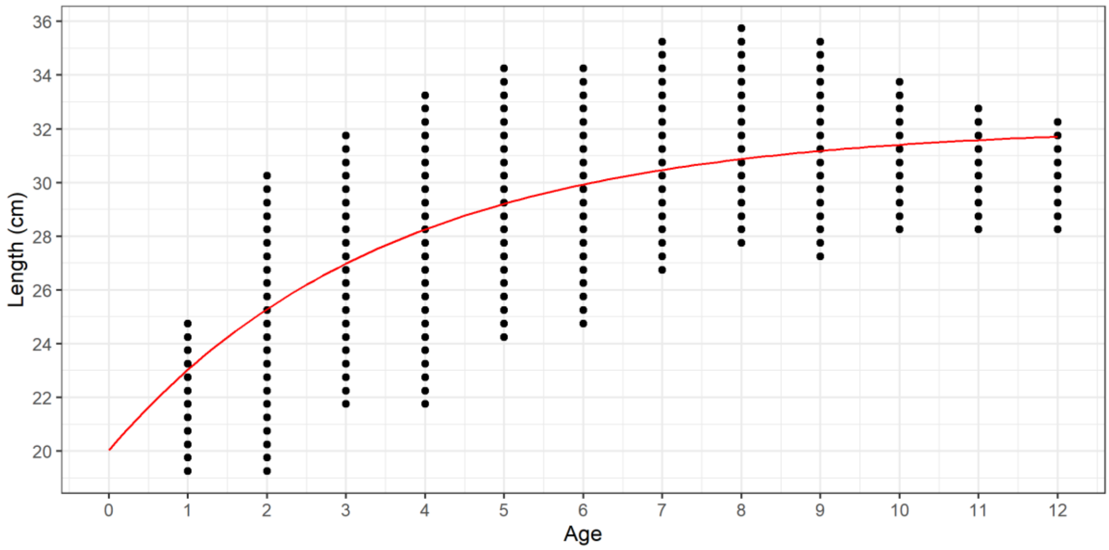


Figure 4.6.1. Growth curve calculated from commercial catches in division 6.aN, and gives an estimated L_∞ value of 30.51 cm and a *k* value of 0.335

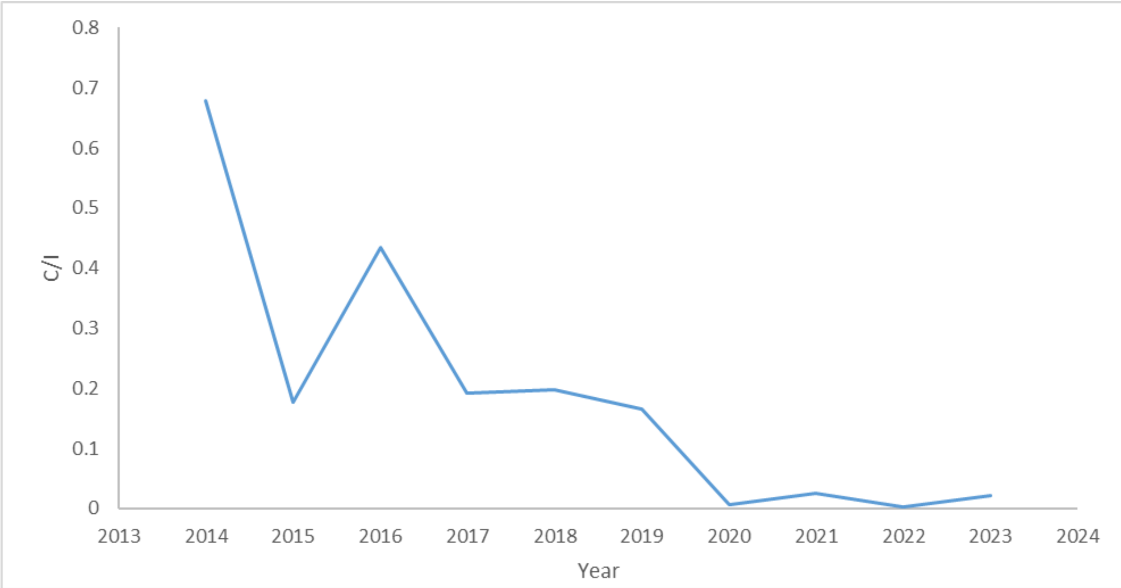


Figure 4.6.3. The ratio C/I for 6.aN herring 2014-2023, from which the $F_{MSY\ proxy}$ value is calculated in the first year of the CHR rule being implemented.

Contents

5 Herring (*Clupea harengus*) in divisions 6.a South and 7.b–c

From 2015 to 2021 this stock was jointly assessed with herring in 6.a North because it was not possible to segregate the two stocks in commercial catches or surveys. Following the benchmark workshop in 2022 (WKNSCS; ICES, 2023) the working group has presented a separate assessment of herring in Division 6.aS, 7.b-c since 2022.

The WG noted that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout this section. However, if the word “age” is used, it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between “age” and “rings”, which is not the case for the spring spawners. Further elaboration on the rationale behind this can be found in the Stock Annex. It is the responsibility of any user of age-based data for any of these herring stocks to consult the stock annex and if in doubt, consult a relevant member of the Working Group.

5.1 The Fishery

5.1.1 Advice applicable to 2023–2024

Following a benchmark in 2022 (WKNSCS, 2023), the advice for 2023 was provided for herring in 6.aS, 7.b-c following a category 3 assessment. This is a biomass or abundance trends based assessment. The method applied is a constant harvest rate (*chr*; Category 3 method 2.2; ICES 2021g) that uses length, survey and catch data from 2014. For 2023, ICES advised a catch of no more than 1,892 t based on the MSY approach and the subsequent agreed TAC for 2023 was 1,892 t.

The advice in 2024 is again provided for herring in 6aS, 7b,c and is a category 3 assessment, which is a biomass or abundance trends based assessment. The method applied is a constant harvest rate (*chr*; Category 3 method 2.2; ICES 2021g) that uses length, survey and catch data from 2014-2023.

5.1.2 Changes in the fishery

Since 2016 the fishery has been restricted to a monitoring fishery with a TAC of 1630 t between 2016 – 2019, and 1360 t in 2020 - 2022. The monitoring TAC, introduced in 2016 and continued up to 2022, has led to a change in the pattern of the fishery. In previous years, larger vessels dominated in the fishery and took their quotas often in one haul, in a somewhat opportunistic basis. The monitoring TAC was allocated to vessels in six different length categories from over 24 m down to under 12 m. In 6.aS, two main areas have been fished in recent years, particularly in Lough Swilly and in inshore areas of Donegal Bay. There has been little effort in 7.b in recent years. In 6.aS a wide size range of pair and single trawlers predominate, and there are also small-scale artisanal fisheries using drift and ringnets in coastal waters.

The Herring fishery in 2023 opened on 1st November and was concentrated in 6.aS, primarily in two statistical rectangles (Figure 5.1.2). This was similar to the 2019-2022 fisheries.

5.1.3 Regulations and their affects

The north–south boundary between 6.aN and 6.aS (56° parallel) is not appropriate as a boundary because it traverses the spawning and feeding grounds of 6.aS herring. Transboundary catches have occurred along this line in the past, although this has been less of an issue recently. Clause #2 from the HER/5B6ANB TAC & Quota regulation states "*It shall be prohibited to target any herring in the part of the divisions subject to this TAC that lies between 56°N and 57°30′N, with the exception of a six nautical mile belt measured from the baseline of the United Kingdom's territorial sea.*"

5.1.4 Catches in 2023

The Working Group's best estimate of removals from the stock is shown in Table 5.1.4 for herring in 6.aS and 7.b–c. The time series from 1957-2023 is presented in Figure 5.1.4 and the Irish catch map is shown in Figure 5.1.2. In 2023 the majority of the catch was taken in the fourth quarter mainly in 6aS and close inshore.

5.2 Biological Composition of the Catch

5.2.1 Catches in numbers-at-age

Catch-at-age data for this fishery are shown in Table 5.2.1.1 and Figure 5.2.1 and in percentage terms since 1994 in Table 5.2.1.2. In 2023, the fishery was dominated by 2- 5-ringers, accounting for 92% of the catch (Table 5.2.1.2). Smaller proportions of 6-9 ringers are evident in the catch data and account for 7% of the total. 2 ringers are the dominant age class (28%) followed by 4 (27%), and 5 (26%) ringers. 2019 was the first year since 2012 that 1-ringers were well represented in the catch-at-age data and this cohort can be tracked through to the 5 ringers in 2023.

The proportion-at-age in the catches from the fishery are similar to the catches from the split Malin shelf acoustic survey for most years (Figure 5.3.1.3). In 2023 the same cohorts are tracked by the catch and the survey. Peaks can be seen for 2 and 4 winter ring fish.

5.2.2 Quality of the catch and biological data

The 6.aS, 7.b–c stock is well sampled and there have been sufficient samples to achieve the precision level sought by the ICES advice on the monitoring fishery from 2016 to 2022 and continues to be the case for the fishery in 2023. The number of samples and the associated biological data collected by Ireland are shown in Table 5.2.2.

5.3 Fishery-independent Information

5.3.1 Acoustic surveys (A9526)

The Malin Shelf Acoustic Survey (MSHAS) is carried out annually in June/July. The Malin Shelf index includes all herring in the stock complex located in ICES areas 6.a and 7.b, c. The survey area is bounded in the west and north by the 200m depth contour, in the south by the 53.5°N latitude, and in the east by the 4°W longitude. The survey targets herring of 6.aN and 6.aS spawning origin in mixed feeding aggregations on the Malin Shelf in the summer. Full details about the survey and the genetic sampling and splitting procedure are presented in the latest WGIPS report (ICES 2023b) and summarised below.

Genetic samples have been collected since 2014 and averaged about 6 samples per year, but varied between 3 samples in 2019 and 10 samples in 2020. The target for an individual sample was 120 fish per haul, with most sampling events reaching that target. In the early years of the project, sampling effort was targeted only at fish > 23cm, this was to align with a corresponding effort that was underway looking into stock splitting using morphometric methods; a continuation of the SGHERWAY project methods (ICES SGHERWAY, 2010). Prior to 2018, hauls comprising mostly < 23 cm fish were not sampled. The stock had also been at a low level during these years, some of the lowest in the time-series, meaning that obtaining samples on the MSHAS survey was generally very difficult during this time. Since 2019 herring of all lengths have been genetically sampled. In 2023 all aged fish (676 herring) were genetically sampled.

Application of the Genetic Assignments

Genetic Analyses: Baseline spawning samples and putatively mixed MSHAS samples were analysed with a panel of 45 informative genetic markers (45 SNPs) derived from whole genome sequencing analyses undertaken as part of a Norwegian/Swedish/Danish funded project entitled '*GENetic adaptations underlying population Structure IN herring*' (GENSINC) (Han et al., 2020). The baseline genetic analyses indicated that herring in ICES Division 6.a comprise at least three distinct populations; 6.aS herring, 6.aN autumn spawning herring and 6.aN spring spawning herring. The 6.aS herring are primarily a winter spawning population though there is a later spawning component present in the area also. These components are currently inseparable and for the purposes of stock assessment should be combined as 6.aS herring. The Celtic Sea herring and Irish Sea herring are distinct from each other and from the populations in ICES Divisions 6.a however the current genetic marker panel is not optimised for their inclusion in the baseline assignment dataset. This is not considered to be a significant issue as there is no robust evidence that Irish Sea herring are found in large abundance west of the Hebrides during summer. Subsequent to the completion of the 6.a Herring EASME project, further analyses were undertaken and additional baseline samples added to the 6.aS herring and 6.aN autumn spawning herring baselines. The revised baseline was used for the final assignment of the MSHAS 2014-2022 samples.

Genetic Assignment method: A Support Vector Machine learning (SVM) algorithm was used for classification of fish from mixed MSHAS samples to baselines, based on (Approach 1) prior knowledge of baseline sample origin and (Approach 2) genetic clustering of baseline samples. Approach 2 is more precautionary but neither approach would artificially inflate either stock in the resulting split as each approach allows for 'mixed' and 'unknown' categories that would not be included in either 6aN or 6aS indices. Both approaches resulted in self-assignment rates of >90% indicating a high level of assignment accuracy and both were endorsed in an independent review by the ICES Stock Identification Methods Working Group (ICES SIMWG 2021). The more objective classification method of approach 2, genetic clustering, was therefore chosen by the sub-group. All further reference to genetic assignment refers to approach 2.

Successful Assignment Threshold (0.67): A probability of classification of 0.67 was used as the threshold for successful stock assignment of an individual herring. This threshold indicated that an individual was twice as likely to be from one baseline group than the alternate group. The effects of different assignment thresholds were investigated by the sub-group. The results of this work are presented in the working document. Most resulting probabilities for approach 2 were in the region of 0.95 and the sub-group decided that a threshold probability of 0.67 struck an appropriate balance between certainty of stock assignment and retaining as many fish as possible in the analysis.

Genotyping fails vs. threshold fails: genotyping fails are disregarded from the analysis (e.g. samples that could not be genetically analysed due to DNA degradation or did not pass genotyping quality control etc. See section 4.8 page 81 of the EASME report for details; Farrell *et al* 2021).

Such samples were NOT included as ‘unknown’ her-27.6a7bc when proportioning biomass. Threshold failures however WERE included in the analysis and were therefore counted towards ‘unknown’ her-27.6a7bc.

<u>StoX survey analysis software:</u> StoX (Johnsen *et al.* 2019) is used to split the MSHAS biomass index. StoX is the accepted survey analysis software tool used by MSHAS and the wider WGIPS group dealing with acoustic surveys for herring in the Northeast Atlantic. StoX programmers (IMR, Norway) designed the StoX project and functions to suit the MSHAS split work. This helps ensure that the project is easily implemented in the Transparent Assessment Framework (ICES TAF) and that the survey projects can be re-run by any StoX user by downloading files from the ICES DB. The StoX project is designed to include bootstrapping of results to generate associated CVs.

MSHAS Splitting Results

The SSB time series for the 6.aS, 7.bc genetically-split MSHAS index is presented in Figure 5.3.1.1. Estimated SSB for herring in 6aS, 7bc remains significantly above the lowest observed in 2016 but the latest two years, 2022 and 2023 have shown a declining trend. The estimated spawning stock biomass for 6aS, 7bc is 100,523 tonnes, almost double the $I_{trigger}$ of 51,340 tonnes. The catch numbers at age from the split are presented in Table 5.3.1.1. The CVs on the split survey estimates are within expected values for acoustic surveys for herring in this area (Table 5.3.1.1). The mean weights from the split survey are presented in Table 5.3.2.2. The maturity at age from the survey shows the most variability at 2 wr, with between 25% and 100% of fish mature at that age (Table 5.3.1.3). Cohort tracking of the catch numbers at age of the split MSHAS for 6aS,7.b,c is shown in figure 5.3.1.2. Some cohorts can be tracked through the age classes and this is expected to improve when more data is added.

A comparison of the proportions at age in the catch versus the split MSHAS 6aS,7b,c index is shown in figure 5.3.1.3. Smaller and younger fish, particularly 1 wr fish are caught sporadically on this survey, and in some years don’t appear in the samples on the survey. Younger immature fish may be outside of the survey area during the survey and can be difficult to sample in some years. In 2023 the most abundant age classes were 2 wr and 4 wr in both the catch and the survey.

The internal consistency for the split Malin shelf survey is presented in Figure 5.3.1.4. and is variable across ages. The time series is relatively short and the internal consistency is expected to improve when more data becomes available.

5.3.2 Industry–Science Acoustic survey

An industry science acoustic survey has been carried out in 6aS, 7b,c since 2016. The survey design has been evolving since its inception. The survey area covered in the first 3 years (2016-18) included significant offshore coverage in areas 6aS and 7b. The survey in 2019 was much reduced and mostly confined to inshore bays because of poor weather. The survey design changed in 2020 compared with previous years in that only 6 core areas with prior knowledge of herring distribution from the monitoring fishery were targeted for surveying. This was largely based on the results from ICES WKHASS (ICES 2020) and from lessons learned in the previous surveys in this area from 2016-2019. This design resulted in a much-reduced survey area compared to previous years, but with better coverage and replication in most of the important inshore bays where the monitoring fishery takes place. The survey design objective remained the same; to capture the distribution of winter spawning herring in the 6aS,7b area. The timing of surveys in the core areas was flexible from the outset by design. The greater flexibility allows for a targeted spatial and temporal approach, which avoids the inevitable poor weather that can happen in this area during this time of the year. Using smaller vessels allows surveys to be conducted in shallow inshore areas where herring are known to inhabit during this time of the year.

At the time of the HAWG 2024 meeting, the 2023/24 industry/science acoustic survey was still underway so could not be reported. The following information relates to the 2022/23 survey. The survey was conducted in ICES areas 6aS/7b in November/December 2022 and January 2023. The 2022 survey was conducted using five vessels; MFVs Crystal Dawn WD201, Ros Ard SO745, Girl Kate SO427, Johnny G S653 (d) and Conquest SO852. The 6aS/7b survey design in 2022 focused on 6 core areas with prior knowledge of herring distribution from previous surveys and the monitoring fishery were targeted for surveying. This survey is the seventh consecutive annual acoustic survey for pre-spawning herring in this area at this time of the year. A pole-mounted system with a combi 38 kHz (split) 200 kHz (single) transducer was used successfully for the survey on small vessels (<18m) in 2022. Herring were again distributed inshore in shallow areas, and the improved survey design and use of small vessels for the survey resulted in a good measure of uncertainty (CV =0.25). The stock was not overall contained in 2022, particularly in the Donegal Bay area (Malin Beg, etc.) and more effort is required to target surveys earlier and later than December and January when herring tend to show up in these areas in difficult to predict patterns. Very strong herring marks were evident in Lough Foyle and Lough Swilly in the channel in marks that extended for many miles in some cases. This was in areas where smaller boats in the fishery were concentrating effort. Herring had left the Swilly and Foyle by mid-February. There was also a series of strong herring marks in Bruckless Bay, Fintra Bay and Inver Bay in discreet areas, particularly in December. The monitoring fishery was being conducted on smaller boats in the same areas and close to the same time as the survey and biological samples from some of these vessels were used. There was a fairly tight distribution of length classes in all hauls, with most hauls dominated by larger (> 22 cm) mature fish. The 2- and 3-wr age class of herring accounted for 72% of the overall numbers in 2022. The total stock biomass (TSB) estimate of 54,046 tonnes is considered to be a minimum estimate of herring in the 6aS/7b survey area at the time of the survey. The 2022 estimate is the highest estimate in the time series. The flexible survey design and focusing on discreet areas was generally successful and is providing a good template for future survey designs. The NASC values from the latest two surveys are presented in Figure 5.3.2.1.

The full time series of herring acoustic surveys carried out in this area since 1994 is presented in Table 5.3.2.1. Surveys were not conducted every year and there are gaps in the time series. These surveys had different timing and design changes and are not comparable. The biomass estimates from the industry survey (2016-2022) are included in this table.

5.3.3 Bottom-trawl surveys

As part of the benchmark (WKNSCS; ICES, 2023a), an exploratory index was developed from three groundfish surveys (IBTS). Further details can be found in the benchmark report.

5.4 Mean Weights-at-age, Maturity-at-age and natural mortality

5.4.1 Mean weight-at-age

Weights-at-age in the catches for 6.aS, 7.b-c are presented in Table 5.4.1.1 and Figure 5.4.1.1. Catch weights are calculated from Irish sampling data from all quarters of the fishery. Over much of the time series of the mean weight there is little trend, with weights stable from the late 80s up to the late 00s. The mean weights have been declining since about 2010 for many age classes.

Weights-at-age in the stock are presented in Table 5.4.1.2 and Figure 5.4.1.2. Variable mean weights are available from 1985. In the previous separate assessment, the stock weights were calculated from Irish samples collected during the main spawning period that extends from October to February. These weights are used from 1985-2007. Mean weights from the Malin Shelf acoustic survey are used from 2008-2013 and from the split acoustic survey from 2014. There is an overall downward trend in the stock weights over time but it is not as pronounced as for the catch weights. Greater variability is seen at the older ages. In some years there were no 1 wr fish found on the survey. In these years a three year running average is used.

5.4.2 Maturity ogive

The proportions at age of herring in 6.aS, 7b-c that are considered mature are presented in Figure 5.4.2. Prior to 2007 a constant maturity ogive was used, which assumes 0%, 57% and 96% maturity at 1, 2 and 3 wr respectively and from 2008 to the present the ogive is derived from the summer acoustic survey in quarter 3. The full survey is used from 2008-2013 and the split survey used from 2014 – 2022. The majority of herring in this area are mature at 4 wr with the greatest annual variability seen for 2 and 3 wr herring. The proportion mature at 2 wr is highly variable without any apparent trend and varies between 25% and 100%. For 3 wr herring the proportion mature varies between 64% and 100%. A high proportion of immature fish were encountered in the 2020 survey. Overall, it is not clear what drives this annual variability and it is also seen for other herring stocks such as North Sea and Irish Sea herring. It is likely a combination of limited sampling of that age group, varying proportions of herring from each population within the survey area and natural variability (ICES, 2015).

5.4.3 Natural mortality

Following the procedure agreed at WKWEST 2015 and applied to other herring stock around Ireland, the natural mortality values for the assessment were updated. The average M at age over the time series 1974-2019 from the 2020 SMS key run was calculated and is presented in figure 5.4.3 with the previous values used in the combined assessment for comparison. The updated values show a lower natural mortality across all ages and are presented in the text table below.

1	2	3	4	5	6	7	8	9
0.528	0.303	0.255	0.225	0.207	0.193	0.186	0.180	0.180

A Detailed explanation regarding the natural mortality estimates can be found in the Stock Annex.

5.5 Recruitment

There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely, with only 2012 and 2019 having significant proportions of 1-ringers (12% and 15% respectively) in the catch-at-age data. Since the mid-1990s recruitment has been low, based on exploratory assessments.

5.6 Assessment of 6.aS and 7.b–c herring

The assessment presented here follows the procedure agreed by the benchmark in 2022 (ICES, 2023) supplemented with stock-specific simulation work to update $F_{proxy\ MSY}$.

5.6.1 Data Exploration

The Malin shelf acoustic survey is used as the index in the assessment because this biomass index is split genetically and known to contain fish from this stock only. The IBTS survey was not used in the final assessment as further investigations are needed to evaluate its utility in the assessment. The fact that the series begins in 2003 means it could be an important element to include in future analytical assessments at the next benchmark. The time-series of the industry/science acoustic survey is relatively short and the methodology has been evolving so the index was ultimately not included. While the genetically-split MSHAS survey biomass was the best biomass index available for the *chr* calculation, the reasons behind the variable internal consistency across age pairs need to be further investigated, particularly if this stock is to move to a category 1 or age-based assessment in the future.

Genetic sampling of the commercial catch began in 2022. Results of this genetic analysis needs to be incorporated into the assessment in the near future. For now, it is sufficient to assume that, due to the timing and the location of the fishery each year, the vast majority of catch is attributable to 6aS, 7bc.

5.6.2 Assessment for 6.aS and 7.b–c herring

The assessment method applied to herring in 6aS, 7b,c and agreed at the 2022 benchmark (WKNSCS; ICES 2023) was the category 3 method 2.2 – constant harvest rate (the *chr* rule). The choice of this rule and its subsequent application are reliant on the values of certain biological growth parameters, as described below.

5.6.2.1 Calculation of k

The growth parameter k was calculated using length data from commercial catch sampling. Herring samples from 6aS and 7b from 2000-2021 were included in the analysis. This totaled over 594 thousand individual herring caught in a variety of gear types. The R packages 'FSA' and 'nlstools' were used to estimate the growth parameters and to plot the fit of the growth curve (Figure 5.2.6.1). The resulting growth parameters were:

- k = 0.339
- L_{inf} = 30.50cm
- t0 = -2.61

Catches of 6aS7bc herring have been taken close to the north-west coast of Ireland since the introduction of the monitoring TAC in 2015. To ensure the growth fit was not influenced by mixed catches before 2015, an estimate using length data from 2015-2021 was also run. The resulting k was almost identical. This value is further supported by the literature, with a k of 0.37 for herring north-west of Ireland reported by Brunel and Dickey-Collas (2010); albeit calculated on the weight rather than the length.

As a further test, k was also calculated using length data from the genetically split MSHAS (6aS only). Due to sampling protocols, herring less than 23cm were not routinely sampled for genetics prior to 2018 so only split data from 2018 onwards were included. The resulting k from this further analysis was 0.5, which is quite different to the other values presented and would place herring 6aS7bc in the short-lived species bracket. It is thought that this unusual growth estimate is due to the difference in timing of the survey versus the catch, which can be separated by up to 6 months. 1-ringed fish encountered during the summer survey would have recently turned 1 whereas 1 ringed fish in the catch would be approaching 2. Further work is required to understand the different survey k but nevertheless the most appropriate k to use for the category 3 flowchart and the *chr* calculation is that from the catch sampling (0.339) as far more data points exist over a much wider timeframe.

5.6.2.2 Calculation of Constant Harvest Rate (*chr*)

The *chr* rule applies a constant harvest rate ($F_{MSY\ proxy}$) that is considered a proxy for an MSY harvest rate and applies this to the biomass index (genetically-split MSHAS). As per the WKLIFEX (2021) report, advised catch (C_{y+1}) is calculated as follows:

$$C_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$$

Definitions of the components used to calculate *chr* are presented in Table 5.6.2.2.

Table 5.6.2.3. shows the estimate of natural mortality (M) used in the exploratory assessments for herring in 6aS, 7bc and various M/k ratio calculations. The M/k ratio of 0.649 for F3-6 was deem the most appropriate by the benchmark meeting.

Target Harvest Rate

Prior to this year, $F_{proxy\ MSY}$ was calculated as per the WKLIFEX methodology (but using an alternative $L_{F=M}$ equation, as per Jardim *et al*. (2015), to account for the specific M/k value of the stock). However, due to the relatively short time-series available for the split survey index and the fact that catches were constrained by the monitoring TAC in most of those years, the resulting $F_{proxy\ MSY}$ was unusually low and led to apparently inconsistent advice with the neighbouring 6.a North stock. Stock-specific simulation work was therefore undertaken to estimate a more appropriate proxy harvest rate for the stock. The methods followed were largely informed by Fischer *et al*. (2022), who used a simulation-based approach "*as an optimisation procedure to tune the parameters of the control rule to meet maximum sustainable yield and precautionary management objectives*." The FLife R package was used to condition operating models (OMs) for both herring stocks in ICES Area 6.a (i.e. 6.aN and 6.aS), simulating FLBRP (equilibrium biological reference point) objects based on life-history parameters. The majority of the life-history parameters used for this simulation exercise were empirically derived, using stock-specific data, or, where appropriate parameters were already available, from stock annexes. Full details of the methodology and results were presented to HAWG in a WD and were favourably reviewed by two external reviewers.

On the basis of the simulation work, $F_{proxy\ MSY}$ is now set at 0.26 (as opposed to 0.034 previously).

Length Based Indicator

Although no longer used in the calculation of the proxy harvest rate, the length based indicator values are still used as an indication of the status of the stock. This requires calculating the target reference length, $L_{F=M}$, from length frequency data using the following equation:

$$L_{F=M} = (0.75 \times Lc_{(y)}) + (0.25 \times L_{inf})$$

where L_c refers to the length at first catch. This calculation assumes that the M/k ratio is equal to 1.5 (ICES 2018). The actual M/k ratio for 6aS7bc herring is 0.649, which is considerably different to the assumed value. ICES Technical Guidelines (2018) state that stock specific M/k values can be applied by using the following alternative $L_{F=M}$ equation from Jardim *et al*. (2015):

$$L_{F=\gamma M,K=\theta M} = \frac{\theta L_{\infty} + L_c(\gamma + 1)}{\theta + \gamma + 1}.$$

Using the assumed M/k of 1.5 and the best estimate of k, 0.339, implies a natural mortality of 0.51, which differs substantially from that used in the exploratory SAM and ASAP runs: Average for ages 3-6 of 0.22. It was therefore deemed appropriate to use the stock specific M/k and the Jardim *et al*. (2015) equation to calculate $F_{MSY\ proxy}$, for herring in 6aS,7bc.

5.6.2.3 Constant Harvest Rate Results

The survey index for herring in 6aS, 7b,c has generally increased since the lowest point in 2016 (36 707 t), however a declining trend has been observed since 2021 with SSB in the latest year, 2023, estimated to be 100 523 t. However, the 2023 SSB estimate is still almost double the trigger (51 390 t), which is 1.4 times the lowest observed survey biomass (Figure 5.6.2.3.1).

$F_{MSY\ proxy}$ is estimated at 0.26. The target reference length for the latest year is 27.11 cm andlength frequency distribution are presented in Figure 5.6.2.3.2.

The multiplier, m, was set at 0.5 as per ICES WKLIFEX guidelines for this method.

See table 5.6.2.3.1 for full details of the constants and calculations used.

A stability clause constraining the change in advised catch to -30% or +20% applies.

Length Based Indicator from the chr

The length-based indicator (LBI) ratio in recent years has been slightly above 1 (Figure 5.6.2.3.3). The indicator ratio $L_{F=\gamma M,K=\theta M}/L_{mean}$ (inverse of fishing proxy, *f*) from the length-based indicator (LBI) method can be used for the evaluation of the exploitation status. The proxy fishing pressure is less than the pressure corresponding to the F_{MSY} proxy ($L_{F=M}$) when the indicator ratio value is lower than 1.

Summary

Table 5.6.2.3.2 presents a summary table and resultant advice based on a *chr* using length, survey and catch data from 2014 – 2023 (inclusive).The advised catch for 2025 is 2 724 t, a 20% capped increase on the advice for 2024.

5.7 State of the Stock

The genetically-split Malin shelf acoustic survey abundance and biomass estimates for 2014-2023 (incl.) provide the most reliable index for this stock. The survey index for herring in 6aS, 7b,c has generally increased since the lowest point in 2016 (36 707 t), however a declining trend has been observed since 2021 with SSB in the latest year, 2023, estimated to be 100 523 t (Table 5.3.1.1. and Figure 5.3.1.1). Fishing pressure on the stock is above $F_{MSY\ proxy}$, and the stock size index is almost double $I_{trigger}$ (51 390 t). Recent catches are among the lowest in the time series, having been constrained by the catch limits. A monitoring TAC was in place for this stock from 2016 to 2022 and this restricted fishing mortality. There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Recruitment of the 2018 year-class was good and this year-class is now 4 winter ring and accounted for 26% of the catch numbers at age in 2023.

5.8 Short-term Projections

5.8.1 Short-term projections

No short-term forecast was conducted.

5.8.2 Yield-per-recruit

No yield-per-recruit analysis was conducted.

5.9 Precautionary and Yield Based Reference Points

$F_{MSY\ proxy}$ is estimated at 0.034 for the years 2014-2021 (inclusive) and the target reference length for the latest year is 27.11 cm. See section 5.6.2.2 for details.

5.10 Quality of the Assessment

Herring in 6.a South, 7.b-c were part of a combined assessment with 6.a North from 2015 until 2021 (ICES, 2015a). Following a benchmark meeting in 2022 (ICES, 2023), these two stocks are now assessed separately. This was made possible by the development of a genetically split acoustic survey index (MSHAS; ICES, 2023). This assessment represents one stock: 6.aS,7.b–c herring.

A proportion of the acoustic survey biomass remains unassigned to either 6aS, 7bc or 6aN (Figure 5.10.1). There is a spring spawning category that could be 6aN fish or late spawning 6aS, 7b,c fish. There is also an unknown category that contains a mix of herring from 6a, 7bc and are unknown or below threshold. Continued genetic work including collection of further baseline spawning samples, will reduce the portion of this unassigned biomass in future years.

The calculation of the length-based indicator (LBI) portion of the constant harvest rate (*chr*) requires adequate length frequency data from the commercial catch. Catch sampling in 6.aS,7.b-c has been comprehensive in all years included in the current assessment (2014-2022). This sampling will continue in future years.

Very low catch to index ratios across the split-survey time series (2014-present) had resulted in an extremely low $F_{proxy\ MSY}$ value. Following the simulation work described in section 5.6.2.2 this has been revised substantially upwards to 0.26, which is in line with neighbouring herring stocks.

5.11 Management Considerations

From 2015 to 2021 this stock was jointly assessed with herring in 6.a North because it was not possible to segregate the two stocks in commercial catches or surveys. The development of a genetic method to split the biomass index of the summer acoustic survey (MSHAS) into the component stocks means that separate advice is now possible. The survey index has been genetically-split from 2014-present but catches are still apportioned geographically (south of 56°N and west of 7°W). This is not an issue in recent years as the agreed 6.aS,7.b-c monitoring TAC has been taken close to the Irish coast at a time when the stocks are geographically isolated. Genetic sampling to split the commercial catches is required, particularly as the stocks recover and fishing expands. Genetic sampling and analysis of commercial catch were trialled in the 6.aS,7.b-c 2022 fishery. The trial was successful, so sampling continued in 2023. Results will be used to begin genetically splitting the catch data from 2022.

The Malin shelf acoustic survey index is an important part of this assessment and the continuation of the genetic sampling and analysis of this survey is also required. New baseline samples should be collected annually if possible and analysed at least with the established 45 SNP panel detailed in Farrell *et al*. (2021). Particular attention should be paid to building up the baseline samples of late spawning 6.a.S and the spring spawning 6aN fish to improve the assignment of these fish.

5.12 Ecosystem Considerations

The Atlantic herring, *Clupea haregus*, is numerically one of the most important pelagic species in North Atlantic ecosystems. As well as being a commercially important species, herring represent an important prey species in the ecosystem west of the British Isles (ICES, 2021). Herring link zooplankton production with higher trophic levels (fish, sea mammals and birds) but also can act as predators on other fish species by their predation on fish eggs (ICES, 2015).

In this area the main oceanographic features are the Islay and Irish Shelf fronts. The waters to the west of Ireland are separated by the Irish shelf front. These fronts create turbulence and this may bring nutrients from deep waters to the surface, promoting the growth of phytoplankton and dinoflagellates in areas of increased stratification. Aggregations of fish are associated with these areas of increased productivity. The Islay front persists throughout the winter due to the stratification of water masses at different salinities (ICES, 2006). The ability to quantify any variability in frontal location and strength is an important element in understanding fisheries recruitment (Nolan and Lyons, 2006). These fronts play an important role in the transport of larvae and juveniles.

5.13 Changes in the Environment

Grainger (1978; 1980) found significant negative correlations between sea surface temperature and catches from the west of Ireland component of this stock at a time-lag of 3–4 years later. This indicates that recruitment responds favourably to cooler temperatures. The influence of the environment on herring productivity means that the biomass will always fluctuate (Dickey-Collas *et al.*, 2010).

Changes in environmental conditions can have significant impacts for a variety of marine fish species. Oceanographic variation associated with temperature and salinity fluctuations appears to impact herring in the first year of life, possibly during the winter larval drift (Grainger, 1980). In addition, temperature increases and a positive AMO (Atlantic multi-decadal oscillation) index are thought to be related to drops in weight-at-age in Celtic Sea herring (Lyashevska, 2020). This study by Lyashevska, 2020 also found more stable size at age for herring in 6aS, 7b,c and this may reflect the stocks more northerly distribution, where there is less exposure to sub optimal temperatures. Reductions in size after 1990 are noted which indicates a vulnerability to future temperature rises.

5.14 Tables and Figures

Table 5.1.4 Herring in divisions 6.aS, 7.b–c. Estimated Herring catches in tonnes, 1992–2023. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	UK (England & Wales)	UK Scotland	Total landings	Unallocated / area misreported	Discards *	ICES estimated catch
1992	0	250	26000	900	0	0	27150	4600	100	31850
1993	0	0	27600	2500	0	200	30300	6250	250	36800
1994	0	0	24400	2500	50	0	26950	6250	700	33900
1995	0	11	25450	1207	24	0	26692	1100	0	27792
1996	0	0	23800	1800	0	0	25600	6900	0	32500
1997	0	0	24400	3400	0	0	27800	700	50	28550
1998	0	0	25200	2500	0	0	27700	11200	0	38900
1999	0	0	16325	1868	0	0	18193	7916	0	26109
2000	0	0	10164	1234	0	0	11398	8448	0	19846
2001	0	0	12820	2088	0	0	14908	1390	0	16298
2002	515	0	13072	366	0	0	13953	3873	0	17826
2003	0	0	12921	0	0	0	12921	3581	0	16502
2004	0	0	12290	64	0	0	12354	2813	0	15167
2005	0	0	13351	0	0	0	13351	2880	0	16231
2006	0	0	14840	353	0	6	15199	4000	0	19199
2007	0	0	12662	13	0	0	12675	5116	0	17791
2008	0	0	10237	0	0	0	10237	3103	0	13340
2009	0	0	8533	0	0	0	8533	1935	0	10468
2010	0	0	7513	0	0	0	7513	2728	0	10241
2011	0	0	4247	0	0	0	4247	2672	0	6919
2012	0	0	3791	0	0	0	3791	2780	0	6571

Year	France	Germany	Ireland	Netherlands	UK (England & Wales)	UK Scotland	Total landings	Unallocated / area misre-ported	Discards *	ICES estimated catch
2013	0	0	1460	40	0	0	1500	2468	0	3968
2014	0	0	2933	0	0	0	2933	2163	0	5096
2015	0	0	73	0	0	5	78	1000	0	1078
2016	0	0	1171	72	0	0	1243	971	0	2214
2017	0	0	1707	0	0	0	1707	520	0	2227
2018	0	0	970	0	0	0	970	525	0	1495
2019	0	0	1625	65	0	0	1690	0	0	1690
2020	0	0	1138	3	0	0	1141	79	0	1220
2021	0	0	1715	0	0	0	1715	106	0	1821
2022	0	0	1295	0	0	0	1295	31	0	1326
2023	0	0	1139	0	0	0	1139	116	0	1255

***unraised discards**

Table 5.2.1.1. Herring in divisions 6.aS, 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2023.

	1	2	3	4	5	6	7	8	9
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264

	1	2	3	4	5	6	7	8	9
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17
2010	1271	13507	20127	6541	7588	6780	2563	661	189
2011	121	14207	9315	9114	3386	3780	2871	980	95
2012	5142	12844	16387	4042	1776	553	541	103	21
2013	61	3118	4532	12238	1665	1792	425	382	202
2014	34	465	8825	6735	12146	2406	1045	437	204
2015	27	1842	598	2553	1699	685	96	9	0
2016	69	1983	4252	1369	3025	2085	824	43	9
2017	30	1051	5241	4078	1025	2250	1061	480	76
2018	6	1567	1838	3280	2288	613	700	260	29
2019	1995	2627	3259	1509	1895	1166	381	464	171
2020	140	5164	2683	1703	597	684	265	98	48
2021	25	1975	8818	2297	1302	315	410	116	21
2022	39	429	3635	4779	1051	529	166	167	56
2023	124	2893	1235	2802	2712	460	163	77	44

Table 5.2.1.2. Herring in divisions 6.aS, 7.b–c. Percentage age composition (winter rings).

Year	1	2	3	4	5	6	7	8	9+
1994	6%	28%	15%	8%	11%	7%	4%	16%	5%
1995	0%	23%	23%	12%	13%	11%	4%	6%	9%
1996	3%	13%	38%	17%	5%	8%	4%	7%	4%
1997	5%	34%	16%	23%	9%	4%	5%	2%	3%
1998	3%	29%	32%	15%	12%	4%	2%	1%	1%
1999	1%	30%	36%	21%	6%	3%	1%	1%	1%
2000	3%	27%	30%	24%	10%	2%	1%	1%	1%
2001	2%	23%	23%	18%	19%	10%	2%	1%	1%
2002	3%	27%	31%	16%	10%	9%	2%	1%	1%
2003	2%	31%	27%	23%	9%	5%	2%	1%	0%
2004	2%	18%	38%	23%	10%	6%	2%	1%	0%
2005	0%	27%	29%	26%	10%	5%	1%	1%	0%
2006	0%	18%	29%	25%	18%	7%	2%	1%	0%
2007	0%	22%	39%	21%	12%	5%	2%	0%	0%
2008	1%	15%	24%	35%	14%	7%	3%	1%	0%
2009	0%	22%	21%	21%	22%	9%	4%	1%	0%
2010	2%	23%	34%	11%	13%	11%	4%	1%	0%
2011	0%	32%	21%	21%	8%	9%	7%	2%	0%
2012	12%	31%	40%	10%	4%	1%	1%	0%	0%
2013	0%	13%	19%	50%	7%	7%	2%	2%	1%
2014	0%	1%	27%	21%	38%	7%	3%	1%	1%
2015	0%	25%	8%	34%	23%	9%	1%	0%	0%
2016	0%	15%	31%	10%	22%	15%	6%	0%	0%
2017	0%	7%	34%	27%	7%	15%	7%	3%	0%
2018	0%	15%	17%	31%	22%	6%	7%	2%	0%
2019	15%	20%	24%	11%	14%	9%	3%	3%	1%
2020	1%	45%	24%	15%	5%	6%	2%	1%	0%

2021	0%	13%	58%	15%	9%	2%	3%	1%	0%
2022	0%	4%	33%	44%	10%	5%	2%	2%	1%
2023	1%	28%	12%	27%	26%	4%	2%	1%	0%

Table 5.2.2. Herring in divisions 6.aS, 7.b–c. Sampling intensity of catches in 2023.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.aS	1	263	7	290	1535	1104
6.aS	4	991	18	913	4583	921
7.b	1	1				
Total 2023		1255	25	1203	6118	959

Table 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the catches 1970–2023.

	1	2	3	4	5	6	7	8	9+
1970	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988	0.082	0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201

	1	2	3	4	5	6	7	8	9+
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217
1996	0.085	0.135	0.172	0.182	0.199	0.209	0.220	0.233	0.237
1997	0.093	0.135	0.155	0.181	0.201	0.217	0.217	0.231	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.106	0.144	0.145	0.163	0.186	0.195	0.200	0.216	0.222
2000	0.102	0.129	0.154	0.172	0.180	0.184	0.204	0.203	0.204
2001	0.086	0.122	0.139	0.167	0.183	0.188	0.222	0.222	0.213
2002	0.097	0.127	0.140	0.155	0.175	0.196	0.204	0.218	0.226
2003	0.102	0.134	0.150	0.167	0.183	0.196	0.216	0.210	0.228
2004	0.085	0.140	0.150	0.167	0.182	0.193	0.222	0.221	0.285
2005	0.105	0.135	0.150	0.162	0.174	0.188	0.200	0.237	0.296
2006	0.106	0.137	0.141	0.158	0.169	0.178	0.199	0.221	0.243
2007	0.118	0.144	0.145	0.168	0.179	0.189	0.197	0.233	0.237
2008	0.1108	0.1478	0.1503	0.1663	0.1745	0.1845	0.1938	0.1990	0.2407
2009	0.077	0.146	0.171	0.194	0.200	0.207	0.211	0.218	0.275
2010	0.104	0.131	0.168	0.189	0.201	0.212	0.218	0.226	0.229
2011	0.094	0.122	0.141	0.174	0.193	0.202	0.217	0.218	0.246
2012	0.09	0.134	0.179	0.196	0.214	0.237	0.228	0.243	0.236
2013	0.083	0.121	0.141	0.170	0.181	0.196	0.202	0.226	0.226
2014	0.105	0.139	0.136	0.155	0.168	0.175	0.184	0.183	0.187
2015	0.090	0.113	0.145	0.152	0.161	0.168	0.176	0.185	0.188
2016	0.09	0.125	0.149	0.163	0.182	0.188	0.19	0.21	0.201
2017	0.072	0.106	0.132	0.145	0.159	0.168	0.172	0.179	0.183

	1	2	3	4	5	6	7	8	9+
2018	0.085	0.101	0.127	0.144	0.155	0.166	0.172	0.170	0.174
2019	0.063	0.099	0.127	0.147	0.159	0.164	0.180	0.174	0.172
2020	0.059	0.091	0.109	0.121	0.134	0.146	0.152	0.158	0.168
2021	0.080	0.108	0.116	0.124	0.134	0.141	0.147	0.151	0.173
2022	0.066	0.103	0.112	0.124	0.133	0.142	0.154	0.167	0.164
2023	0.062	0.094	0.117	0.126	0.135	0.142	0.148	0.152	0.165

Table 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2023.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245

	1	2	3	4	5	6	7	8	9+
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247
2007	0.114	0.133	0.133	0.171	0.186	0.196	0.208	0.228	0.229
2008	0.098	0.136	0.140	0.174	0.185	0.196	0.192	0.205	0.234
2009	0.072	0.141	0.162	0.197	0.215	0.223	0.225	0.221	0.286
2010	0.092	0.128	0.157	0.189	0.208	0.227	0.234	0.239	0.247
2011	0.082	0.118	0.136	0.177	0.199	0.207	0.225	0.239	0.240
2012	0.084	0.135	0.182	0.203	0.214	0.226	0.225	0.21	0.226
2013	0.074	0.114	0.140	0.170	0.188	0.198	0.204	0.223	0.222
2014	0.093	0.128	0.135	0.154	0.169	0.170	0.188	0.169	0.206
2015	0.077	0.112	0.146	0.155	0.165	0.173	0.179	0.183	0.217
2016	0.078	0.119	0.147	0.164	0.185	0.191	0.197	0.21	0.175
2017	0.064	0.099	0.130	0.145	0.163	0.173	0.176	0.185	0.180
2018	0.072	0.097	0.126	0.146	0.156	0.168	0.172	0.169	0.170

	1	2	3	4	5	6	7	8	9+
2019	0.062	0.098	0.124	0.149	0.164	0.166	0.180	0.180	0.175
2020	0.056	0.088	0.110	0.125	0.144	0.154	0.157	0.164	0.168
2021	0.070	0.109	0.151	0.171	0.182	0.196	0.203	0.205	0.211
2022	0.052	0.118	0.148	0.169	0.179	0.190	0.194	0.194	0.214
2023	0.064	0.112	0.145	0.155	0.169	0.158	0.197	0.173	0.163

Table 5.3.1.1. Herring in divisions 6.aS, 7.b–c Total numbers (millions) and biomass (tonnes) of herring June–July 2014-2023. From the Split Malin Shelf acoustic survey

Year	Age(-wr)	1	2	3	4	5	6	7	8	9+	CV	SSB (t)
2014	her-irlw		30.02	118.63	271.01	252.21	99.34	31.38	10.39	4.90	0.26	149270
2015	her-irlw		122.52	255.67	395.26	254.82	225.28	58.96	9.38		0.24	226293
2016	her-irlw		8.09	45.22	42.18	38.06	42.34	26.05	1.71	0.91	0.23	36707
2017	her-irlw		6.55	112.57	87.69	39.22	58.66	39.21	21.65	0.33	0.33	66342
2018	her-irlw	572.95	303.59	68.30	199.14	92.34	36.80	47.08	14.63	6.14	0.57	96138
2019	her-irlw	3.80	170.70	213.96	103.46	91.97	47.16	5.93	17.27	8.92	0.26	92364
2020	her-irlw	895.11	776.20	401.75	188.20	71.45	120.21	24.77	6.64	8.51	0.24	135335
2021	her-irlw	173.49	1389.15	532.79	105.14	66.21	27.17	46.06	12.62	12.82	0.31	189856
2022	her-irlw	175.31	174.95	382.81	210.45	118.18	45.82	15.45	22.45	1.88	0.52	147199
2023	her-irlw	172.43	469.34	126.08	216.74	108.36	22.38	15.67	6.13	3.87	0.42	100523

Table 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Mean Weights at age of herring June–July 2014-2023. From the Split Malin Shelf acoustic survey

Year	Age(-wr)	1	2	3	4	5	6	7	8	9+
2014	her-irlw		134.74	159.19	177.5	201.06	211.04	213.03	224.16	231.2
2015	her-irlw		134.47	173.81	188	194.66	201.2	205.55	206.98	
2016	her-irlw		130.72	133.84	168.5	204.33	204.86	206.58	210.52	274.3
2017	her-irlw		133.46	161.43	172.3	185.24	196.36	194.56	202.98	177
2018	her-irlw	48.67	107.92	149.17	172.5	183.84	206.14	208.64	210.24	218.7
2019	her-irlw	86.42	116.56	153.2	167.5	190.95	182.68	189.54	220.5	218.9
2020	her-irlw	54.98	110.01	136.84	157.8	171.39	190.92	203.78	201.1	233.3
2021	her-irlw	70.22	108.67	151.23	171.12	182.24	195.80	203.31	205.02	210.58

2022	her-irlw	52.45	118.14	148.33	169.26	178.63	190.17	194.17	193.69	213.72
2023	her-irlw	63.96	112.16	145.09	155.35	169.24	157.85	197.15	172.68	163.48

Table 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Maturity at age of herring June–July 2014-2023. From the Split Malin Shelf acoustic survey

Year	Age(-wr)	1	2	3	4	5	6	7	8	9+
2014	her-irlw	0	0.85	0.81	0.99	1	1	1	1	1
2015	her-irlw	0	0.41	0.84	0.98	0.94	0.99	0.98	1	
2016	her-irlw	0	1	1	1	1	1	1	1	1
2017	her-irlw	0	1	0.99	0.99	1	1	1	1	1
2018	her-irlw	0.01	0.42	0.82	0.97	0.98	1	1	1	1
2019	her-irlw	0	0.51	0.94	1	1	1	1	1	1
2020	her-irlw	0	0.25	0.64	1	1	1	1	1	1
2021	her-irlw	0.01	0.38	0.92	1	1	1	1	1	1
2022	her-irlw	0	0.76	0.97	1	1	0.97	1	1	1
2023	her-irlw	0	0.44	0.95	1	1	1	1	1	1

Table 5.3.2.1. Herring in divisions 6.aS, 7.b–c. Details of acoustic surveys dedicated to the 6a.S/7.b–c stock.

Year	Type	Total Biomass	Spawning Stock Biomass
1994	Feeding phase	-	353772
1995	Feeding phase	137670	125800
1996	Feeding phase	34290	12550
1997	-	-	-
1998	-	-	-
1999	Autumn	23762	22788
2000	Autumn	21000	20500
2001	Autumn	11100	9800
2002	Winter	8900	7200
2003	Winter	10300	9500
2004	Winter	41700	41399
2005	Winter	71253	66138

Year	Type	Total Biomass	Spawning Stock Biomass
2006	Winter	27770	27200
2007	Winter	14222	13974
2008-2015	No Surveys		
2016	Winter	35475	35475
2017	Winter	40646	40646
2018	Winter	50145	49523
2019*	Winter	25289	22386
2020**	Winter	45046	44107
2021**	Winter	35944	35859
2022**	Winter	54046	53692
*reduced survey area			
** Survey design changed significantly compared to other years, only 6 core areas covered			

Table 5.6.2.2. Herring in divisions 6.aS, 7.b–c. Definitions of the components used to calculate *chr* from WKLIFEX (note $F_{proxy\ MSY}$ has now been estimated using stock-specific simulations described in section 5.6.2.2 of this report).

Component	Definition	Description and use
I_{y-1}		The index in year *y*−1.
$F_{proxy,MSY}$	$\frac{1}{u}\sum_{y\in U} C_y/I_y$	Is the mean of the ratio C_y/I_y for the set of historical years U for which the quantity *f* > 1, and u is the number of years in the set U. The quantity *f* is the ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2018b).
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock.
m	[0,1]	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	$min\{max(0.7C_y, C_{y+1}), 1.2C_y\}$	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%; i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's advised catch. The stability clause does not apply when *b* < 1.

Table 5.6.2.3. Herring in divisions 6.aS, 7.b–c. Estimate of natural mortality (M) used in the exploratory assessments for herring in 6aS, 7bc and various M/k ratio calculations. Most appropriate M/k ratio highlighted in bold.

Age	1	2	3	4	5	6	7	8	9	1 to 9	2 to 9	3 to 6
M	0.528	0.303	0.255	0.225	0.207	0.193	0.186	0.180	0.180	0.251	0.216	0.220
k										0.339	0.339	0.339
M/k										0.740	0.637	**0.649**

Table 5.6.2.3.1a. Herring in divisions 6.aS, 7.b–c. Catch (C), spawning-stock biomass index (I), harvest rate (C/I) and fishing pressure proxy relative to F $_{MSY\ proxy}$ ($L_{mean}/L_{F=\gamma M,K=\theta M}$) are given for the years used in the application of the *chr* (ICES, 2022e). L_{mean} refers to the mean length above length at first capture (L_c) and $L_{F=\gamma M,K=\theta M}$ refers to the target reference length. Weights are in tonnes. The inverse of f ($L_{F=\gamma M,K=\theta M}/L_{mean}$) is also presented.

Year	SSB index I_y	Catch Cy	Harvest rate C_y/I_y	Modal length in catch L	Lc (Length of first capture)	Mean length > Lc in catch	Target Reference Length $L_{F=\gamma M,K=\theta M}$	f* $L_{mean}/L_{F=\gamma M,K=\theta M}$	Inverse of length-based fishing pressure proxy ($L_{F=\gamma M,K=\theta M}/L_{mean}$)
2014	149270	5,096	0.034	28.0	26.0	27.996	27.958	1.001	0.999
2015	226293	1,078	0.005	27.0	26.5	27.680	28.241	0.980	1.020
2016	36707	2213	0.060	28.0	25.0	27.298	27.393	0.996	1.003
2017	66342	2227	0.034	26.0	25.0	27.006	27.393	0.986	1.014
2018	96138	1495	0.016	27.0	25.5	27.184	27.676	0.982	1.018
2019	92364	1690	0.018	25.5	23.0	26.170	26.264	0.996	1.004
2020	135335	1220	0.009	24.0	22.5	25.030	25.981	0.963	1.038
2021	189856	1821	0.010	25.5	24.5	25.993	27.111	0.959	1.043
2022	147199	1326	0.009	26.0	24.5	26.117	27.111	0.963	1.038
2023	100523	1255	0.012	26.0	24.5	26.187	27.111	0.966	1.035

***Only harvest rates in years where f ratio is above 1 are included in the calculation of F MSY proxy**

Table 5.6.2.3.1b. Herring in divisions 6.aS, 7.b–c. Constants used in the calculation of $F_{MSY\ proxy}$ and target reference lengths.

Description	Value
C_y / I_y where f > 1	0.034
$F_{MSY\ proxy}$	0.26
L_∞	30.50
M	0.220
k	0.339
γ	1.000
Θ (=k/M)	1.541

Notes

Catch (t)	Catch from 6aS7bc only
Biomass estimates (I)	MSHAS split 6aS7bc SSB
modal length in catch L	L = modal abundance (ICES, 2018).
L_c	Length of first capture = length at 50% of modal abundance (ICES,2018)
Mean length > L_c in catch	mean length (L_{y-1}) in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length).
Target reference length	$L_{F=\gamma M,\ k=\theta M}$ using Jardim *et al.* (2015) equation (see text)
f	The quantity f is the ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length).
C_y / I_y where f > 1	Is the ratio Cy/Iy for the set of historical years U for which the quantity f > 1, and u is the number of years in the set.
$F_{,MSY\ proxy}$	Is the mean of the ratio C_y/I_y for the set of historical years U for which the quantity f > 1, and u is the number of years in the set.
L_∞	L infinity estimated from catch sampled length data
M	Mean natural mortality ages 3-6
k	von Bertalannfy growth parameter estimated from catch sampled length data
γ	Gamma set to 1
ϴ	Theta =k/M

Table 5.6.2.3.2. Herring in divisions 6.aS, 7.b–c. *chr* summary table and advice using length, survey and catch data from 2014 – 2023 (inclusive).

Parameter	Value
Ay (previous advice)	2,270 t
Iy-1 (latest survey SSB, t)	100,523 t
Fproxy,MSY	0.26
b (biomass safeguard)	1
m (multiplier)	0.5
chr ($C_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$)	13,068 t
% Change (from previous advice)	+476%
Stability clause applied (-30% or +20%)	Applied
Advised Catch	2,724 t

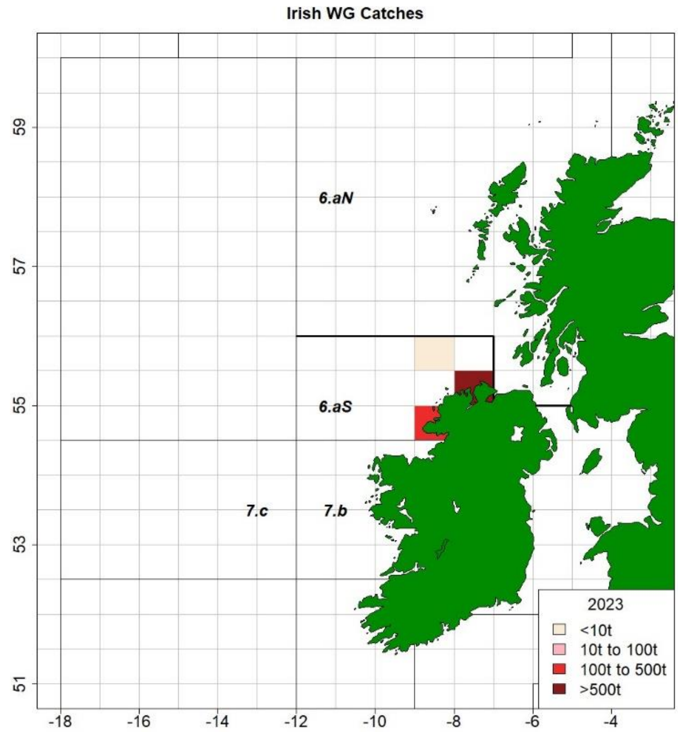


Figure 5.1.2 Herring in divisions 6.aS, 7.b–c. Irish catches in 2023.

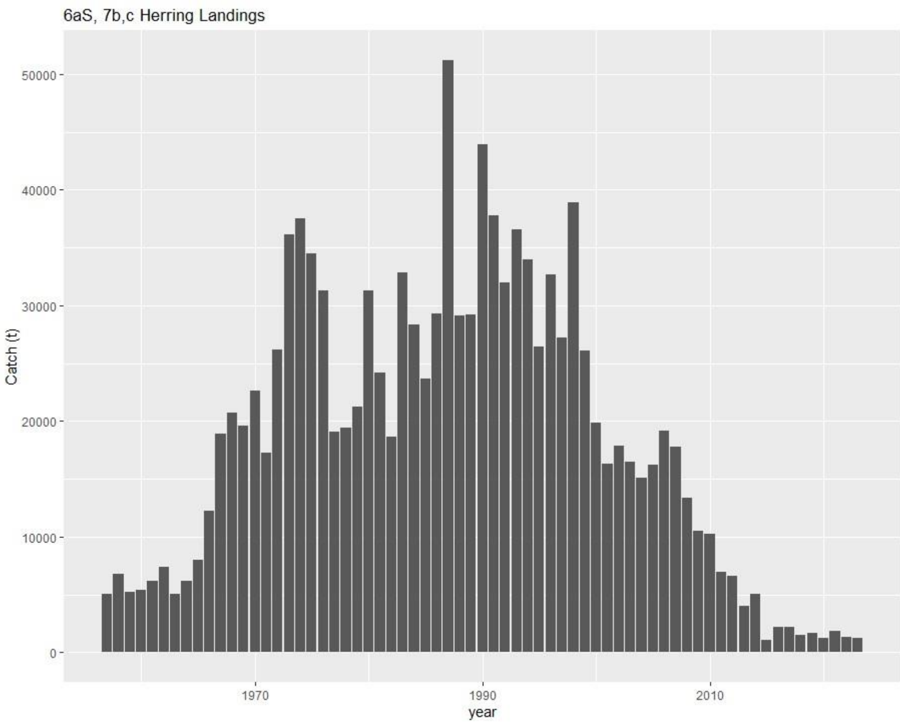


Figure 5.1.4 Herring in divisions 6.aS, 7.b–c. Working group estimate of catches from 1957–2023.

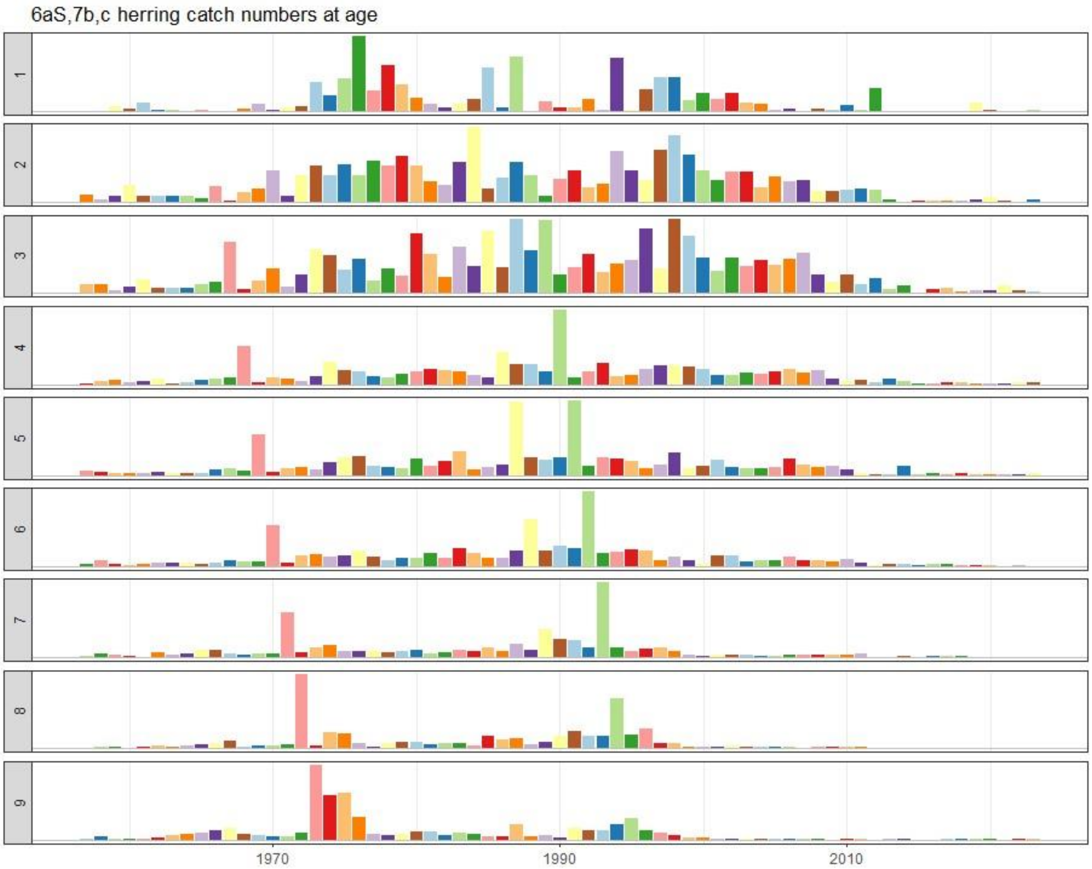


Figure 5.2.1. Herring in divisions 6.aS, 7.b–c. catch numbers-at-age for the fishery 1957–2023.

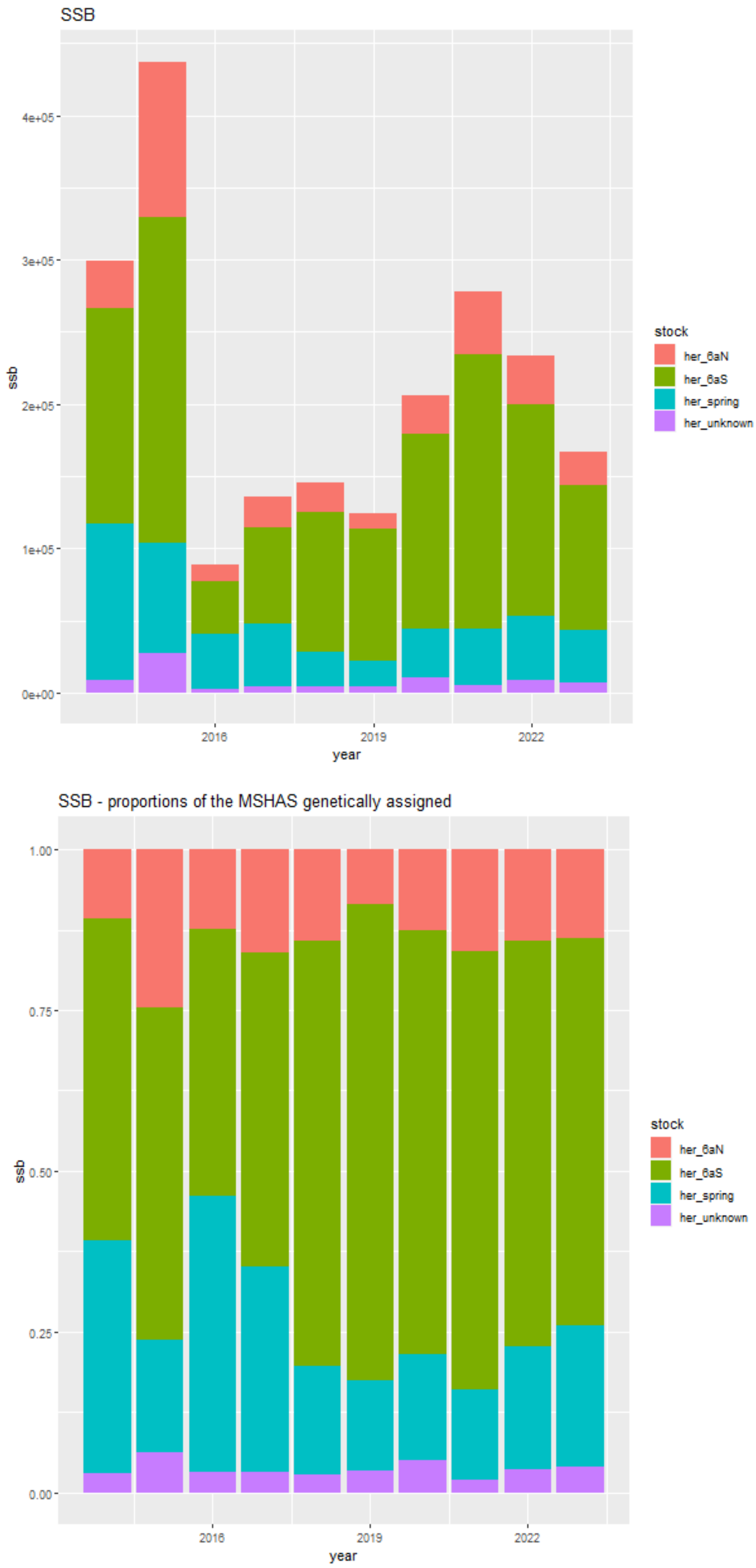


Figure 5.3.1.1. Herring in divisions 6.aS, 7.b–c. Spawning stock biomass (tonnes) by year for the individual MSHAS split indices (top) and stack bar chart of the proportions (below). her-6aS refers to her.27.6aS,7b,c., her_6aN refers to 6.a North, her_spring refers to spring spawning 6aS and 6aN herring that cannot currently be differentiated by the assignment model, and her_unknown refers to fish that could not be assigned to any population.

Figure 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Malin Shelf Acoustic Survey - split catch numbers at age.

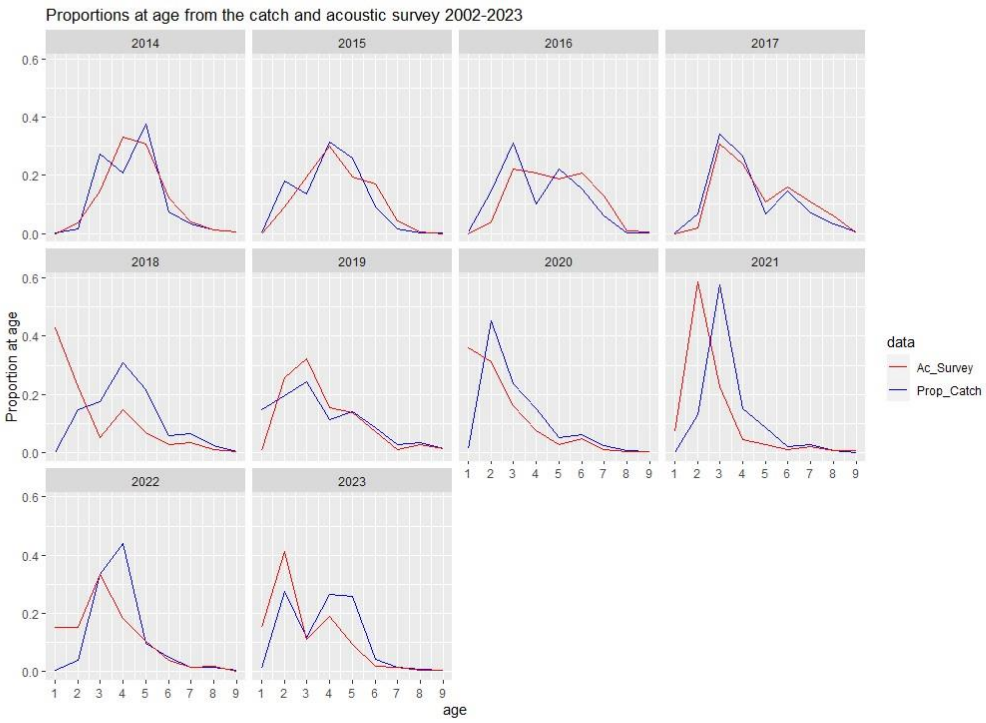


Figure 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Proportions-at-age in the 6aS, 7.b–c catch and 6aS, 7.b–c Split Malin Shelf acoustic survey (MSHAS) 2014–2023.

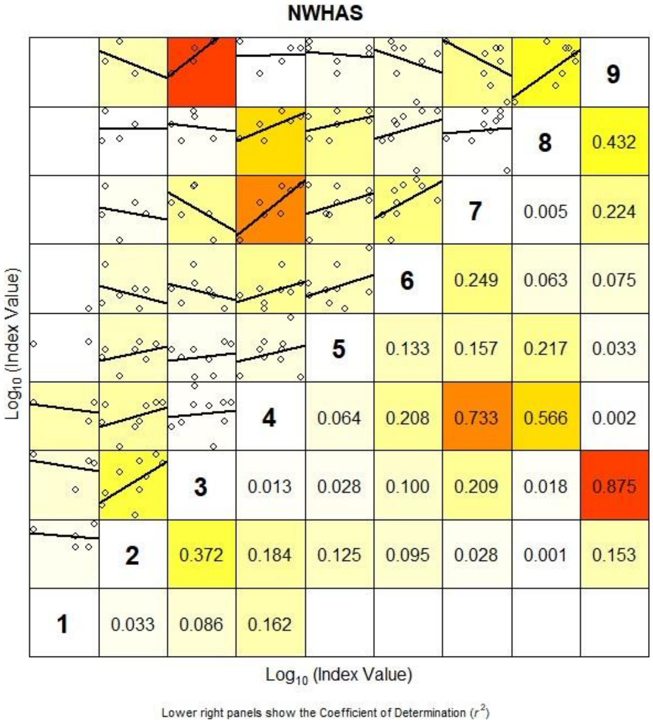


Figure 5.3.1.4 Herring in divisions 6.aS, 7.b–c. Internal consistency between ages (rings) in the Split MSHAS herring acoustic survey time-series (2014–2023).

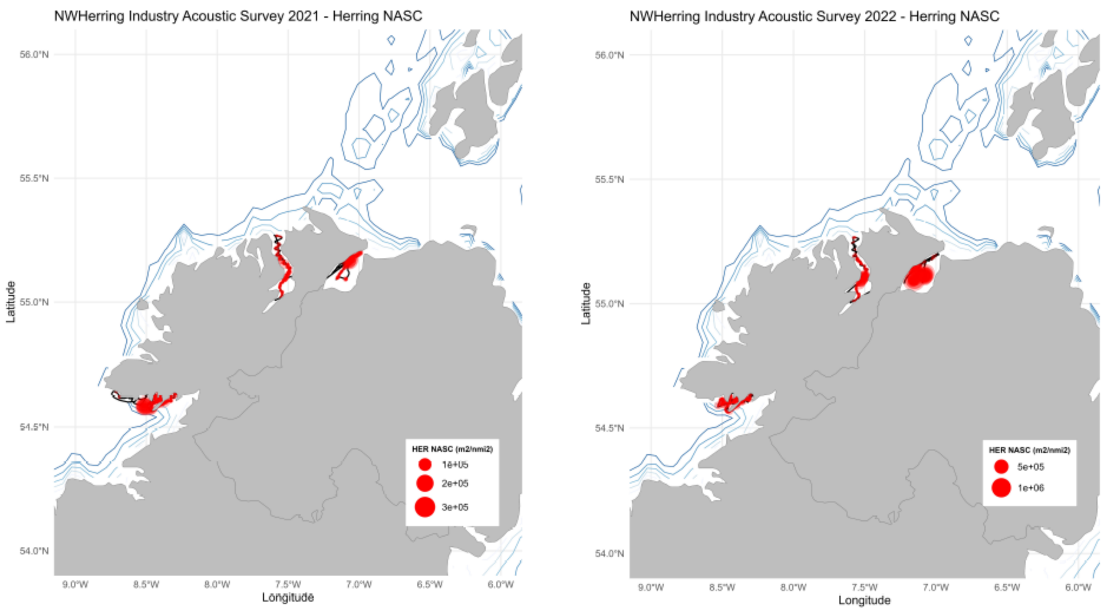


Figure 5.3.2.1. Herring in divisions 6.aS, 7.b–c. NASC distribution in the industry science surveys 2021 and 2022

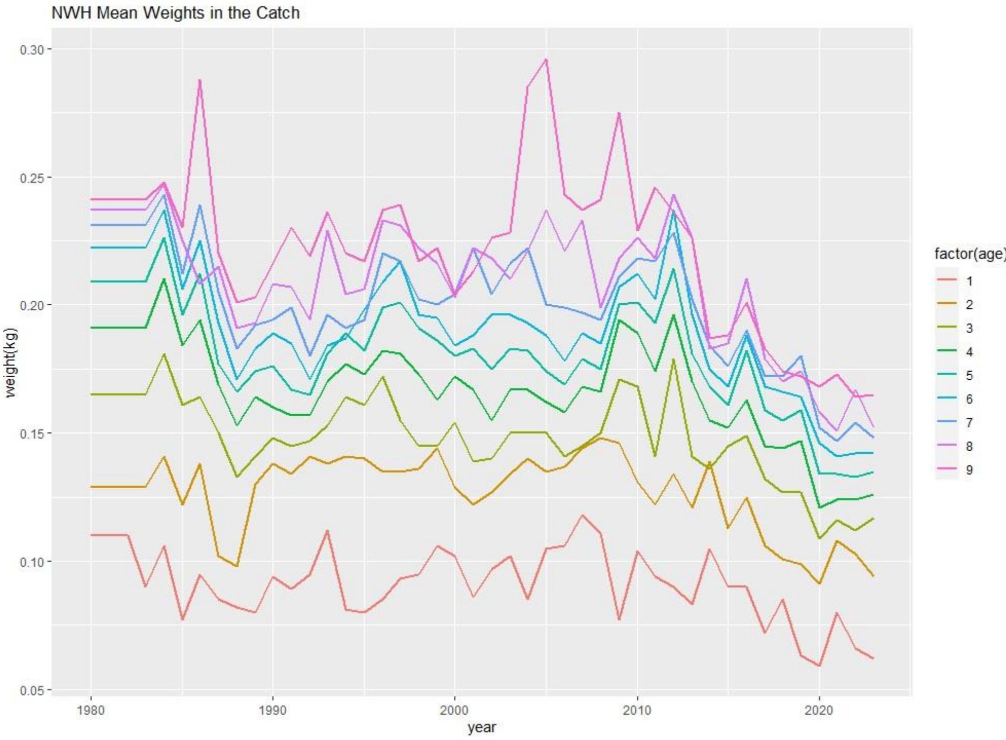


Figure 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2023). Prior to 1981 weights were fixed.

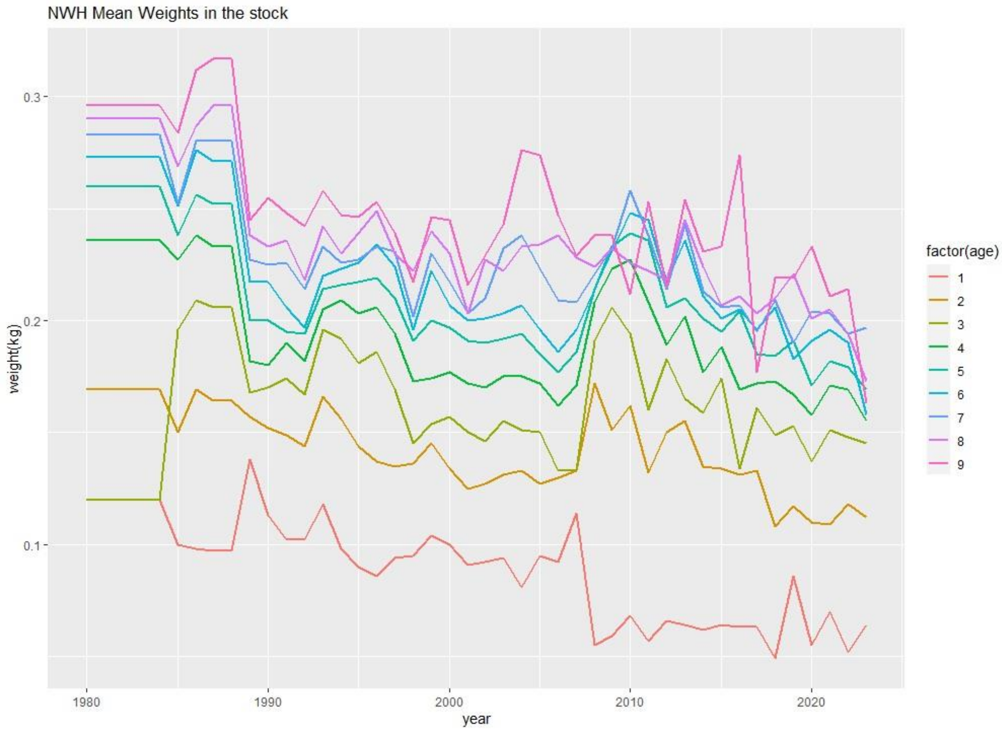


Figure 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2023). Prior to 1981 weights were fixed.

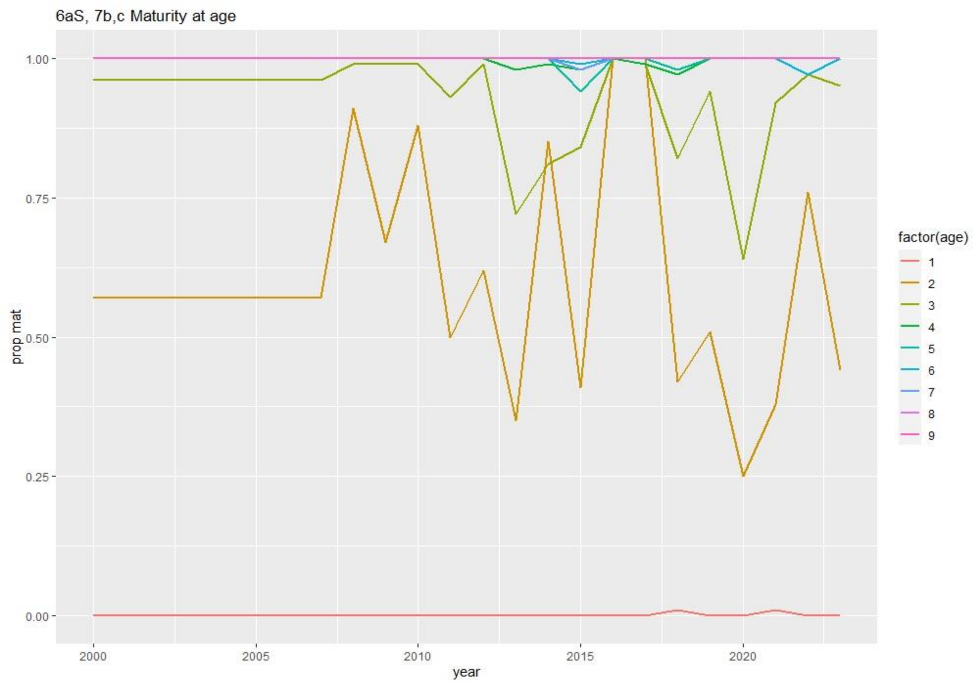


Figure 5.4.2. Herring in divisions 6.aS, 7.b–c. Maturity Ogive.

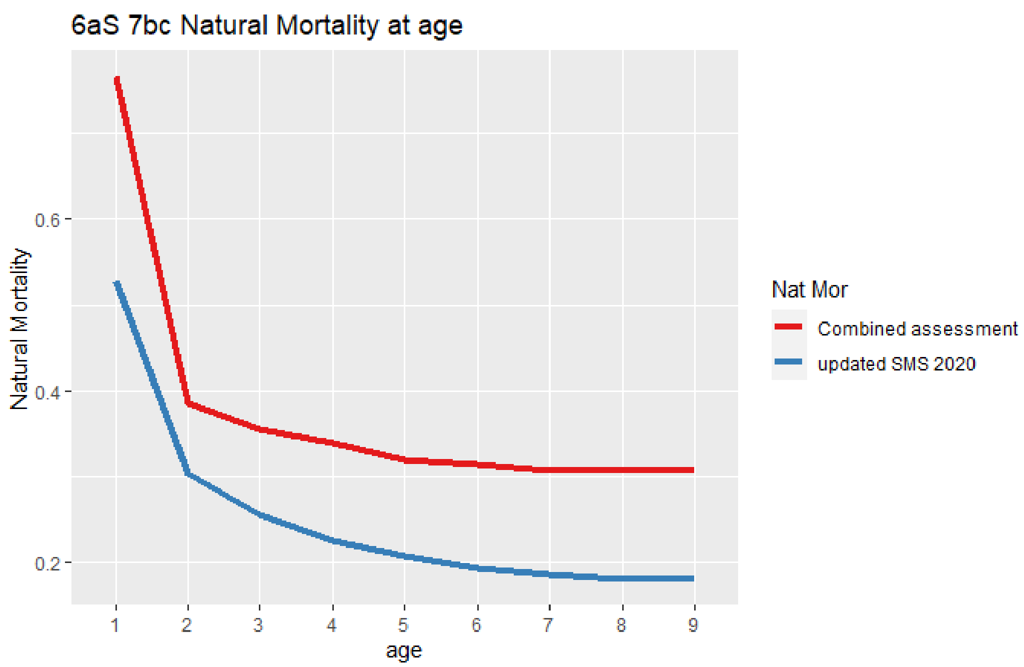


Figure 5.4.3. Herring in divisions 6.aS, 7.b–c. Natural Mortality at age updated at the benchmark in 2022 and the previously used value.

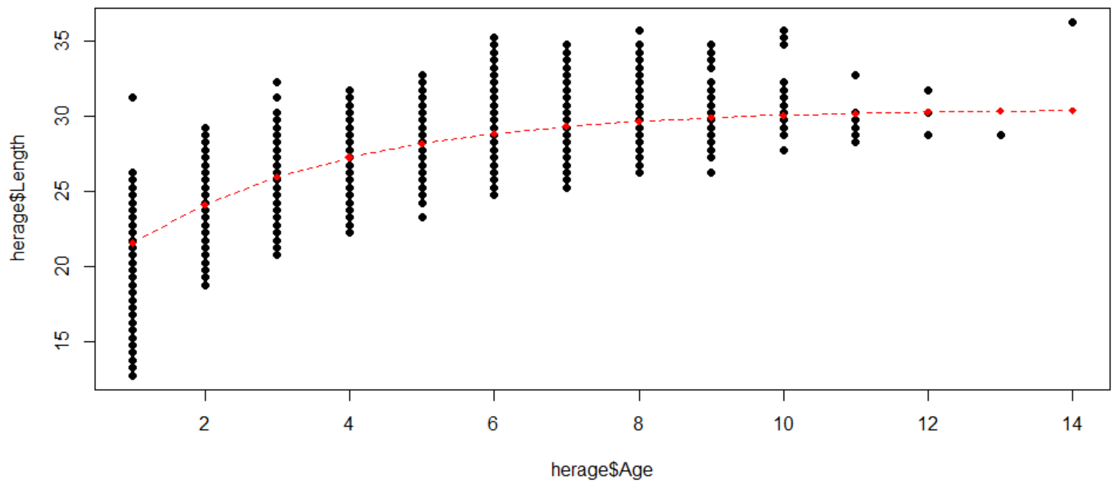


Figure 5.6.2.1. Herring in divisions 6.aS, 7.b–c. Fit of growth curve to length data from commercial catch of herring in 6aS and 7b. n = 594k.

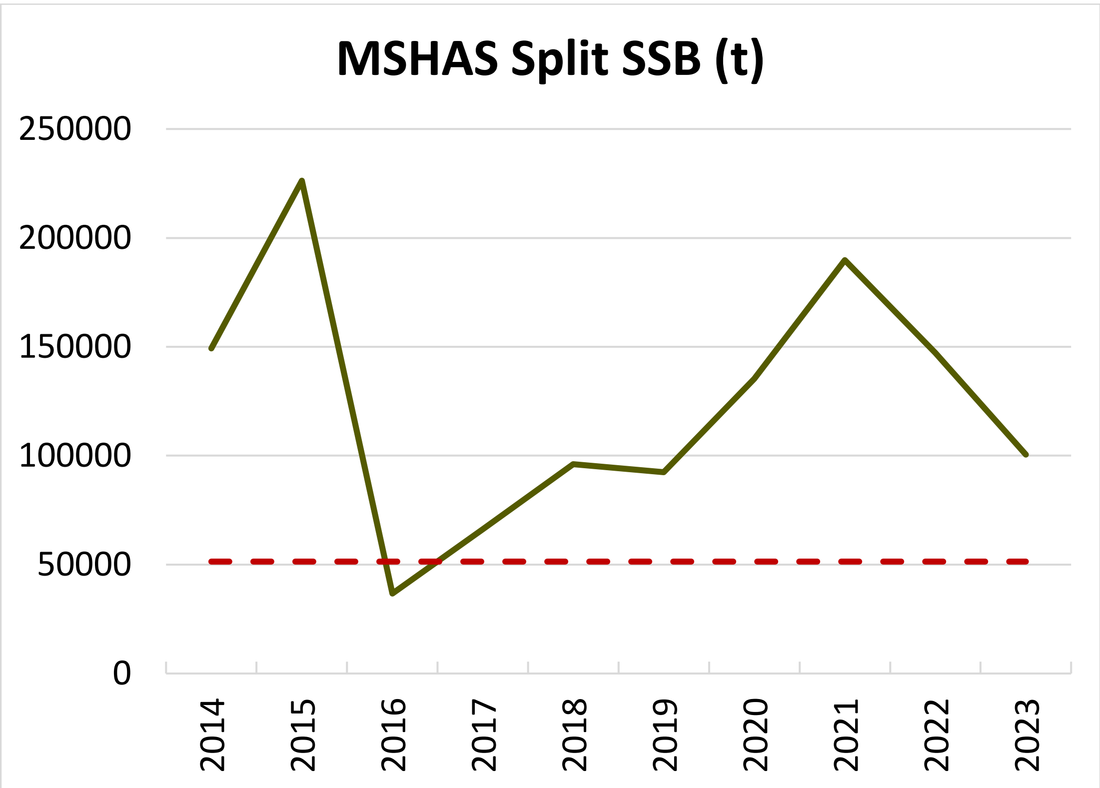


Figure 5.6.2.3.1 Herring in divisions 6.aS, 7.b–c. MSHAS 6aS Split Spawning Stock Biomass (tonnes) by year. Red line shows $I_{trigger}$ (1.4 * I_{loss}).

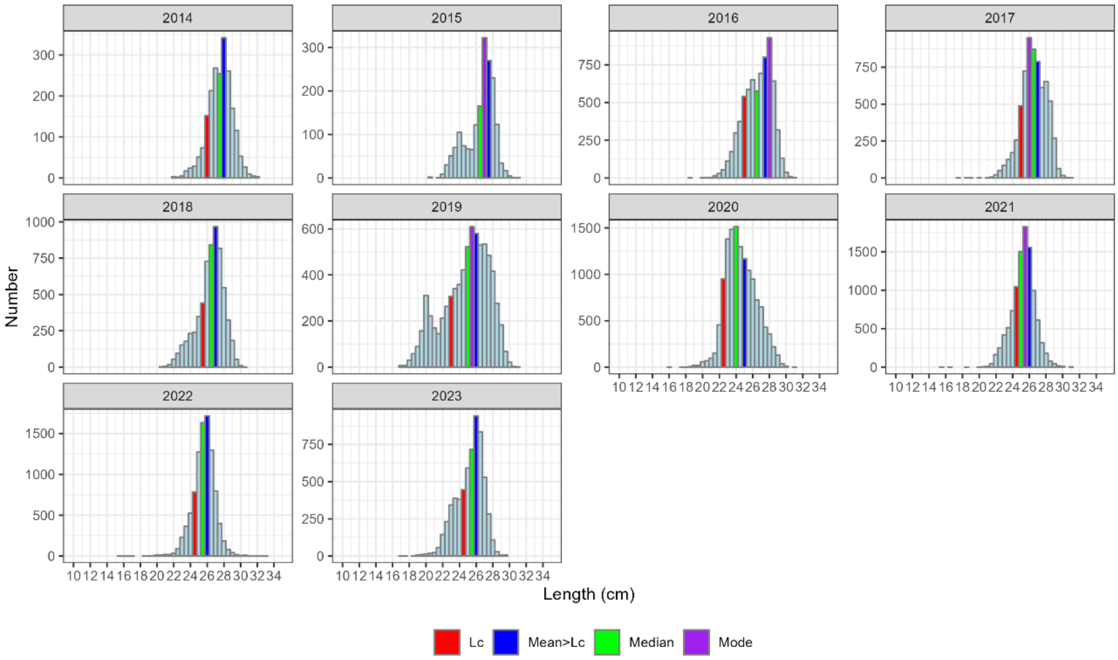


Figure 5.6.2.3.2 Herring in divisions 6.aS, 7.b–c. Length frequency distributions by year showing length at first capture (Lc), Mean length above Lc (Mean>Lc), the median and the mode from catch sampling data.

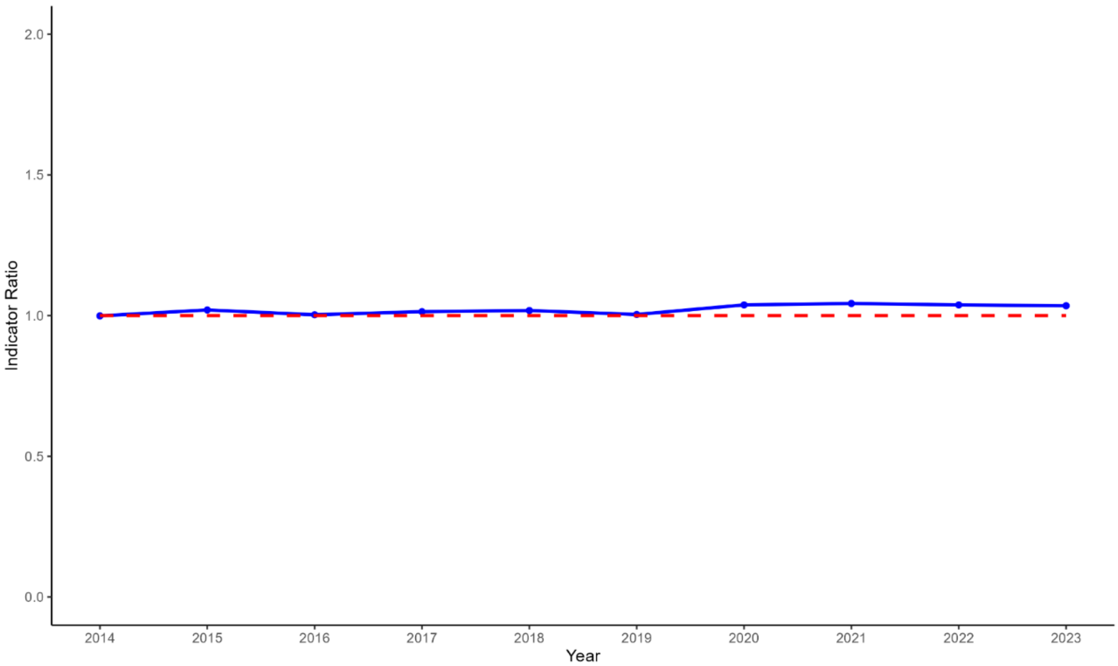


Figure 5.6.2.3.3 Herring in divisions 6.a South and 7.b–c. Indicator ratio $L_{F=\gamma M,K=\theta M}/L_{mean}$ (inverse of fishing proxy, *f*) from the length-based indicator (LBI) method is used for the evaluation of the exploitation status. The proxy fishing pressure is less than the pressure corresponding to the F_{MSY} proxy ($L_{F=M}$) when the indicator ratio value is lower than 1 (shown by a horizontal dotted red line).

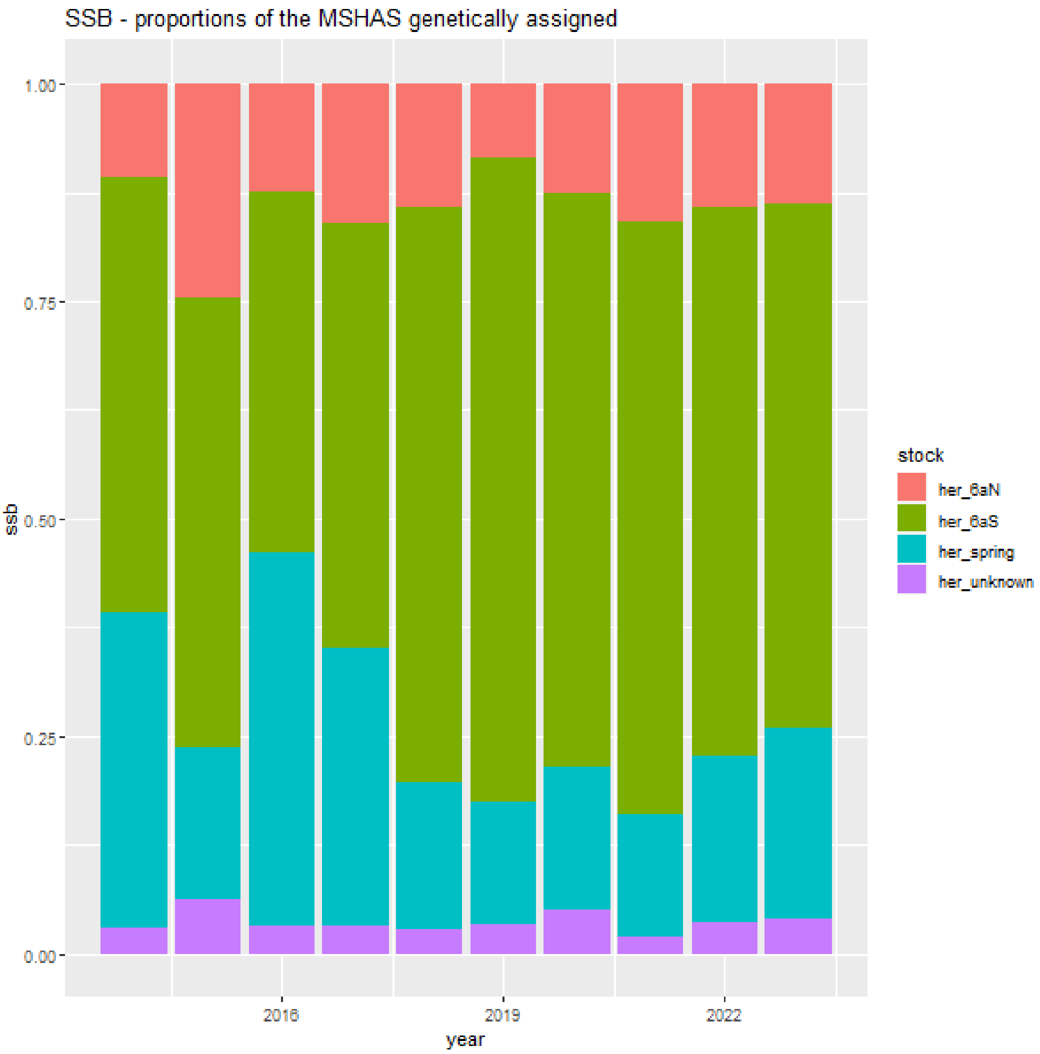


Figure 5.10.1. Herring in divisions 6.aS, 7.b–c. Proportions of the MSHAS genetically assigned.

Contents

6 Herring in the Celtic Sea (divisions 7.a South of 52°30’N and 7.g, 7.h, 7.j and 7.k)

The assessment year for this stock runs from 1st April until 31st March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2023 refers to the 2023–2024 season.

The WG notes that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout the report. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks such as this one, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age-based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

6.1 The Fishery

6.1.1 Advice and management applicable to 2023–2024

The TAC is set by calendar year. In 2019, the EC requested ICES to advise on the minimum level of catches (tonnages) required in a sentinel TAC, which would provide sufficient data for ICES in order to continue providing scientific advice on the state of the stock (ICES, 2019). ICES advised that at least 17 samples from the main and the sentinel fleet would be required to provide advice on similar bases as with a commercial fishery. Those samples could be obtained through a monitoring catch of 869 t. As a result, the monitoring TAC agreed by the Council of the European Union from 2020 to 2024 was 869 t.

6.1.2 The fishery in 2023–2024

In 2023, the Irish fishery took place in 7.g in Q3 (53%) and in 7g (16%) and 7.a.S (27%) in Q4. There was also a small amount of catch (25t) taken from 7.g in Q1 2024.

The Irish fishery is divided into two fleets, the main fleet and the sentinel fleet. The Celtic Sea Herring Management Advisory Committee (CSHMAC) provide input to the management of the Celtic Sea Herring. Fishing opened on the 20th August in 2023, in 7.g and continued until mid October, with over 532 t landed in total. The fishery in 7a.S started in late November and continued until mid-December. In Q1 2024 all of the catch was taken in 7.g.

The Netherlands, Germany, France and the UK did not utilize their quota. The area 7.h is part of the management area, but it is unclear if it is part of the stock area.

The spatial distribution of the 2023 landings is presented in Figure 6.1.2.1. There was full uptake of the Irish quota in 2023.

The estimated catches from 1988–2023 for the combined areas (7.a.S, 7.g, 7.h, 7.j, 7.k) by quota year and by assessment year (1st April–31st March) are given in tables 6.1.2.1 and 6.1.2.2 respectively. The catch taken during the 2023–2024 season increased to 764 t from 350 t in 2022-2023 (Figure 6.1.2.2).

The catch data include discards in the directed fishery until 1997. An independent observer study of the Celtic Sea herring fishery was conducted annually from 2012 to 2017. This observer programme was discontinued in 2018. Discards from these trips were raised to the total international catch using a weighted average for each year from 2012 to 2017.

Regulations and their effects

Under the previous rebuilding plan, the closure of Subdivision 7.a.S from 2007-present, except for a sentinel fishery, meant that only small dry hold vessels, no more than 50 feet total length, could fish in that area. In 2012, local quota management arrangements were adopted to restrict fishing in 7.a.S to vessels under 50 feet, but the total quota allocation increased from 8% to 11%. Therefore, from 2012 there was a slight increase in landings from this area. There is evidence that closure of Subdivision 7.a.S under the rebuilding plan helped to reduce fishing mortality (Clarke and Egan, 2017). The exact mechanisms for this are unclear.

6.1.3 Changes in fishing patterns

In 2019, the high prevalence of fish less than the minimum conservation reference size (MCRS <20 cm) limited the main fleet to 5 days and prevented it from catching the quota. There were no issues with < MCRS fish in 2021 and 745 t of the 869 t available was taken. In 2022 the fishery took 350 t in total. The offshore fishery did not utilise their full quota. The fishery opened one month earlier in 2023 than 2022, and the offshore quota was taken.

Vessels greater than 50 feet total length are excluded from 7.a.S under local Irish legislation.

6.1.4 Discarding

As in all pelagic fisheries, estimation of discarding is very difficult. Individual instances of discarding may be quite infrequent in occurrence. However individual slippages could result in considerable quantities of herring being discarded. The estimates produced by the HAWG in 2012 provided a sensitivity analysis of the assessment to maximum possible discarding. The risk of discarding (slippage induced by restrictive vessel quotas) is now reduced, due to the flexibility mechanism introduced in quota allocation since 2012. Available evidence is that the discard rate is negligible in directed fisheries. In 2023 six observer trips were carried out during the Celtic Sea herring fishery by the Marine Institute with no discarding observed.

Estimates of discarding from observer trips for the purposes of marine mammal bycatch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014), 1.4% in 2015 in the main fishery and 1.5% in the 7.a.S small boat fishery (Pinfield and Berrow, 2015,), 1.13% in 2016 (O'Dwyer *et al.*, 2016) and 1.19% in 2017 (O'Dwyer and Berrow, 2017). This observer programme was discontinued in 2018; no discard estimates are available for subsequent years.

Since 2015, this stock is covered by the landing obligation.

6.2 Biological composition of the catch

6.2.1 Catches in numbers-at-age

Catch numbers-at-age are available for the period 1958-2023 (Table 6.6.1.1). The 2018 year class, four winter ring fish, were again the dominant year class in 2023 representing 49% of the total catch numbers at age (Table 6.2.1.1). The 2017 year class was the second most abundant. These fish are currently 5 winter rings (26% in 2023).

The yearly mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Older ages 7, 8 and 9 wr were barely observed in the catch. Truncation of ages is again evident in this stock.

The overall proportions-at-age in the catch and the survey are presented in Figure 6.2.1.2. There is generally good agreement between the data sources. The Q4 acoustic survey picks up 1-wr fish in larger proportions than the catch data in some years. The 2018 class is being tracked by the catch and the survey. A high proportion of 1 ringers were found in the catch and the survey in 2019 (2018 year class) and these have been tracked through the fishery and appeared as 5 ringers in 2023. The 2019 year class can also be tracked in both the catch and survey.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. In 2023, the samples from 7aS Q4 cover a wider range of lengths from 13.5cm – 27.5cm than from 7g Q3 which has lengths from 19cm – 27.5cm and 7g Q4 where the length range was 21.5cm – 28cm. No samples were taken in Q1 2024.

6.2.2 Quality of catch and biological data

Biological sampling of the catches was carried out in the area exploited by the Irish fishery (Table 6.2.2.1) in 2023. There were 14 samples obtained from the monitoring TAC that was taken. Five samples were obtained from the main fleet and nine from the sentinel fleets in 2023.

6.3 Fishery-Independent Information

6.3.1 Acoustic Surveys

The Celtic Sea herring acoustic survey (CSHAS) time-series currently used in the assessment runs from 2002 to 2023, excluding 2004 (no survey) and 2017 (insufficient biological data). The full survey time-series is presented in Table 6.3.1.1. The internal consistency between ages 1–9 from the acoustic survey is good and presented in Figure 6.3.1.2.

The acoustic survey of the 2023–2024 season was carried out from 9th to 29th October 2023, on the RV Celtic Explorer (O'Donnell *et al.*, 2023, http://hdl.handle.net/10793/1895). Geographical coverage was in line with previous years. The acoustic survey track is shown in Figure 6.3.1.1.

NASC distribution plots from the 2023 survey are presented in Figure 6.3.1.1. Immature herring were found in the eastern part of the core survey area, as well as inshore and occurred in mixed aggregations dominated by sprat. Mature herring were only observed in a high density offshore aggregation.

The mature herring encountered were close to the seabed and were typical of observations over recent years. The age composition was dominated by 4-wr, followed by 5-wr, 6-wr and 3-wr fish by weight. Spawning stock biomass decreased by 25% compared to 2022.

A total of 20 trawl hauls were carried out during the survey in 2023, with eleven containing herring. The numbers of 1-wr and 2-wr fish remain low overall with no obvious signs of emerging strong year classes. The 2019 year class (4wr) accounts for 47% and the 2018 year class (5wr) is 42% of the 2023 survey abundance estimates (Table 6.3.1.1).

6.4 Mean weights-at-age and maturity-at-age and Natural-Mortality

The mean weights in the catch and mean weights in the stock at spawning time are presented in Figure 6.4.1.1 and Figure 6.4.1.2 respectively. There has been an overall downward trend in mean weights-at-age in the catch since the early 1980s. After a slight increase around 2008, they have declined again. In 2023 decreases in mean weight can be seen for the youngest (1 and 2) and oldest (8 and 9+) age classes. Small increases can be seen for all other age classes from 3-7 winter ring. Mean weights in the stock at spawning time were calculated from biological samples from Q4 (Figure 6.4.1.2). The overall trends in stock weights shows decreases for all ages except 7 wr and 9+ wr where small increases can be seen.

In the assessment, 50% of 1-wr fish are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-wr fish are mature (Lynch, 2011). However, the 2014 benchmark (ICES, 2014) concluded that there was insufficient information to change the maturity ogive.

Following the final procedure of HAWG 2015, natural mortality values used in the final assessment incorporated the SMS run as obtained in 2011.

The time-invariant natural mortalities and maturities-at-age are presented in the text table below.

	1	2	3	4	5	6	7	8	9+
Maturity	0.5	1	1	1	1	1	1	1	1
Natural mortality	0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

6.5 Recruitment

At present there are no independent recruitment estimates for this stock.

6.6 Assessment

This stock was benchmarked in 2015 by WKWEST (ICES, 2015) and inter-benchmarked by WKPELA 2018.

6.6.1 Stock Assessment

This update assessment was carried out using ASAP. The assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS) ages 2–7 winter rings and excluding the 2004 and 2017 survey. The input data are presented in tables 6.6.1.1 and 6.6.1.2. The ASAP settings are as per the 2018 inter-benchmark (Table 6.6.1.3). The stock summary is presented in Table 6.6.1.4.

Figure 6.6.1.1 shows the catch proportions-at-age residuals. The residuals are large for the young ages, which is to be expected because these are estimated with low precision. Larger residuals can be seen in recent years. Overall, there is no consistent pattern in the residuals. Figure 6.6.1.2 shows the observed and predicted catches. The model closely followed the observed catches. The observed and predicted catch proportions-at-age are shown in Figure 6.6.1.3. There is some divergence in the most recent years, most notable at 9-wr, with a larger proportion predicted than observed catches. Overall, the fits are good throughout the full time-series.

The selection pattern in the fishery for the final assessment run is shown in Figure 6.6.1.4. Selection is fixed at 1 for 3-wr which is the age that Celtic Sea herring are considered to be fully selected. Selection at all other ages is estimated by the model. This gives a dome-shaped selection pattern which is considered appropriate to this fishery. The model predicts a drop in selection at-age 9-wr. This may be the case given the low abundance of 9-wr in the catch data.

Figure 6.6.1.5 shows the residuals of the index proportions-at-age. In previous years the largest residuals can be seen at the younger ages. The index fit shows generally good agreement with poorest agreement seen for the very large survey index in 2012 (Figure 6.6.1.6). The selectivity parameters were adjusted at the inter-benchmark. Selection is now fixed for ages 3–5. This gives a more dome-shaped selection pattern with selection declining at older ages (6 and 7 wr) (Figure 6.6.1.7).

The analytical retrospective for SSB, fishing pressure and recruitment is shown in Figure 6.6.1.8. The Mohn's Rho on SSB calculated by ASAP is 0.19 in the 2024 assessment over a five-year peel. This is lower than the threshold value of 0.2. and a significant decrease from the 2023 assessment where the Mohns Rho was 0.85. All of the last 5 peels are inside the 95% CI bounds.

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates. Overall, the uncertainty is higher at the start and at the end of the time-series. Recruitment exhibits the highest uncertainty from 2013 to 2023. This is likely related to the lack of a fisheries-independent estimate of recruitment.

State of the stock

The stock summary plots from the final assessment in 2023 and the update assessment in 2022 are presented in Figure 6.6.1.10 and the stock summary in Table 6.6.1.4. The assessment shows that SSB is very low and is estimated to be 15 157 t in 2023, still well below B_{lim} (34 000 t). The 2024 assessment shows a similar SSB trajectory to the 2023 assessment. The assessment indicates that the stock has been below B_{lim} since 2016.

The update assessment estimated mean F (2–5 ring) in 2023 to be 0.058. This is an increase from 0.028 in 2022. F in 2023 is well below the high of 1.13 in 2018. F was estimated to be above F_{pa} (0.26), F_{MSY} (0.26) and F_{lim} (0.45) from 2015 until 2019. Since the introduction of the monitoring TAC in 2020, low F values between 0.019 and 0.058, are seen each year.

Recruitment was good for several years with strong cohorts in 2005, 2007, 2009, 2010, 2011, and 2012 having entered the stock. However, since 2013, recruitment has been below average, and no strong cohort has entered the fishery. The model estimates very low recruitment in 2021 This can be seen in the catch at age data which shows very low numbers of 1 wr fish in 2021, 2 wr fish in 2022 and 3 wr fish in 2023.

6.7 Short-term projections

6.7.1 Deterministic Short-Term Projections

The short-term forecast followed the procedure agreed at the 2014 benchmark (ICES 2014/ACOM 43).

Recruitment (final year, interim year and advice year) in the short-term forecast is to be set to the same value based on the segmented stock–recruit relationship, based on the SSB in the forecast year-2 (2022). As this SSB value (13 987 t) is below the change-point (52 337 t), the following adjustment is applied.

$$Recruitment_{forecast\ year} = plateau\ recruitment \times \frac{SSB_{forecast\ year-2}}{SSB_{changepoint}}$$

$$Recruitment_{2023} = 447859 \times \frac{13987}{52337} = 119\ 690$$

Interim year catch was taken to be the monitoring TAC (869 t), which has been agreed for 2024. No carryover on the national quotas was used as it is a monitoring TAC. Non-Irish intermediate year catches were not adjusted based on recent quota uptake as done prior to the introduction of the monitoring TAC.

The deterministic short-term forecast was performed in FLR. The input data are presented in Table 6.7.1.1.

The results of the short-term projection are presented in Table 6.7.1.2. Fishing in accordance with the MSY approach implies a zero catch in 2025.

6.7.2 Multiannual short-term forecasts

No multiannual simulations were conducted in 2024.

6.7.3 Yield-per-recruit

No yield-per-recruit analyses were conducted in 2024.

6.8 Long-term simulations

Long-term simulations were carried out as part of the ICES evaluation of the long-term management plan for Celtic Sea herring. ICES advised that the harvest control rule was no longer consistent with the precautionary approach. The management plan resulted in >5% probability of the stock falling below B_{lim} in several years throughout the 20 year simulated period. The simulations indicated that the management plan could not ensure that the stock is fished and maintained at levels that can produce maximum sustainable yield as soon as possible or by 2020. The long-term management plan is no longer used to give advice for this stock.

The 2024 assessment shows that the stock is at a low level. Further simulations will be carried out using methods developed by WKREBUILD (ICES, 2023) and options for stock recovery will be explored.

6.9 Precautionary and yield-based reference points

Reference points were re-estimated by WKPELA 2018.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	54 000 t	B_{pa}	ICES (2018a)
	F_{MSY}	0.26	Stochastic simulations using segmented regression stock–recruitment relationship from 1970–2014	ICES (2018a)
Precautionary approach	B_{lim}	34 000 t	B_{loss} = the lowest observed SSB (1980)	ICES (2018a)
	B_{pa}	54 000 t	$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma B)$, with $\sigma B = 0.29$.	ICES (2018a)

	F_{lim}	0.45	Equilibrium F maintaining SSB > B_{lim} with 50% probability	ICES (2018a)
	F_{pa}	0.26*	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with advice rule)	ICES (2018a)

*Fpa changed in 2021; Fpa now equal to Fp0.5 (ICES 2021)

6.10 Quality of the Assessment

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates for the three key parameters (SSB, recruitment and F). The CVs for each of the parameters are between 0.2 and 0.3 for the majority of the time-series; uncertainties have increased in the final years. Recruitment estimates in the final year show the highest uncertainty.

The SSB and F values based on the assessment and forecast in 2023 are compared with the assessment outputs in 2024 and are shown in the table below. The assessment in 2024 shows SSB revised upward in 2021 but downwards in 2022 and 2023. F is revised downwards in 2021, is stable in 2022 and revised upwards in 2023. This can also be seen in the historical retrospective plot in Figure 6.10.1. In previous years there was a tendency to underestimate F and annual upward revisions were seen.

2023 Assessment				2024 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2021	14215	745	0.058	2021	15025	745	0.054	5	-7
2022	16539	350	0.028	2022	13987	350	0.028	-18	0
2023*	22149	869	0.048	2023	15156	764	0.058	-46	17

*** from intermediate year in STF.**

The 2023 acoustic survey estimate is a decrease on the 2022 estimate and is still at a very low level with an SSB estimate of 9,254t. The survey time-series used in the assessment includes data from 2002 to 2023 (no survey in 2004, and the 2017 survey excluded). The 2018 year class (4wr fish) was the strongest encountered in the survey and the catch in 2023. Beginning in 2014, herring had been observed close to the bottom in the acoustic dead–zone of the echosounder meaning the survey estimate was less reliable. This issue was not as pronounced since 2020 although the number of herring marks seen was again very low.

Estimates of recruitment are uncertain, and this may be related to the lack of a fisheries-independent recruitment estimator.

It is known that Celtic Sea herring mix with the Irish Sea stock, but the level of mixing is unquantified. Recent genetic analyses of the 2021, 2022 and 2023 Irish Sea Acoustic Survey samples indicated significant mixing of Irish Sea and Celtic Sea herring and adjacent populations (Cardigan Bay and the Bristol Channel), primarily in the area to the west of the Isle of Man. This included mature and immature individuals. The consequence of this mixing needs to be further evaluated for management and advice.

6.11 Management Considerations

The stock has declined substantially from a high in 2012, as older cohorts have moved through the fishery. Recruitment has been below average since 2013. The stock is again forecasted to be below B_{lim} in 2025 and 2026. F is well below F_{MSY} (0.26) and F_{lim} (0.45). The advice provided for this stock for 2025 is based on the ICES MSY approach, as in recent years. The Council of the

European Union set the 2022-2024 TACs based on the response to a special request where ICES advised that monitoring catches of 869 t would be required to collect sufficient information to provide advice on similar basis as with a commercial fishery.

The change in fish behaviour observed by the acoustic survey since 2014, whereby fish were located close to the bottom and therefore difficult to detect acoustically, seems to have dissipated, but the number of herring marks has been low.

The closure of the Subdivision 7.aS as a measure to protect first-time spawners has been in place since 2007–2008, with limited fishing allowed. Currently only vessels of no more than 50 feet in registered length are permitted to fish in this area. 25% of the Irish proportion of the monitoring TAC is allocated to the fishery in 7.aS.

6.12 Ecosystem considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

The spawning grounds for herring in the Celtic Sea are well known and are located close to the coast (O'Sullivan *et al.,* 2013). These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging, sand and gravel extraction, dumping of dredge spoil, waste from fish cages, and the erection of structures such as wind turbines. There has been an increase in marine anthropogenic activity. Activities that have a negative impact on the spawning habitat of herring are a cause for concern (see for example de Groot, 1979, 1996; ICES, 2003, 2015a).

Herring fisheries are considered to be clean with little bycatch of other fish. Mega-fauna bycatch is unquantified, though anecdotal reports suggest that seals, blue sharks, tunas, and whitefish are caught from time to time. In the 2017 observer study of the Celtic Sea herring fishery, whiting was the most frequently recorded bycatch species followed by haddock and mackerel. No marine mammals or seabirds were recorded as bycatch in the fishery, with only one elasmobranch (an unidentified dogfish species) recorded. A total of 26 marine mammal sightings were recorded during observer trips (O'Dwyer and Berrow, 2017).

6.13 Changes in the environment

Weights in the catch and in the stock at spawning time have shown fluctuations over time (figures 6.4.1.1 and 6.4.1.2), but with a decline to lowest observations in the series at the end. The declines in mean weights are a cause for concern, because of their impact on yield and yield-per-recruit. Harma (unpublished) and Lyashevska *et al*. (2020) found that global environmental factors, reflecting recent temperature increases (AMO and ice extent) were linked to changes in the size characteristics during the 1970s–1980s. Outside this period, size-at-age patterns were correlated with more local factors (SST, salinity, trophic and fishery-related indicators). Generally, length-at-age was mostly correlated with global temperature-related indices (AMO and Ice), and weight was linked to local temperature variables (SST). There was no evidence of density-dependent growth in the Celtic Sea herring population, which is in accordance with previous studies (Molloy, 1984; Brunel and Dickey-Collas, 2010; Lynch, 2011). Rather, stock size exhibited a positive relationship with long-term size-at-age of Celtic Sea herring (Harma, unpublished).

In the Celtic Sea, a change towards spawning taking place later in the season has been documented by Harma *et al.* (2013). The causes of this are likely to be environmental, though to date they have not been elucidated (Harma *et al.*, 2013). The study noted that declines in mean weights are not explained by the relative contribution of heavier-at-age autumn spawners. Rather, both autumn and winter spawners experienced concurrent declines in mean weights in recent years.

A shift towards later spawning has also been reported by local fishers in this area. WKWEST received a submission from the Celtic Sea Herring Management Advisory Committee of substantial spawning aggregations in Division 7.j in January 2015. This area is mainly an autumn spawning area (O'Sullivan *et al.*, 2012).

Analyses of productivity changes over time in European herring stocks was examined by ICES (HAWG, 2006). It was found that this stock was the only one not to experience a change in productivity or so-called regime shift. This is also seen in the surplus production per unit stock biomass using information from the 2013 assessment. Evidence from the ASAP assessment, in terms of recruits per spawner, does not alter this perception (ICES, WKWEST 2015).

6.14 Tables and Figures

Table 6.1.2.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2023. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
1988	-	-	-	16 800	-	-	-	2400	19 200
1989	-	+	-	16 000	1900	-	1300	3500	22 700
1990	-	+	-	15 800	1000	200	700	2500	20 200
1991	-	+	100	19 400	1600	-	600	1900	23 600
1992	-	500	-	18 000	100	+	2300	2100	23 000
1993	-	-	-	19 000	1300	+	-1100	1900	21 100
1994	-	+	200	17 400	1300	+	-1500	1700	19 100
1995	-	200	200	18 000	100	+	-200	700	19 000
1996	-	1000	0	18 600	1000	-	-1800	3000	21 800
1997	-	1300	0	18 000	1400	-	-2600	700	18 800
1998	-	+	-	19 300	1200	-	-200	-	20 300
1999	-		200	17 900	1300	+	-1300	-	18 100
2000	-	573	228	18 038	44	1	-617	-	18 267
2001	-	1359	219	17 729	-	-	-1578	-	17 729
2002	-	734	-	10 550	257	-	-991	-	10 550
2003	-	800	-	10 875	692	14	-1506	-	10 875
2004	-	801	41	11 024	-	-	-801	-	11 065
2005	-	821	150	8452	799	-	-1770	-	8452
2006	-	-	-	8530	518	5	-523	-	8530
2007	-	581	248	8268	463	63	-1355	-	8268
2008	-	503	191	6853	291	-	-985	-	6853
2009	-	364	135	5760	-	-	-499	-	5760
2010	-	636	278	8406	325	-	-1239	na	8406
2011	-	241	-	11 503	7	-	-248	na	11 503
2012	-	3	230	16 132	3135	-	2104	161*	21 765
2013	-	-	450	14 785	832	-	-	118	16 185
2014	-	244	578	17 287	821	-		644	19 574
2015	-	-	477	15 798	1304	+	-	247	17 826
2016	-	-	419	15 107	1025	559	-451	182	16 841
2017	-	-	298	10 184	648	64		130	11 324
2018	-			4398	436		-245		4589

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
2019	-	-	-	1803	38	-	-	-	1841
2020	-	-	-	132	+	-	-	-	132
2021	1	-	-	608	-	-	-	-	609
2022				483					483
2023				743		+			743

*** Added in 2014 after report of 1% discarding.**

+ Designates catch of less than 0.5 tonnes

Table 6.1.2.2. Herring in the Celtic Sea. Landings (t) by assessment year (1 April–31 March) 1988/1989–2023/2024. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
1988/1989	-	-	-	17 000	-	-	-	3400	20 400
1989/1990	-	+	-	15 000	1900	-	2600	3600	23 100
1990/1991	-	+	-	15 000	1000	200	700	1700	18 600
1991/1992	-	500	100	21 400	1600	-	-100	2100	25 600
1992/1993	-	-	-	18 000	1300	-	-100	2000	21 200
1993/1994	-	-	-	16 600	1300	+	-1100	1800	18 600
1994/1995	-	+	200	17 400	1300	+	-1500	1900	19 300
1995/1996	-	200	200	20 000	100	+	-200	3000	23 300
1996/1997	-	1000	-	17 900	1000	-	-1800	750	18 850
1997/1998	-	1300	-	19 900	1400	-	-2100	-	20 500
1998/1999	-	+	-	17 700	1200	-	-700	-	18 200
1999/2000	-		200	18 300	1300	+	-1300	-	18 500
2000/2001	-	573	228	16 962	44	1	-617	-	17 191
2001/2002	-	-	-	15 236	-	-	-	-	15 236
2002/2003	-	734	-	7465	257	-	-991	-	7465
2003/2004	-	800	-	11 536	610	14	-1424	-	11 536
2004/2005	-	801	41	12 702	-	-	-801	-	12 743
2005/2006	-	821	150	9494	799	-	-1770	-	9494
2006/2007	-	-	-	6944	518	5	-523	-	6944
2007/2008	-	379	248	7636	327	-	-954	-	7636
2008/2009	-	503	191	5872	150	-	-844	-	5872
2009/2010	-	364	135	5745	-	-	-499	-	5745
2010/2011	-	636	278	8370	325	-	-1239	na	8370
2011/2012	-	241	-	11 470	7	-	-248	na	11 470
2012/2013	-	3	230	16 132	3135	-	2104	161*	21 765
2013/2014	-	-	450	14 785	832	-	-	118	16 185

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
2014/2015	-	244	578	17 287	821	-	-	644	19 574
2015/2016	-	-	477	16 320	1304	+	-	254	18 355
2016/2017	-	-	419	14 585	1025	559	-451	182	16 319
2017/2018	-	-	298	9627	648	64	-	130	10 767
2018/2019	-	-	-	4227	436	-	-245	-	4418
2019/2020	-	-	-	1803	38	-	-	-	1841
2020/2021	1	-	-	132	+	-	-	-	133
2021/2022	-	-	-	745	-	-	-	-	745
2022/2023	-	-	-	350	-	-	-	-	350
2023/2024	-	-	-	764	-	+	-	-	764

*** Added in 2014 after report of 1% discarding.**

+ Designates catch of less than 0.5 tonnes

Table 6.2.1.1. Herring in the Celtic Sea. Comparison of age distributions (percentages) in the catches of Celtic Sea and 7.j herring from 1970/1971–2023/2024. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9+
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%

Year	1	2	3	4	5	6	7	8	9+
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	12%	38%	30%	10%	4%	3%	2%	1%	1%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%
2010	4%	33%	13%	25%	8%	16%	1%	0%	1%
2011	7%	19%	38%	8%	15%	6%	6%	1%	0%
2012	6%	34%	24%	20%	3%	6%	3%	2%	0%
2013	5%	24%	33%	18%	13%	3%	4%	1%	0%
2014	11%	16%	25%	22%	15%	7%	2%	2%	1%

Year	1	2	3	4	5	6	7	8	9+
2015	0%	9%	18%	24%	21%	15%	7%	3%	2%
2016	2%	8%	20%	18%	20%	18%	8%	4%	1%
2017	1%	15%	34%	17%	12%	10%	7%	3%	2%
2018	4%	19%	51%	15%	6%	3%	1%	1%	0%
2019	60%	18%	8%	10%	3%	1%	0%	0%	0%
2020	13%	61%	15%	4%	4%	1%	1%	0%	0%
2021	0%	25%	61%	9%	2%	2%	0%	0%	0%
2022	3%	0%	49%	34%	9%	2%	1%	1%	0%
2023	1%	12%	4%	49%	26%	6%	1%	1%	0%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2023/2024 season.

Length (cm)	7gQ3	7aS Q4	7gQ4
13.5	0	1	0
14	0	0	0
14.5	0	0	0
15	0	0	0
15.5	0	0	0
16	0	3	0
16.5	0	0	0
17	0	9	0
17.5	0	14	0
18	0	13	0
18.5	0	13	0
19	1	14	0
19.5	0	12	0
20	0	20	0
20.5	1	29	0
21	9	34	0
21.5	13	68	1
22	22	61	2
22.5	17	39	2
23	32	60	4
23.5	50	73	5
24	106	177	20
24.5	167	299	37
25	206	296	51
25.5	166	183	58

Length (cm)	7gQ3	7aS Q4	7gQ4
26	83	101	29
26.5	33	40	16
27	6	4	2
27.5	1	2	0
28	0	0	1

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2023–2024). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
7.g	2023	3	408	4	200	913	490
7.g	2023	4	124	1	50	228	402
7.J	2023	2	0				
7.aS	2023	4	206	9	350	1565	1697
7.g	2024	1	25				
Total			764	14	600	2706	786

Table 6.3.1.1. Herring in the Celtic Sea. Revised acoustic index of abundance used in the assessment. Total stock numbers-at-age (10^6) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes). 2–7 ring abundances are used in tuning. There was no survey in 2004. The survey in 2017 (shaded) was excluded as it was not recommended for tuning by HAWG in 2018.

	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014
0	0	24	-	2	-	1	99	239	5	0	31	4
1	42	13	-	65	21	106	64	381	346	342	270	698
2	185	62	-	137	211	70	295	112	549	479	856	291
3	151	60	-	28	48	220	111	210	156	299	615	197
4	30	17	-	54	14	31	162	57	193	47	330	43
5	7	5	-	22	11	9	27	125	65	71	49	38
6	7	1	-	5	1	13	6	12	91	24	121	10
7	3	0	-	1	-	4	5	4	7	33	25	5
8	0	0	-	0	-	1		6	3	4	23	0
9	0	0	-	0	-	0		1		2	3	1
Nos.	423	183	-	312	305	454	769	1147	1414	1300	2322	1286
SSB	41	20	-	33	36	46	90	91	122	122	246	71

	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014
CV	.49	.34	-	.48	.35	.25	.20	.24	.20	.28	.25	.28

	2014 2015	2015 2016	2016 2017	2017 2018	2018 2019	2019 2020	2020 2021	2021 2022	2022 2023	2023 2024
0	0	0	0	0	109	98	1	252.6	11.3	
1	41	0	125	0	55	22	27.2		0	
2	117	40	21	6	16	8	32.2	17.2	0.8	1.1
3	112	48	43	3	27	0.5	5	35.3	57.3	3.3
4	69	41	40	7	6	0.3	1	3.3	39.1	32.9
5	20	38	36	5	0	0.1	0	1.2	3.36	29.3
6	24	7	25	4	0	0	0	0	0.9	4.0
7	7	6	5	1	-	0	0	0.6	0.52	
8	17	5	6	1	-	0	0	0.1	0	
9	1	0	0	0		0	0	0	0	
Nos.	408	184	301	27	213	129	67	310	113	70.6
SSB	48	25	30	4	8	0.3	3.1	6.6	12.3	9.25
CV	0.59	0.18	0.33	-	0.49	0.55	0.51	0.44	1.24	0.54

Table 6.6.1.1. Herring in the Celtic Sea: Natural mortality inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Maturity inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9+
0.5	1	1	1	1	1	1	1	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the catch inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9+
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263

	1	2	3	4	5	6	7	8	9+
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
2003	0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
2004	0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
2005	0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
2006	0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
2007	0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
2008	0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
2009	0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
2010	0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
2011	0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179
2012	0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
2013	0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
2014	0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176

	1	2	3	4	5	6	7	8	9+
2015	0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182
2016	0.061	0.095	0.119	0.131	0.140	0.144	0.151	0.157	0.162
2017	0.06	0.080	0.090	0.123	0.143	0.160	0.163	0.171	0.178
2018	0.067	0.092	0.11	0.124	0.136	0.146	0.162	0.143	0.15
2019	0.06	0.085	0.109	0.123	0.131	0.155	0.153	0.156	0.163
2020	0.052	0.078	0.096	0.117	0.124	0.128	0.144	0.169	0.052
2021	0.066	0.103	0.12	0.131	0.145	0.158	0.18	0.164	0.177
2022	0.05	0.10	0.018	0.120	0.128	0.140	0.135	0.156	0.210
2023	0.041	0.083	0.115	0.123	0.133	0.14	0.149	0.153	0.163

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the stock inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9+
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284

	1	2	3	4	5	6	7	8	9+
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223
2003	0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
2004	0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257

	1	2	3	4	5	6	7	8	9+
2005	0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
2006	0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188
2007	0.068	0.101	0.122	0.138	0.156	0.159	0.163	0.167	0.251
2008	0.083	0.117	0.14	0.156	0.17	0.18	0.177	0.189	0.232
2009	0.076	0.117	0.142	0.158	0.168	0.176	0.17	0.186	0.226
2010	0.076	0.106	0.127	0.139	0.152	0.157	0.164	0.188	0.18
2011	0.067	0.108	0.127	0.138	0.148	0.16	0.17	0.194	0.197
2012	0.061	0.094	0.125	0.138	0.149	0.159	0.161	0.165	0.167
2013	0.06	0.101	0.126	0.144	0.153	0.159	0.168	0.17	0.186
2014	0.065	0.1	0.128	0.142	0.153	0.158	0.163	0.177	0.169
2015	0.065	0.098	0.119	0.133	0.14	0.146	0.153	0.16	0.162
2016	0.059	0.096	0.117	0.131	0.139	0.143	0.150	0.160	0.165
2017	0.055	0.079	0.088	0.116	0.139	0.158	0.164	0.170	0.177
2018	0.065	0.095	0.121	0.142	0.154	0.166	0.171	0.166	0.170
2019	0.055	0.087	0.106	0.122	0.127	0.141	0.15	0.161	0.16
2020	0.047	0.082	0.099	0.124	0.128	0.138	0.148	0.175	0.162
2021	0.055	0.094	0.118	0.131	0.141	0.153	0.174	0.173	0.163
2022	0.046	0.098	0.109	0.119	0.125	0.133	0.132	0.145	0.163
2023	0.035	0.075	0.093	0.115	0.125	0.127	0.132	0.14	0.163

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Fishery Selectivity block inputs (1–9) to the ASAP model. Age is in winter rings.

Age	Selectivity	Block	#1	Data
1	0.3	1	0	1
2	0.5	1	0	1
3	1	–1	0	1
4	1	1	0	1
5	1	1	0	1
6	1	1	0	1
7	1	1	0	1

Age	Selectivity	Block	#1	Data
8	1	1	0	1
9	1	1	0	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Catch numbers-at-age and total catch inputs to the ASAP model. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9+	Total catch
1958	1642	3742	33094	25746	12551	23949	16093	9384	5584	22978
1959	1203	25717	2274	19262	11015	5830	17821	3745	7352	15086
1960	2840	72246	24658	3779	13698	4431	6096	4379	4151	18283
1961	2129	16058	32044	5631	2034	5067	2825	1524	4947	15372
1962	772	18567	19909	48061	8075	3584	8593	3805	5322	21552
1963	297	51935	13033	4179	20694	2686	1392	2488	2787	17349
1964	7529	15058	17250	6658	1719	8716	1304	577	2193	10599
1965	57	70248	9365	15757	3399	4539	12127	1377	7493	19126
1966	7093	19559	59893	9924	13211	5602	3586	8746	3842	27030
1967	7599	39991	20062	49113	9218	9444	3939	6510	6757	27658
1968	12197	54790	39604	11544	22599	4929	4170	1310	4936	30236
1969	9472	93279	55039	33145	12217	17837	4762	2174	3469	44389
1970	1319	37260	50087	26481	18763	7853	6351	2175	3367	31727
1971	12658	23313	37563	41904	18759	10443	4276	4942	2239	31396
1972	8422	137690	17855	15842	14531	4645	3012	2374	1020	38203
1973	23547	38133	55805	7012	9651	5323	3352	2332	1209	26936
1974	5507	42808	17184	22530	4225	3737	2978	903	827	19940
1975	12768	15429	17783	7333	9006	3520	1644	1136	1194	15588
1976	13317	11113	7286	7011	2872	4785	1980	1243	1769	9771
1977	8159	12516	8610	5280	1585	1898	1043	383	470	7833
1978	2800	13385	11948	5583	1580	1476	540	858	482	7559
1979	11335	13913	12399	8636	2889	1316	1283	551	635	10321
1980	7162	30093	11726	6585	2812	2204	1184	1262	565	13130
1981	39361	21285	21861	5505	4438	3436	795	313	866	17103
1982	15339	42725	8728	4817	1497	1891	1670	335	596	13000

Year	1	2	3	4	5	6	7	8	9+	Total catch
1983	13540	102871	26993	3225	1862	327	372	932	308	24981
1984	19517	92892	41121	16043	2450	1085	376	231	180	26779
1985	17916	57054	36258	16032	2306	228	85	173	132	20426
1986	4159	56747	42881	32930	8790	1127	98	29	12	25024
1987	5976	67000	43075	23014	14323	2716	1175	296	464	26200
1988	2307	82027	30962	9398	5963	3047	869	297	86	20447
1989	8260	42413	68399	19601	8205	3837	2589	767	682	23254
1990	2702	41756	24634	35258	8116	3808	1671	695	462	18404
1991	1912	63854	38342	16916	28405	4869	2588	954	593	25562
1992	10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1993	1608	94061	9372	10221	4491	2790	5932	855	508	18618
1994	12130	35768	61737	3289	3025	4773	1713	1705	474	19300
1995	9450	79159	22591	36541	3686	3420	2651	1859	842	23305
1996	3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
1997	3849	37440	53040	31442	8318	6142	1148	827	603	20496
1998	5818	41510	27102	28274	13178	3746	2675	597	387	18041
1999	14274	34072	36086	14642	15515	8877	1865	2012	551	18485
2000	9953	77378	18952	12060	5230	6227	2320	662	578	17191
2001	15724	62153	35816	5953	4249	1774	1145	466	386	15269
2002	3495	26472	18532	5309	1416	1269	437	154	201	7465
2003	2711	37006	24444	14763	5719	3363	2335	388	542	11536
2004	4276	9470	46243	21863	8638	1412	473	191	75	12743
2005	15419	30710	5766	18666	7349	1923	435	77	60	9494
2006	1460	33894	10914	2469	6261	2331	561	57	48	6944
2007	8043	11028	36223	5509	1365	2040	410	56	4	7636
2008	1288	12468	8144	15565	2328	518	321	58	11	5872
2009	10171	4465	12859	4887	8458	971	279	247	80	5745
2010	2468	20929	8183	15917	4846	10080	919	273	321	8370
2011	6384	17151	33453	7301	13087	5347	5165	1089	141	11470

Year	1	2	3	4	5	6	7	8	9+	Total catch
2012	11712	62528	44819	37500	6303	11811	5549	3540	347	21820
2013	6191	30471	42133	22649	16687	3305	5463	1778	535	16247
2014	16664	24120	39102	33320	22450	11165	3047	2774	1022	19574
2015	286	12247	23835	32140	27382	19861	9820	4207	3279	18355
2016	2023	9822	25030	22800	25310	22447	10484	4684	1464	16318
2017	707	14144	31912	16004	10718	8963	6722	2401	1473	10767
2018	1654	7646	20545	5974	2296	1011	264	380	188	4418
2019	14146	4371	1857	2265	612	212	88	73	33	1841
2020	213	979	242	57	70	24	12	3	1	132
2021	3	1550	3825	586	148	109	23	22	2	745
2022	106	8	1519	1059	278	67	31	20	2	350
2023	86	729	236	3093	1624	390	60	77	1	764

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Survey index selectivity inputs (2–7) to the ASAP model. Age is in winter rings.

Age (wr)	Index-1	Selectivity
2	0.8	4
3	1	-1
4	1	-1
5	1	-1
6	1	4
7	1	4

Table 6.6.1.2. Herring in the Celtic Sea. Survey data input to ASAP. Age is in winter rings.

year	value	CV	2	3	4	5	6	7	Sample Size
2002	381900	0.5	185200	150600	29700	6600	7100	2700	15
2003	146400	0.5	61700	60400	17200	5400	1400	300	15
2004	-1	-1	-1	-1	-1	-1	-1	-1	0
2005	246700	0.5	137100	28200	54200	21600	4900	700	18
2006	284999	0.5	211000	48000	14000	11000	1000	-1	17
2007	346120	0.5	69800	220000	30600	8970	13100	3650	21

year	value	CV	2	3	4	5	6	7	Sample Size
2008	606000	0.5	295000	111000	162000	27000	6000	5000	21
2009	519370	0.5	112040	209850	57490	124630	11710	3650	23
2010	1060760	0.5	548940	155860	193030	65240	91040	6650	18
2011	953000	0.5	479000	299000	47000	71000	24000	33000	16
2012	1995300	0.5	856000	615000	330000	48500	121000	24800	13
2013	584900	0.5	291400	197400	43700	37900	9800	4700	9
2014	349000	0.5	117300	112100	69400	19800	23600	6800	5
2015	179400	0.5	40100	48100	41200	37700	6800	5500	6
2016	169376	0.5	20629	42736	39835	36124	24590	5462	10
2017	-1	-1	-1	-1	-1	-1	-1	-1	0
2018	49130	0.5	16104	26831	5984	110	101	0	9
2019	8873	0.5	98229	7934	524	284	131	0	3
2020	38383	0.5	32190	4625	1348	220	0	0	4
2021	57592	0.5	17213	35326	3271	1198	0	584	12
2022	102062	0.5	793	57320	39146	3366	909	529	7
2023	70633	0.5	1090	3270	32911	29322	4040	0	1

Table 6.6.1.3. Herring in the Celtic Sea. ASAP final Run settings.

Discards Included	No
Use likelihood constant	No
Mean F (F_{bar}) age (wr)range	2–5
Number of selectivity blocks	1
Fleet selectivity	By Age: 1–9-wr: 0.3,0.5,1,1,1,1,1,1,1 Fixed at-age 3-wr
Index units	2 (numbers)
Index month	October (10)
Index selectivity linked to fleet	-1 (not linked)
Index Years	2002–2023 (no survey in 2004 and 2017 not included)
Index age (wr)range	2–7
Index Selectivity	0.8,1,1,1,1,1 Fixed from ages 3–5-wr
Index CV	0.5 all years
Sample size	No of hauls with sufficient herring collected per survey
Phase for F-Mult in 1st year	1
Phase for F-Mult deviations	2
Phase for recruitment deviations	3
Phase for N in 1st Year	1
Phase for catchability in 1st Year	1
Phase for catchability deviations	-5
Phase for Stock recruit relationship	1
Phase for steepness	-5 (Do not fit stock–recruitment curve)
Recruitment CV by year	1
Lambdas by index	1
Lambda for total catch in weight by fleet	1
Catch total CV	0.2 for all years
Catch effective sample size	No of samples from Irish sampling programme. Down-weighted to 5 in 2015-2023 as agreed at WKPELA 2018
Lambda for F-Mult in 1st year	0 (freely estimated)
CV for F mult in the first year	0.5
Lambda for F-Mult deviations	0 (freely estimated)

CV for f mult deviations by fleet	0.5
Lambda for N in 1st year deviations	0 (freely estimated)
CV for N in the 1st year deviations	1
Lambda for recruitment deviations	1
Lambda for catchability in 1st year index	0
CV for catchability in 1st year by index	1
Lambda for catchability deviations	0
CV for catchability deviations	1
Lambda for deviation from initial steep- ness	0
CV for deviation from initial steepness	1
Lambda for deviation from unexplained stock size	0
CV for deviation from unexplained stock size	1

Table 6.6.1.4. Herring in the Celtic Sea. Update assessment stock summary table. Recruitment is at 1-winter ring.

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
1958	22978	213520	288684	0.128	406043
1959	15086	203373	330356	0.110	1576300
1960	18283	193315	260553	0.125	361775
1961	15372	162856	224890	0.119	392976
1962	21552	158799	255560	0.192	843773
1963	17349	146850	209353	0.153	402341
1964	10599	166303	289675	0.096	1380900
1965	19126	170774	240625	0.140	415446
1966	27030	165731	266269	0.199	734010
1967	27658	159380	260332	0.226	767134
1968	30236	162481	274738	0.243	898367
1969	44389	142051	229290	0.362	461121
1970	31727	107198	165724	0.331	247856
1971	31396	98063	192807	0.454	820970
1972	38203	85990	148566	0.560	278883
1973	26936	64670	118114	0.518	325000
1974	19940	50132	86081	0.495	159941
1975	15588	39676	73724	0.517	201599
1976	9771	36811	68451	0.389	225647
1977	7833	37383	64295	0.291	184269
1978	7559	36107	58904	0.269	145155
1979	10321	35944	70434	0.426	277956
1980	13130	32925	59793	0.546	166007

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
1981	17103	36450	86539	0.838	464359
1982	13000	57370	126314	0.459	723843
1983	24981	76340	158792	0.556	784379
1984	26779	78979	148513	0.472	665905
1985	20426	85074	153877	0.319	642085
1986	25024	93068	170517	0.366	653698
1987	26200	105483	211225	0.389	1199870
1988	20447	108996	170619	0.232	475267
1989	23254	95722	164320	0.285	575379
1990	18404	89244	147141	0.248	503075
1991	25562	71082	111650	0.381	207138
1992	21127	70997	152780	0.484	961983
1993	18618	73679	119461	0.326	359477
1994	19300	80431	151751	0.322	768316
1995	23305	81941	149924	0.387	721942
1996	18816	72476	116592	0.308	352246
1997	20496	59955	104879	0.407	373023
1998	18041	48091	83264	0.445	249156
1999	18485	42193	88144	0.621	488851
2000	17191	42461	88104	0.628	482380
2001	15269	42384	84651	0.526	502626
2002	7465	54977	101843	0.206	552814
2003	11536	43919	66525	0.301	144137
2004	12743	40315	72994	0.384	373133
2005	9494	56543	121162	0.298	1096230
2006	6944	69864	106732	0.128	369972
2007	7636	72928	121883	0.126	753367
2008	5872	86551	121950	0.076	305884
2009	5745	98417	167583	0.073	1047080
2010	8370	106451	166897	0.097	774800
2011	11470	114817	182899	0.125	981921
2012	21820	104232	161277	0.245	646484
2013	16247	91959	133117	0.206	371893
2014	19574	71171	108894	0.312	305491
2015	18355	46020	73105	0.447	176208
2016	16318	27230	50756	0.743	201627
2017	10767	12578	25205	1.133	62675
2018	4418	6876	14138	1.057	58038
2019	1841	7524	17219	0.587	216391
2020	132	11365	18432	0.019	168291
2021	745	15025	20340	0.054	58043
2022	350	13987	20060	0.028	116566

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
2023	764	15157	24310	0.058	282344

Table 6.7.1.1. Herring in the Celtic Sea. Input data for short-term forecast.

2024								
Age	N	M	Mat	F prop	M prop	Stock Wt	Sel	Catch Wt
1	119691	0.77	0.5	0.5	0.5	0.045	0.003	0.052
2	130598	0.38	1	0.5	0.5	0.089	0.036	0.095
3	35156	0.36	1	0.5	0.5	0.107	0.050	0.114
4	11777	0.34	1	0.5	0.5	0.122	0.050	0.125
5	23185	0.32	1	0.5	0.5	0.130	0.050	0.135
6	20185	0.31	1	0.5	0.5	0.138	0.050	0.146
7	2414	0.31	1	0.5	0.5	0.146	0.047	0.155
8	708	0.31	1	0.5	0.5	0.153	0.047	0.158
9	2083	0.31	1	0.5	0.5	0.163	0.013	0.180

2025								
Age	N	M	Mat	F prop	M prop	Stock Wt	Sel	Catch Wt
1	119691	0.77	0.5	0.5	0.5	0.045	0.003	0.052
2	-	0.38	1	0.5	0.5	0.089	0.036	0.095
3	-	0.36	1	0.5	0.5	0.107	0.050	0.114
4	-	0.34	1	0.5	0.5	0.122	0.050	0.125
5	-	0.32	1	0.5	0.5	0.130	0.050	0.135
6	-	0.31	1	0.5	0.5	0.138	0.050	0.146
7	-	0.31	1	0.5	0.5	0.146	0.047	0.155
8	-	0.31	1	0.5	0.5	0.153	0.047	0.158
9	-	0.31	1	0.5	0.5	0.163	0.013	0.180

2026								
Age	N	M	Mat	F prop	PropM	Stock Wt	Sel	Catch Wt
1	119691	0.77	0.5	0.5	0.5	0.045	0.003	0.052
2	-	0.38	1	0.5	0.5	0.089	0.036	0.095
3	-	0.36	1	0.5	0.5	0.107	0.050	0.114
4	-	0.34	1	0.5	0.5	0.122	0.050	0.125
5	-	0.32	1	0.5	0.5	0.130	0.050	0.135
6	-	0.31	1	0.5	0.5	0.138	0.050	0.146
7	-	0.31	1	0.5	0.5	0.146	0.047	0.155
8	-	0.31	1	0.5	0.5	0.153	0.047	0.158
9	-	0.31	1	0.5	0.5	0.163	0.013	0.180

Table 6.7.1.2. Herring in the Celtic Sea. Results of short-term deterministic forecast.

Rationale	F_{bar} 2024	Catch (2024)	SSB -2024	Fbar (2025)	Catch (2025)	SSB -2025	SSB -2026
Catch(2025) = Zero	0.046	869	21017	0	0	21024	21215
Catch(2025) = 2024 TAC	**0.046**	**869**	**21017**	**0.043**	**869**	**20616**	**20152**
Fbar(2025) = Fmsy = Fpa	0.046	869	21017	0.26	4756	18688	15779
Fbar(2025) = Flim	0.046	869	21017	0.45	7573	17165	12902
Fbar(2025) = F2024	0.046	869	21017	0.046	919	20593	20110
Fbar(2025) = Fmsy * SSB2024 /MSY Btrigger	0.046	869	21017	0.101	1988	20080	18857

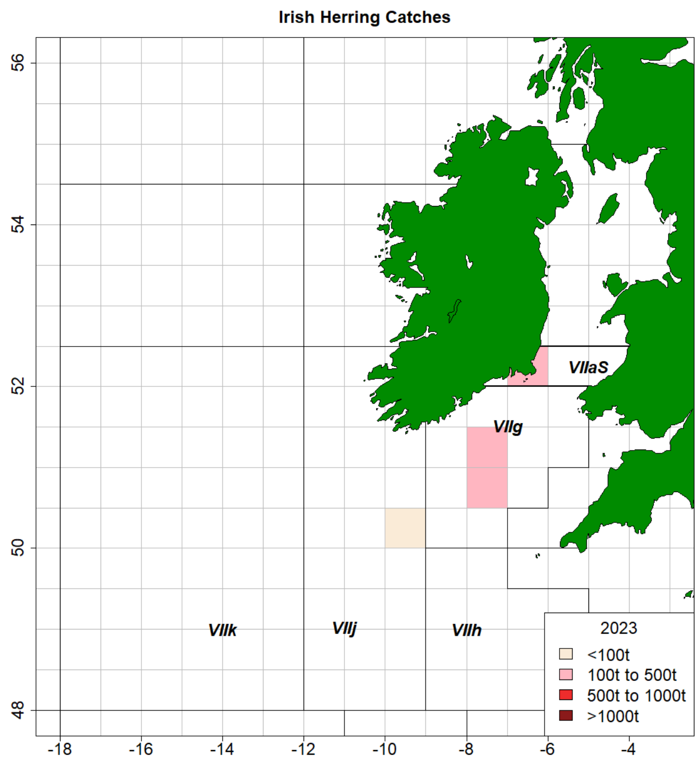


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2023/2024.

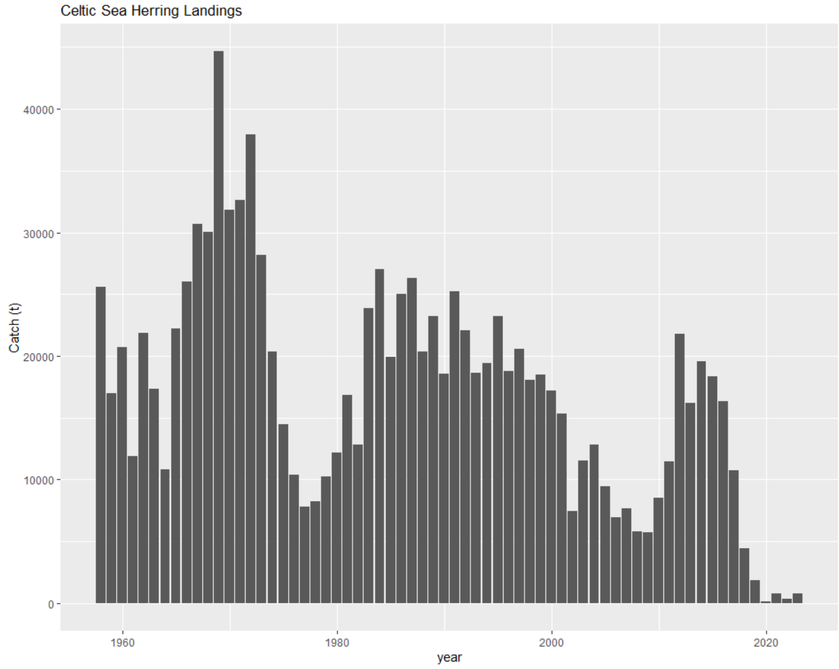


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

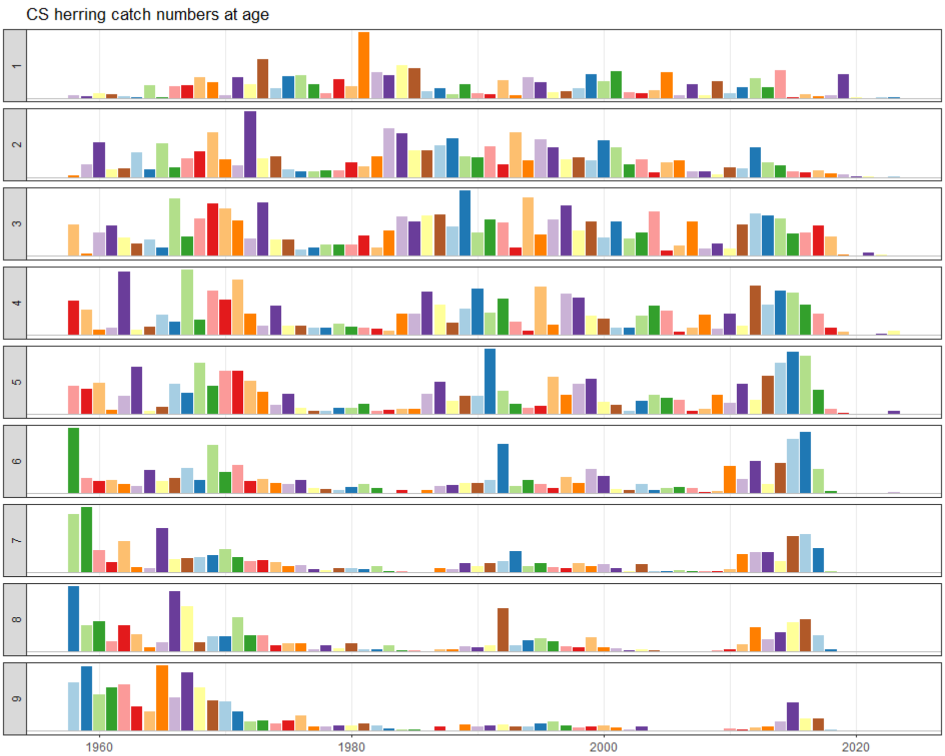


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age. 9-wr is the plus group. Age in winter rings.

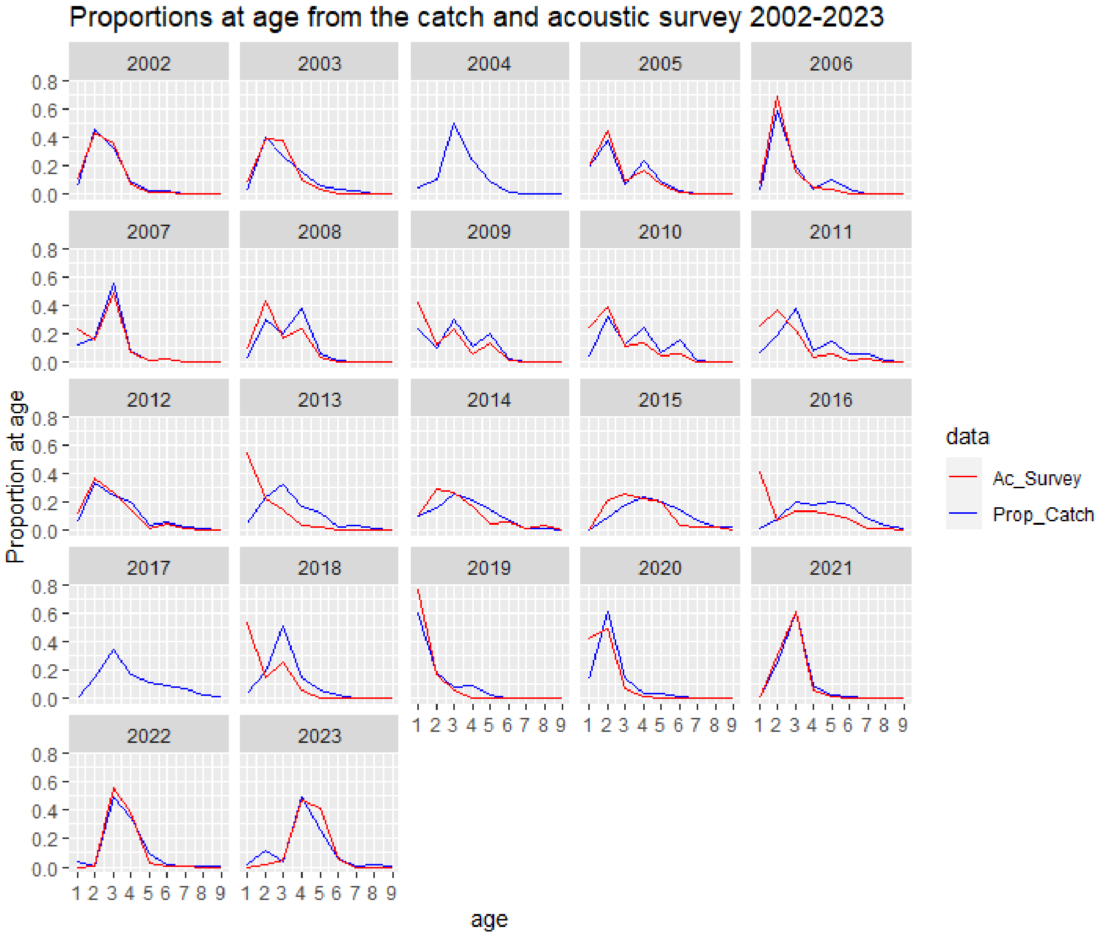


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9+ wr) and the commercial fishery (1–9+ wr) by year. Age in winter rings.

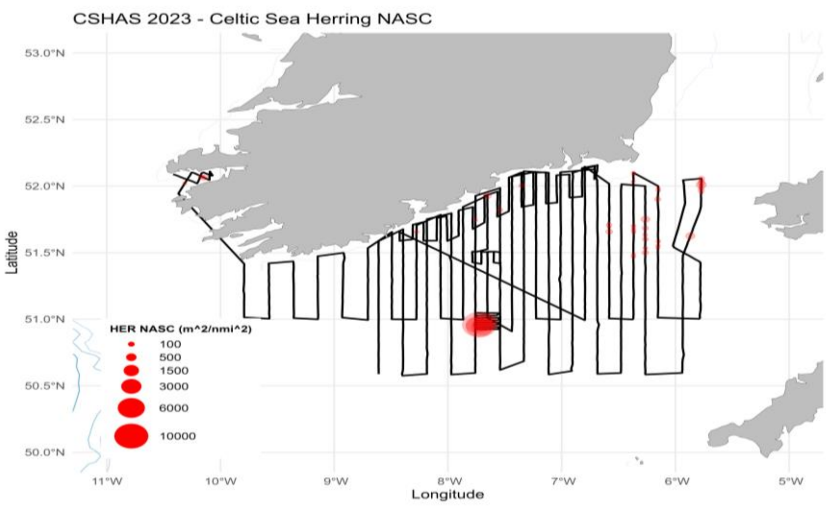


Figure 6.3.1.1. Herring in the Celtic Sea. Herring NASC (Nautical area scattering coefficient) plot of herring distribution 2023 from combined survey effort.

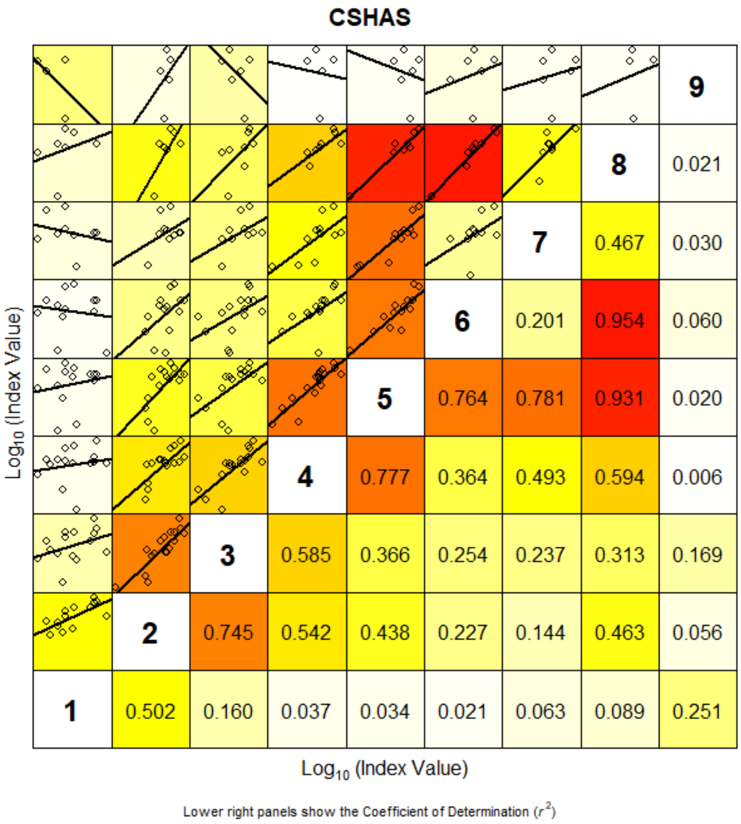


Figure 6.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

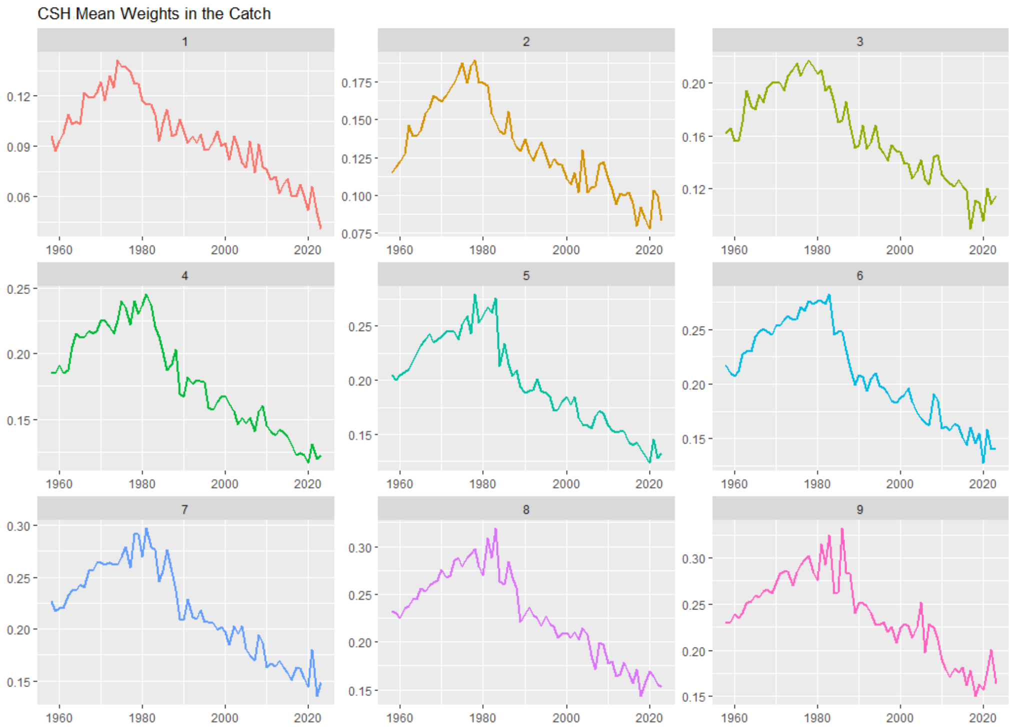


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2023 for 1–9+.

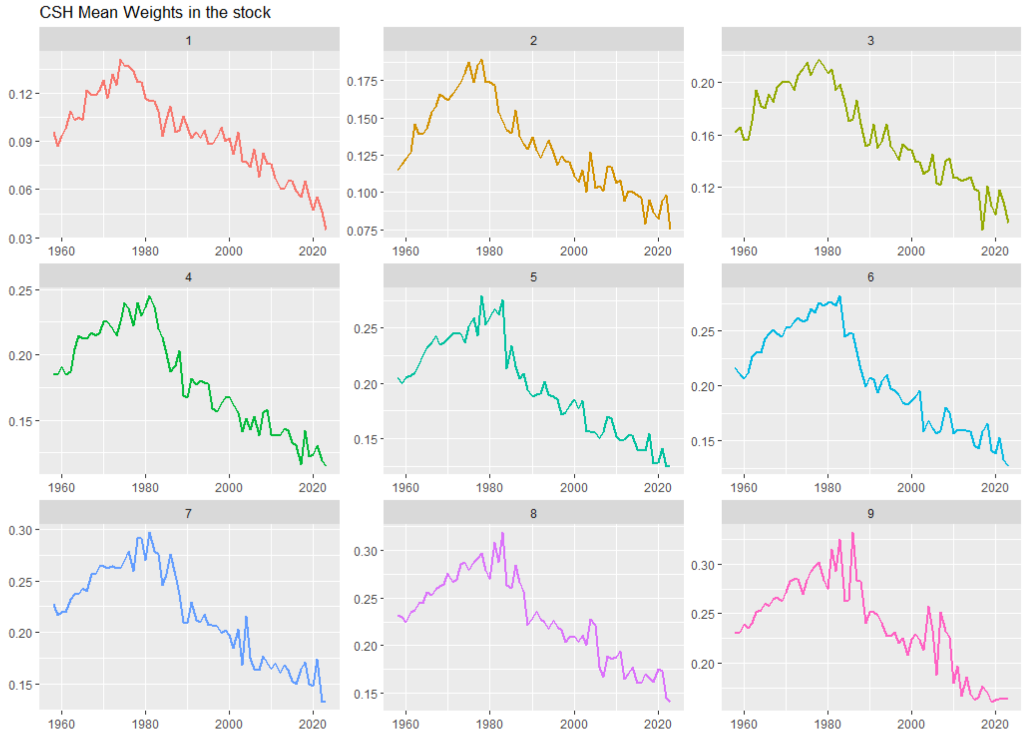


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2023 for 1–9+. Age in winter rings.

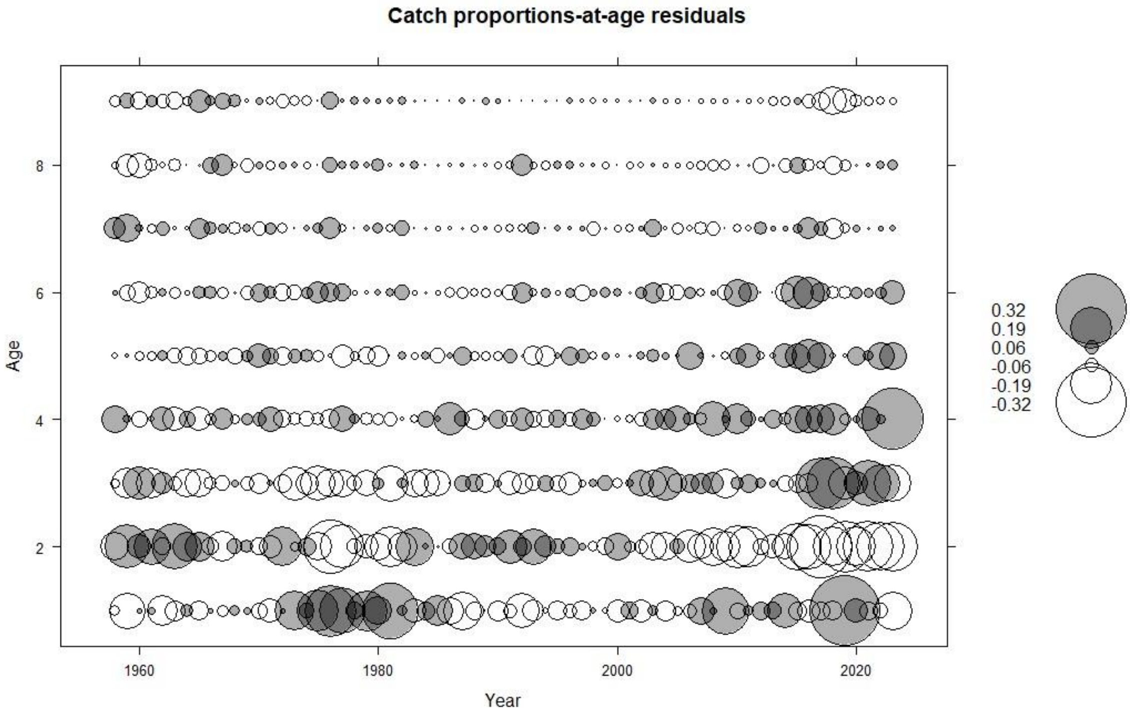


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

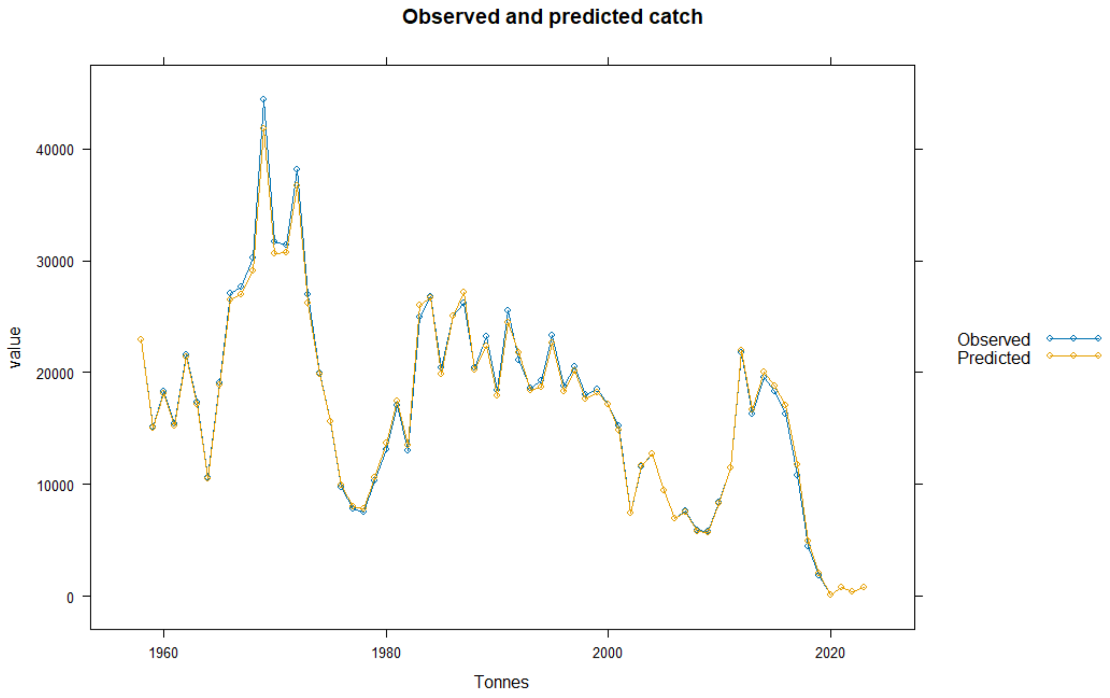


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

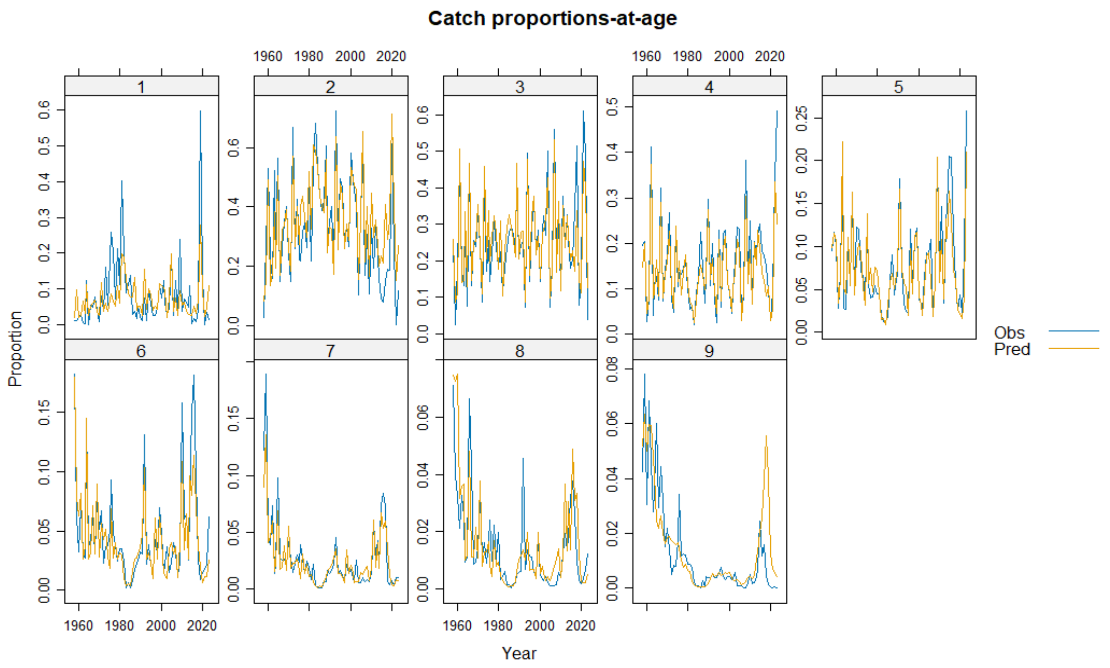


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

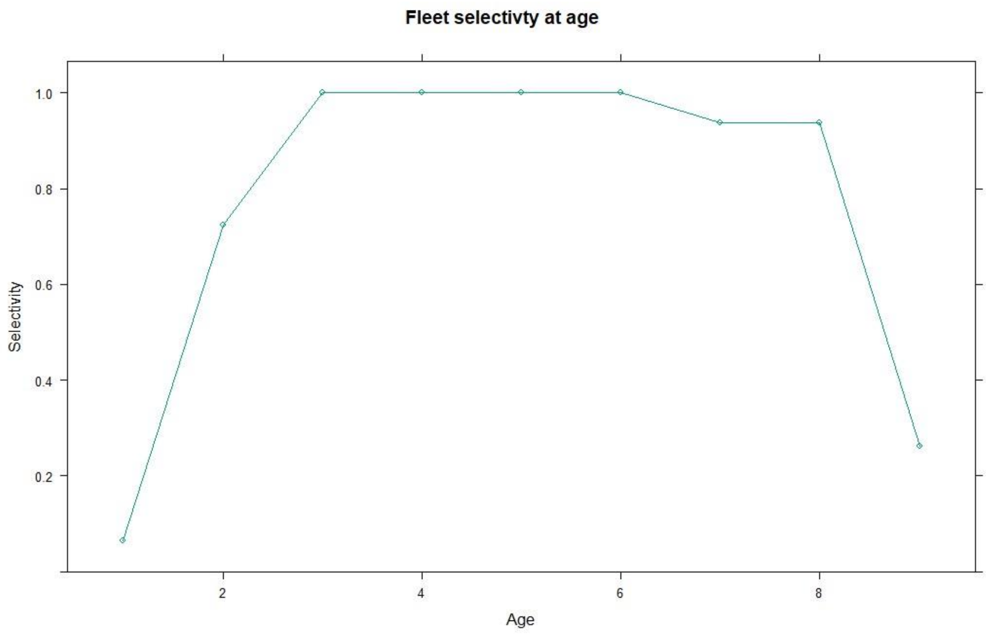


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

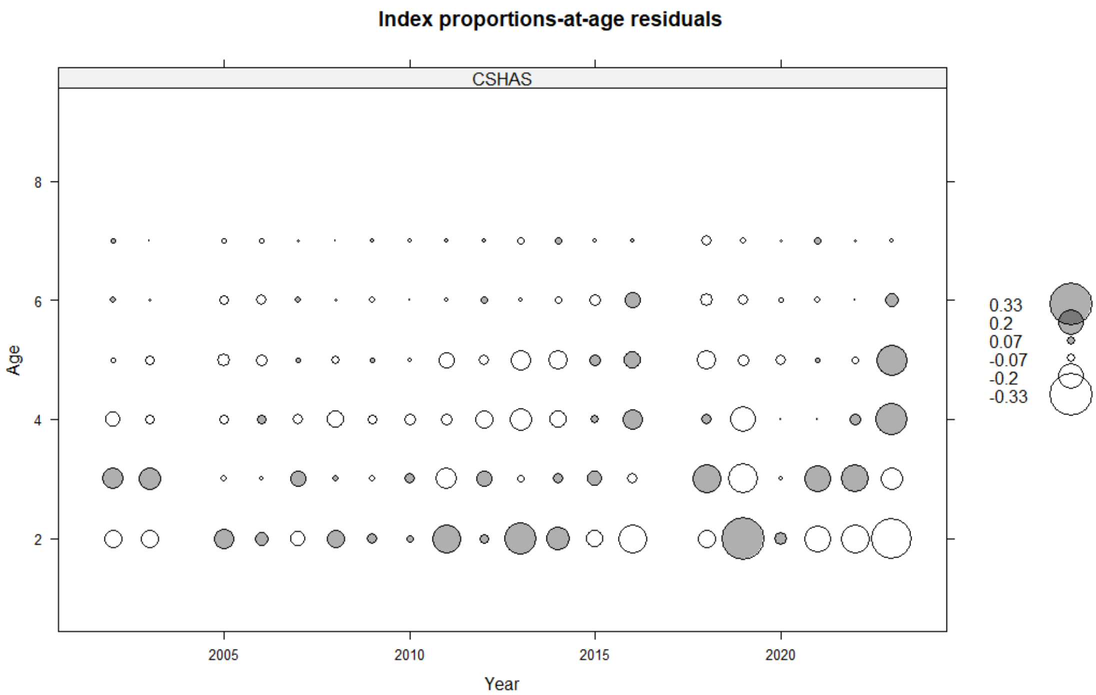


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

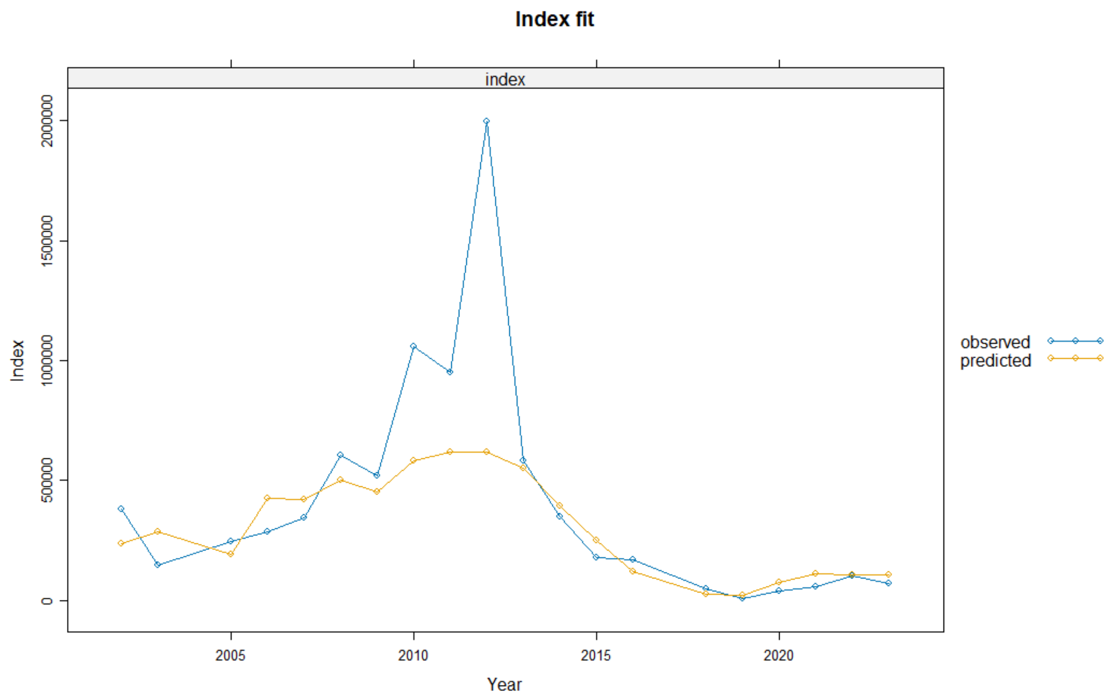


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

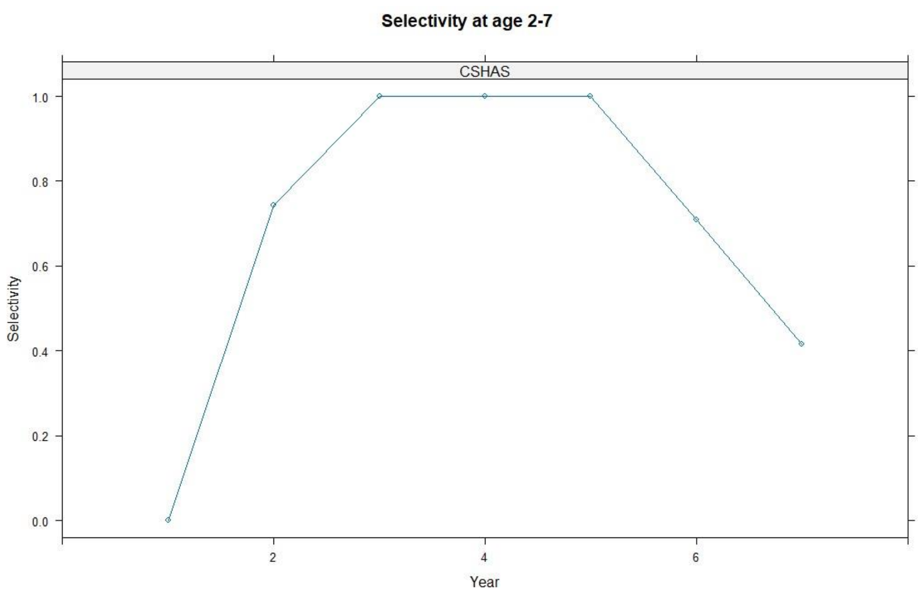


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

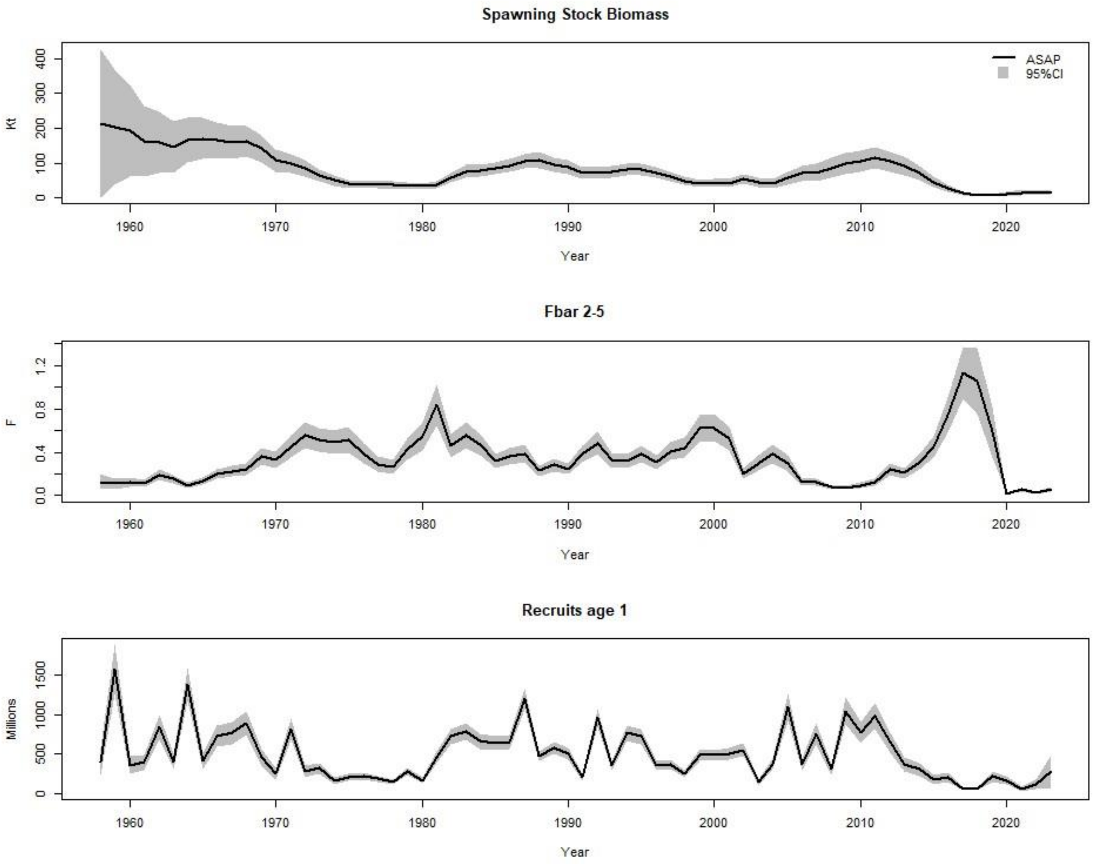


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), and Recruitment (bottom). The shaded area is the 95% confidence interval.

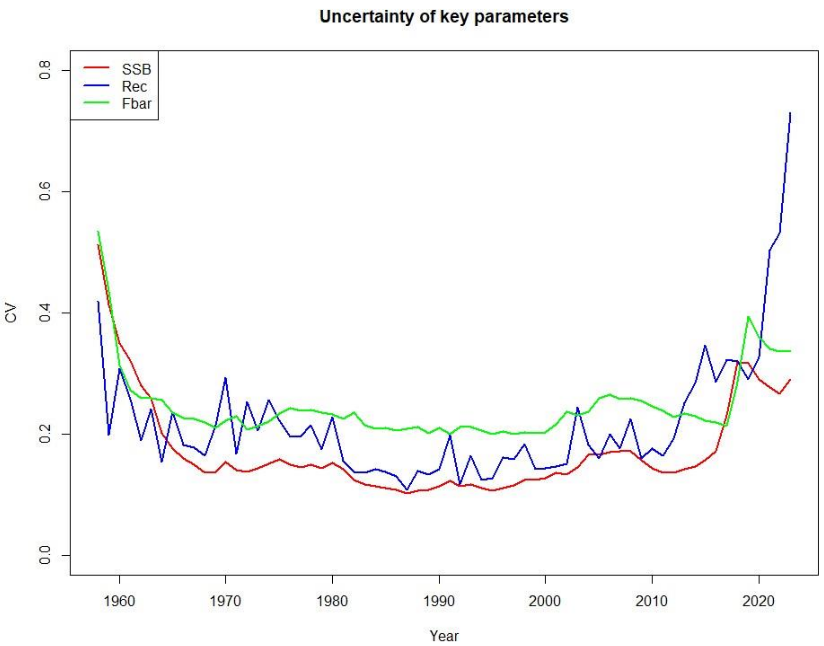


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

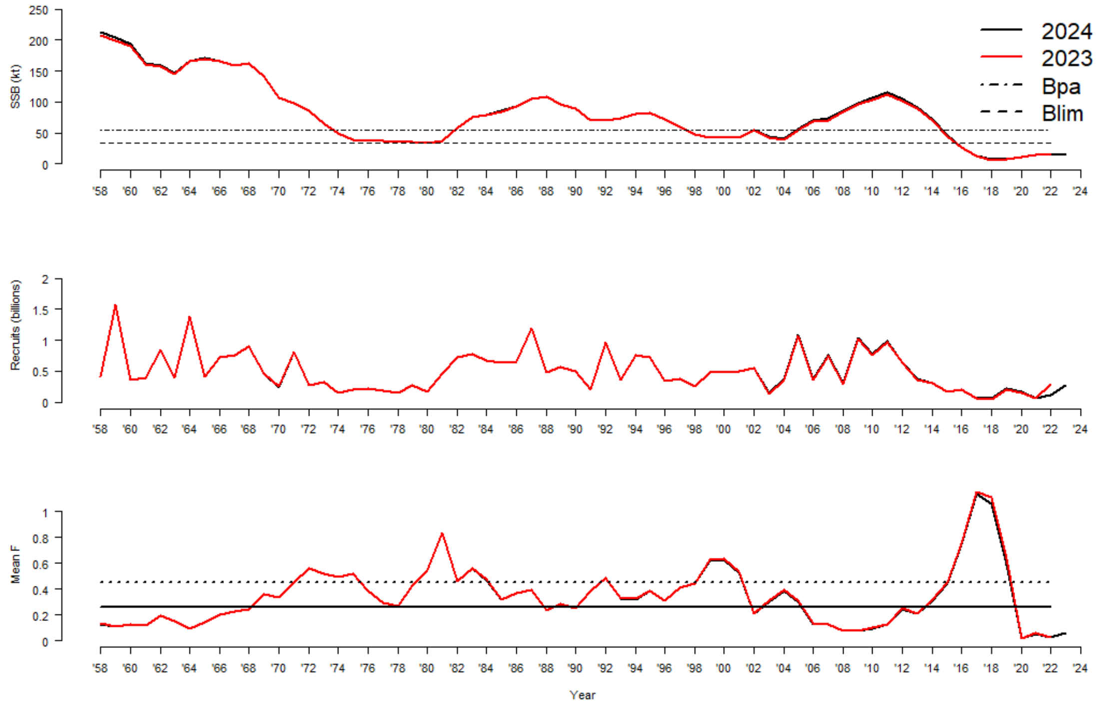


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run in 2023 and 2024 showing SSB (top), Recruitment (middle) and Mean F2–5 (bottom)

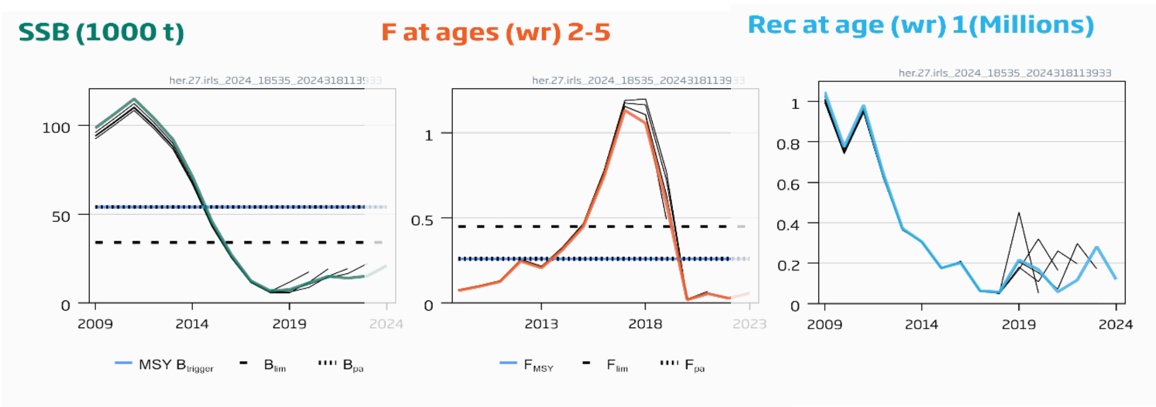


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospectives from the final assessments 2020–2024

Contents

7 Herring (*Clupea harengus*) in Division 7.a North of 52°30’N (Irish Sea)

The stock was benchmarked in 2017 and a state-space assessment model, SAM, was proposed as the assessment model for the stock (WKIRISH, 2017). However, in the 2024 working group meeting a serious issue with the assessment was identified, which resulted in an inter-benchmark being conducted within the WG meeting. This also led to the 2023 advice for 2024 being re-issued.

The WG notes that the use of “age”, “winter rings”, “rings” and “ringers” can cause confusion. The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout the report. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks such as this one, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

7.1 The Fishery

ICES advised that when the MSY approach is applied, catches in 2023 should be no more than 7309 tonnes. ICES advised that when the MSY approach is applied, catches in 2024 should be no more than 7279 tonnes. However, upon detection of the error in the assessment model, the advice for 2024 was re-issued at the 2024WG meeting. After the re-issue the advice for 2024 was 4821 tonnes.

7.1.1 The fishery in 2023

The catches reported from each country for the period 1987 to 2023 are given in Table 7.1.1, and total catches from 1987 to 2023 in Figure 7.1.1. Reported international landings in 2023 for the Irish Sea amounted to 7368 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2023 were taken during the 4th quarter, with landings very similar in the two quarters.

As in previous years, the 2023 7.a (N) herring fishery began in late August, with catches taken to the north-west of the Isle of Man, before moving to the Douglas Bank. The majority of catches were taken by Northern Irish and Irish midwater pelagic fishing vessels. In previous years an extensive ‘Mourne’ gillnet fishery was active, this is limited to boats under 40 ft usually in October and November, this fishery landed 19t in 2023 as well as 27t being landed by the *nephrop* fleet.

7.1.2 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring has a derogation to fish within the Irish closed box. The area to the east of the Isle of Man, encompassing the Douglas Bank spawning ground (described in ICES 2001, ACFM:10), was closed from 21 September to 15 November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man.

The arrangement of closed areas in Division 7.a(N) prior to 1999 is discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21 September to 15 November, and along the east coast of Ireland all year-round. In 2020 theses restrictions were no longer in place due to the changes within the EU Technical Regulations (EU) 2019/1241, however, national licensing measures still restrict vessels from fishing in some areas and seasons.

7.1.3 Changes in fishing technology and fishing patterns

UK Northern Irish and Irish pelagic pair and single trawlers take the majority of catches during the 3rd and 4th quarters. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 3rd or 4th quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, peaking at ~171 t in 2009 and 19t in 2023. Recently there has been a marked increase in the landings made by Irish vessels comprising 19% of the landings in 2018, 21% in 2019 and 27% in 2020. This decreased in 2021 to 10% further declining to 5% in 2023, but remains above the previous low levels of on average of 2% during 2015 - 2017.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component was conducted in 2023. Sampling was carried out on landings at fish processing factories for both Irish, Northern Irish vessels. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. Catches in numbers-at-age are given in Table 7.6.3.1 for the years 1972 to 2023 and a graphical representation is given in Figure 7.2.1. The catch in numbers at length is given in Table 7.2.2 for 1995 to 2023, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 23 in 2023, which are lower sampling levels than has been achieved in the past. Additionally, the majority of samples were collected in Q3, while more than half of the fishery occurred in Q4. The change of staff within AFBI and the loss of the main ager required the samples to be sent to DTU for aging in this year.

The number of measurements remained similar to past sampling levels. At sea observer data have been collected since 2010 (~15% of fishing trips sampled annually) with no discards observed. In 2020 at-sea observations were not carried out due to the Covid-19 'social distancing' requirements, observations were reinstated in 2022 and discarding is not thought to be a feature of this fishery. Details of sampling are given in Table 7.2.3.

As a result of quality issues identified with the ageing of herring in the Irish Sea, an otolith exchange was completed in 2015. The results indicated relatively good agreement between ages and a consistent issue with inexperience readers that can be solved through further training.

The 2017 benchmark concluded to include data back to 1980. Data extends back to 1961 and the entire data series was included in the assessment up to 2016, but there are well documented concerns over the quality of historic landings information, especially in the 1970s (see Stock

Annex). Recent landings data, particularly since the introduction of buyers and sellers regulation in 2006, are considered to be of good quality.

7.3 Fishery Independent Information

7.3.1 Acoustic surveys AC(7.aN)

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.3.1. The SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2023 was carried out over the period 26h August– 13th September. The survey conditions were good. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1). Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1). Highest abundance of 1+ herring targets in 2023 were observed on the Eastern coast of Northern Ireland Local at areas of high abundance on the known spawning banks and to the west of the Isle of Man (Figure 7.3.1). The survey followed the methods described in the ICES WGIPS International Pelagic Survey Manual. Sampling intensity was high during the 2023 survey with 38 successful trawls completed. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.2).

The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2. Results of a microstructure analysis of 1-ringer+ fish (Figure 7.3.6–7) have not been updated since 2011. Winter hatched fish, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of winter hatched fish, leaving only fish of autumn spawning origin, does not change the perception of a significant increase in biomass estimates (Figures 7.3.6–7). The benchmark working group (ICES WKPELA 2012) investigated the mixing issue and its impact on the assessment. The benchmark group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The recruitment data (1 winter rings) have the largest proportion of “alien” stock. The benchmark suggested that this is considered in the assessment model configuration and dealt with objectively within the model.

7.3.2 Spawning-stock biomass survey (7.aNSpawn)

A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). This enhanced survey programme was initiated to investigate the temporal and spatial variability of the population estimates from the routine acoustic survey. The purpose was to track the spawning migration entering into the Irish Sea via the North Channel on route to the main spawning grounds of the Douglas Bank. This informed design of the current survey to concentrate on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (Figure 7.3.3). Herring found in this area represents >75% of the SSB index generated from the routine survey. In 2023 the survey was conducted from the 7th to 10th of October. The spawning stock biomass was estimated to be 64.5 t, this is a considerate increase from recent years estimates but falls within the previously observed range (28.4 – 114 t).

The historic density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimates. The survey results support the high abundance of herring in the Irish Sea. Since 2012 this extended survey series has been reduced to one repeat survey in late September/early October to coincide with the main spawning time. The primary aim to generate an SSB index constituted from her- ring on or around the Irish Sea spawning ground to eliminate some of the ageing and mixing issues.

The 2012 benchmark (ICES WKPELA 2012) also suggested that the survey series could be used to fine tune the main survey used as the tuning fleet in the assessment. The survey uses a stratified design similar to the AC(7.a.N.). Survey methodology, data processing and subsequent analysis is exactly the same as for AC(7.a.N) and follows standard protocols for surveys coordinated by WGIPS. The survey was presented to WGIPS in 2017 prior to inclusion into the benchmark. The results of the survey are reported in the WGIPS 2018 report (ICES, 2018) and updated annually. The survey is included in the assessment as an SSB index. A comparison with the SSB estimates from this survey and the acoustic survey that is conducted earlier confirms the high abundance of herring in the Irish Sea, but with some clear year effect (Figure 7.3.5). This index is generated from a survey where the timing mostly coinciding with the spawners being present on the Douglas Bank. The survey has been conducted on a chartered commercial vessel since 2007, timing of the survey is directed by input from the commercial fishery reporting movements of fish onto the spawning grounds.

7.4 Genetic stock identification

ICES recognises that the Irish Sea herring acoustic surveys and fishery operate on a mixture of Irish Sea autumn spawning herring and herring from the Celtic Sea and neighbouring populations, and that the Irish Sea assessment is conducted on the mixed stocks (ICES, 2023). However, the mixing issue has, until now, been assumed to only affect the younger age classes and it has been suggested that this issue was accounted for in the assessment model (see Section 7.3). At the most recent benchmark, in 2017, numerous issues were highlighted with the current assessment, and it was concluded that more work was needed in the short term to improve the basis of the assessment (see Section 7.6).

Central to this was investigating the stock mixing, which necessitated improving the ability to assign individual herring to their population of origin. Recent advances in genetic stock identification methods have provided the necessary tools to achieve this (see Andersson et al., 2024) and these methods are now widely applied in other herring stocks with the ICES area (see ICES, 2024).

In 2021, AFBI commissioned Swansea University to undertake a study to:

- Conduct a literature review to identify herring populations potentially contributing to the Irish Sea assessment area.
- Develop a genetic assignment model for assigning individual herring caught in the Irish Sea to their population of origin.
- Assess stock mixing, with a particular focus on the samples collected on the two Irish Sea Acoustic surveys.

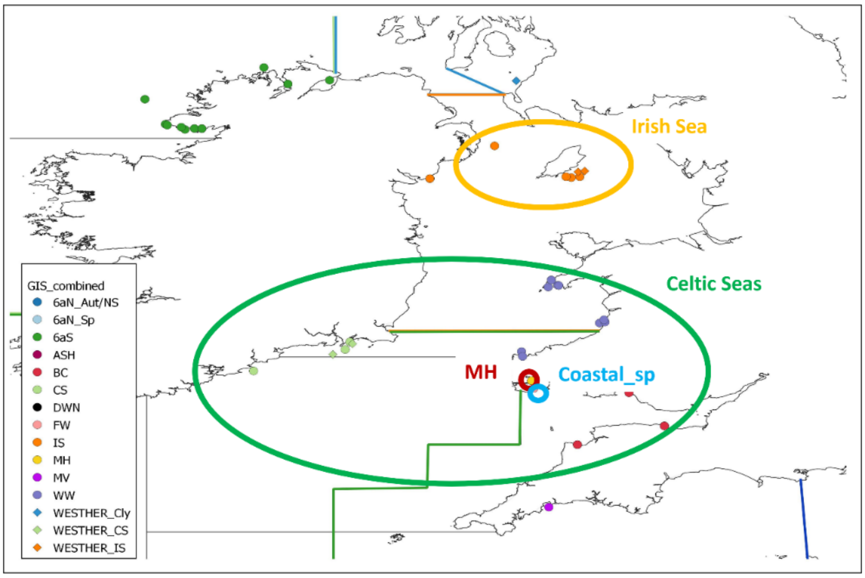


Figure 7.4.1. The spawning baselines samples from the Irish Sea, Celtic Sea, Cardigan Bay, and Bristol Channel included in the assignment model. The ellipses indicate the grouping of samples into the four categories in the assignment model.

The results of the project were presented to AFBI in November 2022 (Gwilliam et al., 2022). Analysis of spawning baseline samples from across the study area, which included the Irish Sea, Cardigan Bay, Celtic Sea, Bristol Channel and the western Channel, indicated that the Irish Sea autumn spawning herring comprised a distinct biological unit which was possible to distinguish from neighbouring populations. The autumn and winter spawning herring in the study area south of Anglesey were genetically similar and for the purposes of developing an assignment model were grouped together as *Celtic Seas* (Figure 7.4.1). A locally adapted low-salinity spring spawning population was identified in Milford Haven and a coastal spring spawning population was also identified in the outer Bristol Channel. An assignment model was developed with four assignment categories (*Irish Sea*, *Celtic Seas*, *Milford Haven*, *Coastal Spring*). The self-assignment rates for the *Irish Sea* and *Celtic Seas* categories were greater than 90% and greater than 85% for the two spring spawning categories. Individuals with an assignment probability lower than the assignment threshold (0.67) were classified as *Below Threshold*. If the individual failed to pass the genotyping quality controls, then it was classified as *Fail*.

Assignment of the 2021 Irish Sea Acoustic Survey (ISAS) samples (n=296 individuals) indicated a significant proportion of *Celtic Seas* herring in the survey samples (Figure 7.4.2). It was concluded that further years of samples should be analysed to assess if this was an annual issue and as such relevant to the Irish Sea stock assessment.

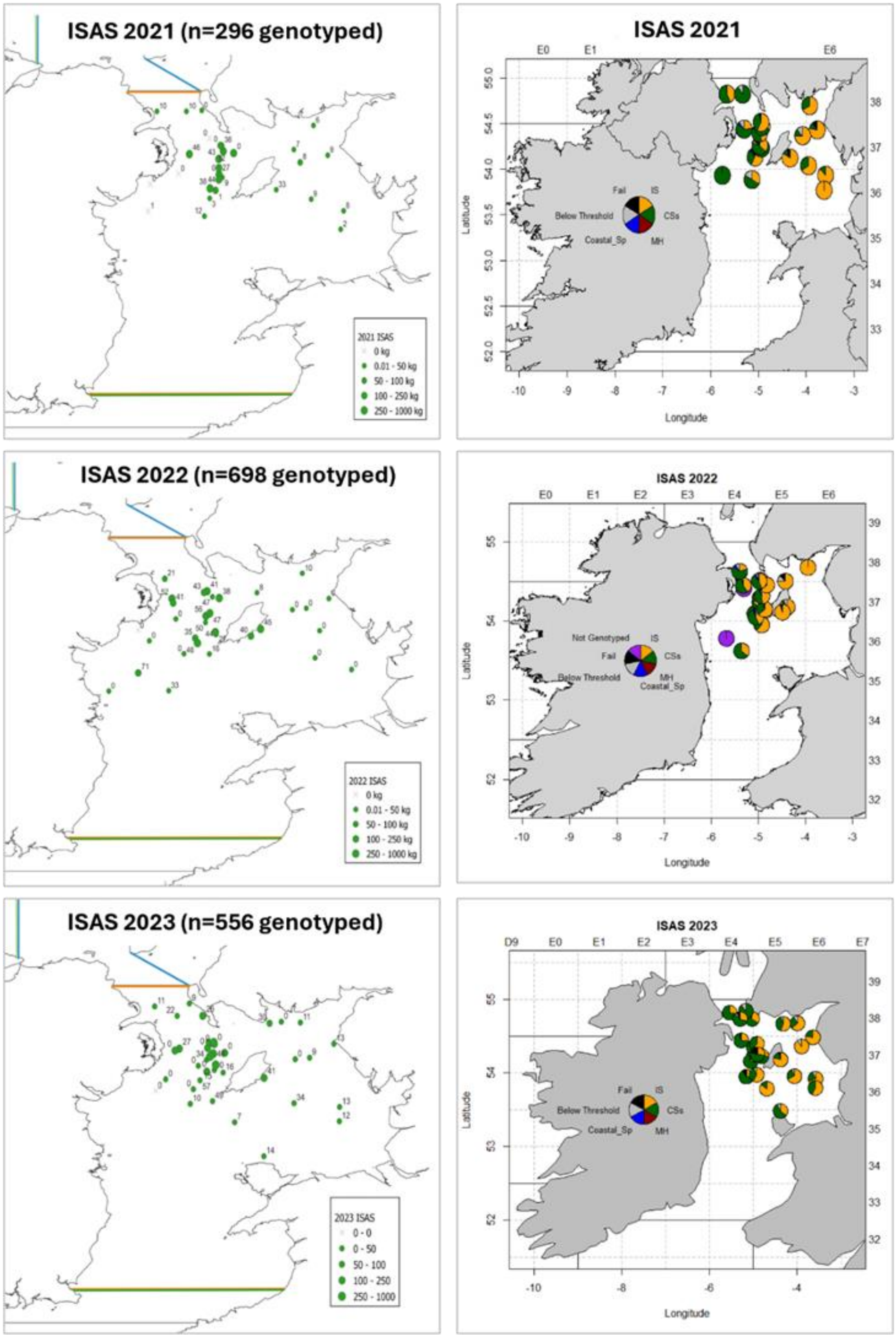


Figure 7.4.2. The left panels show the hauls of herring in the 2021–2023 Irish Sea Acoustic Survey with the estimated herring catch in kg indicated by the size of the green markers. Hauls with no herring catch are indicated with an X. The numbers indicate the number of fish genetically sampled in each haul. The right panels show the genetically assigned ISAS hauls. Assignment categories are indicated in the legend.

Subsequent to the completion of the AFBI-Swansea herring project (Gwilliam et al., 2022) the 2022 and 2023 ISAS were genetically sampled (n = 698 and 556 individuals, respectively) and the samples assigned with the same assignment model as the 2021 survey. Samples from the 2021 Irish Sea Acoustic Spawning Survey (ISSS) were also genetically analysed and assigned with the same model.

The assignment of the ISAS 2021-2023 samples indicated a consistent pattern, in that there was a significant proportion of *Celtic Seas* herring in the hauls in all three survey years (Figure 7.4.2). This was particularly evident in the hauls to the west of the Isle of Man, where the highest abundance is observed annually and where the Irish Sea herring fishery occurs. *Celtic Seas* fish were also present in the hauls of juvenile herring in the eastern Irish Sea.

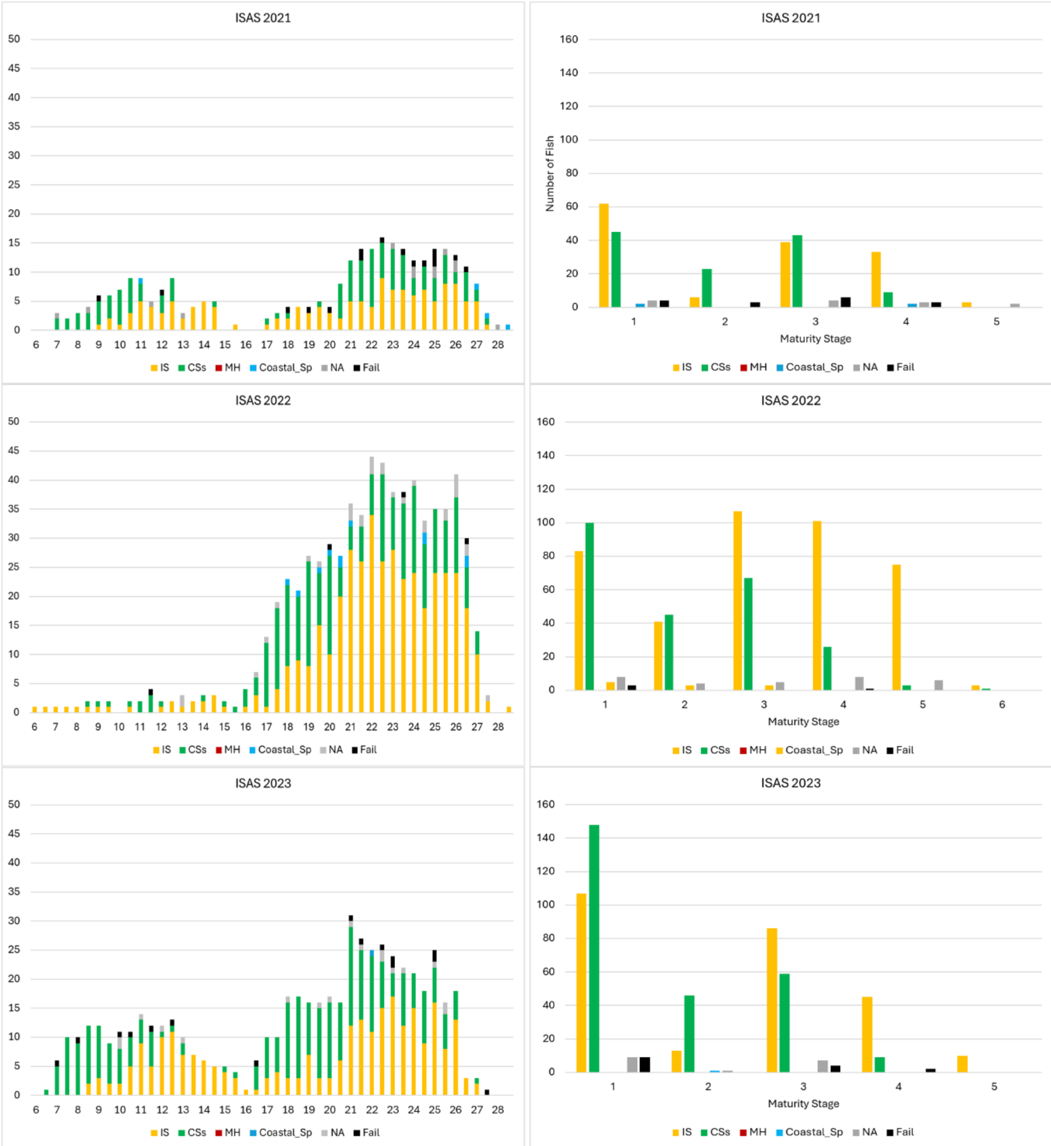


Figure 7.4.3. The 2021–2023 Irish Sea Acoustic Survey (ISAS) samples with the assignments of all individuals divided by (left panels) length class and (right panels) maturity stage.

Analyses of the 2021-2023 ISAS samples by length indicated that *Celtic Seas* herring were represented in all length classes and not just in the juveniles as previously assumed at the 2017 benchmark. This pattern was consistent in the three years of samples analysed (Figure 7.4.3). The lower number of juveniles in the 2022 samples was due to hauls with juveniles in the eastern Irish Sea not being genetically sampled (Figure 7.4.3) rather than a lack of juveniles being encountered in the survey. Of note in the 2021 and 2023 ISAS sample assignments are the assignments of individuals <15cm. These individuals were most likely spawned in the spawning season prior to the survey and it is clear that the individuals assigned to the *Irish Sea* have a larger median length than those assigned to the *Celtic Seas*. This is expected at the Irish Sea herring would have been spawned almost one year prior to being sampled during the survey. The *Celtic Seas* herring may have been spawned as late as February in the year of the survey and as such may be up to five months younger than the Irish Sea juveniles. As all herring sampled in the surveys are assumed to be autumn spawning herring and aged as such then they would all be classified as 0 WR/1 yr despite the differences in spawning time. As a result, the *Celtic Seas* herring would likely would have a lower length- and weight-at-age than the *Irish Sea* herring. The differences in growth and age may also have a significant impact on the length and age at maturity. Depending on the proportion of *Celtic Seas* herring in the survey and catch this may have a significant impact on the input data, including the maturity ogive, for the Irish Sea assessment.

Analyses of the 2021-2023 ISAS samples by maturity stage revealed a biologically meaningful pattern (Figure 7.4.3). The stage 1 individuals comprised an almost equal mix of *Irish Sea* and *Celtic Seas* herring in the three years sampled. There were also significant numbers of stage 2 and 3 *Celtic Seas* and *Irish Sea* herring. As expected the stage 4 and 5 fish were primarily assigned to the *Irish Sea*, which makes biological sense as this population spawns earlier than the *Celtic Seas* populations and these fish should have been at a more advance maturity stage.

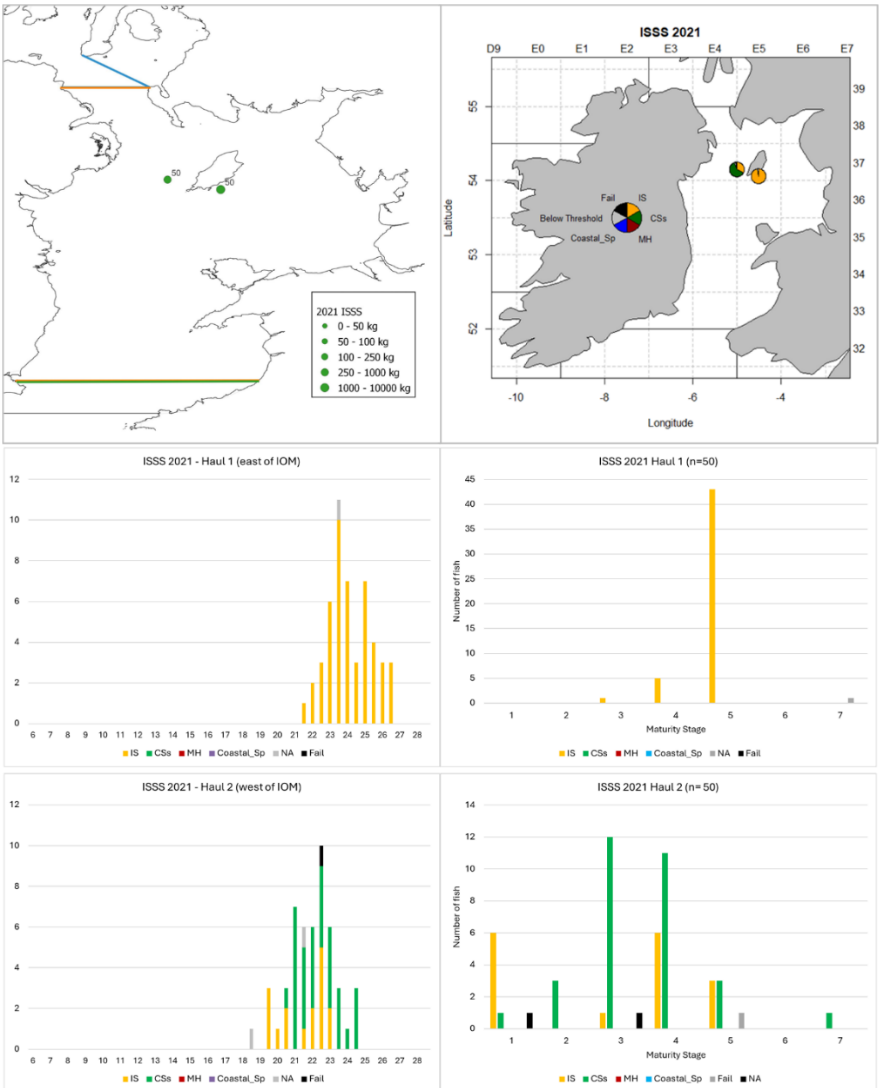


Figure 7.4.4. The 2021 Irish Sea Acoustic Spawning Survey (ISSS) samples with the assignments of all individuals divided by (left panels) length class and (right panels) maturity stage.

Two samples were collected during the 2021 Irish Sea Acoustic Spawning Survey (ISSS), one to the east of the Isle of Man (n=50) and one to the west of the Isle of Man (n=50) (Figure 7.4.4). No genetic samples were collected during the 2022 and 2023 ISSS, though there was a single haul conducted on each survey. Genetic assignment of the 2021 samples indicated that the sample from east of the Isle of Man, collected on the spawning grounds, comprised exclusively *Irish Sea* fish. The majority of these fish were at maturity stage 5 and as such the assignments make biological sense. The assignment of the sample collected from west of the Isle of Man indicated a mix of *Irish Sea* and *Celtic Seas* fish and a range of maturity stages. The majority of the fish were assigned to the *Celtic Seas*.

In summary the analyses conducted have shown, based on the samples analysed, that the ISAS and ISSS indices comprise a significant proportion of herring, of all length and age classes, that are not from the Irish Sea autumn spawning population. These herring most likely originate from the Celtic Sea and neighbouring populations. As the Irish Sea herring fishery takes place at the same time as the ISAS, in the same area to the west of the Isle of Man, the catches like also contain a significant proportion of herring from the Celtic Sea and neighbouring populations. This will likely have an impact on the Irish Sea stock assessment and the perception of the stock size.

7.5 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2023 was used to calculate mean weights-at-age in the catch (Table 7.6.3.2). The mean weights-at-age in the 3rd quarter catches (for the time-series 1980 to present) are used as estimates of stock weights at spawning time (Table 7.6.3.3). Mean weights-at-age have shown a general downward trend (Figure 7.4.1). This has also been observed in other stocks. It is recommended that potential drivers for this decline is investigated to explore potential large- scale ecosystem changes. No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010. The final agreed model from the 2012 benchmark used the natural mortality estimates from the North Sea (Table 7.6.3.4). These were again reviewed at the 2017 benchmark and although not considered ideal it is still the best available in the absence of specific Irish Sea derived natural mortality estimates. A variable maturity ogive is used based on the corresponding annual quarter 3 biological sampling from the catch (Table 7.6.3.5).

7.6 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the AC(7.aN) acoustic survey, with trends also provided by the groundfish surveys. There is evidence that a proportion of these are of Celtic Sea origin (e.g. Brophy and Danilowicz, 2002). Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in Section 7.6.

7.7 Assessment

The stock was benchmarked in 2017. The detection of a critical error (default setting) in the R package version used to run the assessment resulted in an internal process to change the model environment and to have this externally reviewed (See report of external reviewer and annex). This resulted in a considerable change in the perception of the stock. The input data were not further investigated in this process due to time constraints and as this would warrant a full benchmark.

7.7.1 Final assessment

The final assessment was carried out by fitting the state-space model (SAM, in stockassessment.org) using the settings and data inputs in accordance with the updated stock annex and the inter-benchmark document. The input data and model settings are shown in Tables 7.6.3.1–7, the stock summary can be seen in Table 7.6.3.8. SAM outputs and diagnostics are presented in Table 7.6.3.9, and Table 7.6.3.10 shows the short term forecasts.

Diagnostics and selectivity parameters for this run are presented in Figure 7.6.1–8. The "leave on out" figure shows that neither of the model is largely driven by the catches and that the both surveys and the catches show a very similar perception of the stock. The model fits well to the data and the retrospective pattern is acceptable just for the recruitment values.

The retrospectives can be seen in figure 7.6.11 with Mohn's Rho for SSB at -0.075, Fbar 0.061 and recruitment -0.255. Recruitment is fully in the envelope and has continuously been upscaled.

A comparison of the estimates of this year's assessment with last year's re-issued assessment is given in Figure 7.6.10.
The full assessment can be seen in stockassessment.

7.7.2 State of the stock

Trends from the final assessment indicate a stable SSB and recruitment since the last 10 years, although largely below the MSY $B_{trigger}$ reference point, and an increasing trend in recruitment. SSB has recently been between B_{pa} and MSY $B_{trigger}$. The associated F has largely been around F_{lim} . Based on the most recent estimates the stock is not being harvested sustainably above F_{MSY}.

7.8 Short-term projections

7.8.1 Deterministic short-term projections

A deterministic short-term forecast was conducted for Irish Sea herring with code in R (FLR). Population abundances, F at age and input data were taken from the final SAM assessment, 1980–2023 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2012–2021) replaced recruitment for 1-ringers in 2024 and is used as the intermediate year assumption. The forecast was based on catches (2024 advice = 7279 t) assuming full uptake of the ICES fishing opportunity advice, even though the advice is being re-issues in 2024 with a reduced advice of 4821 t. Fishing mortality, maturity-at-age, catch weights at age and stock weights were averaged over the most recent three years. Fishing mortality was not scaled to the last year, as the terminal estimate of F was not considered more informative. The bottom table in Table7.6.3.10 shows the options should the TAC and fishery follow the re-issued advice.

The SSB in 2025 is predicted to stay just below MSY $B_{trigger}$ resulting advice given on the scaled F_{MSY} following the ICES harvest control rule.

7.8.2 Yield per recruit

Not available, previous explorations are detailed in the stock annex.

7.9 Medium term projections

No medium term stock projections of stock size were conducted by the Working Group.

7.10 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2024 assessment (HAWG 2024). B_{lim} was set to the lowest SSB that generate above average recruitment, 6080 t. B_{pa}, 9064 t calculated from B_{lim} with assessment error (σ = 0.201, based on the average CV from the terminal assessment year) MSY $B_{trigger}$ is set at 11208t as the stock has been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is set at F_{p05}=F_{pa}= 0.35. F_{lim} is estimated to be 0.45 as F with 50% probability of SSB <B_{lim} .

7.11 Quality of the assessment

The data used within the assessment, the assessment methods and settings were scrutinized during the 2017 benchmark (WKIRISH3 2017).

The stock is very well sampled and catch information is representative of the fishery (with the exception of 2009 when no samples were provided). The current assessment, being a time-series model, can estimate the missing catch numbers in 2009.

The main issues with the stock are stock mixing (at younger ages from fish of different spawning season origin) and the different trends in mortality observed in the survey and the commercial catches. The majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey, but is also affected by the effect the annual closure of the Douglas Bank spawning grounds has on the fishery patterns. There are some inconsistencies between observed and modelled landings. The magnitude of these differs between years, but is on average +/-12% over the assessment period and mostly falls within the confidence limits of the estimate. The reason behind these needs further investigation, but might be due to conflicting mortality signals from the surveys and catches and the use of a constant M throughout the time-series.

The data are treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The mixing issue was considered in detail during the 2012 benchmark, but no further analysis was performed since given that there was no new information presented. Genetic analysis and biological data collection is ongoing.

The F_{bar} range 2–4 is considered representative of the mortality (Figure 7.6.26) on the autumn spawning stock in the Irish Sea, however this now includes the ages with significant mixed components and represent the age range with highest abundance in the fishery.

The survey data quality is good, but the survey index is linked to the migration and biological characteristics of the stock and the need to assess similar stock components which the fishery exploits to ensure the sustainable exploitation of the Irish Sea spawning stock.

The final assessment model is dominated by information from the catch, but with the noise being added to the survey information as age and year effects.

7.12 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

With the new perception of the stock and the re-issue of the advice for 2024, it is uncertain how the fishery will develop in this year.

The current assessment indicates SSB in 2024 to remain similar to the previous years. The Working Group supports the development of a long-term management plan for this stock. Such a plan should be further developed with stakeholders and for- warded to ICES for evaluation.

Characteristically of most herring stocks, the Irish Sea herring represents a mixture and management of this stock should be considered as part of a metapopulation. The consequence of this needs to be further evaluated for management and advice.

7.13 Ecosystem Considerations

The Sixth Workshop on an Ecosystem Based Approach to Fishery Management for the Irish Sea (WKIRISH6), set out to operationalise the WKIrish regional benchmark process. WKIrish aimed to incorporate ecosystem information into the ICES single-species stock assessment process for the Irish Sea. Three independent ecosystems models have been in development for the Irish Sea. Of these, an Ecopath with Ecosim (EwE) model has been reviewed by the ICES Working Group on Multispecies Assessment Methods (WGSAM). WKIrish propose to use relevant ecosystem indicators to inform the FMSY within the established F ranges ($F_{MSYLower}$ to $F_{MSYUpper}$). F_{ECO} uses indicaors of current ecosystem suitability for individual stocks to refine the F target values within these precautionary ranges. FIND is based on finding ecosystem indicators which are positively related to the stock development over the model tuning range, and where the likely underlying mechanisms for this link are likely to continue acting in the short to medium term. The EwE model was used to provide ecosystem indicator(s) for individual stocks (cod, whiting, haddock, sole, plaice, herring, and *Nephrops*) in the Irish Sea. The selection of the indicator aimed to cover a range of possible ecosystem processes on each stock. For herring, the large zooplankton index was observed to be strongly positively correlated with stock biomass and therefore selected as an appropriate indicator of favourable environmental condition for the stock.

7.14 Tables and Figures

Table 7.1.1 Herring (Clupea harengus) in Division 7.a North of 52°30'N (Irish Sea)Herring in Division 7.a North (Irish Sea).Working Group catch estimates in tonnes by country, 1987–2023. The total catch does not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995
Ireland	1 200	2 579	1 430	1 699	80	406	0	0	0
UK	3 290	7 593	3 532	4 613	4 318	4 864	4 408	4 828	5 076
Unallocated	1 333								
Total	5 823	10 172	4 962	6 312	4 398	5 270	4 408	4 828	5 076

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004
Ireland	100	0	0	0	0	862	286	0	749
UK	5 180	6 651	4 905	4 127	2 002	4 599	2 107	2 399	1 782
Unallocated	22								
Total	5 302	6 651	4 905	4 127	2 002	5 461	2 393	2 399	2 531

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ireland	1 153	581	0	0	0	0	0	18	0
UK	3 234	3821	4 629	4895	4594	4894	5202	5675	4828
Unallocated						-			
Total	4 387	4 402	4 629	4895	4594	4894	5202	5693	4828

Country	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ireland	119	0	82	200	1299	1317	1957	753	492	407
UK	5089	4868	4245	3696	5504	5061	5969	6455	5395	6962
Unallocated		22								
Total	5208	4891	4327	3896	6804	6378	7927	7208	7888	7369

Table 7.2.1 Herring (Clupea harengus) in Division 7.a North of 52°30’N (Irish Sea)Herring in Division 7.a North (Irish Sea).Catch at length data 1995–2023. Numbers of fish in thousands. Table amended with 1990–1994 year-classes removed (see Annex 8).

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
14															-					-				16					
14.5															-					-				0	11				
15															-					15				31	50	11			
15.5					10								16		-	93				14				54	74			19	
16	21	21	17		19	12	9					2			-	107	30		8	0		109		47	233			185	
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165		84	14		174		176	401	106		299	
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356	89	202	213	16	261	86	431	883	428	37	731	
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851	143	470	808	32	413	62	749	1170	1250	54	1 749	
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301	533	1644	72	326	148	594	1532	1934	124	2 197	
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841	533	555	3246	64	457	148	1097	1346	2913	144	2 642	
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029	479	588	5357	136	522	234	841	1051	2832	337	1 946	
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673	1026	493	680	5371	199	718	382	928	1331	1996	368	1 441	
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062	298	1041	4025	271	826	1121	1608	1585	2438	825	1 730	
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888	1502	511	1419	2905	279	1087	1343	1881	2263	2857	970	2 212	
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874	643	2364	2608	439	1783	3154	3352	2716	3624	2 048	3 795	

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758	1396	1104	2963	2381	854	1762	3007	3838	3340	5419	2 879	5 622	
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372	1586	3052	2906	1896	2588	4374	5232	4676	6 594	5 058	6 861	
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362	2778	2404	3599	2766	2028	2675	2711	6046	4289	7 828	6 343	8 440	
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100	3920	3432	2596	2470	2893	3475	7485	4476	7 872	7 176	8 582	
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232	3394	6024	3039	1775	1977	3110	2625	6404	3745	7 378	6 435	8 480	
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759	8849	3882	2161	2124	2849	2649	6912	4841	6 065	5 589	7 469	
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616	3729	7777	3985	1879	1911	2523	2144	4992	5033	5 004	3 986	7 234	
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430	7020	3364	2282	2367	2414	2378	4462	3713	3 362	2 586	4 182	
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582	2662	5759	2693	2264	2319	2458	1824	2632	2079	3 102	1 190	2 308	
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343	4835	1934	1612	1962	1936	1331	1455	1401	1 945	772	1 730	
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950	1595	2664	1026	900	1016	1631	739	798	421	900	290	689	
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083	1716	412	498	827	826	370	458	210	342	181	230	
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216	472	629	179	326	252	283	123	198	41	119	76	185	
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248	231	85	256	141	65	37	104	52	29	18		
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53	159	28	156	48	65	12	0	11	80	2		
29	248	210	280	111	61	42	10	36	163		12	46			-	9		108		57	16	22	25	16				2	
29.5	56	79	59	92		12	0	36	129				7		-			54		14	8		12	0					

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
30	40	32	8	84		6	9		43						-			17		0	8								
30.5																													
31																											1		

Table 7.2.2 Herring (Clupea harengus) in Division 7.a North of 52°30’N (Irish Sea)Herring in Division 7.a North (Irish Sea).Sampling intensity of commercial landings in 2023.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	3493	20	3233	939
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	407	-	-	-
	UK (N. Ireland)	3468	3	503	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.3.1. Herring (Clupea harengus) in Division 7.a North of 52°30'N (Irish Sea)Herring in Division 7.a North (Irish Sea).Summary of acoustic survey AC(7.aN) information for the period 1989–2023. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38 kHz except December 1996, which was at 120 kHz.

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
1989	Douglas Bank	25/09–26/09			18 000	-	-	-
1990	Douglas Bank	26/09–27/09			26 600	-	-	-
1991	W. Irish Sea	26/07–8/08	12 760	0.23			66 0001	0.20
1992	W. Irish Sea + IOM E. coast	20/07–31/07	17 490	0.19			43 200	0.25
1994	Area 7.a(N)	28/08–8/09	31 400	0.36	25 133	-	68 600	0.10
	Douglas Bank	22/09–26/09			28 200	-	-	-
1995	Area 7.a(N)	11/09–22/09	38 400	0.29	20 167	-	348 600	0.13
	Douglas Bank	10/10–11/10		-	9 840	-	-	-
	Douglas Bank	23/10–24/10			1 750	0.51	-	-
1996	Area 7.a(N)	2/09–12/09	24 500	0.25	21 426	0.25	-2	-
1997	Area 7.a(N)-reduced	8/09–12/09	20 100	0.28	10 702	0.35	46 600	0.20
1998	Area 7.a(N)	8/09–14/09	14 500	0.20	9 157	0.18	228 000	0.11
1999	Area 7.a(N)	6/09–17/09	31 600	0.59	21 040	0.75	272 200	0.10
2000	Area 7.a(N)	11/09–21/09	40 200	0.26	33 144	0.32	234 700	0.11
2001	Area 7.a(N)	10/09–18/09	35 400	0.40	13 647	0.42	299 700	0.08
2002	Area 7.a(N)	9/09–20/09	41 400	0.56	25 102	0.83	413 900	0.09
2003	Area 7.a(N)	7/09–20/09	49 500	0.22	24 390	0.24	265 900	0.10
2004	Area 7.a(N)	6/09–10/09	34 437	0.41	21 593	0.41	281 000	0.07

Year	Area	Dates	herring bio-mass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
		15/09–16/09 28/09–29/09						
2005	Area 7.a(N)	29/08–14/09	36 866	0.37	31 445	0.42	141 900	0.10
2006	Area 7.a(N)	30/08–9/09	33 136	0.24	16 332	0.22	143 200	0.09
2007	Area 7.a(N)	29/08–13/09	120 878	0.53	51 819	0.42	204 700	0.09
2008	Area 7.a(N)	27/08–14/09	106 921	0.22	77 172	0.23	252 300	0.12
2009	Area 7.a(N)	1/09–13/09	95 989	0.39	71 180	0.47	175 000	0.08
2010	Area 7.a(N)	28/08–11/09	131 849	0.22	99 877	0.22	107 400	0.10
2011	Area 7.a(N)	27/08–10/09 11–12/10	131 527	0.36	49 128	0.22	280 000	0.11
2012	Area 7.a(N)	29/08–12/09	79 051	0.18	56 759	0.22	171 190	0.11
2013	Area 7.a(N)	29/08–12/09	65 649	0.24	55 350	0.25	255 268	0.09
2014	Area 7.a(N)	27/08–14/09	79 826	0.30	56 629	0.33	393 024	0.10
2015	Area 7.a(N)	29/08–17/09	55 773	0.24	29 056	0.23	237 063	0.09
2016	Area 7.a(N)	31/08–15/09	102840	0.25	91332	0.28	240 926	0.10
2017	Area 7.a(N)	28/08–09/09	40974	0.21	36499	0.23	219 186	0.09
2018	Area 7.a(N)	29/08–13/09	54661	0.29	39997	0.31	196 600	0.13
2019	Area 7.a(N)	28/08–13/09	68078	0.09	39318	0.08	146 140	0.08
2020	Area 7.a(N)	26/08–09/09	59645	0.09	40076	0.09	110401	0.10
2021	Area 7.a(N)	29/08–12/09	69432	0.09	56486	0.09	84398	0.17

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
2022	Area 7.a(N)	27/08–12/09	64827	0.11	30324	0.10	59788	0.10
2023	Area 7.a(N)	26/08-13/09	91706		62409		169520	

[1] sprat only

[2]Data can be made available for the IoM waters only

Table 7.3.2. Herring (Clupea harengus) in Division 7.a North of 52°30'N (Irish Sea)Herring in Division 7.a North (Irish Sea).Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September AC(7.aN). Ages in winter rings.

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6

AGE (RINGS)	1	2	3	4	5	6	7	8+
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6
2009	371.2	182.6	177.8	92.7	32.5	15.1	13.9	6.9

AGE (RINGS)	1	2	3	4	5	6	7	8+
2010	580.6	561.2	117.7	120.8	34.3	16.8	4.3	6.5
2011	1927.0	330.2	43.9	15.0	21.9	6.3	2.7	2.0
2012	369.1	191.9	161.0	51.4	21.6	19.3	12.1	3.1
2013	100.0	285.2	81.6	54.3	41.2	13.4	11.1	6.8
2014	299.7	193.3	127.3	29.7	43.1	17.3	7.8	12.5
2015	491.9	141.9	25.2	17.0	10.3	9.0	1.9	4.3
2016	131.5	449.3	257.2	110.2	32.2	18.3	8.2	7.0
2017	42.2	89.7	104.1	56.5	9.0	20.3	4.4	11.8
2018	237.9	120.7	63.3	110.9	29.6	7.6	7.9	5.1
2019	148.9	247.5	44.7	21.2	14.6	9.0	1.8	0.9
2020	247.4	96.7	115.6	16.2	7.8	11.7	2.7	0.9
2021	101.8	423.9	177.6	24.4	2.0	2.5	0.3	0.1
2022	644.3	182.0	85.6	32.3	8.5	1.1	0.5	0.5
2023	420.8	507.5	135.5	70.2	39.2	11.8	0.6	1.1

Table 7.6.3.1. Irish Sea Herring. Catch in number. Units: thousands

age/year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	5840	5050	5100	1305	1168	2429	4491	2225	2607	1156	2313	1999	12145
2	25760	15790	16030	12162	8424	10050	15266	12981	21250	6385	12835	9754	6885
3	19510	3200	5670	5598	7237	17336	7462	6146	13343	12039	5726	6743	6744
4	8520	2790	2150	2820	3841	13287	8550	2998	7159	4708	9697	2833	6690
5	1980	2300	330	445	2221	7206	4528	4180	4610	1876	3598	5068	3256
6	910	330	1110	484	380	2651	3198	2777	5084	1255	1661	1493	5122
7	360	290	140	255	229	667	1464	2328	3232	1559	1042	719	1036
8+	230	240	380	59	479	724	877	1671	4213	1956	1615	815	392

age/year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	646	1970	3204	5335	9551	3069	1810	1221	2713	179	694	3225	8692
2	14636	7002	21330	17529	21387	11879	16929	3743	11473	9021	4694	8833	13980
3	3008	12165	3391	9761	7562	3875	5936	5873	7151	1894	3345	5405	10555

age/year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
4	3017	1826	5269	1160	7341	4450	1566	2065	13050	1866	2559	2161	3287
5	2903	2566	1199	3603	1641	6674	1477	558	3386	2395	882	623	1422
6	1606	2104	1154	780	2281	1030	1989	347	936	953	2945	213	415
7	2181	1278	926	961	840	2049	444	251	650	474	872	673	292
8+	848	1991	1452	1364	1432	451	622	147	803	337	605	127	368

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	5669	20290	8939	NA	9588	7454	2491	3889	27377	1654	2216	2112
2	15253	18291	18974	NA	17627	17598	9664	18916	9567	15414	19064	12844
3	8198	4980	7487	NA	6679	8984	12247	6836	7917	4840	5992	12419
4	6318	1655	2696	NA	6201	3982	7944	6631	1997	7376	4677	4407
5	1325	1062	2082	NA	3200	3671	3061	2901	1759	1613	2050	609
6	605	325	1761	NA	925	1751	3158	1472	964	4276	1421	1065
7	262	122	328	NA	370	690	1591	625	409	1678	896	487
8+	246	111	216	NA	185	425	652	352	830	1112	759	623

age	2018	2019	2020	2021	2022	2023
1	7991	12176	15260	5708	13155	7183
2	22903	23112	29059	35337	23817	47752
3	15657	11083	20869	13744	23740	9325
4	12364	6776	4099	3033	14134	11115
5	3240	6661	3355	1163	5616	5009
6	538	1360	3200	976	377	1497
7	391	182	777	140	152	195
8+	50	194	209	26	160	183

Table 7.6.3.2. Irish Sea Herring. Weights-at-age in the catch. Units: kg

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.074	0.074	0.074	0.074	0.076	0.087	0.068	0.058	0.070	0.081	0.096	0.073
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.130	0.124	0.128	0.140	0.123
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.160	0.160	0.155	0.166	0.155
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.170	0.174	0.175	0.171
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.180	0.184	0.187	0.181
6	0.251	0.251	0.251	0.251	0.243	0.209	0.228	0.210	0.198	0.195	0.195	0.190
7	0.258	0.258	0.258	0.258	0.240	0.222	0.239	0.218	0.212	0.205	0.207	0.198
8+	0.278	0.278	0.278	0.278	0.273	0.258	0.254	0.229	0.232	0.218	0.218	0.217

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.062	0.089	0.070	0.075	0.067	0.064	0.080	0.069	0.064	0.067	0.085	0.081
2	0.114	0.127	0.123	0.121	0.116	0.118	0.123	0.120	0.120	0.106	0.113	0.116
3	0.140	0.157	0.153	0.146	0.148	0.146	0.148	0.145	0.148	0.139	0.144	0.136
4	0.155	0.171	0.170	0.164	0.162	0.165	0.163	0.167	0.168	0.156	0.167	0.160
5	0.165	0.182	0.180	0.176	0.177	0.176	0.181	0.176	0.188	0.168	0.180	0.167
6	0.174	0.191	0.189	0.181	0.199	0.188	0.177	0.188	0.204	0.185	0.184	0.172
7	0.181	0.198	0.202	0.193	0.200	0.204	0.188	0.190	0.200	0.198	0.191	0.186
8+	0.197	0.212	0.212	0.207	0.214	0.216	0.222	0.210	0.213	0.205	0.217	0.199

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.073	0.067	0.064	0.067	0.071	0.0620	0.053	0.058	0.070	0.059	0.066	0.070
2	0.107	0.103	0.105	0.112	0.110	0.1080	0.106	0.106	0.120	0.100	0.110	0.106
3	0.130	0.136	0.131	0.135	0.135	0.1330	0.131	0.134	0.138	0.130	0.146	0.136
4	0.157	0.156	0.149	0.158	0.153	0.1490	0.145	0.152	0.152	0.142	0.177	0.148
5	0.165	0.166	0.164	0.173	0.156	0.1545	0.153	0.159	0.164	0.157	0.174	0.155
6	0.187	0.180	0.177	0.183	0.182	0.1730	0.164	0.175	0.174	0.165	0.176	0.157
7	0.200	0.191	0.184	0.199	0.196	0.1855	0.175	0.187	0.179	0.170	0.196	0.167
8+	0.205	0.209	0.211	0.227	0.206	0.1890	0.172	0.196	0.191	0.180	0.198	0.171

age	2016	2017	2018	2019	2020	2021	2022	2023
1	0.054	0.072	0.060	0.057	0.057	0.069	0.051	0.058
2	0.102	0.093	0.096	0.096	0.095	0.101	0.086	0.079
3	0.126	0.121	0.120	0.119	0.119	0.119	0.108	0.102
4	0.143	0.140	0.132	0.137	0.138	0.133	0.123	0.118
5	0.159	0.147	0.147	0.143	0.143	0.148	0.137	0.133
6	0.161	0.154	0.159	0.156	0.152	0.148	0.156	0.138
7	0.167	0.154	0.164	0.159	0.160	0.160	0.165	0.159
8+	0.177	0.162	0.204	0.181	0.174	0.167	0.168	0.158

Table 7.6.3.3. Irish Sea Herring. Weights-at-age in the stock. Units: kg.

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.074	0.074	0.074	0.074	0.076	0.087	0.068	0.058	0.070	0.081	0.077	0.070
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.130	0.124	0.128	0.135	0.121
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.160	0.160	0.155	0.163	0.153
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.170	0.174	0.175	0.167
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.180	0.184	0.188	0.180
6	0.251	0.251	0.251	0.251	0.243	0.209	0.229	0.210	0.198	0.195	0.196	0.189
7	0.258	0.258	0.258	0.258	0.240	0.222	0.239	0.218	0.212	0.205	0.207	0.195
8+	0.278	0.278	0.278	0.278	0.273	0.258	0.254	0.229	0.232	0.218	0.217	0.214

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.061	0.088	0.073	0.072	0.067	0.063	0.073	0.068	0.063	0.066	0.085	0.081
2	0.111	0.126	0.126	0.120	0.115	0.119	0.121	0.121	0.120	0.105	0.113	0.116
3	0.136	0.157	0.154	0.147	0.148	0.148	0.150	0.145	0.149	0.139	0.144	0.136
4	0.151	0.171	0.174	0.168	0.162	0.167	0.166	0.168	0.171	0.156	0.167	0.160
5	0.159	0.183	0.181	0.180	0.177	0.178	0.179	0.178	0.188	0.167	0.180	0.167
6	0.171	0.191	0.190	0.185	0.195	0.189	0.190	0.189	0.204	0.183	0.184	0.172
7	0.179	0.198	0.203	0.197	0.199	0.206	0.200	0.199	0.205	0.199	0.191	0.186
8+	0.191	0.214	0.214	0.212	0.212	0.214	0.230	0.214	0.215	0.205	0.217	0.199

age	2004	2005	2006	2007	2008		2009	2010	2011	2012	2013	2014	2015
1	0.067	0.067	0.064	0.073	0.071	0.0660	0.060	0.057	0.059	0.057	0.069	0.070	
2	0.114	0.103	0.105	0.114	0.110	0.1140	0.118	0.109	0.109	0.100	0.112	0.106	
3	0.144	0.136	0.131	0.137	0.135	0.1350	0.134	0.136	0.131	0.131	0.150	0.136	
4	0.161	0.156	0.149	0.158	0.153	0.1500	0.147	0.155	0.149	0.142	0.178	0.148	
5	0.170	0.166	0.164	0.174	0.156	0.1550	0.153	0.162	0.153	0.157	0.174	0.155	
6	0.192	0.180	0.177	0.183	0.182	0.1740	0.165	0.177	0.162	0.167	0.176	0.157	
7	0.202	0.191	0.184	0.199	0.196	0.1860	0.176	0.188	0.168	0.175	0.196	0.167	
8+	0.214	0.209	0.211	0.227	0.206	0.1895	0.173	0.197	0.190	0.180	0.202	0.171	

age	2016	2017	2018	2019	2020	2021	2022	2023
1	0.054	0.072	0.060	0.057	0.057	0.069	0.051	0.058
2	0.102	0.093	0.096	0.096	0.095	0.101	0.086	0.079
3	0.126	0.121	0.120	0.119	0.119	0.119	0.108	0.102
4	0.143	0.140	0.132	0.137	0.138	0.133	0.123	0.118
5	0.159	0.147	0.147	0.143	0.143	0.148	0.137	0.133
6	0.161	0.154	0.159	0.156	0.152	0.148	0.156	0.138
7	0.167	0.154	0.164	0.159	0.160	0.160	0.165	0.159
8+	0.177	0.162	0.204	0.181	0.174	0.167	0.168	0.158

Table 7.6.3.4 Irish Sea Herring. Natural mortality. Units: NA

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8+	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8+	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8+	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age	2016	2017	2018	2019	2020	2021	2022	2023
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8+	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

Table 7.6.3.5. Irish Sea Herring. Proportion mature. Units: NA.

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.20	0.19	0.10	0.02	0.00	0.14	0.31	0.00	0.00	0.07	0.06	0.04	0.28	0.00	0.19
2	0.88	0.89	0.80	0.73	0.69	0.62	0.73	0.85	0.90	0.63	0.66	0.30	0.48	0.46	0.68
3	0.95	0.90	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.90	0.74	0.72	0.99	0.99
4	0.95	0.94	0.91	0.90	0.93	0.88	0.81	0.87	0.99	0.95	0.95	0.82	0.81	1.00	0.97
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.10	0.02	0.04	0.30	0.02	0.14	0.15	0.02	0.11	0.114	0.20	0.19	0.16	0.16	0.13
2	0.86	0.60	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1.000	0.97	0.89	0.94	0.84	0.82
3	0.94	0.96	0.95	0.97	0.95	0.99	0.88	0.95	0.95	0.970	0.99	1.00	0.98	1.00	0.97
4	0.99	0.83	1.00	0.99	0.97	1.00	0.97	0.98	0.97	1.000	1.00	1.00	1.00	1.00	0.98
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
8+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	0.11	0.08	0.10	0.06	0.16	0.11	0.07	0.10	0.08	0.16	0.04	0.12	0.11	0.16
2	0.92	0.90	0.84	0.82	0.94	0.87	0.81	0.85	0.67	0.90	0.80	0.95	0.85	0.62
3	1.00	1.00	1.00	0.99	1.00	1.00	0.99	1.00	0.97	1.00	0.97	1.00	0.92	1.0
4	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
5	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Table 7.6.3.6. Irish Sea Herring. Fraction of harvest before spawning. Units: NA

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8+	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8+	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8+	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Table 7.6.3.7. Irish Sea Herring. Fraction of natural mortality before spawning. Units: NA

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8+	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8+	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8+	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

Table 7.6.3.8: SAM output summary

Year	Recruitment at age (1 wr)			SSB			Total Catch	F at ages (wr) 2-4		
	Low Recruitment	Recruitment	High Recruitment	Low SSB	SSB*	High SSB		Low	F	High
1980	141046	218557	338665	8214	11153	15142	10613	0.40	0.57	0.79
1981	160891	240112	358341	10177	14223	19878	4377	0.21	0.30	0.43
1982	166361	249751	374940	12880	18101	25437	4855	0.135	0.196	0.28
1983	153673	223592	325324	17133	23555	32385	3933	0.075	0.109	0.158
1984	129722	187273	270356	19194	25587	34109	4066	0.086	0.121	0.172
1985	129517	184668	263303	15903	20811	27234	9187	0.173	0.24	0.33
1986	132444	189581	271368	16312	21019	27085	7440	0.171	0.24	0.32
1987	126230	185571	272810	14103	18231	23566	5823	0.160	0.22	0.30
1988	103435	147422	210115	12534	16454	21602	10172	0.27	0.37	0.49
1989	99210	141066	200581	10843	14162	18498	4949	0.175	0.24	0.33
1990	90053	127922	181717	10301	13391	17408	6312	0.21	0.28	0.38
1991	79821	115467	167030	7437	9647	12514	4398	0.174	0.24	0.32
1992	93781	134868	193956	7195	9100	11509	5270	0.21	0.28	0.38
1993	76345	109877	158136	7322	9321	11865	4409	0.184	0.25	0.33
1994	90715	127759	179932	8239	10455	13268	4828	0.23	0.31	0.41
1995	91409	128520	180699	8043	10211	12964	5076	0.23	0.30	0.40
1996	75638	105926	148341	6804	8639	10970	5301	0.25	0.33	0.43
1997	81131	112832	156919	5749	7256	9157	6651	0.38	0.50	0.64
1998	80412	114523	163105	5705	7177	9029	4905	0.38	0.49	0.63
1999	62665	88523	125051	5163	6697	8688	4127	0.29	0.38	0.50
2000	53492	78042	113859	6298	8007	10178	2002	0.142	0.193	0.26
2001	57949	82270	116798	3866	4883	6168	5461	0.39	0.51	0.66
2002	60877	86575	123120	3794	4800	6072	2393	0.26	0.35	0.46
2003	75124	104527	145437	3344	4231	5354	2399	0.35	0.46	0.60
2004	86197	119504	165681	5011	6441	8280	2531	0.24	0.32	0.42
2005	96420	134089	186474	5498	7001	8916	4387	0.35	0.45	0.58
2006	121946	171160	240235	5276	6759	8659	4402	0.37	0.49	0.64
2007	141264	206980	303268	7503	9719	12590	4629	0.20	0.27	0.37
2008	131523	185871	262676	8271	10875	14299	4895	0.26	0.35	0.46
2009	137907	193959	272792	9096	11572	14722	4594	0.171	0.29	0.48

Year	Recruitment at age (1 wr)			SSB			Total Catch	F at ages (wr) 2-4		
	Low Recruitment	Recruitment	High Recruitment	Low SSB	SSB*	High SSB		Low	F	High
2010	136068	190209	265892	10329	13051	16490	4894	0.20	0.27	0.36
2011	121914	171496	241242	9801	12311	15464	5202	0.24	0.31	0.41
2012	115829	161757	225896	7944	10002	12593	5693	0.30	0.40	0.52
2013	90638	133946	197947	7408	9457	12074	4828	0.23	0.31	0.41
2014	113678	156944	216676	8419	10525	13157	5083	0.20	0.27	0.36
2015	123575	173834	244534	6350	7937	9921	4891	0.34	0.44	0.58
2016	107030	149586	209062	6215	7941	10146	4327	0.33	0.43	0.56
2017	106408	151138	214670	6472	8212	10419	3896	0.31	0.41	0.54
2018	141277	196938	274528	5689	7179	9058	6804	0.35	0.45	0.58
2019	156178	220186	310425	6775	8586	10881	6377	0.42	0.54	0.69
2020	172475	250120	362720	4914	6495	8583	7927	0.63	0.79	1.01
2021	153949	223307	323913	9249	12334	16446	7208	0.28	0.37	0.50
2022	173525	276814	441582	6875	9627	13481	7888	0.34	0.47	0.66
2023	149432	265268	470898	5622	9135	14843	7369	0.31	0.49	0.81
2024	133944**	173835**	250122**		11190***					

*** For autumn-spawning stocks, the SSB is determined at spawning time (September) and is influenced by fisheries between 1 January and spawning.**

**** Geometric mean recruitment 2012–2021 and SSB from assessment model.**

***** From the short-term forecast.**

Table 7.6.3.9: Estimated parameter

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	1.04	0.167	2.83	2.028	3.95
logFpar_1	1.412	0.165	4.102	2.948	5.708
logFpar_2	1.22	0.165	3.389	2.436	4.713
logFpar_3	1.205	0.165	3.335	2.399	4.637
logFpar_4	1.254	0.165	3.505	2.522	4.872
logFpar_5	1.502	0.166	4.49	3.221	6.26
logFpar_6	1.52	0.18	4.571	3.192	6.547
logFpar_7	1.739	0.11	5.691	4.563	7.097
logSdLogFsta_0	-0.901	0.138	0.406	0.308	0.535
logSdLogN_0	-1.524	0.341	0.218	0.11	0.431
logSdLogN_1	-1.649	0.164	0.192	0.138	0.267
logSdLogObs_0	-0.169	0.119	0.844	0.665	1.072
logSdLogObs_1	-1.123	0.071	0.325	0.282	0.375
logSdLogObs_2	-0.161	0.081	0.851	0.724	1.001
logSdLogObs_3	-1.029	0.183	0.357	0.248	0.516
transfIRARdist_0	-0.741	0.21	0.477	0.313	0.726
itrans_rho_0	3.109	0.768	22.407	4.821	104.13

Table 7.6.3.10: Forecast assumptions and advice

Variable	Value	Notes
$F_{ages\ (wr)\ 2\text{-}4}$ (2024)	0.460	F based on the assumed catch for 2024
SSB (2024)*	11190	Short-term forecast; in tonnes
$R_{age\ (wr)\ 1}$ (2024–2025)	178242	Resampled recruitment from the years 2012–2021 (geometric mean); in thousands
Total catch (2024)	7279	Agreed TAC for 2024; in tonnes

Basis	Total catch (2025)	$F_{2\text{-}4}$(2025)	SSB* (2025)	SSB*, ^ (2026)	% SSB change**	% advice change^^
ICES advice basis						
MSY approach: F_{MSY} * (SSB2024/MSY $B_{trigger}$)	5223	0.349	10677	10136	-4.6	8.3
Other scenarios						
F = 0	0	0.000	14583	17649	30	-100
F_{MSY}= F_{pa}	5230	0.35	10672	10127	-4.6	8.5
F_{lim}	6411	0.45	9786	8780	-12.5	33
F = F_{sq}	6523	0.46	9703	8654	-13.3	35
SSB (2025) = B_{lim}	11440	1.025	6080	4173	-46	137
SSB (2025) = B_{pa}	7362	0.538	9064	7761	-19.1	54
SSB (2025) = MSY $B_{trigger}$	4557	0.298	11208	10945	<0.1	-5.5

* For autumn-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1 January and spawning (set for September).
** SSB 2026 relative to SSB 2025.
^ Assuming same catch scenario in 2026 as in 2025.
^^ Advice value for 2025 relative to the advice value for 2024 (4821 tonnes).

Table showing catch options should catches in 2024 be at 4821 tonnes, as the re-issued advice for 2024.

Basis	Total catch (2025)	$F_{2\text{-}4}$(2025)	SSB* (2025)	SSB*, ^ (2026)	% SSB change**	% advice change^^
ICES advice basis						
MSY approach: F_{MSY}=F_{pa}	5892	0.35	11912	10780	-9.2	22
Other scenarios						
F = 0	0	0.000	16390	19147	25	-100
F_{lim}	7230	0.45	10896	9305	-17.0	50
F = F_{sq}	4909	0.28	12652	12005	-3.6	18
SSB (2025) = B_{lim}	13709	1.14	6 080	3782	-54	184
SSB (2025) = B_{pa}	9768	0.67	9 023	6846	-31	103
SSB (2025) = MSY $B_{trigger}$	6012	0.42	11 208	9757	-14.6	24

*** For autumn-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1 January and spawning (set for September).**

**** SSB 2026 relative to SSB 2025.**

^ Assuming same catch scenario in 2026 as in 2025.

^^ Advice value for 2025 relative to the advice value for 2024 (4821 tonnes).

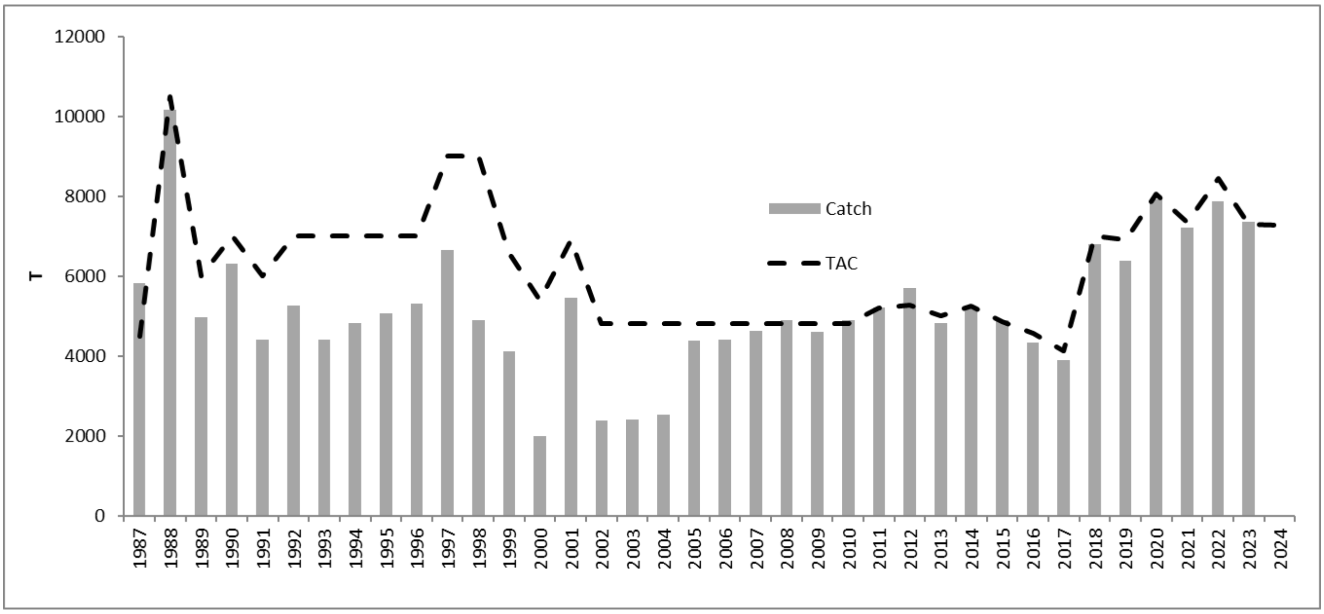


Figure 7.1.1 Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1961 to 2023.

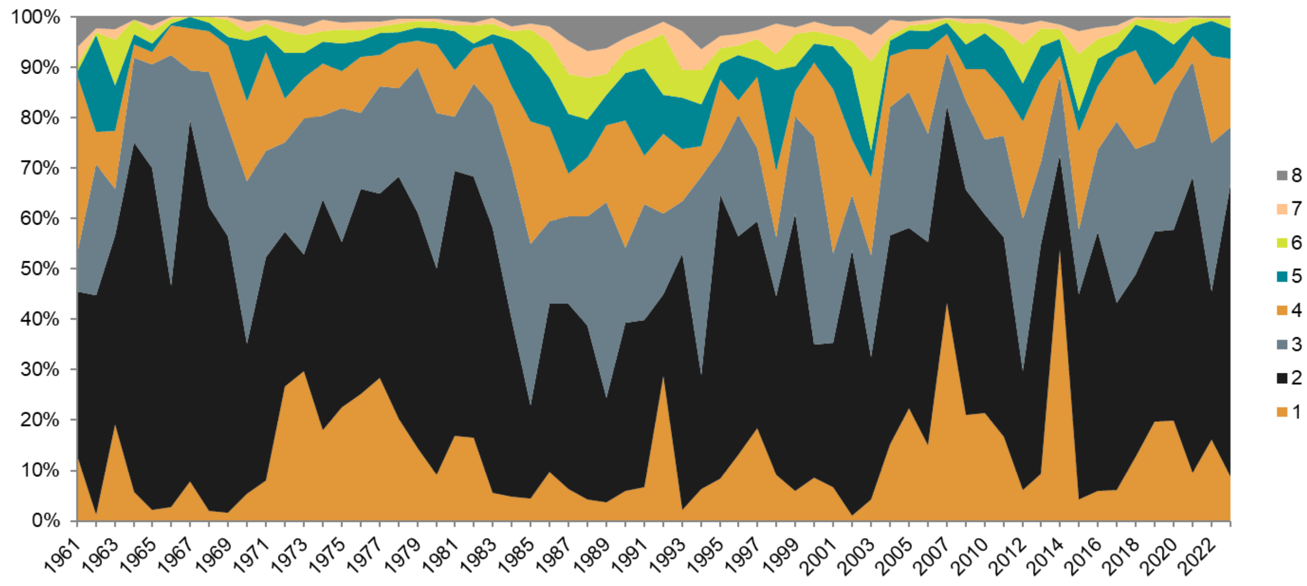


Figure 7.2.1 Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1980 to 2023. No 2009 commercial samples.

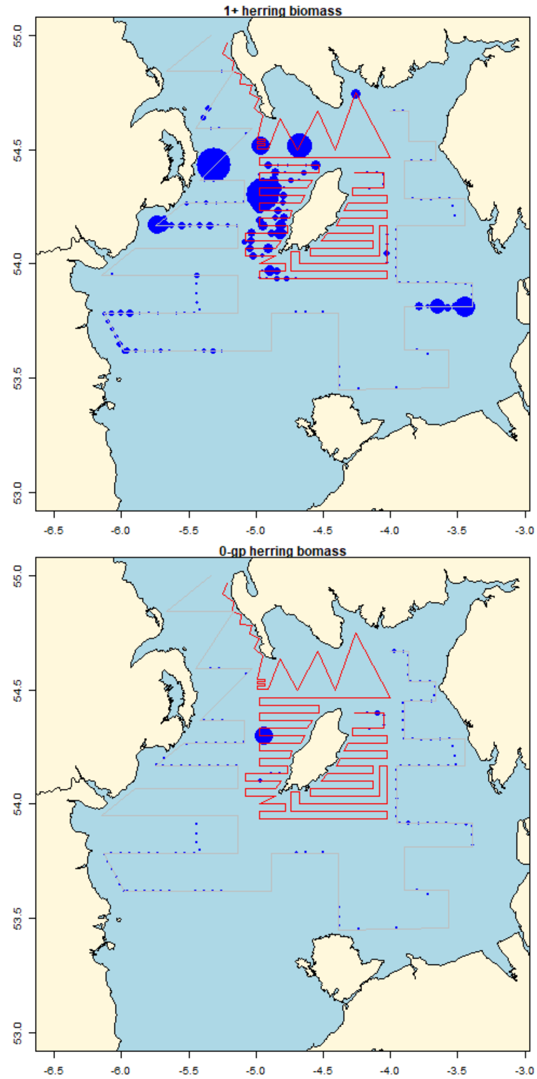
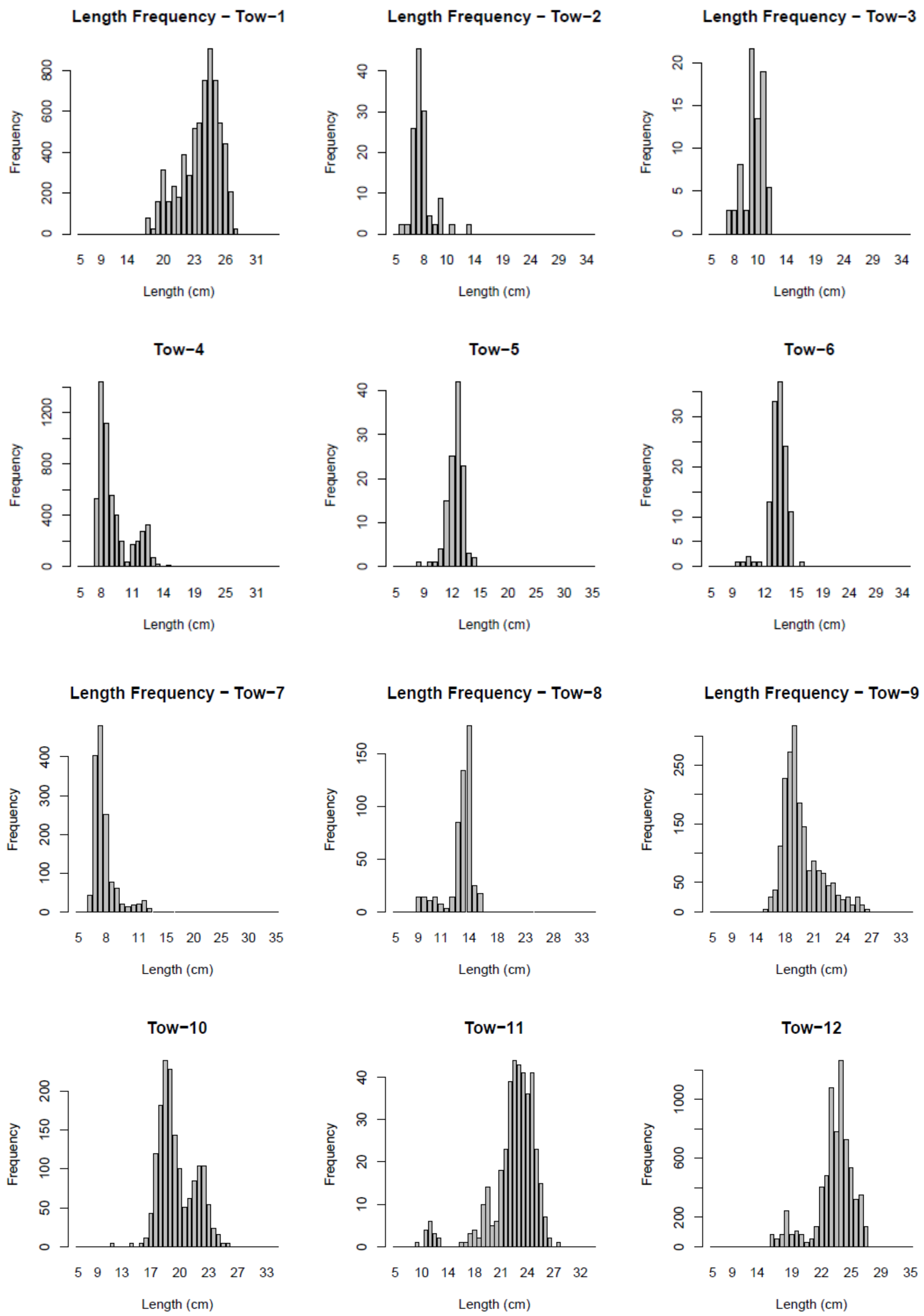
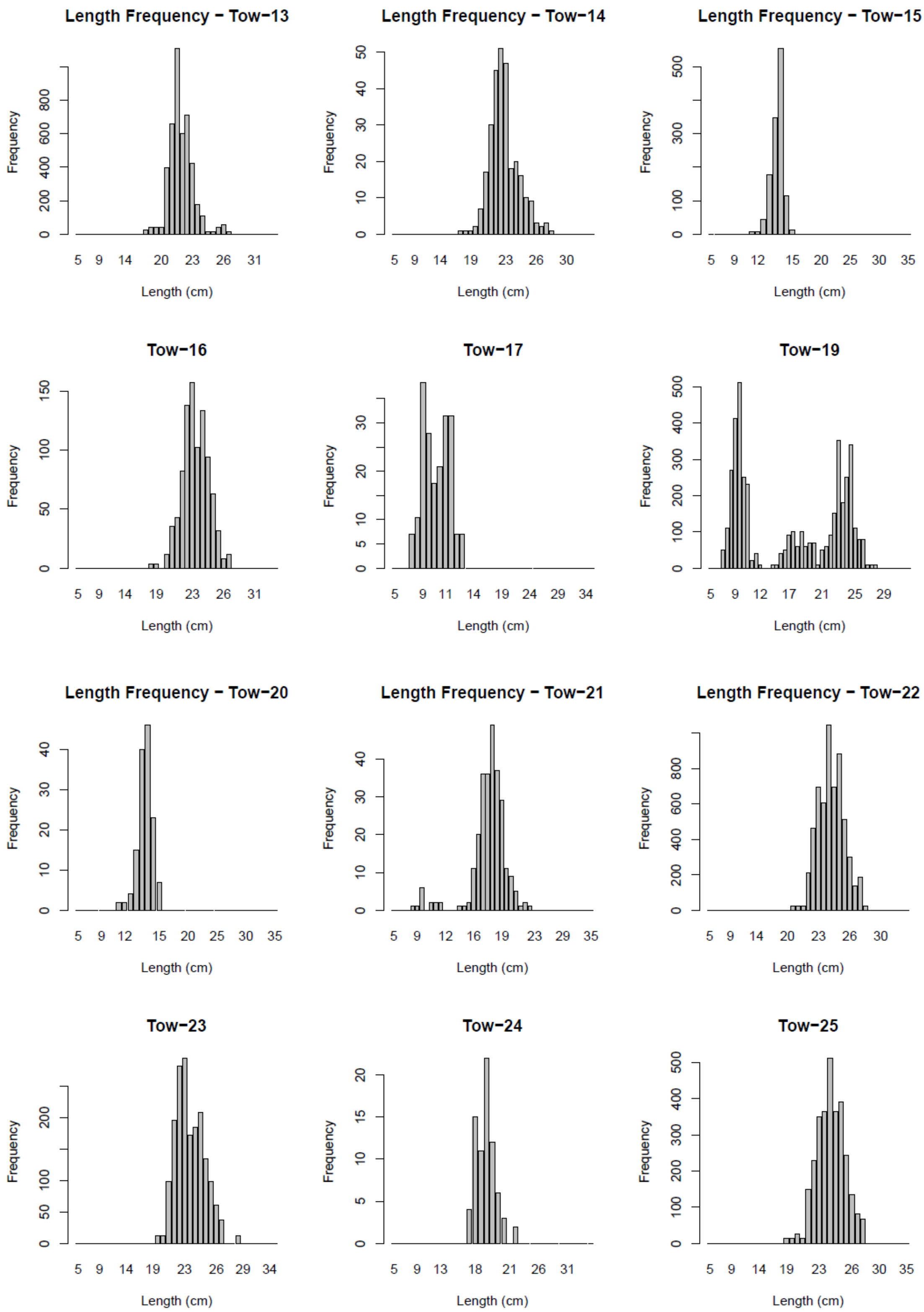


Figure 7.3.1 Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2023 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval and the same scaling is used for all figures.


Length Frequency – Tow–1
Length Frequency – Tow–2
Length Frequency – Tow–3
Tow–4
Tow–5
Tow–6
Length Frequency – Tow–7
Length Frequency – Tow–8
Length Frequency – Tow–9
Tow–10
Tow–11
Tow–12
Frequency
Length (cm)


Length Frequency − Tow−13
Length Frequency − Tow−14
Length Frequency − Tow−15
Tow−16
Tow−17
Tow−19
Length Frequency − Tow−20
Length Frequency − Tow−21
Length Frequency − Tow−22
Tow−23
Tow−24
Tow−25
Frequency
Length (cm)

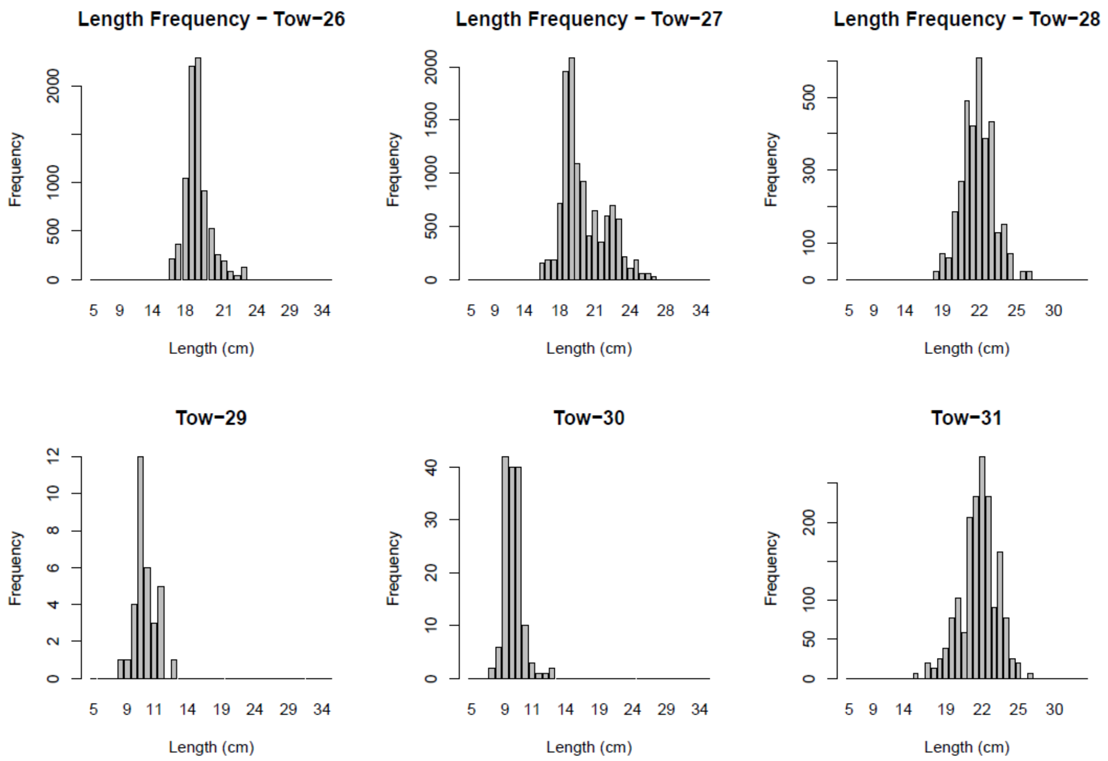


Figure 7.3.2 Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2019 acoustic survey.

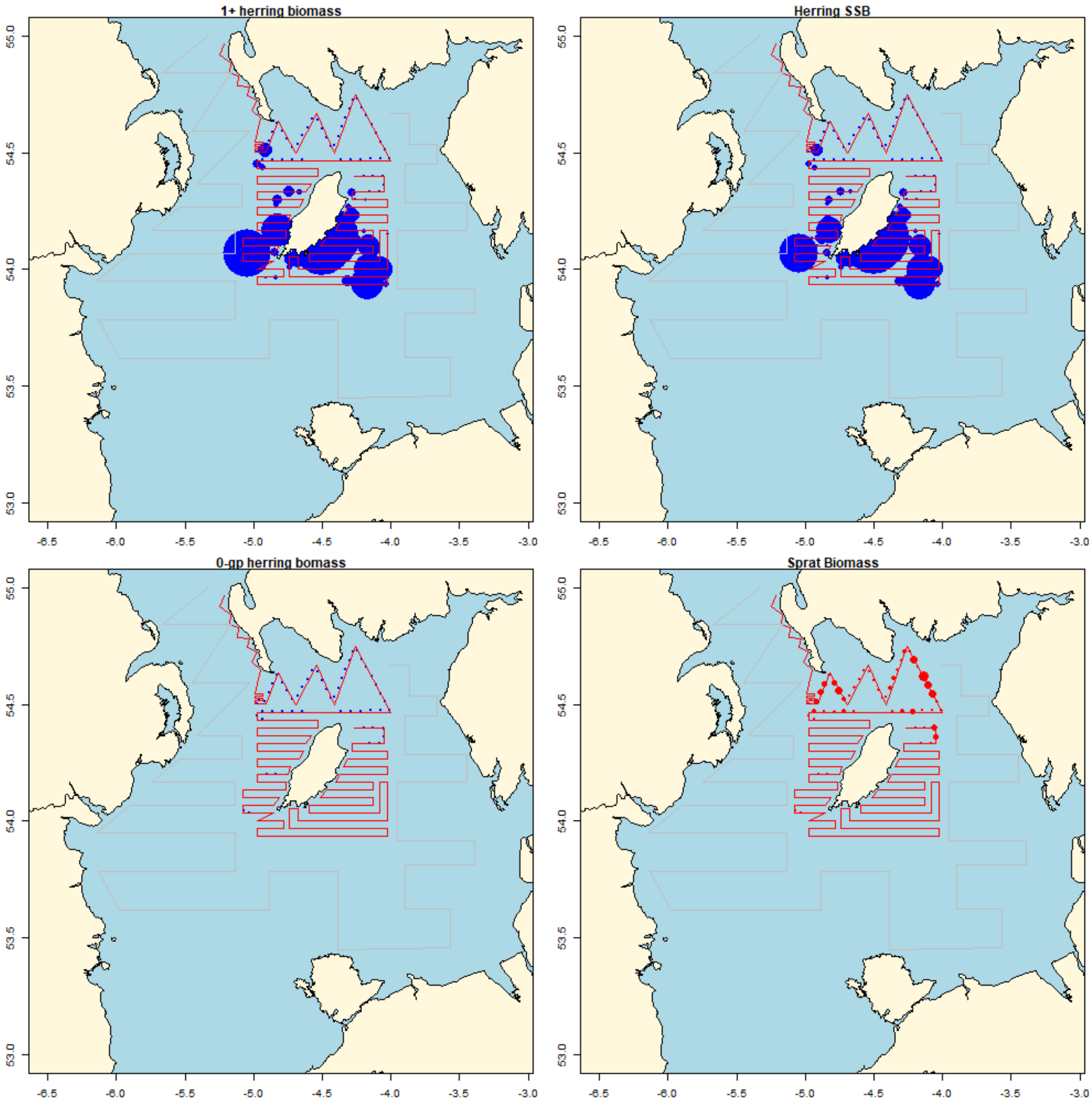
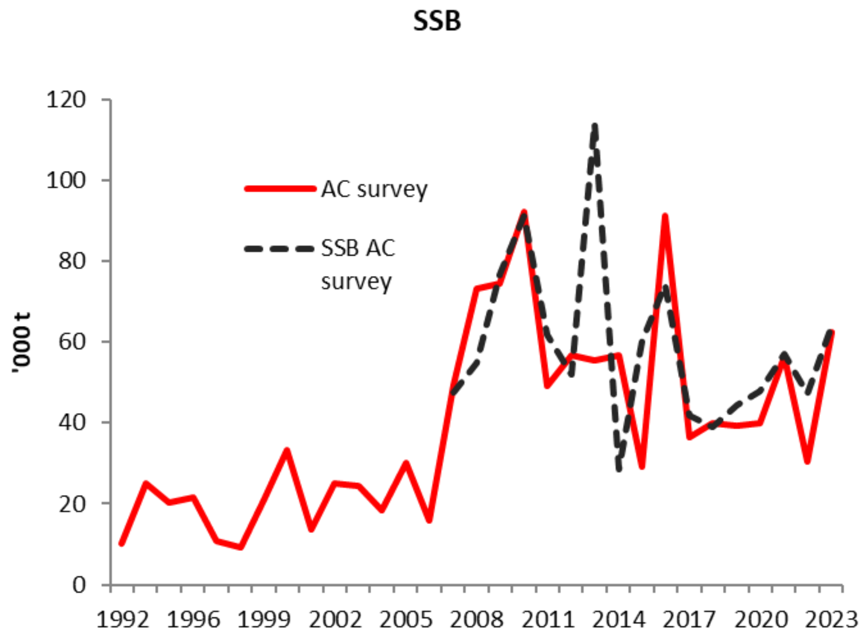

1+ herring biomass
Herring SSB
0-gp herring bomass
Sprat Biomass
55.0
54.5
54.0
53.5
53.0
-6.5
-6.0
-5.5
-5.0
-4.5
-4.0
-3.5
-3.0

Figure 7.3.3 Herring in Division 7.a North (Irish Sea). Distribution plots for the 7.aNSpawn survey (2023) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).



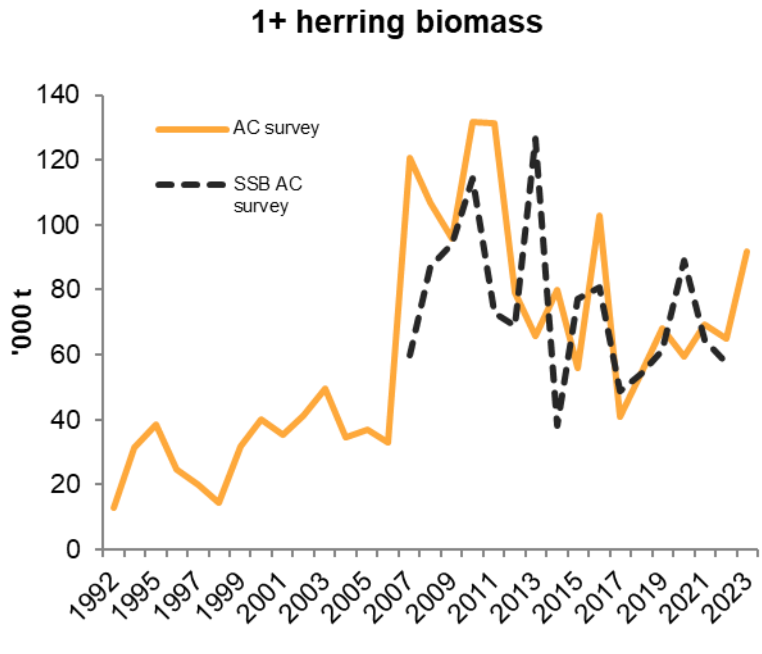


Figure 7.3.5 Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

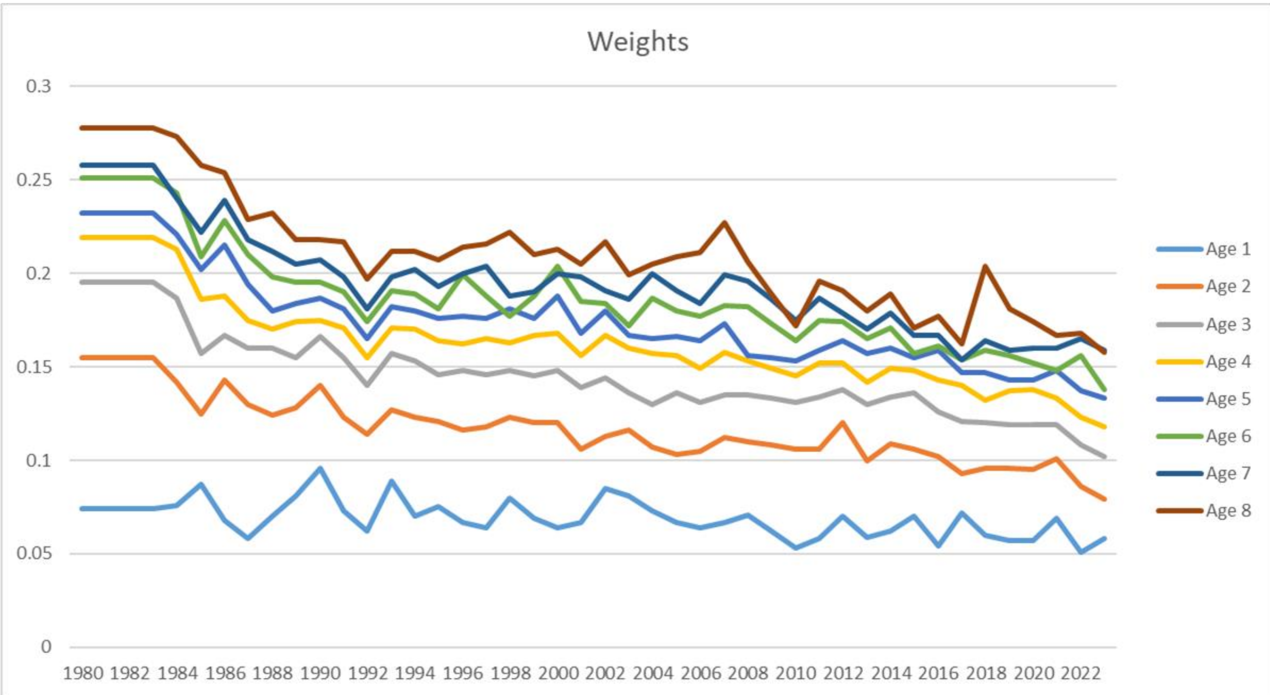


Figure 7.4.1 Herring in Division 7.a North (Irish Sea). Time series of catch weights at age.

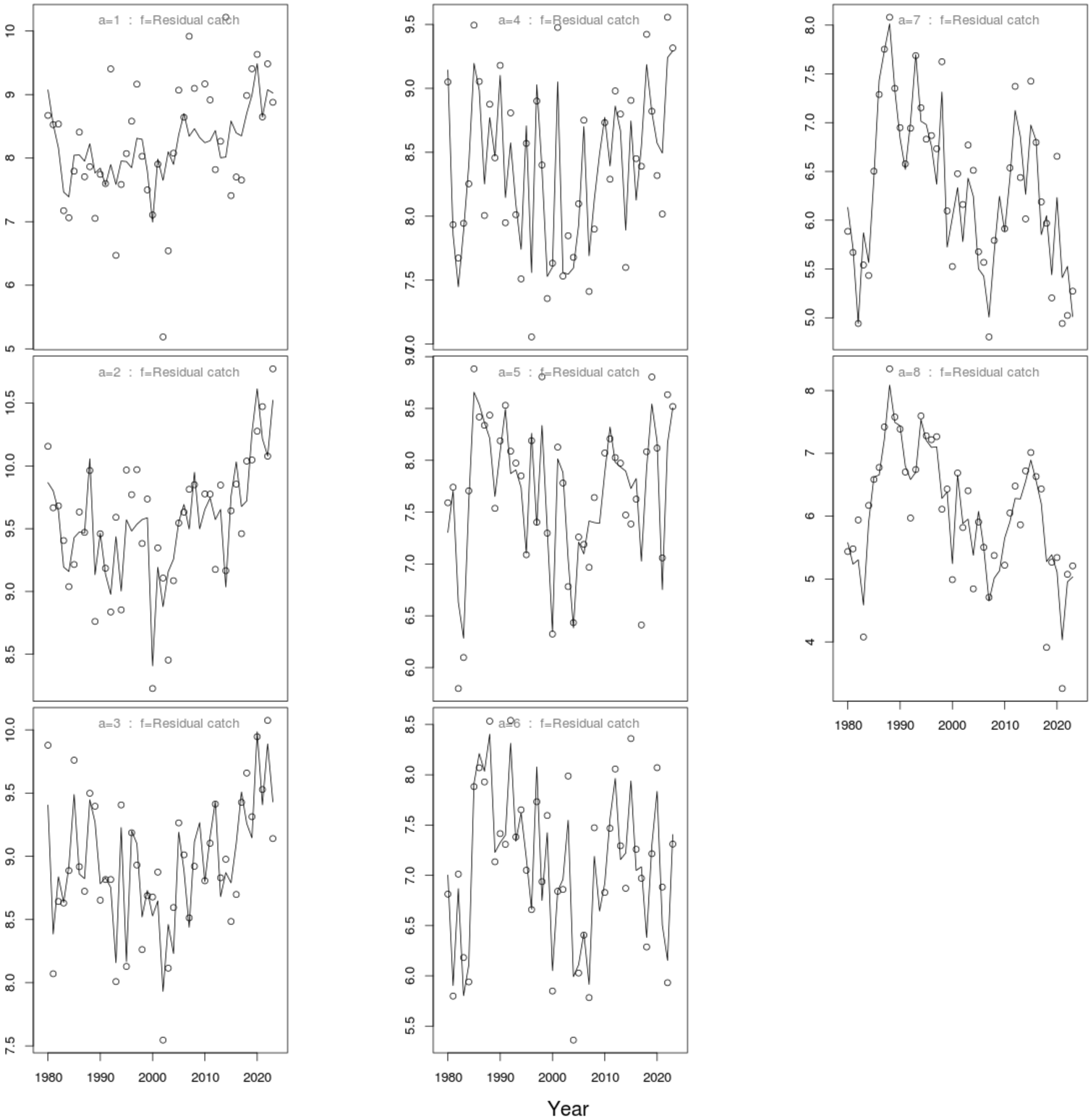


Figure 7.6.1 Herring in Division 7.a North (Irish Sea). SAM run output. Diagnostics of model fit to the catches at age.

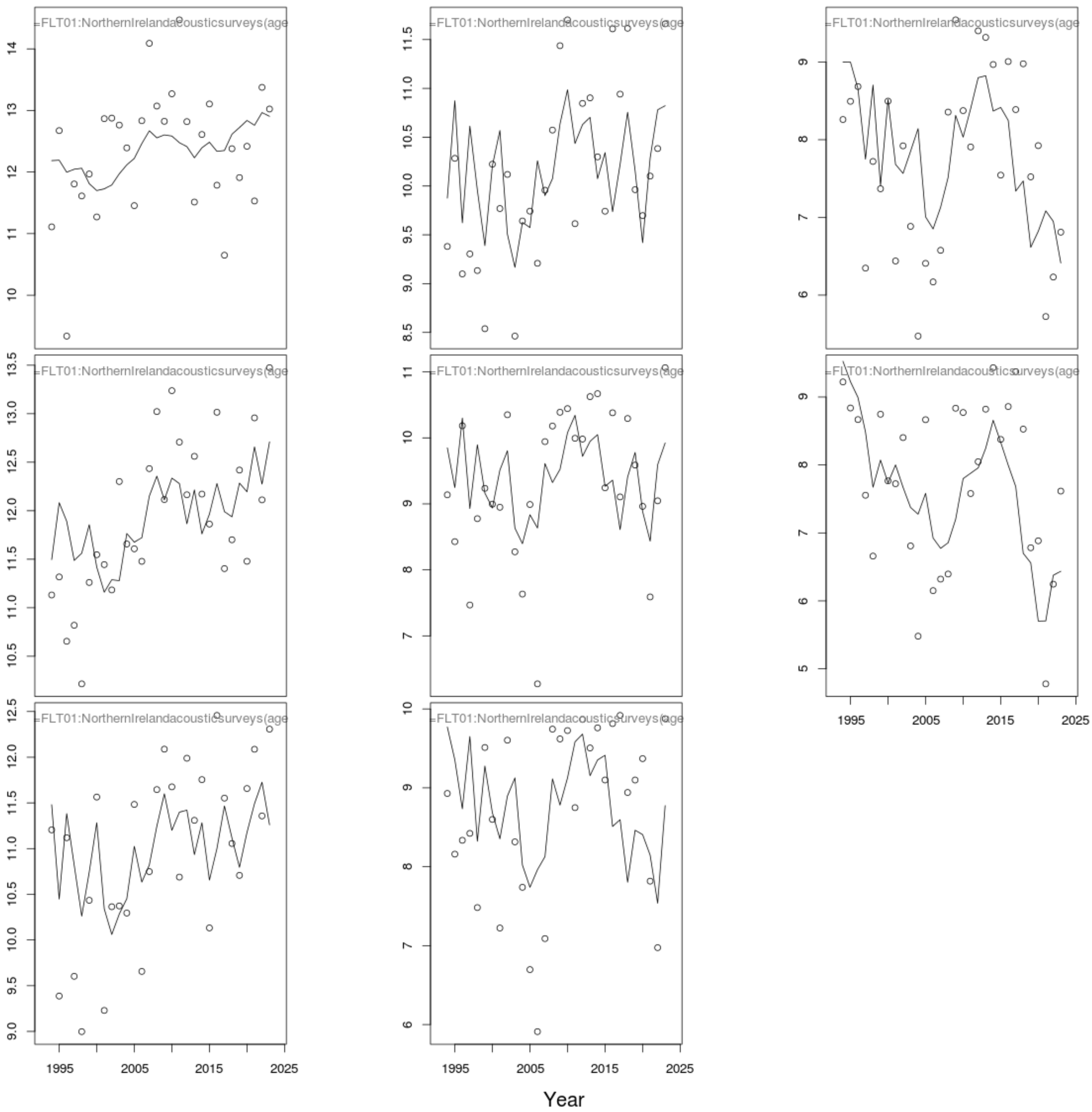


Figure 7.6.2 Herring in Division 7.a North (Irish Sea). SAM fit to ages from the acoustic survey AC(7.aN).

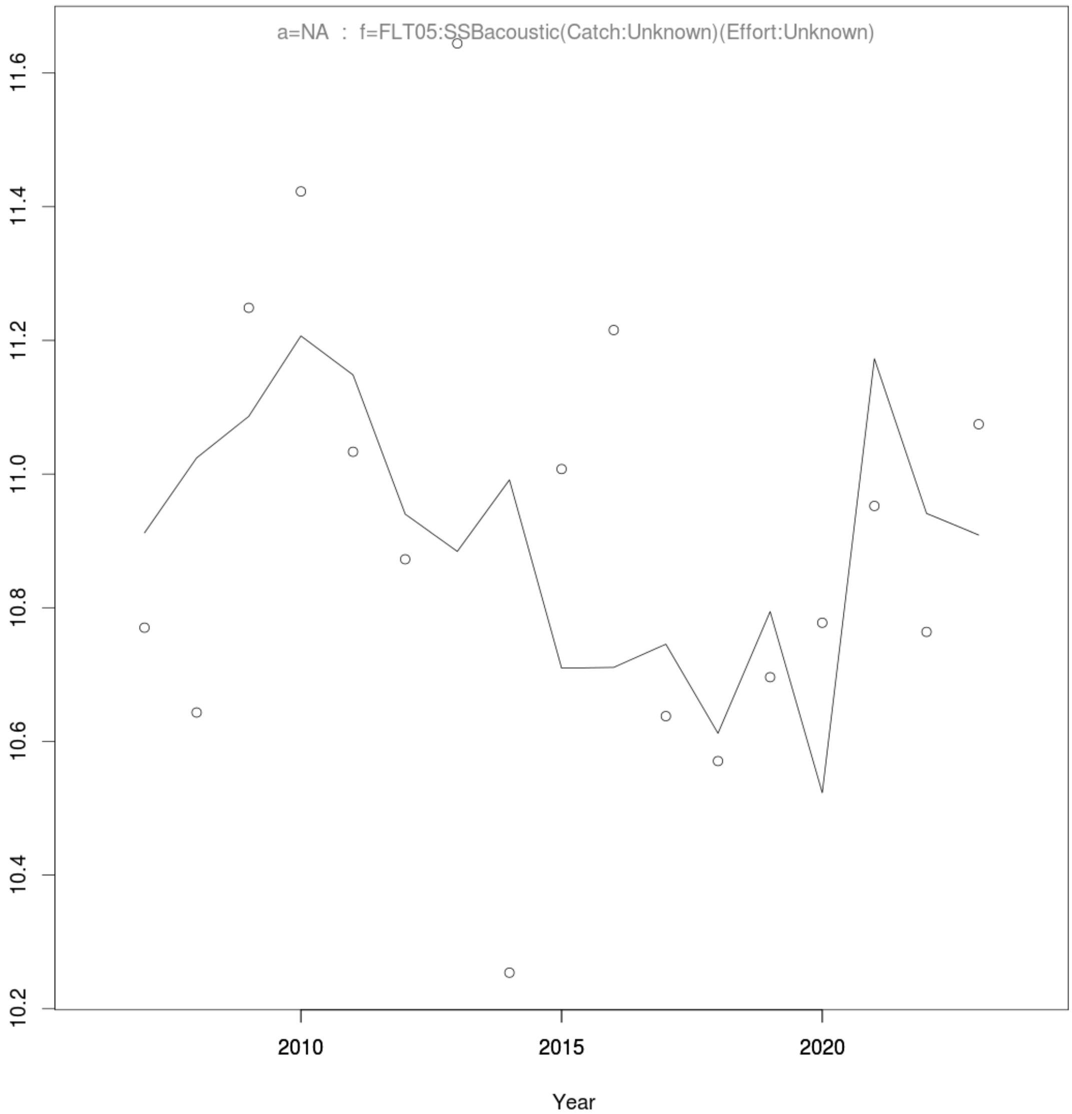


Figure 7.6.3 Herring in Division 7.a North (Irish Sea). SAM fit to the SSB survey.

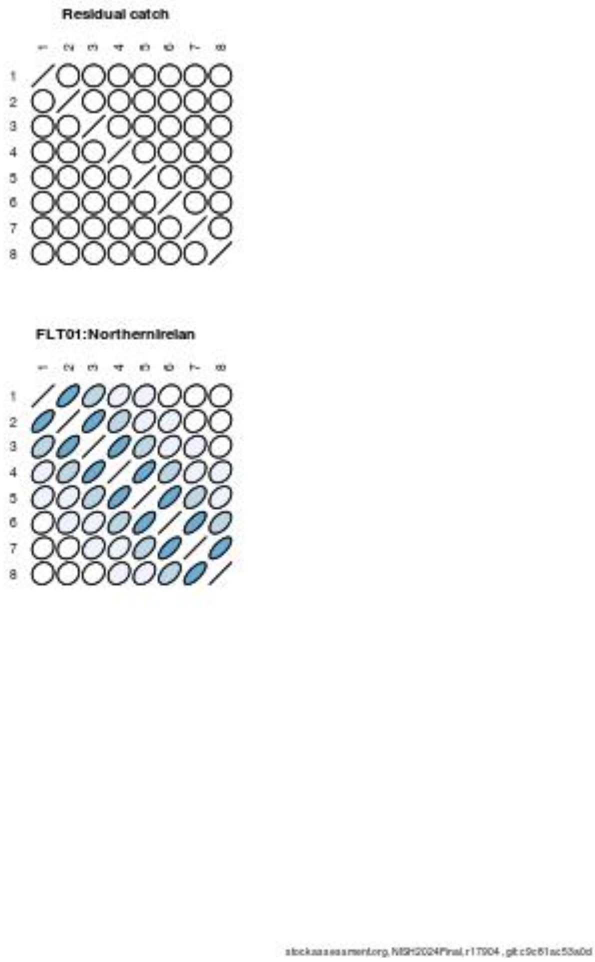


Figure 7.6.4 Estimates correlation

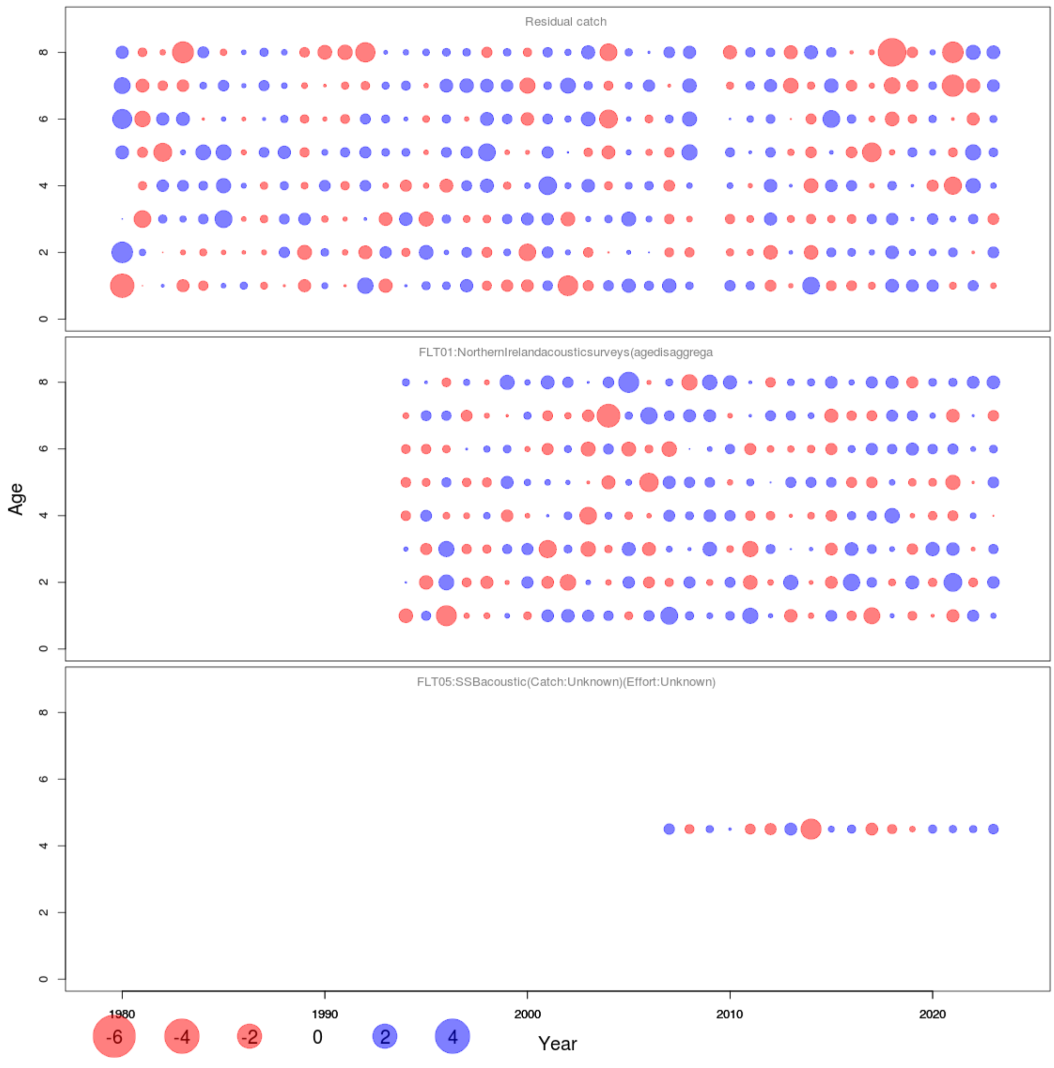


Figure 7.6.5: Standardized one-observation-ahead residuals.

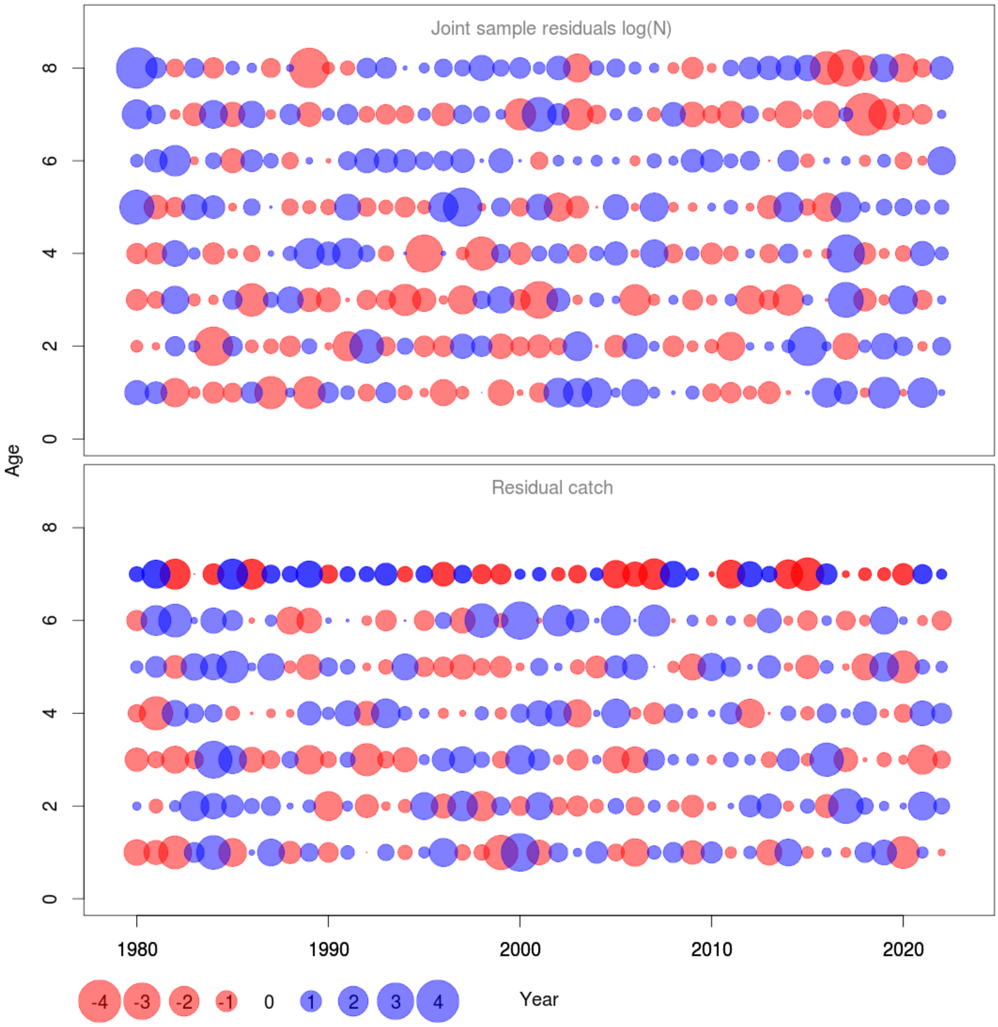
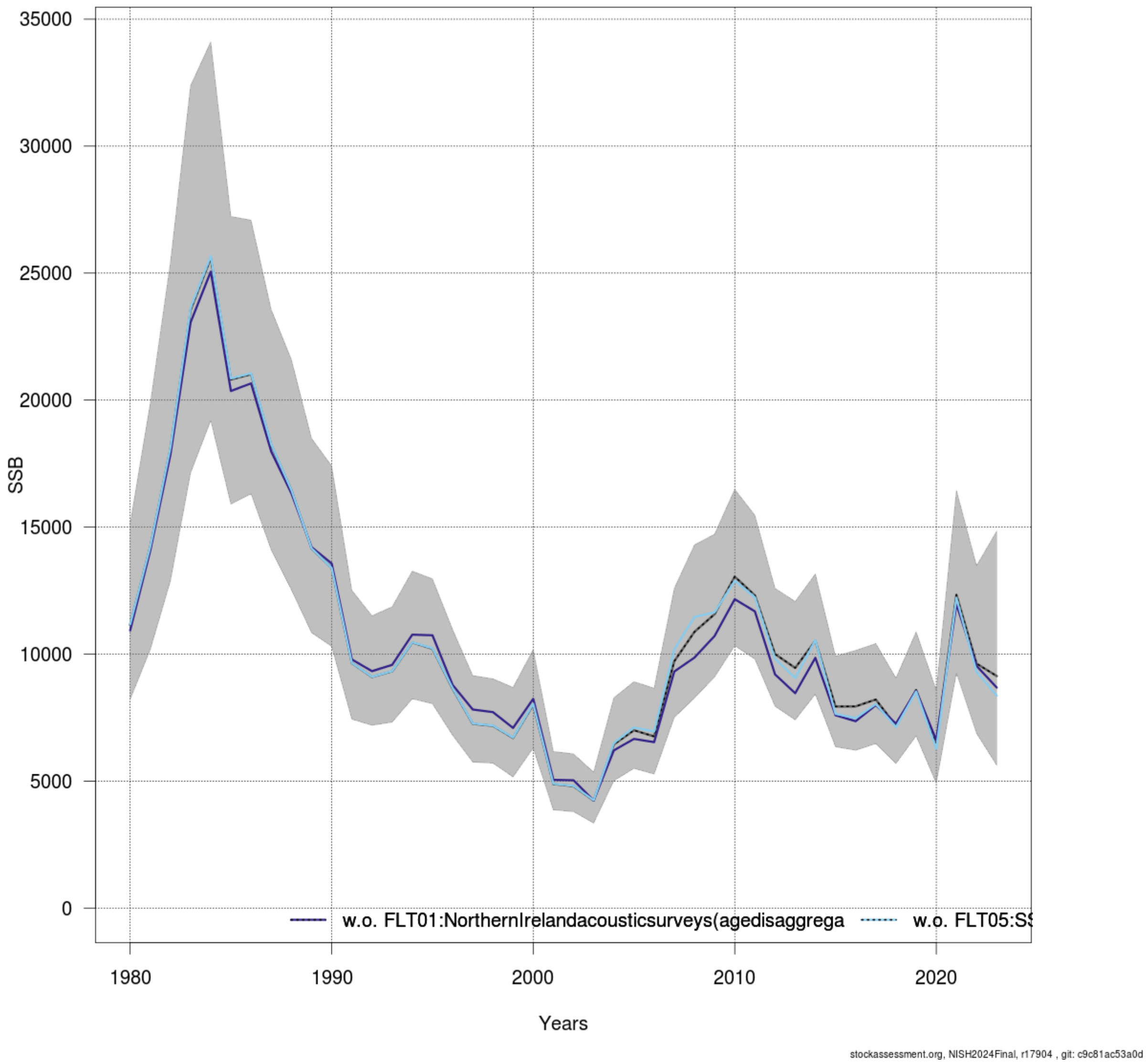


Figure 7.6.6: Standardized single-joint-sample residuals of process increments


35000
30000
25000
20000
15000
10000
5000
0
SSB
1980
1990
2000
2010
2020
Years
w.o. FLT01:NorthernIrelandacousticsurveys(agedisaggrega
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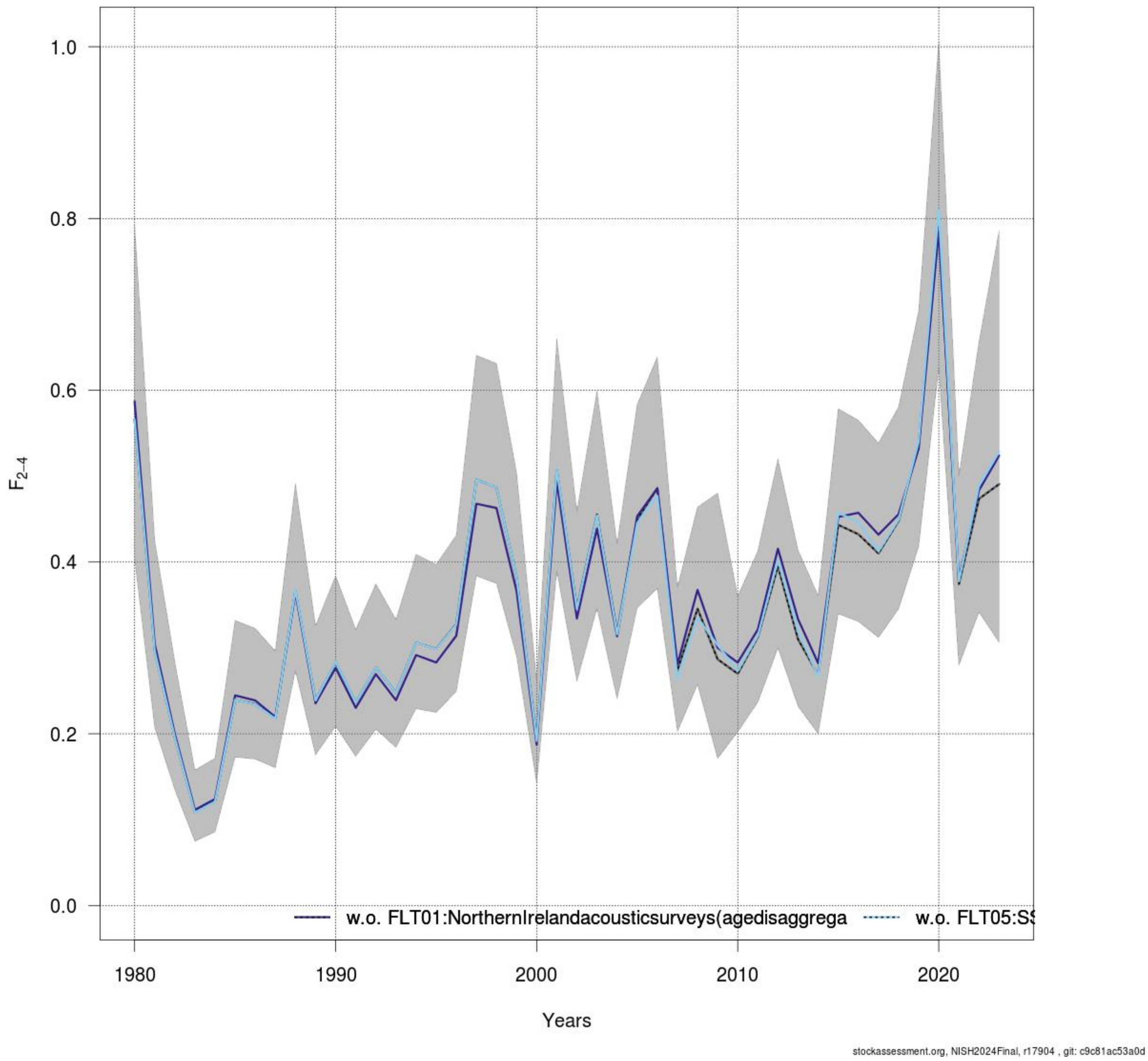
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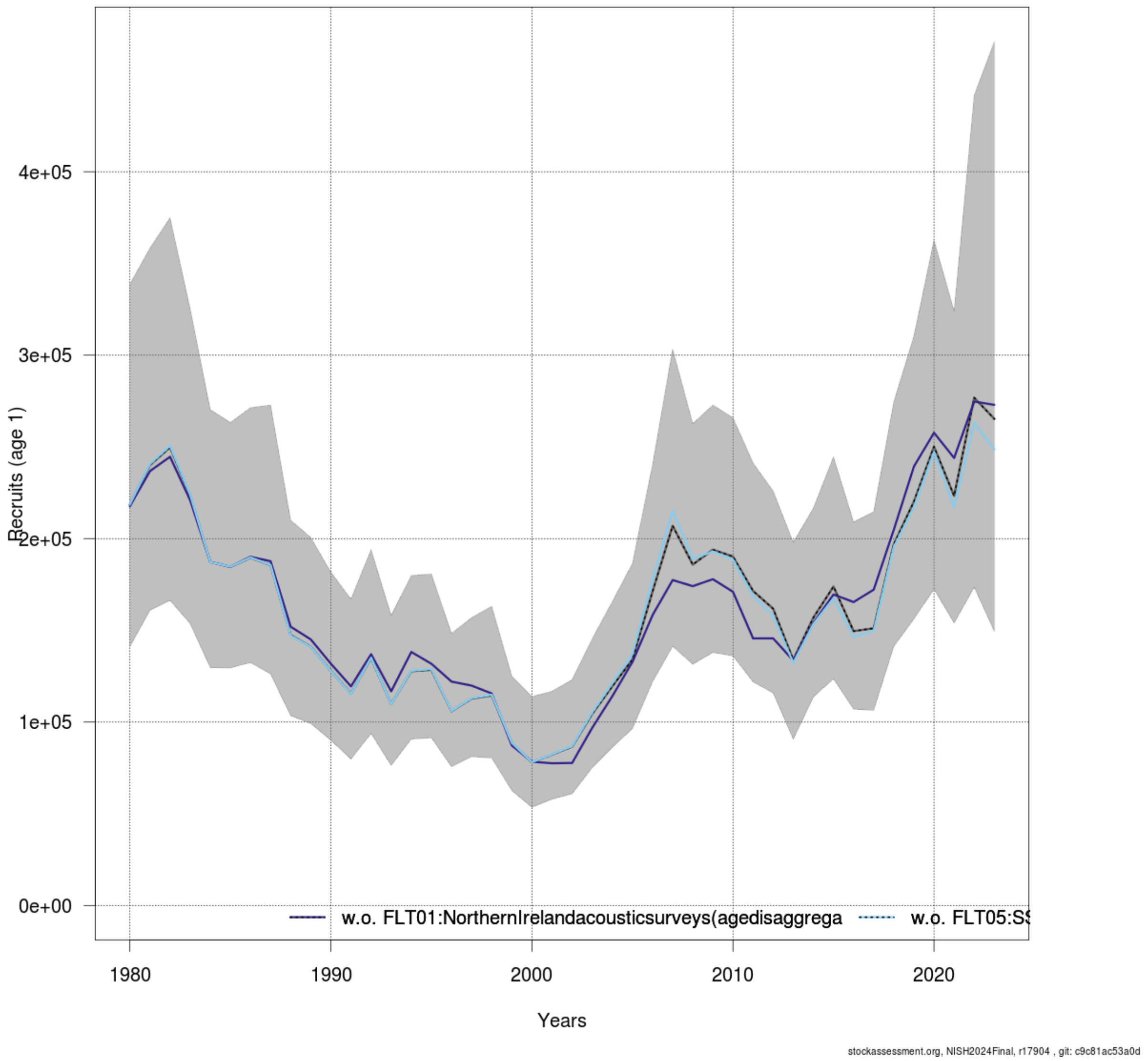
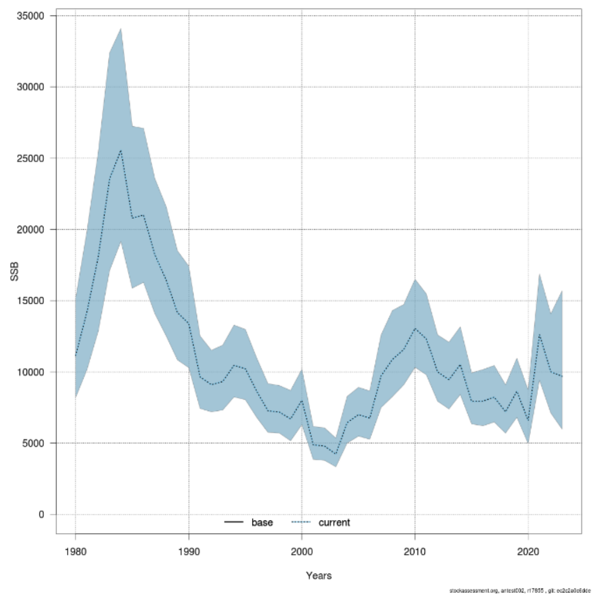


Figure 7.6.7 Leave one out analysis from top to bottom SSB, F and recruitment.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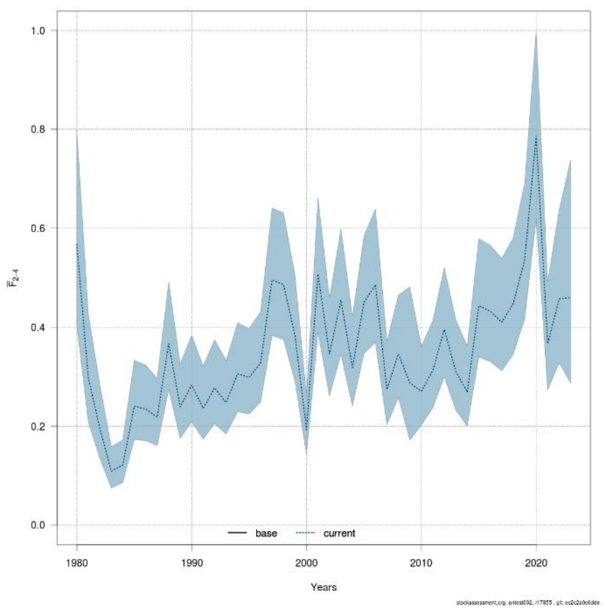
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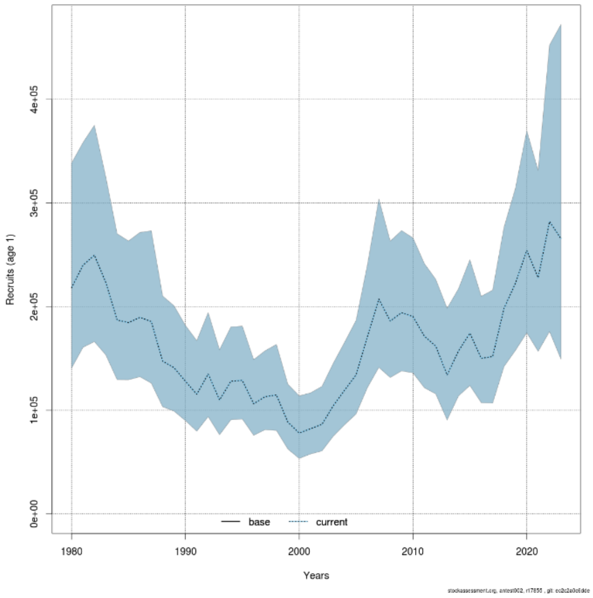

Figure 7.6.9 Herring in Division 7.a North (Irish Sea). Stock trends from the final SAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean $F_{2\text{-}4}$.

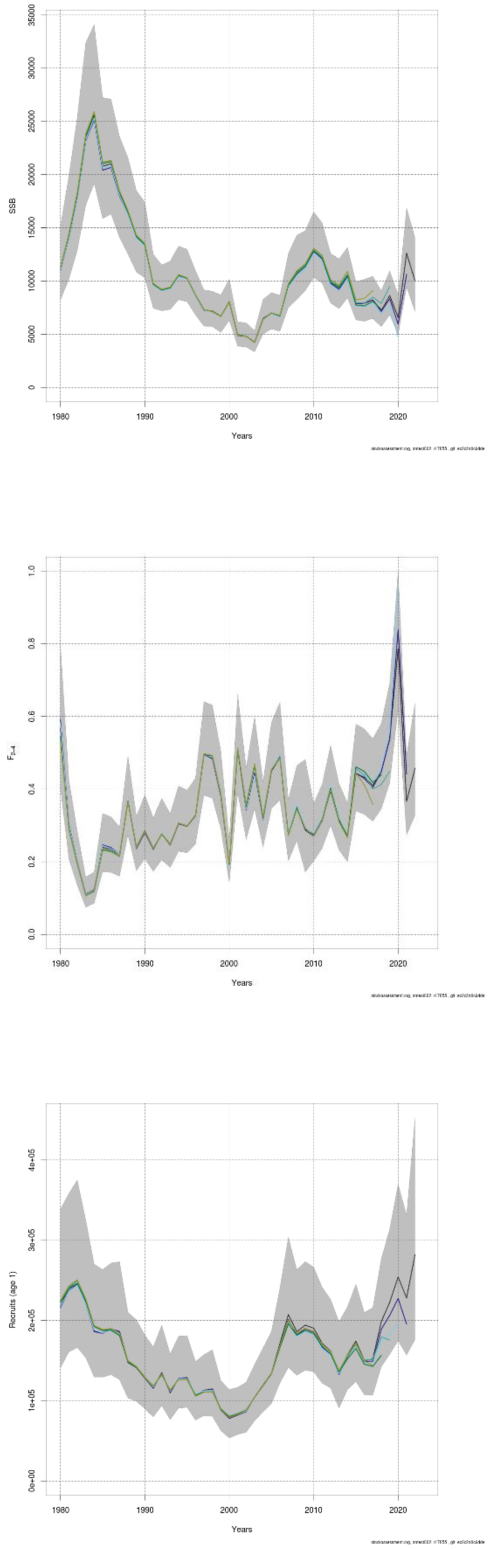

Figure 7.6.11: Retrospectives for the assessment, top to bottom SSB, Fbar and Recruitment. Mohns Rho for SSb is -7.1, Fbar 6.6 and the recruitment -25.5.

Contents

8 Other areas where herring catch is reported

Three herring stocks have very little data associated with them and have been poorly described in recent reports. These are Clyde herring, part of Division 6aN (Section 5.11 in ICES 2005a), herring in 7.e–f and herring in the Bay of Biscay (Subarea 8). In this section, only the time-series of landings are maintained.

8.1 Clyde herring

In 2011, under the provisions of the TAC and Quota Regulations (57/2011), the European Commission delegated the function of setting the TAC for certain stocks which are only fished by one Member State, to that Member State. This provision currently applies to herring in the Firth of Clyde with TAC setting responsibility delegated to Scotland. The stock is as such not an ICES stock with limited data, but it has been decided to continue to display the updated historical landings table for reasons of continuity. Since 1998 the agreed TAC for Clyde herring has never been reached. No reported catches occurred since 2014 apart from in 2021 where 180 tonnes were caught. The TAC in the Clyde from 2015 to 2021 was set at 583 tonnes but was reduced to 466 tonnes in 2022 (Table 12.1). The TAC reverted to 583 tonnes in 2023. In 2023, landings amount to 0 tonnes (Figure 12.1)

8.2 Division 7.e.f

This section is not dedicated to a 'stock', instead relating to a species in a region where data are available. The stock structure of herring populations in this area is not clear, therefore further work is required.

Figures 12.2 and 12.3 show the time-series of landings over the period 1974–2022 in Division 7.e and 7.f. Data are taken from the ICES historical and official nominal databases and adjusted, where possible, with data supplied by working group members. Landings statistics are presented in table 12.2 (7.e) and 12.3 (7.f).

Since 1999, landings in Division 7.e are stable and have fluctuated between 5 and 800 t except in 2008 where they reached more than 1 000 t (Figure 12.1). In 2022, landings amount to 6 tonnes (Figure 12.2). In Division 7.f, there was a pulse of landings in the late 1970s. Since then, landings have fluctuated between 200 t and a very few tonnes in recent years, without any obvious trend. In 2022, landings amount to 200 tonnes. (Figure 12.3).

Herring catches in these divisions were analysed during a Workshop in December 2023: WKRRBWCH (Workshop on a Research Roadmap for Bristol and Western Channel Herring).

8.3 Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1 660 t in 1976, declining gradually to very low levels by the late 1980s. Landings by the Netherlands had peaked in 1985 (8 619 t), and more recently there was a sudden pulse of Dutch landings of 7 575t in 2002, declining to low levels since (Figure 12.4, Table 12.3). Data before 2005 were taken from the ICES Historical Catches database. Data for later years were adjusted, where possible, with data supplied by working group members and from ICES official and preliminary catch statistics. In 2022, landings amount to 1 tonne (Figure 12.3).

8.4 Division 6.aN, spring spawners

Following the WKNSCS benchmark in 2022 (ICES, 2022), the combined assessment for herring in 6.a,7.b-c was split into separate assessments for 6.aN and 6.aS,7.b-c following the genetic splitting of the acoustic survey. These methods were only able to split out the autumn spawning component in 6.aN (Farrell, *et.al*., 2021), therefore the biomass estimates and assessment in place is not relevant to the spring spawning population found in the Minch. The fishery in division 6.aN is focused on the autumn spawning herring around Cape Wrath, and therefore there is no recent catch information available for the spring spawning population.

8.5 Tables and Figures

Table 12.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1959–2023. Spring and autumn-spawners combined.

Country	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Total	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433	10 594	7 763	4 088	4 226	4 715

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770	4 800	4 650	3 612	1 923

Country	1989	1990	1991	1992	1993	1994	1995	1996	1996	1998	1999	2000	2001	2002	2003
Scotland	-	-	713	929	852	608	392	598	371	779	16	1	78	46	88
Other UK	-	-	-	-	1	-	194	127	475	310	240	0	392	325	240
Unallocated*	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	**	**	**	**	**	-	-	-	-	-	-	-	-
Agreed TAC	-	-	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Total	2 343	2 259	731	929	853	608	586	725	846	1 089	256	1	480	381	328

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Scotland	-	-	-	163	54	266	48	90	118	21	0	0	0	0	0
Other UK	-	318	512	458	622	488	301	-	184	-	-	-	-	-	-
Unallocated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	800	800	800	720	720	720	648	648	583	583	583	583
Total	0	318	512	621	676	754	349	90	302	25	0	0	0	0	0

Country	2019	2020	2021	2022	2023
Scotland	0	0	180	0	0
Other UK	-	-	-	-	-
Unallocated*	-	-	-	-	-
Discards	-	-	-	-	-
Agreed TAC	583	583	583	466	583
Total	0	0	180	0	0

*** Calculated from estimates of weight per box and in some years estimated bycatch in the sprat fishery.**

**** Reported to be at a low level, assumed to be zero, for 1989–1995.**

Table 12.4. Stocks with limited data. Landings of herring in Division 7.e. Source: ICES Official Landings database (2006–2021), Historical Catches database (1974–2005), and ICES preliminary catch statistics (2022).

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Denmark	0	0	0	0	0	0	0	0	0	0	194	0	0	0	0	0	0
France	193	21	8	12	50	27	21	56	176	195	0	2	18	0	1	0	0
Germany	0	0	0	0	19	1	0	0	0	0	0	0	0	0	0	0	90
Netherlands	0	8	147	292	17	234	133	566	470	2 110	0	0	0	0	0	0	0
Poland	0	0	262	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK	0	89	57	231	32	14	3	148	69	199	162	83	151	161	69	221	206
Total	193	118	474	535	118	276	157	770	715	2 504	356	85	169	161	70	221	296
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
France	86	42	3	12	503	22	551	26	0	335	526	500	497	496	516	516	502
UK	399	294	855	430	446	471	482	377	165	159	193	163	315	199	66	189	106
Total	485	355	868	451	949	493	1 033	403	165	494	719	663	812	695	582	705	608
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022***		
France	499	489	493	486	278	7	314	3	1	0	380	193	0	0	1		
Netherlands	433	0	2	6	0	0	4	1	0	0	0	0	0	0	0		
UK	78	130	185	218	162	274	435	268	204	22	11	8	11	6	5		
Total	1 010	619	680	710	440	281	753	272	205	23	391	201	12	6	6		

*** Preliminary.**

Table 12.4. Landings of herring in Subarea 8. Source: ICES Official Landings database (2006–2021), Historical Catches database (1974–2005), and ICES preliminary catch statistics (2022–2023).

Year	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Denmark	0	0	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0
France	974	1 115	1 660	613	285	386	531	0	0	0	292	227	272	595	255	0	0
Netherlands	0	0	0	0	30	0	0	0	0	0	0	8 619	0	0	977	0	0
USSR	0	35	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	974	1 150	1 677	613	525	386	531	0	0	0	292	8 846	272	595	1 232	0	0
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
France	0	141	181	68	193	98	86	64	0	80	48	81	43	15	14	6	22
Netherlands	0	0	0	0	0	0	0	0	0	0	0	7 575	1 425	1 396	0	0	0
Portugal	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	232	232	266	197	0	50	214	120
Total	3	141	181	69	193	98	86	64	0	312	280	7 922	1 665	1 411	64	220	142
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022***		
France	22	34	50	81	22	7	5	5	4	1	3	1	1	2	1		
Ireland	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		
Netherlands	0	0	402	222	0	0	0	0	0	0	0	0	0	0	0		
Spain	131	55	38	54	0	0	0	0	0	0	0	0	0	0	0		
Total	153	89	490	357	22	7	5	5	4	2	3	1	1	2	1		

*** Preliminary.**

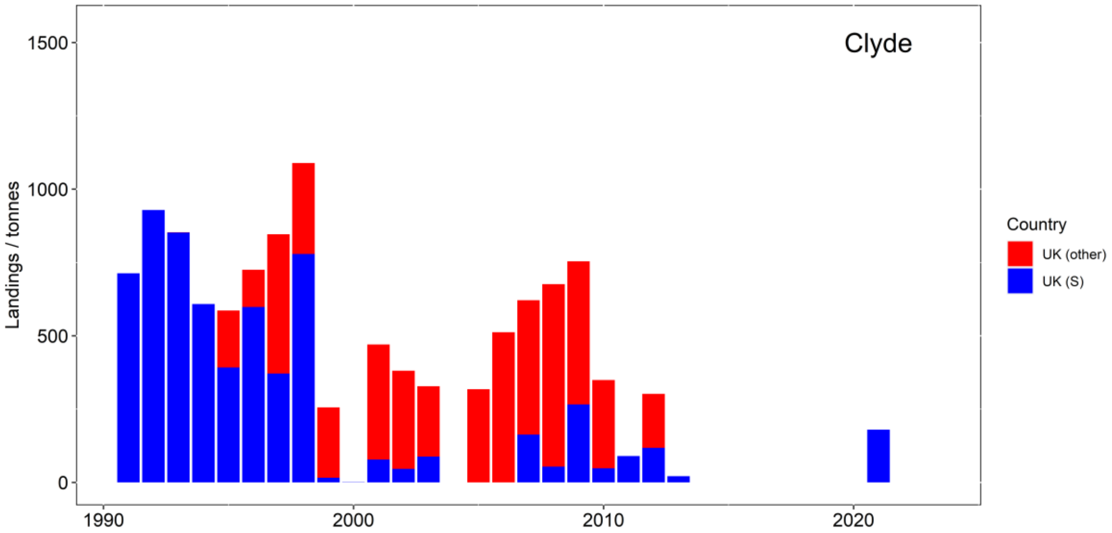

Figure 12.1. Landings over time of herring in the Firth of Clyde.

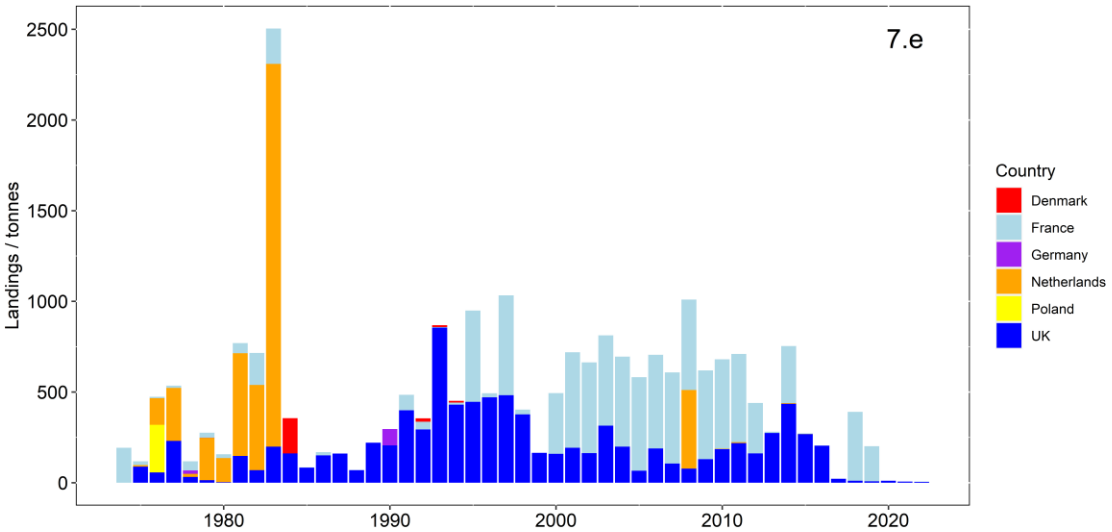

Figure 12.2. Landings over time of herring in Division 7.e (western Channel).

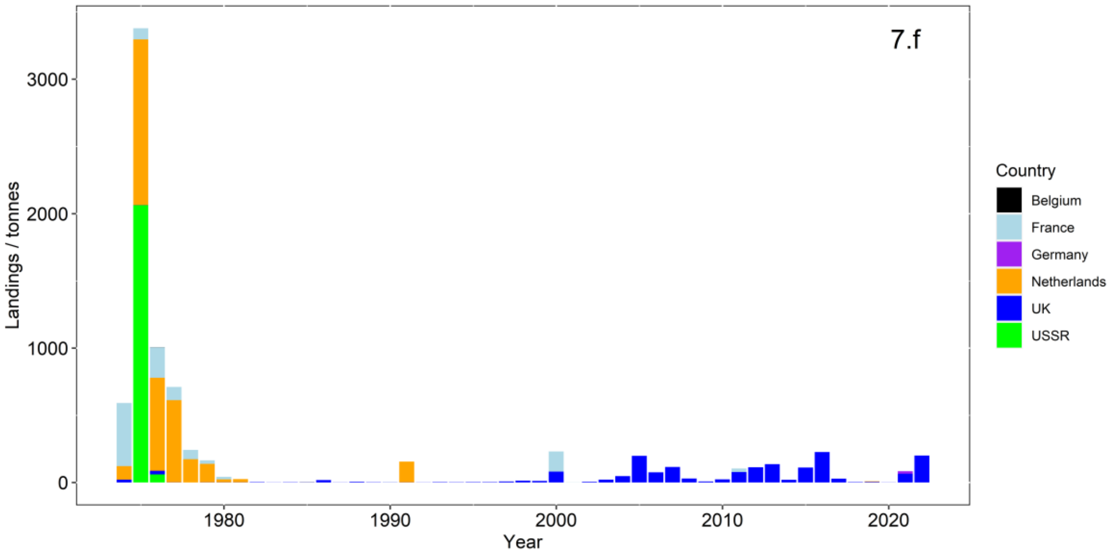

Figure 12.3. Landings over time of herring in Division 7.f (Bristol Channel).

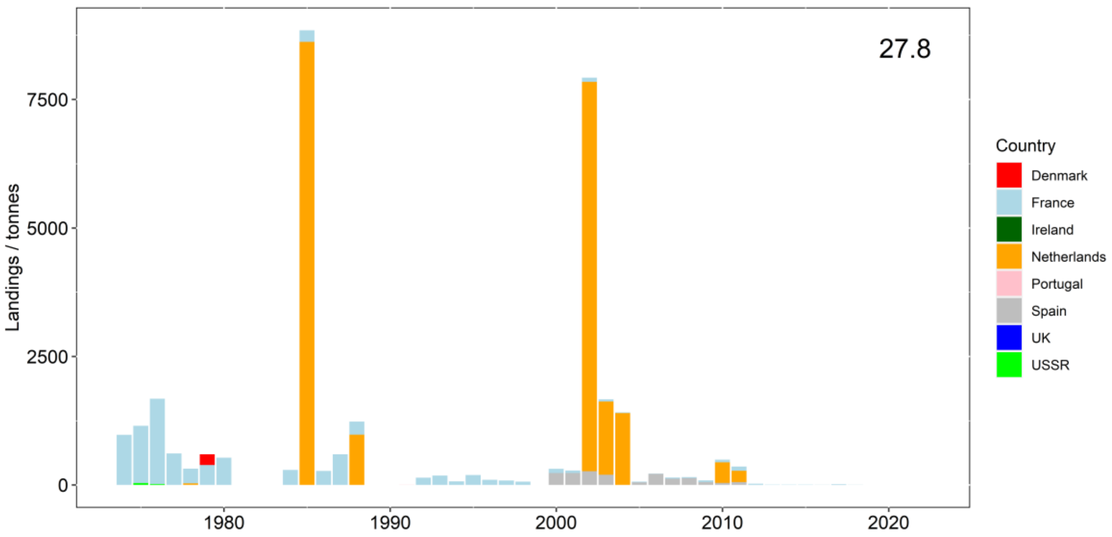

Figure 12.4. Landings over time of herring in Subarea 8 (Bay of Biscay).

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9 Sandeel in Division 3.a and Subarea 4 and Division 6.a

Larval drift models and studies on recruitment and growth differences have indicated that the assumption of a single stock unit in the area is invalid. As a result, the total stock is divided in several sub-populations (ICES, 20, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these eight areas (sandeel area (SA) 1r, 2r, 3r, 4, and 6 and subdivision 6a). Analytical stock assessments are currently carried out in SA 1r–3r and 4, whereas SA5, SA 6, SA 7r and subdivision 6a is managed under the ICES approach for data limited stocks (Category 6, 5, 6 and 6, respectively).

In 2010, the SMS-effort model was used for the first time to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2010. This model assumes that fishing mortality is proportional to fishing effort and is still used to assess sandeel in SAs 1r, 2r, 3r and 4.

Further information on the stock areas and assessment model can be found in the Stock Annexes and in the benchmark report (ICES, 2024a).

9.1 General

9.1.1 Ecosystem aspects

Sandeel in the North Sea can be divided into a number of more or less reproductively isolated sub-populations (see the Stock Annex). A decline in the sandeel population from 20001 to 2007 concurrent with a marked change in distribution increased the concern about local depletion, of which there has been some evidence (ICES, 2007; ICES, 2008; ICES 2016a). Since 2010 this has been accounted for by dividing the North Sea and 3.a into seven management areas.

Local depletion of sandeel aggregations at a distance less than 100 km from seabird colonies may affect some species of birds, especially black-legged kittiwake, and sandwich tern, whereas the more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

The Stock Annex contains a comprehensive description of ecosystem aspects.

9.1.2 Fisheries

General information about the sandeel fishery can be found in the Stock Annex.

The size distribution of the Danish fleet has changed through time, with a clear tendency towards fewer and larger vessels (ICES, 2007). During the last two decades, the number of Danish vessels participating in the North Sea sandeel fishery has been stable with around 100 active vessels.

The same tendency has been seen for the Norwegian vessels towards fewer and larger vessels. In 2008, 42 vessels participated in the sandeel fishery, but in 2023, 26 vessels participated in the fishery. From 2011 to 2023, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1677 tonnes.

The rapid changes of the structure of the fleet that have occurred in the past may introduce more uncertainty in the assessment, as the fishing pattern and efficiency of the current fleet may differ from the previous fleet and the participation of fewer vessels has limited the spatial coverage of the fishery. This is to some degree accounted for in the stock assessments through the introduction of separate catchability periods.

The sandeel fishery in 2023 was opened 1 April and continued until the end of July. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2023 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2024 (Escapement strategy). This approach resulted in an advised catch / TAC for 2023 in SA 1r, SA 2r, SA 3r, and 4 of 120 428 t/ 116 815 t, 40 997/40997 t t, 30 570 t / 62446 t and 35 020 t / 33 969 t, respectively. Advised catches for SA 5, SA 6, SA 7 and subdivision 6a for 2023 and 2024 are based on data limited approaches and set at 0 t, 140 t, 0 t and 0 t, respectively.

9.1.4 Norwegian advice

Based on a recommendation from the Norwegian Institute for Marine Research, an opening TAC of 60 000 tonnes for 2023 was given. The in-season acoustic survey biomass estimate of age 1+ was 105 480 tonnes (RSE=16%), which resulting in no TAC increase. Fishery was allowed in the subareas 1b, 1c, 2a, 2c, 3a, 3c (see Stock Annex for area definitions).

9.1.5 Management

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EEZ was fully implemented in 2011 but was also partly used in 2010. The areas with known sandeel fishing grounds are divided into 5 areas (each divided into subareas). An area is closed for fishery unless the biomass (Age1+) is at least 20 000 tonnes. If an Area is open for fishery, one of the sub-areas is closed. A preliminary TAC for all Areas combined is given in February based on a precautionary prediction of total biomass and a harvesting rate of 0.4. An updated in-season TAC is given 15 May as the 40% percentile of the survey biomass estimate and harvesting rate of 0.4. Areas can be opened based on the updated information (Johnsen, 2022).

Closed periods

Since 2005, Danish vessels have not been allowed to fish sandeel before 31 March and after 1 August.

From 2005 to 2007, the fishery in the Norwegian EEZ opened 1 April and closed again 23 June. In 2008, the ordinary fishery was stopped 2 June, and only a restricted fishery with five vessels continued. No fishery was allowed in 2009. From 2010 to 2014 the fishing season was 23 April–23 June, and from 2015 and onwards from 15 April to 23 June in the Norwegian EEZ.

Closed areas

The Norwegian EEZ was only open for an exploratory fishery in 2006 based on the results of a three-week RTM fishery. In 2007, no regular fishery was allowed north of 57°30′N and in the ICES rectangles 42F4 and 42F5 after the RTM fishery ended. In 2008, the ordinary fishery was closed except in ICES rectangles 42F4 and 44F4, and for five vessels only, the ICES rectangles 44F3, 45F3, 44F2 and 45F2 were open. The Norwegian EEZ was closed to fishery in 2009. In accordance with the Norwegian sandeel management plan, many of the Norwegian management subareas have been closed each year (see Stock Annex for details).

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, there has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000

(ICES rectangles 40-43E7 and 40-44E8). Note that a limited fishery for stock monitoring purposes occurs in May–June in this area.

9.1.6 Catch

Adjustment of official catches

In 2014 and 2015, there was substantial misreporting of catches between areas (ICES, 2015, 2016b (HAWG)). Since 2015, the Danish regulation has not allowed fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German, and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see ICES 2017a, HAWG). Because of this, the 2023 benchmark in accordance with previous year's reallocated reported catches (14 781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1r in 2015. From 2016 onwards, no correction was made.

Catch and trends in catches

Catch statistics for Division 4 are given by country in Table 9.1.1. Catch statistics and effort by assessment area are given in Tables 9.1.2–9.1.7. Figure 9.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and catches peaked in 1997 and 1998 with more than 1 million t. Since 1983 the total catches have fluctuated between 1.2 million t (1997) and 73 420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2023 distributed by ICES rectangle are shown in Figure 9.1.2 (with no spatial adjustment of official catches distribution in 2014 and 2015). The spatial distribution is variable from one year to the next, however with common characteristics. The Dogger Bank area includes the most important fishing banks for SA 1r sandeel. The fishery in SA 3r has varied over time, primarily as a result of changes in regulations and very low abundance of sandeel on the northern fishing grounds.

Table 9.1.2 shows catch weight by area. There are large differences in the regional patterns of the catches. SAs 1r and 3r have consistently been the most important regarding sandeel catches. On average, these areas together have contributed 77% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2r. In the period since 2003 catches from this area contributed 17% of the total catches on average.

SA 4 has contributed 6% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 18, 19 and 19% of the total catches, respectively). In 2017 and 2018, the first non-monitoring fishery was advised in the area since 2011 with a catch advice and TAC at of 54 043 t and 59 345 t, respectively. Catch advice for 2019 was 5000 t for monitoring and for 2020, 39 611 t. In 2021 the catch advice was 77 512 t, followed by zero catch advised in 2022 and in 2023, the catch advice was 35 020 t.

Several banks in the northern areas of Norwegian EEZ have not provided catches between 2001 and 2008. In this period, almost all catches from the Norwegian EEZ came from the Vestbank area (Norwegian management area 3 in Figure 9.1.5). From 2010, catches have been taken mainly from the Norwegian management areas 1, 2 and 3, and from area 4 from 2016.

Effect of vessel size on CPUE

To avoid bias in effort introduced by changes in the average size of fishing vessels over time, the CPUEs are used to estimate a vessel standardization coefficient, *b*. The parameter *b* was estimated using a mixed model for separate periods. Because the model estimates the parameter from several years of data, the time-series for the most recent period is updated for all years as the parameter *b* is updated with the most recent data. More information can be found in the Stock Annex.

9.1.7 Sampling the catch

Sampling activity for commercial catches is shown in Table 9.1.8.

9.1.8 Survey indices

Abundance of sandeel is monitored by a Danish/Norwegian dredge survey (covering SA 1r–3r) and a Scottish dredge survey (SA 4), both in in November/December. See the Stock Annex for more details. An acoustic survey is carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2024a).

The dredge survey in 2023 was carried out as planned in areas 1r, 2r, 3r and 4 and nearly all planned positions were covered in accordance with the survey protocol.

9.2 Sandeel in SA 1r

9.2.1 Catch data

Total catch weight by year for SA 1r is given in Table 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.2.1.

In 2023 as in previous years, the majority of catches were comprised of 1-group (Figure 9.2.1).

9.2.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.2.2 and Figure 9.2.2 by half year. Mean weight-at-age in the first half year increased in 2023 and is just below the long term mean for all age-groups.

9.2.3 Maturity

Maturity estimates are obtained from the average observed in the Danish dredge survey in December as described in the Stock Annex. The values used are given in Table 9.2.3.

9.2.4 Natural mortality

WGSAM 2023 provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, ICES WGSAM, 2024b). Natural mortality was therefore updated. The full time-series was replaced and 3-year moving averages was used (same procedure as last time the time-series was updated). The new time-series did not affect the stock-recruitment plot to an extent that required a revision of reference points. The new time-series contains values of M that are higher than the values in the old time-series in the most recent years, due to an increase in haddock predation. Natural mortalities are listed in Table 9.2.8.

9.2.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.2.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 2001, after which substantial effort reduction has taken place. Effort has fluctuated without a trend since 2006.

The average CPUE in the period 1994 to 2002 was around 60 t^{-day}. In 2003, CPUE declined to the all-time lowest at 21 t^{-day}. Since 2004, the CPUE has increased and reached the all-time highest (101 t^{-day}) in 2010 followed by progressively lower CPUEs ending with CPUEs in 2013–2014 below long-term average. CPUE peaked again in 2015–2017 but have decreased to levels below average in 2018–2023.

Tuning series used in the assessments

A commercial tuning series (RTM) describing the average catch in numbers-at-age per fishing day of a standard vessel in April/early May is used in the assessment.

The index estimated from CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2023 show increases for both age-groups. The indices are below and above the average of age 0 and 1, respectively. The internal consistency, i.e., the ability of the dredge survey to follow cohorts, is low ($R^2 = 0.20$).

9.2.6 Data analysis

Following the three latest Benchmark assessments (ICES, 2010, 2016a and 2024a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2023. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.2.5.

The seasonal effect on the relation between effort and F (“F, Season effect” in the table) is rather constant over the 5-year ranges used. The “age selection” (“F, age effect” in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the assessment period, to a fishery targeting age 1+ in a similar way, and then in the most recent period back to mainly targeting 2+ sandeel.

The CV of the dredge survey (“sqrt (Survey variance) ~CV” in the table) is low (0.38) for age 0 and high (0.75) for age 1 and no boundary effects are detected. The survey residual plot (Figure 9.2.6a) shows no clear patterns.

The CV of the RTM time-series is low to moderate for ages 1, and 2-3 (0.49, 0.47, respectively) and no boundary effects are detected. The survey residual plot (Figure 9.2.6b) shows no clear patterns.

The model CV of catch-at-age (“sqrt(catch variance) ~CV”, in Table 9.2.5 is low (0.47) for age 1 and age 2 in the first half of the year and moderate to high (> 0.75) for the remaining ages and season combinations. The catch-at-age residuals (Figure 9.2.7) show a tendency for the cohorts to die out more rapidly than expected in 2019, 2020 and 2021 (negative catch residuals for all ages), whereas 2022 and 2023 showed the opposite tendency.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.77), which is also indicated by the stock recruitment plot (Figure 9.2.8). The high CV of recruitment is probably due to biological characteristic of the stock (i.e., weak stock-recruitment relationship) and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.2.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 9.2.9) shows consistent assessment results from one year to the next for F with a low Mohn's rho (-0.007). For recruitment and SSB, there seems to have been an overestimation in the previous assessments. It is likely that this is connected to the short period used for the latest exploitation pattern, a decision made under the benchmark to accommodate an intermediate period around 2009 with a significantly different exploitation pattern. Further, the negative catch and dredge residuals observed in 2019–2021 will tend to decrease the recruitment estimate as fish of the different cohorts are observed less frequently than expected after the initial dredge index of recruitment. The stability of F estimates is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years. Recruitment and SSB estimates show a retrospective bias (5-year Mohn´s rho for R and SSB is 0.228 and 0.512, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.2.10) are in general small. The overall pattern with a lower F:effort ratio for older data indicates that the model assumption of no efficiency creeping is violated across periods but not within catchability periods.

9.2.7 Final assessment

The output from the assessment is presented in Tables 9.2.6 (fishing mortality-at-age by year), 9.2.7 (fishing mortality-at-age by half year), 9.2.9 (stock numbers-at-age) and 9.2.10 (stock summary).

9.2.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). The stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{pa} in 2004, 2013–2015, 2019, and 2021-2022, whereas in 2023 SSB has been above B_{pa}. The stock has only been below B_{lim} in 2014. $F_{1\text{–}2}$ is estimated to have been below the long-time average since 2014, and have been historically low in 2021 and 2022 due to low TAC and zero catches (i.e., monitoring TAC). Recruitment in 2017 was estimated to be the lowest observed in the time-series and since then the recruitment have been below the long-term average.

9.2.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2023 is the geometric mean of the recruitment 1983–2022 (101 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2023. However, as the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is probably not critical. Mean weight-at-age in the catch and in the sea is the average value for the years 2018–2023. Natural mortality and maturity is the same as applied in the assessment in the final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.2.12) shows that to obtain an SSB equal to MSY $B_{trigger}$, a TAC of 132 315 t should be set for 2023. The predicted F that follows from this TAC is 0.36. The TAC according to the escapement strategy ($B_{escapement} = B_{pa}$) is therefore 132 315 t in 2024.

9.2.10 Biological reference points

B_{lim} is set at 105 809 t and B_{pa} at 140 824 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in 1 can be found in the Stock Annex.

9.2.11 Quality of the assessment

The quality of the present assessment has improved compared to the combined assessment for the whole of the North Sea previously presented by ICES before 2010. This is mainly because the present division of stock assessment areas better reflects the spatial stock structure and dynamics of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Together with the application of the statistical assessment model SMS-effort, this has removed the retrospective bias in F, whereas SSB and recruitment still seem to have some bias. The model provides rather narrow confidence limits for the model estimates of F, SSB and recruitment, but a poorer fit for the oldest data.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international catches. Danish catches are by far the largest in the area, but effort data from the other countries could improve the quality of the assessment.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0.

9.2.12 Status of the stock

The SSB has only been below B_{lim} in 2014. The SSB in 2024 is within the level expected from the forecast in 2023, where recruitment were around average. SSB is above B_{pa} in 2024. As noted in a previous HAWG report (ICES, 2019), the status of the stock may be impacted in cases where catches is exceeding TAC advice (due to “borrowing and banking”).

9.2.13 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the so-called escapement strategy, i.e., to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the latest benchmark (ICES, 2024a) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the escapement strategy corresponds to an F_{bar} that exceeds F_{cap}, then the escapement strategy should be disqualified, and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 1r is 0.36 (ICES, 2024a).

Based on the misreporting of catches as observed in 2014 and 2015, management measures to avoid area misreporting (only one fishing area per trip) have been mandatory for the Danish fishery since 2015. There are indications of area misreporting for other nations (e.g., Sweden) in 2015 but likely not in the most recent years. Similar management measures as used for the Danish fishery would reduce further the risk of misreporting for other nations as well.

The so-called to "borrowing and banking", allocating catches that are not taken within a TAC in a previous year to the next (~10%), have been flagged as unsustainable several times by the expert group. The effects was investigated further at the latest benchmark (ICES 2024a) and it was concluded that while this did increase the risk, the effect on the risk of SSB falling below B_{lim} when fishing on Fcap was less than 0.2%. In individual years of low biomass the risk of SSB falling below B_{lim} in the subsequent year may be higher. This can potentially be investigated through adding an option to the forecast table investigating this.

Self-sampling on board the commercial vessels for biological data should be mandatory for all nations utilising a monitoring TAC. Today, samples are only obtained from the Danish fishery.

9.3 Sandeel in SA 2r

9.3.1 Catch data

Total catch weight by year for SA 2r is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year are given in Table 9.3.1.

The majority of the individuals caught were 1-group in the period 2020–2023, although the proportion was not as high as in 2017 (98%), following the high recruitment in 2016 (Figure 9.3.1).

9.3.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.3.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time-series of mean weight in the catch and in the stock is shown in Figure 9.3.2. Mean weight-at-age for all age groups seem to have increased since 2019, except for decreases 2020 for age-1 and in 2021 for age-1, 2 and 3. In 2023, weights had decreased across all age-groups compared to 2022.

9.3.3 Maturity

Maturity estimates are obtained from the average observed in the Danish dredge survey in December as described in the Stock Annex. The values used are given in Table 9.3.3.

9.3.4 Natural mortality

Long-term averages of natural mortality-at-age from WGSAM 2023 (ICES, 2024b) multispecies modelling of southern and northern sandeel (SMS) were used. More details are given in the Stock Annex. Natural mortalities are listed in Table 9.3.8. Mortalities were updated in response to the WGSAM 2023 key run (ICES, 2024b) as the update did not affect long-term averages greatly.

9.3.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.3.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size and does not take changes in efficiency into account.

Total international standardized effort in 2022 and 2023 was above the long term average. The CPUE increased accordingly coming up from a record low CPUE in 2022.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

The dredge survey in SA 2r (Table 9.3.4 and Figure 9.3.5) increased coverage in 2010 and this is therefore used as the start year of the dredge time-series for the assessment. The coverage has however varied somewhat in this period and the time-series is still short. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2016a). Dredge CPUEs of age 0 were very low in 2023, resulting in the third lowest age-0 index in the time-series. SA 2r has high internal consistency ($R^2 = 0.57$ on log-scale), i.e., the ability of the dredge survey to follow cohorts is good.

9.3.6 Data analysis

The diagnostics output from SMS-effort are shown in Table 9.3.5.

The CV of the dredge survey (Table 9.3.5) is moderate for the 0-group (0.60). The CV for age-1 is low (0.48). The residual plot (Figure 9.3.6) shows no clear bias for this time-series, although seemingly negative values have been apparent since 2017.

The model CV of catch-at-age 1 and 2 is low (0.47) in the first half of the year and high (> 0.82) for the remaining ages and season combinations. The residual plots for catch-at-age (Figure 9.3.7) confirm that the fit is generally poor except for age 1 and 2 in the first half year. The residual plot shows no long-term bias for this time-series for ages 1 and 2 in the first half year.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.95) which is also indicated by the stock recruitment plot (Figure 9.3.8). The high CV of recruitment is probably due to highly variable recruitment success and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set relatively low (0.05in "objective function weight" in Table 9.3.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.3.10) are in general low, which gives narrow confidence limits on estimated values (Figure 9.3.11).

The plot of standardized fishing effort (Figure 9.3.12) shows a good relationship between effort and F as specified by the model. An effort unit in the early part of the time-series gives a smaller F than an effort unit in the most recent years. This indicates technical creep, i.e., a standard 200 GT vessel has become more efficient over time (see Stock Annex for further discussion, ICES 2024a).

The retrospective analysis (Figure 9.3.9) shows consistent assessment estimates of F from one year to the next. The 5-year Mohn´s rho values are moderate for SSB (0,158) and high for recruitment (0.86). Reasons for this pattern can be connected to lower than expected survival of the cohorts, or lower than expected catchability of the older ages in the fishery.

9.3.7 Final assessment

The output from the assessment is presented in tables 9.3.6 (fishing mortality-at-age by year), 9.3.7 (fishing mortality-at-age by half year), 9.3.9 (stock numbers-at-age) and 9.3.10 (stock summary).

9.3.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). The stock summary (Figure 9.3.13 and Table 9.3.10) show that recruitment has been highly variable and with a decreasing trend over the full time-series until the 2016 year-class, which is estimated to be the fifth strongest on record. In recent times, the recruitment was above the long-term average only in 2016 and 2021, but being below average in 2022 and 2023. The lowest recruitment on record were in 2023, similar to the observed recruitment in 2017. SSB has been at or below B_{lim} in 2006-2007 and 2016-2017. In the same periods SSB has been below B_{pa}, as well as in 2009-2010 and 2021. Since 2022, SSB has been above B_{lim} and B_{pa}. $F_{1–2}$ is estimated to have been below the long-time average since 2010 except for 2013, 2017, 2020 and 2022.

9.3.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.3.11. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in 2024 is the geometric mean of the recruitment in 2013–2022. The exploitation pattern and F_{sq} (2023-value) is taken from the 2024-assessment. As the SMS-model assumes a fixed exploitation pattern since 2010, the choice of year is not critical. Mean weight-at-age in the catch and in the sea is the average (i.e., 5-year mean) value for the years 2019–2023. Natural mortality and proportion mature are the values applied in the terminal year in the assessment.

Output

The short-term forecast (Table 9.3.12) shows that a fishing mortality of 0.51 will bring SSB down to B_{pa} in 2024. Accordingly, a TAC of 35 925 t should be set for 2023 to keep SSB equal to MSY $B_{trigger}$.

9.3.10 Biological reference points

B_{lim} is set at 18 949 t and B_{pa} at 27 757 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.52 (ICES, 2024a). Further information about biological reference points can be found in the Stock Annex and Benchmark report (ICES, 2024a).

9.3.11 Quality of the assessment

This stock was benchmarked in 2023 (ICES, 2024a). The assessment includes fisheries independent information from a dredge survey representative for the area and temporally variable maturity while natural mortality is constant over time. There seems to be issues with time variability in survival from age 0 to 1 and age 1 to 2 which cannot be explained by F. The assessment is considered to be of medium to good quality.

9.3.12 Status of the Stock

A moderate F being under the long-term averaged in most of the years from 2010, except high in 2017 and low in 2021 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004-2010. SSB in the period for 2019-2024 were estimated above B_{lim}, where SSB only have been blow B_{pa} in 2021. The recruitment have generally been low compared to the period before 1997. The recruitment in 2023 is the lowest on record and currently the relative low F in recent times in combination with increasing build-up in SSB are keeping the biomass above reference points.

9.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e., to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 2024a) established that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality and estimated this F_{cap} for SA 2r at 0.52. This means that if the TAC that results from the escapement strategy corresponds to an $F_{bar(1-2)}$ that exceeds F_{cap}, then the TAC is determined based on a fishing mortality corresponding to F_{cap}.

9.4 Sandeel in SA 3r

9.4.1 Catch data

Total catch weight by year for SA 3r is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.4.1.

In 2023, the catches consisted of almost equal proportions of all age groups, where the proportion in numbers of 1-, 2-, 3- and 4-group, respectively, were 25%, 22%, 17% and 27%. This pattern reflects the age composition of the stock and is caused by the progressive decline in recruitment since the very high 2019 yearclass (see below)

9.4.2 Weight-at-age

The mean weights-at-age observed in the catch are given in Table 9.4.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time-series of mean weight in the catch and in the stock is shown in Figure 9.4.2. Mean weight-at-age in the first half-year hincreased from 2018 to 2020 and has remained fairly stable since 2020 at a level 26% and 17% above the long term average for ages 1 and 2 respectively, while weight at age of older ages are below the long term average.

9.4.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey in December as described in the Stock Annex. The values used are given in Table 9.4.3.

9.4.4 Natural mortality

In 2023, WGSAM (ICES, 2024b) provided updated estimates of natural mortality-at-age from multispecies modelling of northern sandeel (SMS).

The effect of using 3-year averages of these new values on historical development and stock recruitment relationship of the stock was evaluated by the working group and it was decided that the new natural mortality values did not result in a substantial change in the historic perception of the stock, including possible changes to reference points. Further, the recent increase in mortality induced by the increasing haddock populations agreed with the impression of increased mortality derived from the surveys. For this reason, it was decided to use the new natural mortalities in the 2024 assessment.

As described in the stock annex, 3-year averages of natural mortality-at-age from the WGSAM 2023 (ICES, 2024b) multispecies modelling of northern sandeel (SMS) were used. The last value provided was used for all years following the latest data point. More details are given in the stock annex. Natural mortalities are listed in Table 9.4.8.

9.4.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.4.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 1998 and declined thereafter and has been less than 2000 days per year between 2003 and 2019. The effort increased to 3492 days in 2020. In 2021 and 2022, the effort decreased to about the same level as in 2019 and in 2023 it fell to a level below that observed in the past 6 years.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2023 show very low indices for both age 0 and age 1 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e., $r^2 = 0.34$on log scales). In 2014, 13 new positions were included in the survey in SA 3r. Only two of the new positions were taken in squares not included before (42F5 and 42F6). All the new positions have been included in the survey index since 2014 (Table 9.4.4) for assessment purposes, to obtain a better spatial coverage. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2024a).

The Norwegian acoustic survey (2009–2023) carried out in Norwegian EEZ is used as tuning series in the assessment in SA 3r (Table 9.4.13 and Figures 9.4.14–9.4.16). The survey covers the main sandeel grounds in SA 3r. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.13. The internal consistency plot (Figure 9.4.16) shows high consistency for age 1 vs. age 2 ($r^2 = 0.87$ on log scales), age 2 vs. age 3 ($r^2 = 0.88$ on log scales), and age 3 vs. age 4 ($r^2 = 0.41$ on log scales).

9.4.6 Data Analysis

The diagnostics output from SMS-effort model is shown in Table 9.4.5.

The CV of the dredge survey (Table 9.4.5) is low for age 0 (0.30) and high for age 1 (1.14), showing an overall poor consistency between the results from the dredge survey of age 1 and the overall model results. The internal consistency of the survey seems to indicate the large and small year-classes can be followed in the dredge, but the exact size of small or large cohorts cannot.

The CV of the acoustic survey (Table 9.4.5) is medium for all ages (0.63), showing an overall medium consistency between the results from the acoustic survey and the overall model results. After a string of 3 years from 2020 to 2022 where the survey consistently reported a larger abundance of sandeel than could be seen in the catches, this pattern has now disappeared (Fig 9.8.5-9.8.6.).

The model CV of catch-at-age is high (0.829) for age 1 and age 2 in the first half of the year (Table 9.4.5). For the older ages and for all ages in the second half year, the CVs are higher (> 0.96). The catch residual plots for catch-at-age (Figure 9.4.7) confirm that the fits are generally very poor. There is a tendency for clusters of negative or positive residuals for ages 1, 2 and 3, in particular in later years where the cacthes show substantially less fish than expected in the model.

The recruitment CV (Table 9.4.5) is very high (1.54), which is also indicated by the stock recruitment plot (Figure 9.4.8). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.4.5) such that SSB-R estimates do not contribute much to the overall model likelihood and fit.

There used to be a large retrospective pattern in recruitment that consistently overestimated large recruiting year-classes, resulting in a retrospective pattern also in SSB. However, after the adjustment made at the benchmark in 2023, the retrospective bias was reduced (Mohn´s rho for R and SSB of 0.237 and -0.029, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.4.10) are in general medium, which gives wide confidence limits (Figure 9.4.11) on output variables.

The plot of standardized fishing effort and estimated F (Figure 9.4.12) shows a moderate relation between effort and F as assumed by the model specification. The the model assumes that the relation between effort and F is constant over time, corresponding to no technical creep(ICES, 2024a).

9.4.7 Final assessment

The output from the final assessment is presented in Tables 9.4.6 (fishing mortality-at-age), 9.4.7 (fishing mortality-at-age by half year), 9.4.9 (stock numbers-at-age) and 9.4.10 (Stock summary).

9.4.8 Historic Stock Trends

The perception of the stock have changed dramatically after the last benchmark (ICES, 2024a). SSB has been below below B_{pa} in 2000, 2004, 2006 and 2009, where SSB was under B_{lim} in a single year 2004 (Figure 9.4.13 and Table 9.4.10). Above average recruitments in 2016, 2018, 2019 and 2020 together with a fishing mortality below average in most years and increased weights have resulted in SSB being above B_{pa} the last decade. Yet, a recent drop in recruitment have been observed, where the recent three years have been below the long-term average.

9.4.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.4.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2024 is the geometric mean of the recruitment 1987–2022 (18 491 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2023. As the SMS-model assumes a fixed exploitation pattern, the choice of year is not critical. Mean weight-at-age in the catch and in the sea is the average value (i.e., 5-year mean) for the years 2019–2023. Proportion mature and natural mortality are equal to the terminal assessment year.

The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.4.12) shows that even in the absence of fishing SSB in 2025 will be at 106 889 t which is below B_{pa}. Accordingly, the advised catch is zero ton. A monitoring fishery of 5000 t is recommended to achieve the necessary samples to monitor the age distribution of the stock. This will lead to an SSB in 2025 at 107627t.

9.4.10 Biological reference points

B_{lim} is set at 72 713 t and B_{pa} is estimated to 108 978 t. MSY $B_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex and in the benchmark report (ICES, 2024a).

9.4.11 Quality of the assessment

This stock was benchmarked in 2023 (ICES, 2024a). Sandeel area 3r mainly consists of fishing grounds in Norwegian EEZ. There is a large variation in the various sources of information with low agreement between commercial catch age composition and age composition of 1+ fish in the surveys This pattern may be caused by a variety of issues in the assessment, most likely of which are the shift in 2011 from using Danish to using Norwegian effort data, the change in the spatial coverage of the dredge survey and the management system of surveying all grounds but only allowing fishing in a subset of the grounds in a year and then changing this in the subsequent year. Even though the new assessment for SA 3r sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

9.4.12 Status of the Stock

The SSB has increased since 2013, due to above average recruitment in 2016, 2018-2020 combined with a low fishing mortality. However, fishing mortality has increased since 2016, peaking in 2020, but decreased in last three years, where SSB have decreased considerably in the same period. This may be a result of high fishing mortality and decreasing recruitment (but SSB is still well above B_{pa}). Recruitment have been below average in the same period. Recruitment in 2023 was the fourth lowest on record.

9.4.13 Management Considerations

Since 2011 the Norwegian sandeel fishery in the current SA3r has been managed according to an area-based management plan for the Norwegian EEZ and an advice provided by the IMR in Bergen.

9.5 Sandeel in SA 4

9.5.1 Catch data

Catch numbers-at-age by half-year from area SA 4 is given in Table 9.5.1. Total catch weight by year for SA 4 is given in Table 9.5.2. In 2022, catch numbers were dominated by age 1-group and, to a lower extent, age 3-group as a result of their relatively large number (as age 2-group) in 2021. Other age-groups were not common (Figure 9.5.1). In 2023, the same two cohorts remained abundant while the proportion of 1-year olds was 23%, the lowest since 2011.Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex. The mean weights-at-age observed in the catch are given in Table 9.5.2 and Figure 9.5.2 by half year. Mean weight-at-age in the first half year seems to have recovered to around average and currently stable for all ages after the very low levels in 2001 to 2005. The second half year mean weights are affected by the very limited sampling at this time of year.

9.5.2 Maturity

Maturity estimates are constant throughout the times series in Area 4. Maturities are listed in Table 9.5.3.

9.5.3 Natural mortality

Long-term averages of natural mortality-at-age from the WGSAM 2023 (ICES, 2024b) multi-species modelling of northern sandeel (SMS) were used. More details are given in the stock annex. Natural mortalities are listed in Table 9.5.8. Mortalities were updated in response to the new WGSAM 2023 key run (ICES, 2024b) as the update did not appear to affect long-term averages and model output greatly.

9.5.4 Effort and research vessel data

Trends in overall effort and CPUE

Table 9.1.5–9.1.7 and Figure 9.5.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 1994, after which substantial effort reduction has taken place and the effort is now fluctuating around a lower level than before 2003. The effort in 2023 was relatively low, but above the effort in the period 2004–2016 and 2022 which reflect either a closed or very limited monitoring fishery.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment. CPUE data from the dredge survey (Table 9.5.4 and Figure 9.5.5) show that 2023 recruitment is extremely low.

The internal consistency, i.e., the ability of the survey to follow cohorts, (Figure 9.5.4) shows a low correlation between the 0-group and 1-group explaining 36% of the variation.

9.5.5 Data analysis

Following the Benchmark assessment (ICES, 2024a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2023. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.5.5. The CV of the new dredge survey (going from 2008–2023) ("sqrt (Survey variance) ~CV" in the table) is low to moderate (<0.30) for age 0 and high for age 1 (0.81). The old dredge survey CV (years 1999–2003) is on the lower boundary of 0.3 for both 0- and 1-year olds. The survey residuals appear to fluctuate without a trend for both ages (Figure 9.5.6).

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.69) for all ages. While they look similar, they are freely estimated for ages 1+2 and 3+4 and the similar value for the two groups is a model estimate. The catch-at-age residuals (Figure 9.5.7) show no alarming patterns.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.48, which is also indicated by the stock recruitment plot (Figure 9.5.8). The high CV of recruitment is probably due to biological characteristic of the stock and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.5.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 9.5.9) shows very consistent assessment results from one year to the next (Monhs rho for R and SSB of 0.145 and 0.067, respectively).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.5.10) are moderate to high.

9.5.6 Final assessment

The output from the assessment is presented in tables 9.5.6 (fishing mortality-at-age by year), 9.5.7 (fishing mortality-at-age by half year), 9.5.9 (stock numbers-at-age) and 9.5.10 (stock summary).

9.5.7 Historic Stock Trends

The perception of the stock have changed after the last benchmark (ICES, 2024a). The stock summary (Figure 9.5.13 and Table 9.5.10) shows that SSB have been below B_{lim} in 2008 to 2009. Furthermore, SSB have been in 2004-2005, 2007-2010, 2014-2015 2020, and 2022-2024. As such, SSB have decreased in recent years. F_{1-2} is estimated to have been low throughout the time-series peaking in 1994. 2004-2017 represent a period with no or very limited fishing, whereas sporadic fishing activity have been evident since, e.g. in 2018, 2021 and 2023. The fishing mortality in 2021 where the second largest in the time-series. Recruitment has been variable through time with highs in 2014, 2016, 2019 and 2022. The 2023 recruitment were the lowest in the time-series.

9.5.8 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.5.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2023 is the geometric mean of the recruitment 2012–2021 (61 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2022. However, as the SMS-model assumes a fixed exploitation pattern, the choice of years is not critical. Mean weight-at-age in the catch and in the sea is the average value (i.e., 5-year mean) for the years 2018–2022. Natural mortality and maturity are as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.5.12) shows that even in the absence of fishing SSB in 2025 will be at 69 406 t which is below B_{pa}. Accordingly, the advised catch is zero ton. A monitoring fishery of 5000 t is recommended to achieve the necessary samples to monitor the age distribution of the stock. This will lead to an SSB in 2025 at 66 570 t.

Biological reference points

B_{lim} is set at 44 716 t and B_{pa} at 88 995 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in SA 4 can be found in the Stock Annex.

9.5.9 Quality of the assessment

The analytical assessment of SA 4 was initiated in 2017 following the 2016 benchmark of the stock.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0 but the CV on SSB in the terminal year is high (Figure 9.5.10).

9.5.10 Status of the Stock

Recruitment in 2014, 2016, 2019, and 2022 are above the long-term average, while the remaining years after 2010 are below. A very restrictive F since 2004, with the exception of 2018, 2021 and 2023, together with recruitment peaks has resulted in a SSB fluctuating around B_{pa} since 2019, but have been below B_{pa} in recent three years..

9.5.11 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e., to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations presented at the latest benchmark (ICES, 2024a) indicated that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality. This means that if the TAC that comes out of the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy should be disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}. F_{cap} for SA 4 is set at 0.36 (ICES, 2024a).

However, it is important to acknowledge that the assessment model does not consider that a significant part of SA 4 (East coast of Scotland, sand banks covered by the dredge survey) is closed to fishing. Accordingly, the estimated TAC would in practice be achieved in a much smaller region than the whole SA 4 which raises concerns of local depletion.

9.6 Sandeel in SA 5r

9.6.1 Catch data

Total catch weight by year for SA 5 is given in tables 9.1.2–9.1.4. No catches from this area have been taken since 2004. Acoustic surveys have been carried out since 2009 on Vikingbanken, which is the main sandeel ground in SA 5. The survey estimates (2009–2023) show that the biomass of sandeel on Vikingbanken still is very low (Table 9.6.1).

9.7 Sandeel in SA 6

9.7.1 Catch data

Total catch weight by year for SA 6 is given in tables 9.1.2–9.1.4.

9.8 Sandeel in SA 7

9.8.1 Catch data

Total catch weight by year for SA 7 is given in tables 9.1.2–9.1.4. No catches from this area have been taken since 2003.

9.9 Sandeel in ICES Division 6.a

9.9.1 Catch data

Total catch weight by year for sandeel in ICES Division 6.a is given in Table 9.9.1. Catches from this area have been zero or very low since 2005 with the exception of 2020. There was anecdotal evidence presented at HAWG that indicated that the catch recorded in that year was the result of a sampling error.

9.10 References

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Stock annexes

San.sa.1r – stock annex

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San.sa.2r – stock annex

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San.sa.3r – stock annex

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San.sa.4 – stock annex

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San.sa.5r – stock annex

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San.sa.6 – stock annex

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9.11 Tables and Figures

Table 9.1.1 Sandeel. Official catches ('000 t), 1952-2023 for area 27.4 and 27.3.a. Note that catches from 27.3.a are only availible form 1973-2023.

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1952	27.4	1.6	-	-	-	-	-	-	-	-	-	1.6
1953	27.4	4.5	-	-	-	-	-	-	-	-	-	4.5
1954	27.4	10.8	-	-	-	-	-	-	-	-	-	10.8
1955	27.4	37.6	-	-	-	-	-	-	-	-	-	37.6
1956	27.4	81.9	5.3	-	-	-	1.5	-	-	-	-	88.7
1957	27.4	73.3	25.5	-	-	3.7	3.2	-	-	-	-	105.7
1958	27.4	74.4	20.2	-	-	1.5	4.8	-	-	-	-	100.9
1959	27.4	77.1	17.4	-	-	5.1	8	-	-	-	-	107.6
1960	27.4	100.8	7.7	-	-	-	12.1	-	-	-	-	120.6
1961	27.4	73.6	4.5	-	-	-	5.1	-	-	-	-	83.2
1962	27.4	97.4	1.4	-	-	-	10.5	-	-	-	-	109.3
1963	27.4	134.4	16.4	-	-	-	11.5	-	-	-	-	162.3
1964	27.4	104.7	12.9	-	-	-	10.4	-	-	-	-	128.0
1965	27.4	123.6	2.1	-	-	-	4.9	-	-	-	-	130.6
1966	27.4	138.5	4.4	-	-	-	0.2	-	-	-	-	143.1
1967	27.4	187.4	0.3	-	-	-	1	-	-	-	-	188.7
1968	27.4	193.6	-	-	-	-	0.1	-	-	-	-	193.7
1969	27.4	112.8	-	-	-	-	-	-	0.5	-	-	113.3
1970	27.4	187.8	-	-	-	-	-	-	3.6	-	-	191.4
1971	27.4	371.6	0.1	-	-	-	2.1	-	8.3	-	-	382.1
1972	27.4	329.0	-	-	-	-	18.6	8.8	2.1	-	-	358.5
1973	27.3.a + 27.4	282.9	-	1.4	-	-	17.2	1.1	4.2	-	-	306.8
1974	27.3.a + 27.4	432.0	-	6.4	-	-	78.6	0.2	15.5	-	-	532.7
1975	27.3.a + 27.4	372.0	-	4.9	-	-	54	0.2	13.6	-	-	444.7

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1976	27.3.a + 27.4	446.1	-	-	-	-	44.2	0.1	18.7	-	-	509.1
1977	27.3.a + 27.4	680.4	-	11.4	-	-	78.7	6.1	25.5	-	-	802.1
1978	27.3.a + 27.4	669.2	-	12.1	-	-	93.5	2.3	32.5	-	-	809.7
1979	27.3.a + 27.4	483.1	-	13.2	-	-	101.4	-	13.4	-	-	611.1
1980	27.3.a + 27.4	581.6	-	7.2	-	-	144.8	-	34.3	-	-	767.9
1981	27.3.a + 27.4	523.8	-	4.9	-	-	52.6	-	46.7	-	-	628.1
1982	27.3.a + 27.4	528.4	-	4.9	-	-	46.5	0.4	52.2	-	-	632.4
1983	27.3.a + 27.4	515.2	-	2	-	-	12.4	0.2	37	-	-	566.8
1984	27.3.a + 27.4	618.9	-	11.3	-	-	28.3	-	32.6	-	-	691.1
1985	27.3.a + 27.4	601.7	-	3.9	-	-	13.1	-	17.2	-	-	635.9
1986	27.3.a + 27.4	832.7	-	1.2	-	-	82.1	-	12	-	-	928.0
1987	27.3.a + 27.4	609.2	-	18.6	-	-	193.4	-	7.2	-	-	828.4
1988	27.3.a + 27.4	708.8	-	15.5	-	-	185.3	-	5.8	-	-	915.3
1989	27.3.a + 27.4	841.6	-	16.6	-	-	186.8	-	11.5	-	-	1056.3
1990	27.3.a + 27.4	512.1	-	2.2	-	0.3	89	-	3.9	-	-	607.5
1991	27.3.a + 27.4	726.5	-	11.2	-	-	128.8	-	1.2	-	-	867.7
1992	27.3.a + 27.4	803.7	-	9.1	-	-	89.3	0.6	4.9	-	-	907.6
1993	27.3.a + 27.4	533.4	-	0.3	-	-	95.5	-	1.5	-	-	630.8
1994	27.3.a + 27.4	688.6	-	10.3	-	-	165.8	-	5.9	-	-	870.7
1995	27.3.a + 27.4	672.6	-	-	-	-	263.4	-	6.7	-	-	942.8

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
1996	27.3.a + 27.4	649.5	-	5	-	-	160.7	-	9.7	-	-	824.8
1997	27.3.a + 27.4	831.8	-	11.2	-	-	350.2	-	24.6	-	-	1217.8
1998	27.3.a + 27.4	628.2	-	11	-	-	343.3	8.6	23.8	-	-	1014.8
1999	27.3.a + 27.4	511.3	-	13.2	0.4	-	187.6	23.2	11.5	-	-	747.1
2000	27.3.a + 27.4	557.3	-	-	-	-	119	28.6	10.8	-	-	715.7
2001	27.3.a + 27.4	650.0	-	-	-	-	183	50	1.3	-	-	884.3
2002	27.3.a + 27.4	659.5	-	-	-	-	176	19.2	4.9	-	-	859.6
2003	27.3.a + 27.4	282.8	-	-	-	-	29.6	21.8	0.5	-	-	334.7
2004	27.3.a + 27.4	288.8	2.7	-	-	-	48.5	33.3	-	-	-	373.3
2005	27.3.a + 27.4	158.9	-	-	-	-	17.3	0.5	-	-	-	176.6
2006	27.3.a + 27.4	255.4	3.2	-	-	-	5.6	27.9	-	-	-	292.8
2007	27.3.a + 27.4	166.9	1	2	-	-	51.1	7.9	1	-	-	229.9
2008	27.3.a + 27.4	246.9	4.4	2.4	-	-	81.6	12.5	-	-	-	347.8
2009	27.3.a + 27.4	293.0	12.2	2.5	-	1.8	27.4	12.4	3.6	-	-	352.9
2010	27.3.a + 27.4	285.9	13	-	-	-	78	32.7	4	0.6	-	414.2
2011	27.3.a + 27.4	278.5	9.8	-	-	-	109	32.7	6.1	1.6	-	437.8
2012	27.3.a + 27.4	51.8	1.7	-	-	0.3	42.5	5.7	-	-	-	101.9
2013	27.3.a + 27.4	208.7	7.9	-	-	0.4	30.4	26.8	2.4	1.3	-	278.0
2014	27.3.a + 27.4	156.5	5.1	-	-	-	82.5	18.8	-	0.8	-	263.8
2015	27.3.a + 27.4	166.5	9.1	-	-	-	100.9	33.4	2	-	-	311.9

Year	Area	Den-mark	Ger-many	Fa-roes	Ire-land	Nether-lands	Nor-way	Swe-den	UK	Lithu-ania	France	Total
2016	27.3.a + 27.4	28.4	-	-	-	-	40.9	4.3	-	-	-	73.5
2017	27.3.a + 27.4	353.9	5.8	-	-	-	120.2	42.3	3.3	-	-	525.5
2018	27.3.a + 27.4	175.6	5.9	-	-	-	69.5	16.7	1.8	-	-	269.6
2019	27.3.a + 27.4	93.7	4	-	-	-	124.8	11.5	1.1	-	-	235.1
2020	27.3.a + 27.4	169.2	3.8	-	-	-	244.4	25.5	3.9	-	-	446.8
2021	27.3.a + 27.4	69.5	1.8	-	-	-	146.4	14.8	-	-	-	232.6
2022	27.3.a + 27.4	72.7	-	-	-	-	81.7	12.3	-	-	-	166.6
2023	27.3.a + 27.4	118.6	4	-	-	-	15.9	26	-	-	-	164.5

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1998	372604	99305	474843	58911	3010	941	5228	1014841
1999	425478	70085	193621	53338	145	0	4415	747083
2000	374724	101952	196525	37792	303	0	4371	715667
2001	540248	97210	196209	47918	1678	26	971	884260
2002	610161	120520	115207	12762	8	493	453	859604
2003	178642	56248	35365	64049	44	111	260	334718
2004	215352	116837	33658	6882	0	573	0	373302
2005	126261	34569	13994	1557	0	259	0	176640
2006	247510	37952	7094	86	0	161	0	292802
2007	110395	44069	75376	11	4	0	0	229855
2008	236069	35655	74943	1168	0	0	0	347836
2009	309712	37049	6161	0	0	0	0	352922
2010	300896	52470	60542	275	0	0	0	414183
2011	320241	24310	92450	270	0	489	0	437761
2012	45954	12672	40141	2618	0	214	0	101599
2013	214787	48172	9838	5119	0	72	0	277989
2014	96430	64707	98055	4505	0	65	0	263762
2015	160764	39492	106703	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	132213	20226	76656	42515	0	0	0	271610
2019	86539	5132	138674	6648	0	96	0	237089
2020	108944	70198	247411	20116	0	97	0	446765
2021	17082	4146	157524	53765	0	93	0	232610
2022	5195	71614	84240	5541	0	38	0	166628
2023	88581	39653	18955	17269	0	77	0	164535
arith.mean	273220	97266	147233	29697	5265	1066	894	554642

Table 9.1.3 Sandeel. Total catch (tonnes) by area, first half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	314744	92566	21008	2782	0	364	0	431465
1984	419640	86141	43578	2563	5821	735	744	559223
1985	377702	76422	17131	37900	3004	973	0	513132
1986	346053	181733	138020	12539	108	12020	7832	698305
1987	307194	36400	394339	7833	1713	1091	0	748570
1988	395186	107289	288174	1257	0	2114	0	794020
1989	435721	173510	371557	4382	1587	897	450	988104
1990	285321	101899	105554	2926	0	485	0	496185
1991	257591	153869	215770	17140	1168	17	2529	648083
1992	521575	135823	83068	67068	1099	4270	3455	816357
1993	129403	86179	155984	123143	250	4393	3	499354
1994	177685	184792	242027	147019	2754	3222	4	757503
1995	365681	70518	203151	52497	152269	1829	0	845945
1996	257507	63193	110862	48496	14551	1168	0	495777
1997	345199	178735	394181	47668	8615	2194	2448	979040
1998	352275	70075	354639	57373	2907	939	4565	842773
1999	395813	27461	94655	51183	145	0	2152	571409
2000	333044	82405	192474	37792	288	0	3808	649812
2001	368782	49319	59951	47492	1678	26	735	527983
2002	604584	105397	114646	12762	8	493	101	837991
2003	155006	25111	22803	62580	44	111	187	265841
2004	199483	91405	21632	6860	0	571	0	319951
2005	121795	24841	13982	1557	0	259	0	162434
2006	241345	23497	6959	55	0	160	0	272015
2007	110389	44069	75376	11	4	0	0	229849
2008	232249	32602	74943	1168	0	0	0	340963
2009	293529	25399	6024	0	0	0	0	324952
2010	293359	44910	60251	275	0	0	0	398796

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2011	316351	24045	92450	270	0	489	0	433605
2012	45946	11520	40141	2618	0	213	0	100438
2013	207886	43818	9838	5119	0	72	0	266733
2014	92393	62110	97310	4505	0	65	0	256383
2015	160763	38723	106703	4736	0	197	0	311123
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	125610	19943	76081	42515	0	0	0	264149
2019	71464	5129	138669	6648	0	96	0	222006
2020	107762	69894	247411	19896	0	97	0	445060
2021	16615	4142	157397	51448	0	93	0	229695
2022	5193	71613	84240	5541	0	38	0	166626
2023	88111	38426	18950	17269	0	77	0	162833
arith.mean	247100	70856	124674	25356	4830	973	708	474496

Table 9.1.4 Sandeel. Total catch (tonnes) by area, second half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	67885	63641	3820	0	0	0	0	135345
1984	79031	47257	5532	0	0	55	0	131875
1985	82355	35468	3728	222	0	953	0	122726
1986	36791	43848	144314	179	519	1199	2818	229668
1987	65828	12667	959	321	0	72	0	79847
1988	27619	44254	48744	81	0	612	0	121310
1989	10407	53782	2694	2	1316	12	0	68214
1990	20981	31896	57670	388	374	14	0	111323
1991	74613	61697	59069	24232	0	0	0	219611
1992	37027	48418	3954	1837	0	6	0	91243
1993	14986	61785	44138	9993	336	97	78	131414
1994	15557	60152	25254	11671	3	526	0	113163

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1995	35078	51637	10017	94	5	1	0	96831
1996	34202	123267	48441	109994	13020	95	1	329019
1997	81215	63945	79912	10779	2157	179	613	238799
1998	20329	29230	120203	1538	103	1	663	172068
1999	29666	42624	98967	2155	0	0	2263	175674
2000	41680	19547	4051	0	15	0	562	65855
2001	171466	47891	136258	426	0	0	236	356277
2002	5577	15123	561	0	0	0	352	21613
2003	23636	31137	12562	1469	0	0	73	68877
2004	15869	25432	12026	22	0	2	0	53351
2005	4466	9728	11	0	0	0	0	14206
2006	6165	14455	136	30	0	0	0	20787
2007	6	0	0	0	0	0	0	6
2008	3821	3053	0	0	0	0	0	6873
2009	16183	11650	137	0	0	0	0	27970
2010	7537	7560	291	0	0	0	0	15387
2011	3891	265	0	0	0	0	0	4156
2012	8	1153	0	0	0	0	0	1161
2013	6902	4354	0	0	0	0	0	11256
2014	4037	2598	744	0	0	0	0	7379
2015	1	769	0	0	0	0	0	771
2016	0	50	0	0	0	0	0	51
2017	2327	10673	0	0	0	0	0	13000
2018	6603	283	576	0	0	0	0	7461
2019	15074	3	5	0	0	0	0	15082
2020	1182	304	0	220	0	0	0	1705
2021	468	3	126	2317	0	0	0	2915
2022	2	0	0	0	0	0	0	2
2023	470	1227	5	0	0	0	0	1702

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
arith.mean	26120	26410	22559	4341	435	93	187	80146

Table 9.1.5 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	8982	4290	840	64	8	0	0	14184
1984	10155	3794	1362	47	45	213	37	15653
1985	10887	3485	614	657	62	140	0	15845
1986	7375	5049	4659	284	470	12	145	17995
1987	5766	1123	5167	181	41	65	0	12343
1988	7938	3987	7504	41	97	0	0	19568
1989	8619	6302	7759	57	40	31	0	22808
1990	8412	4394	5175	52	27	0	0	18060
1991	6130	4794	6069	365	1	21	0	17381
1992	8945	4480	2413	602	161	0	0	16601
1993	3935	4206	5311	1436	235	29	0	15153
1994	3159	4126	4956	1627	104	0	0	13972
1995	5871	2519	3837	437	50	1953	0	14667
1996	5627	4511	4425	1501	44	572	0	16681
1997	5685	5085	8142	680	47	0	6	19645
1998	7077	2704	12062	683	19	105	0	22650
1999	8871	1974	6125	848	0	0	0	17819
2000	7314	2590	4271	438	0	5	153	14770
2001	11285	2481	4901	692	1	0	0	19361
2002	8533	3050	2560	151	12	1	0	14305
2003	7018	2342	1698	1153	6	20	0	12236
2004	7355	4191	1313	216	25	0	0	13099
2005	3788	1171	519	102	9	0	0	5587
2006	5163	1144	213	2	3	0	0	6525
2007	1838	863	1382	1	0	0	0	4085

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2008	3960	810	1660	10	0	0	0	6440
2009	4872	710	124	0	0	0	0	5707
2010	3348	1067	1453	4	0	0	0	5871
2011	4874	564	1364	10	13	0	0	6824
2012	696	425	688	78	12	0	0	1898
2013	5202	1680	327	44	7	0	0	7260
2014	2398	1512	1095	52	5	0	0	5062
2015	1860	1386	1107	40	8	0	0	4401
2016	195	431	711	118	5	0	0	1460
2017	3818	2497	1460	249	0	0	0	8023
2018	3352	593	1405	610	0	0	0	5960
2019	2466	168	1496	169	3	0	0	4302
2020	3390	1606	3935	226	5	0	0	9162
2021	434	259	1799	1297	3	0	0	3792
2022	132	1693	2127	113	2	0	0	4067
2023	2623	1136	983	385	4	0	0	5131
arith.mean	5350	2468	3049	384	38	77	8	11374

Table 9.1.6 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, first half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	6922	2777	717	64	8	0	0	10488
1984	7899	2353	1164	47	41	213	37	11755
1985	8462	2499	506	653	28	140	0	12289
1986	6570	3891	2517	281	438	4	81	13781
1987	4353	757	5136	165	38	65	0	10515
1988	7134	2743	6045	40	74	0	0	16034
1989	8306	4655	7668	57	38	31	0	20756
1990	7895	3522	3770	47	27	0	0	15260
1991	4715	3337	4903	119	1	21	0	13096

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1992	8056	3416	2319	327	160	0	0	14278
1993	3537	2487	4081	1239	226	29	0	11599
1994	2865	3024	4497	1440	89	0	0	11915
1995	5273	1544	3629	436	50	1953	0	12885
1996	4931	1593	3203	535	44	408	0	10714
1997	4229	3247	6131	533	41	0	0	14181
1998	6455	1645	7787	643	19	101	0	16650
1999	7841	771	3151	848	0	0	0	12612
2000	6335	1988	4190	438	0	5	153	13108
2001	8236	1350	1754	678	1	0	0	12019
2002	8300	2387	2560	151	12	1	0	13410
2003	6095	1026	1297	1077	6	20	0	9521
2004	6881	3155	895	214	25	0	0	11169
2005	3642	838	519	102	9	0	0	5109
2006	4938	734	208	2	3	0	0	5886
2007	1838	863	1382	1	0	0	0	4085
2008	3843	708	1660	10	0	0	0	6222
2009	4653	538	123	0	0	0	0	5314
2010	3200	889	1442	4	0	0	0	5535
2011	4709	554	1364	10	13	0	0	6650
2012	696	403	688	78	12	0	0	1876
2013	5005	1520	327	44	7	0	0	6903
2014	2310	1434	1091	52	5	0	0	4892
2015	1860	1362	1107	40	8	0	0	4377
2016	195	418	711	118	5	0	0	1447
2017	3759	2207	1460	249	0	0	0	7674
2018	3044	587	1393	610	0	0	0	5634
2019	2130	168	1496	169	3	0	0	3967
2020	3347	1530	3935	226	5	0	0	9043

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2021	405	242	1791	1197	3	0	0	3636
2022	132	1693	2127	113	2	0	0	4067
2023	2602	1097	982	385	4	0	0	5069
arith.mean	4722	1755	2481	328	35	73	7	9401

Table 9.1.7 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	2060	1513	123	0	0	0	0	3696
1984	2256	1441	198	4	0	0	0	3899
1985	2425	985	108	34	3	0	0	3556
1986	805	1159	2142	32	3	8	64	4214
1987	1413	366	31	3	16	0	0	1828
1988	805	1244	1460	23	2	0	0	3533
1989	313	1647	90	1	0	0	0	2052
1990	517	872	1405	0	5	0	0	2800
1991	1415	1457	1167	0	246	0	0	4285
1992	890	1064	94	0	275	0	0	2323
1993	398	1719	1231	9	197	0	0	3554
1994	294	1102	459	15	186	0	0	2057
1995	598	975	208	0	1	0	0	1782
1996	696	2919	1222	0	966	165	0	5967
1997	1457	1837	2011	6	147	0	6	5464
1998	622	1059	4276	0	40	3	0	6000
1999	1030	1203	2974	0	0	0	0	5207
2000	979	602	81	0	0	0	0	1663
2001	3050	1132	3146	0	14	0	0	7342
2002	233	663	0	0	0	0	0	895
2003	923	1316	400	0	76	0	0	2715
2004	474	1036	417	0	2	0	0	1929

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2005	145	333	0	0	0	0	0	478
2006	224	410	5	0	0	0	0	639
2008	116	102	0	0	0	0	0	219
2009	219	172	2	0	0	0	0	393
2010	148	178	11	0	0	0	0	336
2011	165	10	0	0	0	0	0	174
2012	0	22	0	0	0	0	0	22
2013	198	160	0	0	0	0	0	358
2014	88	78	4	0	0	0	0	170
2015	0	24	0	0	0	0	0	24
2016	0	13	0	0	0	0	0	13
2017	59	290	0	0	0	0	0	349
2018	307	6	12	0	0	0	0	325
2019	335	0	0	0	0	0	0	335
2020	43	76	0	0	0	0	0	118
2021	30	18	8	0	100	0	0	156
2023	22	39	1	0	0	0	0	62
arith.mean	660	750	597	3	58	5	2	2075

Table 9.1.8 Sandeel. Number of samples from commercial catches by year and area.

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1983	79	49	0	0	0	1	0	129
1984	116	46	13	0	2	3	0	180
1985	103	32	1	19	2	3	0	160
1986	27	17	37	1	0	1	0	83
1987	63	12	70	1	0	2	0	148
1988	43	15	75	0	0	1	0	134
1989	40	9	48	0	0	1	0	98
1990	1	4	39	0	0	2	0	46

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
1991	25	32	39	1	1	0	0	98
1992	56	42	31	5	2	7	0	143
1993	24	63	72	16	0	7	0	182
1994	22	38	61	15	1	4	0	141
1995	41	33	59	7	66	2	0	208
1996	43	63	170	26	78	1	0	381
1997	41	78	153	26	8	4	0	310
1998	54	31	158	7	0	3	0	253
1999	267	54	49	45	2	2	0	419
2000	110	48	53	73	0	3	0	287
2001	226	47	59	97	1	1	0	431
2002	307	112	50	72	1	6	0	548
2003	303	115	34	175	1	4	0	632
2004	464	219	30	48	2	1	0	764
2005	327	43	35	30	0	1	0	436
2006	565	60	101	4	2	2	0	734
2007	299	167	124	1	0	1	0	592
2008	297	134	113	5	0	1	0	550
2009	317	123	15	0	0	1	0	456
2010	176	272	57	1	0	3	0	509
2011	173	54	50	4	0	11	0	292
2012	227	115	45	24	0	12	0	423
2013	287	224	62	5	0	3	0	581
2014	143	134	72	18	0	5	0	372
2015	307	121	187	41	0	4	0	660
2016	154	157	156	47	0	0	0	514
2017	280	205	79	40	0	0	0	604
2018	350	136	179	78	0	0	0	743
2019	287	86	187	32	0	0	0	592

	Area-1r	Area-2r	Area-3r	Area-4	Area-5r	Area-6	Area-7r	All
2020	255	196	194	40	0	1	0	686
2021	70	53	172	123	0	2	0	420
2022	25	160	126	24	0	1	0	336
2023	164	94	69	75	0	0	0	402
arith.mean	175	90	81	30	4	3	0	382

Table 9.2.1 Sandeel 1r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	790	1846	28971	772	320	10223	264	3085	564	2
1984	15	47117	1701	10002	333	0	9241	90	566	43
1985	5249	6221	31386	1989	212	8556	1359	2314	1601	214
1986	0	44940	7553	1652	31	87	4163	228	188	14
1987	0	4504	23572	1199	171	187	1938	4173	123	32
1988	1207	1997	8564	15229	2354	0	0	162	1439	47
1989	41	62503	6364	1346	4737	0	757	77	16	58
1990	0	16850	13920	2060	622	522	1257	417	62	18
1991	0	14939	6870	983	338	7344	6917	209	67	0
1992	2	50883	8451	845	524	104	3041	298	122	26
1993	3700	2317	6359	1732	524	1625	371	240	145	41
1994	0	22720	2979	1545	1103	0	1694	119	66	102
1995	3	38499	6461	750	307	21	3654	955	108	26
1996	8752	11404	13642	5157	966	6809	1062	1071	249	72
1997	0	40182	2558	4269	1032	0	9097	166	243	107
1998	9	9699	30835	2449	1749	1	502	1566	167	124
1999	313	42153	5531	10580	851	559	1597	164	884	313
2000	17555	34456	3435	688	1188	6291	3270	202	129	269
2001	5302	59492	8277	1069	863	63785	3105	418	41	75
2002	705	82675	10768	1279	425	10	594	111	27	53
2003	12786	3739	13443	1265	496	2025	368	4213	155	48

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2004	5134	30780	814	2350	498	655	2191	114	244	49
2005	1558	11137	4007	258	424	153	387	154	12	26
2006	2212	33506	2528	792	158	40	767	103	47	22
2007	171	10257	4416	301	164	0	1	0	0	0
2008	469	26721	4168	1315	214	8	268	80	48	7
2009	3659	16911	13219	1532	341	832	1923	387	40	3
2010	140	42232	2226	1033	123	28	1116	35	3	1
2011	229	1848	31984	1417	315	8	53	418	35	4
2012	0	392	340	3174	108	0	0	0	0	0
2013	130	18403	7515	2205	4362	8	791	184	79	54
2014	6987	8133	3083	364	360	931	69	57	14	14
2015	206	26828	1729	550	167	0	0	0	0	0
2016	0	136	1246	99	16	0	0	0	0	0
2017	64	35135	3165	4808	112	3	268	41	40	7
2018	653	1844	15538	1032	365	93	164	824	44	12
2019	12111	5708	857	1972	107	6021	321	16	17	0
2020	938	12644	1170	285	478	46	89	13	3	5
2021	23	1141	991	53	33	2	49	28	2	1
2022	58	554	35	31	5	0	0	0	0	0
2023	2512	9582	3167	399	291	45	45	13	1	1

Table 9.2.2 Sandeel 1r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	5.51	9.96	13.74	16.90	2.42	7.50	10.75	14.12	17.71
1984	5.51	9.96	13.74	16.95	3.05	7.50	10.75	14.12	17.71
1985	5.51	9.96	13.74	16.51	2.42	7.50	10.75	14.12	18.66
1986	5.51	9.96	13.74	16.30	2.42	7.50	10.75	14.12	18.76
1987	5.80	11.00	15.60	18.04	3.05	8.90	10.80	21.40	19.85

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1988	4.00	12.50	15.50	18.73	3.05	6.46	14.00	17.00	19.11
1989	4.00	12.50	15.50	18.01	3.05	10.50	14.00	17.00	19.01
1990	4.00	12.50	15.50	19.28	3.05	10.50	14.00	17.00	20.05
1991	8.20	16.40	16.90	17.20	2.60	7.50	13.60	12.00	18.70
1992	7.43	13.83	17.51	22.60	3.40	9.43	16.61	20.04	22.58
1993	7.42	10.75	15.00	20.54	4.07	6.68	11.76	15.28	20.82
1994	5.11	8.33	13.50	14.54	3.05	6.46	11.04	15.42	18.70
1995	7.09	12.23	14.57	22.47	3.03	6.33	10.01	15.49	26.68
1996	5.02	7.59	10.83	17.36	1.69	5.34	10.86	13.71	21.71
1997	6.84	7.10	8.96	13.44	2.94	7.88	13.21	15.62	17.17
1998	5.84	8.03	10.17	14.23	3.27	4.70	9.40	11.24	17.01
1999	5.14	8.18	11.35	15.27	4.23	5.53	10.51	13.39	16.18
2000	6.58	9.98	14.22	16.45	2.94	4.43	9.72	16.25	17.50
2001	4.10	8.46	12.60	21.17	2.37	4.63	8.32	15.76	27.67
2002	6.01	7.86	10.62	16.89	3.05	6.46	11.04	15.42	18.70
2003	3.44	6.95	12.29	12.65	1.39	1.48	4.30	11.68	5.33
2004	4.87	7.89	9.69	11.91	2.69	4.70	8.33	9.24	12.76
2005	6.48	9.22	11.22	13.31	3.05	6.46	11.04	15.42	18.70
2006	5.88	10.68	12.82	14.61	3.05	6.46	11.04	15.42	18.70
2007	5.50	10.59	15.89	16.25	3.05	6.46	11.04	15.42	18.70
2008	6.12	11.41	13.67	16.10	3.05	6.46	11.04	15.42	18.70
2009	5.85	11.79	17.10	18.54	3.05	6.46	11.04	15.42	18.70
2010	5.87	12.79	14.99	19.72	3.05	6.46	11.04	15.42	18.70
2011	5.53	8.80	13.37	17.26	3.05	6.46	11.04	15.42	18.70
2012	6.67	9.84	12.08	15.84	3.05	6.46	11.04	15.42	18.70
2013	4.37	6.63	11.19	12.28	3.05	6.46	11.04	15.42	18.70
2014	4.48	8.39	12.80	18.54	3.05	6.46	11.04	15.42	18.70
2015	5.19	8.46	10.29	14.24	3.05	6.46	11.04	15.42	18.70
2016	4.35	10.67	13.17	14.37	3.05	6.46	11.04	15.42	18.70

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2017	4.84	7.11	9.64	11.02	3.05	5.41	8.69	10.84	11.44
2018	3.78	6.63	9.73	11.87	3.05	6.46	11.04	15.42	18.70
2019	3.99	7.97	9.00	11.04	2.23	3.50	11.45	18.05	18.65
2020	6.64	9.65	13.08	14.59	3.05	6.46	11.04	15.42	18.70
2021	5.31	9.56	11.50	13.08	3.05	6.46	11.04	15.42	18.70
2022	4.91	8.18	10.59	12.32	2.89	5.66	10.65	15.03	17.24
2023	4.73	8.85	11.21	13.49	2.38	5.09	8.67	12.25	14.72
2024	5.12	8.84	11.08	12.90	2.72	5.43	10.57	15.23	17.60

Table 9.2.3 Sandeel 1r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1984	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1985	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1986	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1987	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1988	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1989	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1990	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1991	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1992	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1993	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1994	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1995	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1996	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1997	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1998	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
1999	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2000	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2001	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2002	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2003	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2004	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2005	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2006	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2007	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2008	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2009	0.04	0.63	0.92	0.96	0	0.04	0.63	0.92	0.96
2010	0.03	0.57	0.90	0.96	0	0.03	0.57	0.90	0.96
2011	0.04	0.58	0.89	0.98	0	0.04	0.58	0.89	0.98
2012	0.03	0.58	0.88	0.97	0	0.03	0.58	0.88	0.97
2013	0.03	0.54	0.88	0.97	0	0.03	0.54	0.88	0.97
2014	0.03	0.52	0.87	0.96	0	0.03	0.52	0.87	0.96
2015	0.04	0.61	0.91	0.97	0	0.04	0.61	0.91	0.97
2016	0.04	0.61	0.91	0.97	0	0.04	0.61	0.91	0.97
2017	0.03	0.55	0.91	0.98	0	0.03	0.55	0.91	0.98
2018	0.04	0.54	0.91	0.98	0	0.04	0.54	0.91	0.98
2019	0.04	0.49	0.87	0.94	0	0.04	0.49	0.87	0.94
2020	0.03	0.52	0.87	0.95	0	0.03	0.52	0.87	0.95
2021	0.03	0.45	0.84	0.93	0	0.03	0.45	0.84	0.93
2022	0.03	0.48	0.84	0.93	0	0.03	0.48	0.84	0.93
2023	0.03	0.47	0.78	0.91	0	0.03	0.47	0.78	0.91
2024	0.03	0.49	0.85	0.94	0	0.03	0.49	0.85	0.94

Table 9.2.4 Sandeel 1r. Survey index scaled.

year	survey	0	1	2	3
2004	Dredge	482257027	2.769312e+07	-	-
2005	Dredge	991192952	1.675959e+07	-	-
2006	Dredge	522762576	6.074692e+07	-	-
2007	Dredge	1620640116	2.853984e+07	-	-
2008	Dredge	134823329	4.917682e+07	-	-

year	survey	0	1	2	3
2009	Dredge	1199268186	3.634360e+07	-	-
2010	Dredge	194486093	4.551273e+08	-	-
2011	Dredge	201832528	1.048964e+08	-	-
2012	Dredge	467160953	1.334699e+07	-	-
2013	Dredge	166480345	3.137431e+07	-	-
2014	Dredge	1030765513	1.574684e+07	-	-
2015	Dredge	104487552	5.916521e+07	-	-
2016	Dredge	910488504	2.474110e+07	-	-
2017	Dredge	120804876	1.681141e+08	-	-
2018	Dredge	495120015	5.108405e+07	-	-
2019	Dredge	664965965	7.956823e+07	-	-
2020	Dredge	241867263	3.444528e+07	-	-
2021	Dredge	223843312	3.784715e+07	-	-
2022	Dredge	397653294	6.815302e+07	-	-
2023	Dredge	393520342	2.537684e+07	-	-
2014	RTM	-	5.100920e+04	12911.888	820.822
2015	RTM	-	1.102658e+05	9547.949	3017.843
2016	RTM	-	6.223111e+03	88696.479	7252.466
2017	RTM	-	1.010084e+05	12984.292	21850.023
2018	RTM	-	1.016697e+04	77981.871	5679.823
2019	RTM	-	4.634750e+04	10103.263	26144.144
2020	RTM	-	5.714265e+04	6802.857	2379.535
2023	RTM	-	3.295690e+04	15763.386	2713.564

Table 9.2.5 Sandeel 1r. SMS settings and statistics.

```
Model evaluation date:  2024-02-02 13:02:24.009385

Time to run model (seconds):  4.3

number of parameters: 64

Maximum gradient:  0.0041

AIC: 884

Observations used in likelihood:

Catch: 302 Survey: 64 Stock recruitment: 41 Sum: 407

Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.4000124	0	Dredge
0.7438342	1	Dredge
0.4770372	1	RTM
0.4898499	2	RTM
0.4898499	3	RTM

catchCV	ages	season

surveyCV	ages	survey
0.4689274	1	1
0.4689274	2	1
0.7568953	3	1
0.7568953	4	1
0.5562196	1	2
0.5562196	2	2
1.2048231	3	2
1.2048231	4	2

Table 9.2.6 Sandeel 1r.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0	0.5044581	0.8942963	1.1418737	1.1418737	0.6993772
1984	0	0.5700776	1.0106256	1.2904077	1.2904077	0.7903516
1985	0	0.6111931	1.0835147	1.3834754	1.3834754	0.8473539
1986	0	0.4113427	0.7292226	0.9311009	0.9311009	0.5702826
1987	0	0.3241361	0.5746239	0.7337031	0.7337031	0.4493800
1988	0	0.4425888	0.7846152	1.0018285	1.0018285	0.6136020
1989	0	0.4787653	0.8487485	1.0837165	1.0837165	0.6637569
1990	0	0.4679246	0.8295303	1.0591779	1.0591779	0.6487275
1991	0	0.3442880	0.6103490	0.7793183	0.7793183	0.4773185
1992	0	0.4986747	0.8840436	1.1287827	1.1287827	0.6913592
1993	0	0.2193623	0.3888825	0.4965409	0.4965409	0.3041224
1994	0	0.1760563	0.3121102	0.3985149	0.3985149	0.2440833
1995	0	0.3273376	0.5802996	0.7409500	0.7409500	0.4538186
1996	0	0.3141481	0.5569173	0.7110946	0.7110946	0.4355327
1997	0	0.3198007	0.5669383	0.7238897	0.7238897	0.4433695
1998	0	0.3942354	0.6988950	0.8923774	0.8923774	0.5465652
1999	0	0.7494755	1.0014002	0.7765438	0.7765438	0.8754379
2000	0	0.6187041	0.8266720	0.6410494	0.6410494	0.7226881
2001	0	0.9637147	1.2876526	0.9985205	0.9985205	1.1256837
2002	0	0.7164517	0.9572759	0.7423273	0.7423273	0.8368638
2003	0	0.5935845	0.7931089	0.6150226	0.6150226	0.6933467

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2004	0	0.6191288	0.8272394	0.6414894	0.6414894	0.7231841
2005	0	0.3182598	0.4252379	0.3297542	0.3297542	0.3717489
2006	0	0.4339876	0.5798658	0.4496616	0.4496616	0.5069267
2007	0	0.1540227	0.2057951	0.1595854	0.1595854	0.1799089
2008	0	0.3325348	0.4443113	0.3445448	0.3445448	0.3884231
2009	0	0.4095691	0.5472394	0.4243612	0.4243612	0.4784042
2010	0	0.2814347	0.3760346	0.2915990	0.2915990	0.3287346
2011	0	0.4093886	0.5469983	0.4241742	0.4241742	0.4781935
2012	0	0.0583214	0.0779253	0.0604278	0.0604278	0.0681233
2013	0	0.4193981	0.5603723	0.4345452	0.4345452	0.4898852
2014	0	0.2014784	0.2692023	0.2087551	0.2087551	0.2353404
2015	0	0.1558805	0.2082774	0.1615104	0.1615104	0.1820790
2016	0	0.0163295	0.0218184	0.0169193	0.0169193	0.0190740
2017	0	0.3202913	0.4279523	0.3318590	0.3318590	0.3741218
2018	0	0.2826800	0.3776986	0.2928894	0.2928894	0.3301893
2019	0	0.2086044	0.2787235	0.2161384	0.2161384	0.2436640
2020	0	0.2843133	0.3798808	0.2945816	0.2945816	0.3320971
2021	0	0.0365488	0.0488342	0.0378688	0.0378688	0.0426915
2022	0	0.0110479	0.0147614	0.0114469	0.0114469	0.0129046
2023	0	0.2199799	0.2939228	0.2279248	0.2279248	0.2569514
arith.mean	0	0.3712078	0.5641906	0.5763476	0.5763476	0.4676992

Table 9.2.7 Sandeel 1r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.384	0.680	0.868	0.868	0.121	0.214	0.273	0.273
1984	0.438	0.776	0.991	0.991	0.132	0.234	0.299	0.299
1985	0.469	0.831	1.062	1.062	0.142	0.252	0.322	0.322
1986	0.364	0.646	0.824	0.824	0.047	0.084	0.107	0.107
1987	0.241	0.428	0.546	0.546	0.083	0.147	0.188	0.188

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1988	0.395	0.701	0.895	0.895	0.047	0.084	0.107	0.107
1989	0.460	0.816	1.042	1.042	0.018	0.033	0.042	0.042
1990	0.438	0.776	0.991	0.991	0.030	0.054	0.069	0.069
1991	0.261	0.463	0.592	0.592	0.083	0.147	0.188	0.188
1992	0.447	0.792	1.011	1.011	0.052	0.092	0.118	0.118
1993	0.196	0.348	0.444	0.444	0.023	0.041	0.053	0.053
1994	0.159	0.282	0.359	0.359	0.017	0.031	0.039	0.039
1995	0.292	0.518	0.662	0.662	0.035	0.062	0.079	0.079
1996	0.273	0.485	0.619	0.619	0.041	0.072	0.092	0.092
1997	0.234	0.416	0.531	0.531	0.085	0.151	0.193	0.193
1998	0.358	0.634	0.810	0.810	0.036	0.065	0.083	0.083
1999	0.657	0.878	0.681	0.681	0.092	0.123	0.096	0.096
2000	0.531	0.709	0.550	0.550	0.088	0.117	0.091	0.091
2001	0.690	0.922	0.715	0.715	0.274	0.365	0.283	0.283
2002	0.696	0.929	0.721	0.721	0.021	0.028	0.022	0.022
2003	0.511	0.682	0.529	0.529	0.083	0.111	0.086	0.086
2004	0.577	0.770	0.597	0.597	0.042	0.057	0.044	0.044
2005	0.305	0.408	0.316	0.316	0.013	0.017	0.014	0.014
2006	0.414	0.553	0.429	0.429	0.020	0.027	0.021	0.021
2007	0.154	0.206	0.160	0.160	0.000	0.000	0.000	0.000
2008	0.322	0.430	0.334	0.334	0.010	0.014	0.011	0.011
2009	0.390	0.521	0.404	0.404	0.020	0.026	0.020	0.020
2010	0.268	0.358	0.278	0.278	0.013	0.018	0.014	0.014
2011	0.395	0.527	0.409	0.409	0.015	0.020	0.015	0.015
2012	0.058	0.078	0.060	0.060	0.000	0.000	0.000	0.000
2013	0.419	0.560	0.435	0.435	0.000	0.000	0.000	0.000
2014	0.194	0.259	0.201	0.201	0.008	0.011	0.008	0.008
2015	0.156	0.208	0.162	0.162	0.000	0.000	0.000	0.000
2016	0.016	0.022	0.017	0.017	0.000	0.000	0.000	0.000

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2017	0.315	0.421	0.326	0.326	0.005	0.007	0.006	0.006
2018	0.255	0.341	0.264	0.264	0.028	0.037	0.029	0.029
2019	0.179	0.239	0.185	0.185	0.030	0.040	0.031	0.031
2020	0.280	0.375	0.291	0.291	0.004	0.005	0.004	0.004
2021	0.034	0.045	0.035	0.035	0.003	0.004	0.003	0.003
2022	0.011	0.015	0.011	0.011	0.000	0.000	0.000	0.000
2023	0.218	0.291	0.226	0.226	0.002	0.003	0.002	0.002

Table 9.2.8 Sandeel 1r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.38	0.36	0.29	0.27	0.44	0.42	0.35	0.29	0.29
1984	0.38	0.36	0.29	0.27	0.44	0.42	0.35	0.29	0.29
1985	0.36	0.34	0.28	0.26	0.46	0.44	0.36	0.31	0.31
1986	0.37	0.35	0.29	0.27	0.46	0.44	0.37	0.32	0.32
1987	0.38	0.37	0.30	0.28	0.47	0.45	0.38	0.34	0.34
1988	0.39	0.38	0.30	0.28	0.48	0.46	0.37	0.34	0.34
1989	0.41	0.40	0.32	0.29	0.48	0.46	0.36	0.34	0.34
1990	0.41	0.40	0.32	0.29	0.49	0.46	0.35	0.33	0.33
1991	0.41	0.39	0.32	0.29	0.49	0.46	0.34	0.33	0.33
1992	0.41	0.39	0.31	0.29	0.48	0.44	0.32	0.31	0.31
1993	0.40	0.37	0.30	0.28	0.47	0.44	0.31	0.30	0.30
1994	0.39	0.36	0.29	0.27	0.49	0.45	0.32	0.31	0.31
1995	0.38	0.37	0.29	0.26	0.48	0.46	0.34	0.32	0.32
1996	0.35	0.34	0.27	0.24	0.51	0.48	0.35	0.33	0.33
1997	0.35	0.35	0.29	0.24	0.51	0.48	0.36	0.32	0.32
1998	0.38	0.38	0.31	0.25	0.57	0.53	0.37	0.32	0.32
1999	0.41	0.41	0.33	0.26	0.59	0.53	0.40	0.32	0.32
2000	0.42	0.42	0.35	0.27	0.59	0.53	0.41	0.32	0.32
2001	0.38	0.38	0.33	0.25	0.59	0.52	0.44	0.31	0.31

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2002	0.42	0.41	0.37	0.28	0.61	0.55	0.49	0.31	0.31
2003	0.44	0.44	0.39	0.29	0.63	0.56	0.53	0.31	0.31
2004	0.49	0.49	0.44	0.32	0.64	0.58	0.57	0.32	0.31
2005	0.50	0.50	0.44	0.33	0.66	0.58	0.58	0.33	0.31
2006	0.54	0.54	0.46	0.35	0.71	0.62	0.62	0.35	0.33
2007	0.55	0.55	0.46	0.37	0.72	0.63	0.63	0.37	0.35
2008	0.55	0.55	0.46	0.38	0.67	0.61	0.61	0.37	0.36
2009	0.48	0.48	0.40	0.34	0.63	0.58	0.58	0.37	0.36
2010	0.46	0.46	0.39	0.34	0.66	0.61	0.61	0.40	0.38
2011	0.51	0.51	0.43	0.36	0.74	0.68	0.68	0.44	0.41
2012	0.58	0.57	0.47	0.39	0.77	0.71	0.71	0.44	0.41
2013	0.59	0.58	0.47	0.38	0.72	0.67	0.67	0.40	0.37
2014	0.52	0.52	0.43	0.35	0.70	0.64	0.63	0.38	0.35
2015	0.53	0.53	0.44	0.34	0.69	0.62	0.62	0.37	0.34
2016	0.49	0.49	0.42	0.33	0.71	0.63	0.63	0.38	0.35
2017	0.50	0.50	0.44	0.33	0.67	0.60	0.59	0.37	0.33
2018	0.47	0.47	0.41	0.31	0.62	0.55	0.55	0.35	0.31
2019	0.47	0.47	0.42	0.32	0.59	0.52	0.51	0.33	0.29
2020	0.48	0.48	0.43	0.34	0.59	0.51	0.51	0.32	0.30
2021	0.47	0.47	0.43	0.34	0.58	0.49	0.49	0.31	0.29
2022	0.33	0.32	0.30	0.23	0.58	0.49	0.49	0.31	0.29
2023	0.33	0.32	0.30	0.23	0.58	0.50	0.50	0.32	0.30
2024	0.38	0.37	0.34	0.27	0.58	0.50	0.50	0.32	0.30

Table 9.2.9 Sandeel 1r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1983	245077047	11170752	45056399	2527705.7	296978.9
1984	65500662	158077493	3035165	9026892.7	507594.9
1985	424615323	42248675	40222756	541306.2	1475160.0

years	Age 0	Age 1	Age 2	Age 3	Age 4
1986	59675539	268028389	10270949	6722640.8	285254.4
1987	44482724	37785011	79411660	2415233.8	1505634.0
1988	183632700	27726572	11834301	21258329.4	1008884.7
1989	92470964	113379874	7570935	2548229.3	4320094.6
1990	138818658	56993222	29303504	1510590.5	1227182.1
1991	148637372	84986617	14873051	6052802.5	500177.9
1992	42105123	90632596	25227277	3881656.7	1586113.5
1993	181486231	26097958	23425763	5125029.4	958494.3
1994	252848163	112949497	9007341	7995443.3	2037833.5
1995	59314859	155550354	40773652	3318023.7	3712598.6
1996	421303514	36534591	48529513	11319759.3	1853319.2
1997	63014491	253227808	11740702	13894780.3	3566989.9
1998	109972300	37662894	80020168	3277079.4	4661883.0
1999	158808396	62235559	10262904	18739081.5	1790080.5
2000	220876438	88425827	11495420	1687708.9	4942841.7
2001	406183593	122893006	18495920	2194454.3	1912315.9
2002	31700748	225871200	19092356	2251392.0	829531.3
2003	180874509	17185889	42071356	2957358.8	761010.8
2004	94940920	96403304	3472734	7197320.0	1016581.9
2005	223195839	49891375	17805203	526068.5	2073334.6
2006	130334943	114795305	12271400	3965375.6	962550.4
2007	273978793	64146249	23294049	2163975.9	1429724.1
2008	95050587	133241247	16839593	5826231.0	1390535.2
2009	580173032	48500976	29941455	3393989.8	2275839.7
2010	48548431	309330017	11182949	6031087.4	1760748.2
2011	51769630	25160003	79694693	2627470.7	2677882.1
2012	132646258	24716796	5081149	14067668.6	1536821.8
2013	79321813	61634834	6453416	1305656.7	5941835.5
2014	296846755	38527521	11547286	1053434.7	2156650.6

years	Age 0	Age 1	Age 2	Age 3	Age 4
2015	44965443	147914395	9901009	2780587.4	1257612.6
2016	339725775	22563802	40166732	2557986.2	1589418.4
2017	30615606	166511673	7241909	12863615.7	1921269.0
2018	61316958	15687840	40318748	1580861.5	4827021.7
2019	117436752	32848216	4248887	9971933.5	2487132.7
2020	37768054	65409788	9907859	1200158.7	4880001.1
2021	62569563	21005282	18290141	2533522.2	2350944.2
2022	86161161	35115172	7688947	6669990.0	2360642.6
2023	97295785	48355204	15288549	3360468.1	4953337.5

Table 9.2.10 Sandeel 1r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1983	245077047	550062	321665	261037	0.699
1984	65500662	1033870	178732	412388	0.79
1985	424615323	665201	292091	330970	0.847
1986	59675539	1676154	216717	513689	0.57
1987	44482724	1157521	619474	382150	0.449
1988	183632700	607236	420061	289486	0.614
1989	92470964	665459	190141	260450	0.664
1990	138818658	641341	284383	273180	0.649
1991	148637372	1051704	285638	286674	0.477
1992	42105123	1126107	345202	450175	0.691
1993	181486231	542094	256539	129776	0.304
1994	252848163	789676	199871	132564	0.244
1995	59314859	1732448	485214	489051	0.454
1996	421303514	706234	383415	245386	0.436
1997	63014491	1989065	287049	494242	0.443
1998	109972300	961867	507826	380516	0.547
1999	158808396	643472	288918	292683	0.875

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2000	220876438	801946	197260	304390	0.723
2001	406183593	728827	184353	379927	1.126
2002	31700748	1544684	187478	672407	0.837
2003	180874509	397452	229151	161922	0.693
2004	94940920	578435	113179	215125	0.723
2005	223195839	520913	148957	122249	0.372
2006	130334943	870476	171502	248318	0.507
2007	273978793	656857	224112	81603	0.18
2008	95050587	1109584	250450	255801	0.388
2009	580173032	736912	328266	223510	0.478
2010	48548431	2084846	245337	416704	0.329
2011	51769630	921973	488400	294826	0.478
2012	132646258	408969	206415	19117	0.068
2013	79321813	399429	114639	111267	0.49
2014	296846755	323155	105780	50876	0.235
2015	44965443	897524	124022	104672	0.182
2016	339725775	583119	319035	9364	0.019
2017	30615606	1003326	183835	223171	0.374
2018	61316958	399102	217841	95795	0.33
2019	117436752	282167	125157	44826	0.244
2020	37768054	616539	144524	128988	0.332
2021	62569563	346142	134493	11502	0.043
2022	86161161	335075	120968	3395	0.013
2023	97295785	468573	159384	87113	0.257
2024	115580737		175408		

Table 9.2.11 Sandeel 1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	116079425	54439791.000	16990940.000	5023326.000	3772938.000
Exploitation pattern season 1	-	0.848	1.134	0.879	0.879
Exploitation pattern season 2	-	0.008	0.010	0.008	0.008
west season 1	2.18	5.115	8.842	11.075	12.902
weca season 1	2.18	5.115	8.842	11.075	12.902
weca season 2	2.719	5.434	10.570	15.230	17.603
Proportion mature (2024)	-	0.026	0.465	0.783	0.914
Proportion mature (2025)	-	0.026	0.465	0.783	0.914
Natural mortality season 1	-	0.327	0.324	0.299	0.232
Natural mortality season 2	0.581	0.499	0.495	0.316	0.296

Table 9.2.12 Sandeel 1r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	132314.85	0.36	166003.0	-5	10
F = 0	0.00	0.00	229840.1	31	-100
Bescapement (no cap)	185442.71	0.55	140824.0	-20	54
Blim	260656.89	0.87	105809.0	-40	116
F = F 2023	98713.66	0.26	182077.7	4	-18
Obs TAC	5000.00	0.01	227404.1	30	-96

Table 9.3.1 Sandeel 2r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	147	4162	6191	203	67	12882	476	877	104	0
1984	2	10284	912	1154	38	0	3846	186	193	10
1985	830	1406	5479	472	109	1795	387	760	381	49
1986	5	24479	3144	436	6	1443	3495	208	95	7
1987	0	831	2621	131	20	45	512	591	17	4
1988	400	1030	3379	3163	478	5602	545	226	775	31

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1989	1237	23364	1666	938	909	2819	3809	273	10	34
1990	0	7328	3964	587	177	5046	854	196	29	9
1991	0	14203	2099	451	156	10053	3628	110	35	1
1992	117	12016	4066	475	298	6830	886	85	34	7
1993	7835	6341	873	467	220	18579	548	440	153	35
1994	0	35123	3616	158	54	0	5885	683	217	71
1995	901	4230	1381	201	66	1000	1669	1646	201	143
1996	4447	4614	708	420	107	28160	6457	258	156	39
1997	43	37584	1381	387	55	29	8809	207	125	38
1998	1920	850	4805	201	115	1081	42	1493	91	76
1999	736	1343	104	706	118	6817	682	100	484	81
2000	0	8296	430	255	583	0	1043	179	108	167
2001	2273	4438	735	82	310	7117	2691	559	73	229
2002	15	17190	250	142	58	3	1415	195	51	31
2003	559	297	1689	96	59	6843	221	488	39	15
2004	1283	10301	671	454	170	741	1921	198	252	51
2005	26	1896	640	66	165	2	514	317	31	90
2006	0	2249	291	96	28	0	1123	105	46	18
2007	32	4961	302	40	5	0	0	0	0	0
2008	37	3658	479	50	16	0	247	51	7	1
2009	482	3128	337	14	5	271	1950	24	3	2
2010	0	7164	85	90	15	1	1247	40	26	5
2011	0	548	1351	226	46	0	3	14	3	1
2012	8	291	315	308	41	5	12	81	1	0
2013	0	4501	1045	320	77	0	372	38	15	3
2014	39	5543	2978	318	81	191	38	34	16	34
2015	0	2146	853	655	228	0	10	20	17	7
2016	2451	310	144	103	63	24	4	0	0	0

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2017	0	22369	233	82	13	0	1269	5	24	1
2018	0	53	1996	57	12	0	0	19	2	0
2019	12	206	50	171	4	0	0	0	0	0
2020	408	7526	426	180	349	4	15	2	1	3
2021	0	606	96	3	3	0	0	0	0	0
2022	160	5925	1016	459	278	0	0	0	0	0
2023	0	4257	1049	179	166	0	57	45	9	9

Table 9.3.2 Sandeel 2r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	5.63	10.45	18.34	20.78	3.01	13.08	23.79	25.47	17.71
1984	5.58	12.48	14.62	18.41	3.51	10.73	26.64	23.52	17.71
1985	5.54	10.20	17.66	33.85	2.60	10.10	19.57	22.17	30.20
1986	5.60	11.75	18.16	16.30	3.01	9.90	18.74	14.12	18.76
1987	5.72	11.15	16.16	21.51	1.96	10.76	11.00	21.40	19.85
1988	5.20	12.84	16.04	18.87	3.03	13.23	24.06	18.82	26.93
1989	5.00	12.86	16.06	18.01	5.00	9.11	15.64	17.00	19.01
1990	4.85	12.65	18.80	26.30	3.00	12.67	23.73	30.51	36.87
1991	7.62	15.80	19.68	24.18	3.13	7.72	13.76	12.43	44.00
1992	6.07	11.32	18.36	28.95	5.47	9.86	16.90	20.04	22.58
1993	7.02	15.66	16.81	21.19	2.34	13.84	15.80	17.32	19.33
1994	4.20	9.10	22.13	27.48	3.51	7.26	16.63	23.34	23.86
1995	9.31	15.37	19.86	20.84	5.27	9.26	14.75	19.08	20.97
1996	5.79	15.90	19.48	28.83	3.03	4.60	17.59	19.22	26.10
1997	4.35	7.99	9.33	18.45	4.55	6.68	11.47	16.12	17.77
1998	6.15	10.96	16.25	21.03	3.73	14.45	14.48	16.86	17.71
1999	7.10	13.15	15.98	18.52	3.83	6.83	12.59	17.58	26.67
2000	7.25	13.67	16.97	20.10	3.49	11.54	13.50	18.60	18.76
2001	5.66	13.84	17.54	20.60	2.97	4.59	12.68	18.41	22.00

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2002	5.67	12.57	17.41	20.48	3.50	7.69	14.66	15.73	17.81
2003	6.10	11.51	13.91	15.73	3.23	5.84	12.56	25.04	29.76
2004	7.03	10.53	13.29	16.51	3.61	8.70	11.90	12.80	13.61
2005	7.32	11.83	14.25	14.45	3.51	9.15	15.76	19.27	25.06
2006	8.39	11.36	13.27	14.48	3.51	9.15	15.76	19.27	25.06
2007	7.12	14.37	15.91	19.30	3.51	9.15	15.76	19.27	25.06
2008	5.83	14.99	22.76	30.57	3.51	9.15	15.76	19.27	25.06
2009	6.19	12.09	16.50	17.89	3.31	5.08	24.89	38.52	18.16
2010	5.63	10.76	23.29	25.17	3.51	9.15	15.76	19.27	25.06
2011	7.25	12.01	13.83	14.70	3.51	9.15	15.76	19.27	25.06
2012	8.73	12.73	14.07	15.63	3.51	9.15	15.76	19.27	25.06
2013	6.39	8.66	15.11	15.38	3.51	9.65	12.85	15.19	16.44
2014	5.04	9.89	12.65	16.42	3.51	9.15	15.76	19.27	25.06
2015	6.87	12.63	14.72	15.71	3.51	9.15	15.76	19.27	25.06
2016	3.37	12.73	14.22	15.25	3.51	9.15	15.76	19.27	25.06
2017	5.76	8.87	12.79	18.89	3.50	8.13	13.47	11.05	21.17
2018	4.97	9.42	13.03	14.58	3.51	9.15	15.76	19.27	25.06
2019	7.97	12.96	15.91	18.62	3.51	9.15	15.76	19.27	25.06
2020	6.73	14.98	17.60	24.35	3.51	9.15	15.76	19.27	25.06
2021	4.85	11.77	16.64	18.85	3.51	9.15	15.76	19.27	25.06
2022	6.06	11.60	15.20	19.06	3.51	8.94	15.31	17.63	24.28
2023	5.34	10.34	13.64	14.43	2.74	7.02	11.89	14.58	19.38
2024	6.19	12.33	15.80	19.06	3.36	8.68	14.90	18.01	23.77

Table 9.3.3 Sandeel 2r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1984	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1985	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1986	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1987	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1988	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1989	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1990	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1991	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1992	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1993	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1994	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1995	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1996	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1997	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1998	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
1999	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2000	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2001	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2002	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2003	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2004	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2005	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2006	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2007	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2008	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2009	0.05	0.78	0.95	1.00	0	0.05	0.78	0.95	1.00
2010	0.03	0.78	0.95	1.00	0	0.03	0.78	0.95	1.00
2011	0.03	0.79	0.95	1.00	0	0.03	0.79	0.95	1.00
2012	0.03	0.78	0.95	1.00	0	0.03	0.78	0.95	1.00
2013	0.03	0.68	0.95	1.00	0	0.03	0.68	0.95	1.00
2014	0.03	0.67	0.99	1.00	0	0.03	0.67	0.99	1.00

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2015	0.01	0.77	0.99	1.00	0	0.01	0.77	0.99	1.00
2016	0.01	0.64	0.98	1.00	0	0.01	0.64	0.98	1.00
2017	0.02	0.64	0.98	1.00	0	0.02	0.64	0.98	1.00
2018	0.01	0.60	0.98	1.00	0	0.01	0.60	0.98	1.00
2019	0.02	0.58	0.98	0.99	0	0.02	0.58	0.98	0.99
2020	0.01	0.59	0.97	0.99	0	0.01	0.59	0.97	0.99
2021	0.01	0.50	0.97	0.99	0	0.01	0.50	0.97	0.99
2022	0.02	0.59	0.98	0.99	0	0.02	0.59	0.98	0.99
2023	0.02	0.59	0.97	0.99	0	0.02	0.59	0.97	0.99
2024	0.02	0.57	0.98	0.99	0	0.02	0.57	0.98	0.99

Table 9.3.4 Sandeel 2r. Survey index scaled.

year	survey	0	1
2004	Dredge	2068867991	396885535
2005	Dredge	2703278191	394345595
2006	Dredge	10570111832	399752088
2007	Dredge	6962204638	1351598928
2008	Dredge	1657628704	252831436
2009	Dredge	3993255249	260845097
2010	Dredge	702870863	1501230744
2011	Dredge	1208675259	283802056
2012	Dredge	4007437682	198514104
2013	Dredge	3280449563	1305205108
2014	Dredge	4322256934	749308778
2015	Dredge	329351448	147881716
2016	Dredge	23624078663	85417595
2017	Dredge	391037552	2680128753
2018	Dredge	1473864070	228801528
2019	Dredge	12397583925	501892168

year	survey	0	1
2020	Dredge	5030520985	712723398
2021	Dredge	19349964817	470303399
2022	Dredge	10759723421	2054281329
2023	Dredge	433200143	1971456343

Table 9.3.5 Sandeel 2r. SMS settings and statistics.

```
Model evaluation date:  2024-01-31 16:02:33.104762

Time to run model (seconds):  3.4

number of parameters: 67

Maximum gradient:  5e-04

AIC: 976

Observations used in likelihood:

Catch: 312 Survey: 40 Stock recruitment: 41 Sum: 393

Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.5992212	0	Dredge
0.4802853	1	Dredge

catchCV	ages	season
0.4656523	1	1
0.4656523	2	1
0.9325990	3	1
0.9325990	4	1
0.8194081	1	2
0.8194081	2	2
1.2988993	3	2
1.2988993	4	2

Table 9.3.6 Sandeel 2r.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0	0.4923959	0.7742001	0.9916167	0.9916167	0.6332980
1984	0	0.4337831	0.6820426	0.8735788	0.8735788	0.5579129
1985	0	0.4040066	0.6352245	0.8136129	0.8136129	0.5196155
1986	0	0.5898270	0.9273923	1.1878294	1.1878294	0.7586097
1987	0	0.1294137	0.2034787	0.2606211	0.2606211	0.1664462

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1988	0	0.4602725	0.7236921	0.9269246	0.9269246	0.5919823
1989	0	0.7328974	1.1523438	1.4759533	1.4759533	0.9426206
1990	0	0.5155158	0.8105519	1.0381770	1.0381770	0.6630339
1991	0	0.5541209	0.8712512	1.1159223	1.1159223	0.7126860
1992	0	0.5227433	0.8219158	1.0527322	1.0527322	0.6723295
1993	0	0.4788645	0.7529246	0.9643663	0.9643663	0.6158945
1994	0	0.4794717	0.7538793	0.9655892	0.9655892	0.6166755
1995	0	0.2876803	0.4523232	0.5793479	0.5793479	0.3700017
1996	0	0.4958449	0.7796231	0.9985626	0.9985626	0.6377340
1997	0	0.5828766	0.9164641	1.1738322	1.1738322	0.7496703
1998	0	0.3086226	0.4852512	0.6215229	0.6215229	0.3969369
1999	0	0.5495992	0.4415786	0.5299354	0.5299354	0.4955889
2000	0	0.6301615	0.5063069	0.6076154	0.6076154	0.5682342
2001	0	0.6554768	0.5266466	0.6320249	0.6320249	0.5910617
2002	0	0.7378099	0.5927976	0.7114123	0.7114123	0.6653037
2003	0	0.6418037	0.5156609	0.6188410	0.6188410	0.5787323
2004	0	1.0255684	0.8239989	0.9888754	0.9888754	0.9247837
2005	0	1.2574156	1.1822128	0.9223706	0.9223706	1.2198142
2006	0	1.2884489	1.2113901	0.9451349	0.9451349	1.2499195
2007	0	0.7539890	0.7088949	0.5530847	0.5530847	0.7314420
2008	0	0.7800267	0.7333753	0.5721845	0.5721845	0.7567010
2009	0	0.7421778	0.6977900	0.5444206	0.5444206	0.7199839
2010	0	0.3251831	0.4793922	0.4989766	0.4989766	0.4022876
2011	0	0.1745138	0.2572721	0.2677824	0.2677824	0.2158929
2012	0	0.1310028	0.1931273	0.2010171	0.2010171	0.1620651
2013	0	0.5158548	0.7604846	0.7915525	0.7915525	0.6381697
2014	0	0.4662145	0.6873038	0.7153820	0.7153820	0.5767592
2015	0	0.4289722	0.6324004	0.6582357	0.6582357	0.5306863
2016	0	0.1332219	0.1963987	0.2044221	0.2044221	0.1648103

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2017	0	0.7649472	1.1277021	1.1737718	1.1737718	0.9463247
2018	0	0.1834955	0.2705132	0.2815644	0.2815644	0.2270044
2019	0	0.0521417	0.0768684	0.0800087	0.0800087	0.0645051
2020	0	0.4953729	0.7302897	0.7601241	0.7601241	0.6128313
2021	0	0.0748727	0.1103790	0.1148883	0.1148883	0.0926259
2022	0	0.5246523	0.7734541	0.8050518	0.8050518	0.6490532
2023	0	0.3508933	0.5172948	0.5384277	0.5384277	0.4340941
arith.mean	0	0.5159062	0.6462461	0.7257877	0.7257877	0.5810762

Table 9.3.7 Sandeel 2r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.335	0.527	0.674	0.674	0.157	0.248	0.317	0.317
1984	0.284	0.446	0.571	0.571	0.150	0.236	0.302	0.302
1985	0.301	0.474	0.607	0.607	0.103	0.161	0.207	0.207
1986	0.469	0.738	0.945	0.945	0.121	0.190	0.243	0.243
1987	0.091	0.144	0.184	0.184	0.038	0.060	0.077	0.077
1988	0.331	0.520	0.666	0.666	0.129	0.204	0.261	0.261
1989	0.561	0.883	1.131	1.131	0.171	0.270	0.345	0.345
1990	0.425	0.668	0.855	0.855	0.091	0.143	0.183	0.183
1991	0.402	0.633	0.811	0.811	0.152	0.238	0.305	0.305
1992	0.412	0.648	0.830	0.830	0.111	0.174	0.223	0.223
1993	0.300	0.472	0.604	0.604	0.179	0.281	0.360	0.360
1994	0.365	0.574	0.735	0.735	0.115	0.180	0.231	0.231
1995	0.186	0.293	0.375	0.375	0.101	0.160	0.204	0.204
1996	0.192	0.302	0.387	0.387	0.304	0.478	0.612	0.612
1997	0.392	0.616	0.789	0.789	0.191	0.301	0.385	0.385
1998	0.198	0.312	0.400	0.400	0.110	0.173	0.222	0.222
1999	0.171	0.137	0.165	0.165	0.379	0.304	0.365	0.365
2000	0.441	0.354	0.425	0.425	0.189	0.152	0.183	0.183
2001	0.299	0.240	0.289	0.289	0.356	0.286	0.343	0.343

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2002	0.529	0.425	0.510	0.510	0.209	0.168	0.201	0.201
2003	0.228	0.183	0.219	0.219	0.414	0.333	0.399	0.399
2004	0.699	0.562	0.674	0.674	0.326	0.262	0.314	0.314
2005	0.732	0.688	0.537	0.537	0.526	0.494	0.386	0.386
2006	0.641	0.603	0.470	0.470	0.648	0.609	0.475	0.475
2007	0.754	0.709	0.553	0.553	0.000	0.000	0.000	0.000
2008	0.618	0.581	0.454	0.454	0.162	0.152	0.119	0.119
2009	0.470	0.442	0.345	0.345	0.272	0.256	0.200	0.200
2010	0.276	0.406	0.423	0.423	0.050	0.073	0.076	0.076
2011	0.172	0.253	0.264	0.264	0.003	0.004	0.004	0.004
2012	0.125	0.184	0.192	0.192	0.006	0.009	0.009	0.009
2013	0.471	0.695	0.723	0.723	0.045	0.066	0.068	0.068
2014	0.445	0.655	0.682	0.682	0.022	0.032	0.033	0.033
2015	0.422	0.622	0.648	0.648	0.007	0.010	0.010	0.010
2016	0.130	0.191	0.199	0.199	0.004	0.005	0.006	0.006
2017	0.684	1.008	1.050	1.050	0.081	0.119	0.124	0.124
2018	0.182	0.268	0.279	0.279	0.002	0.002	0.002	0.002
2019	0.052	0.077	0.080	0.080	0.000	0.000	0.000	0.000
2020	0.474	0.699	0.728	0.728	0.021	0.031	0.032	0.032
2021	0.075	0.110	0.115	0.115	0.000	0.000	0.000	0.000
2022	0.525	0.773	0.805	0.805	0.000	0.000	0.000	0.000
2023	0.340	0.501	0.522	0.522	0.011	0.016	0.017	0.017

Table 9.3.8 Sandeel 2r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1983	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1984	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1985	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1986	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1988	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1989	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1990	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1991	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1992	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1993	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1994	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1995	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1996	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1997	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1998	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
1999	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2000	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2001	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2002	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2003	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2004	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2005	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2006	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2007	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2008	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2009	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2010	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2011	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2012	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2013	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2014	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2015	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2016	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2017	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2018	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2019	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2020	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2021	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2022	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2023	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36
2024	0.52	0.46	0.37	0.32	0.8	0.61	0.46	0.38	0.36

Table 9.3.9 Sandeel 2r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1983	123674288	15406883	12669477.1	589390.72	46788.09
1984	37915230	55619583	3063416.4	2340445.72	111922.53
1985	246491158	17051477	11726655.9	620539.51	484510.06
1986	44948897	110853561	3703738.0	2489260.86	238466.76
1987	28008431	20214702	19995262.2	587015.56	394788.36
1988	135635566	12596129	5778295.9	6536242.36	367375.18
1989	60457329	60998884	2586302.8	1122729.20	1293797.53
1990	102968083	27189252	9535964.9	327335.85	270748.67
1991	60145601	46307457	5282599.2	1698701.80	103209.74
1992	75439939	27049060	8656361.0	885602.47	279621.92
1993	144703712	33927326	5217515.2	1524588.36	195183.47
1994	48867331	65077068	6837817.6	984562.91	311821.98
1995	63569666	21976925	13107870.3	1289088.15	236935.78
1996	321307369	28588952	5362472.2	3340883.90	407873.20
1997	11037585	144500381	5664891.4	985257.51	656634.68
1998	22353693	4963893	26246112.3	907709.81	246467.55
1999	53824536	10053044	1186111.1	6472824.15	296995.82

years	Age 0	Age 1	Age 2	Age 3	Age 4
2000	29975024	24206310	1887755.7	305577.18	1885734.48
2001	114610572	13480557	4193619.2	455858.66	598466.29
2002	10933558	51543391	2277057.4	992293.19	275327.01
2003	36690057	4917109	8018300.2	504308.14	298224.32
2004	16675214	16500484	842003.9	1918246.28	209426.02
2005	17952422	7499282	1925014.7	147988.05	376028.45
2006	27481310	8073677	693852.4	236470.12	103438.53
2007	19025175	12359069	724171.1	82782.36	63698.98
2008	14268916	8556122	1891770.9	142804.79	41007.53
2009	55854309	6417107	1276003.2	364031.04	49725.49
2010	12431878	25119153	993920.5	254434.57	114227.82
2011	11203734	5590943	5903585.2	246561.36	107978.02
2012	46404649	5038614	1527674.2	1828751.56	130801.55
2013	24182165	20869392	1437981.7	504576.87	759684.43
2014	9620241	10875356	4053339.4	269308.34	282126.90
2015	4071265	4326476	2219755.6	816754.35	131963.08
2016	126157455	1830955	916579.3	472528.36	234062.09
2017	2823549	56736328	521382.2	301749.06	278268.22
2018	7724069	1269824	8589837.9	67635.10	87567.71
2019	30045964	3473717	343865.5	2625870.54	57527.12
2020	19397165	13512461	1072718.3	127578.01	1170245.10
2021	59290298	8723416	2678753.8	207059.71	305174.10
2022	51921706	26664407	2633333.4	961095.47	224797.40
2023	2641494	23350558	5133509.9	486821.46	253551.02

Table 9.3.10 Sandeel 2r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1983	123674288	230902	118395	99697	0.633
1984	37915230	384786	79907	124031	0.558

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1985	246491158	241509	124414	85325	0.52
1986	44948897	713203	111897	269793	0.759
1987	28008431	356546	196406	44285	0.166
1988	135635566	251535	167687	109202	0.592
1989	60457329	379706	81564	172560	0.943
1990	102968083	265816	113277	108860	0.663
1991	60145601	472158	116884	163345	0.713
1992	75439939	286639	107921	110241	0.672
1993	144703712	349609	103943	120621	0.616
1994	48867331	366206	91380	125420	0.617
1995	63569666	436778	196073	97463	0.37
1996	321307369	327614	148225	102140	0.638
1997	11037585	695586	87607	247469	0.75
1998	22353693	338217	244183	99565	0.397
1999	53824536	195918	119667	52876	0.496
2000	29975024	244366	71577	86969	0.568
2001	114610572	154672	68805	44462	0.591
2002	10933558	343908	58997	134824	0.665
2003	36690057	133988	84526	38418	0.579
2004	16675214	153800	40439	74132	0.925
2005	17952422	85199	27861	45661	1.22
2006	27481310	80290	14007	41151	1.25
2007	19025175	100954	14980	42862	0.731
2008	14268916	82723	28871	34304	0.757
2009	55854309	62038	20579	23754	0.72
2010	12431878	161024	21666	36829	0.402
2011	11203734	116388	61971	19091	0.216
2012	46404649	91193	43172	11155	0.162
2013	24182165	165112	30961	56827	0.638

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2014	9620241	102967	36502	36231	0.577
2015	4071265	71855	36076	24806	0.531
2016	126157455	28128	17687	3901	0.165
2017	2823549	340313	18301	146210	0.946
2018	7724069	89399	50406	16858	0.227
2019	30045964	75004	44909	4131	0.065
2020	19397165	137766	41060	49040	0.613
2021	59290298	83031	25217	5900	0.093
2022	51921706	210892	39671	75240	0.649
2023	2641494	188096	44234	50139	0.434
2024	32828956		60736		

Table 9.3.11 Sandeel 2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	18491928	1187949.000	5348627.000	1226103.000	208948.000
Exploitation pattern season 1	-	0.783	1.154	1.202	1.202
Exploitation pattern season 2	-	0.025	0.037	0.039	0.039
west season 1	3.587	6.190	12.331	15.797	19.061
weca season 1	3.587	6.190	12.331	15.797	19.061
weca season 2	3.355	8.682	14.897	18.006	23.766
Proportion mature (2024)	-	0.023	0.589	0.972	0.991
Proportion mature (2025)	-	0.023	0.589	0.972	0.991
Natural mortality season 1	-	0.516	0.455	0.369	0.319
Natural mortality season 2	0.799	0.607	0.459	0.383	0.362

Table 9.3.12 Sandeel 2r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	35924.97	0.51	27757.00	-54	-12
F = 0	0.00	0.00	49824.05	-18	-100
Bescapement (no cap)	35924.97	0.51	27757.00	-54	-12
Blim	51026.01	0.85	18949.00	-69	24
F = F 2023	31637.98	0.43	30321.71	-50	-23
Obs TAC	5000.00	0.06	46687.99	-23	-88

Table 9.4.1 Sandeel 3r. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0	33760	14020	453	200	5	65	4	0	0
1988	1639	6584	17321	893	19	8769	853	233	144	13
1989	5075	47004	1844	2806	4	159	190	13	0	0
1990	0	9302	2791	413	125	9793	1377	286	43	13
1991	0	24009	1391	526	184	14442	942	30	9	3
1992	95	7100	2862	342	215	525	87	8	3	1
1993	5672	14068	734	263	1606	8541	944	172	73	14
1994	0	24557	5200	1185	475	0	532	657	77	11
1995	3	34567	2245	275	15	606	255	107	22	23
1996	70	4555	3735	492	419	5334	3013	101	35	242
1997	1565	70877	1082	1003	688	175	15588	194	102	11
1998	1675	5352	30538	1774	248	32690	647	1679	29	5
1999	271	5535	1183	1773	287	19750	1347	88	453	307
2000	1806	18127	4229	228	634	312	182	28	33	30
2001	1842	4365	1719	12	205	26259	10521	52	4	41
2002	0	8655	2953	817	337	0	35	5	8	3
2003	483	965	918	41	215	3845	98	57	4	1
2004	623	2096	249	222	112	1826	951	13	4	10
2005	0	1492	235	7	27	0	1	0	0	0

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0	590	200	35	19	0	7	2	1	1
2007	39	7505	584	100	29	0	0	0	0	0
2008	78	3332	1800	381	134	0	0	0	0	0
2009	1	890	91	5	1	5	31	1	0	0
2010	0	1758	1531	333	122	0	48	2	1	0
2011	0	255	5397	353	68	0	0	0	0	0
2012	0	3	48	1063	326	0	0	0	0	0
2013	0	517	91	16	108	0	0	0	0	0
2014	1480	6070	938	90	92	34	26	23	0	2
2015	0	7115	1781	147	119	0	0	0	0	0
2016	728	132	2308	224	216	0	0	0	0	0
2017	87	12266	246	525	144	0	0	0	0	0
2018	0	405	6426	48	393	0	2	45	1	1
2019	388	6584	757	4135	157	0	0	0	0	0
2020	529	20203	1764	367	1056	0	0	0	0	0
2021	25	2293	4239	997	2359	10	7	1	0	0
2022	238	1712	1147	888	766	0	0	0	0	0
2023	99	290	247	199	305	0	0	0	0	0

Table 9.4.2 Sandeel 3r. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	5.64	13.02	27.07	43.68	3.03	13.23	27.01	21.40	19.85
1988	5.64	13.05	27.20	40.73	3.03	13.23	27.27	26.17	39.03
1989	6.20	14.00	16.30	18.01	5.00	9.00	15.82	17.00	19.01
1990	5.63	13.04	27.16	44.02	3.03	13.14	27.12	35.21	42.76
1991	7.44	14.34	22.29	30.60	3.41	9.18	14.75	15.38	44.00
1992	5.51	10.89	18.48	29.85	5.47	9.79	16.85	20.04	22.58
1993	5.52	19.58	20.56	25.13	3.52	9.47	33.76	43.33	45.74

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1994	5.63	14.00	18.41	21.85	3.63	8.40	25.99	43.54	31.25
1995	5.07	11.93	22.65	21.85	5.07	14.08	19.93	27.83	42.78
1996	7.54	12.59	30.23	43.49	2.99	5.72	23.21	30.89	44.48
1997	4.66	9.97	24.28	43.23	1.81	5.32	18.56	26.19	25.64
1998	5.31	9.05	13.91	29.26	2.63	5.53	15.46	20.40	32.67
1999	6.77	9.16	14.27	34.26	3.05	9.86	16.05	19.84	34.07
2000	7.09	8.70	12.22	25.17	3.60	9.17	19.87	25.79	31.69
2001	5.81	14.06	18.89	30.65	3.32	5.87	22.58	31.85	45.57
2002	7.95	11.30	17.40	34.17	3.60	9.17	19.87	25.79	31.69
2003	4.57	13.50	20.52	30.01	2.80	4.79	23.84	24.65	30.30
2004	5.62	9.06	15.06	22.72	3.38	4.87	10.17	26.00	16.22
2005	6.98	16.16	21.23	27.80	3.60	9.17	19.87	25.79	31.69
2006	6.94	13.50	16.23	35.03	3.60	9.17	19.87	25.79	31.69
2007	8.19	19.73	28.06	41.72	3.60	9.17	19.87	25.79	31.69
2008	8.74	17.76	25.46	33.20	3.60	9.17	19.87	25.79	31.69
2009	5.87	8.16	15.08	17.78	3.60	9.17	19.87	25.79	31.69
2010	8.37	22.17	23.35	29.45	3.60	9.17	19.87	25.79	31.69
2011	9.16	14.87	26.01	34.31	3.60	9.17	19.87	25.79	31.69
2012	7.42	15.03	26.43	35.16	3.60	9.17	19.87	25.79	31.69
2013	10.90	14.69	17.51	28.65	3.60	9.17	19.87	25.79	31.69
2014	12.24	15.91	19.10	36.26	3.60	9.17	19.87	25.79	31.69
2015	9.35	17.79	27.89	39.46	3.60	9.17	19.87	25.79	31.69
2016	5.50	12.98	23.90	38.36	3.60	9.17	19.87	25.79	31.69
2017	7.81	14.52	21.31	39.28	3.60	9.17	19.87	25.79	31.69
2018	4.60	9.81	16.28	26.86	3.60	9.17	19.87	25.79	31.69
2019	8.95	11.52	16.19	24.44	3.60	9.17	19.87	25.79	31.69
2020	9.05	16.53	23.36	27.62	3.60	9.17	19.87	25.79	31.69
2021	7.66	14.10	19.39	25.97	3.60	9.17	19.87	25.79	31.69
2022	7.66	14.10	19.39	25.97	3.60	9.17	19.87	25.79	31.69

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2023	9.28	15.52	20.04	26.81	3.87	9.44	20.59	25.03	31.39
2024	9.28	15.52	20.04	26.81	3.87	9.44	20.59	25.03	31.39

Table 9.4.3 Sandeel 3r. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1988	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1989	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1990	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1991	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1992	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1993	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1994	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1995	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1996	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1997	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1998	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
1999	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2000	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2001	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2002	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2003	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2004	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2005	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2006	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2007	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2008	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2009	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2010	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2011	0.04	0.77	0.97	1	0	0.04	0.77	0.97	1
2012	0.04	0.65	0.97	1	0	0.04	0.65	0.97	1
2013	0.03	0.70	0.99	1	0	0.03	0.70	0.99	1
2014	0.03	0.78	0.99	1	0	0.03	0.78	0.99	1
2015	0.03	0.78	0.99	1	0	0.03	0.78	0.99	1
2016	0.02	0.73	0.99	1	0	0.02	0.73	0.99	1
2017	0.02	0.70	0.97	1	0	0.02	0.70	0.97	1
2018	0.02	0.71	0.95	1	0	0.02	0.71	0.95	1
2019	0.03	0.66	0.93	1	0	0.03	0.66	0.93	1
2020	0.05	0.68	0.93	1	0	0.05	0.68	0.93	1
2021	0.05	0.68	0.93	1	0	0.05	0.68	0.93	1
2022	0.05	0.75	0.94	1	0	0.05	0.75	0.94	1
2023	0.05	0.78	0.95	1	0	0.05	0.78	0.95	1
2024	0.05	0.78	0.95	1	0	0.05	0.78	0.95	1

Table 9.4.4 Sandeel 3r. Survey index scaled.

year	survey	0	1	2	3	4
2006	Dredge	109489700	3.960227e+06	-	-	-
2007	Dredge	53539271	3.228496e+07	-	-	-
2008	Dredge	44505681	2.785160e+07	-	-	-
2009	Dredge	171710032	5.117976e+07	-	-	-
2010	Dredge	8077222	8.141064e+07	-	-	-
2011	Dredge	4089183	6.532610e+06	-	-	-
2012	Dredge	109828602	1.981268e+06	-	-	-
2013	Dredge	237153171	3.009294e+06	-	-	-
2014	Dredge	191222557	1.929739e+07	-	-	-
2015	Dredge	4678592	5.071715e+07	-	-	-
2016	Dredge	843113265	7.223742e+06	-	-	-
2017	Dredge	10329906	1.049193e+08	-	-	-

year	survey	0	1	2	3	4
2018	Dredge	428303012	9.432981e+07	-	-	-
2019	Dredge	371715138	1.128082e+08	-	-	-
2020	Dredge	227560452	1.527814e+08	-	-	-
2021	Dredge	72413279	3.845242e+07	-	-	-
2022	Dredge	51221588	1.652314e+07	-	-	-
2023	Dredge	12349458	1.553681e+06	-	-	-
2009	Acoustic	-	8.436308e+04	46177.178	11347.5859	967.7967
2010	Acoustic	-	1.623198e+05	64604.721	15295.8361	9536.0285
2011	Acoustic	-	9.539135e+03	86770.207	8847.8131	2324.0455
2012	Acoustic	-	1.680344e+03	3289.784	36767.6958	5401.5010
2013	Acoustic	-	2.153535e+04	2851.779	761.6271	6502.7392
2014	Acoustic	-	2.195769e+05	18920.349	1890.2820	29109.5963
2015	Acoustic	-	9.514132e+04	22304.581	7034.4082	8076.3331
2016	Acoustic	-	7.411159e+02	48870.046	6038.7513	9310.7153
2017	Acoustic	-	3.520750e+05	1216.158	36144.0271	11878.2135
2018	Acoustic	-	1.657811e+04	174487.632	862.0764	4296.8746
2019	Acoustic	-	1.125712e+05	7256.262	154383.3986	10552.6611
2020	Acoustic	-	4.147335e+05	101528.664	5465.6095	102700.8503
2021	Acoustic	-	1.483761e+05	128431.156	27911.8539	43578.9152
2022	Acoustic	-	4.810194e+04	50351.985	56016.2514	21435.6213
2023	Acoustic	-	2.120757e+04	13668.419	13951.6308	36452.5770

Table 9.4.5 Sandeel 3r. SMS settings and statistics.

```
Model evaluation date:  2024-02-08 04:02:18.444161

Time to run model (seconds):  1.6

number of parameters: 55

Maximum gradient:  0.001

AIC: 1037

Observations used in likelihood:

Catch: 232 Survey: 96 Stock recruitment: 37 Sum: 365
```

```
Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.3000009	0	Dredge
1.1180297	1	Dredge
0.6262946	1	Acoustic
0.6262946	2	Acoustic
0.6262946	3	Acoustic
0.6262946	4	Acoustic
catchCV	ages	season
0.8247664	1	1
0.8247664	2	1
1.0000648	3	1
1.0000648	4	1
0.9526143	1	2
0.9526143	2	2
2.6900616	3	2
2.6900616	4	2

Table 9.4.6 Sandeel 3r.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1987	0	0.4743313	0.6884416	0.4840461	0.4840461	0.5813864
1988	0	0.6549013	0.9505199	0.6683145	0.6683145	0.8027106
1989	0	0.7111642	1.0321794	0.7257297	0.7257297	0.8716718
1990	0	0.4420670	0.6416134	0.4511210	0.4511210	0.5418402
1991	0	0.5300002	0.7692391	0.5408552	0.5408552	0.6496196
1992	0	0.2196047	0.3187329	0.2241024	0.2241024	0.2691688
1993	0	0.4587739	0.6658617	0.4681701	0.4681701	0.5623178
1994	0	0.4446172	0.6453146	0.4537234	0.4537234	0.5449659
1995	0	0.3477578	0.5047336	0.3548803	0.3548803	0.4262457
1996	0	0.3775087	0.5479139	0.3852405	0.3852405	0.4627113
1997	0	0.7003001	1.0164114	0.7146431	0.7146431	0.8583558
1998	0	1.0063208	1.4605679	1.0269314	1.0269314	1.2334444
1999	0	0.4917449	0.7137155	0.5018164	0.5018164	0.6027302
2000	0	0.3907317	0.5671057	0.3987344	0.3987344	0.4789187
2001	0	0.3750067	0.5442824	0.3826872	0.3826872	0.4596445
2002	0	0.2353314	0.3415586	0.2401512	0.2401512	0.2884450

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2003	0	0.1464683	0.2125831	0.1494681	0.1494681	0.1795257
2004	0	0.1106526	0.1606006	0.1129189	0.1129189	0.1356266
2005	0	0.0476834	0.0692074	0.0486600	0.0486600	0.0584454
2006	0	0.0194980	0.0282992	0.0198973	0.0198973	0.0238986
2007	0	0.1270801	0.1844432	0.1296828	0.1296828	0.1557617
2008	0	0.1526641	0.2215758	0.1557909	0.1557909	0.1871200
2009	0	0.0113927	0.0165352	0.0116260	0.0116260	0.0139639
2010	0	0.1333110	0.1934868	0.1360414	0.1360414	0.1633989
2011	0	0.1253909	0.1819916	0.1279590	0.1279590	0.1536912
2012	0	0.0632306	0.0917725	0.0645256	0.0645256	0.0775016
2013	0	0.0300189	0.0435693	0.0306337	0.0306337	0.0367941
2014	0	0.1005818	0.1459838	0.1026418	0.1026418	0.1232828
2015	0	0.1018146	0.1477731	0.1038999	0.1038999	0.1247938
2016	0	0.0653853	0.0948999	0.0667245	0.0667245	0.0801426
2017	0	0.1341944	0.1947689	0.1369428	0.1369428	0.1644817
2018	0	0.1280825	0.1858982	0.1307058	0.1307058	0.1569904
2019	0	0.1375732	0.1996729	0.1403909	0.1403909	0.1686231
2020	0	0.3617862	0.5250943	0.3691960	0.3691960	0.4434402
2021	0	0.1646214	0.2389305	0.1679931	0.1679931	0.2017760
2022	0	0.1955899	0.2838780	0.1995958	0.1995958	0.2397340
2023	0	0.0902406	0.1309747	0.0920889	0.0920889	0.1106077
arith.mean	0	0.2785790	0.4043279	0.2842846	0.2842846	0.3414534

Table 9.4.7 Sandeel 3r. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.472	0.685	0.482	0.482	0.002	0.003	0.002	0.002
1988	0.556	0.807	0.567	0.567	0.099	0.144	0.101	0.101
1989	0.705	1.023	0.719	0.719	0.006	0.009	0.006	0.006
1990	0.347	0.503	0.354	0.354	0.095	0.138	0.097	0.097

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1991	0.451	0.654	0.460	0.460	0.079	0.115	0.081	0.081
1992	0.213	0.310	0.218	0.218	0.006	0.009	0.006	0.006
1993	0.375	0.545	0.383	0.383	0.084	0.121	0.085	0.085
1994	0.413	0.600	0.422	0.422	0.031	0.045	0.032	0.032
1995	0.334	0.484	0.340	0.340	0.014	0.021	0.014	0.014
1996	0.295	0.427	0.301	0.301	0.083	0.120	0.085	0.085
1997	0.564	0.818	0.575	0.575	0.137	0.198	0.139	0.139
1998	0.716	1.039	0.731	0.731	0.290	0.422	0.296	0.296
1999	0.290	0.421	0.296	0.296	0.202	0.293	0.206	0.206
2000	0.385	0.559	0.393	0.393	0.006	0.008	0.006	0.006
2001	0.161	0.234	0.165	0.165	0.214	0.310	0.218	0.218
2002	0.235	0.342	0.240	0.240	0.000	0.000	0.000	0.000
2003	0.119	0.173	0.122	0.122	0.027	0.039	0.028	0.028
2004	0.082	0.119	0.084	0.084	0.028	0.041	0.029	0.029
2005	0.048	0.069	0.049	0.049	0.000	0.000	0.000	0.000
2006	0.019	0.028	0.020	0.020	0.000	0.000	0.000	0.000
2007	0.127	0.184	0.130	0.130	0.000	0.000	0.000	0.000
2008	0.153	0.222	0.156	0.156	0.000	0.000	0.000	0.000
2009	0.011	0.016	0.012	0.012	0.000	0.000	0.000	0.000
2010	0.133	0.192	0.135	0.135	0.001	0.001	0.001	0.001
2011	0.125	0.182	0.128	0.128	0.000	0.000	0.000	0.000
2012	0.063	0.092	0.065	0.065	0.000	0.000	0.000	0.000
2013	0.030	0.044	0.031	0.031	0.000	0.000	0.000	0.000
2014	0.100	0.146	0.102	0.102	0.000	0.000	0.000	0.000
2015	0.102	0.148	0.104	0.104	0.000	0.000	0.000	0.000
2016	0.065	0.095	0.067	0.067	0.000	0.000	0.000	0.000
2017	0.134	0.195	0.137	0.137	0.000	0.000	0.000	0.000
2018	0.128	0.186	0.131	0.131	0.000	0.000	0.000	0.000
2019	0.138	0.200	0.140	0.140	0.000	0.000	0.000	0.000

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2020	0.362	0.525	0.369	0.369	0.000	0.000	0.000	0.000
2021	0.165	0.239	0.168	0.168	0.000	0.000	0.000	0.000
2022	0.196	0.284	0.200	0.200	0.000	0.000	0.000	0.000
2023	0.090	0.131	0.092	0.092	0.000	0.000	0.000	0.000

Table 9.4.8 Sandeel 3r. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1987	0.59	0.46	0.32	0.29	1.10	0.53	0.37	0.33	0.28
1988	0.57	0.45	0.30	0.29	1.18	0.54	0.35	0.32	0.28
1989	0.54	0.43	0.30	0.29	1.17	0.48	0.31	0.31	0.27
1990	0.54	0.44	0.28	0.27	1.22	0.48	0.31	0.31	0.25
1991	0.56	0.47	0.29	0.28	1.29	0.51	0.33	0.32	0.25
1992	0.60	0.51	0.32	0.29	1.31	0.54	0.35	0.34	0.27
1993	0.60	0.52	0.34	0.31	1.32	0.55	0.36	0.35	0.29
1994	0.61	0.54	0.38	0.31	1.29	0.61	0.40	0.40	0.33
1995	0.62	0.56	0.42	0.34	1.13	0.61	0.40	0.40	0.34
1996	0.58	0.53	0.41	0.33	1.04	0.65	0.42	0.42	0.35
1997	0.55	0.49	0.40	0.33	0.86	0.63	0.38	0.38	0.34
1998	0.52	0.47	0.37	0.31	0.94	0.69	0.37	0.36	0.32
1999	0.59	0.52	0.42	0.31	0.98	0.77	0.43	0.43	0.35
2000	0.66	0.59	0.49	0.36	1.06	0.85	0.53	0.52	0.44
2001	0.67	0.61	0.52	0.40	1.08	0.91	0.62	0.61	0.54
2002	0.69	0.62	0.52	0.46	1.04	0.88	0.60	0.59	0.57
2003	0.66	0.58	0.47	0.44	1.00	0.83	0.54	0.54	0.53
2004	0.67	0.58	0.45	0.43	1.00	0.81	0.49	0.48	0.48
2005	0.67	0.56	0.43	0.40	1.00	0.81	0.48	0.47	0.47
2006	0.68	0.55	0.43	0.40	1.03	0.81	0.47	0.46	0.46
2007	0.66	0.53	0.42	0.38	0.98	0.79	0.47	0.47	0.47
2008	0.63	0.48	0.40	0.38	0.92	0.74	0.43	0.42	0.42

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2009	0.57	0.44	0.38	0.35	0.87	0.71	0.44	0.43	0.43
2010	0.56	0.43	0.38	0.35	0.91	0.75	0.47	0.45	0.45
2011	0.60	0.44	0.40	0.37	0.96	0.79	0.50	0.48	0.48
2012	0.64	0.44	0.41	0.40	0.94	0.79	0.48	0.46	0.46
2013	0.63	0.42	0.39	0.38	0.89	0.73	0.43	0.41	0.41
2014	0.57	0.39	0.35	0.35	0.89	0.73	0.44	0.42	0.42
2015	0.59	0.41	0.37	0.36	0.88	0.71	0.42	0.41	0.41
2016	0.57	0.40	0.35	0.34	0.89	0.72	0.43	0.42	0.42
2017	0.58	0.41	0.36	0.35	0.83	0.68	0.40	0.39	0.39
2018	0.54	0.39	0.33	0.32	0.84	0.65	0.39	0.39	0.38
2019	0.57	0.42	0.34	0.32	0.90	0.66	0.41	0.41	0.41
2020	0.63	0.49	0.39	0.34	1.00	0.73	0.50	0.50	0.50
2021	0.70	0.58	0.47	0.42	1.08	0.82	0.61	0.61	0.61
2022	0.51	0.43	0.36	0.32	1.08	0.82	0.61	0.61	0.61
2023	0.51	0.43	0.36	0.32	1.05	0.79	0.58	0.57	0.57
2024	0.51	0.43	0.36	0.32	1.05	0.79	0.58	0.57	0.57

Table 9.4.9 Sandeel 3r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1987	86715893	81656023	4681670.2	343756.2	207689.2
1988	219977880	28800532	16589234.2	1020719.4	183412.8
1989	84317199	67894271	4911107.6	2877580.4	334843.1
1990	125005644	26241222	11962081.8	830479.1	855114.1
1991	87163822	37033166	6073266.1	2982922.3	616719.5
1992	265964656	23924181	7516062.3	1268369.8	1158195.2
1993	241912613	71950287	6161237.7	2295457.4	1051694.7
1994	232731426	64513525	14361722.7	1312731.0	1080989.6
1995	120214686	63781623	12190139.7	2922649.4	743077.6
1996	1197825192	38851934	13165423.6	2817524.0	1167277.8

years	Age 0	Age 1	Age 2	Age 3	Age 4
1997	55247762	423879628	7762634.6	2952913.8	1239874.2
1998	87991855	23373701	64832999.1	1169427.6	969595.5
1999	206799693	34290771	2564137.1	6554254.9	386296.3
2000	172160493	77451608	5420051.9	482443.3	1818935.1
2001	137530718	59691252	11539549.9	1003373.7	665638.8
2002	25139688	46800566	8454299.7	1958338.7	395928.0
2003	73649650	8883765	7707230.4	1780002.2	617637.0
2004	63755131	27131635	1728605.8	2018584.3	761324.6
2005	46410572	23547061	5532252.7	506344.3	980265.4
2006	118784433	16996225	5150669.0	1821242.0	583169.0
2007	76088361	42564065	3762143.9	1801937.3	970960.1
2008	86967836	28505469	8797245.2	1151006.1	1017845.8
2009	241108896	34785641	6248696.3	2817477.1	821868.3
2010	9748930	100547174	9582364.3	2541382.7	1617015.3
2011	5427574	3943230	23875957.7	3211916.8	1593891.2
2012	83632997	2083939	864158.3	7718593.0	1759291.6
2013	156484318	32585774	467509.3	311753.5	3710187.1
2014	175105274	64517218	8133553.4	190862.4	1759835.5
2015	4875538	72082384	15906747.3	3065800.8	817476.7
2016	848067977	2024831	17580507.6	5964257.9	1613812.0
2017	18292832	348680534	522050.7	6936906.1	3284865.0
2018	313817694	7938666	86163219.9	192492.5	4213098.7
2019	497920180	135851298	2121724.3	32902617.3	1909054.8
2020	207650536	203230225	34709972.1	754317.3	14336326.6
2021	74536731	76737529	36490658.0	7615404.5	4473453.8
2022	46067439	25277096	14197654.7	8747367.0	3545936.1
2023	15134722	15622514	5474844.1	3771990.2	3845714.6

Table 9.4.10 Sandeel 3r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1987	86715893	539907	81993	165981	0.581
1988	219977880	414148	206315	191772	0.803
1989	84317199	542418	119958	231440	0.872
1990	125005644	364043	184435	128079	0.542
1991	87163822	447818	160422	152658	0.65
1992	265964656	271637	124843	47482	0.269
1993	241912613	591653	179449	183665	0.562
1994	232731426	612179	214617	189729	0.545
1995	120214686	551570	204034	138789	0.426
1996	1197825192	594422	271160	153792	0.463
1997	55247762	2177049	256093	835625	0.858
1998	87991855	755296	497937	462333	1.233
1999	206799693	362337	130751	106350	0.603
2000	172160493	647634	107942	162190	0.479
2001	137530718	548213	175928	115554	0.46
2002	25139688	515080	133675	86134	0.288
2003	73649650	199657	135149	24748	0.18
2004	63755131	215923	64462	15618	0.136
2005	46410572	291864	112206	11674	0.058
2006	118784433	237528	106750	3939	0.024
2007	76088361	513892	159355	49592	0.156
2008	86967836	468512	191104	58828	0.187
2009	241108896	312348	102535	2995	0.014
2010	9748930	1160745	299208	122680	0.163
2011	5427574	529398	408934	65059	0.154
2012	83632997	294331	268840	15289	0.078
2013	156484318	473700	127421	10860	0.037
2014	175105274	986652	191651	77992	0.123

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2015	4875538	1074780	356106	91206	0.125
2016	848067977	443814	368589	28754	0.08
2017	18292832	3007640	321290	291856	0.164
2018	313817694	998445	718756	135172	0.157
2019	497920180	1819211	588119	188167	0.169
2020	207650536	2827005	885195	721251	0.443
2021	74536731	1365962	631739	181789	0.202
2022	46067439	655408	409270	107890	0.24
2023	15134722	408699	247285	31691	0.111
2024	94904752		145862		

Table 9.4.11 Sandeel 3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	99870116	5281662	3875842	1756337	2773642
Exploitation pattern season 1	-	0.816	1.184	0.833	0.833
Exploitation pattern season 2	-	-	-	-	-
west season 1	2.583	8.52	14.354	19.671	26.16
weca season 1	2.514	9.284	15.521	20.037	26.81
weca season 2	3.874	9.443	20.589	25.028	31.394
Proportion mature (2024)	-	0.046	0.78	0.949	0.996
Proportion mature (2025)	-	0.046	0.78	0.949	0.996
Natural mortality season 1	-	0.515	0.43	0.365	0.324
Natural mortality season 2	1.053	0.789	0.576	0.574	0.574

Table 9.4.12 Sandeel 3r. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	0.00	0.00	107626.60	-26	-100
F = 0	0.00	0.00	107626.60	-26	-100
Bescapement (no cap)	0.00	0.00	107626.60	-26	-100
Blim	68509.06	0.51	72712.99	-50	124

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
F = F 2023	17552.67	0.11	98555.61	-32	-43
Obs TAC	5000.00	0.03	105035.23	-28	-84

Table 9.5.1 Sandeel 4. Catch at age numbers (million) by half year.

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	88	1196	6103	1791	517	735	152	368	118	37
1994	0	1139	1741	5945	2353	0	243	58	245	151
1995	0	2983	1411	606	34	4	4	1	0	0
1996	0	0	0	0	0	2419	2417	3190	204	991
1997	0	3000	321	1829	442	0	1383	36	43	10
1998	0	2373	4072	250	139	0	66	102	7	4
1999	0	1543	1057	1439	236	0	84	44	44	11
2000	25	5819	343	325	345	0	0	0	0	0
2001	3	2143	5103	623	403	10	64	19	1	0
2002	10	342	792	477	88	0	0	0	0	0
2003	169	4080	864	2543	1247	165	162	11	6	2
2004	0	938	217	44	69	0	4	1	0	0
2005	0	54	159	35	19	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0
2012	0	92	50	213	3	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0
2014	59	480	161	15	13	0	0	0	0	0
2015	0	919	33	10	16	0	0	0	0	0
2016	14	189	374	19	34	0	0	0	0	0

year	Age 0 season 1	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2017	0	711	436	523	27	0	0	0	0	0
2018	0	893	1262	347	1111	0	0	0	0	0
2019	2	316	161	144	61	0	0	0	0	0
2020	10	2452	259	72	85	27	22	0	0	0
2021	398	3321	2167	349	373	1	20	78	12	40
2022	11	331	72	124	40	0	0	0	0	0
2023	52	342	531	226	324	0	0	0	0	0

Table 9.5.2 Sandeel 4. Individual mean weight (gram) at age in the catch and in the sea.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	6.70	11.96	15.82	23.54	3.64	8.23	14.48	17.64	25.64
1994	10.10	8.57	12.97	18.71	3.64	8.23	14.48	17.64	25.64
1995	5.80	15.14	19.20	21.85	3.64	8.23	14.48	17.64	25.64
1996	5.84	14.74	20.67	31.93	3.10	4.72	16.10	25.33	34.34
1997	6.39	7.12	10.51	17.41	3.64	8.23	14.48	17.64	25.64
1998	4.93	9.51	13.21	13.40	3.64	8.23	14.48	17.64	25.64
1999	5.35	11.13	18.11	22.57	3.64	8.23	14.48	17.64	25.64
2000	4.10	8.89	14.31	18.54	3.64	8.23	14.48	17.64	25.64
2001	3.59	5.68	8.70	14.17	3.64	8.23	14.48	17.64	25.64
2002	3.68	6.10	10.43	19.93	3.64	8.23	14.48	17.64	25.64
2003	3.77	7.54	9.57	12.93	2.44	4.93	13.03	15.88	23.07
2004	3.99	7.53	9.69	15.61	3.64	8.23	14.48	17.64	25.64
2005	3.79	4.77	6.86	18.24	3.64	8.23	14.48	17.64	25.64
2006	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2007	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2008	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2009	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2010	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2011	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2012	3.46	7.40	8.88	12.25	3.64	8.23	14.48	17.64	25.64
2013	4.18	7.73	13.02	15.04	3.64	8.23	14.48	17.64	25.64
2014	5.48	10.50	15.60	20.76	3.64	8.23	14.48	17.64	25.64
2015	4.40	9.42	11.22	16.62	3.64	8.23	14.48	17.64	25.64
2016	4.47	10.80	20.96	28.74	3.64	8.23	14.48	17.64	25.64
2017	6.93	10.99	15.64	22.17	3.64	8.23	14.48	17.64	25.64
2018	4.49	9.30	13.77	20.12	3.64	8.23	14.48	17.64	25.64
2019	5.77	9.95	13.71	20.34	3.64	8.23	14.48	17.64	25.64
2020	6.19	9.25	15.61	14.18	3.64	8.23	14.48	17.64	25.64
2021	5.52	9.78	12.98	18.58	3.63	9.77	13.31	19.62	21.04
2022	5.78	9.85	14.34	19.08	3.64	8.54	14.25	18.04	24.72
2023	4.98	10.91	13.27	20.23	3.78	8.56	15.59	18.65	26.24
2024	5.65	9.95	13.98	18.48	3.66	8.67	14.42	18.32	24.65

Table 9.5.3 Sandeel 4. Proportion mature.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1994	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1995	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1996	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1997	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1998	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
1999	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2000	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2001	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2002	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2003	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2004	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2005	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2007	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2008	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2009	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2010	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2011	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2012	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2013	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2014	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2015	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2016	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2017	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2018	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2019	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2020	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2021	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2022	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2023	0.08	0.53	0.81	0.98	0	0.08	0.53	0.81	0.98
2024	0.08	0.53	0.81	0.98	-	-	-	-	-

Table 9.5.4 Sandeel 4. Survey index scaled.

year	survey	0	1
1999	Dredge	61500000	49400000
2000	Dredge	58600000	317000000
2001	Dredge	4800000	265600000
2002	Dredge	24300000	40400000
2003	Dredge	58000000	-
2008	Dredge2	94510377	281322558
2009	Dredge2	5148033831	832577971

year	survey	0	1
2010	Dredge2	245679534	3108360870
2011	Dredge2	200732519	466969729
2012	Dredge2	315658858	78508071
2013	Dredge2	250401011	303751827
2014	Dredge2	1092995067	61578361
2015	Dredge2	698757894	2249006428
2016	Dredge2	1807022574	178026284
2017	Dredge2	590032532	984803970
2018	Dredge2	291927930	323876495
2019	Dredge2	900897159	606608010
2020	Dredge2	602635232	1569864813
2021	Dredge2	510112080	943304521
2022	Dredge2	1481784839	714129399
2023	Dredge2	27546360	848904427

Table 9.5.5 Sandeel 4. SMS settings and statistics.

```
Model evaluation date:  2024-01-31 15:51:23.676403

Time to run model (seconds):  4.5

number of parameters: 49

Maximum gradient:  1e-04

AIC: 423

Observations used in likelihood:

Catch: 132 Survey: 41 Stock recruitment: 31 Sum: 204

Objective function weight: Catch: 1 Survey: 1 Stock recruitment: 0.05
```

surveyCV	ages	survey
0.300000	0	Dredge
0.300000	1	Dredge
0.300000	0	Dredge2
0.809663	1	Dredge2

catchCV	ages	season
0.6850183	1	1
0.6850183	2	1
0.6873710	3	1

surveyCV	ages	survey
0.6873710	4	1
0.4133140	1	2
0.4133140	2	2
1.0585777	3	2
1.0585777	4	2

Table 9.5.6 Sandeel 4.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0	0.2434999	0.4602684	0.5096903	0.5096903	0.3518841
1994	0	0.2777569	0.5250217	0.5813965	0.5813965	0.4013893
1995	0	0.0772658	0.1460493	0.1617316	0.1617316	0.1116576
1996	0	0.2138312	0.4041880	0.4475882	0.4475882	0.3090096
1997	0	0.1123765	0.2124164	0.2352249	0.2352249	0.1623965
1998	0	0.1187371	0.2244393	0.2485387	0.2485387	0.1715882
1999	0	0.1500821	0.2836883	0.3141497	0.3141497	0.2168852
2000	0	0.0773992	0.1463016	0.1620109	0.1620109	0.1118504
2001	0	0.1217153	0.2300687	0.2547726	0.2547726	0.1758920
2002	0	0.0266427	0.0503605	0.0557680	0.0557680	0.0385016
2003	0	0.1998782	0.3778139	0.4183821	0.4183821	0.2888461
2004	0	0.0380374	0.0718990	0.0796193	0.0796193	0.0549682
2005	0	0.0180329	0.0340862	0.0377462	0.0377462	0.0260596
2006	0	0.0003169	0.0005991	0.0006634	0.0006634	0.0004580
2007	0	0.0002239	0.0004232	0.0004686	0.0004686	0.0003235
2008	0	0.0017318	0.0032735	0.0036250	0.0036250	0.0025026
2009	0	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
2010	0	0.0007175	0.0013562	0.0015019	0.0015019	0.0010369
2011	0	0.0017598	0.0033264	0.0036836	0.0036836	0.0025431
2012	0	0.0137374	0.0259667	0.0287549	0.0287549	0.0198520
2013	0	0.0078330	0.0148061	0.0163960	0.0163960	0.0113196
2014	0	0.0091900	0.0173711	0.0192364	0.0192364	0.0132806
2015	0	0.0070634	0.0133515	0.0147851	0.0147851	0.0102074
2016	0	0.0209373	0.0395761	0.0438256	0.0438256	0.0302567

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2017	0	0.0440418	0.0832488	0.0921877	0.0921877	0.0636453
2018	0	0.1079430	0.2040360	0.2259446	0.2259446	0.1559895
2019	0	0.0298539	0.0564305	0.0624897	0.0624897	0.0431422
2020	0	0.0400254	0.0756569	0.0837807	0.0837807	0.0578412
2021	0	0.2240578	0.4235186	0.4689944	0.4689944	0.3237882
2022	0	0.0200759	0.0379478	0.0420225	0.0420225	0.0290118
2023	0	0.0681098	0.1287426	0.1425665	0.1425665	0.0984262
arith.mean	0	0.0733185	0.1385881	0.1534692	0.1534692	0.1059533

Table 9.5.7 Sandeel 4. Fishing mortality (F) at age.

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.219	0.414	0.459	0.459	0.024	0.046	0.051	0.051
1994	0.255	0.482	0.533	0.533	0.023	0.043	0.048	0.048
1995	0.077	0.146	0.161	0.161	0.000	0.000	0.000	0.000
1996	0.095	0.179	0.198	0.198	0.119	0.225	0.250	0.250
1997	0.094	0.178	0.197	0.197	0.018	0.034	0.038	0.038
1998	0.114	0.215	0.238	0.238	0.005	0.009	0.010	0.010
1999	0.150	0.284	0.314	0.314	0.000	0.000	0.000	0.000
2000	0.077	0.146	0.162	0.162	0.000	0.000	0.000	0.000
2001	0.120	0.227	0.251	0.251	0.002	0.003	0.004	0.004
2002	0.027	0.050	0.056	0.056	0.000	0.000	0.000	0.000
2003	0.191	0.360	0.399	0.399	0.009	0.018	0.020	0.020
2004	0.038	0.071	0.079	0.079	0.000	0.000	0.001	0.001
2005	0.018	0.034	0.038	0.038	0.000	0.000	0.000	0.000
2006	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.002	0.003	0.004	0.004	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.001	0.001	0.002	0.002	0.000	0.000	0.000	0.000

	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2011	0.002	0.003	0.004	0.004	0.000	0.000	0.000	0.000
2012	0.014	0.026	0.029	0.029	0.000	0.000	0.000	0.000
2013	0.008	0.015	0.016	0.016	0.000	0.000	0.000	0.000
2014	0.009	0.017	0.019	0.019	0.000	0.000	0.000	0.000
2015	0.007	0.013	0.015	0.015	0.000	0.000	0.000	0.000
2016	0.021	0.040	0.044	0.044	0.000	0.000	0.000	0.000
2017	0.044	0.083	0.092	0.092	0.000	0.000	0.000	0.000
2018	0.108	0.204	0.226	0.226	0.000	0.000	0.000	0.000
2019	0.030	0.056	0.062	0.062	0.000	0.000	0.000	0.000
2020	0.040	0.076	0.084	0.084	0.000	0.000	0.000	0.000
2021	0.212	0.400	0.443	0.443	0.012	0.023	0.026	0.026
2022	0.020	0.038	0.042	0.042	0.000	0.000	0.000	0.000
2023	0.068	0.129	0.143	0.143	0.000	0.000	0.000	0.000

Table 9.5.8 Sandeel 4. Natural mortality (M) at age.

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
1993	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1994	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1995	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1996	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1997	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1998	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
1999	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2000	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2001	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2002	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2003	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2004	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2005	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44

year	Age 1 season 1	Age 2 season 1	Age 3 season 1	Age 4 season 1	Age 0 season 2	Age 1 season 2	Age 2 season 2	Age 3 season 2	Age 4 season 2
2006	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2007	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2008	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2009	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2010	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2011	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2012	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2013	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2014	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2015	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2016	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2017	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2018	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2019	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2020	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2021	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2022	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2023	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44
2024	0.61	0.49	0.4	0.36	0.99	0.74	0.46	0.46	0.44

Table 9.5.9 Sandeel 4. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

years	Age 0	Age 1	Age 2	Age 3	Age 4
1993	96871460	25056431	24862791.7	8771227.6	1856323.1
1994	221564535	36094561	5101590.3	6023879.7	2727250.4
1995	61533546	82555530	7101506.6	1158537.1	2109157.5
1996	310958592	22927561	19848472.3	2355811.3	1224312.3
1997	87716707	115863991	4808716.6	5086380.9	988354.6
1998	40484216	32683476	26895584.7	1492781.8	2049632.2
1999	207666431	15084526	7538733.5	8249481.7	1211696.8

years	Age 0	Age 1	Age 2	Age 3	Age 4
2000	173122934	77377060	3372009.8	2179277.6	2943243.9
2001	22249691	64506062	18600952.3	1118328.2	1910050.7
2002	78402088	8290294	14834649.0	5673303.9	1032869.0
2003	140952392	29212825	2096699.4	5415323.7	2705903.0
2004	10874687	52519233	6213045.8	551660.8	2307130.5
2005	6651044	4051937	13132154.1	2219717.1	1174755.2
2006	4435231	2478196	1033637.2	4872489.9	1412196.3
2007	15960674	1652579	643480.1	396575.9	2691966.6
2008	10141960	5946989	429142.9	246927.7	1379304.4
2009	329532842	3778921	1541991.8	164209.7	722899.1
2010	23253475	122784806	981532.8	591971.1	394944.1
2011	17791747	8664306	31869117.6	376300.0	427236.8
2012	31842437	6629252	2246500.6	12193933.9	350052.2
2013	24466035	11864576	1698382.3	840326.0	5156829.7
2014	148981236	9116109	3057647.5	642426.8	2633992.6
2015	52223991	55510801	2346147.8	1153617.0	1429891.9
2016	121200949	19458797	14316831.3	888741.2	1114609.7
2017	45545811	45159793	4949485.4	5282963.9	839728.1
2018	33126323	16970489	11224366.5	1748332.4	2379470.6
2019	109961138	12342955	3956875.0	3513731.2	1443997.2
2020	42993895	40971810	3111650.3	1435698.8	2004973.3
2021	49966979	16019639	10224435.5	1107520.6	1388053.9
2022	94156062	18617828	3325696.9	2569957.7	683752.8
2023	2482901	35082797	4739660.1	1229194.4	1335944.1

Table 9.5.10 Sandeel 4. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1993	96871460	647771	327310	172563	0.352
1994	221564535	537362	167124	126318	0.401

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
1995	61533546	654853	160125	46918	0.112
1996	310958592	514437	244237	41055	0.309
1997	87716707	845373	140018	73994	0.162
1998	40484216	463915	191897	63092	0.172
1999	207666431	341288	199515	64756	0.217
2000	173122934	432971	121244	31758	0.112
2001	22249691	373772	109679	44438	0.176
2002	78402088	200792	118872	7703	0.039
2003	140952392	212672	94070	43907	0.289
2004	10874687	297660	81947	11105	0.055
2005	6651044	114694	67937	2998	0.026
2006	4435231	129768	97532	0	0
2007	15960674	77886	64312	0	0
2008	10141960	69573	36380	0	0.003
2009	329532842	54457	27135	0	0
2010	23253475	700364	76885	0	0.001
2011	17791747	396692	194679	0	0.003
2012	31842437	152130	102971	3200	0.02
2013	24466035	151218	96225	0	0.011
2014	148981236	146742	83070	1812	0.013
2015	52223991	303051	65887	1970	0.01
2016	121200949	292336	135801	7910	0.03
2017	45545811	468728	140341	20958	0.064
2018	33126323	252450	128252	33420	0.156
2019	109961138	188188	94839	7184	0.043
2020	42993895	333251	82485	12541	0.058
2021	49966979	228571	97382	53479	0.324
2022	94156062	190298	69103	4270	0.029
2023	2482901	269823	81750	18430	0.098

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F (1-2)
2024	46694233		81162		

Table 9.5.11 Sandeel 4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2024)	61501687	925135	8512390	1599755	971892
Exploitation pattern season 1	-	0.692	1.308	1.448	1.448
Exploitation pattern season 2	-	-	-	-	-
west season 1	2.045	5.649	9.949	13.982	18.48
weca season 1	2.045	5.649	9.949	13.982	18.48
weca season 2	3.664	8.667	14.423	18.319	24.654
Proportion mature (2024)	-	0.083	0.53	0.813	0.983
Proportion mature (2025)	-	0.083	0.53	0.813	0.983
Natural mortality season 1	-	0.608	0.493	0.404	0.361
Natural mortality season 2	0.987	0.74	0.464	0.458	0.437

Table 9.5.12 Sandeel 4. Short term forecast (000 tonnes).

Basis	Total Catch (2024)	F (2024)	SSB (2025)	SSB change %	TAC change %
Bescapement (Fcap)	0.00	0.00	69406.25	-14	-100
F = 0	0.00	0.00	69406.25	-14	-100
Bescapement (no cap)	0.00	0.00	69406.25	-14	-100
Blim	44422.77	0.41	44715.99	-45	31
F = F 2023	12846.93	0.10	62145.95	-23	-62
Obs TAC	5000.00	0.04	66571.04	-18	-85

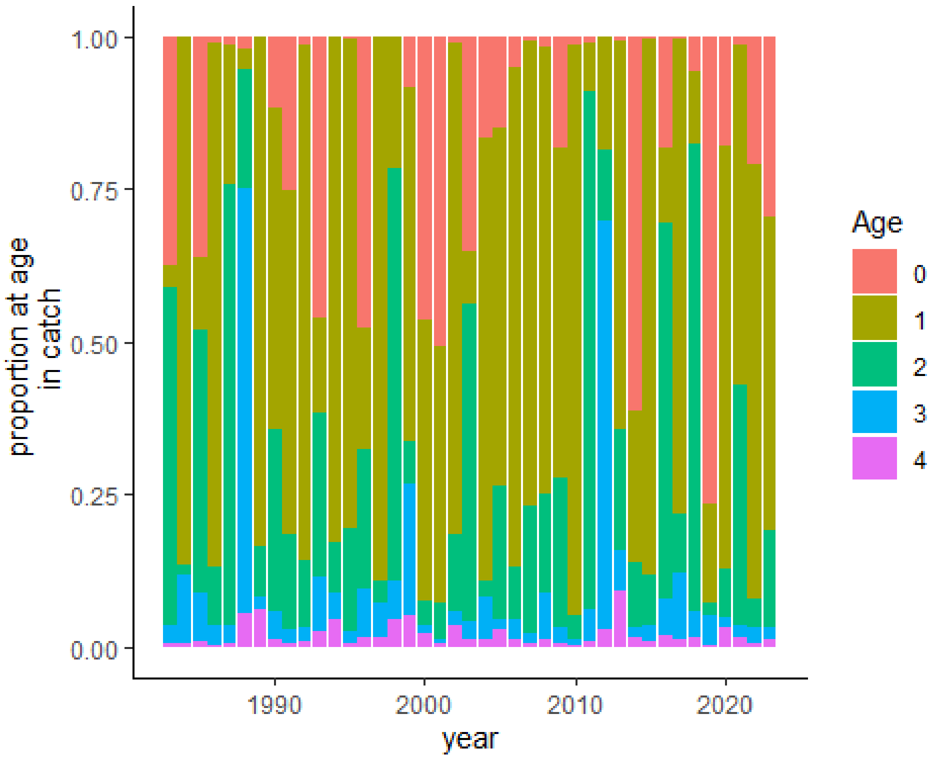
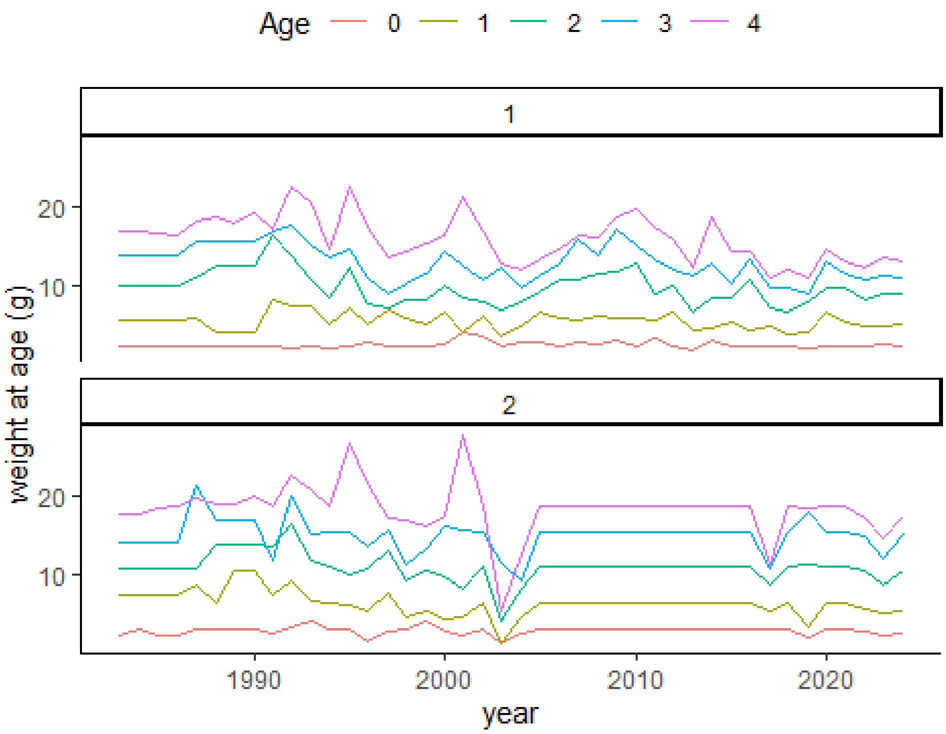


Figure 9.2.1 Sandeel 1r. Catch numbers, proportion at age.



Age
0
1
2
3
4
1
2
weight at age (g)
20
10
20
10
1990
2000
2010
2020
year

Figure 9.2.2 Sandeel 1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

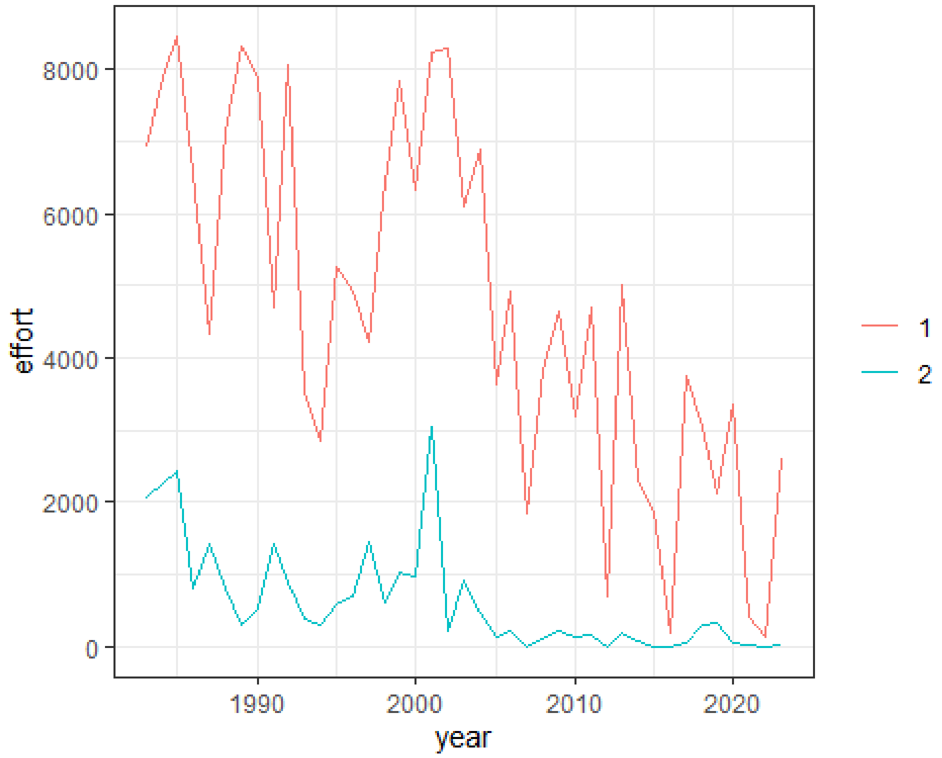
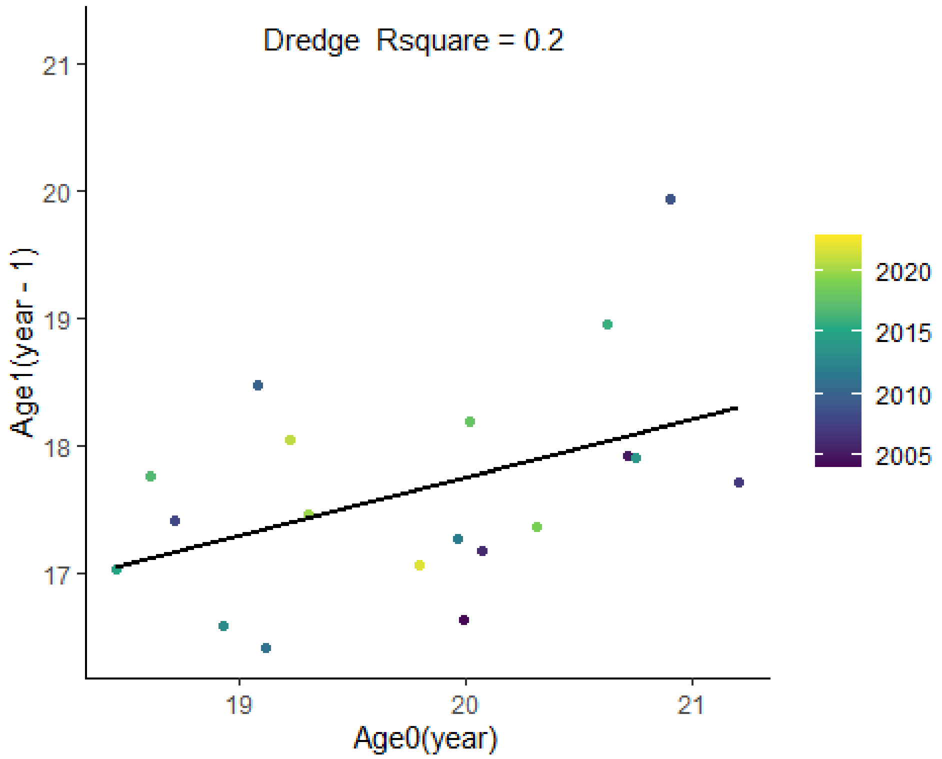
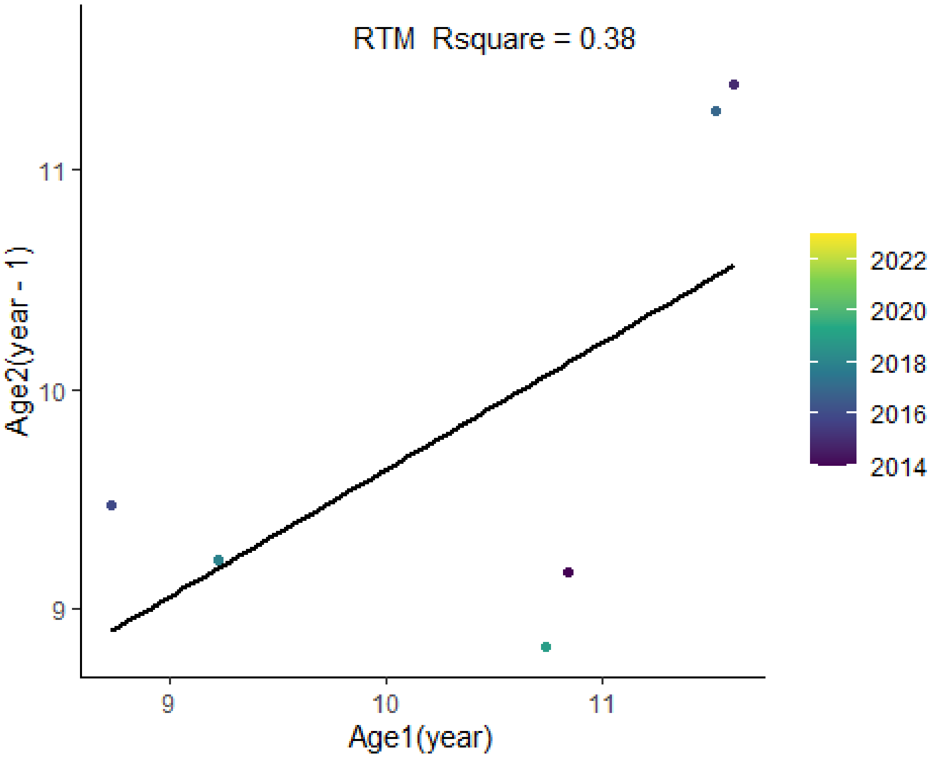


Figure 9.2.3 Sandeel 1r. Standardized effort. Line color denotes the season.




RTM Rsquare = 0.38
Age2(year - 1)
Age1(year)
11
10
9
9
10
11
2022
2020
2018
2016
2014

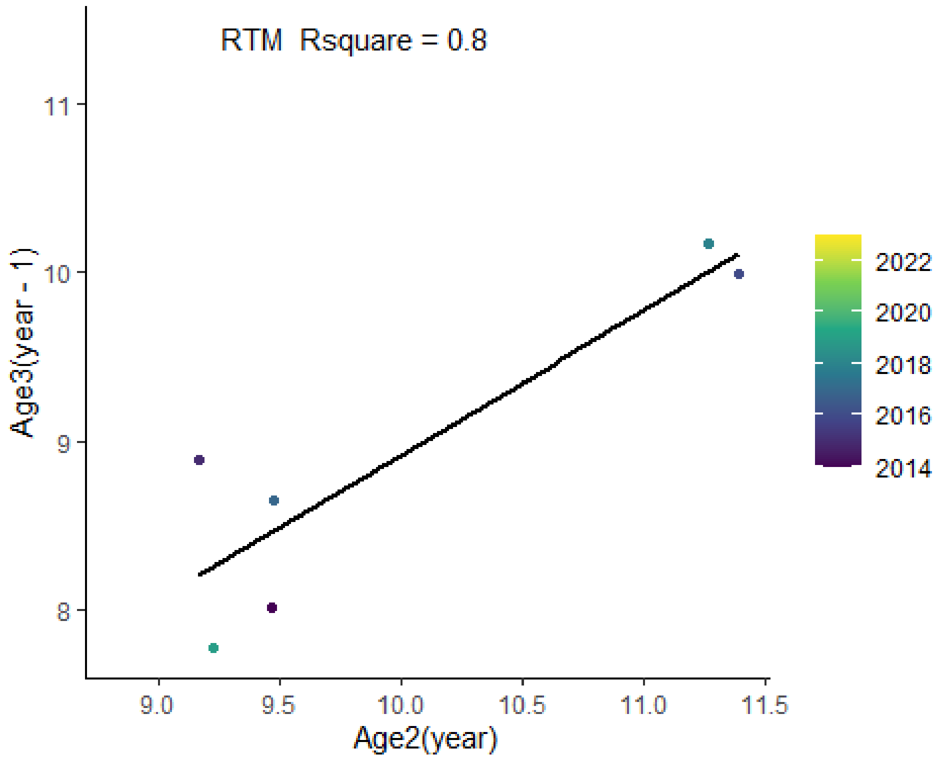


Figure 9.2.4 Sandeel 1r. Internal consistency by ages in the survey.

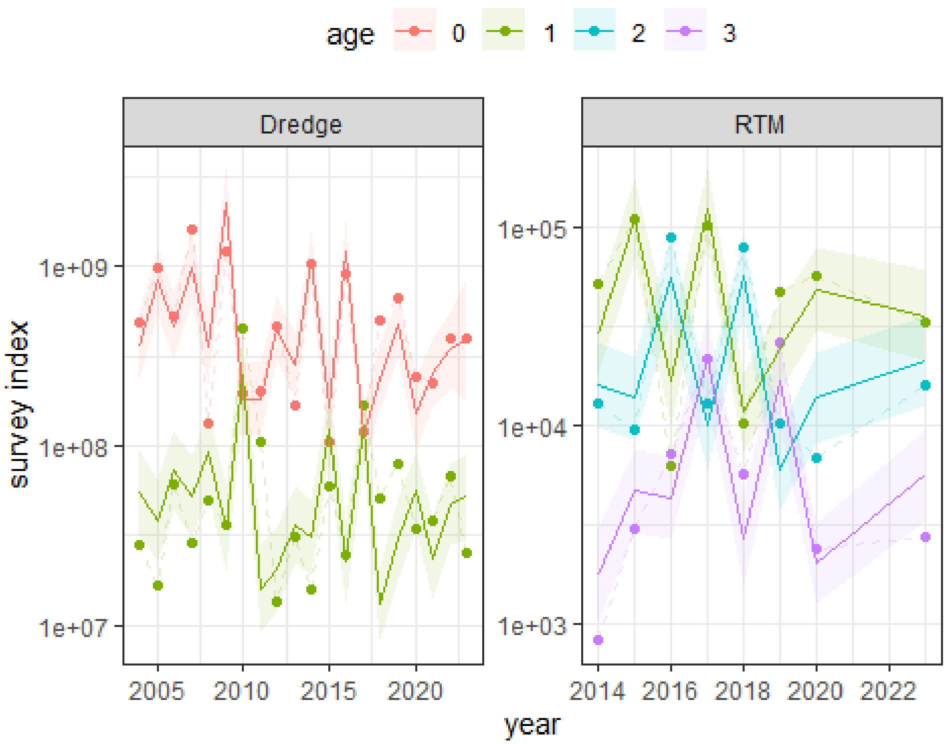


Figure 9.2.5 Sandeel 1r. Surveys (dots) and model fit (full lines). Color denotes the age.

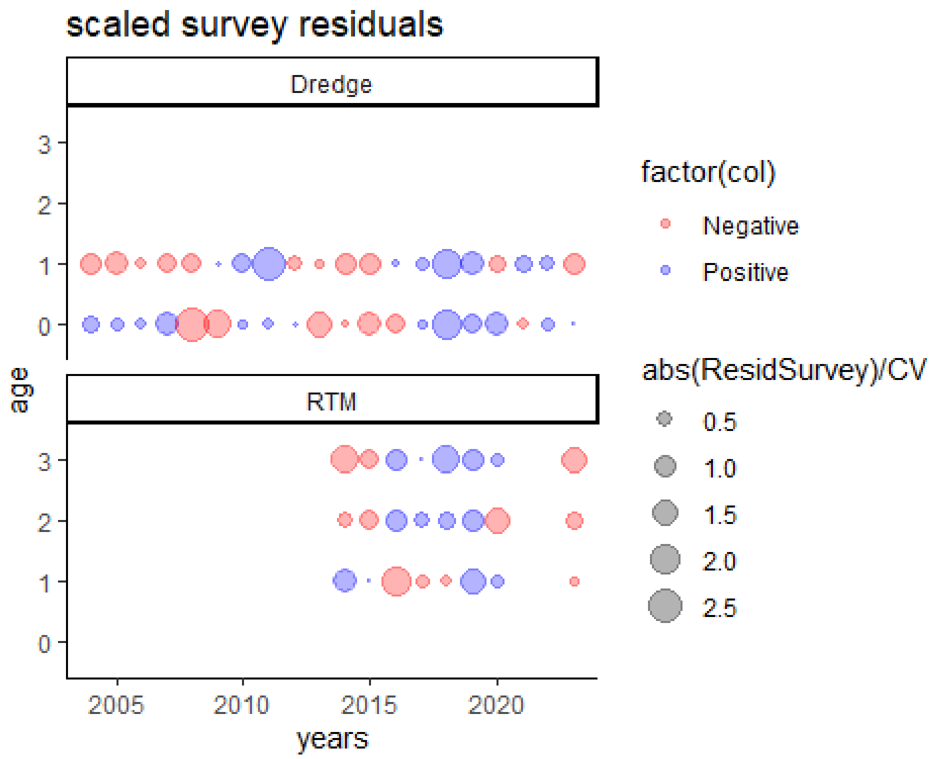


Figure 9.2.6 Sandeel 1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

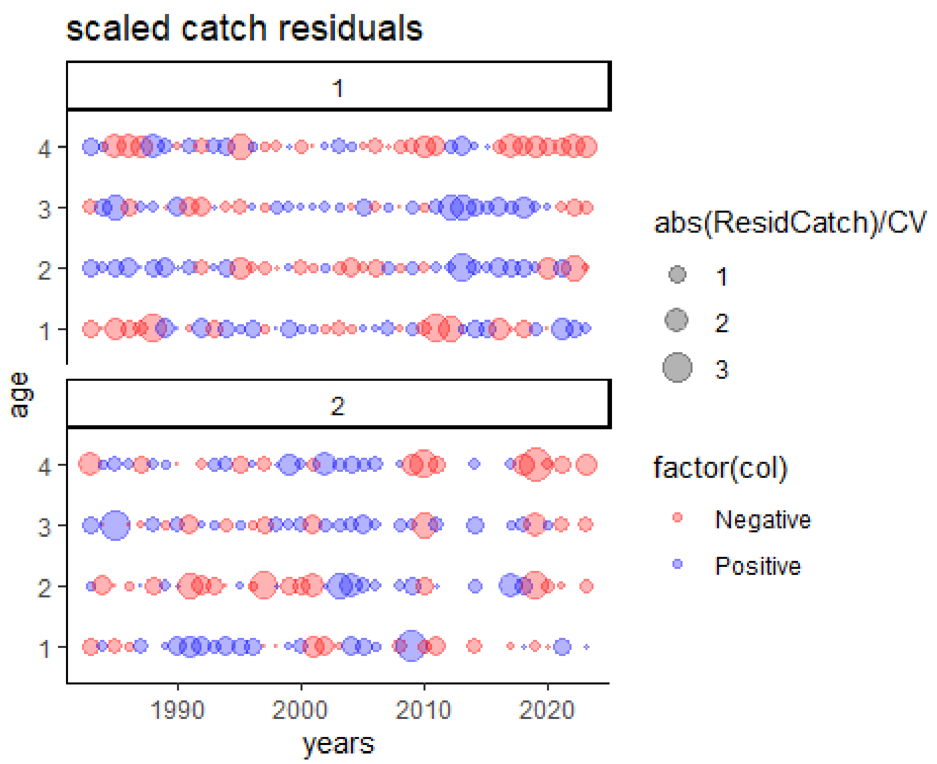


Figure 9.2.7 Sandeel 1r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

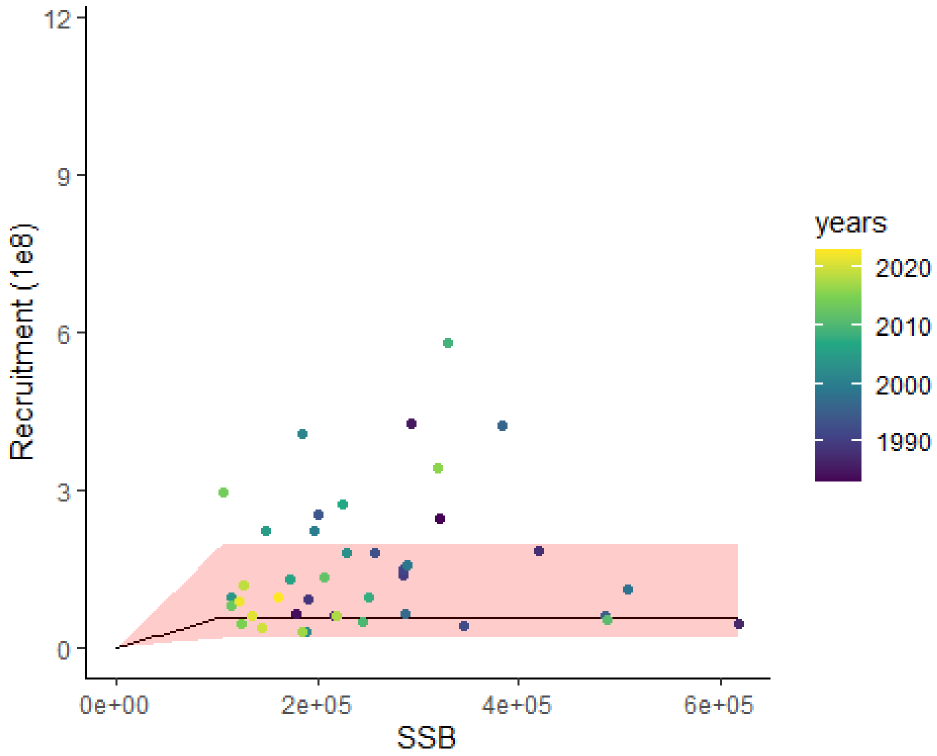


Figure 9.2.8 Sandeel 1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

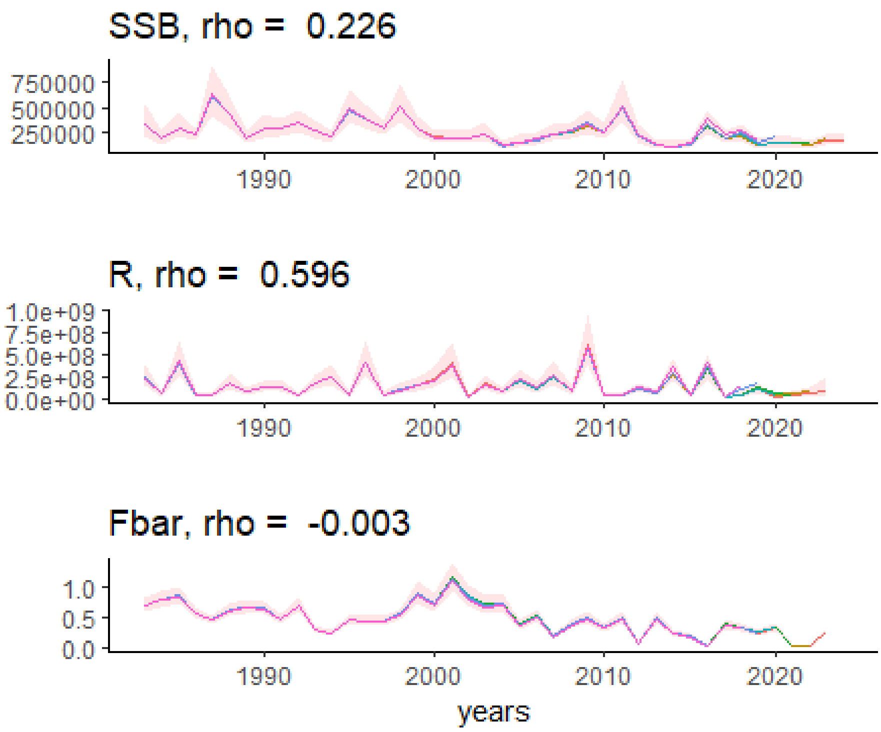


Figure 9.2.9 Sandeel 1r. Retrospective analysis.

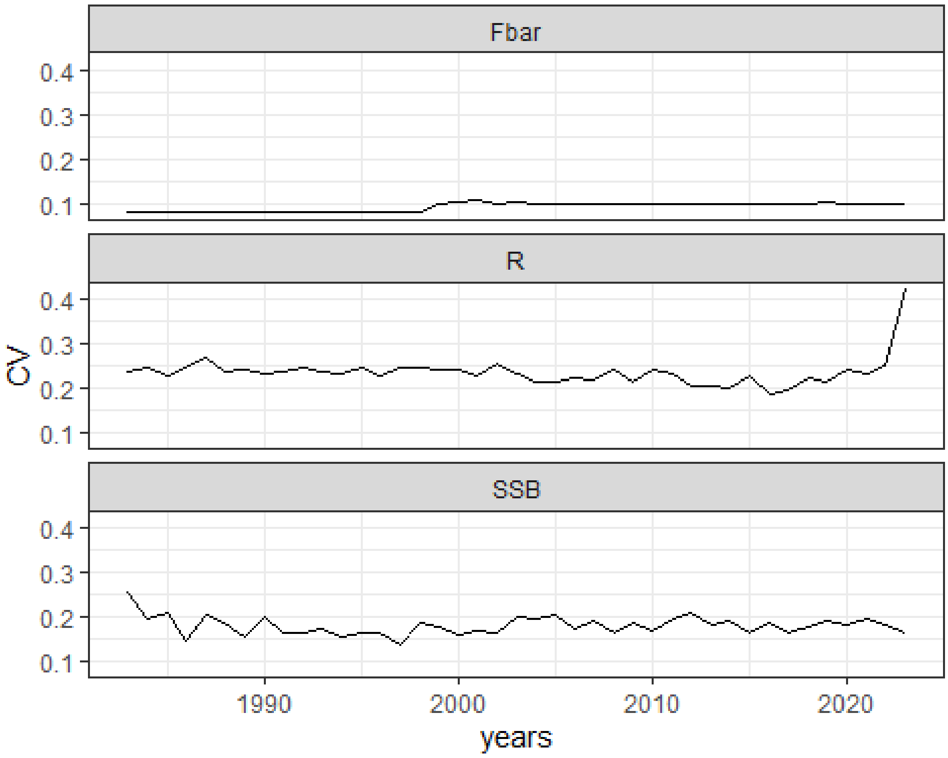


Figure 9.2.10 Sandeel 1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

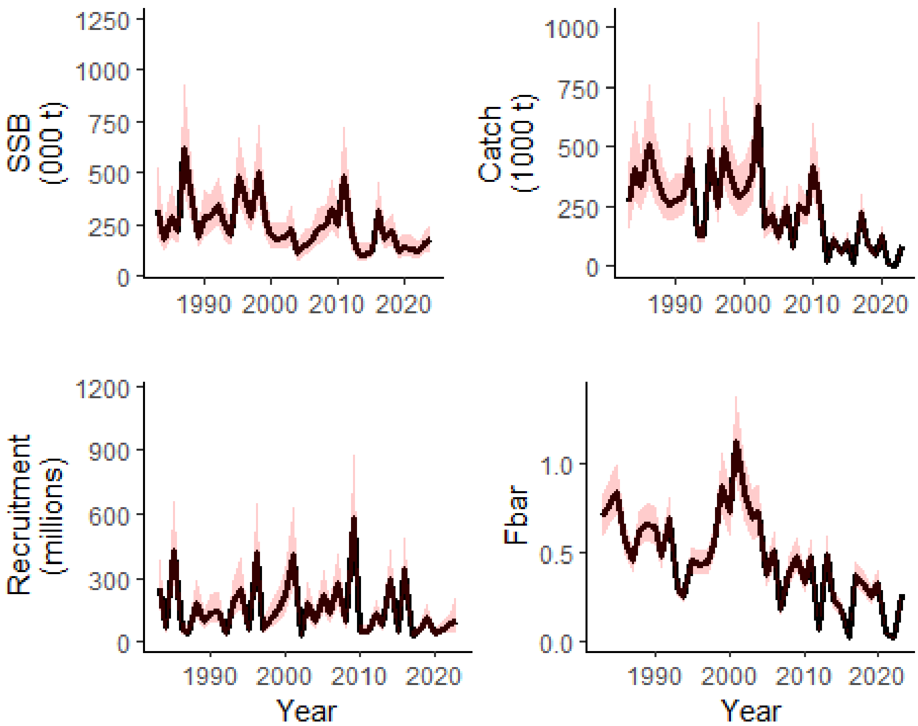


Figure 9.2.11 Sandeel 1r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

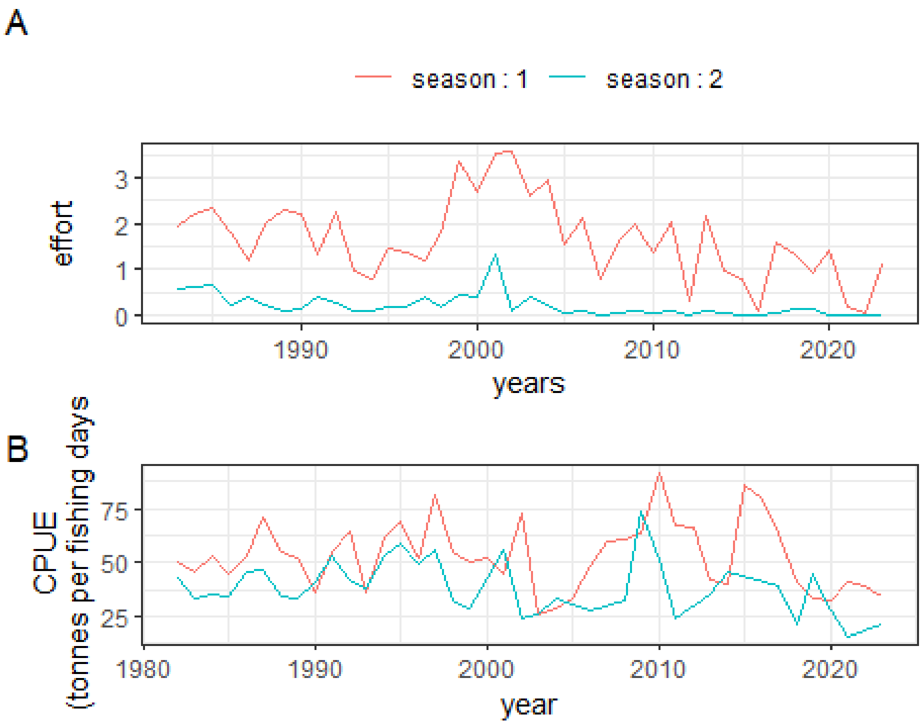


Figure 9.2.12 Sandeel 1r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

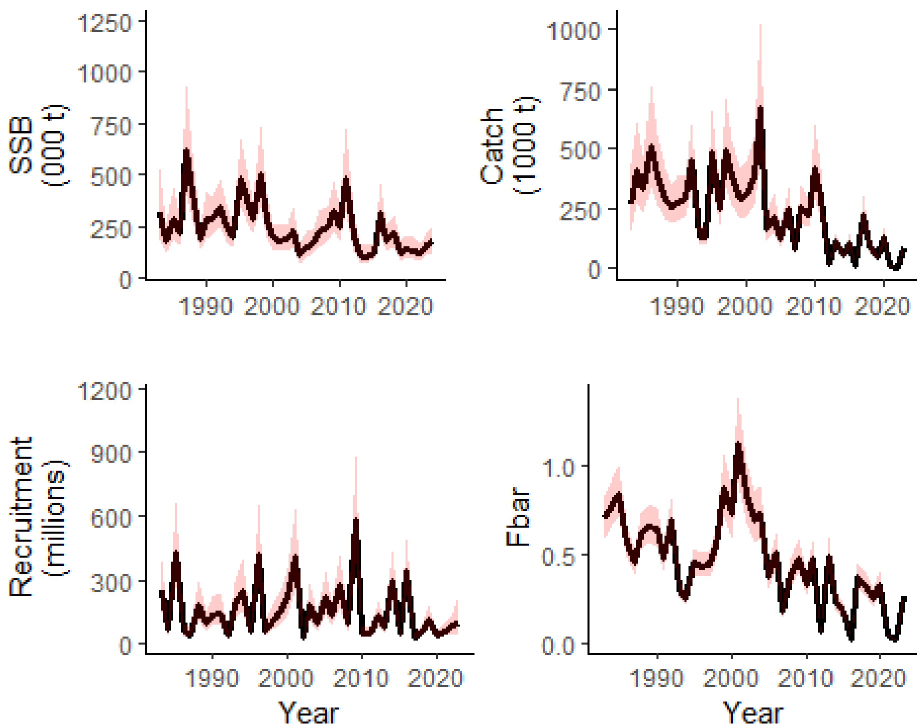


Figure 9.2.13 Sandeel 1r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

Figure 9.3.1 Sandeel 2r. Catch numbers, proportion at age.

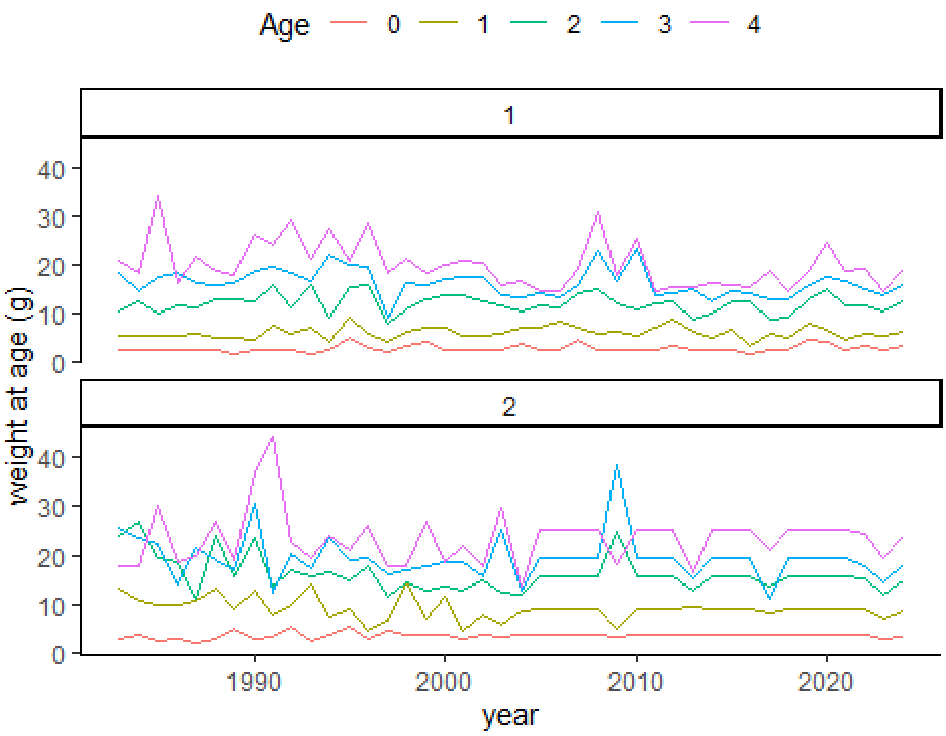


Figure 9.3.2 Sandeel 2r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

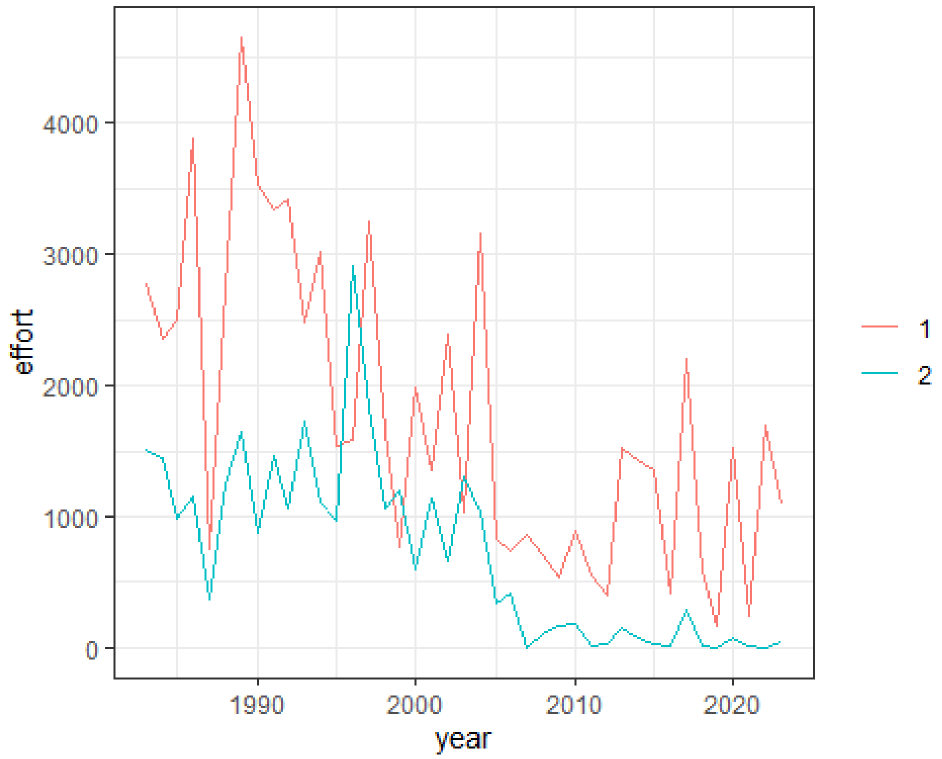


Figure 9.3.3 Sandeel 2r. Standardized effort. Line color denotes the season.

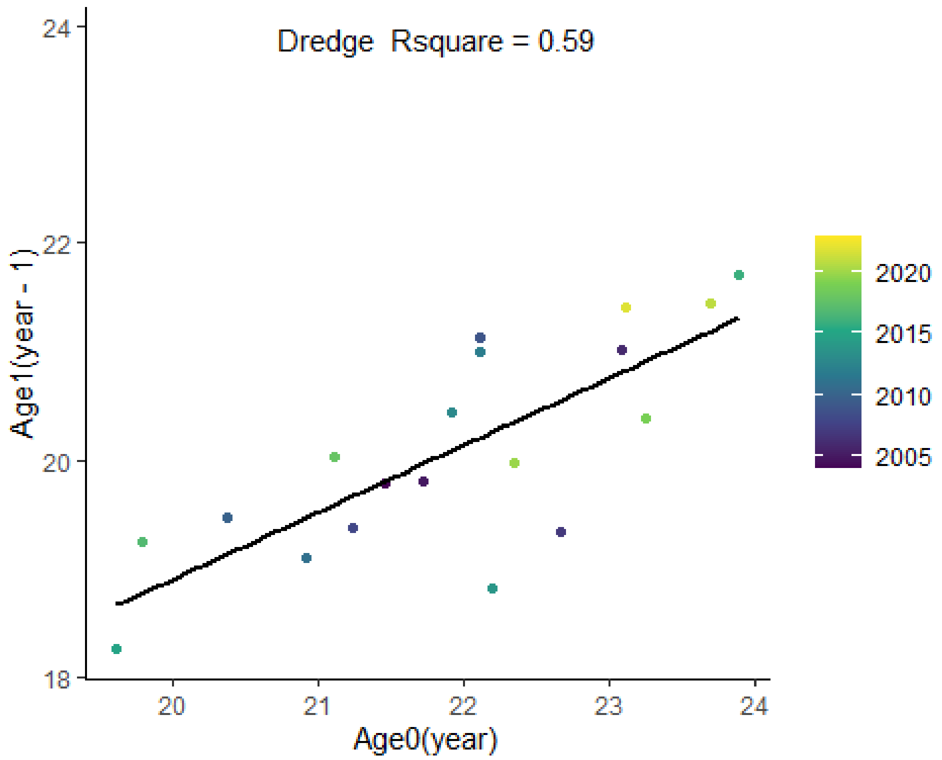


Figure 9.3.4 Sandeel 2r. Internal consistency by ages in the survey.

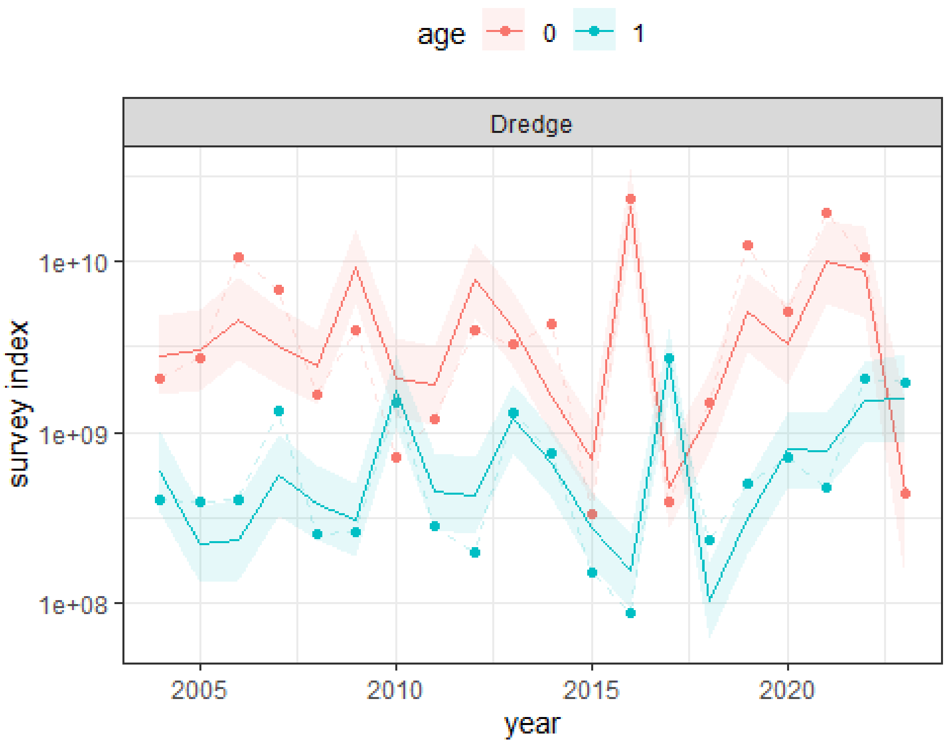


Figure 9.3.5 Sandeel 2r. Surveys (dots) and model fit (full lines). Color denotes the age.

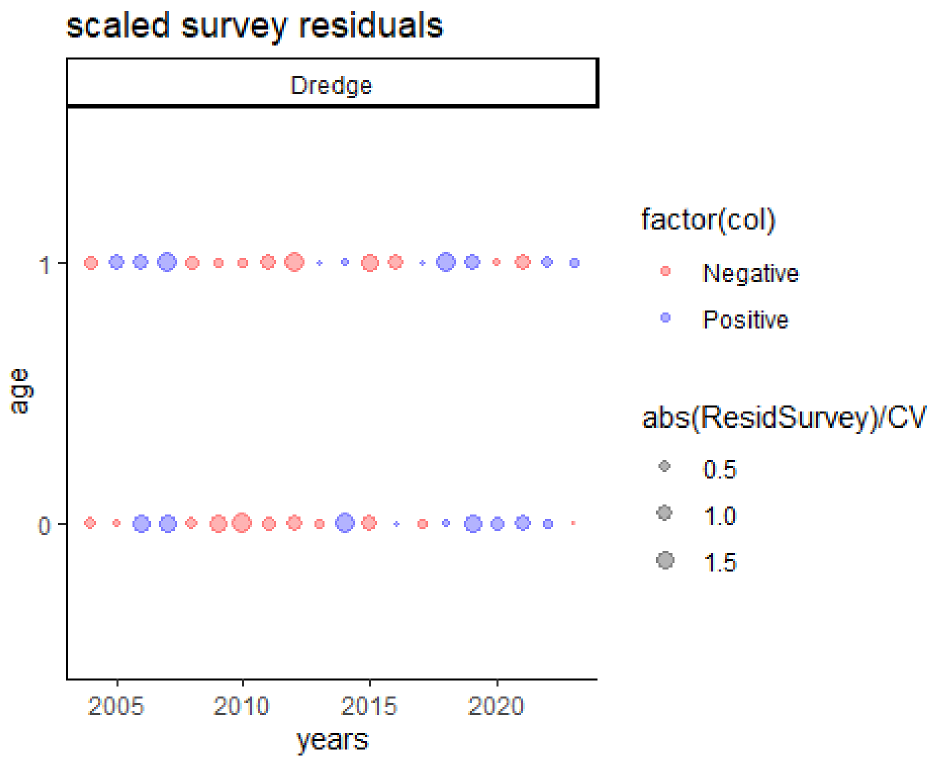


Figure 9.3.6 Sandeel 2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

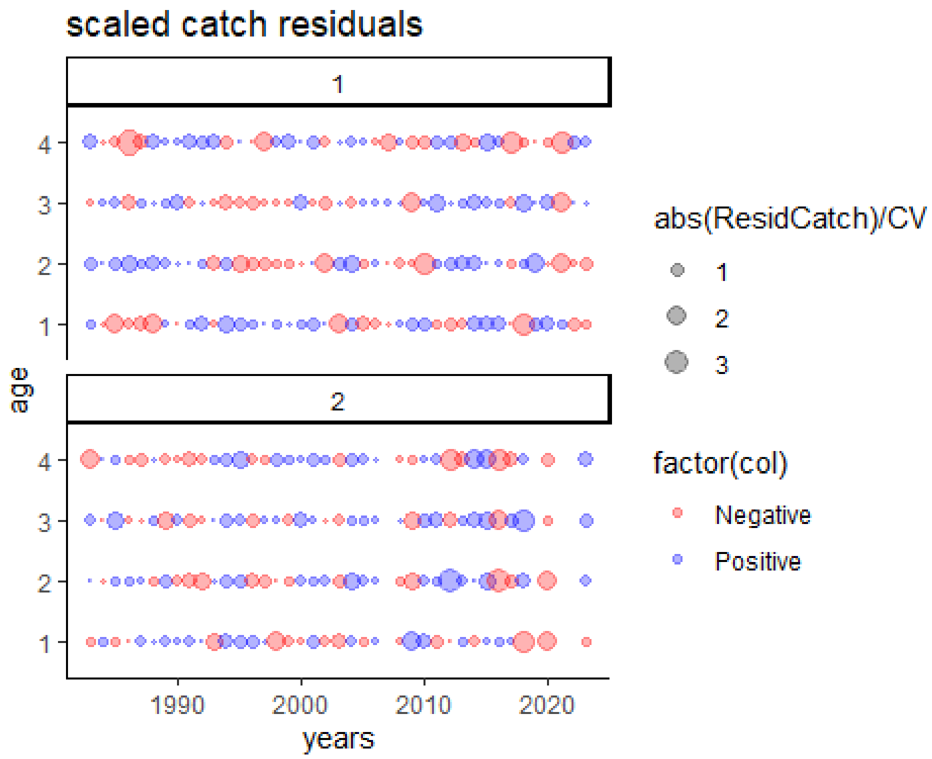


Figure 9.3.7 Sandeel 2r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

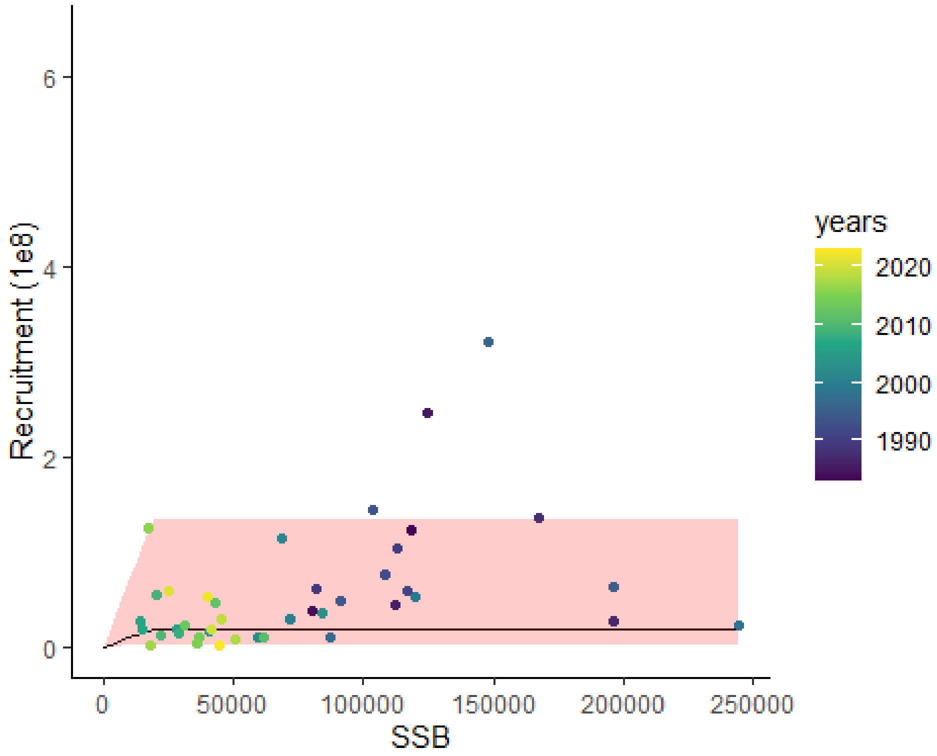


Figure 9.3.8 Sandeel 2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

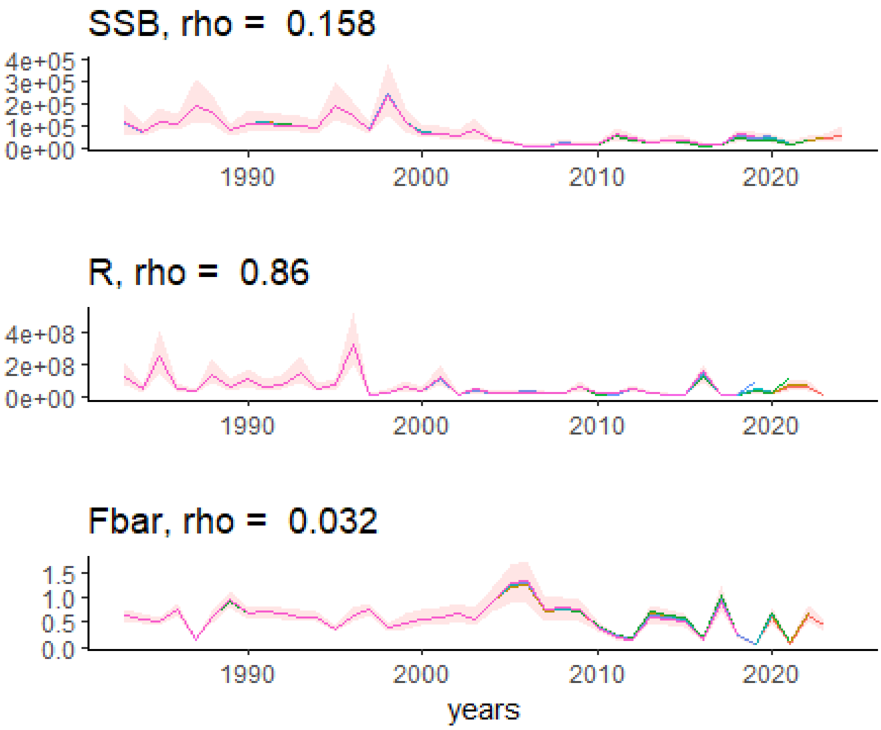


Figure 9.3.9 Sandeel 2r. Retrospective analysis.

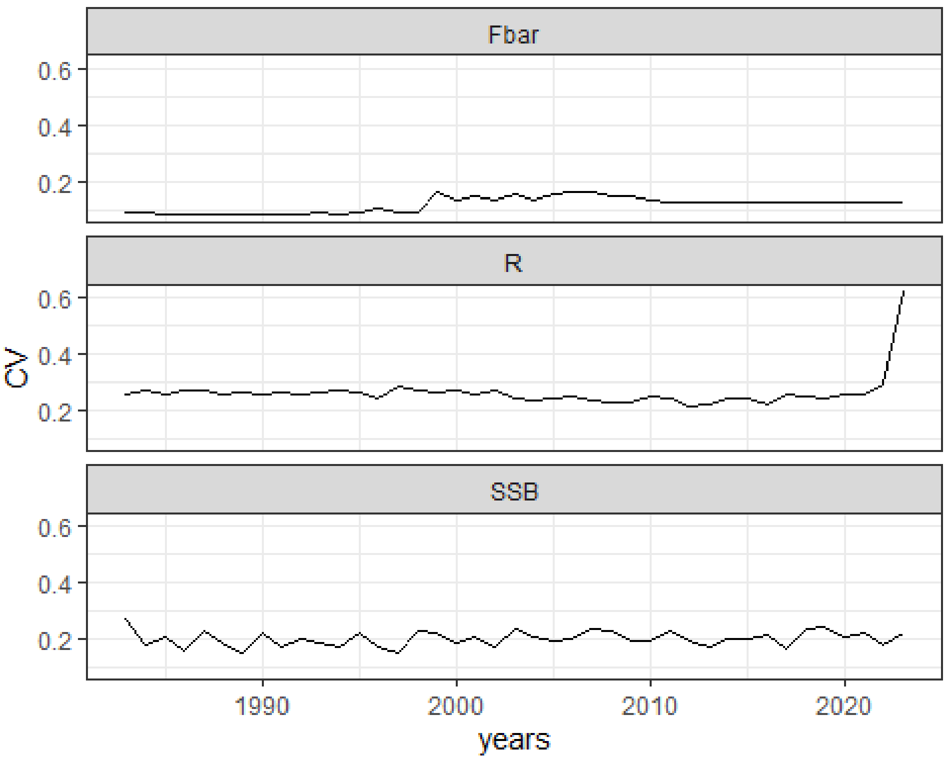


Figure 9.3.10 Sandeel 2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

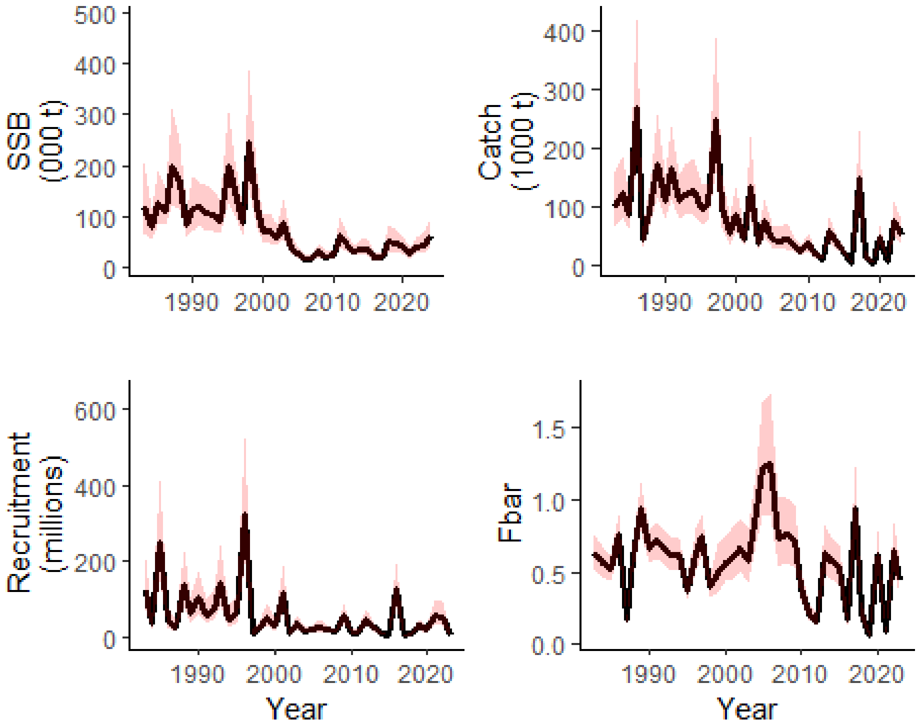


Figure 9.3.11 Sandeel 2r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

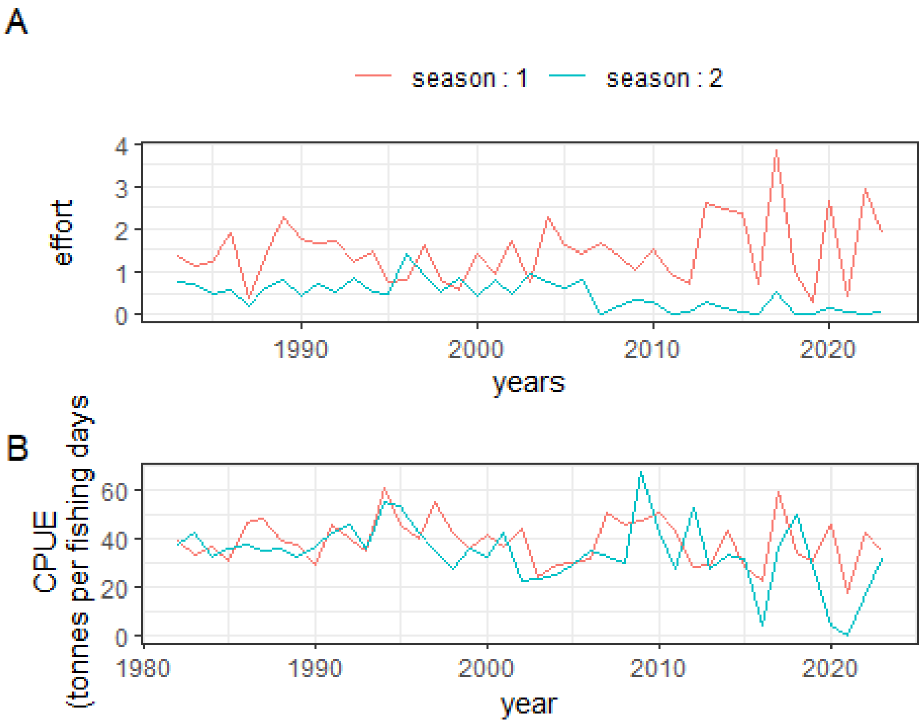


Figure 9.3.12 Sandeel 2r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

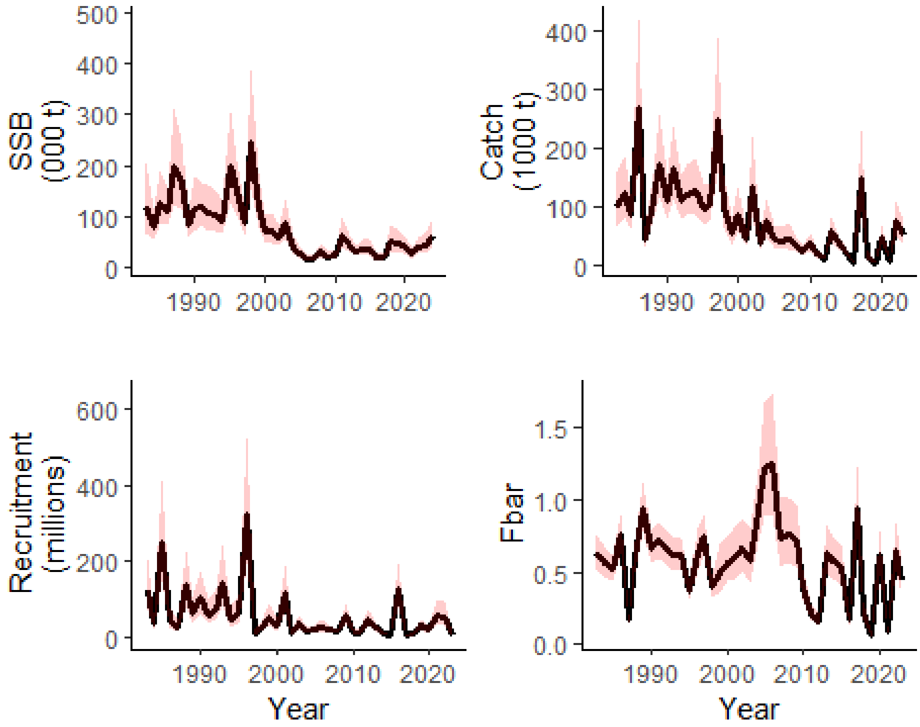


Figure 9.3.13 Sandeel 2r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

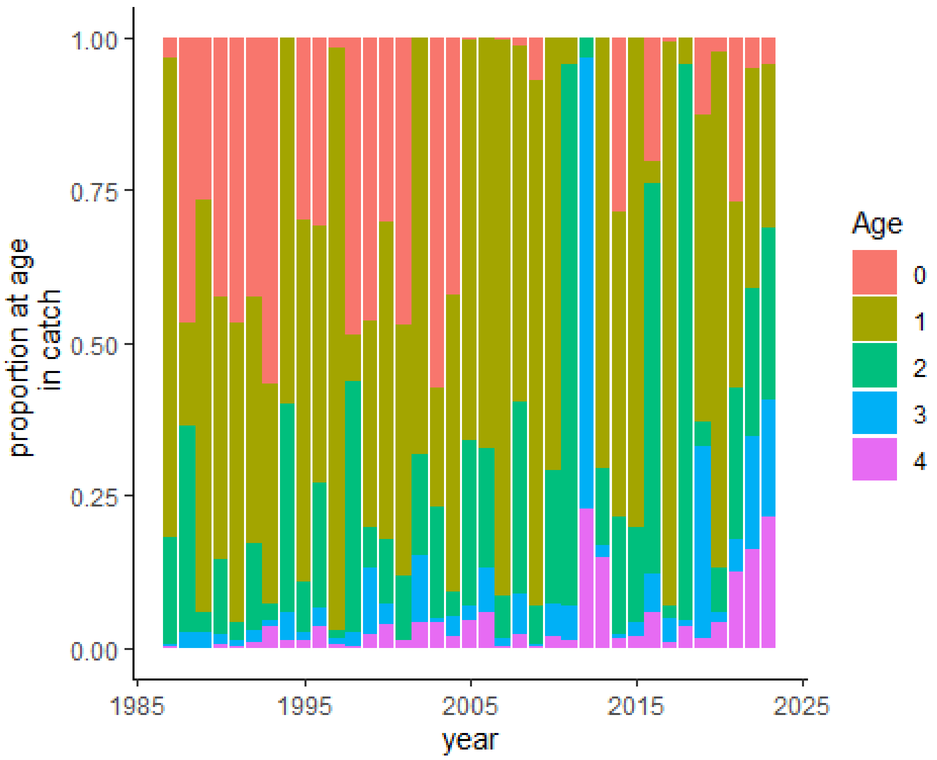


Figure 9.4.1 Sandeel 3r. Catch numbers, proportion at age.

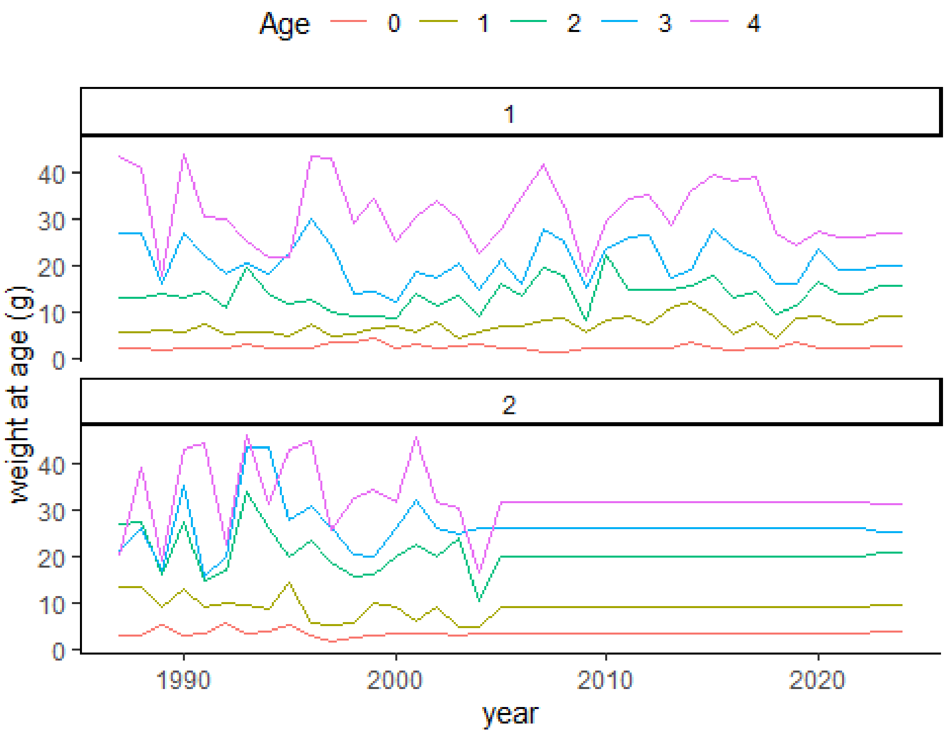


Figure 9.4.2 Sandeel 3r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

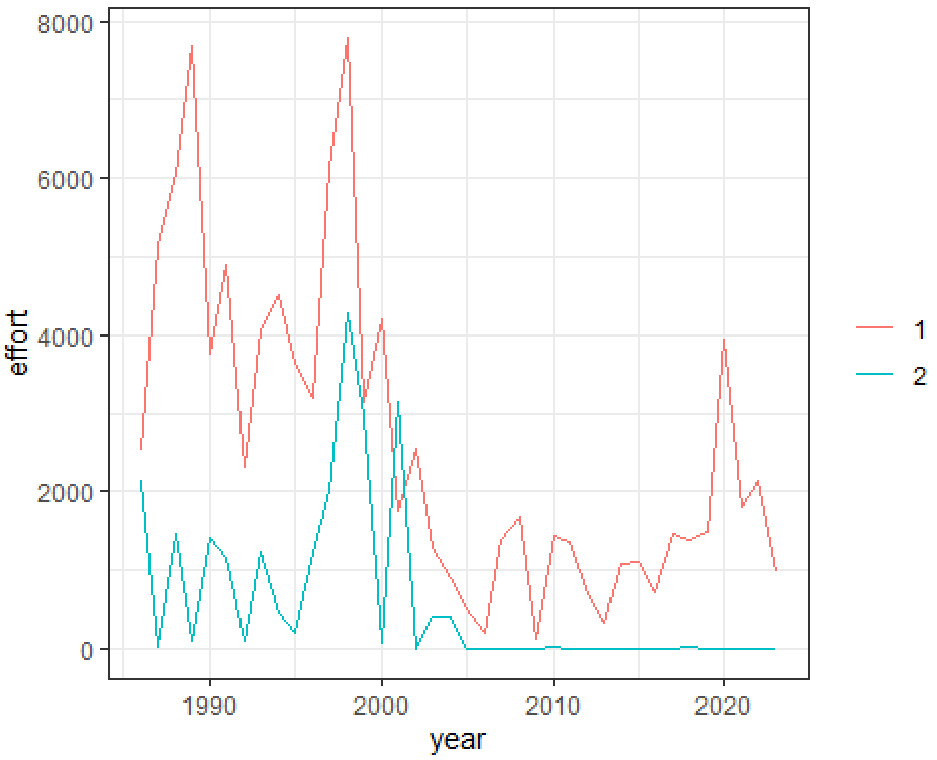
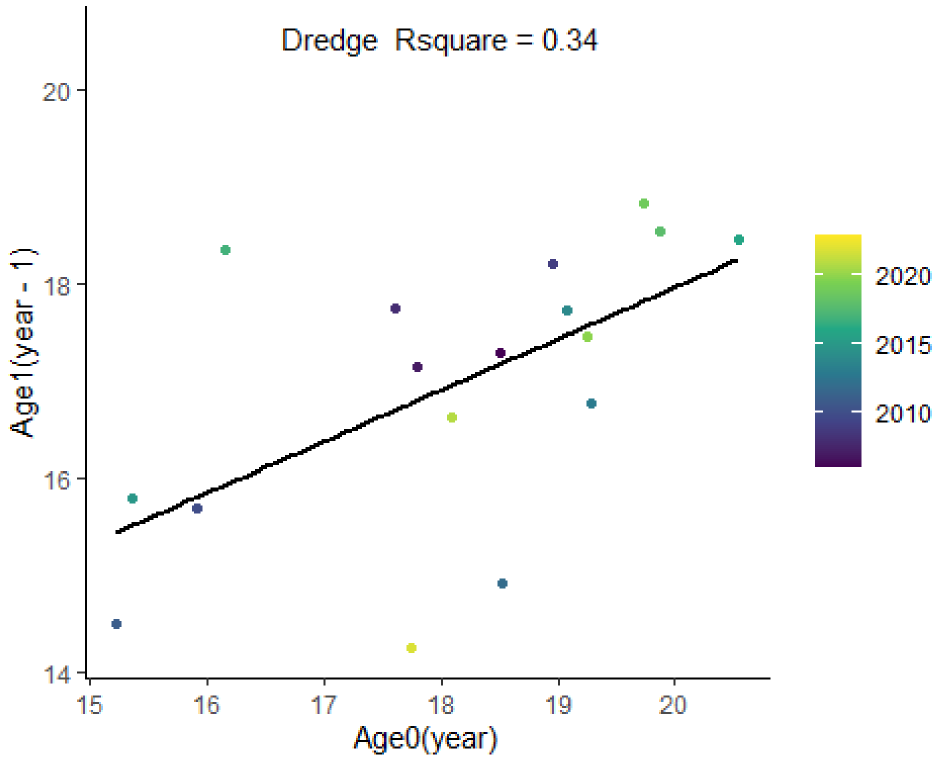
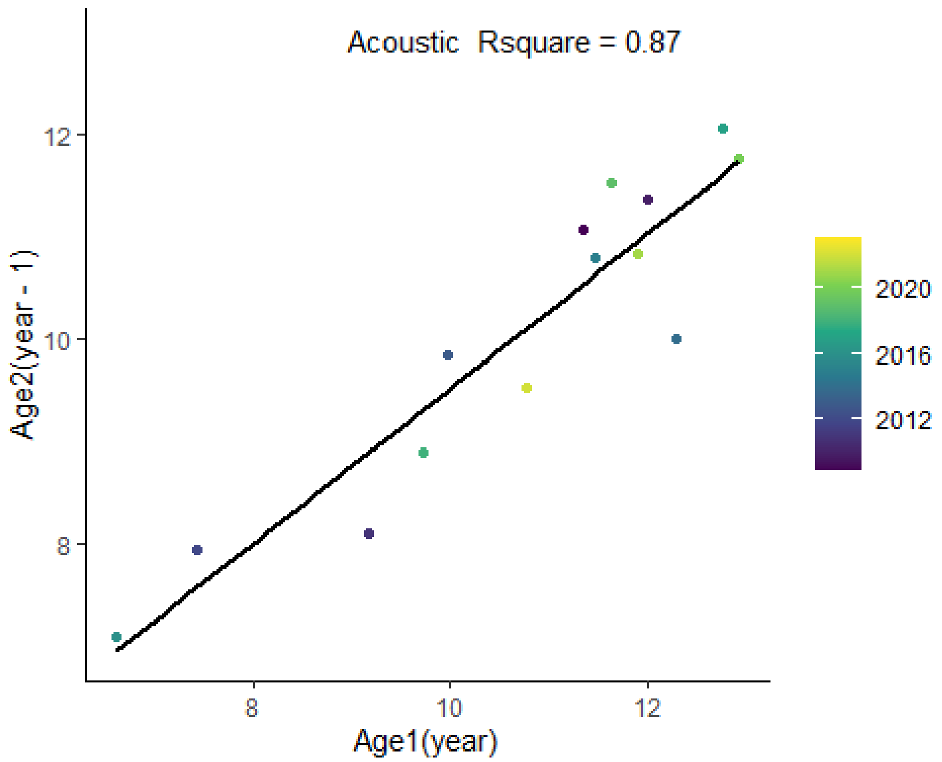


Figure 9.4.3 Sandeel 3r. Standardized effort. Line color denotes the season.


Dredge Rsquare = 0.34
Age1(year - 1)
Age0(year)
20
18
16
14
15
16
17
18
19
20
2020
2015
2010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Age2(year - 1)
Age1(year)
12
10
8
8
10
12
2020
2016
2012

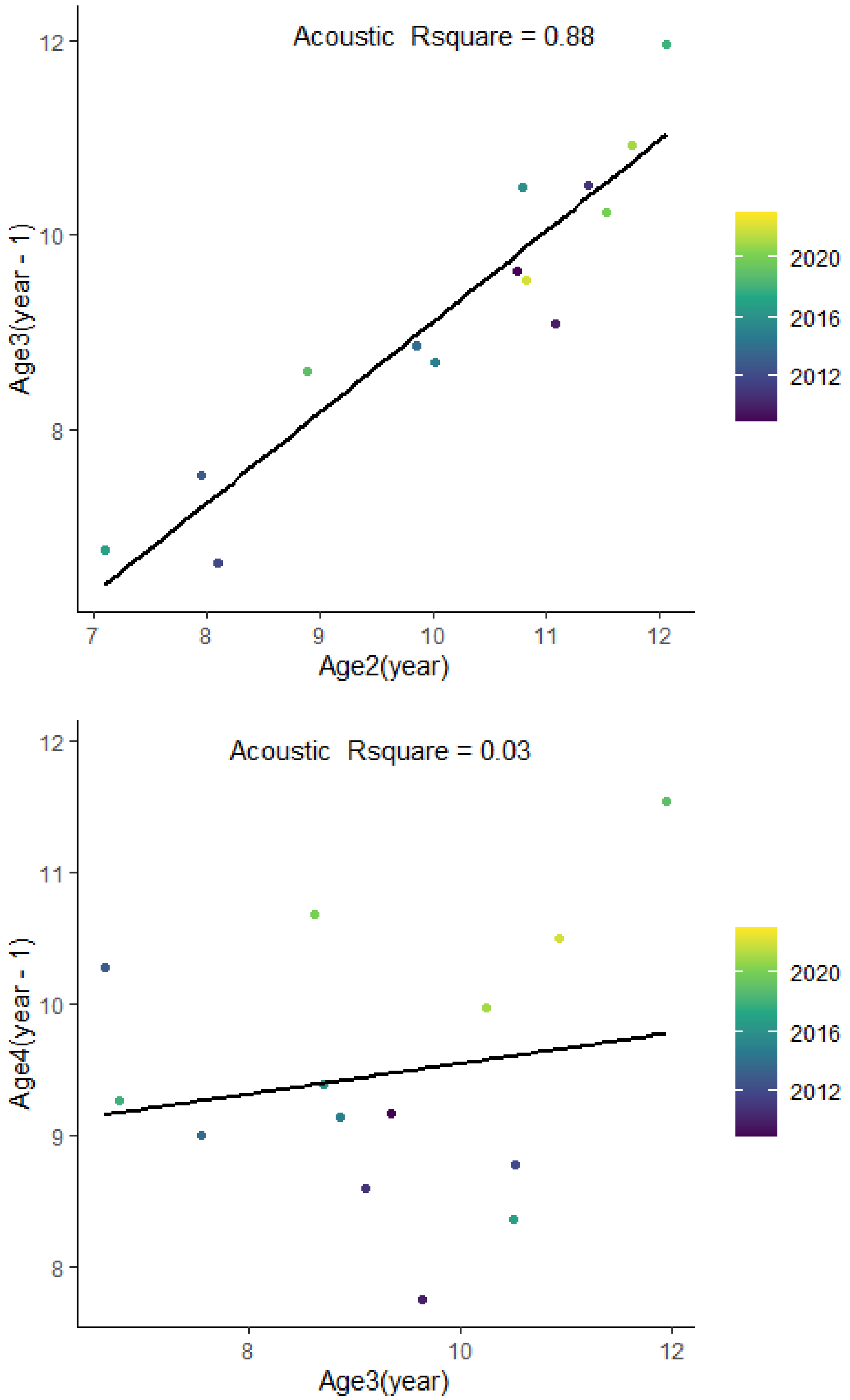


Figure 9.4.4 Sandeel 3r. Internal consistency by ages in the survey.

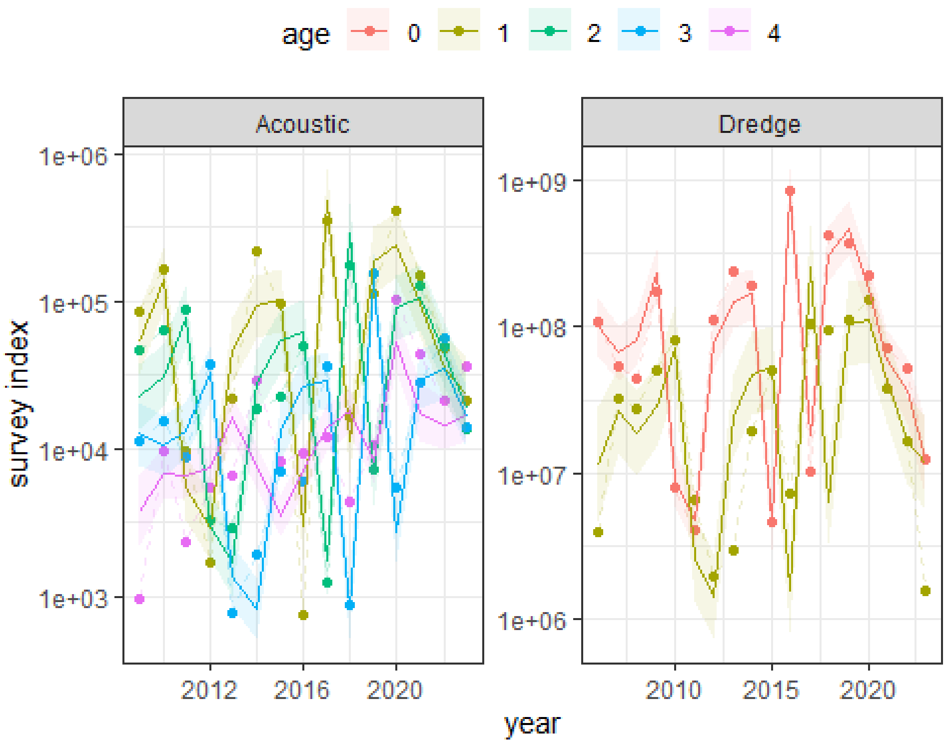


Figure 9.4.5 Sandeel 3r. Surveys (dots) and model fit (full lines). Color denotes the age.

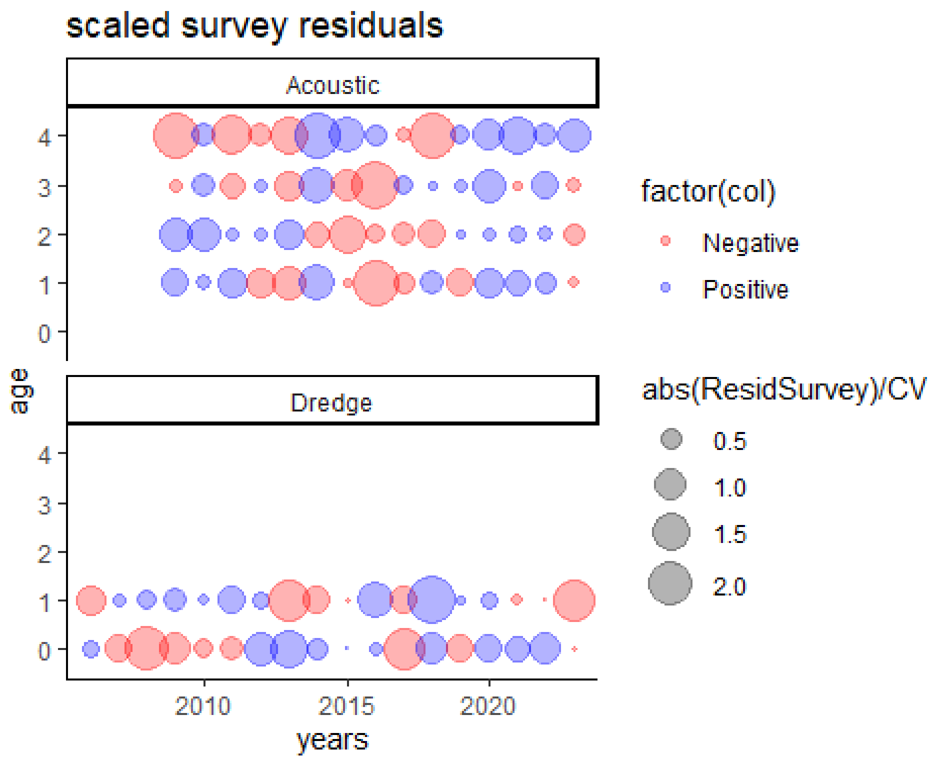


Figure 9.4.6 Sandeel 3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

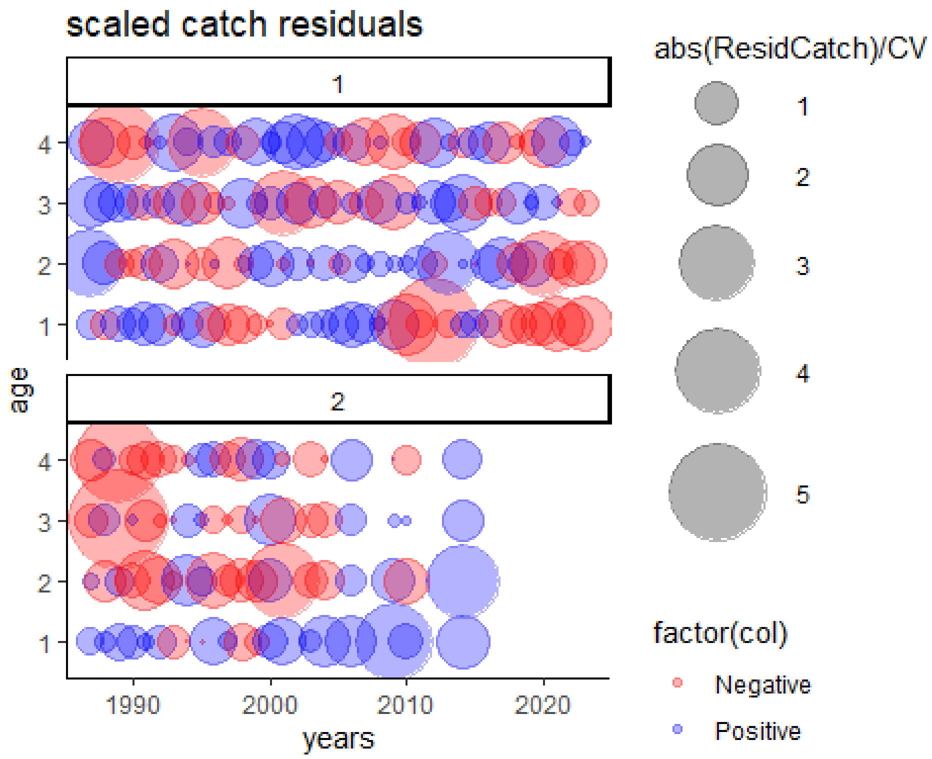


Figure 9.4.7 Sandeel 3r. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

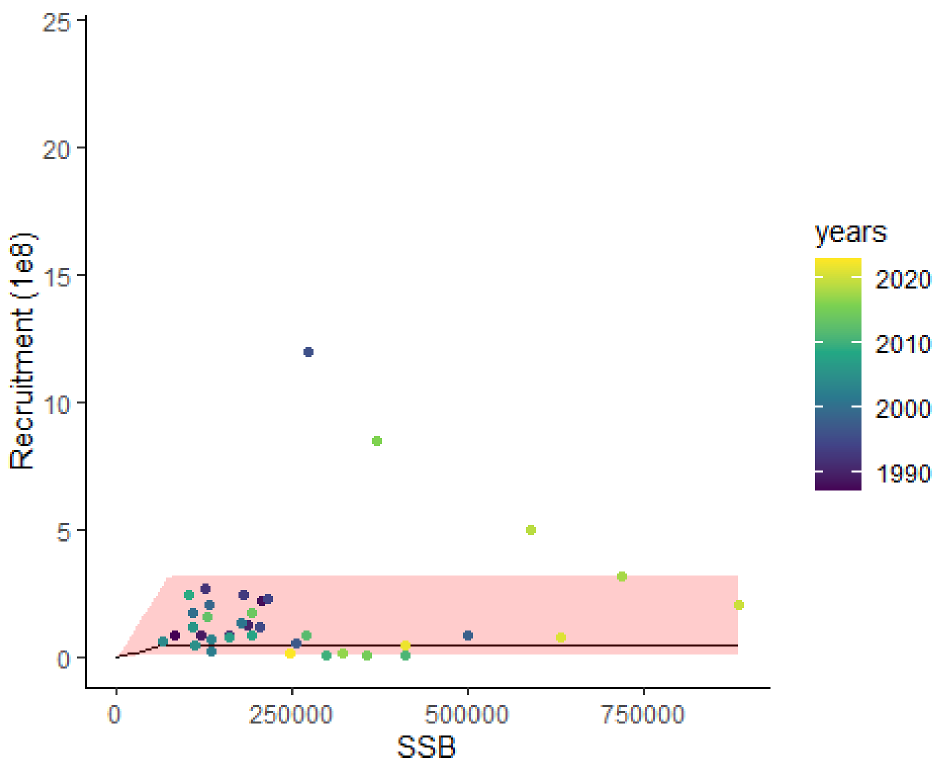


Figure 9.4.8 Sandeel 3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

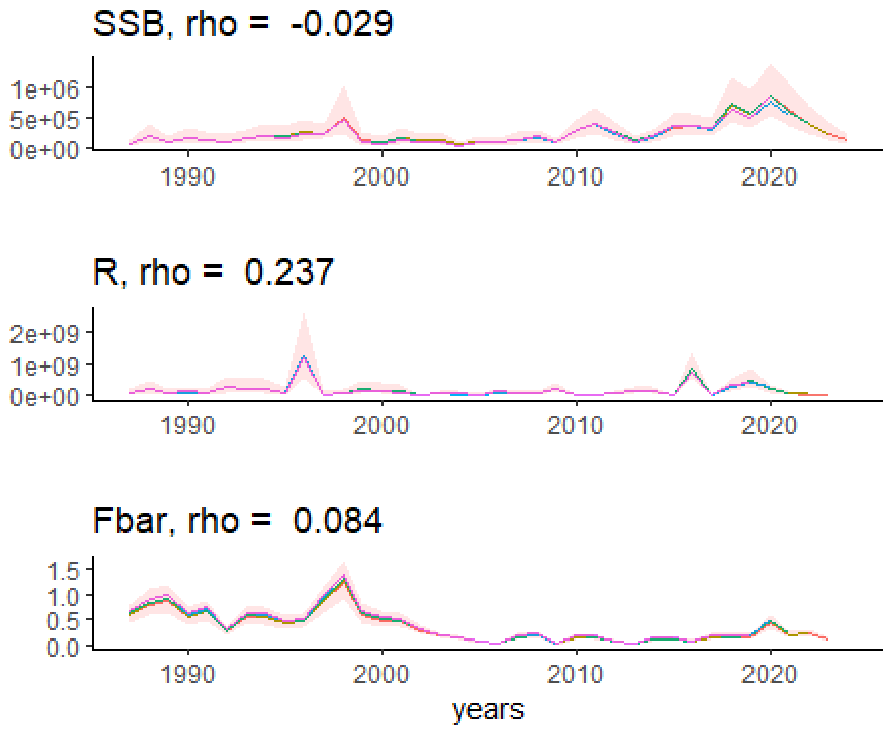


Figure 9.4.9 Sandeel 3r. Retrospective analysis.

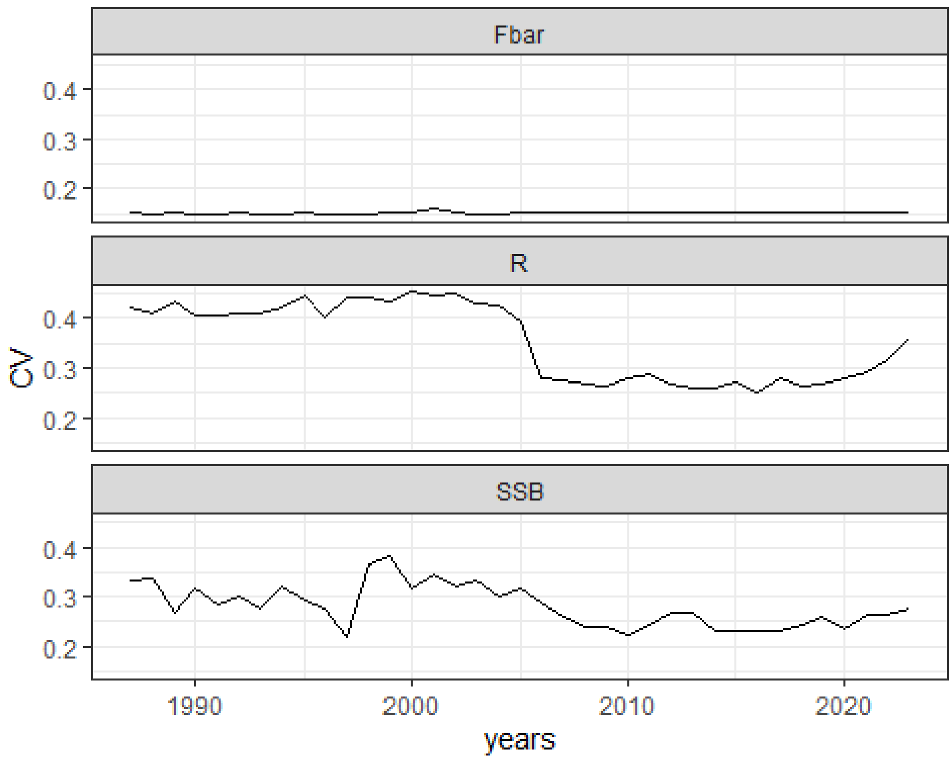


Figure 9.4.10 Sandeel 3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

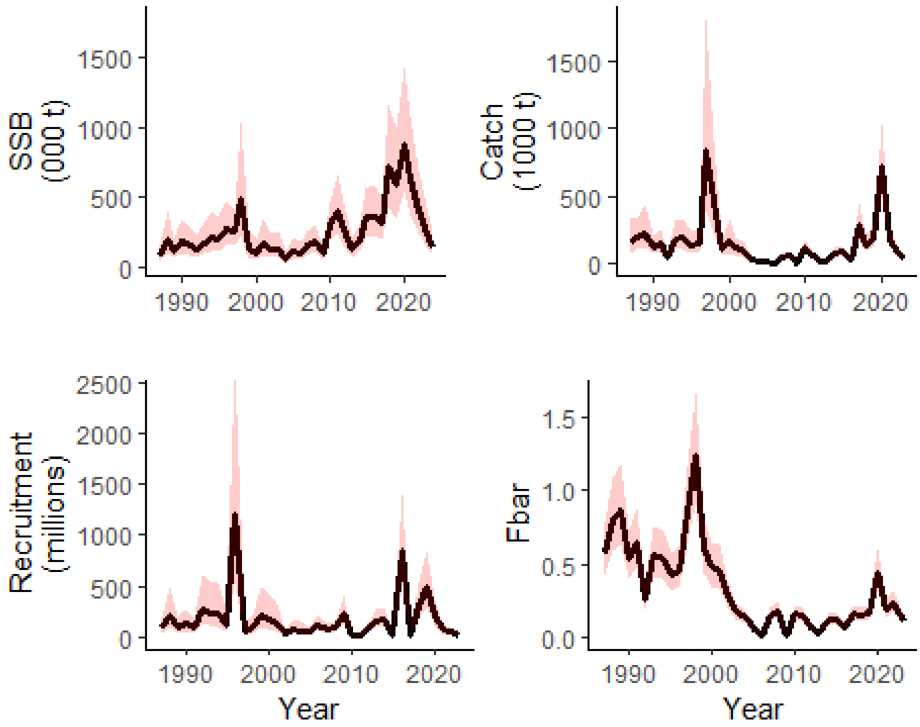


Figure 9.4.11 Sandeel 3r. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

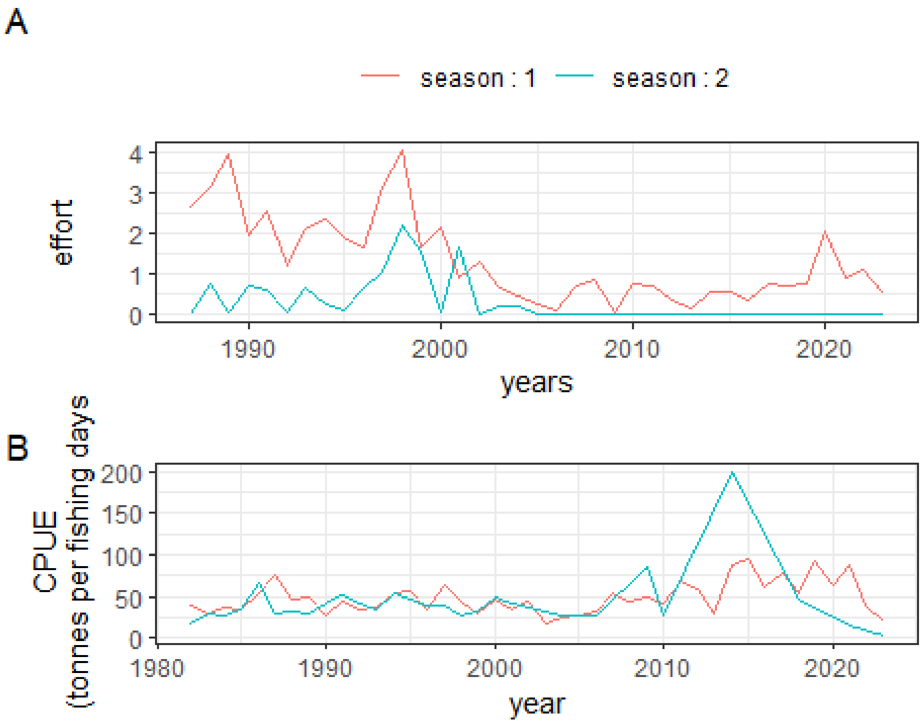


Figure 9.4.12 Sandeel 3r. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

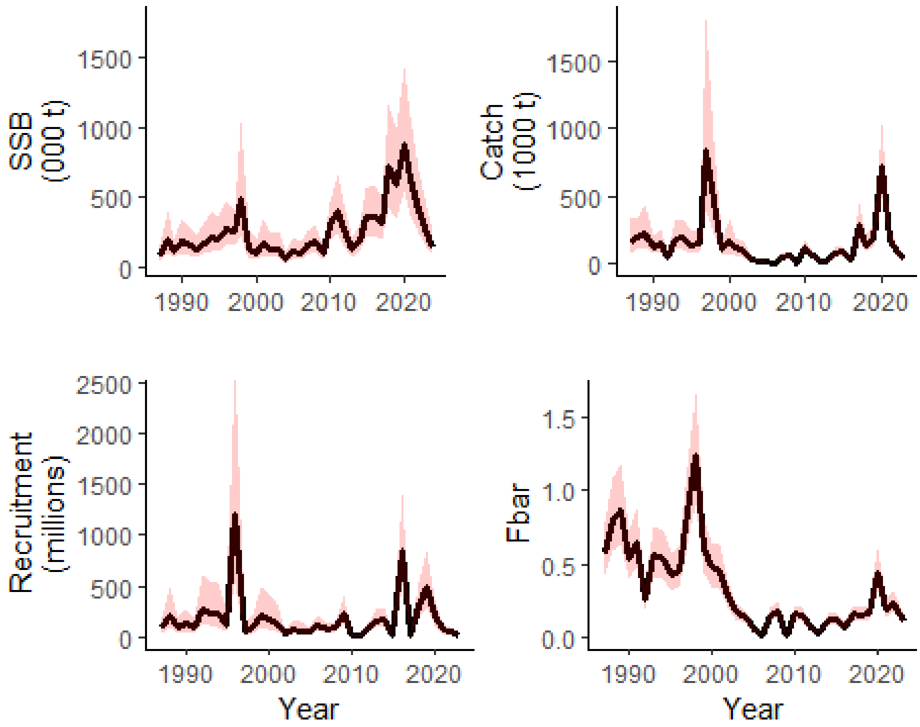


Figure 9.4.13 Sandeel 3r. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

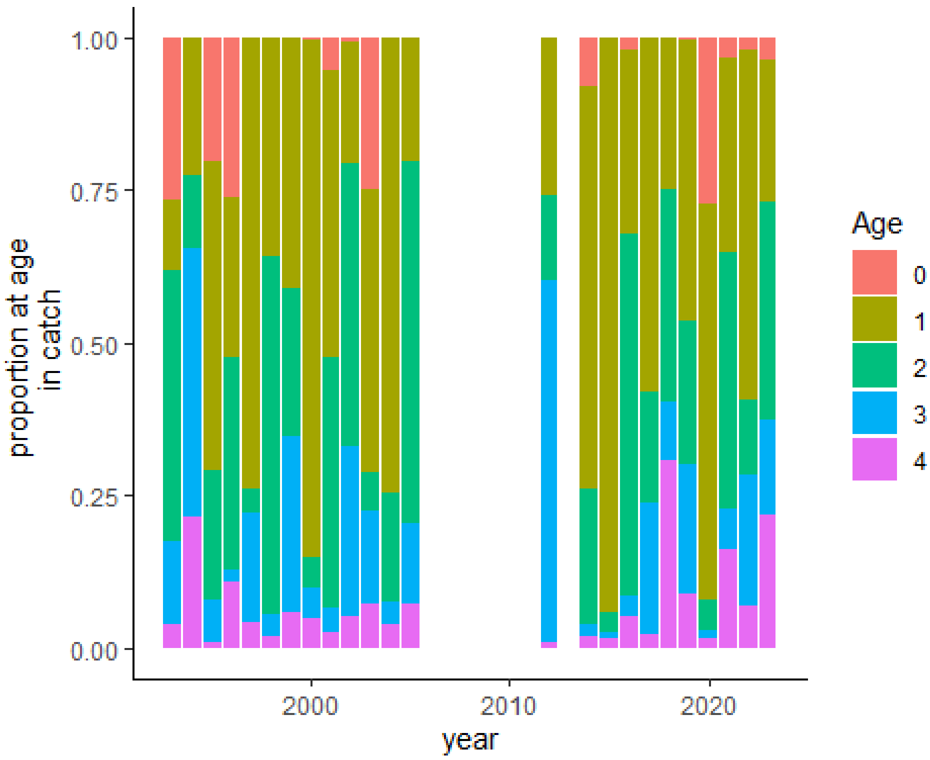


Figure 9.5.1 Sandeel 4. Catch numbers, proportion at age.

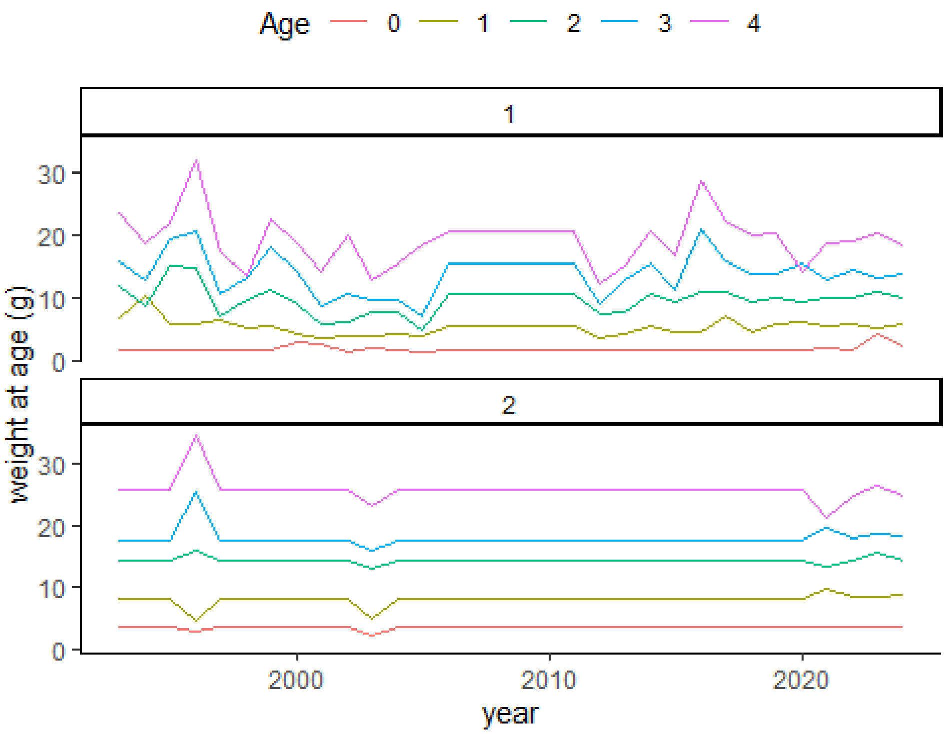


Figure 9.5.2 Sandeel 4. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

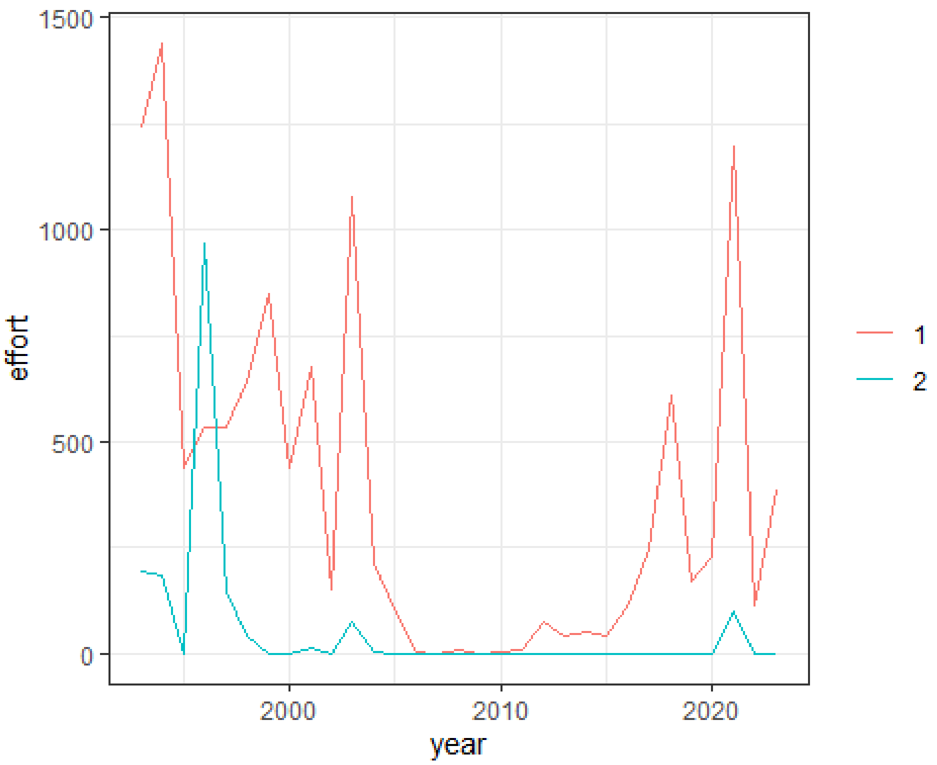


Figure 9.5.3 Sandeel 4. Standardized effort. Line color denotes the season.

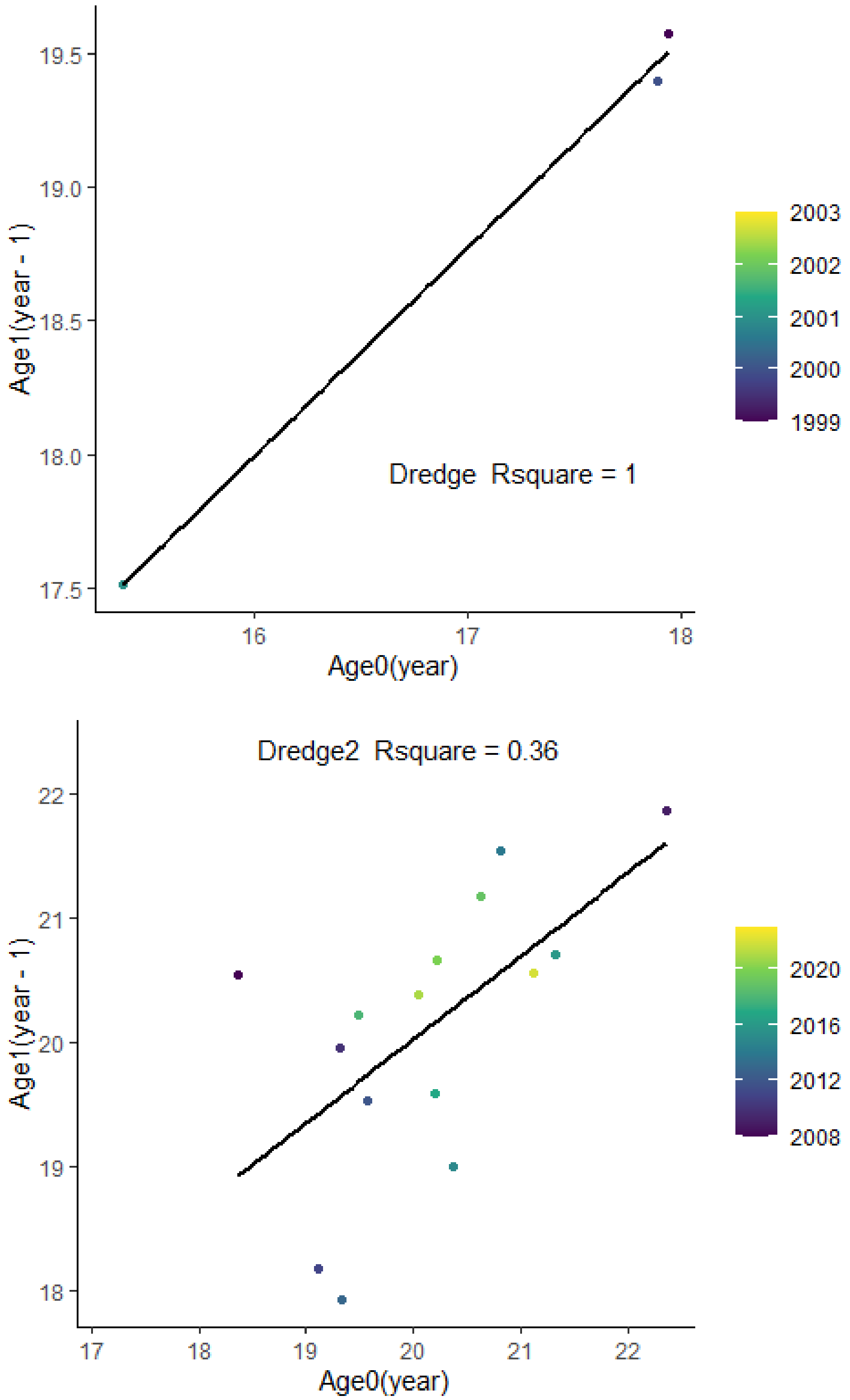


Figure 9.5.4 Sandeel 4. Internal consistency by ages in the survey.

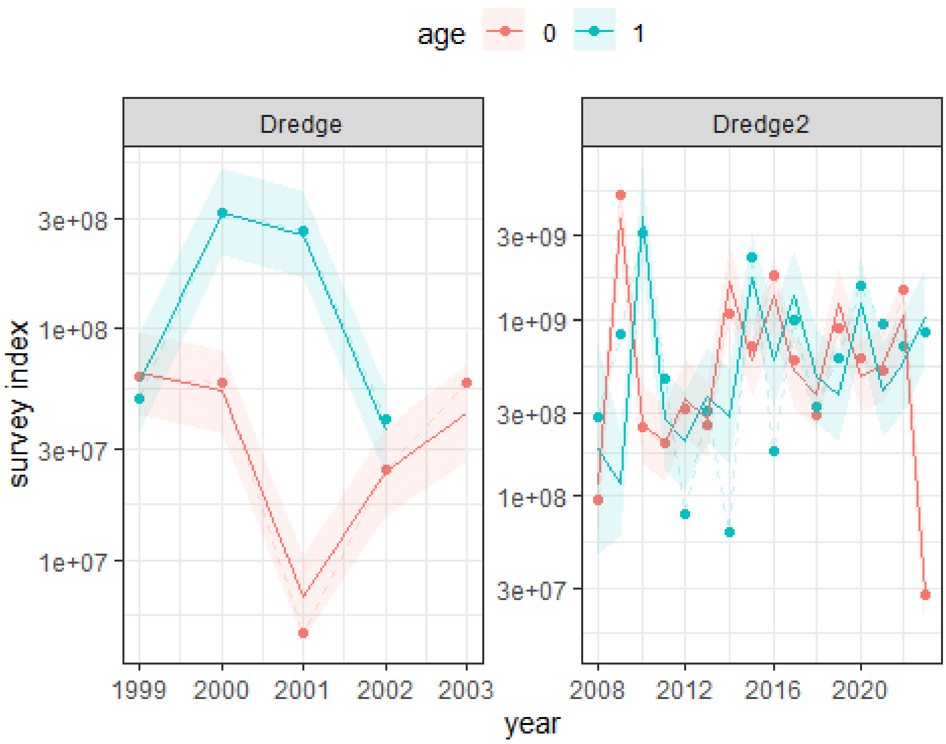


Figure 9.5.5 Sandeel 4. Surveys (dots) and model fit (full lines). Color denotes the age.

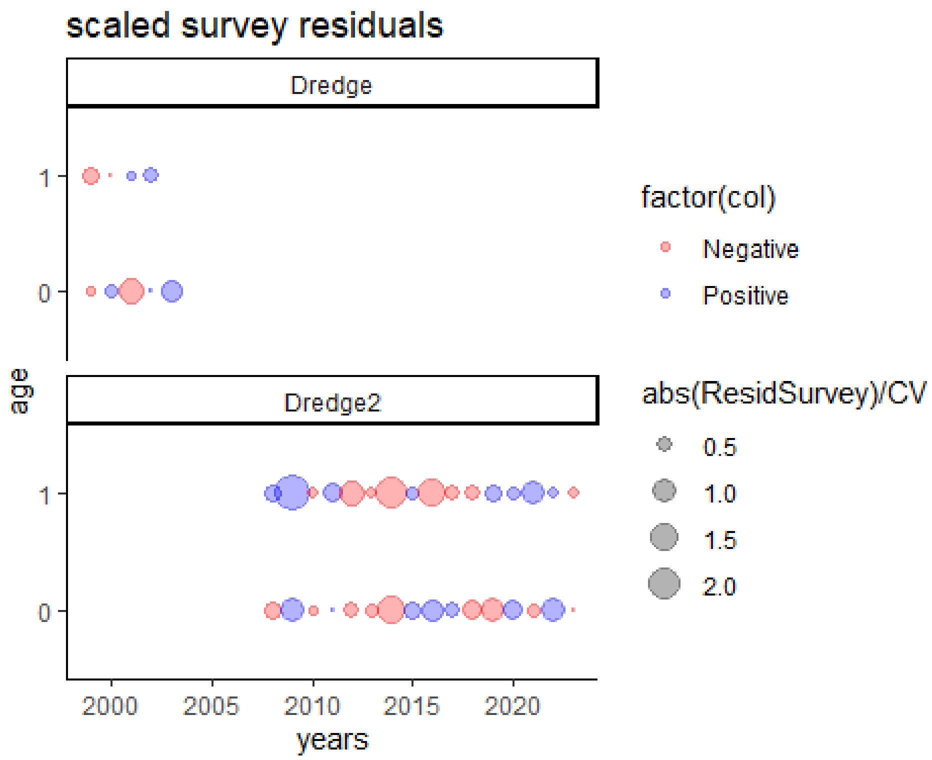


Figure 9.5.6 Sandeel 4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed)

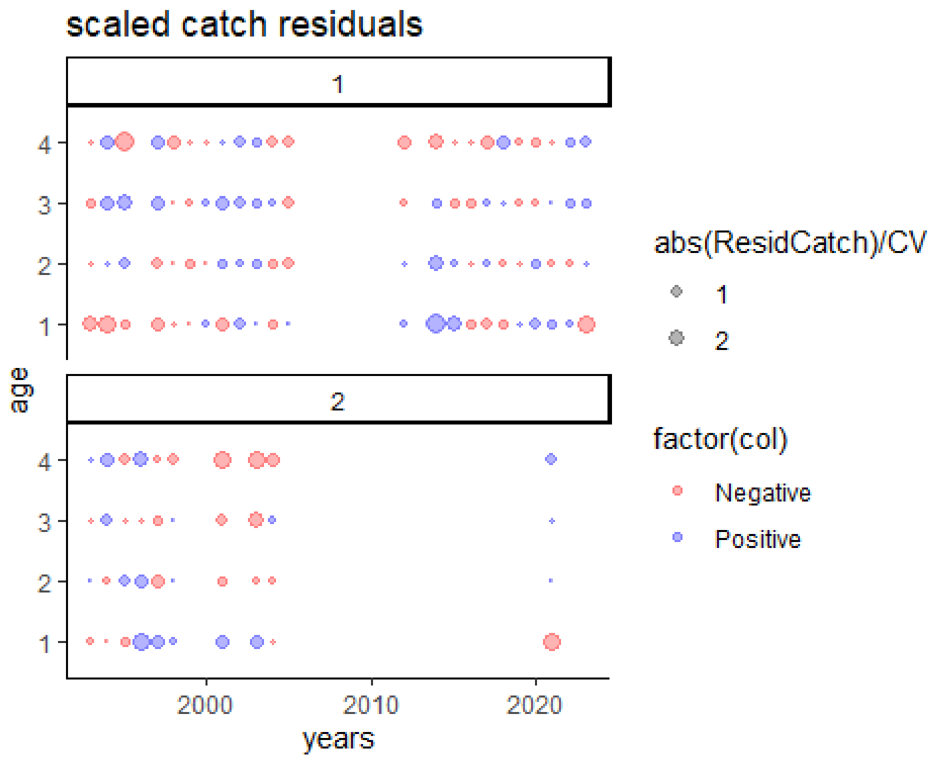


Figure 9.5.7 Sandeel 4. Catch at age residuals (log(observed catch)- log(expected catch) scaled by the estimated CV. "Red" dots show a negative residual (estimated is higher than observed).

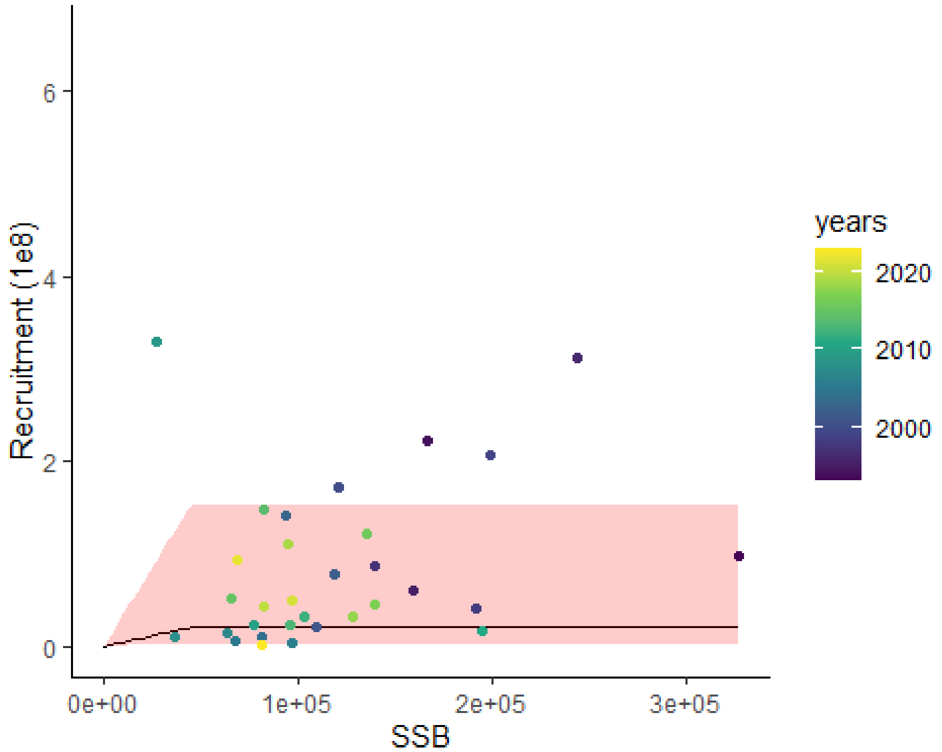


Figure 9.5.8 Sandeel 4. Estimated stock recruitment relation. Red line = median of the expected recruitment, The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

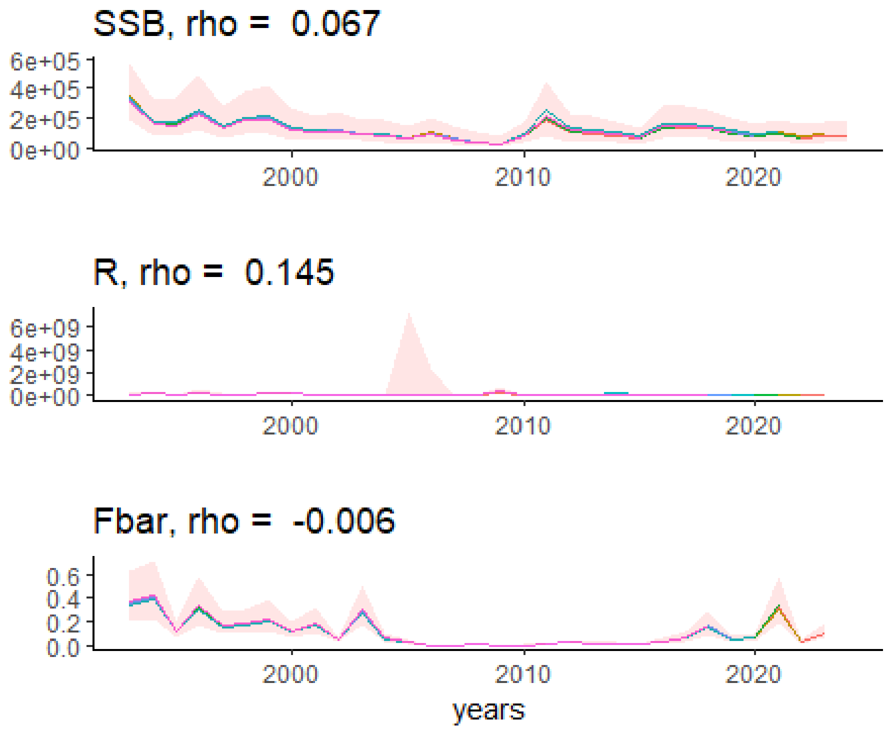


Figure 9.5.9 Sandeel 4. Retrospective analysis.

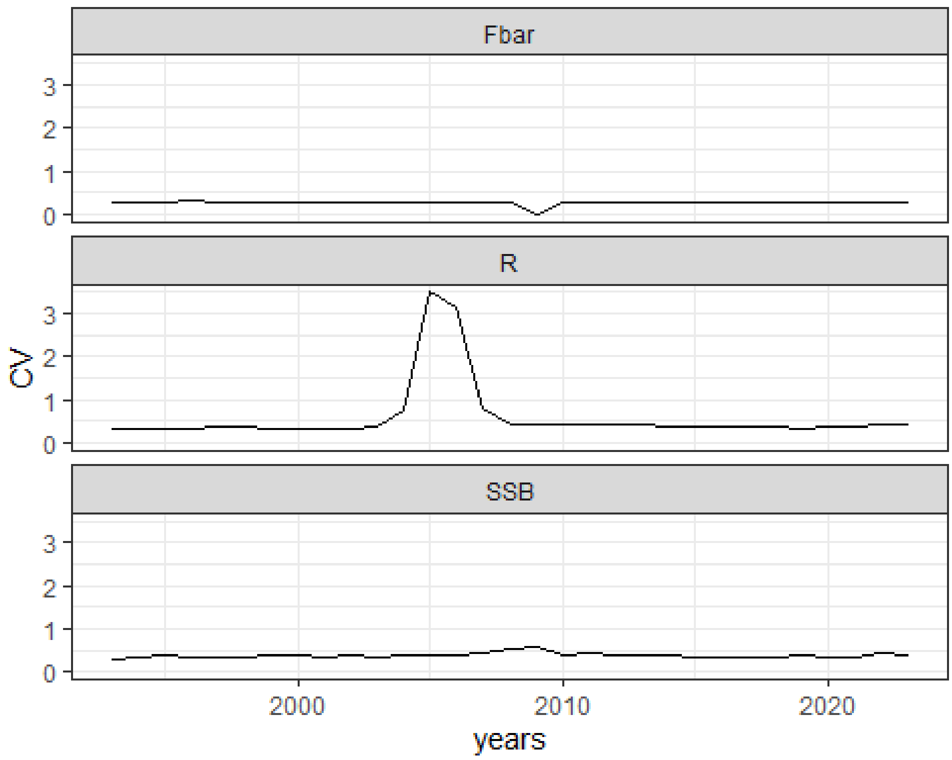


Figure 9.5.10 Sandeel 4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

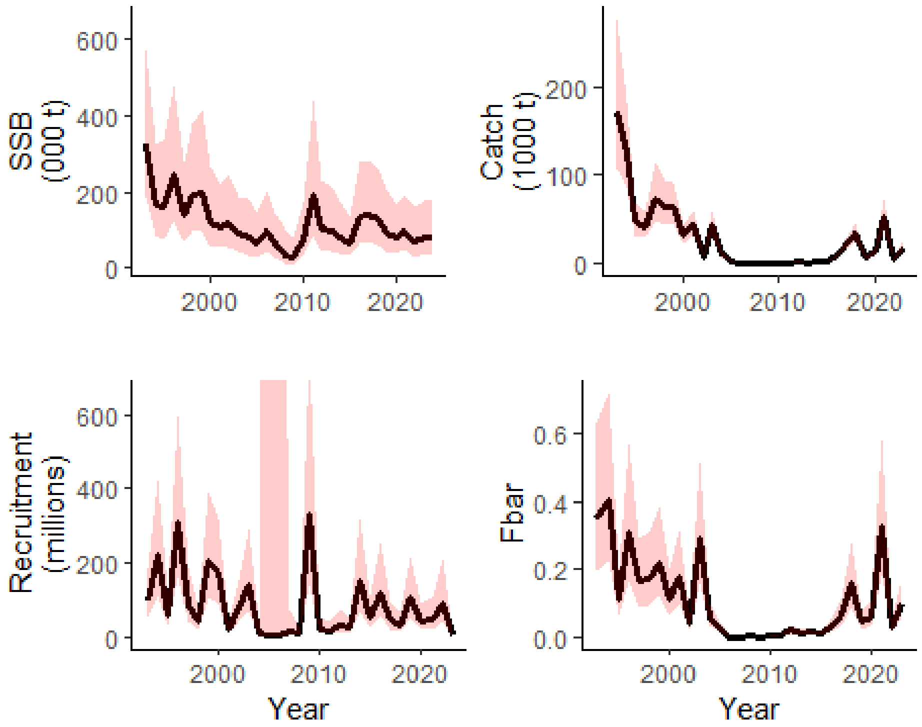


Figure 9.5.11 Sandeel 4. Model output (mean F, SSB, estimated Catch and Recruitment) with mean values and plus/minus 2 * standard deviations.

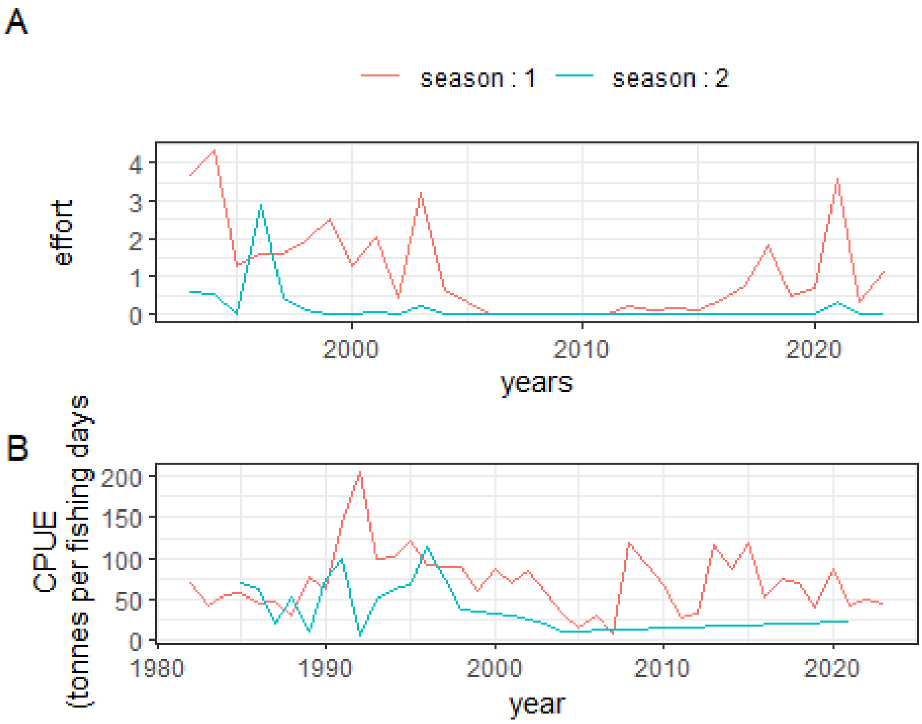


Figure 9.5.12 Sandeel 4. A) Total effort standardized per selectivity block (days fishing for a standard 200 GT vessel) and B) CPUE as tonnes divided by the standardized number of fishing days per season. Color denotes the season.

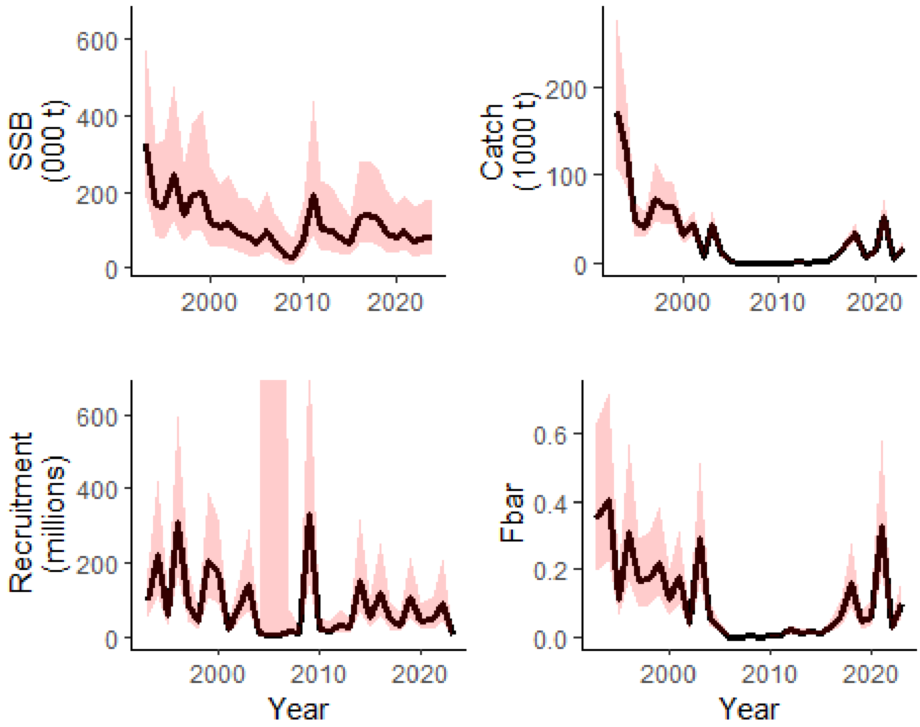


Figure 9.5.13 Sandeel 4. Stock summary. Dashed lines indicate Bpa and Blim on SSB plot.

Contents

10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)

10.1 The Fishery

10.1.1 ACOM advice applicable to 2023 and 2024

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2023 to June 2024) was set to 143 598 t for sprat in Subarea 4 and Division 3.a. Sprat catches often have some herring as bycatch. There is a herring bycatch quota, and the sprat fishery may be limited by this quota. The 2023 and 2024 herring bycatch quotas were both years 7 716 t for the North Sea and 6 659 t for Division 3.a. For 2023 and 2024 EU agreed to only fish 969 t of herring in total in Division 3.a, including both the directed fishery and bycatch. During the WKSPRAT benchmark meeting in 2018, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, several other modifications were made to the configurations of the assessment model (see (WKSPRAT: ICES, 2018a) for further details). Furthermore, at HAWG 2024 the expert group decided to accept changes to the model configurations and input data (catch data and natural mortalities), which also lead to a re-calculation of reference points for the biomass (B_{lim} and B_{pa}) and fishing mortality (F_{cap}) (Please see below for more details and WD01).

10.1.2 Catches in 2023

Catch statistics for 2000–2023 for sprat in the North Sea and Division 3.a by area and country are presented in Table 10.1.1. Catch data prior to 1996 are considered less reliable due to uncertainty of potential bycatches of North Sea herring (see Stock Annex). The small catches of sprat from the fjords of Norway are neither included in the catch tables nor the assessment (Table 10.1.1–10.1.2). The WG estimate of total catches for the North Sea and Division 3.a in 2023 was 92 206 t (total official catches amounted to 91 420 t). The Danish catches represent 85% of the total catches.

The spatial distribution of landings was overall like most years, although catches were seen closer to the coast (Figure 10.1.1). Since 2019, less than 1% on average of the catches have been taken in season 3 (quarter 1) compared to the period of 2014-2018 (range; 2-17%, Figure 10.6.1a) (Figure 10.6.1a).

10.1.3 Regulations and their effects

Most sprat catches are taken in an industrial fishery where catches are limited by herring bycatch quantities. Bycatches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. Bycatch is especially considered to be a problem in area 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where large bycatches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation showed that fishing inside the sprat box would be expected to reduce unwanted catches of herring by weight but not in number and concluded that other management measures are sufficient to control herring bycatch. The sprat box was removed in 2017.

The Norwegian vessels have a maximum vessel quota of 550 t when fishing in the North Sea. A herring bycatch of up to 10% in biomass is allowed in Norwegian sprat catches.

10.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years, the Norwegian catches were mainly taken by purse-seine, and the catches taken by trawl were low. In recent years, the share of the total Norwegian catches taken by trawl has increased (2023: 100% taken by trawl).

10.2 Biological composition of the catch

Only data on bycatch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 7% and 19% bycatch of herring in 2023 in the North Sea and Division 3.a, respectively. The percentage of by-catch in division 3.a is high in 2023, but due to the reduced sprat fishery in 3.a only accounted for 4 t of herring. The total amount of herring caught as bycatch in the sprat fishery has mostly been less than 10%. From 1st of April 2020 the Danish methodology behind the bycatch estimation in the fisheries for reduction changed. Before, the Danish fishery control regularly sampled the landings for reduction, and afterwards a species composition was estimated per month, square and fishery. Now, each and every landing for reduction into Denmark is subsampled by the buyer and the estimated species composition is reported directly in the sale slips. Many of the buyers use independent companies, 3rd party, for sampling.

The estimated quarterly landings at age in numbers for the period 1974–2023 is presented in Table 10.2.2. In the model year 2023, 1-year-old sprat so far has contributed 63% of the total landings. 2-year-olds contributed 26%, which is above the 1990–2020 average (15%). 0-year-olds contributed 10% of the total landings, whereas other older age-groups contributed with 2% (Figure 10.6.1b). Since 2019, the proportion of catches during season 3 (quarter 1) has dropped to less than 1% on average, in contrast to the period spanning 2014 to 2018, where it ranged from 2% to 17% (Figure 10.6.1a).

Denmark, Norway, and Sweden provided age data of commercial landings in 2023 (Table 10.2.4). Quarters 1, 3 and 4 were covered. Quarter 1 in 2023 had very low catches and only a single sample. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by the Netherlands (29 t), UK-England and Wales (141 t) and Belgium (<1 t) were unsampled and Germany and UK-Scotland didn't catch the stock in 2023.

The Danish sampling has been greatly improved since 2014 because of the implementation of a sampling programme for collecting haul-based samples from the Danish sprat fishery. However, the sampling in 2020 (model year) was substantially reduced with only 0.6 samples taken per 2000 t, which was caused by a not fully implemented change in the Danish sampling program with the introduction of the new bycatch estimation method (see above). Since this change, samples from most of the buyers / 3rd party companies have been regularly obtained. The sampling strategy from 2020 targets vessels above 24 meters, which are sampled with a higher frequency than smaller vessels. Vessels above 24 meters are still being encouraged to deliver self-samples, but if not, a 3rd party sample is used as a substitute. All samples from vessels below 24 meters comes from the 3rd party companies. In general, the new sampling strategy has secured a high level of sampling. Since 2019, the number of samples has dropped in season 3 (quarter 1), presumably due to negligible catches in this season.

The 2022-2024 Swedish sampling of sprat in the area 3a and 4 is part of a self-sampling program designed to sample small pelagic vessels targeting herring and sprat. Fishing trips are sampled from both consumption and industrial small-pelagic vessels. The sampling follows a stratified multi-stage cluster design where a random draw of vessels is taken using simple random sampling without replacement (SRSWOR) from pre-defined lists every week of each quarter. In such a set-up vessel*week is considered the PSU. Each week vessels are contacted and asked to collect samples from a trip starting the following week (SSU). In each haul/set (TSU) registering herring or sprat in the trip a sample of 3-5 kg (QSU) is collected from the catch. In the lab the boxes are stratified by subdivision and a subsample of 2 to 4 hauls analysed.

The number of samples used for the assessment, both length and age-length samples, is shown in Table 10.2.4–5 and Figure 10.2.1.

10.3 Fishery Independent Information

10.3.1 IBTS Q1 and Q3

Tables 10.3.1a-b and Figures 10.3.1-2 give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report for further details, ICES, 2018a)). The data source is the IBTS Q1 from 1983–2024 and IBTS Q3 from 1992-2023. The index for IBTS Q1 1-year-old in 2023 (age-0 in the model and the table, serving as a recruitment index) was the fourth lowest since 2000, being 44% of the 10 year geometric mean and 85% lower than last year's index. Overall, there has been a tendency for an increasing trend in the IBTS Q1 age-0 in the time-series since 1990. Furthermore, older age-groups of age-1 and age-2 decreased by 80% and 84% compared to the year before. The coverage of the survey was good and the CV for the index was reported to be similar to the average. Spatial pattern in residuals was checked and did not raise any concerns. The model is designed to handle issues of varying coverage to some extent.

IBTS Q3 survey indices were also used in the assessment for older age-groups, and the 2023 values increased by 97% and 148% from indices for 2022 for age-1 and age-2, respectively.

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2023) (see Section 1.4.2). The abundance indices for Subarea 4 and Division 3.a were summed (Table 10.3.2 and Figure 10.3.3). The 2023 values decreased by 20% for age-1, and increased by 15% and 143% for age-2 and age-3, respectively, compared to 2022.

10.4 Mean weights- and maturity-at-age

Mean weights-at-age in catches are given in Table 10.2.3 and Figure 10.4.1. Mean weights in model season 1 and 2 (S1 and S2; quarter 3 and 4), where most of the catches are taken, has shown a declining trend over the past decade for the younger age-groups. In 2019, the mean weights of age-1 and age-3 fish in S1 were the lowest observed for nearly two decades but since 2020 this decline have been arrested. In 2023-2022 mean weights were similar to the year before in S1, whereas it declined for all age-groups in S2 (Figure 10.4.1).

Proportion of mature fish was derived from IBTS Q1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2014).

10.5 Recruitment

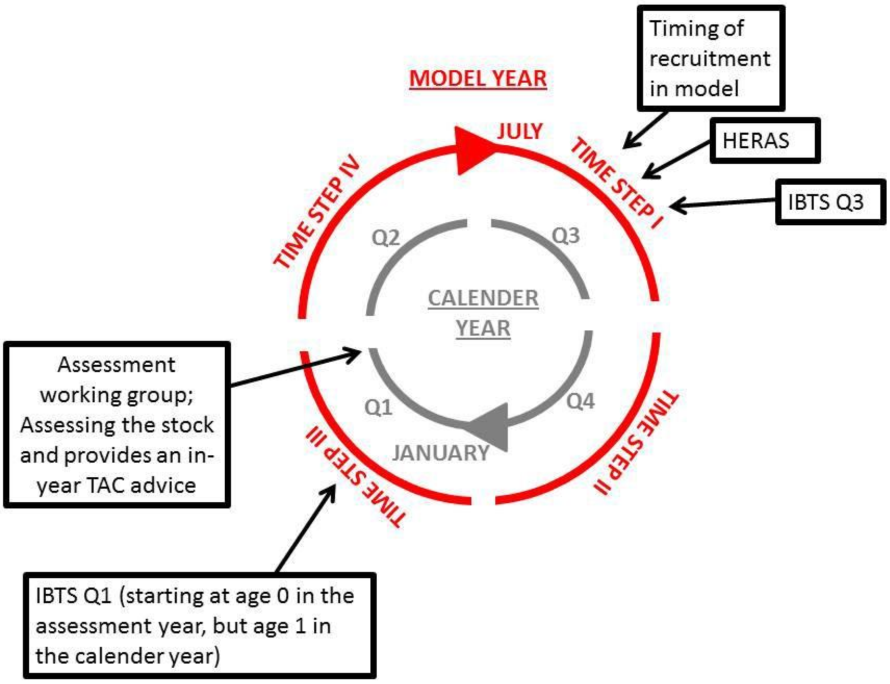
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1a) is used as a recruitment index for this stock. At the most recent benchmark, it was decided to implement a power model (directly within the assessment model) to the age-0 IBTS Q1 index to dampen the effect of very high index values. This was done to reduce the retrospective bias on recruitment (see WKSPRAT (ICES, 2018) for further details). At HAWG 2023, it was noticed that the model had issues with convergence (revealed by a very high maximum gradient of 81.52). The problem was tracked back to the 2019 assessment, when the power model was implemented for the first time. Basically, SMS has convergence problems when the catchability parameters are very different in magnitude. This is solved in SMS by scaling all numbers by a fixed factor per survey. Therefore, a small hack was applied to achieve an acceptable maximum gradient (<0.001) for the model, by splitting the IBTS Q1 into two fleets: one for the recruiting fish, IBTS Q1 Rec, and one for all other ages, IBTS Q1. The two fleets were scaled differently, $0.1e^{-7}$ and 0.1, respectively. Scaling has no effect on model results or forecast otherwise. The 2024 IBTS Q1 Rec value, indicative of the 2023 recruitment, was the lowest observed since 2000, experiencing a decrease by 85% from the 2023 index. The 2024 recruitment estimated by the model is only 44% of the 2014-2023 geometric mean (Table 10.6.4).

10.6 Stock Assessment

The stock assessment was benchmarked in November 2018 (WKSPRAT: ICES, 2018a). During this benchmark meeting, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, several other modifications were made to the configuration of the assessment model (see WKSPRAT report (ICES, 2018a) for further details).

In-year advice is the only possible type of advice for this short-lived species with catches dominated by 1- and 2-year-old fish. This, however, requires information about incoming 1-year-old fish. To meet this requirement and to come up with a model that logically matches the natural life cycle of sprat, the annual time-step in the model was shifted, relative to the calendar year, to a time-step going from July to June (see text table below). SSB and recruitment were estimated at 1st July. In figures and tables with assessment output and input, the years refer to the shifted model year (July to June) and in each figure and table it is noted whether model year or calendar year applies (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 1st July 2000 to 30th June 2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Model year		Calendar year	
2000	Season 1	2000	Quarter 3
2000	Season 2	2000	Quarter 4
2000	Season 3	2001	Quarter 1
2000	Season 4	2001	Quarter 2


Timing of recruitment in model
HERAS
IBTS Q3
MODEL YEAR
JULY
TIME STEP I
TIME STEP II
TIME STEP III
TIME STEP IV
Q1
Q2
Q3
Q4
CALENDER YEAR
JANUARY
Assessment working group; Assessing the stock and provides an in-year TAC advice
IBTS Q1 (starting at age 0 in the assessment year, but age 1 in the calender year)

10.6.1 Input data

10.6.1.1 Catch data

Information on catch data is provided in Tables 10.1.1–2 and in Figures 10.1.1 and 10.6.1ab. Sampling effort is presented in Table 10.2.5 and Figure 10.2.1.

Catches in quarter 2 (season 4 in the model, S4) are often less than 5000 tonnes, these are poorly estimated by the model and the number of samples from these catches are low (sometimes no samples). Furthermore, at the time of the assessment working group, S4 catches are unknown. Therefore, during the latest benchmark it was decided to move S4 catches into S1 in the following model year. A recent shift in fishing patterns during S3 appears to have resulted in similar issues as observed in S4. The catch input data indicates a decline in catches since 2019. On average, catches accounted for only 0.6% of the total catch tonnage during the period 2019-2022 (1.2% in 2019, 0.5% in 2020, 0.6% in 2021, and 0.2% in 2022), compared to 8.6% during the period 2015-2018 (Table 10.2.2 and Figure 10.6.1a). Furthermore, the number of biological samples collected from the fishery for generating the catch-at-age matrix in the assessment model has also decreased significantly compared to pre-2019 levels (Table 10.2.5). These sudden changes caused estimation problems for the predicted fishery mortalities in the model, similarly to what was found for S4 during WKSPRAT. Therefore, HAWG decided to move catches from S3 to S2 for 2019-2022 and exclude catch estimation for S3 in this period. HAWG found that this improved the model without changing historical dynamics, and recommended its adoption, which were reviewed by external experts in 2024 (WD01).

10.6.1.2 Weight-at-age

The mean weight-at-age by season for all age-groups observed in the catch are given in Table 10.2.3 and Figure 10.4.1. It is assumed that the mean weights in the stock are the same as in the catch. The mean weight-at-age of S1 is used to calculate SSB 1st of July.

10.6.1.3 Surveys

Three surveys, divided into four fleets as described below, were included (Tables 10.3.1ab–2), IBTS Q1 (1983–present), IBTS Q3 (1992–present), and HERAS (Q3) (2006–present). The IBTS Q1 indices were divided into two fleets in the model: IBTS Q1 Rec age-1 representing recruitment, i.e., age-0 in the model, and IBTS Q1 for all other age-groups. 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and for this reason these age indices were excluded from the model.

10.6.1.4 Natural mortality

HAWG 2021 (ICES. 2021a) reviewed natural mortalities (M) available from the 2020 North Sea key run from WGSAM , but did not update (for more details see annual HAWG reports; ICES, 2021-23). Therefore, the use of the old mortalities from the 2017 North Sea key run (ICES, 2018b) was continued. Variable mortality was applied as three-year averages up till 2015, and after 2015 the average mortality for 2013–2015 is used. During HAWG 2024, new natural mortalities were available from the 2023 North Sea key run from WGSAM (ICES, 2023). Compared to 2021, the recent removal of the inter-benchmark process decided by ACOM Leadership gave the WG more responsibility making them eligible for decisions on more drastic changes to the configurations and settings of the assessment model, as well as a potential re-calculation of reference points. HAWG 2024 reviewed stock assessments based on both the old and new M's. The retrospective patterns where improved for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), whereas it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22). The AIC for the model fit increased with the updated M's (AIC = 863) compared to a model with the current M's (AIC = 860), but the difference was evaluated and found to be small and acceptable.

HAWG 2024 inspected the stock-recruitment plot and found substantial changes to the stock-recruitment relationship and perception of the stock. The changes included an upward shift in both recruitment (since 1991) and SSB (since 1982), as well as a downscaling of fishing mortality (since 1981). Furthermore, the stock-recruitment relationship showed that the changes in both recruitment and SSB resulted in a down-scaling causing points to be less variable in the early part of the time-series, whereas the period from 1981 and onwards became more variable. As such, HAWG deemed the old M's from the 2015 key run to be obsolete and not able not capture the trophodynamics that characterise the North Sea food web during the last decade. Enhancements to the multispecies model since 2015, such as integrating more precise data on seabirds, and recent shifts in predator biomass (e.g., whiting and mackerel), significantly affect the estimated M's for all age-groups in all seasons (quarters) for sprat. Consequently, the notable alterations in natural mortalities for sprat led HAWG to their conclusive decision to revise the assessment's mortality estimates. The expert group have documented the changes in a revised working document, which were reviewed by external experts and approved by the ADG (WD01). Natural mortalities used in the model are given in Table 10.6.1.

10.6.1.5 Proportion mature

Proportion of mature fish was derived from IBTS Q1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+, respectively). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2014).

10.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther, 2004) with quarterly time-steps (referred to as season S1–S4). Three surveys divided into four fleets were included, IBTS Q1 Rec age 1, IBTS Q1 ages 2 to 4+ (age 0, 1, 2 and 3+ in the model), IBTS Q3 ages 1–3 and HERAS (Q3) ages 1–3. 0-group sprat is unlikely to be fully recruited to the IBTSQ3 or HERAS in Q3 and these age indices were excluded from runs. External consistency between IBTS Q1, IBTS Q3 and HERAS can be found in the benchmark report (WKSPRAT2018: ICES, 2018a). As described above in more detail, it was noticed that the model had issues with convergence after the introduction of the power model for the recruitment index, and therefore two different scaling estimators were used for IBTS Q1 Rec and IBTS Q1 in order to attain acceptable values for the maximum gradient. The model hack by scaling has no effect on model results and forecast otherwise. Additionally, during HAWG 2024, the expert group approved alterations to the model configurations and input data, including catch data and natural mortalities. These changes necessitated a recalculation of reference points for biomass (B_{lim} and B_{pa}) and fishing mortality (F_{cap}) (WD01).

The model converged and fitted the catches of the main ages of 1 and 2 caught in the main seasons of S1 and S2 reasonably well and having a maximum gradient at $5.5e^{-5}$ (Table 10.6.2). The CVs for the catches were high, possibly getting close to upper boundaries set in the model. As such, the model has difficulties in following the catches and therefore catches add little information to the assessment. All surveys had low CVs (<0.54), with IBTS Q1 Rec hitting the lower CV boundary of 0.3 (Table 10.6.2). There were no patterns in the residuals raising concern (Figures 10.6.2–3). Although, there appears to be a periodic cycling (on a decadal timescale) between positive and negative residuals in the IBTS Q3 survey and the catches (Figures 10.6.2–3). Common CVs were estimated for the following groups: 1- to 3-year-olds in IBTS Q1 and 2- and 3-year-olds in IBTS Q3 and HERAS.

The retrospective analyses have shown a tendency to overestimate recruitment in for large year-classes and underestimate recruitment at low year-classes (Figure 10.6.5). As 41% of the recruiting year-class mature in their first year and thus contributes to the SSB at the end of the year, there is a similar retrospective pattern in SSB (5-year Mohn´s rho = 0.25). The assessment model was improved with this respect to the retrospective pattern during the last benchmark and Mohn´s rho was reduced by roughly a factor of 3 due to the improvement. In 2024, the inclusion of new natural mortalities and changes to the model configurations (WD01) improved the retrospective pattern for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), although it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22).

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 10.6.4–7 and Tables 10.6.3–4.

10.7 Reference points

During HAWG 2024, modifications to both model configurations and input data (catch data and natural mortalities) were approved. These adjustments prompted a recalculation of reference points for biomass, which were reviewed by external experts. A decision was made to set B_{lim} based on the average SSB of the two years with lowest SSB with recruitment above the median. Consequently, the average of the SSBs from 1991 and 2013 was used to establish reference points at B_{lim} = 107 598 t and $B_{escapement}$ = B_{pa} = 135 952 t. (Figure 10.7.1, but see WD01). This is higher than the estimates from the last benchmark (B_{lim} = 94 000 t and B_{pa} = 125 000 t). B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.173.

10.8 State of the stock

The stock has been well above B_{pa} since 2013 and above B_{lim} since 1992, with the exception of 2024 where it is estimated to be below B_{pa}. Fishing mortality has fluctuated without a trend, but the F of 2.654 in 2023 was the highest in the time-series. The advised TAC was based on the predicted catch at F equal to F_{cap}. A large overshoot of the F used as basis for advice is often seen in simulations applying the escapement strategy on large incoming year-classes, where the uncertainty on absolute numbers and hence the TAC matching a given F is large. This trait is the reason for implementing F_{cap} as otherwise, the escapement strategy is not precautionary when incoming recruitment is estimated to be large.

A stock summary from the assessment output can be found in Table 10.6.4 and Figure 10.6.7.

10.9 Short-term projections

Management strategy evaluations for this stock were made in December 2018 (WKSPRATMSE: ICES, 2019). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). During the benchmark, the optimal F_{cap} value was found to be 0.69 (from both a full MSE and a shortcut MSE - see WKSPRATMSE report for further details), which were a revision of the previous value of 0.7. The most recent modifications to both model configurations and input data prompted the EG to also re-calculate F_{cap} using a shortcut MSE, which resulted in an F_{cap} of 1.01 (WD Ref). This means, that the fishing mortality ($F_{bar(1–2)}$) derived from the $B_{escapement}$ strategy, should not exceed 1.01. The realized fishing mortality is often higher than the fishing mortality used to provide advice in recent years (F_{cap}). This pattern was also observed when the escapement strategy advice rule was evaluated. Thus, despite the mismatch between the predicted and realized fishing mortalities, the escapement strategy is considered adequate to provide advice.

The forecast input is given in Table 10.9.1.

SSB in 2025 is expected to be higher than in 2024, above the long-term average and above B_{pa}. Using the input and assumptions detailed above, the F = 0 catch option projects an SSB in July 2025 of 187 012 t (Table 10.9.2). The F_{MSY} approach prescribes the use of an F value of 1.01 (F_{cap}, see explanation above) and results in a catch advice of 75 321 t (July 2024–June 2025), which is expected to result in an SSB of 158 851 t in July 2025 above B_{pa}.

10.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2018 WKSPRAT benchmark and during HAWG 2024. A complete overview of the choices made during the benchmark can be found in the report (ICES, 2018a) and working document (WD01). These are also described in the Stock Annex for sprat in Division 3.a and Subarea 4.

The assessment shows medium to high CVs for the catches but low CVs for surveys. The CVs of F, SSB and recruitment are generally low (see Table 10.6.2 and Figure 10.6.4). The model converged and fitted the catches of the main ages caught in the main seasons (the periods with most samples) reasonably well (ages 1–2, season 2, Table 10.6.2). The retrospective pattern in SSB and recruitment (5-years Mohn´s rho of 0.04 for both), although the retrospective pattern has increased for fishing mortality (Mohn’s rho of 0.22). Yet, all are below the advised limit for Mohn’s rhoof 0.3 agreed in WKFORBIAS (ICES, 2020).

There appears to be a systematic pattern in the catch residuals in model season 1 (quarter 3), which remains unexplained. Furthermore, the model gets very little information from the catches (as shown by the high CVs). This should be investigated further.

10.11 Management Considerations

A management plan needs to be developed for this stock. Sprat is an important forage fish; thus, also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year-class. Thus, the fishery in a given year will be dependent on that year’s incoming year-class.

Industrial fisheries are allocated a bycatch of 7716 t and 6659 t of juvenile herring in 2024 in the North Sea and Division 3.a, respectively. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation.

10.11.1 Stock unit

After the latest benchmark, sprat in the Subarea 4 and Division 3.a is considered to be one cohesive stock. This is documented in the WKSPRAT report (ICES, 2018a). In addition, there are several peripheral areas of the North Sea and Division 3.a where there may be populations of sprat that behave as separate stocks from the main stock. Local depletion of sprat in such areas can be an issue of ecological concern.

10.12 Ecosystem Considerations

Sprat is an important prey species in the North Sea ecosystem. The influence of the sprat fishery on other fish species and seabirds are at present not documented to be substantial.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds though this information is as described under natural mortality not up to date. Impacts of changes in zooplankton communities and consequent changes in food densities for sprat are not included in the assessment, but it may be useful to explore the possibility of including this, or a similar proxy bottom-up driver, in future assessments. However, the effect of changes in productivity is included in the observed quarterly weight-at-age and in the estimated recruitment, as a decline in e.g., available food can lead to lower observed weights and lower estimated recruitment even in the absence of a causal link in the model.

10.13 Changes in the environment

Temperatures in this area have been increasing over the last few decades. This may have implications for sprat, although the correlation between temperature and recruitment from the model has been found to be low (see WKSPRAT: ICES, 2018a).

10.14 Tables and Figures

Table 10.1.1. North Sea & 3.a sprat. Landings (' 000 t) 2004–2023. See ICES (2006) for earlier data. Catch in coastal areas of Norway excluded. Data provided by Working Group members. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Division 27.4.a																				
Denmark	*		*	0.8	*	*					*	*	0.1	0.1		*	0.5	*	*	
Norway						*		*								0.1	*			
Sweden																				
UK (Scotland)								0.5						*	*					
Germany												*	*						*	
Netherlands												*								
France																			*	
Total	*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1	0.5	*	*	
Division 27.4.b																				
Denmark	175.9	204	79.5	55.5	51.4	115.6	80.8	90.9	65.7	44.7	121.3	234.4	177.6	100.6	156.5	110.3	138.4	66	79.7	76.4
Norway	0.1		0.8	3.7	1.3	4	8	0.1	6.2	*	8.9	0.3	19.6	9.7	9.3	10	9.3			3.6
Sweden		*				0.3	0.6	1.1	1.8	0.1	3.9	5.5	11.7	8.1	7.6	7.5	3.5	5.9	6.6	8.7
UK (Scotland)				0.1		2.5	1.1	1.9	0.7						*	1.3	1.7	*	0.4	
UK (Engl. & Wales)						*								*	*		0.1		0.2	*
Germany								3.3	0.5	0.6	1.5	3.1	5.4	6	3.7	3.4	10	3.6	2.4	
Netherlands								1.1	2.7	0.4	2.4	1.2	1	1.6	1.6		0.5		0.4	*
Faroe Islands													4.7	1	1		1			
Total	176	204.1	80.3	59.3	52.7	122.4	90.4	98.4	77.5	45.8	138	244.6	220	127	179.7	132.6	164.7	75.5	89.6	88.7
Division 27.4.c																				
Denmark	16.8	2	23.8	20.6	8.1	8.2	48.5	20	3.2	15.4	2.2	34	18.7	1.5	6.2	8.9	2.4	2.7		2

Norway			9	2.9		1.8	3.2	9.9	3	1.7	0.1	8.8	0.6		0.5	0.6	0.7			
Sweden						0.6	0.6	0.2	0.4	1.3		1.2	0.4					1.1		0.5
UK (Scotland)					0.2			0.4					*				0.7	0.1		
UK (Engl. & Wales)	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	0.1	0.2	0.1	*	0.1	0.1
Germany								*	*	1		0.6	0.2				0.1			
Netherlands								4.2	1	0.7	*	1.2	0.8	*	0.7		1.6	0.1	*	*
Belgium								*		*	*	*	*	*		*	*	*	*	*
France												*		*						
Total	18.3	3.6	33.4	23.8	8.4	10.6	53	35.2	8	20.1	2.3	45.8	20.6	1.6	7.5	9.6	5.6	4	0.1	2.6
Division 27.3.a																				
Denmark	14.4	31.9	7.8	9.9	5.8	6.9	8.4	8	8.4	1.9	16.7	11.7	6.7	1	2.9	3.9	9.5	0.6	0.3	*
Sweden	6.5	7.7	4.4	4.2	2.4	1.6	1.4	2	1.5	1.1	1.5	1.3	1.1	0.2	1.1	1.7	2.4	0.7	0	0.1
Germany											*				*					
Faroe Islands													*							
Total	20.9	39.6	12.2	14.1	8.2	8.5	9.8	10	9.9	3	18.3	13	7.9	1.2	4	5.6	11.9	1.3	0.4	0.1
Total North Sea and Skagerrak-Kattegat																				
Denmark	207.1	237.9	111.2	86.7	65.4	130.7	137.7	119	77.4	62.1	140.2	280.1	203.1	103.3	165.6	123.1	150.9	69.3	80.1	78.4
Norway	0.1		9.8	6.7	1.3	5.8	11.1	10	9.1	1.7	9	9.1	20.2	9.7	9.8	10.6	10			3.6
Sweden	6.5	7.8	4.4	4.2	2.4	2.5	2.6	3.3	3.7	2.5	5.4	8.1	13.2	8.3	8.7	9.2	5.9	7.6	6.6	9.2
UK (Scotland)				0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3	2.5	0.1	0.4	
UK (Engl. & Wales)	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	*	0.2	0.2	*	0.3	0.1
Germany								3.3	0.5	1.6	1.6	3.7	5.6	6	3.7	3.4	10.1	3.6	2.4	
Netherlands								5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3		2.1	0.1	0.4	*
Faroe Islands													4.7	1	1		1			
Belgium								*		*	*	*	*	*		*	*	*	*	*
France												*		*					*	
Total	215.2	247.3	125.9	97.9	69.3	141.6	153.3	144.1	95.5	68.9	158.7	303.3	248.5	129.9	191.2	147.8	182.7	80.8	90.1	91.4

Table 10.1.2. North Sea & 3.a sprat. Catches (tonnes) by quarter. Catches in coastal areas of Norway excluded. Data for 1996–1999 in ICES (2006).

Year	Quarter	27.4.a	27.4.b	27.4.c	27.3.a	Total	Year	Quarter	27.4.a	27.4.b	27.4.c	27.3.a	Total
2000	1		18 126	28 063		46 189	2012	1		81	1649	4668	6399
	2		1722	45		1767		2		2924	0	909	3832
	3		131 306	1216		132 522		3		26 779	307	1631	28 717
	4		12 680	2718		15 398		4		47 765	6060	2728	56 553
	Total		163 834	32 042		195 876		Total		77 549	8016	9936	95 501
2001	1	115	40 903	9716		50 734	2013	1		1281	3158	1296	5734
	2		1071			1071		2		32	0	443	474
	3		44 174	481		44 655		3		25 577	720	211	26 509
	4	79	65 102	8538		73 719		4		18 892	16 276	943	36 110
	Total	194	151 249	18 735		170 177		Total		45 781	20 154	2893	68 827

Year	Quar-ter	27.4.a	27.4.b	27.4.c	27.3.a	Total
2002	1	1 136	2182	2790		6108
	2		435	93		528
	3		70 504	647		71 151
	4		52 942	12 911		65 853
	Total	1 136	126 063	16 441		143 640
2003	1		11 458	7727	5217	24 402
	2		625	26	1397	2049
	3		56 207	165	1720	58 092
	4		84 629	15 651	7349	107 629
	Total		152 919	23 570	15 683	192 172
2004	1		827	1831	4456	7113
	2	7	260	16	1510	1793
	3		54 161	496	4138	58 794
	4		120 685	15 937	10 775	147 397
	Total	7	175 932	18 280	20 879	215 097
2005	1		11 538	2457	8148	22 143
	2		2515	123	4722	7360
	3		107 530		19 418	126 948
	4		82 474	1033	7296	90 803
	Total		204 057	3613	39 584	247 254
2006	1	47	13 713	33 534	8105	55 399
	2		190	8	324	522
	3		40 051	8	1440	41 499
	4	2	26 579	77	2335	28 993
	Total	49	80 533	33 627	12 204	126 413
2007	1		582	247	2646	3475
	2		241	3	1291	1535
	3		16 603		5357	21 960
	4	769	41 850	23 531	4761	70 911
	Total	769	59 276	23 781	14 055	97 881
2008	1		2872	43	2890	5805
	2		52	*	1017	1069
	3		21 787		636	22 423
	4		27 994	8334	3672	40 001
	Total		52 706	8377	8215	69 298
2009	1		36	1268	2600	3904
	2		2526	1	300	2827
	3	22	41 513		3300	44 835
	4		78 373	9336	2400	90 109
	Total	22	122 448	10 604	8600	141 675
2010	1		10 976	17 072	1462	29 510
	2		3235	3	648	3886
	3		14 220		3405	17 625
	4		62 006	35 973	4278	102 257
2014	1		59	125	384	568
	2		11 631	3	1415	13 050
	3	1	88 457	1428	9622	99 507
	4	7	37 851	822	6905	45 586
	Total	8	137 999	2378	18 327	158 711
2015	1	*	14 816	16 972	1442	33 230
	2		16 843	107	619	17 568
	3		124 512	335	6528	131 375
	4	25	88 395	28 375	4389	121 184
	Total	25	244 566	45 789	12 978	303 358
2016	1	68	18 487	5969	746	25 250
	2		8927	51	669	9 647
	3	*	158 522	111	4664	163 297
	4	2	34 070	14 466	1764	50 301
	Total	70	220 007	20 596	7843	248 516
2017	1	1	3432	1220	92	4 745
	2		1327	0	33	1 360
	3	*	92 885	217	227	93 329
	4	94	29 310	174	849	30 426
	Total	95	126 954	1611	1200	129 860
2018	1	*	8994	1628	168	10 790
	2		11 898	0	224	12 122
	3		112 361	1	1328	113 690
	4		46 411	5922	2249	54 582
	Total	*	179 664	7551	3969	191 184
2019	1		389	9 592	627	10 609
	2	2	3 606	11	379	3 999
	3	2	95 829	7	2 249	98 087
	4	49	32 750	3	2 296	35 098
	Total	53	132 574	9 614	5 551	147 793
2020	1	3	298	1 076	378	1 746
	2		19 430	*	173	19 603
	3	2	120 890	*	4 268	125 160
	4	520	24 049	4 489	7 087	36 145
	Total	526	164 667	5 566	11 896	182 654
2021	1	0	137	236	445	818
	2	*	326	1	11	338
	3	1	63 401	902	57	64 361
	4	1	11 601	2 850	791	15 244
	Total	2	75 464	3 989	1 305	80 761
2022	1		82	85	331	499
	2		19 449		16	19 465
	3	*	52 852			52 852
	4	8	17 237	8	36	17 289

Year	Quarter	27.4.a	27.4.b	27.4.c	27.3.a	Total
	Total		90 437	53 048	9793	153 278
2011	1		3747	21 039	3216	28 002
	2		2067	3	617	2687
	3		22 309	451	2311	25 072
	4	8	70 256	13 759	3887	87 910
	Total	8	98 380	35 252	10 031	143 671

Year	Quarter	27.4.a	27.4.b	27.4.c	27.3.a	Total
	Total	8	89 620	94	383	90 105
2023	1		7	130	1	138
2023	2		479	0	34	512
2023	3		69 151	1	17	69 168
2023	4		19 062	2475	64	21 601
2023	Total		88 698	2606	116	91 420
2024	1**		535	424	1	959
2024	2					
2024	3					
2024	4					
2024	Total					

* < 0.5 t

** Until the 1st of March

Table 10.2.1. North Sea & 3.a sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch. Left: North Sea, right: Division 3.a.

Unit	Year	Area	Sprat	Herring	Horse mackerel	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
t	1998	27.4	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
t	1999	27.4	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
t	2000	27.4	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
t	2001	27.4	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
t	2002	27.4	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
t	2003	27.4	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
t	2004	27.4	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
t	2005	27.4	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
t	2006	27.4	103 236	8 983	577	343	25	905	4	5 384	576	120 033
t	2007	27.4	74 734	6 596	168	900	6	126	18	6	253	82 807
t	2008	27.4	61 093	7 928	26	380	10	367	0	23	1 735	71 563
t	2009	27.4	112 721	7 222	44	307	3	116	1	1 526	407	122 345
t	2010	27.4	112 395	4 410	11	119	2	18	0	1 236	577	118 769
t	2011	27.4	109 376	8 073	35	191	0	127	0	1 881	345	120 026
t	2012	27.4	67 263	8 573	2	354	0	246	0	93	411	76 943
t	2013	27.4	55 792	5 176	47	445	0	277	2	1	369	62 109
t	2014	27.4	123 180	11 402	0	897	0	70	16	16	1 700	137 280
t	2015	27.4	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
t	2016	27.4	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
t	2017	27.4	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394
t	2018	27.4	161 536	7 528	174	716	0	366	0	24	344	170 687
t	2019	27.4	118 302	2 757	1	897	1	176	0	3	503	122 639
t	2020	27.4	140 954	6 227	19	898	93	1 188	0	11	724	150 114
t	2021	27.4	68 492	5 518	39	1 064	345	747	0	3	602	76 809
t	2022	27.4	78 825	3 829	1	488	124	397		4	227	83 895
t	2023	27.4	78 222	6 390	14	1 802	1 120	686		4	375	88 613
%	1998	27.4	89	8	0	1	0	0	0	2	1	100
%	1999	27.4	91	4	0	1	0	0	0	3	0	100
%	2000	27.4	90	6	2	1	0	0	0	0	1	100
%	2001	27.4	80	8	0	1	0	0	0	10	1	100
%	2002	27.4	84	10	1	2	0	0	0	2	1	100
%	2003	27.4	89	5	0	1	0	0	0	3	2	100
%	2004	27.4	90	5	0	0	0	2	0	2	1	100
%	2005	27.4	86	9	1	0	0	0	0	3	0	100
%	2006	27.4	86	8	1	0	0	1	0	5	1	100
%	2007	27.4	90	8	0	1	0	0	0	0	0	100
%	2008	27.4	85	11	0	1	0	1	0	0	2	100
%	2009	27.4	92	6	0	0	0	0	0	1	0	100
%	2010	27.4	95	4	0	0	0	0	0	1	1	100
%	2011	27.4	91	7	0	0	0	0	0	2	0	100
%	2012	27.4	87	11	0	1	0	0	0	0	1	100
%	2013	27.4	90	8	0	1	0	0	0	0	1	100
%	2014	27.4	90	8	0	1	0	0	0	0	1	100
%	2015	27.4	96	2	0	1	0	0	0	0	1	100
%	2016	27.4	92	5	0	2	0	0	0	0	1	100
%	2017	27.4	84	4	0	1	0	0	0	0	10	100
%	2018	27.4	95	4	0	0	0	0	0	0	0	100
%	2019	27.4	97	2	0	1	0	0	0	0	0	100
%	2020	27.4	94	4	0	1	0	1	0	0	1	100
%	2021	27.4	90	6	0	1	1	1	0	0	1	100
%	2022	27.4	94	5	0	1	0	0	0	0	0	100
%	2023	27.4	88	7	0	2	1	1	0	0	0	100
t	1998	27.3.a	9 143	3 385	230	467	54	0	49	7	2 866	16 202
t	1999	27.3.a	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
t	2000	27.3.a	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
t	2001	27.3.a	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
t	2002	27.3.a	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
t	2003	27.3.a	8 182	4 928	340	252	4	4	4	1	567	14 282
t	2004	27.3.a	13 374	4 620	97	976	18	24	27	116	2 155	21 408
t	2005	27.3.a	30 157	6 171	244	871	63	18	20	746	1 758	40 047
t	2006	27.3.a	6 814	2 852	215	276	13	3	45	1	232	10 451
t	2007	27.3.a	7 116	2 043	34	190	31	8	4	1	469	9 896
t	2008	27.3.a	4 805	1 948	14	285	0	0	11	462	39	7 563
t	2009	27.3.a	4 839	3 016	37	169	15	0	1	53	47	8 177
t	2010	27.3.a	2 851	2 134	25	142	6	1	2	135	171	5 466
t	2011	27.3.a	4 754	2 461	0	43	0	7	1	141	40	7 447
t	2012	27.3.a	5 707	5 495	9	149	7	10	5	0	228	11 610
t	2013	27.3.a	1 143	1 751	2	46	0	0	1	1	27	2 971
t	2014	27.3.a	16 751	3 777	5	343	1	20	5	12	888	21 801
t	2015	27.3.a	11 448	5 831	0	565	0	29	8	1	154	18 036
t	2016	27.3.a	7 001	2 140	0	335	1	19	3	0	78	9 579
t	2017	27.3.a	963	328	0	172	0	19	1	0	32	1 515
t	2018	27.3.a	2 872	257	2	150	1	11	0	0	12	3 304
t	2019	27.3.a	3 429	351	0	59	0	2	0	0	8	3 850
t	2020	27.3.a	9 494	551	4	249	5	41	1	0	27	10 372
t	2021	27.3.a	638	82	0	13	1	1	0	0	32	767
t	2022	27.3.a	316	19	0	1	0	0	0	0	31	368
t	2023	27.3.a	17	4		0	0				0	21
%	1998	27.3.a	56	21	1	3	0	0	0	0	18	100

%	1999	27.3.a	51	26	0	3	1	0	0	10	9	100
%	2000	27.3.a	49	31	0	4	1	0	0	0	14	100
%	2001	27.3.a	55	25	0	4	0	0	0	13	4	100
%	2002	27.3.a	40	46	0	4	0	0	0	2	8	100
%	2003	27.3.a	57	35	2	2	0	0	0	0	4	100
%	2004	27.3.a	63	22	1	5	0	0	0	1	10	100
%	2005	27.3.a	75	15	1	2	0	0	0	2	4	100
%	2006	27.3.a	65	27	2	3	0	0	0	0	2	100
%	2007	27.3.a	72	21	0	2	0	0	0	0	5	100
%	2008	27.3.a	64	26	0	4	0	0	0	6	1	100
%	2009	27.3.a	59	37	1	2	0	0	0	1	1	100
%	2010	27.3.a	52	39	1	3	0	0	0	3	3	100
%	2011	27.3.a	64	33	0	1	0	0	0	2	1	100
%	2012	27.3.a	49	47	0	1	0	0	0	0	2	100
%	2013	27.3.a	39	59	0	2	0	0	0	0	1	100
%	2014	27.3.a	77	17	0	2	0	0	0	0	4	100
%	2015	27.3.a	64	32	0	3	0	0	0	0	1	100
%	2016	27.3.a	73	22	0	4	0	0	0	0	1	100
%	2017	27.3.a	64	22	0	11	0	1	0	0	2	100
%	2018	27.3.a	87	8	0	5	0	0	0	0	0	100
%	2019	27.3.a	89	9	0	2	0	0	0	0	0	100
%	2020	27.3.a	92	5	0	2	0	0	0	0	0	100
%	2021	27.3.a	83	11	0	2	0	0	0	0	4	100
%	2022	27.3.a	86	5	0	0	0	0	0	0	8	100
%	2023	27.3.a	81	19	0	0	0	0	0	0	0	100

Table 10.2.2. North Sea & 3.a sprat. Catch in numbers by age (1000's) by season and year. (Model year, e.g., 2021 = July 2021–June 2022)

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022

Year	Season	age 0	age 1	age 2	age 3
1974	1	0	16101061	2155723	475613
1974	2	1884146	11544114	866399	48228
1974	3	2842702	11091303	1336036	34534
1974	4	1302331	2511315	359117	14822
1975	1	250931	27723510	10052550	260182
1975	2	1179567	14541887	4378415	166807
1975	3	5240024	4755878	2206781	66186
1975	4	0	0	0	0
1976	1	2143211	42209830	2888653	180913
1976	2	7439656	18762732	1613139	88604
1976	3	7703416	6925346	267638	8289
1976	4	0	0	0	0
1977	1	2690194	12786056	5181867	109712
1977	2	2520082	4904593	3679153	67688
1977	3	15857197	1843468	2200876	37836
1977	4	0	0	0	0
1978	1	454090	32184524	427473	96435
1978	2	5517665	10344970	1209584	116695
1978	3	6154606	4973568	1119045	29941
1978	4	0	0	0	0
1979	1	3579389	36866800	644042	117139
1979	2	1052920	11355949	2152261	63386

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1979	3	3882781	6399259	332781	25964
1979	4	0	0	0	0
1980	1	0	14237558	17421360	1481066
1980	2	0	9415158	11520576	979415
1980	3	2536060	3866612	389674	8724
1980	4	0	0	0	0
1981	1	428776	12322431	1483241	130805
1981	2	40632	3540737	3025289	202048
1981	3	374254	3854059	319763	9835
1981	4	0	0	0	0
1982	1	545769	6350511	601581	64879
1982	2	818525	5021082	1070960	55333
1982	3	2530673	401839	46913	3525
1982	4	0	0	0	0
1983	1	5613728	2819244	969599	155653
1983	2	2375763	1334333	588678	91112
1983	3	1697718	596857	7271	0
1983	4	0	0	0	0
1984	1	954757	6475021	417235	2532
1984	2	521866	2535354	247654	4803
1984	3	405095	612407	10648	1053
1984	4	0	0	0	0
1985	1	0	1304457	1972027	37680
1985	2	0	576004	870780	16638
1985	3	84760	215856	150819	14916
1985	4	0	0	0	0
1986	1	0	177780	452745	347620
1986	2	0	156913	399604	306818
1986	3	580936	58710	740	0
1986	4	0	0	0	0
1987	1	2236	2250587	128512	2525
1987	2	49451	1790264	267597	978
1987	3	209788	826994	34626	32980
1987	4	0	0	0	0
1988	1	4082942	2096911	2830054	42364
1988	2	1163964	314106	527986	11526
1988	3	1817700	637489	129384	5491

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022

Year	Season	age 0	age 1	age 2	age 3
1988	4	0	0	0	0
1989	1	12451	1706824	3613841	5716
1989	2	783	76415	88925	342
1989	3	469458	416920	34789	12751
1989	4	0	0	0	0
1990	1	1568	2633068	2234213	342514
1990	2	1225	2058041	1746290	267714
1990	3	291837	62050	1941	429
1990	4	0	0	0	0
1991	1	40504	1684266	2416750	8159
1991	2	1552315	2936717	614233	9587
1991	3	208352	64565	1036	99
1991	4	0	0	0	0
1992	1	18948	9695465	1315325	177584
1992	2	222991	1185132	132166	16491
1992	3	1279875	1583952	259251	5821
1992	4	0	0	0	0
1993	1	264173	3026867	5339043	247839
1993	2	1441317	4911453	1324444	31435
1993	3	1867838	1819506	338969	43965
1993	4	0	0	0	0
1994	1	445326	40720484	516854	100737
1994	2	1856101	7146622	1455656	142774
1994	3	818875	2936362	559871	22813
1994	4	0	0	0	0
1995	1	170693	24466578	3192395	371759
1995	2	612010	8620522	2863267	505875
1995	3	1797666	4488224	533786	128194
1995	4	0	0	0	0
1996	1	299367	233497	816511	286503
1996	2	1083655	776795	2208631	911256
1996	3	1670742	289815	113580	49534
1996	4	0	0	0	0
1997	1	6447	2286585	130593	202822
1997	2	148657	4395265	1078225	277615
1997	3	596223	728240	181187	46667
1997	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1998	1	86124	3567341	1498339	258993
1998	2	5465889	2665032	1451844	326463
1998	3	1615982	1096547	489541	241493
1998	4	0	0	0	0
1999	1	830	15939248	477815	69219
1999	2	90557	2456063	254931	44836
1999	3	1967130	3351942	641059	183015
1999	4	0	0	0	0
2000	1	6101	9822669	1767256	70160
2000	2	81906	801375	384854	49827
2000	3	1093613	2807143	1310052	176418
2000	4	0	0	0	0
2001	1	13056	5767627	315550	7694
2001	2	550512	3967343	1528712	498496
2001	3	143017	531588	59709	13418
2001	4	0	0	0	0
2002	1	63416	6586442	594557	108679
2002	2	927294	4326530	661656	59022
2002	3	1182692	1199165	296900	65718
2002	4	0	0	0	0
2003	1	197639	4003316	594498	68144
2003	2	2785630	6826281	1115905	218400
2003	3	713229	39824	29774	26427
2003	4	0	0	0	0
2004	1	229309	4217281	731500	78913
2004	2	24806798	4735686	264373	53425
2004	3	5233945	309955	44145	15707
2004	4	0	0	0	0
2005	1	97602	13409729	479222	88858
2005	2	839944	7903545	228337	22051
2005	3	1089274	5408581	230703	38557
2005	4	0	0	0	0
2006	1	0	1987696	1401797	295158
2006	2	319709	493221	1003837	235542
2006	3	176742	129541	176585	10933
2006	4	0	0	0	0
2007	1	0	1693273	189551	67672

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2007	2	609939	4186796	1681648	254768
2007	3	404452	329724	19675	20964
2007	4	0	0	0	0
2008	1	11590	422430	1447939	329770
2008	2	2087187	1901763	1006626	260966
2008	3	893785	131774	41692	21858
2008	4	0	0	0	0
2009	1	0	4776947	219922	39037
2009	2	231412	8163927	554425	137328
2009	3	168362	3385107	519516	88967
2009	4	0	0	0	0
2010	1	12414	1732171	689166	90040
2010	2	349703	3105417	3011291	2157387
2010	3	298472	2412405	683264	90603
2010	4	0	0	0	0
2011	1	2469	1847215	1105017	281708
2011	2	420004	4234059	2917969	999295
2011	3	57320	250247	95834	42266
2011	4	0	0	0	0
2012	1	147896	2527701	729427	121665
2012	2	187098	3756225	1690250	281071
2012	3	78240	463743	86910	30157
2012	4	0	0	0	0
2013	1	10002	1973364	411558	72705
2013	2	462029	2176971	745578	144434
2013	3	193678	1554	2447	4794
2013	4	0	0	0	0
2014	1	2640874	9499013	627237	105519
2014	2	1215080	4046244	323320	92685
2014	3	1755944	2496884	177328	21685
2014	4	0	0	0	0
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year and that all catches in S3 have been moved to S2 for the period 2019-2022					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	2420231	9775216	3342785	163696
2019	2	1010279	2433674	1045309	140003
2019	3	0	0	0	0
2019	4	0	0	0	0
2020	1	207574	10153348	3429492	429318
2020	2	97488	2773937	394226	139520
2020	3	0	0	0	0
2020	4	0	0	0	0
2021	1	539434	5840604	1505982	255540
2021	2	286005	813983	392934	138813
2021	3	0	0	0	0
2021	4	0	0	0	0
2022	1	362805	7103177	813995	99384
2022	2	829589	282596	350985	101007
2022	3	0	0	0	0
2022	4	0	0	0	0
2023	1	578572	4943797	1984638	98171
2023	2	389454	1497984	618160	68121
2023	3	0	0	0	0
2023	4	0	0	0	0

Table 10.2.3. North Sea & 3.a sprat. Mean weight at age (kg) in catches by season and year. (Model year, e.g., 2021 = July 2021–June 2022)

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1974	1	0.0063	0.0083	0.0135	0.0184
1974	2	0.0058	0.0089	0.0150	0.0197
1974	3	0.0050	0.0077	0.0150	0.0197
1974	4	0.0066	0.0107	0.0183	0.0163
1975	1	0.0048	0.0086	0.0129	0.0172
1975	2	0.0075	0.0111	0.0168	0.0216
1975	3	0.0048	0.0106	0.0154	0.0192
1975	4	0.0062	0.0116	0.0170	0.0171
1976	1	0.0049	0.0070	0.0113	0.0134
1976	2	0.0043	0.0090	0.0153	0.0190
1976	3	0.0022	0.0059	0.0104	0.0126
1976	4	0.0034	0.0057	0.0085	0.0106
1977	1	0.0054	0.0082	0.0126	0.0180
1977	2	0.0059	0.0110	0.0146	0.0196
1977	3	0.0023	0.0080	0.0106	0.0138
1977	4	0.0025	0.0063	0.0083	0.0122
1978	1	0.0038	0.0069	0.0122	0.0146
1978	2	0.0044	0.0103	0.0155	0.0196
1978	3	0.0031	0.0089	0.0123	0.0166
1978	4	0.0020	0.0052	0.0087	0.0094
1979	1	0.0050	0.0058	0.0087	0.0113
1979	2	0.0057	0.0105	0.0150	0.0173
1979	3	0.0032	0.0077	0.0129	0.0165
1979	4	0.0029	0.0106	0.0121	0.0153
1980	1	0.0063	0.0052	0.0068	0.0083
1980	2	0.0051	0.0052	0.0069	0.0083
1980	3	0.0032	0.0086	0.0131	0.0168
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156
1981	2	0.0082	0.0126	0.0153	0.0194
1981	3	0.0049	0.0089	0.0157	0.0194
1981	4	0.0060	0.0139	0.0191	0.0192
1982	1	0.0085	0.0089	0.0171	0.0155
1982	2	0.0071	0.0110	0.0160	0.0219
1982	3	0.0029	0.0075	0.0115	0.0174
1982	4	0.0044	0.0078	0.0114	0.0160
1983	1	0.0044	0.0092	0.0128	0.0152

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1983	2	0.0042	0.0124	0.0169	0.0211
1983	3	0.0034	0.0094	0.0174	0.0163
1983	4	0.0038	0.0093	0.0127	0.0156
1984	1	0.0060	0.0081	0.0121	0.0166
1984	2	0.0053	0.0122	0.0168	0.0164
1984	3	0.0093	0.0135	0.0197	0.0197
1984	4	0.0093	0.0135	0.0197	0.0197
1985	1	0.0063	0.0093	0.0135	0.0197
1985	2	0.0051	0.0093	0.0135	0.0197
1985	3	0.0073	0.0099	0.0166	0.0166
1985	4	0.0073	0.0099	0.0166	0.0166
1986	1	0.0063	0.0073	0.0099	0.0166
1986	2	0.0051	0.0073	0.0099	0.0166
1986	3	0.0083	0.0164	0.0228	0.0163
1986	4	0.0084	0.0156	0.0208	0.0156
1987	1	0.0066	0.0086	0.0117	0.0153
1987	2	0.0060	0.0093	0.0112	0.0165
1987	3	0.0064	0.0125	0.0175	0.0206
1987	4	0.0068	0.0125	0.0167	0.0189
1988	1	0.0042	0.0088	0.0115	0.0138
1988	2	0.0046	0.0085	0.0113	0.0137
1988	3	0.0052	0.0132	0.0208	0.0158
1988	4	0.0063	0.0117	0.0155	0.0175
1989	1	0.0054	0.0086	0.0099	0.0170
1989	2	0.0044	0.0082	0.0109	0.0130
1989	3	0.0048	0.0077	0.0125	0.0155
1989	4	0.0046	0.0086	0.0115	0.0129
1990	1	0.0046	0.0070	0.0092	0.0115
1990	2	0.0038	0.0069	0.0092	0.0113
1990	3	0.0044	0.0099	0.0133	0.0156
1990	4	0.0048	0.0089	0.0119	0.0135
1991	1	0.0128	0.0143	0.0154	0.0168
1991	2	0.0048	0.0146	0.0189	0.0168
1991	3	0.0052	0.0101	0.0147	0.0172
1991	4	0.0062	0.0118	0.0152	0.0186
1992	1	0.0081	0.0099	0.0124	0.0148
1992	2	0.0058	0.0121	0.0153	0.0178
1992	3	0.0035	0.0096	0.0141	0.0179

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1992	4	0.0042	0.0078	0.0104	0.0118
1993	1	0.0065	0.0109	0.0123	0.0138
1993	2	0.0075	0.0107	0.0135	0.0164
1993	3	0.0022	0.0080	0.0116	0.0152
1993	4	0.0023	0.0128	0.0154	0.0134
1994	1	0.0068	0.0067	0.0095	0.0129
1994	2	0.0087	0.0104	0.0125	0.0151
1994	3	0.0030	0.0082	0.0097	0.0140
1994	4	0.0038	0.0068	0.0090	0.0131
1995	1	0.0032	0.0082	0.0117	0.0121
1995	2	0.0051	0.0101	0.0133	0.0155
1995	3	0.0084	0.0096	0.0129	0.0158
1995	4	0.0058	0.0107	0.0142	0.0161
1996	1	0.0071	0.0108	0.0142	0.0175
1996	2	0.0079	0.0115	0.0150	0.0169
1996	3	0.0029	0.0062	0.0087	0.0103
1996	4	0.0031	0.0057	0.0077	0.0086
1997	1	0.0071	0.0128	0.0148	0.0163
1997	2	0.0058	0.0120	0.0161	0.0199
1997	3	0.0071	0.0097	0.0122	0.0147
1997	4	0.0052	0.0095	0.0127	0.0144
1998	1	0.0056	0.0139	0.0166	0.0186
1998	2	0.0050	0.0124	0.0153	0.0177
1998	3	0.0043	0.0061	0.0095	0.0094
1998	4	0.0039	0.0073	0.0097	0.0110
1999	1	0.0053	0.0097	0.0115	0.0121
1999	2	0.0046	0.0116	0.0135	0.0164
1999	3	0.0036	0.0094	0.0118	0.0138
1999	4	0.0052	0.0097	0.0129	0.0146
2000	1	0.0067	0.0122	0.0148	0.0185
2000	2	0.0062	0.0149	0.0174	0.0183
2000	3	0.0051	0.0105	0.0131	0.0150
2000	4	0.0036	0.0046	0.0080	0.0135
2001	1	0.0078	0.0109	0.0118	0.0159
2001	2	0.0048	0.0116	0.0136	0.0166
2001	3	0.0062	0.0127	0.0150	0.0162
2001	4	0.0065	0.0120	0.0161	0.0181
2002	1	0.0073	0.0109	0.0141	0.0154

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2002	2	0.0077	0.0122	0.0142	0.0158
2002	3	0.0047	0.0101	0.0133	0.0145
2002	4	0.0060	0.0116	0.0129	0.0155
2003	1	0.0042	0.0125	0.0146	0.0228
2003	2	0.0058	0.0108	0.0145	0.0167
2003	3	0.0049	0.0115	0.0135	0.0141
2003	4	0.0050	0.0092	0.0123	0.0139
2004	1	0.0088	0.0116	0.0139	0.0154
2004	2	0.0041	0.0094	0.0126	0.0153
2004	3	0.0030	0.0097	0.0112	0.0130
2004	4	0.0044	0.0093	0.0115	0.0129
2005	1	0.0076	0.0097	0.0130	0.0154
2005	2	0.0066	0.0103	0.0115	0.0141
2005	3	0.0055	0.0080	0.0114	0.0138
2005	4	0.0047	0.0087	0.0115	0.0130
2006	1	0.0063	0.0108	0.0133	0.0152
2006	2	0.0055	0.0143	0.0158	0.0180
2006	3	0.0041	0.0095	0.0129	0.0134
2006	4	0.0050	0.0093	0.0124	0.0139
2007	1	0.0063	0.0119	0.0131	0.0149
2007	2	0.0065	0.0101	0.0127	0.0151
2007	3	0.0045	0.0075	0.0106	0.0126
2007	4	0.0048	0.0089	0.0118	0.0133
2008	1	0.0088	0.0103	0.0114	0.0131
2008	2	0.0044	0.0076	0.0126	0.0142
2008	3	0.0034	0.0076	0.0082	0.0085
2008	4	0.0044	0.0068	0.0090	0.0081
2009	1	0.0063	0.0096	0.0123	0.0142
2009	2	0.0046	0.0095	0.0130	0.0160
2009	3	0.0043	0.0077	0.0103	0.0135
2009	4	0.0087	0.0096	0.0105	0.0141
2010	1	0.0066	0.0080	0.0097	0.0137
2010	2	0.0047	0.0094	0.0114	0.0148
2010	3	0.0050	0.0072	0.0094	0.0130
2010	4	0.0038	0.0071	0.0095	0.0107
2011	1	0.0052	0.0085	0.0101	0.0134
2011	2	0.0044	0.0089	0.0114	0.0145
2011	3	0.0042	0.0102	0.0128	0.0171

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2011	4	0.0050	0.0092	0.0123	0.0139
2012	1	0.0085	0.0087	0.0106	0.0150
2012	2	0.0072	0.0087	0.0119	0.0152
2012	3	0.0040	0.0069	0.0113	0.0146
2012	4	0.0047	0.0087	0.0117	0.0132
2013	1	0.0061	0.0096	0.0120	0.0150
2013	2	0.0043	0.0097	0.0124	0.0156
2013	3	0.0026	0.0051	0.0071	0.0084
2013	4	0.0022	0.0094	0.0128	0.0153
2014	1	0.0086	0.0086	0.0104	0.0168
2014	2	0.0070	0.0079	0.0116	0.0139
2014	3	0.0053	0.0083	0.0116	0.0119
2014	4	0.0065	0.0099	0.0101	0.0115
2015	1	0.0076	0.0082	0.0104	0.0150
2015	2	0.0072	0.0088	0.0109	0.0155
2015	3	0.0038	0.0078	0.0107	0.0153
2015	4	0.0044	0.0082	0.0109	0.0123
2016	1	0.0041	0.0077	0.0112	0.0145
2016	2	0.0051	0.0074	0.0118	0.0145
2016	3	0.0073	0.0143	0.0199	0.0235
2016	4	0.0076	0.0141	0.0188	0.0212
2017	1	0.0064	0.0083	0.0103	0.0139
2017	2	0.0038	0.0078	0.0099	0.0162
2017	3	0.0042	0.0064	0.0098	0.0130
2017	4	0.0076	0.0141	0.0188	0.0212
2018	1	0.0046	0.00664	0.0086	0.0126
2018	2	0.0053	0.0074	0.0097	0.0134
2018	3	0.0041	0.0067	0.0095	0.0136
2018	4	0.0057	0.0065	0.00762	0.0129
2019	1	0.0034	0.0064	0.0088	0.0116
2019	2	0.0041	0.0076	0.0098	0.0141
2019	3	0.0059	0.0100	0.0130	0.0164
2019	4	0.0064	0.0078	0.0105	0.0157
2020	1	0.0049	0.0093	0.0121	0.0162
2020	2	0.0071	0.0107	0.0141	0.0168
2020	3	0.0061	0.0087	0.0108	0.0138
2020	4	0.0064	0.0102	0.0133	0.0160
2021	1	0.0061	0.0071	0.0110	0.0131

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2021	2	0.0061	0.0087	0.0117	0.0158
2021	3	0.0072	0.0124	0.0161	0.0203
2021	4	0.0070	0.0088	0.0103	0.0157
2022	1	0.0062	0.0084	0.0109	0.0135
2022	2	0.0076	0.0123	0.0166	0.0183
2022	3	0.0058	0.0100	0.0143	0.0165
2022	4	0.0065	0.0102	0.0132	0.0160
2023	1	0.0048	0.0091	0.0107	0.0125
2023	2	0.0051	0.0083	0.0108	0.0133
2023	3	0.0058	0.0100	0.0143	0.0165
2023	4	0.0065	0.0102	0.0132	0.0160

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2023. This table only shows age-length samples, and therefore the number of samples may differ from Table 10.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	0.0	0	0	0
	2	0.5	0	0	0
	3	60.0	62	6538	3027
	4	17.9	45	4989	2313
	Total	78.4	107	11527	5340
Norway	1	0.0	0	0	0
	2	0.0	0	0	0
	3	3.6	4	400	120
	4	0.0	0	0	0
	Total	3.6	4	400	120
Sweden	1	0.0	1	60	60
	2	0.0	0	0	0
	3	5.5	12	900	900
	4	3.7	6	293	293
	Total	9.2	19	1253	1253
All countries	1	0.1	1	60	60

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
	2	0.5	0	0	0
	3	69.2	78	7838	4047
	4	21.6	51	5282	2606
Total	Total	91.4	130	13180	6713

Table 10.2.5. North Sea and Division 3.a sprat. Number of biological samples taken from 1974 and onward. The number of samples may differ from Table 10.2.4, since this table shows both length and age-length samples. These are the samples used to generate the catch-at-age matrix for the assessment model (Model year, e.g., 2021 = July 2021–June 2022).

Year	S1	S2	S3	S4
1974	15	31	102	25
1975	67	46	40	11
1976	54	70	53	16
1977	37	51	32	18
1978	52	78	47	22
1979	86	55	90	9
1980	0	0	49	28
1981	61	32	29	14
1982	27	48	13	16
1983	11	44	27	8
1984	9	23	29	7
1985	4	4	0	4
1986	4	1	0	1
1987	16	15	4	3
1988	8	4	9	1
1989	13	0	7	2
1990	4	0	13	1
1991	6	56	15	8
1992	42	35	24	4
1993	21	30	24	7
1994	42	50	32	5
1995	40	47	41	4
1996	2	12	8	3
1997	9	34	12	1
1998	25	38	16	3
1999	41	25	25	1
2000	29	23	22	14
2001	23	9	17	4
2002	26	37	28	7

Year	S1	S2	S3	S4
2003	12	60	17	2
2004	26	43	24	15
2005	77	56	56	2
2006	23	7	13	0
2007	34	40	13	4
2008	10	9	14	5
2009	33	36	18	5
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	2	12
2020	27	30	6	0
2021	85	22	0	8
2022	41	29	1	0
2023	78	49	NA	NA

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q1

IBTS Q1 survey index (area 4 and 3a combined; years apply to the calendar year and ages the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
1983	252619	551262	574173	47111
1984	619180	553686	100186	25687
1985	374594	292408	75083	19254
1986	116338	137304	39250	9993
1987	503284	86061	25143	9769
1988	248663	789924	77117	15148
1989	744970	154929	114877	11326
1990	360108	185946	47580	21180
1991	1412224	176334	33438	7582
1992	1882139	281520	36961	9645
1993	1863182	1224852	103248	10709
1994	1195289	887347	132008	8288
1995	2258852	2257140	263386	10391
1996	604673	967027	199658	28253

IBTS Q1 survey index (area 4 and 3a combined; years apply to the calendar year and ages the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
1997	599335	270098	168138	27513
1998	1072937	1104108	180777	16056
1999	5183400	583736	73757	5308
2000	2017439	1164352	150449	25036
2001	1997862	1309083	239142	13995
2002	1191954	968965	87712	10393
2003	2493114	589410	66441	5540
2004	4084377	685280	106637	9076
2005	8918279	675529	29062	2718
2006	1230441	1416990	58676	7654
2007	1917763	1035569	162880	12506
2008	1526985	803061	47400	8526
2009	4133598	312030	34043	3833
2010	3288300	2489705	118665	17586
2011	1078333	926246	206207	47562
2012	3356603	3143308	245116	36666
2013	1137772	1116849	203191	29306
2014	3886605	443621	50655	9871
2015	7727188	3460669	317090	26651
2016	2112309	3409890	675849	37763
2017	10317128	1707447	128002	15146
2018	10440866	1547476	94598	11384
2019	6097175	2511994	226057	9585
2020	7316245	2219294	421523	40023
2021	3308192	1977916	196830	16693
2022	1810546	769303	57700	6537
2023	84401712	1710545	93914	7639
2024	1229364	336007	14974	3206

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q3

IBTS Q3 survey index (area 4 and 3a combined; years and ages apply to both the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
1992	14555861	2633020	104865
1993	5767651	3015219	217792
1994	16468664	1326478	95089
1995	30622687	7433288	454582
1996	2317117	2219591	215543

IBTS Q3 survey index (area 4 and 3a combined; years and ages apply to both the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
1997	13080865	1171944	200385
1998	2676263	1107920	117795
1999	13792780	1719505	82599
2000	8212868	3228536	133847
2001	8998081	2277278	187452
2002	10011480	1319291	102476
2003	11610320	1272970	66231
2004	14371331	1945227	122791
2005	52835449	2266372	102272
2006	9340785	5459057	155440
2007	10549586	1552282	184767
2008	7894186	2085499	130785
2009	35252950	3032568	337850
2010	35355908	9422666	428224
2011	16742275	8341042	1191533
2012	11469646	5231406	575643
2013	9052264	3060010	414534
2014	63182232	3573736	215965
2015	59775893	18619852	653613
2016	27891385	4266699	482295
2017	27754797	2886164	173266
2018	18709889	3123833	200733
2019	40210818	8468920	521293
2020	53930015	16906066	1479519
2021	21858420	5602150	519985
2022	29786037	3579909	464099
2023	58581633	8893743	524218

Table 10.3.2. North Sea and Division 3.a sprat. HERAS survey index.

HERAS abundance index (area 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to both the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2006	21923	21368	1413
2007	42862	5837	2252
2008	17188	7868	840
2009	47690	16920	2815
2010	20328	14087	1174
2011	26581	14207	3412
2012	22036	12831	4693

HERAS abundance index (area 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to both the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2013	9347	6342	2049
2014	59020	20274	3982
2015	27082	22676	10142
2016	58604	33989	8160
2017	38135	3664	1465
2018	109180	10113	779
2019	93775	28020	5275
2020	38415	17993	2055
2021	46918	7051	1509
2022	60224	16200	2882
2023	48125	18542	7015

Table 10.6.1. North Sea and Division 3.a sprat. Natural mortality input (Model year, e.g., 2021 = July 2021–June 2022). From multispecies SMS (WKSAM: ICES, 2023) 2023 key run.

Year	Season	age 0	age 1	age 2	age 3
1974	1	0.4533	0.4350	0.4200	0.3973
1974	2	0.3640	0.2157	0.1903	0.1630
1974	3	0.2493	0.2153	0.1680	0.1680
1974	4	0.3283	0.2923	0.2640	0.2640
1975	1	0.4533	0.4350	0.4200	0.3973
1975	2	0.3640	0.2157	0.1903	0.1630
1975	3	0.2633	0.2287	0.1723	0.1723
1975	4	0.3433	0.3227	0.2987	0.2987
1976	1	0.4250	0.4077	0.3917	0.3770
1976	2	0.3720	0.2280	0.2087	0.1800
1976	3	0.2890	0.2503	0.1907	0.1907
1976	4	0.3430	0.3237	0.2983	0.2983
1977	1	0.3687	0.3513	0.3290	0.3207
1977	2	0.3793	0.2310	0.2117	0.1833
1977	3	0.2940	0.2797	0.2190	0.2190
1977	4	0.3340	0.3170	0.2993	0.2993
1978	1	0.3230	0.3330	0.3097	0.2977
1978	2	0.3453	0.2137	0.2053	0.1807
1978	3	0.2837	0.2703	0.2123	0.2123
1978	4	0.3037	0.2780	0.2603	0.2603
1979	1	0.3453	0.3650	0.3357	0.3270
1979	2	0.3680	0.2767	0.2370	0.2163
1979	3	0.2973	0.2773	0.2257	0.2257

Year	Season	age 0	age 1	age 2	age 3
1979	4	0.3087	0.2917	0.2737	0.2737
1980	1	0.3733	0.3867	0.3647	0.3560
1980	2	0.3940	0.2900	0.2577	0.2227
1980	3	0.2917	0.2703	0.2043	0.2043
1980	4	0.3083	0.2890	0.2537	0.2537
1981	1	0.4007	0.4050	0.3843	0.3553
1981	2	0.3637	0.2963	0.2647	0.2180
1981	3	0.2770	0.2457	0.1887	0.1887
1981	4	0.2910	0.2697	0.2213	0.2213
1982	1	0.4017	0.3883	0.3760	0.3267
1982	2	0.3013	0.2227	0.2097	0.1627
1982	3	0.2237	0.1990	0.1533	0.1533
1982	4	0.2537	0.2203	0.1773	0.1773
1983	1	0.4143	0.3983	0.3880	0.3333
1983	2	0.2967	0.2237	0.1980	0.1680
1983	3	0.2137	0.1773	0.1357	0.1357
1983	4	0.2337	0.1990	0.1543	0.1543
1984	1	0.4243	0.4027	0.3990	0.3420
1984	2	0.3330	0.2293	0.2007	0.1730
1984	3	0.2283	0.1997	0.1393	0.1393
1984	4	0.2410	0.2097	0.1713	0.1713
1985	1	0.4513	0.4367	0.4303	0.3880
1985	2	0.4050	0.3040	0.2513	0.2143
1985	3	0.2423	0.1973	0.1390	0.1390
1985	4	0.2480	0.2123	0.1513	0.1513
1986	1	0.4777	0.4700	0.4583	0.4123
1986	2	0.4310	0.3310	0.2870	0.2357
1986	3	0.2627	0.2073	0.1483	0.1483
1986	4	0.2687	0.2230	0.1483	0.1483
1987	1	0.5007	0.4917	0.4810	0.4263
1987	2	0.4617	0.3457	0.3047	0.2507
1987	3	0.2730	0.1927	0.1653	0.1653
1987	4	0.2767	0.2223	0.1610	0.1610
1988	1	0.5227	0.5043	0.4927	0.4167
1988	2	0.4687	0.3283	0.3137	0.2753
1988	3	0.2863	0.2073	0.1850	0.1850
1988	4	0.2897	0.2340	0.1930	0.1930
1989	1	0.5177	0.5013	0.4883	0.4113
1989	2	0.4537	0.3327	0.3097	0.2857
1989	3	0.2857	0.2253	0.2017	0.2017

Year	Season	age 0	age 1	age 2	age 3
1989	4	0.2963	0.2530	0.2340	0.2340
1990	1	0.4920	0.4827	0.4627	0.4187
1990	2	0.4417	0.3290	0.2940	0.2850
1990	3	0.2730	0.2430	0.2133	0.2133
1990	4	0.2993	0.2617	0.2380	0.2380
1991	1	0.4580	0.4530	0.4373	0.4177
1991	2	0.4060	0.2917	0.2673	0.2480
1991	3	0.2627	0.2527	0.2080	0.2080
1991	4	0.3013	0.2717	0.2473	0.2473
1992	1	0.4283	0.4173	0.4087	0.3990
1992	2	0.3677	0.2557	0.2430	0.2130
1992	3	0.2527	0.2437	0.1953	0.1953
1992	4	0.2853	0.2560	0.2350	0.2350
1993	1	0.4133	0.4103	0.4007	0.3887
1993	2	0.2997	0.2310	0.2297	0.2053
1993	3	0.2417	0.2300	0.1833	0.1833
1993	4	0.2707	0.2420	0.2197	0.2197
1994	1	0.4487	0.4233	0.4057	0.4013
1994	2	0.3127	0.2430	0.2330	0.2193
1994	3	0.2363	0.2187	0.1833	0.1833
1994	4	0.2613	0.2243	0.2063	0.2063
1995	1	0.4543	0.4277	0.4100	0.3953
1995	2	0.3160	0.2433	0.2330	0.2193
1995	3	0.2107	0.1980	0.1727	0.1727
1995	4	0.2460	0.2017	0.1793	0.1793
1996	1	0.4607	0.4160	0.3983	0.3670
1996	2	0.3893	0.2580	0.2470	0.2170
1996	3	0.2107	0.1827	0.1527	0.1527
1996	4	0.2380	0.1867	0.1520	0.1520
1997	1	0.4237	0.3853	0.3690	0.3377
1997	2	0.3780	0.2380	0.2357	0.1880
1997	3	0.2070	0.1887	0.1473	0.1473
1997	4	0.2450	0.2027	0.1623	0.1623
1998	1	0.4117	0.3757	0.3533	0.3323
1998	2	0.4030	0.2313	0.2290	0.1907
1998	3	0.2237	0.2000	0.1620	0.1620
1998	4	0.2563	0.2210	0.1810	0.1810
1999	1	0.4050	0.3680	0.3537	0.3467
1999	2	0.3393	0.2263	0.2253	0.2037
1999	3	0.2323	0.2267	0.1927	0.1927

Year	Season	age 0	age 1	age 2	age 3
1999	4	0.2757	0.2447	0.2117	0.2117
2000	1	0.3900	0.3643	0.3583	0.3447
2000	2	0.3527	0.2370	0.2350	0.2223
2000	3	0.2157	0.2007	0.1840	0.1840
2000	4	0.2437	0.2080	0.1710	0.1710
2001	1	0.3923	0.3607	0.3600	0.3357
2001	2	0.3380	0.2507	0.2497	0.2383
2001	3	0.2200	0.2113	0.1897	0.1897
2001	4	0.2617	0.2263	0.1873	0.1873
2002	1	0.4010	0.3677	0.3670	0.3197
2002	2	0.3573	0.2537	0.2517	0.2417
2002	3	0.2100	0.1953	0.1683	0.1683
2002	4	0.2540	0.2123	0.1833	0.1833
2003	1	0.3867	0.3543	0.3537	0.3130
2003	2	0.3300	0.2520	0.2397	0.2397
2003	3	0.2307	0.2133	0.1907	0.1907
2003	4	0.3020	0.2590	0.2350	0.2350
2004	1	0.3910	0.3697	0.3607	0.3307
2004	2	0.3063	0.2393	0.2257	0.2257
2004	3	0.2140	0.1970	0.1840	0.1840
2004	4	0.2950	0.2523	0.2310	0.2310
2005	1	0.4023	0.3840	0.3747	0.3747
2005	2	0.3130	0.2490	0.2247	0.2247
2005	3	0.2067	0.1830	0.1693	0.1693
2005	4	0.2970	0.2493	0.2133	0.2133
2006	1	0.4503	0.4310	0.4217	0.4217
2006	2	0.3223	0.2417	0.2273	0.2250
2006	3	0.1927	0.1813	0.1653	0.1653
2006	4	0.2820	0.2410	0.2030	0.2030
2007	1	0.4697	0.4453	0.4417	0.4417
2007	2	0.3397	0.2560	0.2333	0.2310
2007	3	0.1867	0.1617	0.1440	0.1440
2007	4	0.2640	0.2213	0.1830	0.1830
2008	1	0.4720	0.4573	0.4473	0.4473
2008	2	0.3217	0.2377	0.2223	0.2077
2008	3	0.1803	0.1693	0.1583	0.1583
2008	4	0.2513	0.2237	0.1957	0.1957
2009	1	0.4547	0.4497	0.4350	0.4300
2009	2	0.3237	0.2507	0.2223	0.2073
2009	3	0.1807	0.1700	0.1593	0.1593

Year	Season	age 0	age 1	age 2	age 3
2009	4	0.2460	0.2187	0.1943	0.1943
2010	1	0.4997	0.4903	0.4680	0.4623
2010	2	0.3517	0.2760	0.2407	0.2257
2010	3	0.1970	0.1883	0.1630	0.1630
2010	4	0.2667	0.2237	0.2030	0.2030
2011	1	0.5360	0.5267	0.5007	0.4947
2011	2	0.3690	0.3050	0.2590	0.2520
2011	3	0.2113	0.2013	0.1767	0.1767
2011	4	0.2937	0.2517	0.2320	0.2320
2012	1	0.5507	0.5320	0.5067	0.4797
2012	2	0.3617	0.3000	0.2603	0.2507
2012	3	0.2017	0.1837	0.1457	0.1457
2012	4	0.2783	0.2273	0.1970	0.1970
2013	1	0.4817	0.4723	0.4517	0.4023
2013	2	0.3110	0.2633	0.2313	0.2217
2013	3	0.1847	0.1787	0.1527	0.1527
2013	4	0.2580	0.2270	0.2030	0.2030
2014	1	0.4363	0.4270	0.4077	0.3460
2014	2	0.3030	0.2487	0.2200	0.2133
2014	3	0.2013	0.1823	0.1547	0.1547
2014	4	0.2580	0.2283	0.2043	0.2043
2015	1	0.4373	0.4303	0.4060	0.3703
2015	2	0.3090	0.2713	0.2177	0.2163
2015	3	0.2217	0.2010	0.1750	0.1750
2015	4	0.2653	0.2450	0.2320	0.2320
2016	1	0.4573	0.4423	0.4140	0.4013
2016	2	0.3363	0.3033	0.2290	0.2277
2016	3	0.2460	0.2163	0.1927	0.1927
2016	4	0.2833	0.2643	0.2447	0.2447
2017	1	0.4567	0.4353	0.4080	0.4080
2017	2	0.3363	0.3140	0.2277	0.2277
2017	3	0.2387	0.2153	0.1937	0.1937
2017	4	0.2753	0.2577	0.2390	0.2390
2018	1	0.4257	0.4047	0.3787	0.3787
2018	2	0.3300	0.3080	0.2190	0.2190
2018	3	0.2437	0.2230	0.2120	0.2120
2018	4	0.2880	0.2720	0.2530	0.2530
2019	1	0.4243	0.4037	0.3800	0.3800
2019	2	0.3447	0.3227	0.2280	0.2280
2019	3	0.2670	0.2493	0.2390	0.2390

Year	Season	age 0	age 1	age 2	age 3
2019	4	0.3107	0.2943	0.2750	0.2750
2020	1	0.4447	0.4240	0.4007	0.4007
2020	2	0.3707	0.3490	0.2600	0.2600
2020	3	0.2953	0.2810	0.2717	0.2717
2020	4	0.3353	0.3190	0.2993	0.2993
2021	1	0.4453	0.4267	0.4050	0.4050
2021	2	0.3713	0.3527	0.2760	0.2760
2021	3	0.2953	0.2810	0.2717	0.2717
2021	4	0.3353	0.3190	0.2993	0.2993
2022	1	0.4453	0.4267	0.4050	0.4050
2022	2	0.3713	0.3527	0.2760	0.2760
2022	3	0.2953	0.2810	0.2717	0.2717
2022	4	0.3353	0.3190	0.2993	0.2993
2023	1	0.4453	0.4267	0.4050	0.4050
2023	2	0.3713	0.3527	0.2760	0.2760
2023	3	0.2953	0.2810	0.2717	0.2717
2023	4	0.3353	0.3190	0.2993	0.2993

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 04/02/24 Start time:22:15:02 run time:19 seconds

objective function (negative log likelihood): 284.005

Number of parameters: 147

Maximum gradient: 5.51547e-05

Akaike information criterion (AIC): 862.01

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
800	318	50	0	1168

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.10

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
383.4	-100.1	6.5	0.0	0.0	0.00	290

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.48	-0.31	0.13	0.00

contribution by fleet:

IBTS Q1 Rec total: -31.471 mean: -0.749

IBTS Q1 total: -31.705 mean: -0.252

IBTS Q3 total: -23.856 mean: -0.249

Acoustic total: -13.035 mean: -0.241

F, Year effect:

1974: 1.000

1975: 1.797

1976: 1.829

1977: 1.746

1978: 1.163

1979: 0.704

1980: 2.408

1981: 1.132

1982: 0.939

1983: 1.629

1984: 0.768

1985: 1.207

1986: 1.150

1987: 0.331

1988: 1.164

1989: 0.276

1990: 1.497

1991: 0.638

1992: 0.809

1993: 1.402

1994: 0.665

1995: 1.191

1996: 1.173

1997: 0.809

1998: 1.453

1999: 0.783

2000: 1.390

2001: 1.333

2002: 1.487

2003: 1.177

2004: 1.812

2005: 1.180

2006: 1.427

2007: 1.296

2008: 1.092

2009: 0.646

2010: 0.763

2011: 0.609

2012: 1.152

2013: 0.755

2014: 0.498

2015: 0.975

2016: 1.893

2017: 1.019

2018: 1.043

2019: 1.001

2020: 1.612

2021: 1.502

2022: 0.604

2023: 3.003

F, season effect:

----

age: 0

1974-2023: 0.038 0.199 0.408 0.250

age: 1

1974-2023: 0.594 0.550 0.255 0.250

age: 2

1974-2023: 0.274 0.530 0.149 0.250

age: 3

1974-2023: 0.245 0.553 0.302 0.250

F, age effect:

	0	1	2	3
1974-2023:	0.046	0.438	1.392	1.392

Exploitation pattern (scaled to mean F=1)

		0	1	2	3
1974-2023	season 1:	0.001	0.217	0.318	0.284
	season 2:	0.008	0.201	0.616	0.643
	season 3:	0.016	0.093	0.173	0.351
	season 4:	0.010	0.091	0.290	0.290

sqrt(catch variance) ~ CV:

----

season

----

age	1	2	3	4
0	1.414	1.414	1.100	0.100
1	0.864	0.834	1.399	0.100
2	0.951	1.050	1.414	0.100
3	0.951	1.050	1.414	0.100

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	18.340			
IBTS Q1		1.428	2.280	3.148
IBTS Q3		0.821	1.088	0.888
Acoustic		1.091	2.404	5.103

Stock size dependent catchability (power model)

---	age 0	age 1	age 2	age 3
IBTS Q1 Rec	1.72			
IBTS Q1		1.00	1.00	1.00
IBTS Q3		1.00	1.00	1.00
Acoustic		1.00	1.00	1.00

sqrt(Survey variance) ~ CV:

----

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			

IBTS Q1	0.47	0.47	0.47
IBTS Q3	0.53	0.45	0.45
Acoustic	0.44	0.50	0.50

Average F:

----

	sp. 1
1974:	1.158
1975:	1.788
1976:	1.849
1977:	1.819
1978:	1.220
1979:	0.750
1980:	2.429
1981:	1.146
1982:	0.927
1983:	1.563
1984:	0.750
1985:	1.161
1986:	1.103
1987:	0.321
1988:	1.124
1989:	0.276
1990:	1.478
1991:	0.649
1992:	0.818
1993:	1.390
1994:	0.664
1995:	1.160

1996: 1.135

1997: 0.797

1998: 1.437

1999: 0.800

2000: 1.378

2001: 1.335

2002: 1.471

2003: 1.200

2004: 1.810

2005: 1.177

2006: 1.388

2007: 1.241

2008: 1.052

2009: 0.630

2010: 0.738

2011: 0.594

2012: 1.089

2013: 0.733

2014: 0.494

2015: 0.971

2016: 1.868

2017: 1.024

2018: 1.067

2019: 0.917

2020: 1.472

2021: 1.377

2022: 0.571

2023: 2.654

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1269.427	9.000e+04	0.478	0.691

Table 10.6.3. North Sea and Division 3.a Sprat. Assessment output: Stock numbers (thousands) (years, seasons (S1-S4), and age (A0-A3+) refer to the model year, e.g., 2021 = July 2021–June 2022)

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
1974	396298000	251406000	173095000	132368000	122228000	60983000	38638000	27859400	11266100	5054130	1997470	1371770	548399	262192	103112	57240
1975	519480000	329090000	224920000	167068000	94221400	38201500	19978400	13003100	18641100	6169400	1353920	784478	774838	282374	60099	23756
1976	234629000	152900000	103638000	74985000	118519000	48973800	25103700	15931600	9417060	3167220	666487	376638	599554	220562	45026	17241
1977	375634000	259012000	174414000	125762000	53212200	23772800	12395600	7710750	11526300	4260800	950667	531350	292279	117031	25391	9788
1978	640638000	462856000	324197000	238813000	90052500	47689600	29112200	19509400	5615980	2643790	912745	579696	401153	200460	68323	33881
1979	366682000	259283000	178293000	130683000	176269000	101880000	65215500	45682400	14774400	8073760	3789130	2612240	472942	268332	125675	74589
1980	203892000	139773000	92184800	65795800	95976600	34834800	14599500	8512910	34125600	9454060	1235610	610708	2043570	630332	78939	23372
1981	60089600	40172300	27634600	20504700	48338200	24014900	13598700	9373330	6376280	2819160	938617	614380	492015	234571	78896	40591
1982	32970100	22027300	16155800	12690300	15327600	8140590	5197320	3835140	7157790	3434330	1392430	982725	524926	274984	113368	65518
1983	49315300	32493300	23791700	18631400	9847080	4327270	2337970	1632280	3076750	1121220	276521	172127	877904	361231	87103	38340
1984	29746800	19434200	13831500	10849200	14749100	8074150	5336300	4011150	1337740	669648	310896	230578	180367	98641	45929	28929
1985	19110800	12143500	8009700	6143970	8525720	4023480	2220070	1592490	3252460	1334220	425692	288254	218646	98319	31308	16397
1986	56723000	35110100	22575800	16987000	4794510	2221470	1209740	864667	1287840	525107	168679	114519	261866	117197	38187	20299
1987	36156000	21902400	13761500	10408500	12984800	7286710	4762640	3785550	691833	376973	217781	172338	116232	67805	40907	30172

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
1988	58410200	34562600	21399300	15720900	7892810	3520200	1915350	1366780	3030890	1187480	367435	239748	172395	76440	23670	12055
1989	45003800	26805200	16985900	12698700	11767300	6634100	4451280	3445440	1081620	597448	357638	276045	207607	125262	76124	55409
1990	70847500	43202300	27396400	20268900	9441990	3946660	1980940	1314320	2675280	951398	234915	139054	262300	103646	24606	10592
1991	103894000	65643900	43482400	33036500	15025500	8090220	5183080	3748790	1011720	512128	244769	174117	117951	62506	29837	18530
1992	98170500	63876300	43895800	33577200	24441400	13045500	8315530	5954200	2856990	1394450	602100	418658	150434	76637	33220	19447
1993	104347000	68849400	50366200	38518200	25242100	11627300	6586290	4474450	4609400	1808650	510955	317893	346353	145679	40304	18609
1994	109041000	69539200	50556500	39416500	29384400	16186300	10818100	8071270	3512690	1816930	881392	639123	270140	144211	69415	43698
1995	39378300	24947800	17989600	14247600	30351600	14514600	8543240	6135290	6449340	2716850	893565	587025	555517	249359	80008	40794
1996	60154400	37870900	25381600	20108800	11140500	5415430	3154750	2305210	5014790	2152070	707320	475838	524749	243809	79506	41672
1997	58709800	38379200	26103000	20899800	15849800	8734030	5666010	4286270	1912680	971188	422315	308063	444535	240758	106974	65692
1998	132527000	87580500	57751600	44924900	16358300	7697720	4305590	2996940	3499960	1412050	384387	241722	317751	138951	37504	17313
1999	80733300	53773000	38023700	29697300	34766700	19624700	12960900	9466440	2402690	1251130	560280	392692	216148	117041	52225	30985
2000	77038300	52031800	36102600	28343600	22542200	10906400	6158820	4314380	7411890	3048010	864130	538608	342854	151312	41540	19264
2001	63241400	42618100	30023300	23493900	22214300	10946500	6180710	4310800	3504170	1469870	428067	268426	470187	213438	60220	28435
2002	87377200	58359100	40267900	31734600	18084900	8501550	4611580	3212480	3437660	1350130	350229	217282	246147	107733	26904	12163
2003	115953000	78606000	55901400	43408500	24616300	12715300	7445370	5274000	2597920	1164210	384434	248792	191011	93557	29743	14985
2004	184669000	124509000	90135700	70317300	32093600	13835400	7040310	4721570	4070590	1421210	297681	169937	208535	80813	15965	6198

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
2005	63078800	42096900	30450100	24218100	52353500	26231900	15395100	11237400	3668590	1608030	537832	355352	139805	64316	20708	10645
2006	84932300	54001300	38609800	30995200	17995100	8065960	4492930	3195440	8757520	3332410	926085	583543	295684	119293	31734	14760
2007	69623600	43430200	30555100	24738100	23378900	10689100	6057820	4458910	2511110	984726	299698	198252	488381	201967	59089	29669
2008	140051000	87189500	62573300	51179400	18998200	9049600	5485830	4099230	3573590	1506010	538531	366344	189806	83652	29304	15801
2009	110047000	69762900	50172800	41370900	39805400	21459200	14295800	11220900	3277670	1657940	823987	614351	314232	164032	81048	52666
2010	91477200	55427700	38720700	31341400	32348900	16243600	10258500	7803260	9016960	4220840	1889740	1370180	549211	266760	118290	72919
2011	99565900	58192000	40010100	32017400	24005200	12099800	7703700	5884750	6239340	2998060	1476710	1090560	1177970	583821	283952	184229
2012	74985400	43146400	29734400	23780100	23869800	10390400	5834100	4269050	4575420	1776450	585359	398335	1010840	422701	135508	72174
2013	166704000	102845000	74832500	61331200	18002600	9221510	5908360	4541650	3400960	1622730	737301	540966	386377	199771	89442	55880
2014	196841000	127127000	93465000	75703600	47384200	27156300	18784400	14805900	3619340	1990750	1106090	854401	487193	290898	160114	111240
2015	110892000	71486200	52013700	40910700	58488200	29510000	17791800	13050200	11783400	5412260	2120200	1453440	787181	389970	148234	82580
2016	199512000	125865000	88358600	66658300	31376500	12317100	5766250	3759080	10214500	3278690	644943	358942	1217980	427891	79288	29497
2017	235741000	149048000	105481000	81498600	50211600	24920700	14245700	10249900	2885910	1300870	488415	325638	304135	142941	51932	27876
2018	201033000	131101000	93349100	71732900	61883400	31475600	17998200	12817100	7921700	3644070	1356200	883431	278362	133641	48092	25094
2019	193661000	126471000	88775500	67973000	53782600	27680700	15754700	12278000	9764790	4557690	1733420	1364920	705441	343057	126328	99472

Year/Age Quarter	A0_S1	A0_S2	A0_S3	A0_S4	A1_S1	A1_S2	A1_S3	A1_S4	A2_S1	A2_S2	A2_S3	A2_S4	A3+_S1	A3+_S2	A3+_S3	A3+_S4
2020	138842000	88750700	60357900	44923400	49821400	21433600	10258000	7745050	9147450	3312920	777611	592624	1112310	430362	95896	73084
2021	125288000	80048800	54458700	40532700	32124700	14182200	6943370	5242440	5629690	2116750	530133	404019	493497	197339	47085	35884
2022	204585000	130920000	89808200	66842800	28984900	16164900	9823200	7416800	3810600	2018240	980523	747264	326105	177050	84356	64288
2023	75569500	48155300	32310300	24048000	47799300	14278000	4870900	3677670	5391090	1143240	94586	72085	601614	144294	10836	8258
2024	0				17196700				2673210				59559			

Table 10.6.4. North Sea & 3.a Sprat. Assessment output: Estimated recruitment, spawning-stock biomass (SSB), average fishing mortality (F), and landings weight (Yield). All estimates refer to the model year, e.g., 2022 = July 2022–June 2023.

Year	Recruitment (thousands)	High	Low	SSB (tonnes)	High	Low	Catches (tonnes)	F ages 1-2 (per year)	High	Low
1974	396298000	711911137	220606332	558968	896742	348423	463344	1.158	1.8	0.745
1975	519480000	918665062	293751751	554695	900682	341615	732312	1.788	2.606	1.226
1976	234629000	411465735	133791864	440558	717994	270325	628598	1.849	2.633	1.298
1977	375634000	638410603	221019045	311303	485669	199538	385257	1.819	2.569	1.289
1978	640638000	1176455494	348858966	318256	498981	202987	458804	1.22	1.959	0.76
1979	366682000	660303640	203627060	536507	893956	321984	463638	0.75	1.394	0.403
1980	203892000	326036507	127507033	423353	720116	248888	387434	2.429	3.309	1.783
1981	60089600	91855385	39309182	273781	406650	184326	280582	1.146	1.734	0.757
1982	32970100	42591842	25521965	169910	252859	114172	162357	0.927	1.367	0.629
1983	49315300	63613897	38230621	83997	109721	64303	115440	1.563	1.978	1.235
1984	29746800	39404087	22456354	65770	81664	52969	113444	0.75	1.127	0.5
1985	19110800	25660170	14233057	74879	95165	58917	62514	1.161	1.581	0.852
1986	56723000	73126086	43999329	29448	38267	22662	27520	1.103	1.527	0.796
1987	36156000	47374518	27594082	54530	68560	43370	53942	0.321	0.505	0.204
1988	58410200	76463302	44619463	61122	75536	49458	103652	1.124	1.467	0.861
1989	45003800	58743006	34478011	54176	68250	43004	58420	0.276	0.505	0.151
1990	70847500	90129129	55690855	51176	64259	40757	78180	1.478	1.877	1.164
1991	103894000	131479870	82095938	103464	128833	83090	125815	0.649	0.986	0.426
1992	98170500	123940686	77758542	132086	162128	107611	156471	0.818	1.145	0.585
1993	104347000	132682435	82062833	166541	203671	136180	208848	1.39	1.731	1.116
1994	109041000	138409534	85904051	112818	138028	92213	424206	0.664	0.91	0.484
1995	39378300	50492493	30710516	173878	211928	142659	446555	1.16	1.466	0.918
1996	60154400	76218031	47476323	120347	148126	97778	95496	1.135	1.471	0.876
1997	58709800	74589846	46210587	114437	140225	93392	125174	0.797	1.109	0.574
1998	132527000	167668591	104750721	149639	183230	122206	188907	1.437	1.766	1.17
1999	80733300	102440506	63625864	165023	204136	133404	243158	0.8	1.129	0.567
2000	77038300	97676463	60760796	214321	263232	174498	222027	1.378	1.761	1.078
2001	63241400	80074041	49947207	141908	174850	115172	153321	1.335	1.739	1.025
2002	87377200	110781456	68917447	126308	155475	102612	174713	1.471	1.83	1.182
2003	115953000	147018629	91451664	162718	200699	131925	174988	1.2	1.567	0.92
2004	184669000	234835193	145219458	204387	251957	165798	231352	1.81	2.183	1.5
2005	63078800	79077234	50317074	251165	313111	201475	280275	1.177	1.511	0.916
2006	84932300	106347320	67829594	185788	229090	150671	78028	1.388	1.734	1.111
2007	69623600	86843717	55818035	149229	182149	122259	99902	1.241	1.581	0.975
2008	140051000	174813651	112201093	118162	143396	97369	69892	1.052	1.401	0.79

Year	Recruitment	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
2009	110047000	137346415	88173705	195548	238352	160431	170934	0.63	0.911	0.436
2010	91477200	114670665	72974881	189055	228205	156622	145415	0.738	1.029	0.53
2011	99565900	124676821	79512522	153530	184541	127730	122472	0.594	0.887	0.397
2012	74985400	93667155	60029689	141307	170634	117021	96030	1.089	1.4	0.847
2013	166704000	210149710	132240123	111731	135652	92029	60207	0.733	1.23	0.437
2014	196841000	251184113	154254896	206623	253735	168258	190268	0.494	0.714	0.342
2015	110892000	140259814	87673264	313569	384768	255545	298227	0.971	1.285	0.734
2016	199512000	250113462	159147924	215611	264938	175468	227169	1.868	2.199	1.587
2017	235741000	298472248	186194259	200416	247001	162617	135824	1.024	1.356	0.773
2018	201033000	257582120	156898573	230073	282653	187274	190779	1.067	1.402	0.812
2019	193661000	247769334	151368946	223301	275491	180998	137029	0.917	1.292	0.651
2020	138842000	174661154	110368565	303434	376056	244836	182205	1.472	1.847	1.173
2021	125288000	160261473	97946703	153180	187372	125228	80183	1.377	1.808	1.049
2022	204585000	268500743	155884195	140181	172691	113791	89625	0.571	0.94	0.347
2023	75569500	102140781	55910571	235389	297419	186296	92204	2.654	3.195	2.206
2024	172781786*			83754	107867	65031				

* Geometric mean recruitment (2012–2021)

Table 10.9.1. North Sea and Division 3.a Sprat. Input to forecast (years and age refer to the model year, e.g., 2022 = July 2022–June 2023).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2023) (millions)	172782	17197	2673	60
Exploitation pattern S1	0.0011	0.1573	0.2306	0.2058
Exploitation pattern S2	0.0056	0.1454	0.4459	0.4654
Exploitation pattern S3	0.0000	0.0000	0.0000	0.0000
Exploitation pattern S4	0.0000	0.0000	0.0000	0.0000
Weight in the stock S1 (gram)	5.6797	8.1980	10.8618	13.0539
Weight in the catch S1 (gram)	5.6797	8.1980	10.8618	13.0539
Weight in the catch S2 (gram)	6.2849	9.7338	13.0368	15.7918
Weight in the catch S3 (gram)	6.2703	10.7911	14.8726	17.7723
Weight in the catch S4 (gram)	6.6799	9.7275	12.2439	15.8939
Proportion mature(2021)	0.0000	0.4093	0.8719	0.9468
Proportion mature(2022)	0.0000	0.4093	0.8719	0.9468
Natural mortality S1	0.4453	0.4267	0.4050	0.4050
Natural mortality S2	0.3713	0.3527	0.2760	0.2760
Natural mortality S3	0.2953	0.2810	0.2717	0.2717
Natural mortality S4	0.3353	0.3190	0.2993	0.2993

Table 10.9.2. Sprat North Sea Division 3.a. Short-term predictions options table. Years refer to the model year, e.g., 2023 = July 2023–June 2024.

Catch options. Catches and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2022) = geometric average 2012–2021.					
Basis	**Catches(2023)**	**F(2023)**	**SSB(2024)**	**SSB change***	**TAC change****
F_{cap}	75321	1.01	158851	90%	-48%
F=0.0	1	0	187012	123%	-100%
F=0.1	9943	0.1	183123	119%	-93%
F=0.2	19196	0.2	179543	114%	-87%
F=0.3	27825	0.3	176241	110%	-81%
F=0.4	35884	0.4	173192	107%	-75%
F=0.5	43425	0.5	170371	103%	-70%
F=0.6	50493	0.6	167759	100%	-65%
F=0.7	57128	0.7	165335	97%	-60%
F=0.8	63367	0.8	163084	95%	-56%
F=0.9	69242	0.9	160990	92%	-52%
F=1.0	74784	1	159039	90%	-48%
$B_{escapement}$ without F_{cap}	149495	3.275	135952	62%	4%

* SSB 1st July 2024 relative to SSB 1st July 2023

** Catch (July 2023-June 2024) relative to the sum of the TACs (68 690 tonnes) for July 2022–June 2023 in Subarea 4 and Division 3.a.

Figure 10.1.1. North Sea and Division 3.a sprat. Sprat catches in the North Sea and Division 3.a (in tonnes) for each calendar year by statistical rectangle.

Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

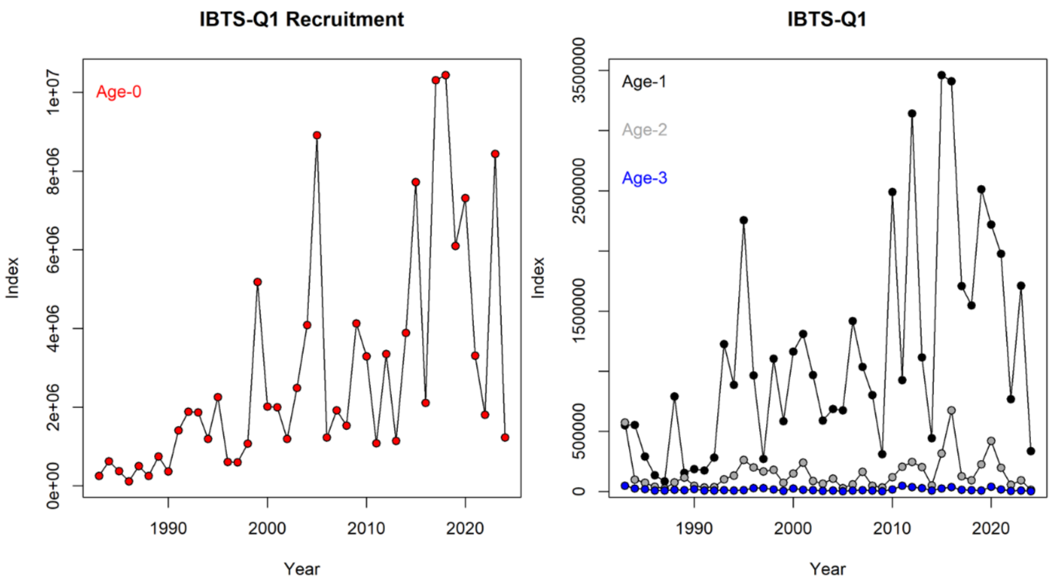


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

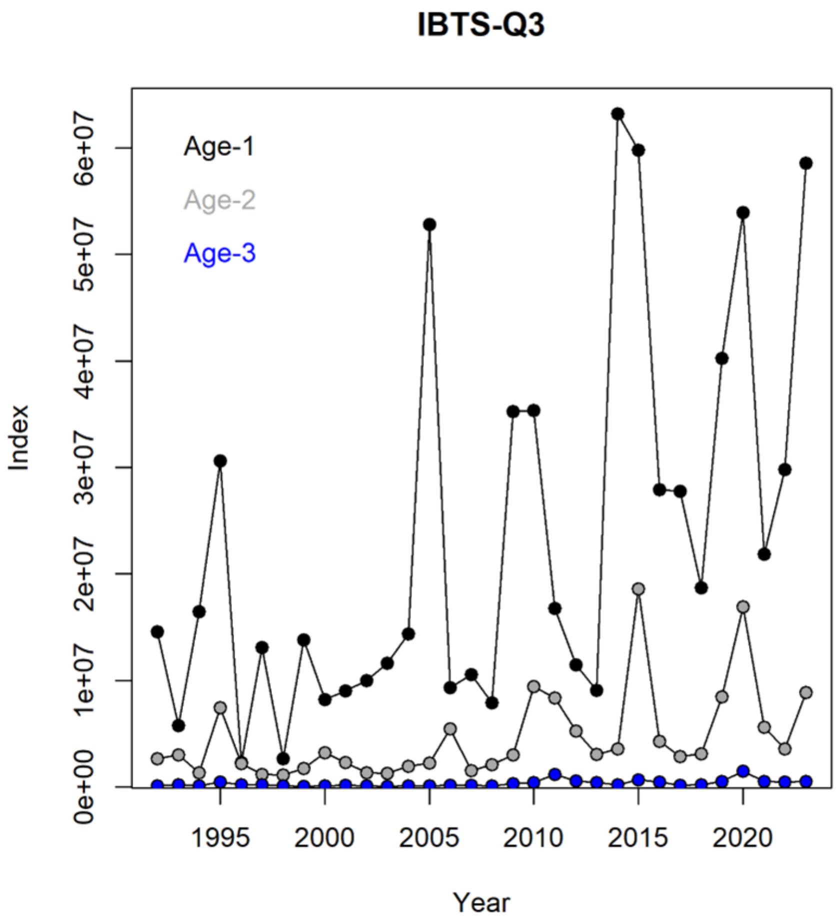


Figure 10.3.2. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

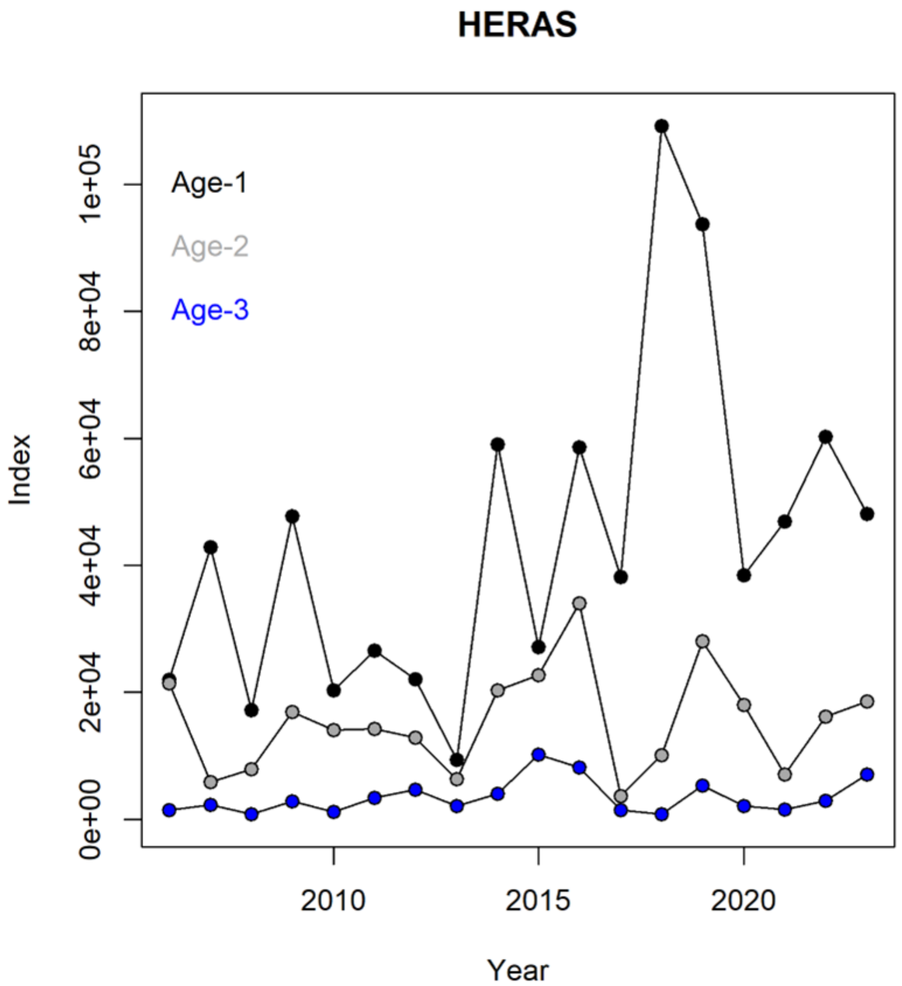


Figure 10.3.3. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS [ICES *in press*]). Years refer to the calendar year.

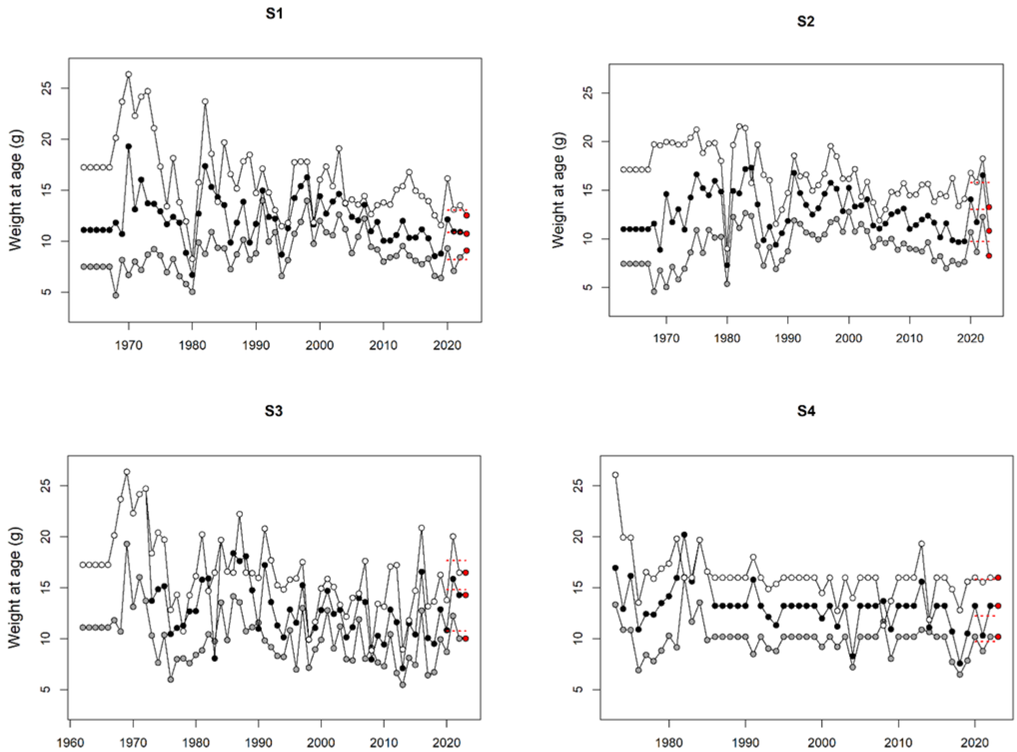


Figure 10.4.1. North Sea & 3.a sprat. Mean weight at age in season 1–4 (S1–S4) (years refer to the model year, e.g., 2021 = July 2021–June 2022). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year.

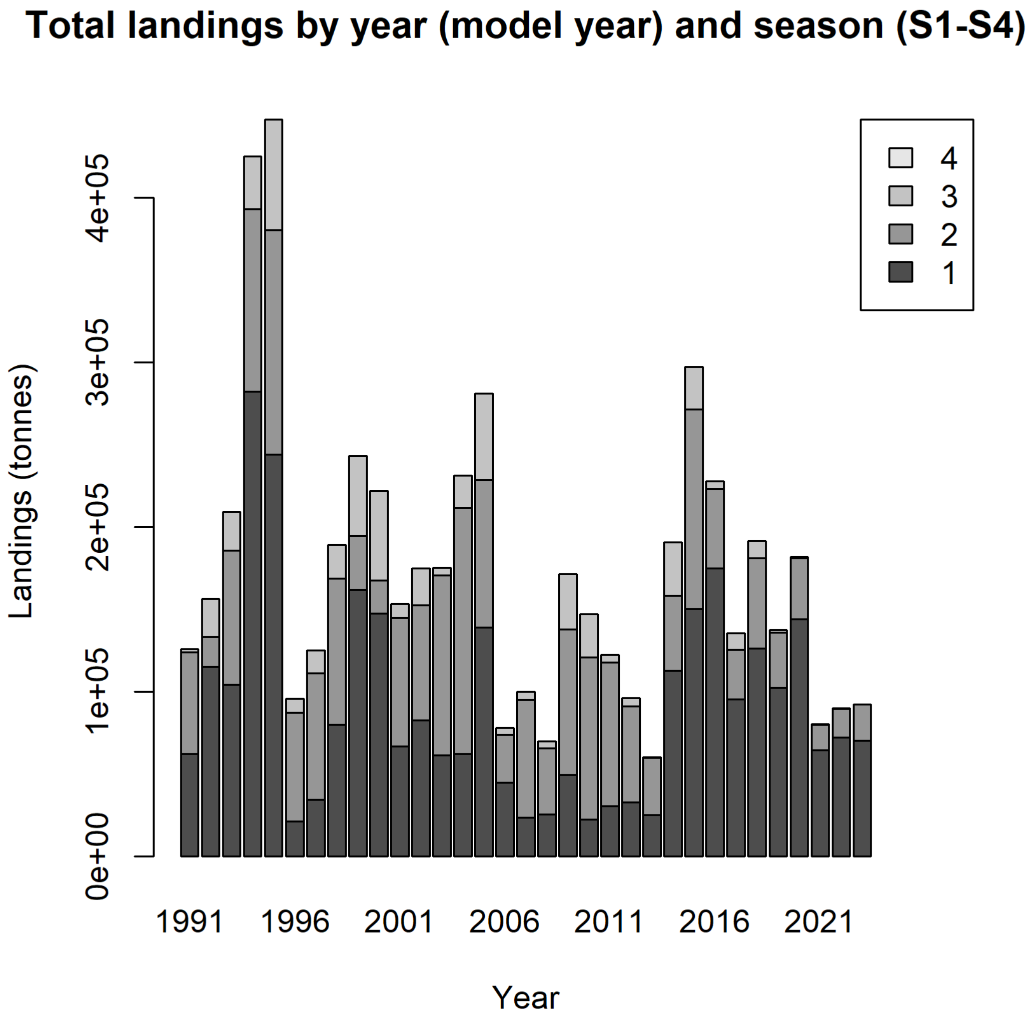


Figure 10.6.1a. North Sea & 3.a sprat. Seasonal distribution of catches. Year and season 1-4 refer to the time-steps of the model (e.g., 2021 = July 2021–June 2022). Note that since the model year of 2022 is not yet finished, the 2022 column

will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT 2018 report (ICES, 2018a) for details).

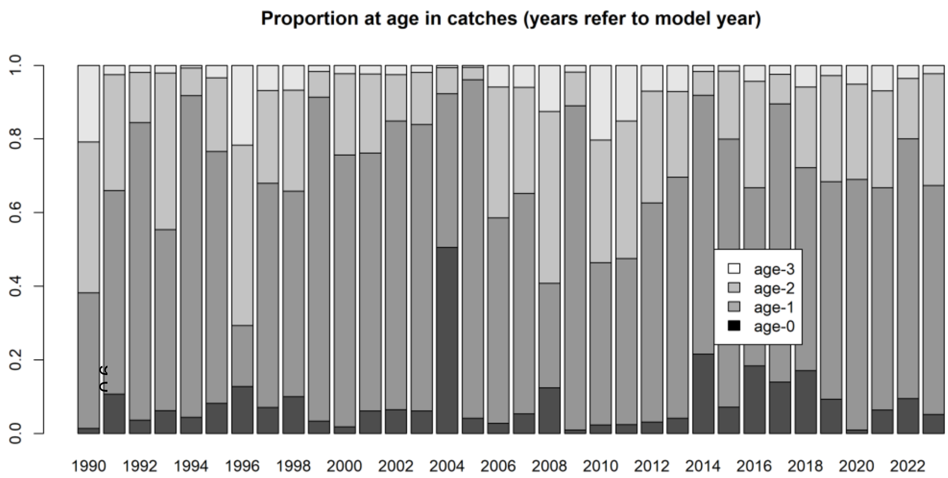


Figure 10.6.1b. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year (e.g., 2021 = July 2021–June 2022).

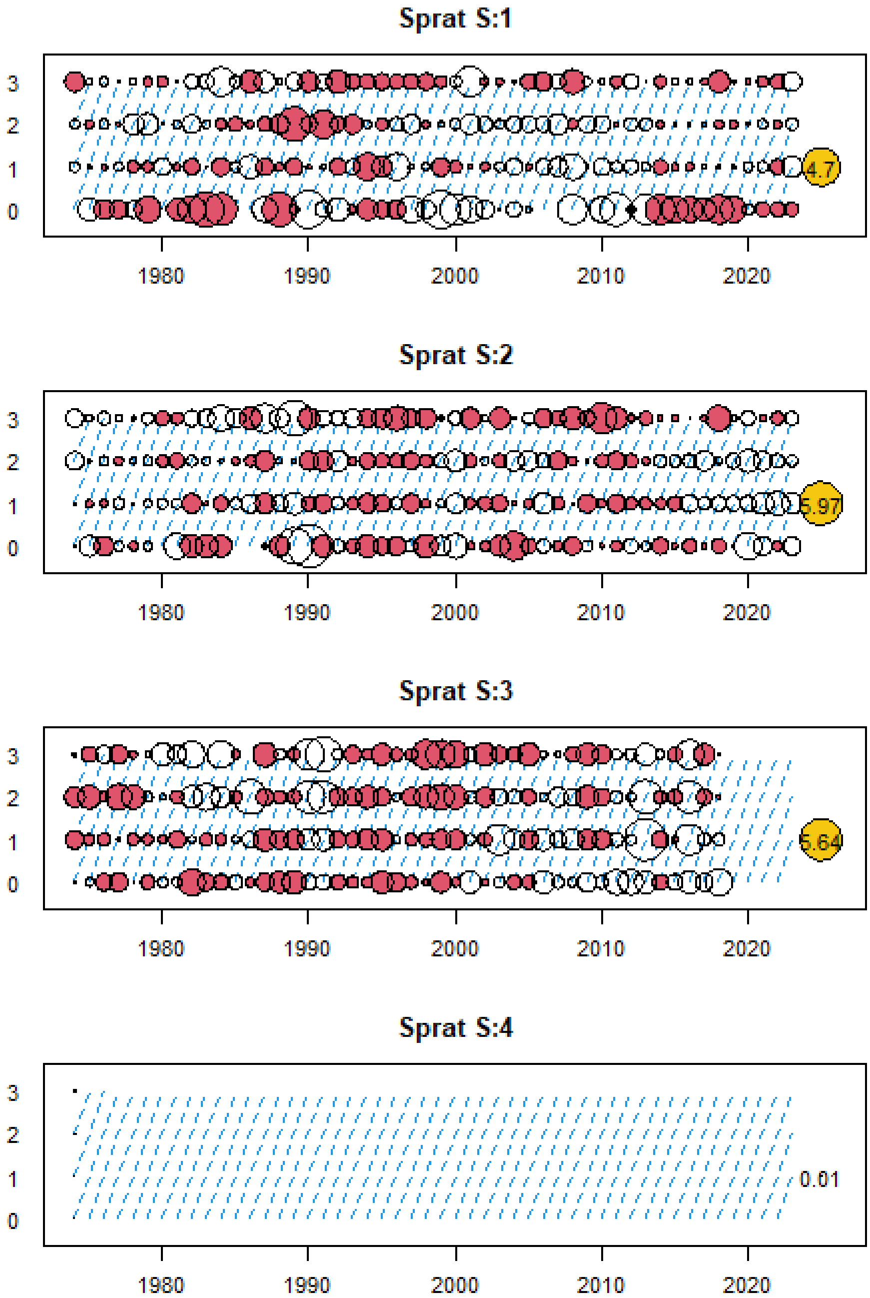


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

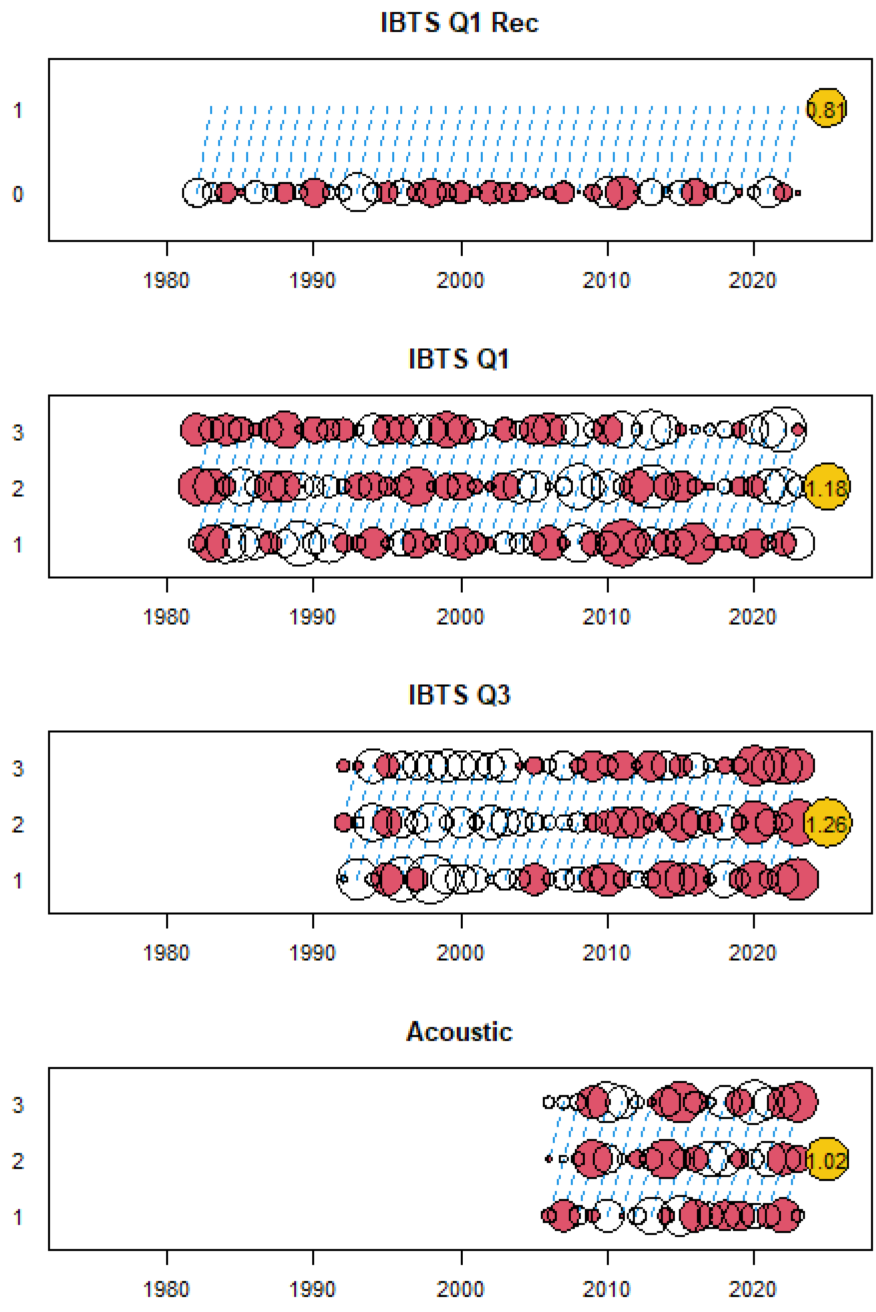


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

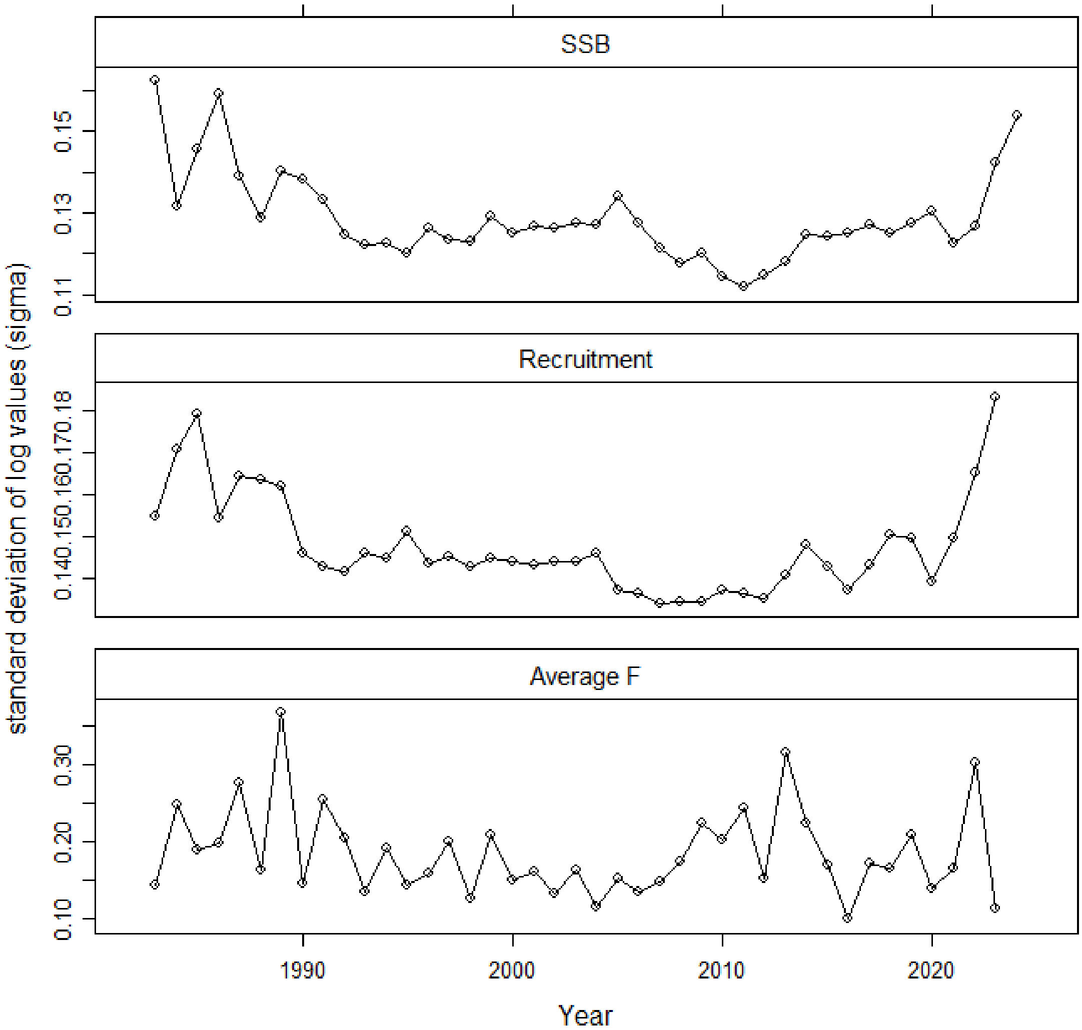


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year, e.g., 2021 = July 2021–June 2022).

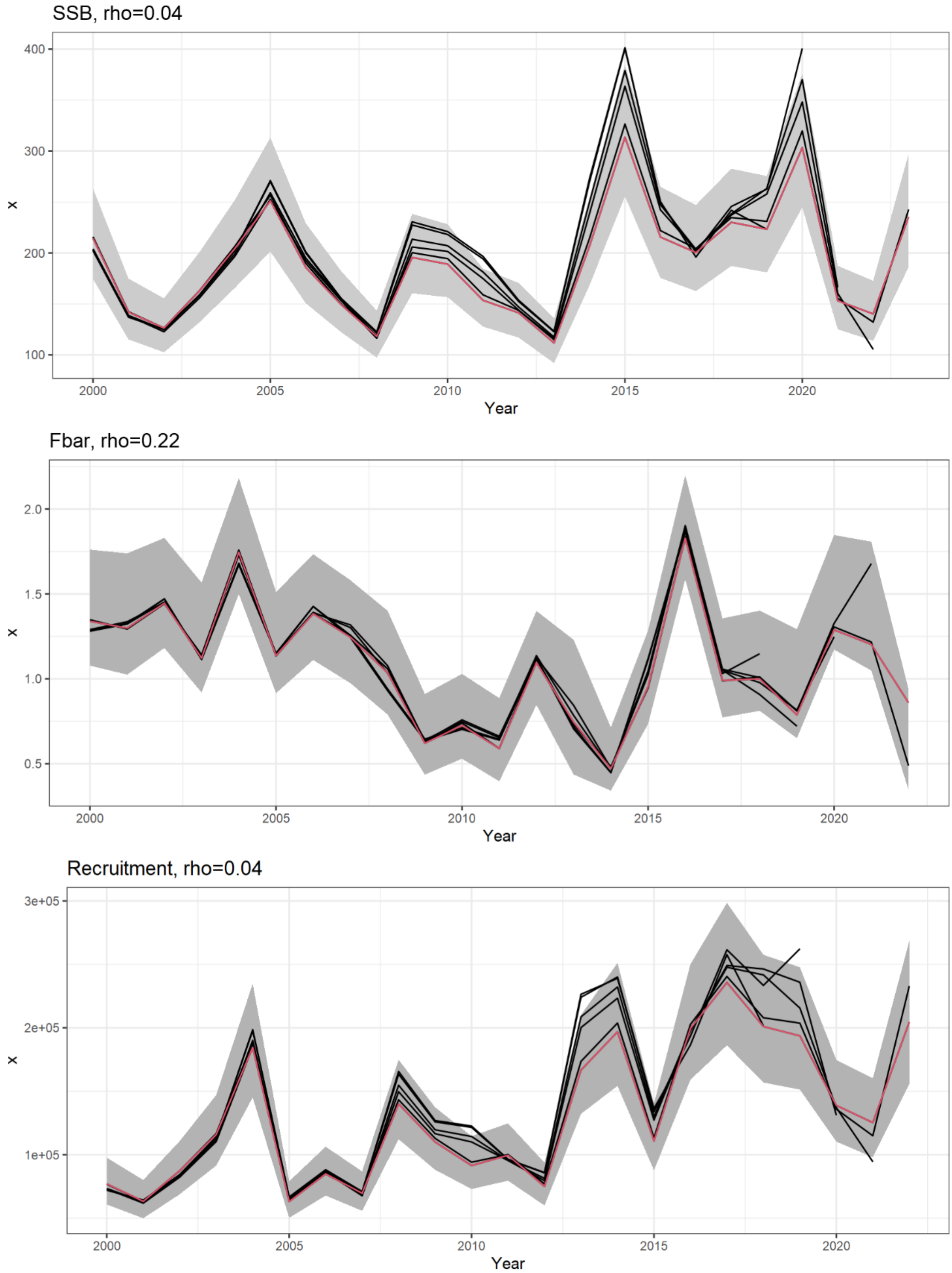


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year, e.g., 2021 = July 2021–June 2022)

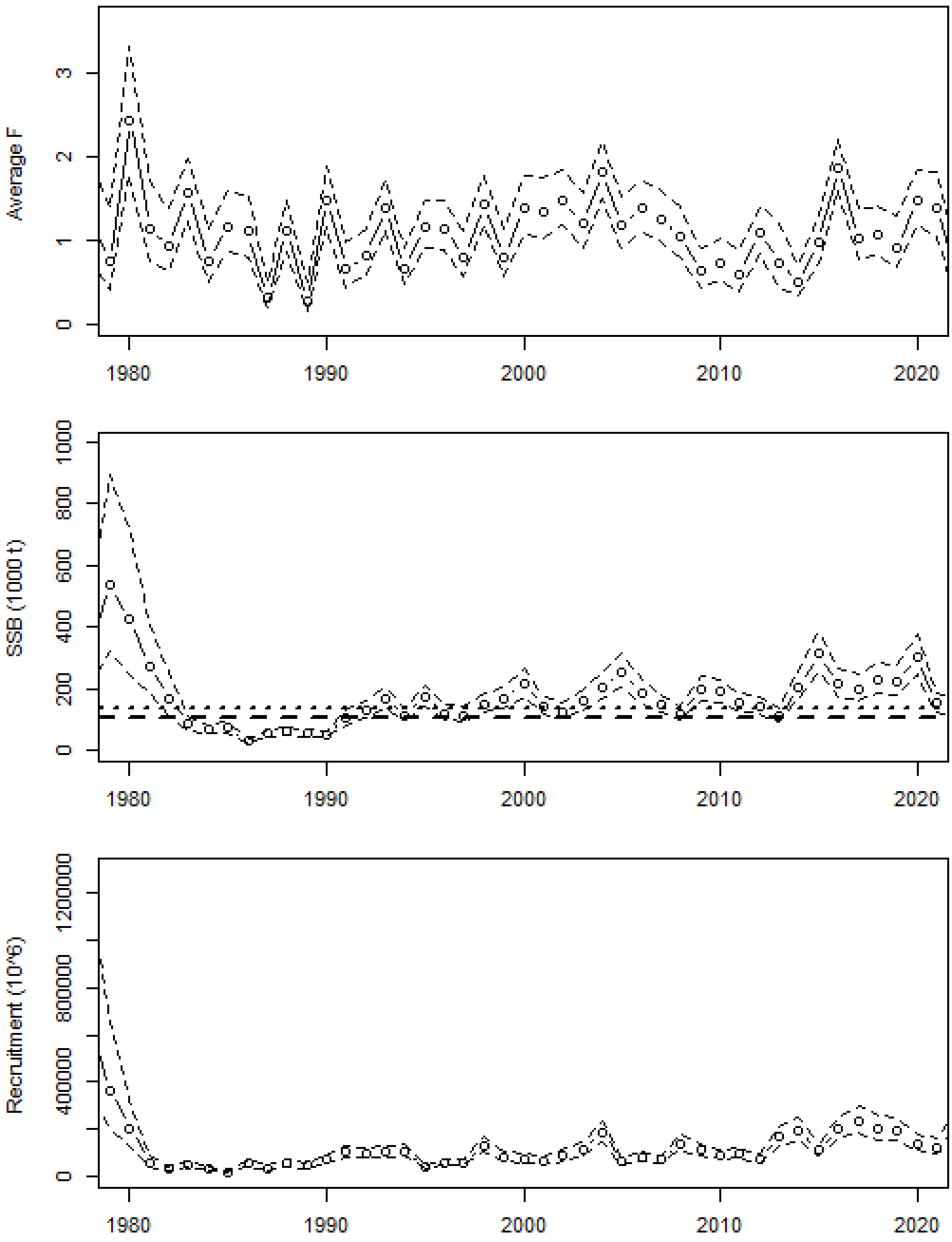


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year, e.g., 2021 = July 2021–June 2022).

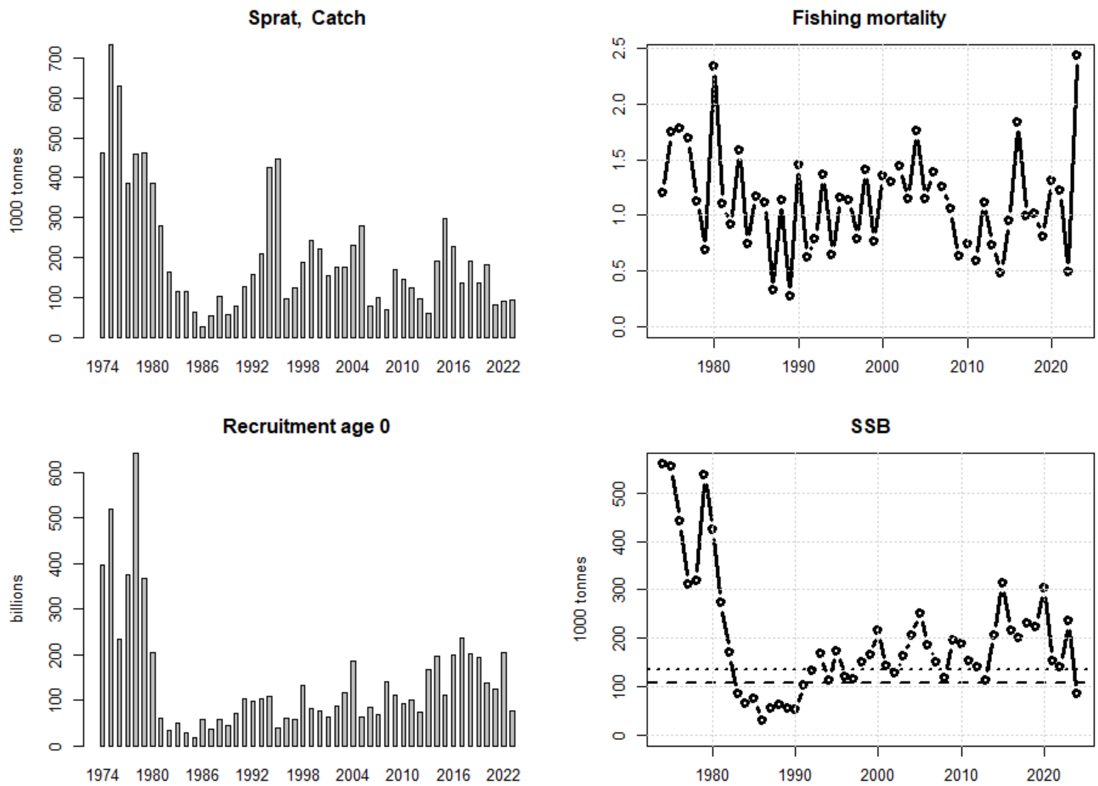


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year, e.g., 2021 = July 2021–June 2022).

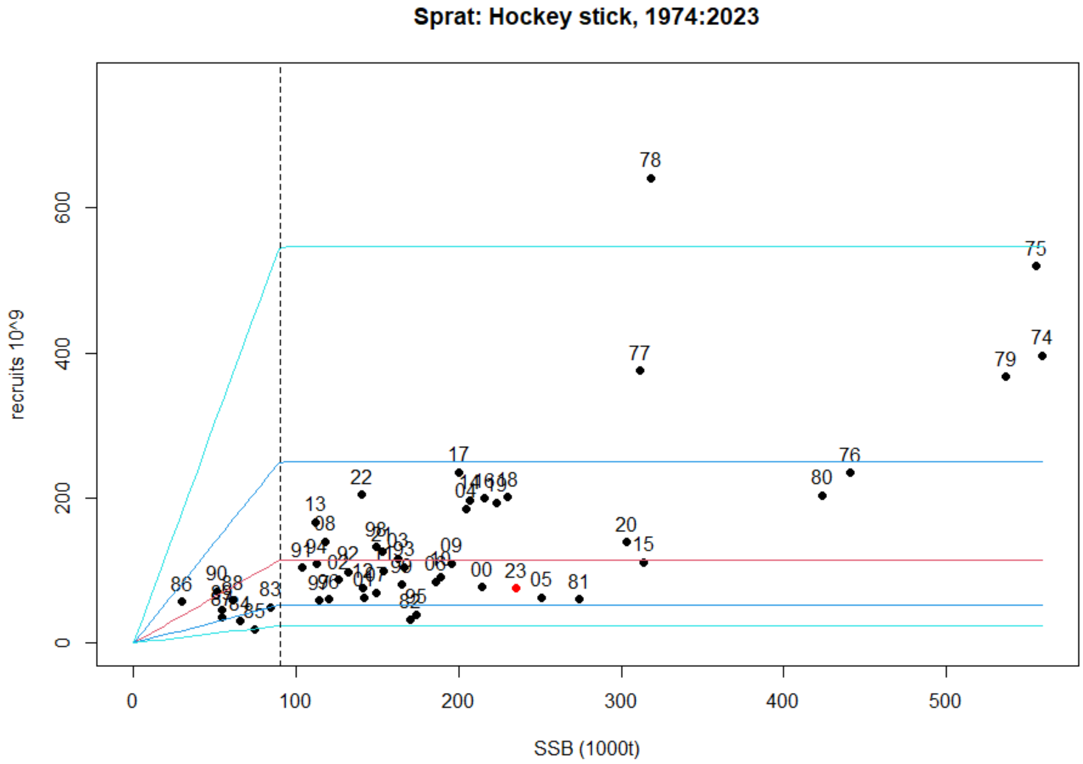


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year, e.g., 2021 = July 2021–June 2022).

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Contents

11 Sprat in the English Channel (divisions 7. de)

The stock structure of sprat populations in this region is not clear, despite evidence from acoustic surveys suggesting the stock is mainly confined to the UK side of 7.e. Further investigations and work are required to resolve this uncertainty.

11.1 The Fishery

11.1.1 ICES advice applicable for 2023

The advised catch for the English Channel (7.d and e) was set equal to 5 250 tonnes.

11.1.2 Landings

The total sprat landings by country from 1986-2023 are provided in Table 11.1.1. Total landings from the international sprat fishery are available since 1950 (Figure 11.1.1.). Sprat landings prior to 1985 in 7.de were extracted from official catch statistics dataset (STATLANT27, Historical Nominal Catches 1950–2010, Official Nominal Catches 2006–2013), from 1985 onwards they come from WG estimates. Since 1985 sprat catch has been taken mainly by the UK (England, Wales and Northern Ireland). According to official catch statistics large catches were taken by Danish trawlers in the English Channel between the late 1970s and 1980s. The identity of these catches was not confirmed by the Danish data managers, raising the question of whether those reported catches were the result of species misreporting (i.e. herring misreported as sprat). Therefore, ICES cannot verify the quality of catch data prior to 1988.

The fishery starts in August and runs into February and sometimes March of the following year. Most of the catch is taken in 7.e, in the Lyme Bay area. In the last decade catch from the UK covered about 93% of landed sprat, however in 2015 and 2016 this percentage diminished, with the Netherlands and Denmark taking a portion of the catch. Denmark and the Netherlands represent the two principle “transient fishing fleets” that appear occasionally in the time series and have been allocated a portion of the TAC under the common fisheries policy in previous years. Since 2021, landings have been very low and this has been attributed to inadequate large sprat in the catch, leading to a short season for the UK fleet.

Sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation. This offshore/near shore shift may be related to environmental variability such as spatial and temporal changes in temperature and/or salinity.

11.1.3 Fleets

In the English Channel the primary gear used for the capture of sprat is midwater trawl. Within that gear type three vessels under 15 m have actively targeted sprat and have been responsible for the majority of landings. Since 2003 the UK fleet took on average 96% of the total landings. Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

11.1.4 Regulations and their effects

There is a TAC for sprat in ICES divisions 7.de, English Channel. Figure 11.1.2. shows the agreed TAC and the ICES catch from 2000-2023 and shows the catch is always below the agreed TAC.

11.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

11.2 Biological Composition of the Catch

11.2.1 Catches in number and weight-at-age

During the 2017/2018 fishing season a pilot self-sampling program started in the southwest of the UK, involving sprat fishers from Lyme Bay. This program has continued through to 2024 however very few sprat data have been received since 2021 as fish have not been of a marketable size. The graphs have therefore not been updated as data collected in 2019-2020 better represents the stock, when taken by the fishery. The 2019-2020 data shown are raw numbers-at-length in the samples, and not raised to the total catches (Figure 11.2.1 and Figure 11.2.2).

The skippers have collected length measurements from the catches and recorded information on fishing trips since 2018. In 2019, the sprat lengths in the fishers' samples ranged from 7.5 to 15 cm (Figure 11.2.1). The main processors for the fishery were engaged in 2019 and have provided length and weight data from landings subsamples. The length distributions recorded by the processors was reasonably consistent in 2020 (Figure 11.2.2). Due to low uptake in the fishery during 2021, the fishery operated for only two months of the season (August and September) and the FSP program provided very little data.

In 2021, the PELTIC survey reported a huge increase in sprat biomass combined with very strong recruitment (0-group) (Figure 11.3.3). These small fish were very widespread throughout the survey area. Anecdotal evidence from the fisheries self-sampling program (FSP) and fishers also support the survey findings, with the pelagic fisheries noting difficulties in being able to fish because of too much "whitebait" below marketable size. The demand in the fishery is tied more to size and marketability than stock biomass, with the processors reluctant to take catches with small fish.

11.3 Fishery-independent information

PELTIC Acoustic Survey (A6259)

Cefas carried out the annual PELTIC survey (Pelagic Ecosystem Survey of the Celtic Sea and Western Channel) in autumn in the English Channel and the Celtic Sea to acoustically assess the biomass of the small pelagic fish community within this area (divisions 7.e–f). Sprat is a target species of the PELTIC. The survey, conducted from the RV *Cefas Endeavour*, started in 2013, when it first focused only on UK waters but, from 2017, it expanded to also cover the southern area of division 7.e (French waters). In 2018 a one-off extension of the survey was conducted into division 7.d to investigate the presence of the stocks in the eastern Channel, the survey found almost no sprat present. This does not rule out the presence of the sprat in the eastern Channel, but was used in the absence of other evidence.

As detailed in the ICES survey manual (Doray *et al*., 2021), calibrated acoustic data were collected during daylight hours only at three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2 m below the surface. All non-fish acoustic targets were removed by creating a multi-frequency filter and only backscatter from swimbladder fish was retained for further analyses. The resulting echotraces were further partitioned by species based on the trawl catches and were converted into abundance and biomass estimates (plus Coefficient of Variation) in StoX software.

To convert acoustic biomass to abundance, a Target Strength (TS) equation is used. As no dedicated sprat specific TS equation is available for the area, the generic clupeid value of b20 = -71.2 dB is used. This was found to be an acceptable conversion and it was noted that more negatively values (leading to a higher biomass) have been used for sprat stocks in adjacent waters.

As part of the 2021 sprat inter benchmark process (IBP), the ability of the survey to capture the sprat stock (catchability) was evaluated, as this feeds heavily into assumptions of the management strategy evaluation (MSE). It was noted that the assessment is based on a biomass estimate from only a small area of the total management unit and is therefore likely to be a conservative estimate.

The survey also provides age and length structure for sprat aged 0–6 (Figure 11.3.2 and Figure 11.3.3). While there is high variability in the age distributions, this does not affect the overall estimate of biomass. However, it does preclude cohort tracking in the survey. The IBP found that the survey provided a robust estimate of biomass for application of a constant harvest rate (CHR) and is evaluated at two ICES working groups, WGIPS and WGACEGG, each year.

Biological data

Biological information from trawl catches carried out during the 2021 PELTIC acoustic survey, identified 5 age classes from 0 to 4 contributing on average to 91.61%, 2.1%, 5.9%,0.32%, and 0.02% respectively in the samples collected. The age structure observed in 2021 is shown in Figure 11.3.2 and 11.3.3.

2022 saw a large reduction in the PELTIC biomass index for the western survey stratum, down from 107 kt in 2021 to 28 kt in 2022. The number of age 1 fish identified by the PELTIC survey in 2022 was an order of magnitude below the number of age 0 fish identified in 2021 (7%), which may indicate either high mortality or migration of sprat. However, similar to 2021, age 0 sprat contributed the highest proportion of numbers of sprat observed.

In 2023, age 0 sprat also constituted the highest proportion of numbers of sprat observed. 25% of the number of age 0 fish identified in 2022 were observed as age 1 in 2023. Biological information from trawl catches for the 2023 survey were not made available in time for HAWG in 2024.

The large abundance of age 0 sprat identified during the PELTIC in recent years supports information from the fishery and is linked to the reduced catches in recent years, due to a high volume of small fish which are not of marketable size.

11.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

11.5 Recruitment

The acoustic surveys may provide an index of sprat recruitment in divisions 7.d–e.

11.6 Stock Assessment

This stock is considered a category 3 stock with the assessment and advice based on survey trends (ICES Advice 2018).

The stock went through an interbenchmark in February 2021 to update the assessment method based on the new guidance issued by WKLIFEX and developed by WKDLSSSLS2. The IBP tested the available data against the updated guidelines and assessed the suitability of three data limited methods for the stock.

1. 1 over 2 ratio-based advice with a 20% and an 80% uncertainty cap
2. Constant Harvest Rate
3. Surplus Production model (SPiCT)

Three exploratory SPiCT assessments were performed:

- an annual model using calendar year (January–December)
- an annual model using fishing year (July–June);
- a model using quarterly data.

The IBP concluded that SPICT analysis of the stock was not viable at this point in time due to the limited time series available for the PELTIC survey (2014–2020). There is also a strong transient component to the fishery from Denmark and the Netherlands which has not been present in recent years. The IBP determined that SPICT should be re-examined in the future.

A constant harvest rate (CHR) was determined by management strategy evaluation (MSE). The CHR was tested alongside the 1o2 with 80% and 20% uncertainty caps. The MSE tested three survey catchability options, with an assumption of 0%, 50% and 100% over estimation of the underlying biomass from the PELTIC survey. Assuming that some overestimation may take place on the survey, the IBP determined that the 50% overestimation should be adopted. Three scenarios of fishing pressure, prior to implementation of the catch advice options, were simulated for 25 years to establish starting points for the stock.

This MSE was carried out on a seasonal time step due to limitations in the framework. The IBP recommended that the annual advice move to an annual-seasonal calendar toreduce the time lag between survey and advice, while keeping the stock within the HAWG. WKDLSSLS determined that the reduced lag between survey and advice was the key component of providing precautionary advice for short lived species. A CHR determined on a seasonal timestep will still be applicable to the stock and is more precautionary than the 1o2 rule.

The CHR was found to be more precautionary for the stock than the current 1o2 rule (with both UC values), supporting the findings of WKDLSSL1 & 2. The CHR of 12% was the maximum value estimated under the 50% survey catchability overestimation level that kept the risk <5% in the long term under all fishing histories while giving the highest yield. A correction factor to the CHR was applied to account for a mismatch between survey weight at age in the PELTIC biomass and the weight at age in survey biomass simulated in the MSE. This was done to account for in year growth and results in a correction factor of 0.714 equal to the ratio of the MSEindex/"PelticIndex", where PelticIndex equates to the weight-at-age structure present at the time of the survey. This time-step accounts for a seven-month growth period, comprising the months between spawning in March and the survey in October. The IBP concluded that an adjusted CHR to 8.57% was the most appropriate assessment method for the stock (ICES, 2021).

Further investigation of the CHR, specifically using sprat in 7.de, was conducted at WKDLSSLS3 in 2021. The group examined the effect of applying an 80% uncertainty cap (UC) to the CHRs. The conclusion from this was an UC resulted in minimal risk reduction for CHR's below the 5% risk threshold. It did reduce risk for CHR's that are too high but could not bring them below the

ICES risk threshold. The only significant difference between CHR and CHR+UC was a decrease in interannual variability in the stock. This contrasts with work by other members of the WKDLSSLS group, who note that UC's may introduce unnecessary risks to the stock when requiring rapid reduction of catches. Alternatively following a drop of catch advice, may prevent recovery of yield (Fischer *et al*. 2020, 2021 and Sánchez-Maroño *et al*. 2021). The group found that unconstrained CHRs appear robust to past fishing history, initial stock status and advice schedule but are sensitive to survey catchability. No recommendations from the WKDLSSLS were made in regard to applying a UC to CHR's. Application of uncertainty cap is a current research topic and future guidelines may clarify how they are applied as part of a CHR.

11.6.1 Data exploration

Biomass Index

A 11-year time-series of biomass estimates from the PELTIC survey is shown in Table 11.6.1. The extension of the survey into ICES division 7.d and the southern part of 7.e suggests that the stock is mainly located in the more northerly part of division 7.e during October. The survey conducted in 2021 showed a very large concentration of age 0 sprat in Lyme bay (Figure 11.6.1 and 11.3.2). The 2022 survey only covered the western Channel substratum (Figure 11.6.2), however, did not identify large amounts of age 1 or 2 sprat in this area, indicating that these age 0 sprat either migrated or succumbed to high mortality between the 2021 and 2022 autumn surveys.

As in previous years, the highest sprat densities in autumn 2023 were found in the Lyme Bay region, although high numbers were also found in coastal waters further west around Eddystone (Figure 11.6.3).

In 2018, the PELTIC survey was extended into the eastern Channel and found no discernible sprat biomass, indicating a separation between 27.7.de and Sprat in the eastern Channel.

For more details on the survey design see Figure 11.3.1 and ICES (2022).

A 2015 analysis of the age distribution of sprat in the survey area shows a marked distinction between the young fish (0 and 1) found in the Bristol Channel and the older age classes that occupy the western English Channel (ICES 2015). Whether the two clusters belong to the same stock has yet to be determined: the circulation pattern of the area would allow sprat eggs/larvae to travel northward, from division 7.e to 7.g; however, the formation of a front in late spring/early summer seems to suggest these may be two different stocks.

The stock was examined using RAD-seq-derived SNPs (Restriction-site-associated DNA *sequencing* and single nucleotide polymorphisms) in 2020 (McKeown *et al*., 2020). This was part of a larger study of North Sea and Baltic sprat. The study found that amongst the North Sea population there was a lack of genetic differentiation between sampled stocks, indicating a high gene flow in the North Sea population. This would indicate that all sprat in the North Sea form one genetic unit, however the study suggests further work is needed. Specifically, for fisheries management, it should be noted that genetically connected stocks may still be isolated on the time scale of fisheries management.

11.7 State of the Stock

The acoustic estimates for 2017 (32 751 t) saw a threefold increase compared to the all-time low value in 2016 (9826 t), although the biomass is still half of the high levels recorded in the period 2013–2015 (70 680 t, 85 184 t and 65 219 t respectively) (Table 11.6.1). The PELTIC biomass increased substantially from 36 798 tonnes in 2020 to 107 355 tonnes in 2021, and reduced to 28 439 tonnes in 2022. In 2023, the biomass increased to 61 270 t which is comparable to the long-term average. The harvest rate has been less than 0.001%, attributed to a large number small sprat mixed in with the catch in 2021 and a continued absence of large marketable sprat since.

11.8 Catch Advice

Applying the constant harvest rate of 8.57% to the current estimate of PELTIC biomass gives an advised catch of 5 250 tonnes.

11.9 Short-term projections

No projections are presented for this stock.

Reasons for change in advice

The increase in advised catch this year is caused by the increased PELTIC biomass index in 2023, as the advised catch is derived by multiplying the survey index in tonnes by 0.0857.

Survey year	Advice year	Western Channel stratum tonnage	Advice (surveyed tonnage x 0.0857)
2022	2023	28439	2437
2023	2024	61270	5250

11.10 Reference Points

The IBP suggested the use of the Istat value developed as part of WKDSLLS2 (ICES, 2021b) as a proxy B_{lim} for the stock. The Istat is defined as:

Geomean(*Ihist*)*exp(-1.645*sd(log(*Ihist*))

Where *Ihist* refers to the biomass index, this gives a value of 11527.9 tonnes biomass for the stock. Note this should not be referred to as SSB or total biomass as SSB cannot be derived for the stock and the PELTIC does not capture the total biomass of the stock. Length based F (MSY) proxies were suggested by the ADG as being possibly applicable to the stock and providing useful information. They have not been explored to date but could be looked at in the future. The inclusion of the FSP sampling data (which includes length frequencies) could also be incorporated into these methods and provide interesting comparison between survey and fisheries derived data.

11.11 Quality of the Assessment

The coverage of the PELTIC acoustic survey was extended in 2017 towards the southern part of Division 7.e: this extension confirmed that the bulk of the sprat distribution in 7.e is located in Lyme Bay and surrounding areas, and it does not tend to extend outside the western Channel stratum. The transects carried out off the French coast found very little sprat, mostly of ages 0 and 1. Sprat have since been recorded off the coast of France and around the Channel Islands in 2018, 2019, whilst 2021 also saw sprat present off the coast of France. These fish do not feed into the advice, as they lie outside of the core Lyme bay area.

The extent to which the population migrates into division 7.d was investigated during the 2018 survey. The survey showed that very little sprat was found on the eastern border of division 7.e and very little found in 7.d.

Concerns have been raised about the connection between the western English Channel stock and the Bristol Channel, where large numbers of juveniles are found. It is currently believed the Bristol Channel may represent a separate stock. See the data exploration section for details.

Material presented in 2023 to HAWG on the channel groundfish survey (CGFS) indicated that the amount of sprat in 7.d should not be assumed to be negligible. Issues may exist with indices derived from this survey due to a vessel change in 2015, however it is advised that a comparison is made with the PELTIC index from 2015 onwards. The survey gear is a GOV like for the IBTS, and hence not targeted to sprat. However, CGFS results indicate a large presence of sprat on the French side of the Channel around the Baie de la Seine (Figure 11.1.1; Figure 11.1.2). Also shown in CGFS data are a decreasing mean length of sprat over the last decade in both the eastern and the western English Channel (Figure 11.1.3). Considering the low fishing pressure in the stock area over the last decade, this is suspected to be ecologically (climate change) driven.

11.12 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat annual landings from 7.d–e over the past 20 years have been 2 338 tonnes on average. The average harvest rate for the 10-year time-series is 0.06%.

The strong biomass fluctuations observed in the acoustic index and the relatively large increase in biomass observed in 2017 and 2021 suggests that the low level of catch is not impairing the stock.

As of 2021, an agreement has been reached between the ICES members to move the advice to a seasonal calendar in line with the fishery for 2022/2023. The advice will now run across the fishing season (1 July–30 June) instead of on an annual basis.

The PELTIC survey takes place in October of the advice year minus 1, with the advice issued in April of the advice year for the fishing season. The fishing season runs from 1 July advice year, to 30 June advice year plus 1. Therefore, there is an 8-month delay between survey and advice. This is a weakness in the advice as sprat can undergo rapid changes in biomass. The TAC issued separately to the ICES advice has been issue on a seasonal basis since 2022. A small delay is still present but has been greatly reduced. A further improvement to better respond to changing stock conditions would be a review mechanism at the time of the PELTIC in October to update the advice, if needed. However, this would present problems for issuing of the advice and there is currently little appetite to reopen advice mid-year for stocks in ICES or member states.

11.13 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no analysis available on the total amount of sprat, and in general of other pelagic species, taken by seabirds, marine mammals, and large predators in the Celtic Seas Ecoregion. However, a wide spectrum of data that covers the whole trophic chain have been collected during the PELTIC acoustic survey: these data will in the future provide a substantial contribution to the knowledge base for the area.

11.14 Tables and Figures

Table 11.1.1 Sprat in 7.d-e. Landings of sprat, 1988–2023.

Country	Denmark	France	Germany	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Total
1988	2529	2	0	1	2944	0	5476
1989	2092	10	0	0	1520	0	3622
1990	608	79	0	0	1562	0	2249
1991	0	0	0	0	2567	0	2567
1992	5389	35	0	0	1791	0	7215
1993	0	3	0	0	1798	0	1801
1994	3572	1	0	0	3176	40	6789
1995	2084	0	0	0	1516	0	3600
1996	0	2	0	0	1789	0	1791
1997	1245	1	0	0	1621	0	2867
1998	3741	0	0	0	1973	0	5714
1999	3064	0	0	1	3558	0	6623
2000	0	1	0	1	1693	0	1695
2001	0	0	0	0	1349	0	1349
2002	0	0	0	0	1196	0	1196
2003	0	2	0	72	1368	0	1442
2004	0	6	0	0	836	0	842
2005	0	0	0	0	1635	0	1635
2006	0	7	0	0	1969	0	1976
2007	0	0	0	0	2706	0	2706
2008	0	0	0	0	3367	0	3367
2009	0	2	0	0	2773	0	2776
2010	0	2	0	0	4408	0	4411
2011	0	1	0	37	3138	0	3176
2012	6	2	0	8	4458	0	4474
2013	0	2	0	0	3793	0	3795
2014	45	3	0	268	3357	0	3674

Country	Denmark	France	Germany	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Total
2015	0	1	0	352	2659	0	3012
2016	185	7	49	227	2867	0	3334
2017	0	0	34	232	2496	0	2762
2018	474	1	0	0	1804	0	2279
2019	0	1	28	0	1544	0	1573
2020	0	1	0	0	873	0	873
2021	0	0.3	0	0	48.7	0	49
2022	0	4	0	0	8	0	12
2023	0	0	0	4	37	0	41

Table 11.6.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas PELTIC acoustic survey)

Year	Western Channel stratum	Full survey area
2013	70680	96682.4
2014	85184	153126.9
2015	65219	286902.8
2016	9826	30788.8
2017	32751	198454.2
2018	21772	106431.2
2019	36789	111072.8
2020	33798	61222.1
2021	107355	265765.9
2022	28439	NA
2023	61270	NA

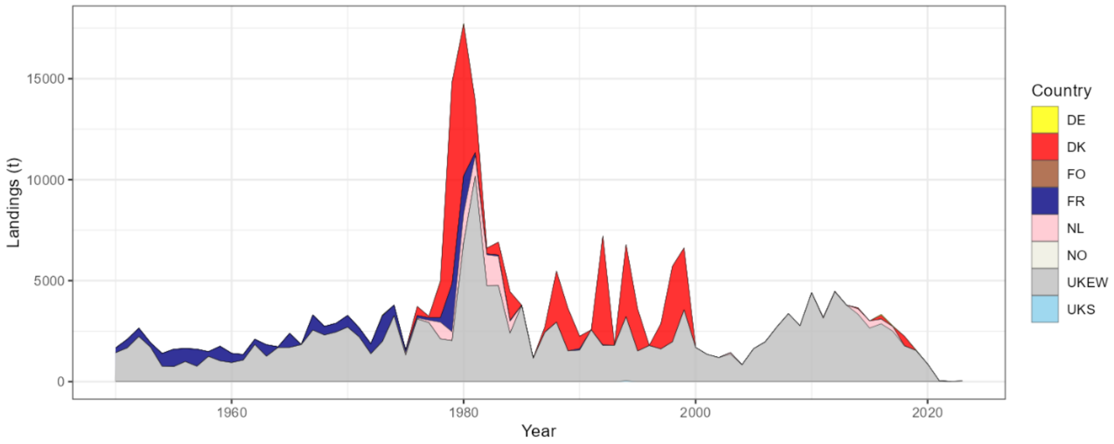

Figure 11.1.1. Sprat in 7.d-e. Landings of sprat 1950–2023.

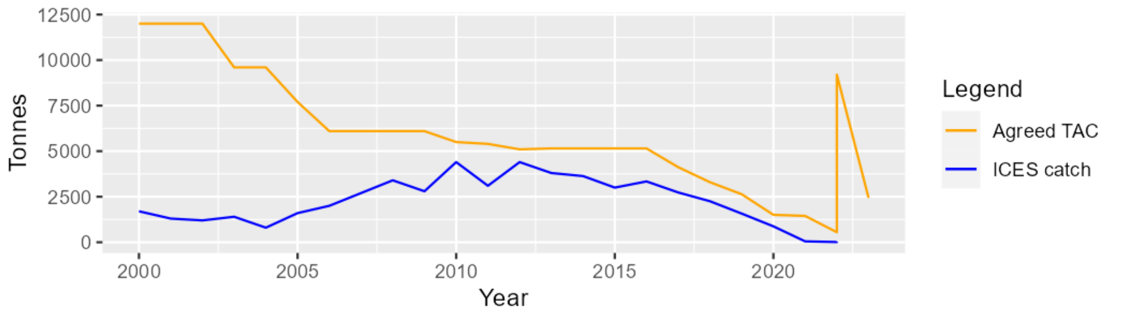

Figure 11.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2023. The two TAC values for 2022 reflect the change in advice period in the same year from calendar year to 1st July-30th June. The lower TAC value (550 t) represents the agreed TAC for 1st January 2022-30th June 2022 while the higher TAC value represents the agreed TAC for 1st July 2022-30th June 2023.

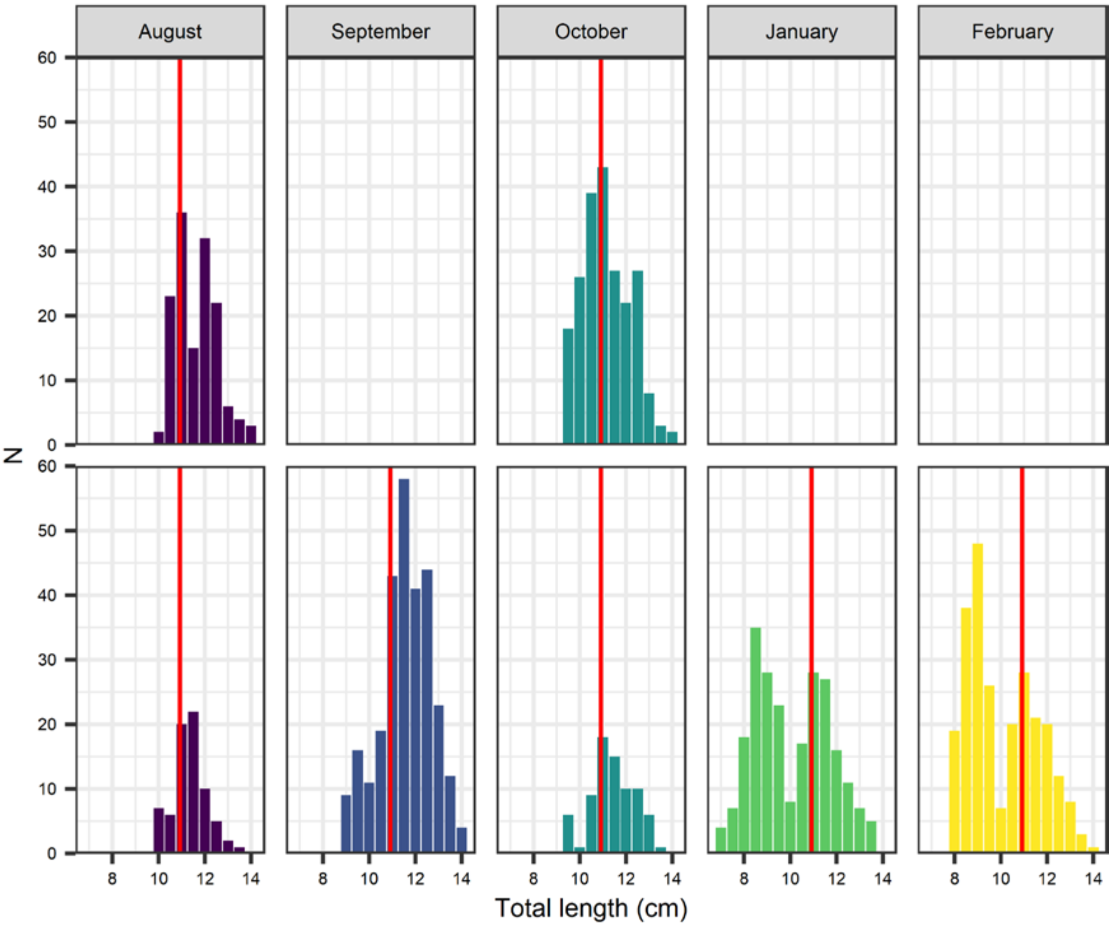

Figure 11.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month 2019, for the two boats supplying the FSP program.

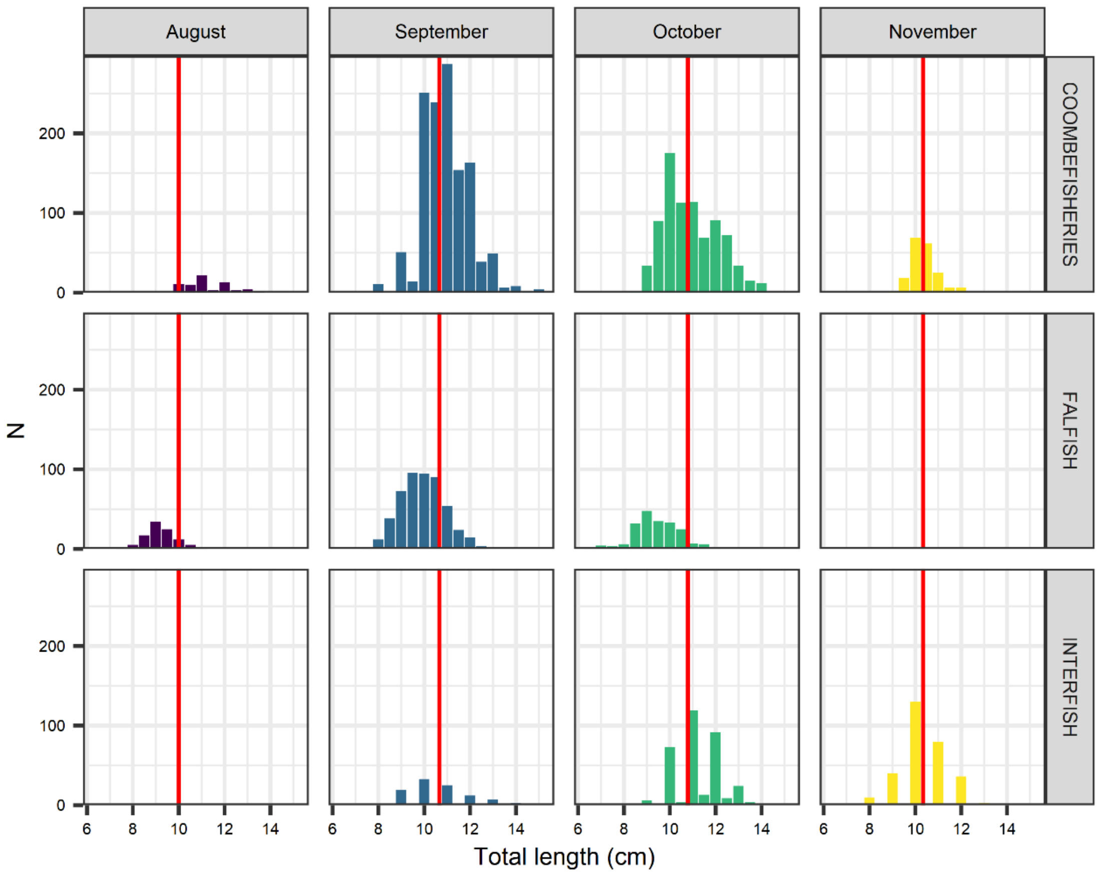

Figure 11.2.2. Monthly sprat total length distribution collected by the three processors in the 2020 season. Red line indicates weighted mean length at each month.

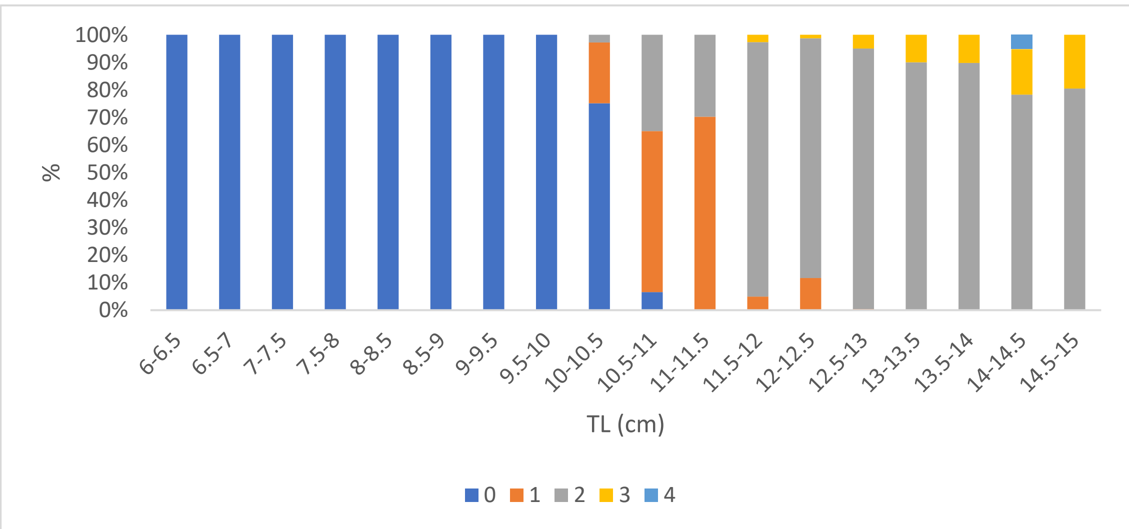

Figure 11.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2021 PELTIC acoustic survey.

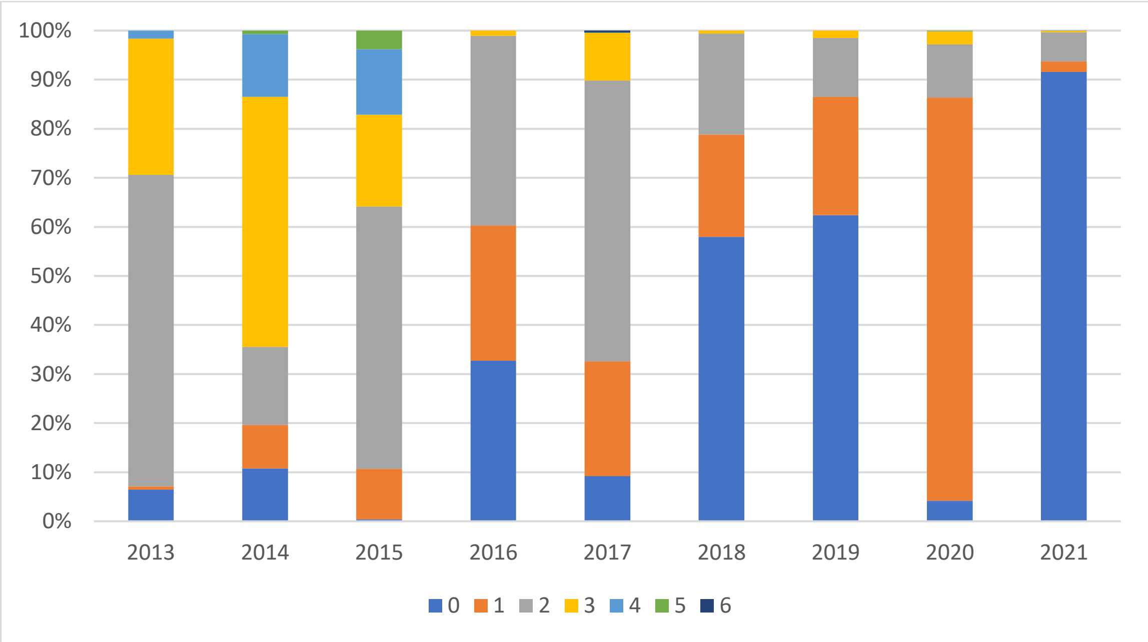

Figure 11.3.3. Sprat in 7.d-e. Proportion of numbers-at-age in the biological samples collected during the 2013–2021 PELTIC acoustic surveys.

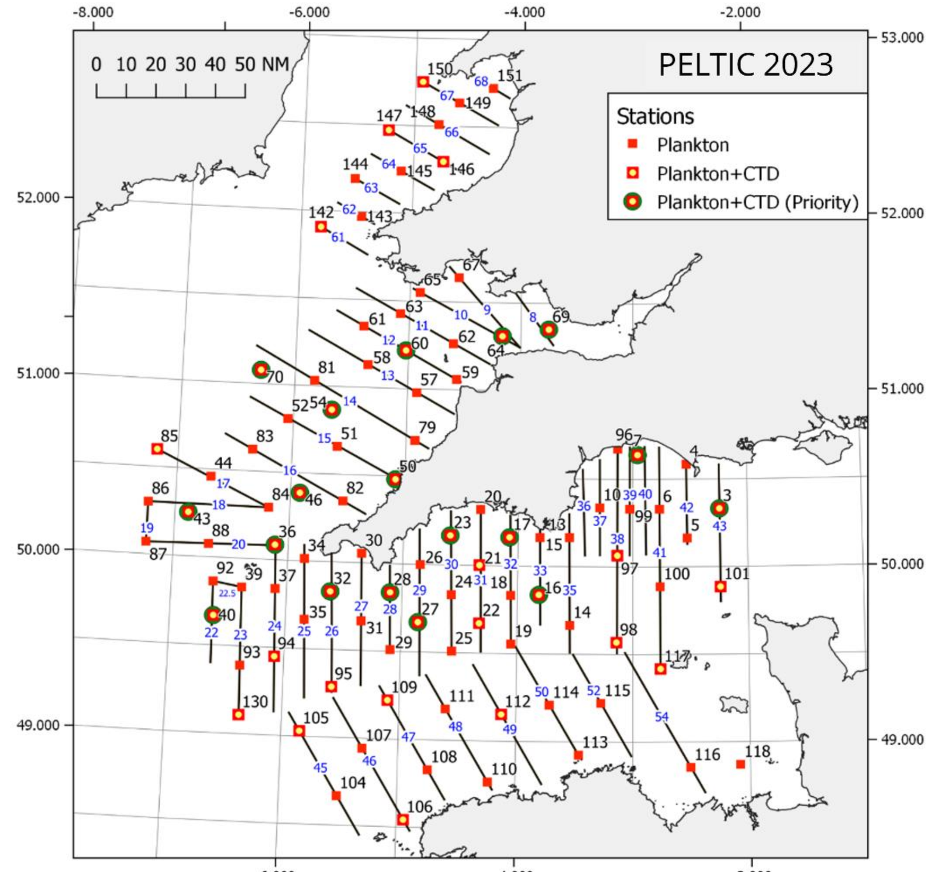

Figure 11.3.1. Sprat in 7.d–e. Survey design (2023) with acoustic transects (black lines, numbers in blue), plankton stations (red squares) and hydrographic stations (yellow circles).

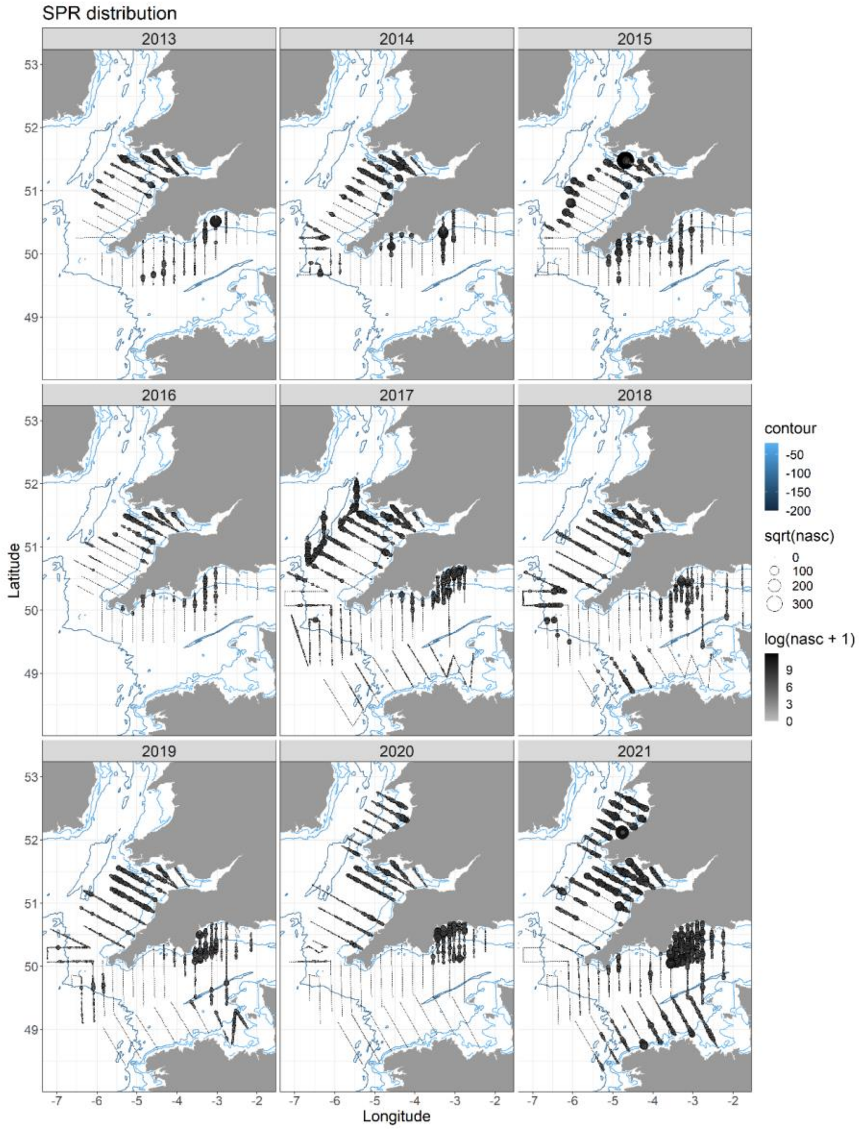

Figure 11.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2013–2021 PELTIC surveys.

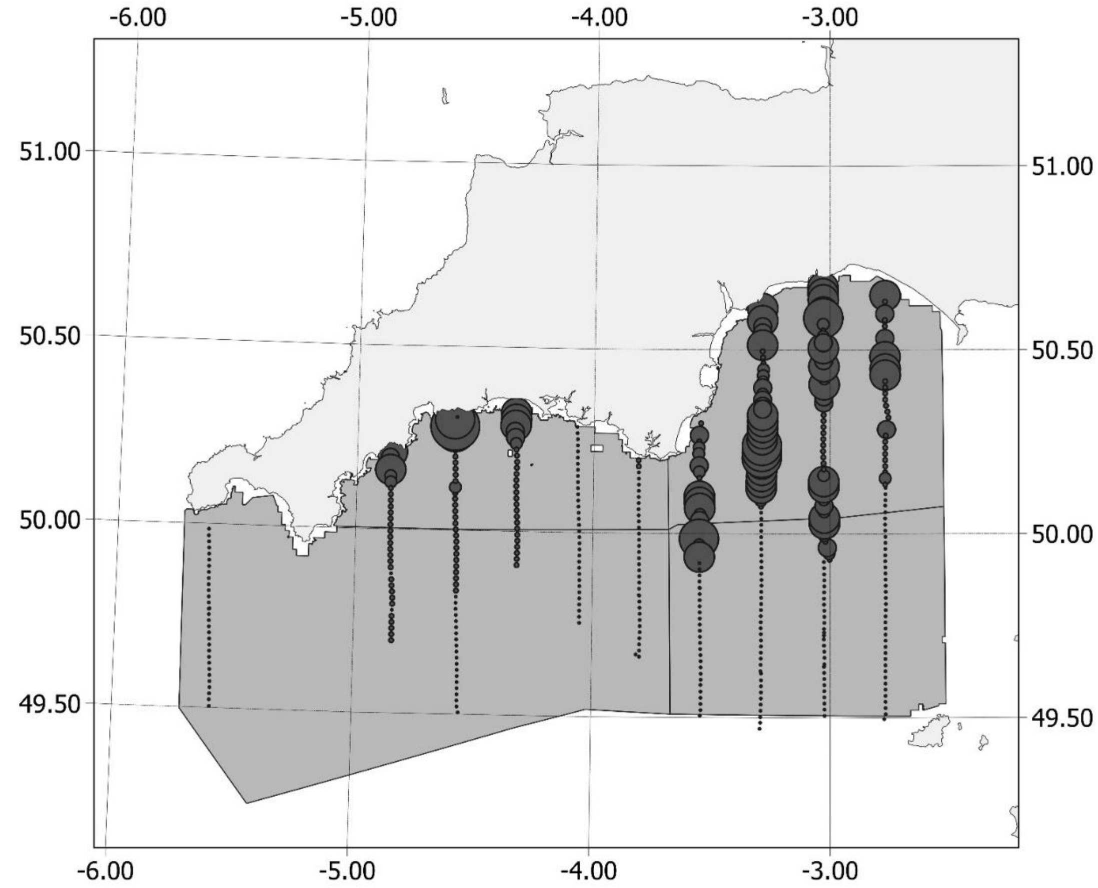

Figure 11.6.2. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2022 PELTIC survey, which reduced spatial coverage.

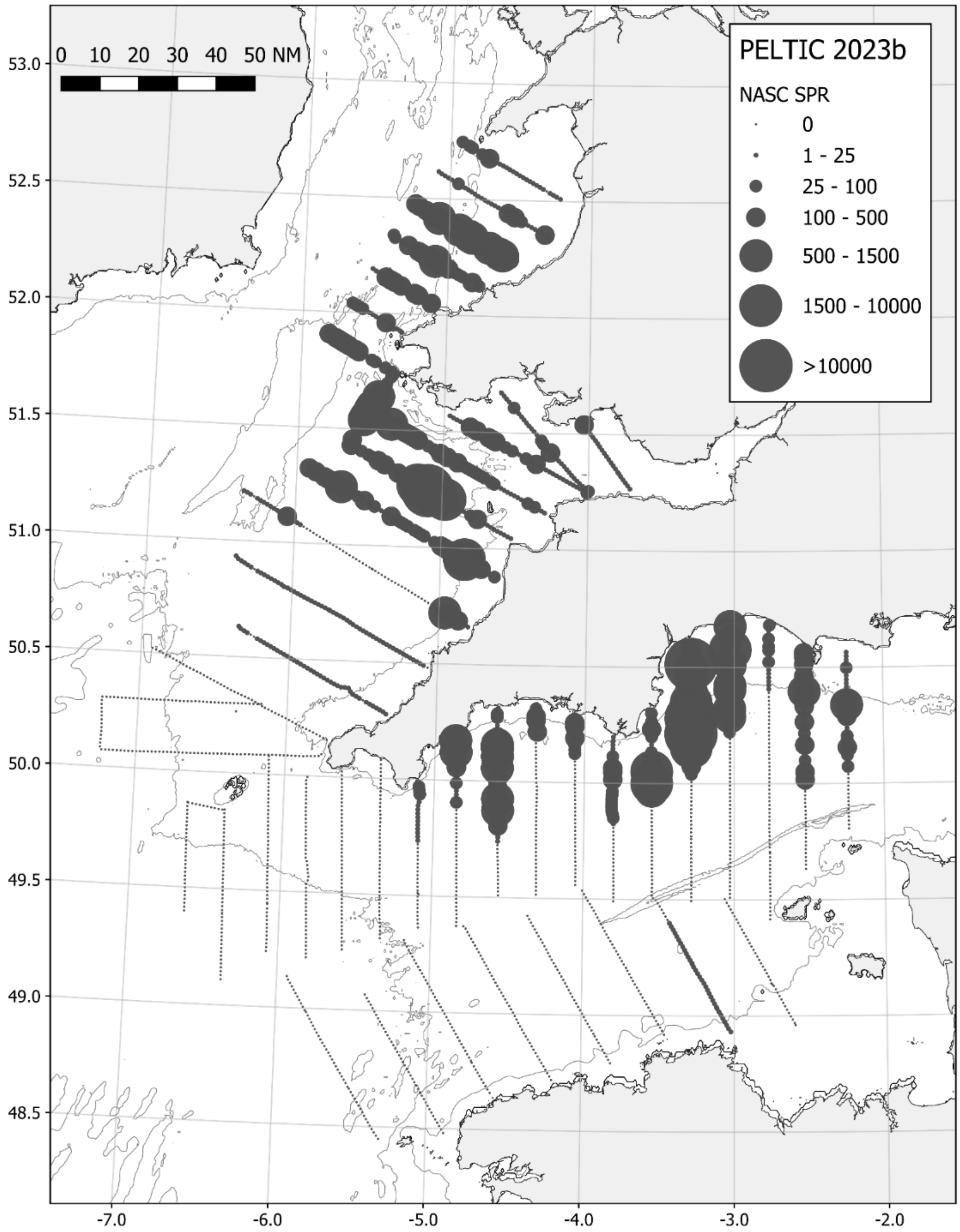

Figure 11.6.3. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2023 PELTIC survey.

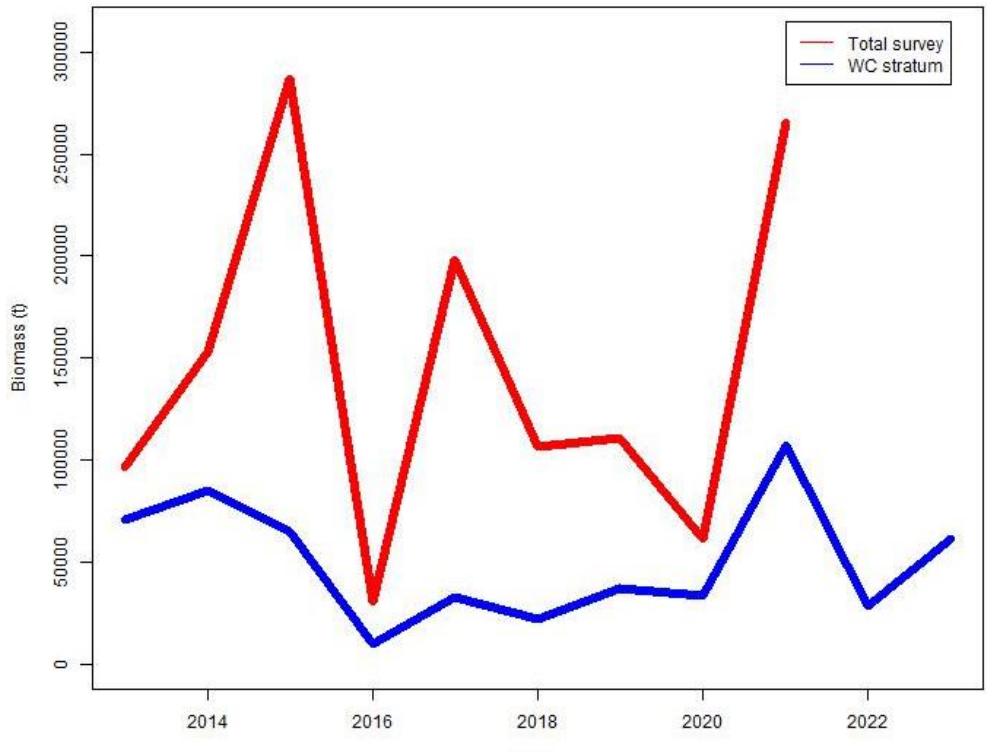

Figure 11.6.4. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2023 for the total survey area (red line) and the western Channel substratum (blue line). A biomass estimate for the total survey area could not be estimated for 2022 due to reduced survey coverage. A total survey area biomass estimate for 2023 was not yet available for HAWG 2024.

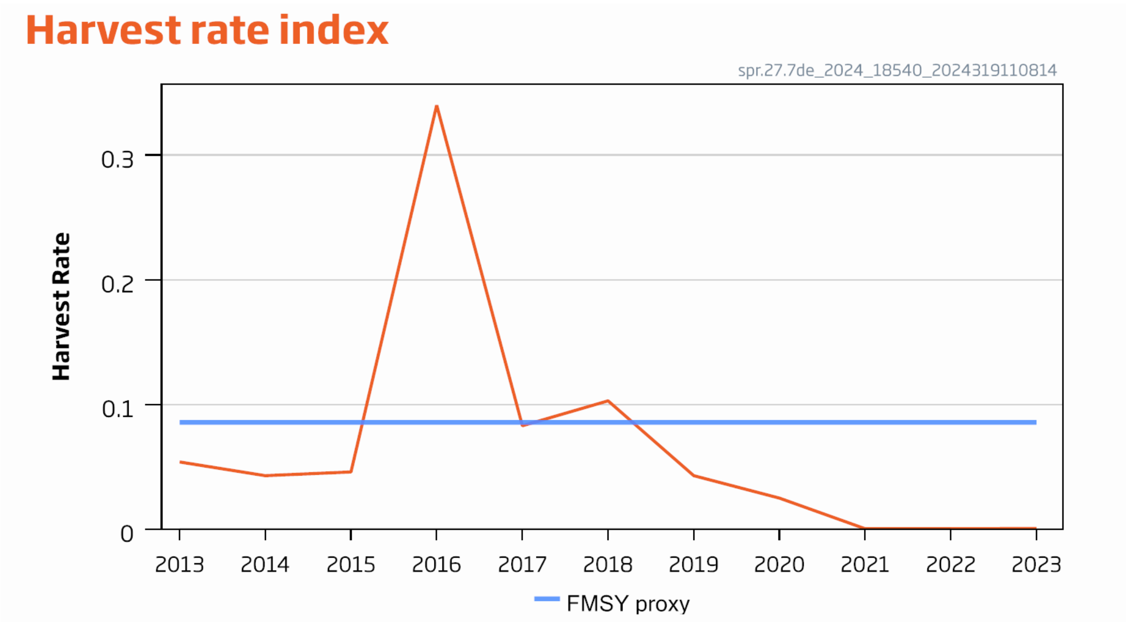

Figure 11.7.1. Sprat in 7.d-e. Constant Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

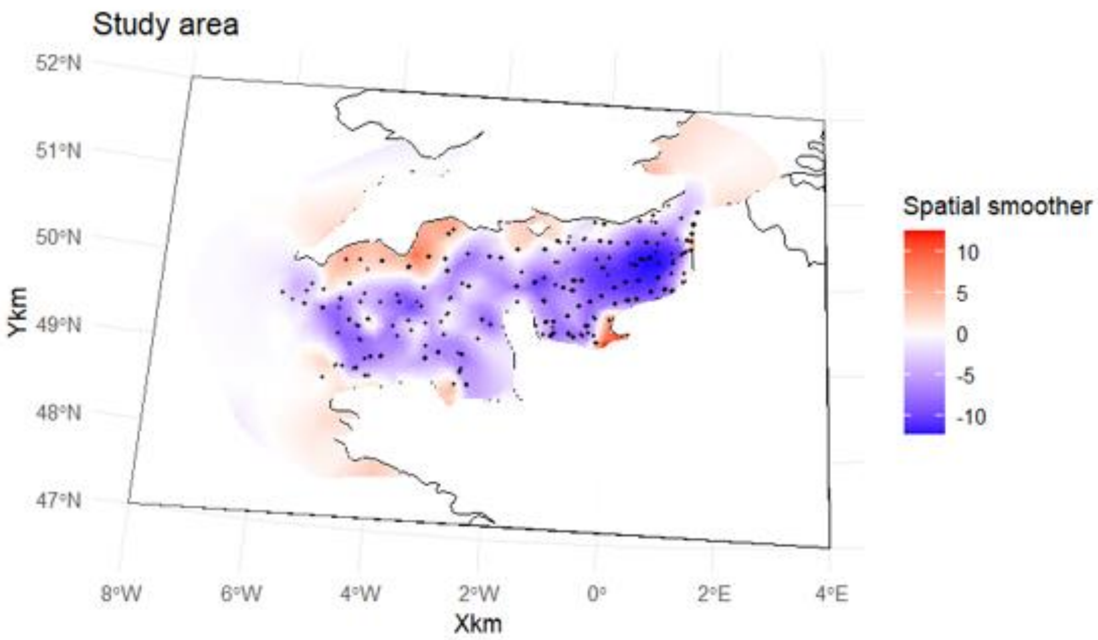

Figure 11.11.1. Spatial distribution of sprat in the English Channel estimated during the CGFS groundfish survey over the period 2018-2023.

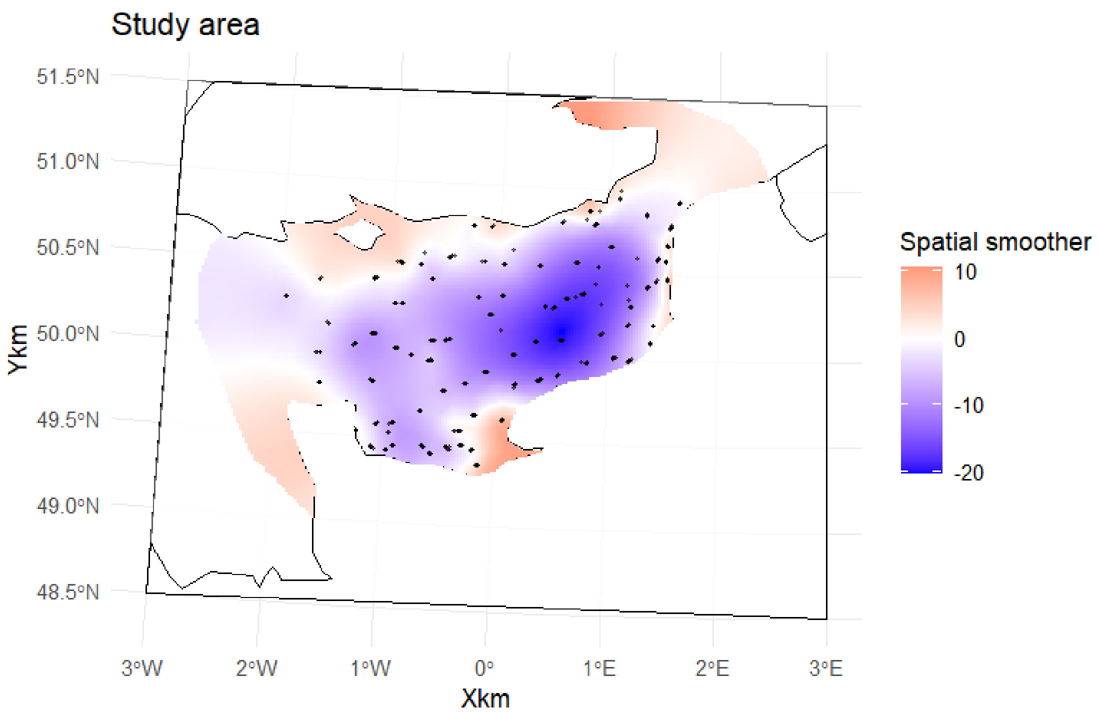

Figure 11.11.2. Spatial distribution of sprat in the eastern English Channel estimated during the CGFS groundfish survey over the period 2015-2023.

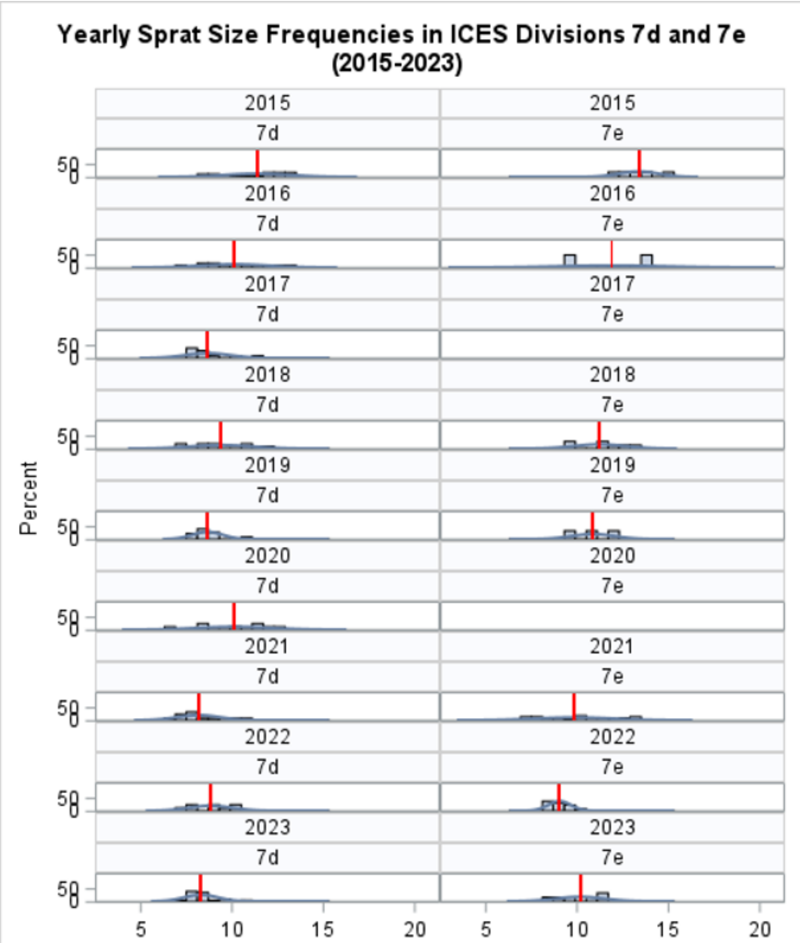

Figure 11.11.3. Length frequency (%) plots for 7d and 7e from the IBTS groundfish survey between 2015-2023. Red vertical line indicates mean length.

11.15 References

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Contents

12 Sprat in the Celtic Seas (Subarea 6 and divisions 7.a-c and 7.f-k)

Most sprat fisheries in the Celtic Seas area are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (6.aN); in Donegal Bay (6.aS); Galway Bay and in the Shannon Estuary (7.b); in various bays in 7.j; in 7.aS; in the Irish Sea. A map of these areas is provided in Figure 12.1.

The stock structure of sprat populations in this ecoregion is not clear. In 2014, HAWG presented an update of the available data on these sprat populations, in a single chapter. However, HAWG does not necessarily advocate that subareas 6 and 7 constitutes a management unit for sprat, and further work is required to resolve the problem.

12.1 The Fishery

12.1.1 ICES advice applicable for 2024 and 2025

ICES analysed data for sprat in the Celtic Sea and West of Scotland. Currently there is no TAC for sprat in these areas, and it is not clear whether there should be one or several management units. ICES stated that there is insufficient information to evaluate the status of sprat in this area. There- fore, when the precautionary approach is applied, ICES advises that catches should be no more than 2240 t in 2024 and 2025. The TAC for the English Channel (7.d and e) is the only one in place for sprat in this area.

12.1.2 Catches

The total sprat catches, by ICES Subdivision (where available) are provided in Tables 12.1.1–12.1.7, with the total catches in Table 12.1.8, and in Figures 12.2.1–12.2.8. Only Ireland and the United Kingdom (Scotland) recorded catches from the stock in 2023, with Ireland taking the majority of the catches (Table 12.1.8).

12.1.3 Division 6.a (West of Scotland and Northwest of Ireland)

Catches have been dominated by UK-Scotland and Ireland (Table 12.1.1). The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in catches between the two countries are similar. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

The Scottish fishery is mainly for human consumption and is typically a winter fishery taking place in November and December, occasionally continuing into January. Catches were high in the early part of the time-series, with two periods of intense fishing pressure where annual catches exceeded 10000 t in the period 1972 to 1978 (Figure 12.2.1) and again in the period 1995 to 2000. In 2005 to 2009. The fishery was virtually absent but has fluctuated greatly since 2010, with only 1 t taken in 2018 followed by of 4575 t in 2019. A total of 976 tonnes was taken in 2023, by both Ireland and Scotland.

12.1.4 Division 7.a

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea. This was an industrial fishery and catches were high throughout the 1970s, peaking at over 8000 t in 1978 (figures for 7.aN are presented in Table 12.1.2 and 7.aS presented in Table 12.1.3). The fishery came to an end in 1979, due to the closure of the fishmeal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s, UK vessels landed up to 500 t per year.

Irish Catches from 1950–1994 may be from 7.aN or 7.aS. Very high catches in 7.aS were reported in 2012 (Table 12.1.3) with a decrease in 2013 and only 16 t reported in 2014. In 2015 the catches increased to over 3500 t and dropped again to less than 1000 t in 2016. Despite the high catches registered in some years, those figures should be interpreted with caution because they may be overestimated. In 2020 catches from 7.aS were 6888 tonnes up from 2785 tonnes in 2019. Another 7861 t were landed in 2021 and 2026 t were landed in 2022. A total of 1432 t were landed in 2023. Irish catches from 7.aS are predominantly from Waterford Harbour (Table 12.1.3)

No catches from 7.aN were reported by Ireland in 2009–2013 or 2018 (Table 12.1.2), however there have been reported catches of 522 t in 2014, 771 t in 2015 and 150 t in 2016 and 2017. Irish catches in 2020 were 2521 tonnes up from 9 tonnes in 7.aN in 2019. Scotland reported less than a tonne of catches over 2021-2022 while Ireland took 381 tonnes in 2021 and 491 tonnes in 2022. No catches from 7.aN were reported in 2023.

12.1.5 Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the River Shannon. The highest recorded catches were taken during the winter of 1980-1981, when over 5000 t were landed by Irish boats (Table 12.1.4, Figure 12.2.4) in Galway Bay (Department of Fisheries and Forestry, 1982). Since the early 1990s, catches fluctuated from very low levels to no more than 700 t per year in 2000. Zero catches were reported for 2016, increasing to above 500 tonnes in the two subsequent years. Irish catches were 1308 tonnes in 2020, 295 tonnes in 2021, 197 tonnes in 2022, and 59 tonnes in 2023. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.6 Divisions 7.g–k (Celtic Sea)

Sprat catches in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated catches. Patterns of Irish catches in divisions 7.g and 7.j are similar, though the 7.j catches have been higher. Catches for 7.g and 7.j were aggregated in this report. Catches have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4200 t in 2005 (Table 12.1.7). The average catches in the last 10 years were equal to 3164 t. Irish catches increased to 5524 tonnes in 2021 and decreased to 2793 tonnes in 2022 and 1170 tonnes in 2023. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.7 Fleets

Most sprat in the Celtic Seas Ecoregion are caught by small pelagic vessels that also target herring, mainly Irish, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as other small pelagics. Targeted fishing takes place when there are known sprat abundances. However, the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery around Ireland.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown, but based on a limited number of samples available to the working group this is estimated to be less than 1% of the catch.

In Ireland, larger sprats are sold for human consumption while smaller ones for fishmeal. Other countries mainly land catches for industrial purposes.

12.1.8 Regulations and their effects

There is a TAC for sprat for 7.d–e, English Channel. No other TACs or quotas for sprat exist in this ecoregion. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fishmeal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

In 2019 the Irish government changed the regulation relating to the access of the inshore fishing grounds. The plan (Policy Directive No 1 of 2019) was that vessels >18 m LOA would not have access to the 6nm inshore zone from 1 January 2020. For vessels targeting sprat, an exemption from this regulation was in place to phase in this regulation gradually by 2022 . However, the policy directive was subject to a protracted legal case and as of 2023 the Court of Appeal has quashed Policy Directive No 1 of 2019. Despite being quashed for 2023 onwards, the policy will have placed temporary restrictions on sprat fishing in the interim period 2020-2023.

12.1.9 Changes in fishing technology and fishing patterns

There is insufficient information available.

12.2 Biological Composition of the Catch

12.2.1 Catches by number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

12.2.2 Biological sampling from the Scottish Fishery (6.a)

Between 1985 and 2002 the fishery was relatively well sampled and length and age data exists for this period with some gaps. Unfortunately, the data are not available electronically at the present time.

Sampling of sprat in 6.a came to an end in 2003 and no information on biological composition of catches exists in the period 2003–2011. Sampling was resumed in 2012 where a total of 8 catches were sampled. The sampling programme has been carried out since and it is anticipated that it will continue in the future.

12.3 Fishery-independent information

12.3.1 Celtic Sea Acoustic Survey (A4057)

The Irish Celtic Sea Herring Acoustic Survey (CSHAS) calculates an annual estimate of sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2020 are shown in Figure 12.3.1 and Table 12.3.1. However, the survey results prior to 2002 are not comparable with the latter surveys because different survey designs were applied.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 38 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large interannual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al*., 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time-series up to 2009 is highly variable, more so than could be accounted for by 'normal' inter survey variability (Table 12.3.1). The variability in the latter years is in part due to the behaviour of sprats in the Celtic Sea which are often seen in the highest numbers after the survey has ended in November/December and again in spring during spawning. The survey is placed to coincide with peak herring abundance and is temporally mismatched with what would be considered sprat peak abundance. The CSHAS survey design has changed over time and the survey primarily aims to quantify the nominal herring biomass. Any sprat biomass identified is incidental as it is not the target species, meaning the index will not be completely comparable between years. Survey trends should be interpreted with this in mind, and so should be perceived as a potential lower bound for the sprat abundance in the area.

2020 saw the lowest sprat biomass in the last decade, with each subsequent year showing an increase in biomass identified except in 2023 when the biomass decreased to a value similar to that estimated in 2021.

12.3.2 Scottish Acoustic Surveys (A9481)

A Clyde herring and sprat acoustic survey was carried out in June/July 1985–1990 and then discontinued (Figure 12.3.2 for coverage). Biomass estimates from all years as well as lengths and ages from some years are available from this survey but not presented here.

In 2012 this survey was reinstated as an October/November survey for herring mainly. Full results from these surveys for sprats are not available at the moment. Age and length distribution from the survey in 2012 are in Figure 12.3.4. In 2013 the survey was called off due to technical problems. The survey was resumed between 2012-2018. Total Biomass results from 2015 and 2018 are unavailable however data on the distribution of sprat in the Clyde are available for these years. These surveys were not conducted during the years 2019 – 2021.

12.3.3 DATRAS-hosted groundfish surveys

A number of groundfish surveys are carried out in the Celtic Seas ecoregion. These are freely available public datasets. Whilst these surveys do not target sprat, some sprat can be caught incidentally and may provide a coarse indication of sprat presence. The catchability is very low and it would not be meaningful to compare groundfish-derived biomass indices year-on-year for small pelagics (this is in contrast to acoustic surveys). Despite this, when records are considered across many months, multiple years and multiple surveys, presences can be confirmed.

Figure 12.3.3 shows a presence map using these groundfish data, however it is important to interpret this in the context that the summed number is reflective of the amount of sampling effort.

12.3.4 Northern Ireland Groundfish Survey (G7144)

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) groundfish survey of ICES Division 7.aN are carried out in March and October at standard stations between 53° 20′N and 54° 45′N (see Stock Annex for more detail on the survey). Sprat is routinely caught in the groundfish surveys however; data were not available at the time of submission of this report.

12.3.5 AFBI Acoustic Survey (A4075)

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) carries out an annual acoustic survey in the Irish Sea each September (see the Stock Annex for a description of the survey).

The annual calculated sprat biomass from 1998–2023 is shown in Figure 12.3.5 and from 1994-2023 in Table 12.3.2. The biomass is estimated to have peaked in 2002 with 405 000 t and it declined to just under 95 000 t in 2010. This was followed by an increase with 2014 being the second highest estimate in the time-series, followed by a decline each year between 2016 and 2022, terminating at a new 15-year minimum in 2022. However, the biomass estimate doubled in 2023 to 169 520 t. Spatial distribution of sprat at the time of the survey is shown in Figure 12.3.6. The AFBI survey is taken on a consistent annual survey grid, meaning the index is considered more comparable between years than the CSHAS survey index. Despite this, further work is required to investigate which populations the survey index applies to.

12.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

12.5 Recruitment

The various groundfish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

12.6 Stock Assessment

There is currently no assessment for sprat in Subarea 6 and divisions 7.a-c and 7.f-k. The only assessment carried out in the Celtic Seas ecoregion is for sprat in 7.d-e and it is based on a survey index of biomass (Please refer to Section 11 - Sprat in divisions 7.d-e).

12.7 State of the Stock

The state of the sprat stock in the Celtic Seas is currently unknown and the data available are not enough to provide any indication on its status. There has been no change in advice this year. The precautionary buffer was applied in 2021 and therefore it is not applied in this advice period.

12.8 Short-term projections

No projections are presented for this stock.

12.9 Reference Points

No precautionary reference points are defined for sprat populations in the region.

12.10 Quality of the Assessment

The stock status is unknown and the Working Group does not have enough information to assess the status of the stock in relation to reference points.

Work to improve the information available for sprat in the Celtic Seas began with the Workshop on a Research Roadmap for Channel and Celtic Seas sprat (WKRRCCSS). A second iteration of this workshop met in September 2023 (ICES, 2023d).

12.11 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat are mainly fished together with herring. The human consumption fishery only accounts for a minor proportion of the total catch. Within the current management regime, where there is a bycatch ceiling limitation of herring as well as bycatch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in 7.d–e, English Channel, which has not been fully utilized.

12.12 Ecosystem Considerations

In the North Sea, multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem for both fish and seabirds. At present, there are no data available on the total amount of sprat, and in general of other pelagic species, taken by seabirds in the Celtic Seas Ecoregion.

The Celtic Seas Ecoregion is a feeding ground for several species of large baleen whales (O'Donnell *et al.*, 2004–2009). These whales feed primarily on sprat and herring from September to February.

12.13 Tables and Figures

Table 12.1.1 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, Division 6.a. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1985	0	0	51	557	0	2946	0	3554
1986	0	0	348	0	2	520	0	870
1987	269	0	0	0	0	582	0	851
1988	364	0	150	0	0	3864	0	4378
1989	0	0	147	0	0	1146	0	1293
1990	0	0	800	0	0	813	0	1613
1991	0	0	151	0	0	1526	0	1677
1992	28	0	360	0	0	1555	0	1943
1993	22	0	2350	0	0	2230	0	4602
1994	0	0	39	0	0	1491	0	1530
1995	241	0	0	0	0	4124	0	4365
1996	0	0	269	0	0	2350	0	2619
1997	0	0	1596	0	0	5313	0	6909
1998	40	0	94	0	0	3467	0	3601
1999	0	0	2533	0	310	8161	0	11004
2000	0	0	3447	0	0	4238	0	7685
2001	0	0	4	0	98	1294	0	1396
2002	0	0	1333	0	0	2657	0	3990
2003	887	0	1060	0	0	2593	0	4540
2004	0	0	97	0	0	1416	0	1513
2005	0	252	1134	0	13	0	0	1399
2006	0	0	601	0	0	0	0	601
2007	0	0	333	0	0	14	0	347
2008	0	0	892	0	0	0	0	892
2009	0	0	104	0	0	70	0	174
2010	0	0	332	0	0	537	0	869
2011	0	0	468	0	248	507	0	1223
2012	0	0	113	0	0	1688	0	1801

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	487	0	0	968	0	1455
2014	0	0	3	0	0	1540	0	1543
2015	0	0	1305	0	0	1060	0	2365
2016	0	0	431	0	0	2177	0	2608
2017	0	0	604	0	0	1354	0	1958
2018	0	0	1	0	0	0	0	1
2019	0	1	3243	0	66	1265	1	4575
2020	0	0	796	0	0	724	0	1520
2021	0	0	85	0	0	161	0	246
2022	0	0	1697	0	0	161	0	1858
2023	0	0	701	0	0	275	0	976

Table 12.1.2 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2023 from Division 7.aN. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
1985	668	0	20	0	688
1986	1152	1	6	0	1159
1987	41	0	0	0	41
1988	0	0	4	6	10
1989	0	0	1	0	1
1990	0	0	0	0	0
1991	0	0	3	0	3
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	30	0	30
1996	0	0	0	0	0
1997	0	0	2	0	2
1998	0	0	3	0	3

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
1999	0	0	146	0	146
2000	0	0	371	0	371
2001	0	0	269	3	272
2002	0	0	306	0	306
2003	0	0	592	0	592
2004	0	0	134	0	134
2005	0	0	591	0	591
2006	0	0	563	0	563
2007	0	0	0	0	0
2008	0	0	2	0	2
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	522	0	0	0	522
2015	792	0	0	0	792
2016	150	0	0	0	150
2017	150	0	0	0	150
2018	0	0	0	0	0
2019	9	0	0	0	9
2020	2521	0	0	0	2521
2021	381	0	0	0.078	381
2022	491	0	0	0	491
2023	0	0	0	0	0

Table 12.1.3 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2023 from Division 7.aS. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	7
1999	25
2000	123
2001	7
2002	0
2003	3103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	433
2011	1535
2012	6261

Country	Ireland
2013	2545
2014	16
2015	3659
2016	935
2017	935
2018	1117
2019	2785
2020	6888
2021	7861
2022	2026
2023	1432

Table 12.1.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, from divisions 7.b–c. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Ireland
1985	0
1986	0
1987	100
1988	0
1989	0
1990	400
1991	40
1992	50
1993	3
1994	145
1995	150
1996	21
1997	28
1998	331
1999	5

Country	Ireland
2000	698
2001	138
2002	11
2003	38
2004	68
2005	260
2006	40
2007	32
2008	1
2009	238
2010	0
2011	0
2012	23
2013	237
2014	0
2015	250
2016	0
2017	874
2018	508
2019	842
2020	1308
2021	294
2022	197
2023	59

Table 12.1.6 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, Division 7.f. (tonnes)

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
1985	273	0	273
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	1	1
1992	0	0	0
1993	0	0	0
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	0	1	1
2012	0	2	2

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
2013	0	2	2
2014	0	1	1
2015	0	0	0
2016	0	1	1
2017	0	0	0
2018	0	0	0
2019	0	0	0
2020	0	3	3
2021	0	0.35	0.35
2022	0	0.017	0.017
2023	0	0	0

Table 12.1.7 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023, divisions 7.g–k. Irish data may be underestimated due to difficulties in quantifying the catches from vessels of less than 10 m length. (tonnes)

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
1985	0	0	3245	0	0	0	3245
1986	538	0	3032	0	0	2	3572
1987	0	1	2089	0	0	0	2090
1988	0	0	703	1	0	0	704
1989	0	0	1016	0	0	0	1016
1990	0	0	125	0	0	0	125
1991	0	0	14	0	0	0	14
1992	0	0	98	0	0	0	98
1993	0	0	0	0	0	0	0
1994	0	0	48	0	0	0	48
1995	250	0	649	0	0	0	899
1996	0	0	3924	0	0	0	3924
1997	0	0	461	0	0	6	467
1998	0	0	1146	0	0	0	1146

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
1999	0	0	3263	0	0	0	3263
2000	0	0	1764	0	0	0	1764
2001	0	0	306	0	0	0	306
2002	0	0	385	0	0	0	385
2003	0	0	747	0	0	0	747
2004	0	0	3523	0	0	0	3523
2005	0	0	4173	0	0	0	4173
2006	0	0	768	0	0	0	768
2007	0	0	3380	0	1	0	3381
2008	0	0	1358	0	0	0	1358
2009	0	0	3431	0	0	0	3431
2010	0	0	2436	0	0	0	2436
2011	0	0	1767	0	0	12	1779
2012	0	0	2632	0	0	0	2632
2013	0	0	1648	0	0	0	1648
2014	0	0	2311	0	0	0	2311
2015	0	0	3322	0	0	0	3322
2016	0	0	3248	0	0	0	3248
2017	0	0	1755	0	0	0	1755
2018	10	0	1955	0	0	0	1965
2019	0	0	6148	0	0	0	6148
2020	0	0	2933	0	0	0	2933
2021	0	0	5524	0	0	0	5524
2022	0	0	2793	0	0	0	2793
2023	0	0	1170	0	0	0	1170

Table 12.1.8 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2023 in Subarea 6 and divisions 7.a–c and 7.f–k.

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
1985	538	0	0	4532	1	0	0	0	10	520	5601
1986	269	0	1	2230	0	0	0	0	0	582	3082
1987	364	0	0	853	0	1	0	0	4	3870	5092
1988	0	0	0	1163	0	0	0	0	1	1146	2310
1989	0	0	0	1325	0	0	0	0	0	813	2138
1990	0	0	0	205	0	0	0	0	4	1526	1735
1991	28	0	0	508	0	0	0	0	0	1555	2091
1992	22	0	0	2353	0	0	0	0	0	2230	4605
1993	0	0	0	232	0	0	0	0	2	1491	1725
1994	491	0	0	799	0	0	0	0	30	4124	5444
1995	0	0	0	4214	0	0	0	0	0	2350	6564
1996	0	0	0	2085	0	0	0	0	8	5313	7406
1997	40	0	0	1578	0	0	0	0	54	3467	5139
1998	0	0	0	5826	0	0	0	0	456	8161	14443
1999	0	0	0	6032	0	0	0	0	371	4238	10641
2000	0	0	0	455	0	0	0	0	367	1297	2119
2001	538	0	0	4532	1	0	0	0	10	520	5601
2002	0	0	0	1729	0	0	0	0	306	2657	4692
2003	887	0	0	4948	0	0	0	0	592	2593	9020
2004	0	0	0	4096	0	0	0	0	134	1416	5646
2005	0	252	0	5928	0	0	0	0	604	0	6784
2006	0	0	0	1523	0	0	0	0	563	0	2086
2007	0	0	0	3745	0	0	0	1	2	14	3762
2008	0	0	0	2353	0	0	0	0	2	0	2355
2009	0	0	0	3773	0	0	0	0	1	70	3844
2010	0	0	0	3200	0	0	0	0	7	537	3744
2011	0	0	0	3770	0	0	0	0	261	507	4538

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
2012	0	0	0	9029	0	0	0	0	2	1688	10719
2013	0	0	0	4917	0	0	0	0	2	968	5887
2014	0	0	0	2852	0	0	0	0	1	1540	4393
2015	0	0	0	9328	0	0	0	0	0	1060	10388
2016	0	0	0	4763	0	0	0	0	1	2177	6941
2017	0	0	0	4318	0	0	0	0	0	1354	5672
2018	10	0	0	3580	0	0	0	0	0	0	3590
2019	0	1	0	13018	0	3	0	0	66	1265	14353
2020	0	0	0	14446	0	0	0	0	3	724	15173
2021	0	0	0	14145	0	0	0	0	0.35	0.078	14145
2022	0	0	0	7204	0	0	0	0	0.017	161	7365
2023	0	0	0	3362	0	0	0	0	0	275	3637

Table 12.3.1. Sprat in the Celtic Seas Ecoregion. Sprat biomass by year from the MI Celtic Sea Herring Acoustic Survey.

Year	Biomass (t)
Nov/Dec-91	36880
Jan-92	15420
Jan-92	5150
Nov-92	27320
Jan-93	18420
Nov-93	95870
Jan-94	8035
Nov-95	75440
2002	20600
2003	1395
2004	50810
2005	29019
2008	5493

Year	Biomass (t)
2009	16229
2011	31593
2012	35114
2013	44685
2014	54826
2015	83779
2016	42694
2017	70745
2018	47806
2019	60608
2020	4523
2021	12376
2022	34508
2023	11342

Table 12.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.a (Source: AFBI annual herring acoustic survey).

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
1994	68 600	0.1	95	65,200
1995	348 600	0.13	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	45 600	0.2	n/a	n/a
1998	228 000	0.11	97	221 300
1999	272 200	0.1	98	265 400
2000	234 700	0.11	94	221 400
2001	299 700	0.08	99	295 100
2002	413 900	0.09	98	405 100
2003	265 900	0.1	95	253 800
2004	281 000	0.07	96	270 200

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
2005	141 900	0.1	96	136 100
2006	143 200	0.09	87	125 000
2007	204 700	0.09	91	187 200
2008	252 300	0.12	83	209 800
2009	175 200	0.08	78	136 200
2010	107 400	0.1	87	93 700
2011	280 000	0.11	85	238 400
2012	171 200	0.11	95	162 600
2013	255 300	0.09	77	197 500
2014	393 000	0.1	93	367 100
2015	237 000	0.09	84	199 100
2016				236 000
2017				222 000
2018				219 000
2019				146 000
2020				117 000
2021				110 000
2022				84 000
2023				169 520

Figure 12.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

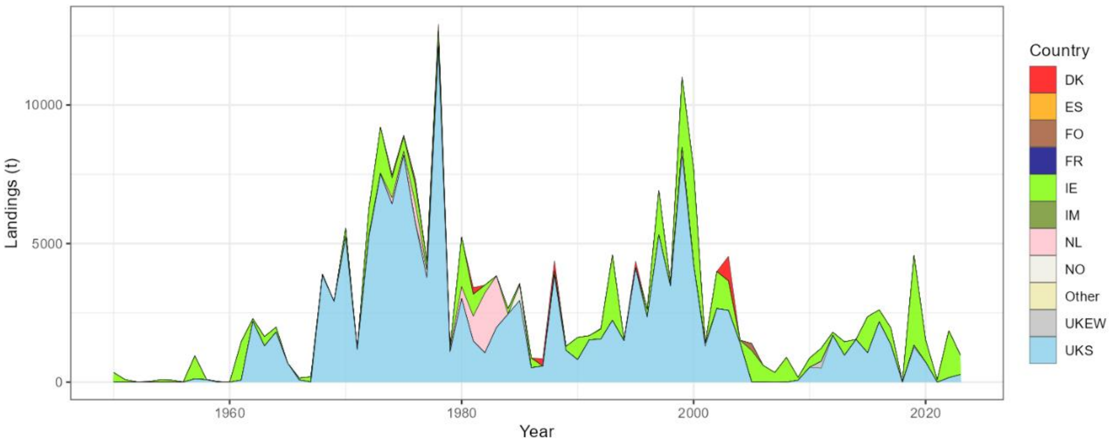

Figure 12.2.1. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 6.a.

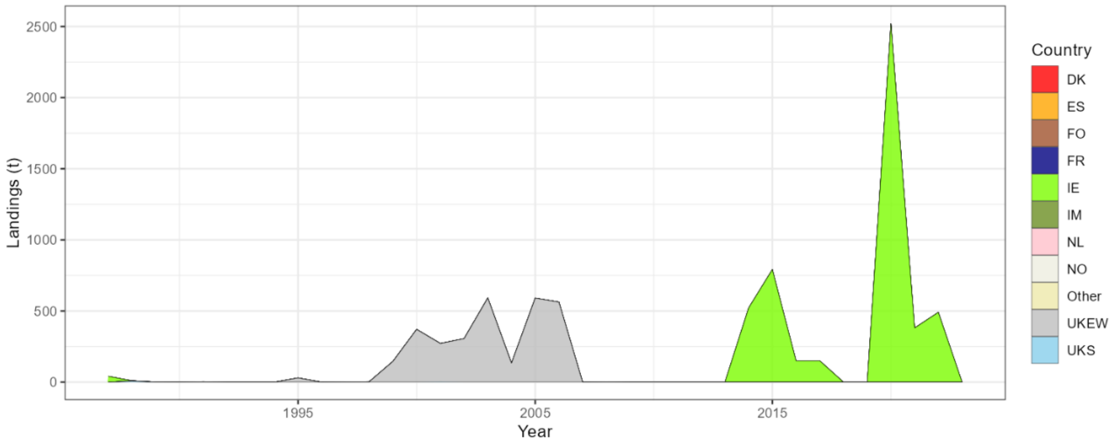

Figure 12.2.2. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.aN. Note: Irish catches from 1973–1995 may be from 7.aN or 7.aS.

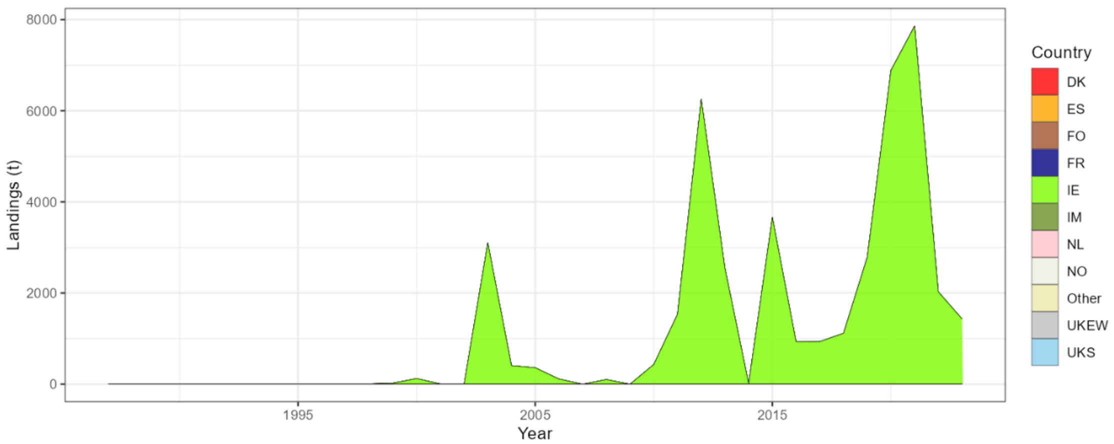

Figure 12.2.3. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.aS.

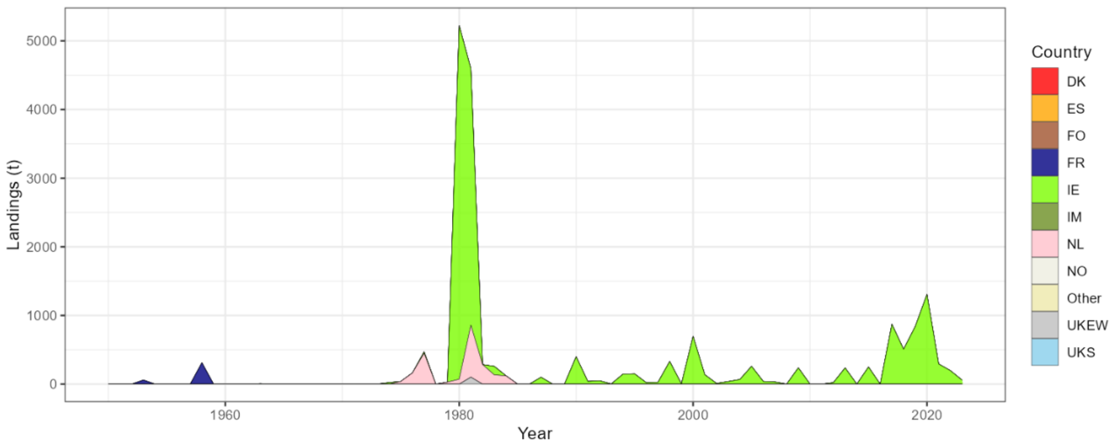

Figure 12.2.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES divisions 7.b–c.

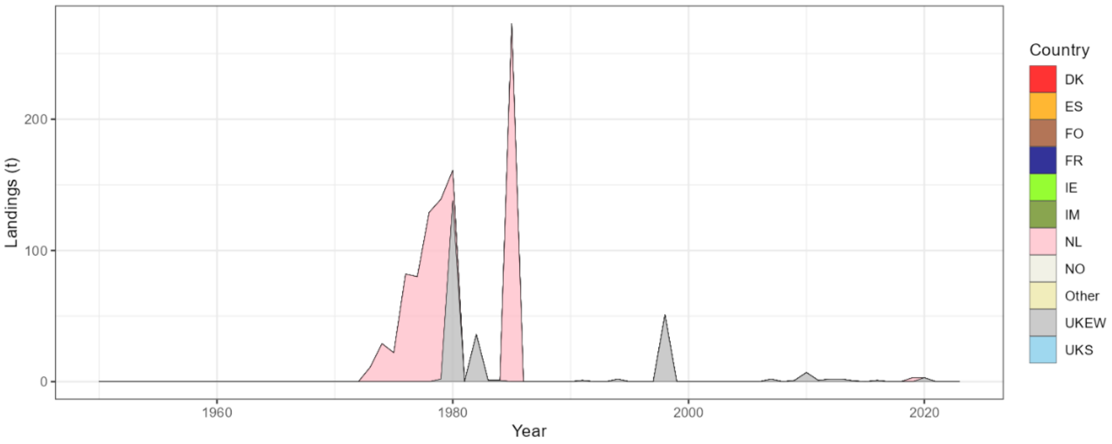

Figure 12.2.6. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES Division 7.f.

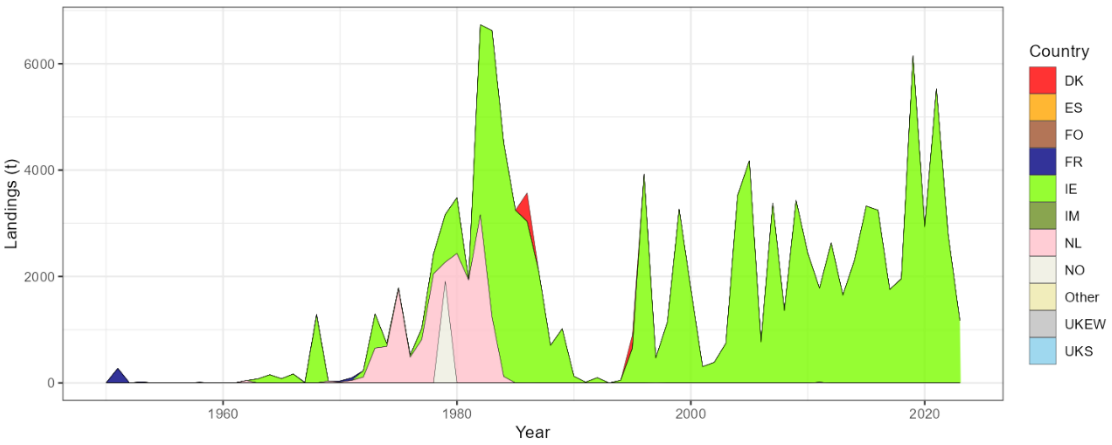

Figure 12.2.7. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2023 ICES divisions 7.g–k.

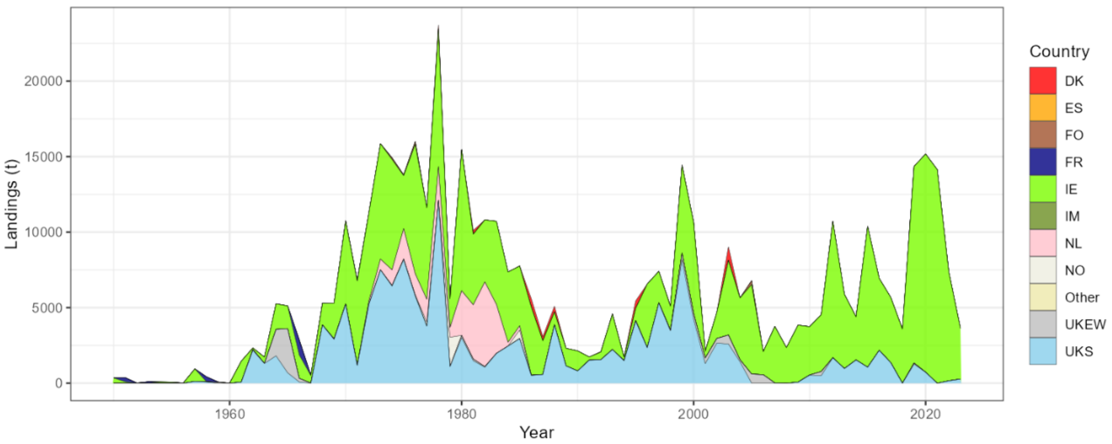

Figure 12.2.8. Catches of sprat 1987–2023 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by country.

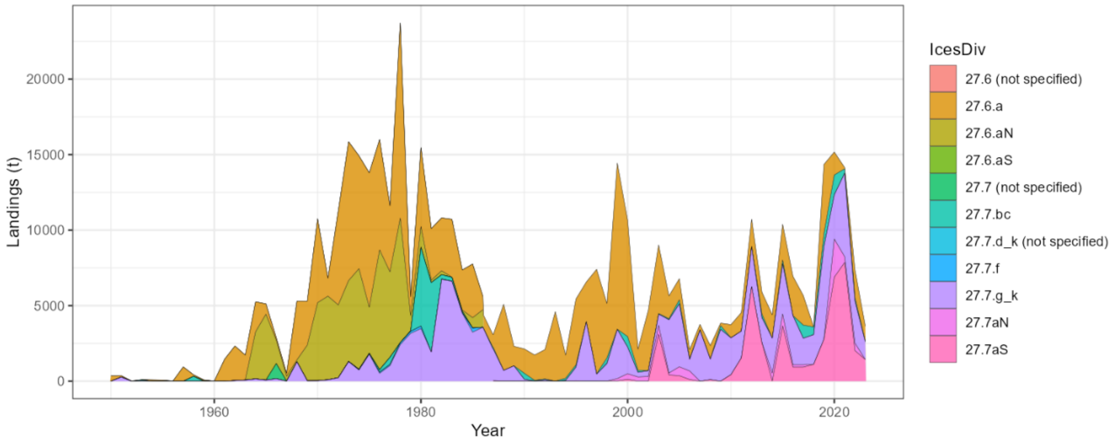

Figure 12.2.9.Catches of sprat 1987–2023 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by Ices Division.

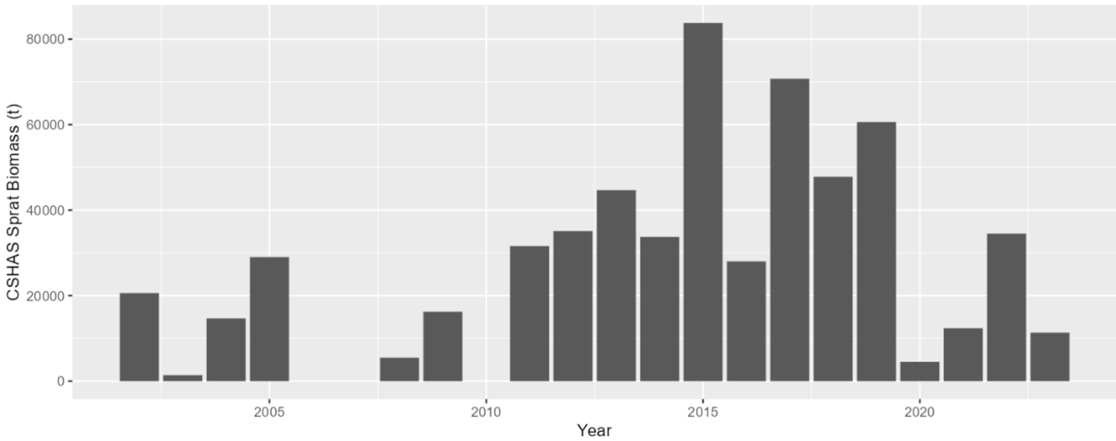

Figure 12.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass from the MI Celtic Sea Herring Acoustic Survey 2004–2023 (A4705).

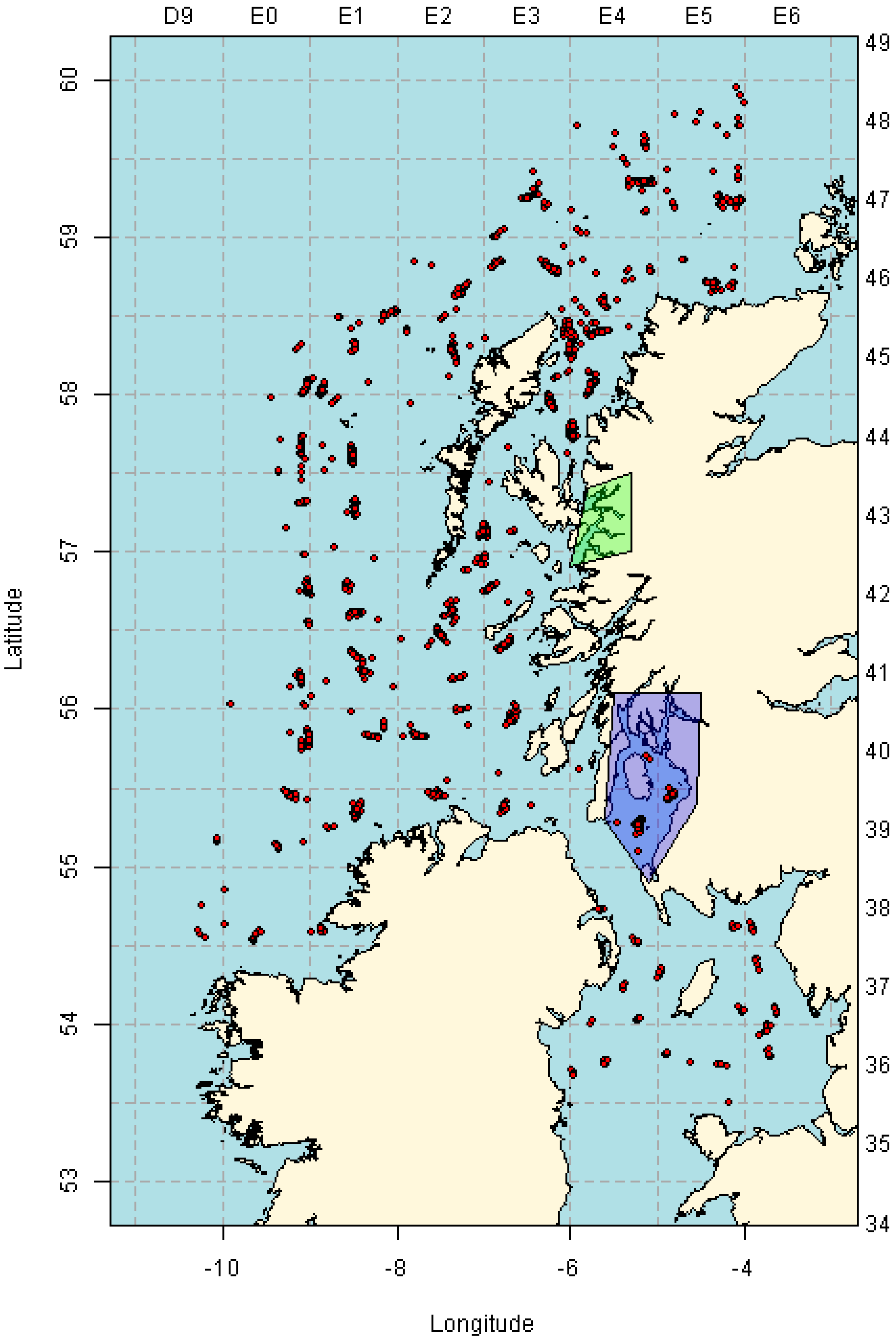

Figure 12.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually in Q1 and Q4 between 2001 and 2005. Red markers indicate all hauls from the Q1 and Q4 Scottish West Coast IBTS between 1985 and 2012 (G7144).

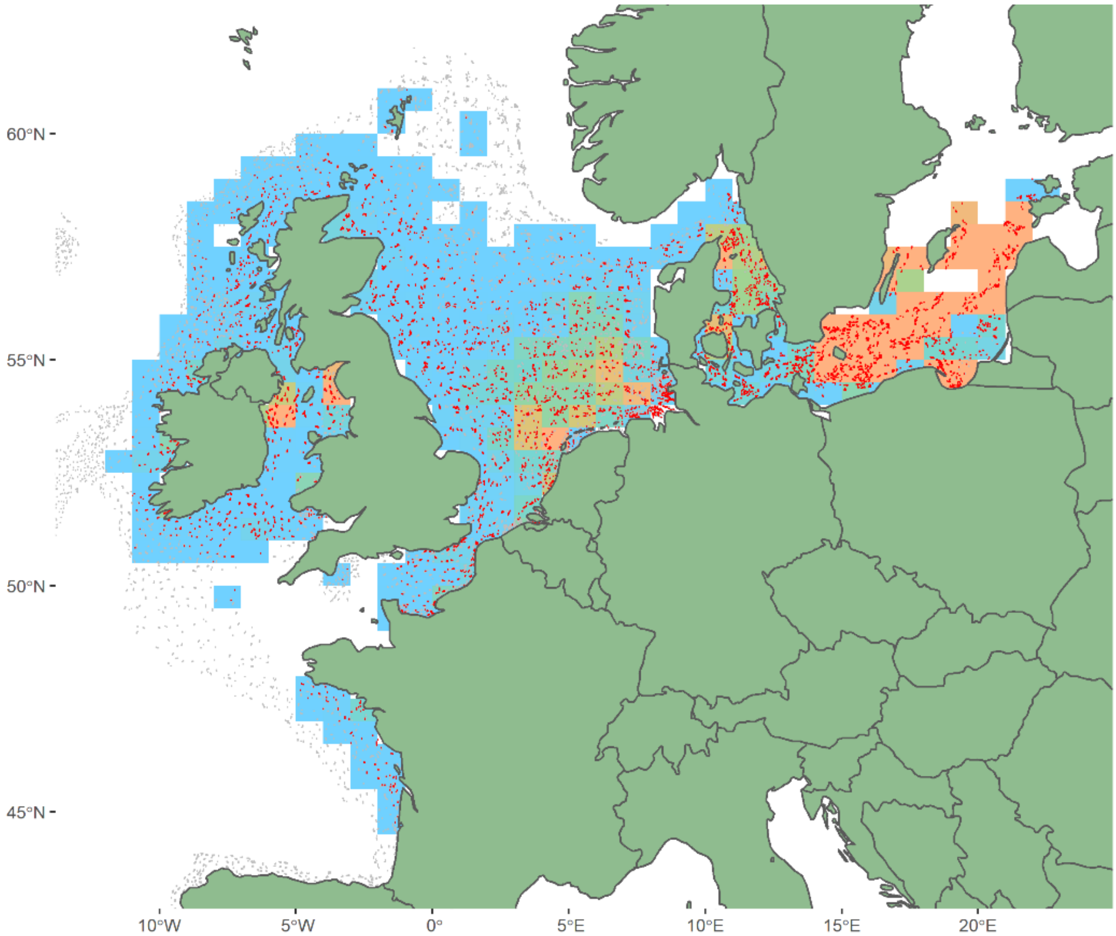

Figure 12.3.3. Total numbers of sprat caught by DATRAS surveys by ICES rectangle, adjusted for tow duration but not adjusted for number of hauls. Since this is a sum, no compensation is made for the varying number of hauls per rectangle. Generated using DATRAS records downloaded 29 Oct 2022, Figure applies to sum over time period 2011-2022. Red dots indicate hauls which caught sprat, grey dots indicate hauls with no sprat recorded. Combined DATRAS survey data for the surveys of acronym: BITS, BTS, BTS-VIII, DYFS, FR-CGFS, IE-IGFS, NIGFS, NS-IBTS, PT-IBTS, SCOROC, SCOWCGFS, SNS, SP-ARSA, SP-NORTH, SP-PORC, EVHOE. See DATRAS website for details on survey acronyms.

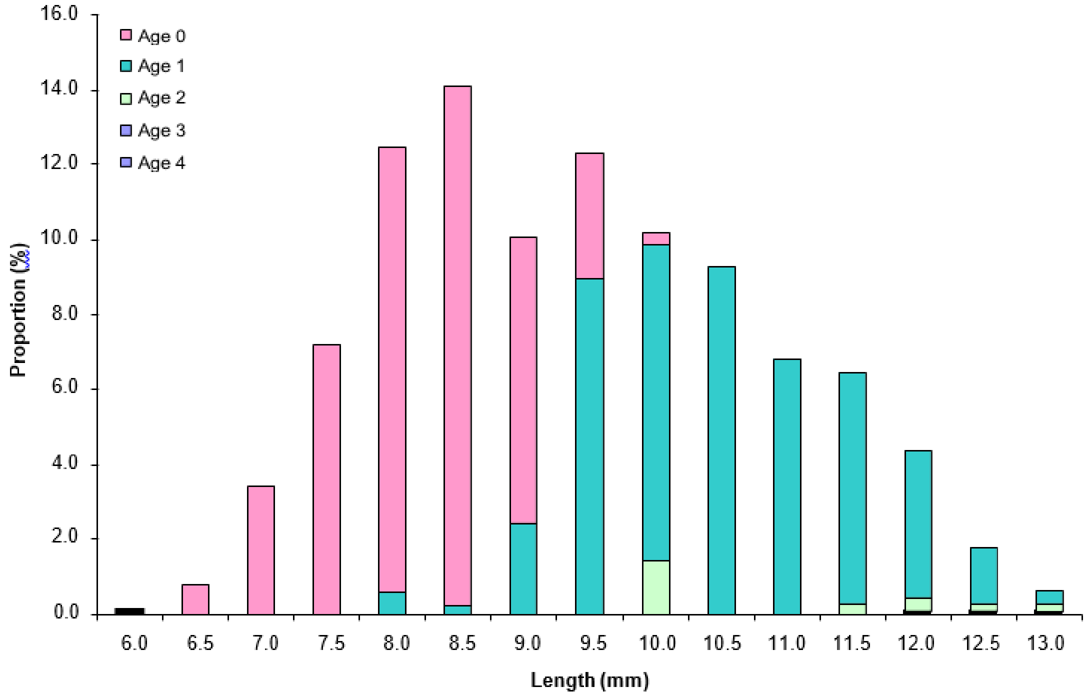

Figure 12.3.4. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged (G7144).

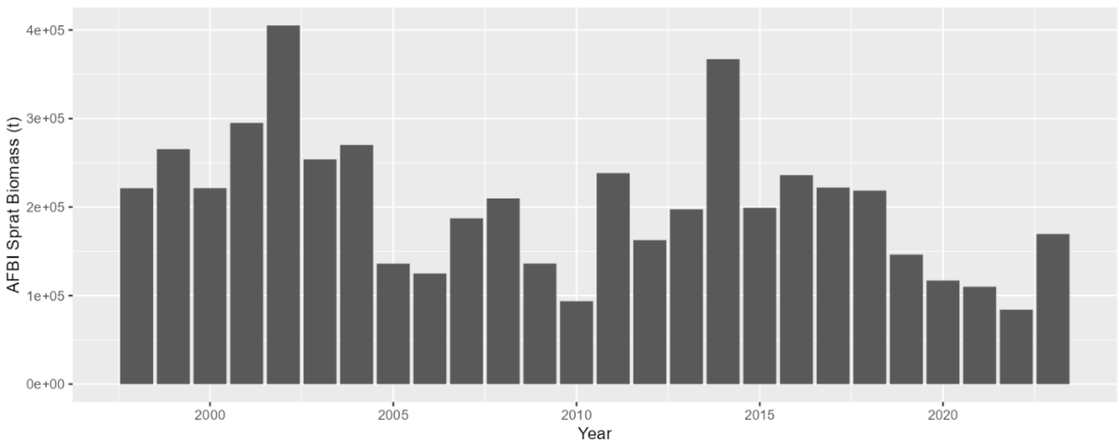

Figure 12.3.5. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN from the AFBI Acoustic Survey (A4075)

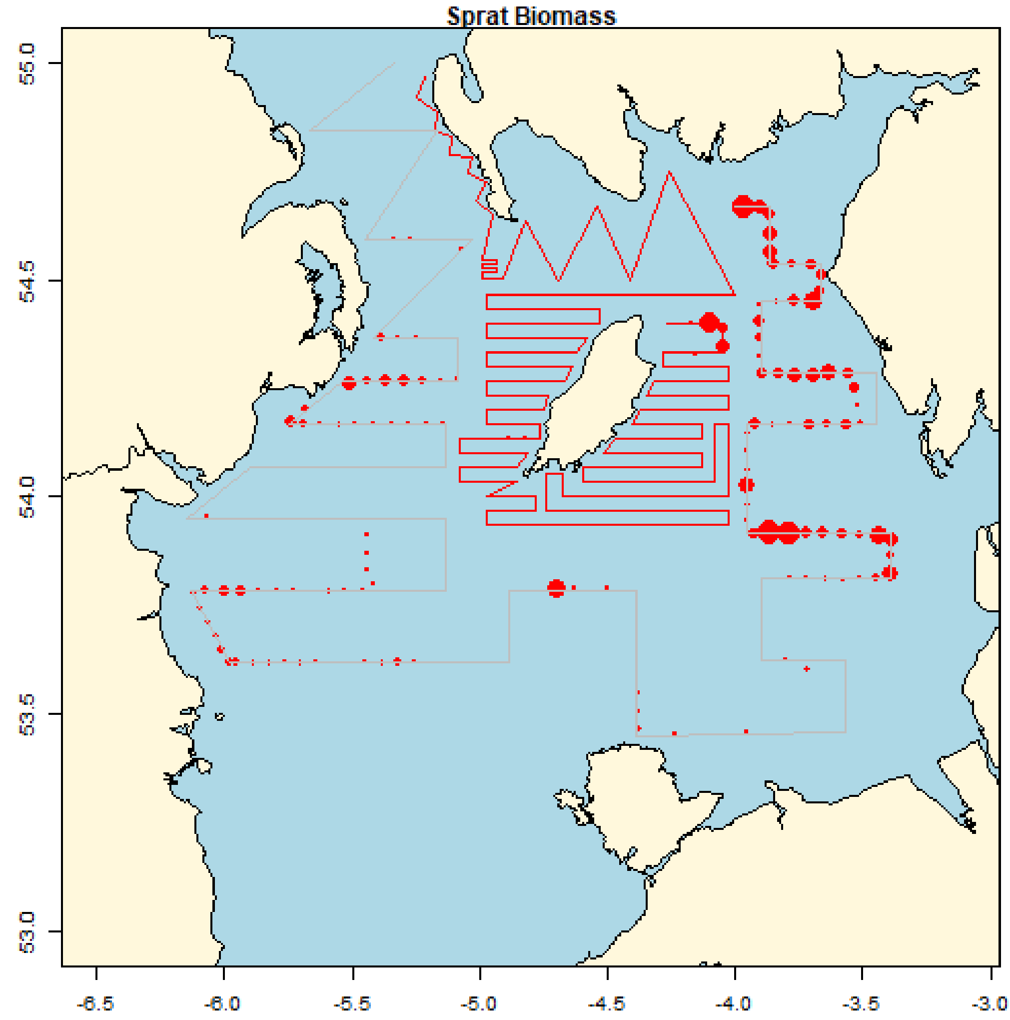

Figure 12.3.6. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) which include juvenile herring and sprat. Obtained during the 2021 AFBI acoustic survey (A4705).

Annex 1: Working Documents

Working document

1 Revision of data input, model configuration and reference points used for the stock assessment of sprat in the North Sea and 3.a

During the annual meeting for Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) the input data used in the assessment model for sprat in the North Sea and 3.a (Skagerrak-Kattegat) were revised. This included 1) a change in catch input data and associated model adjudgments, 2) an update of natural mortalities from the SMS key run 2023, 3) re-calculation of biomass reference points (Blim and Bpa) and 4) re-calculation of reference point set on fishing mortality (harvest control rule, F_{cap}). In short, the assessment for sprat uses the SMS model (Lewy and Vinther, 2004) with quarterly time steps. The model was benchmarked in 2018 (WKSPRAT, ICES 2018;). Due to the short lifespan and fishery composition of sprat, only in-year advice is viable. To align with sprat's lifecycle, the model is based on TAC years from July to June rather than calendar years, estimating SSB and recruitment on 1 July. Output and input data refer to the adjusted model year, i.e. TAC year (S1-S4; season 1 is quarter 3, season 2 is quarter 4, season 3 is quarter 1, and season 4 is quarter 2). The management of the sprat stock in the North Sea and 3.a employs an escapement strategy ($B_{escapement}$), which involves aiming to fish the stock down to B_{pa} (= $B_{escapement}$). However, it has been demonstrated that this approach is not precautionary for this type of stock without the implementation of a reference point for F as a limit control rule (ICES, 2014). For a more detailed description please see stock annex and report.

The changes were reviewed by external experts Mikel Aristegui and Amy Schueller, and the expert group have revised the working document to accommodate both reviewers by extending the justification and conclusive remarks on the choice of method for the calculation of B_{lim} based on the stock-recruitment relationship, as well as extending the F_{cap} estimation to include the target risk of 0.05.

1.1 Catch data input and model configuration

The SMS-model faces challenges with extended time-series of low catches used as input for the quarterly time-steps. Such catch data can lead to inaccurate estimation of fishing pressure and associated CV's. Historically, catches below a threshold were set to zero to prevent model misfits. During WKSPRAT, a redistribution of low catches from specific seasons provided appropriate model adjudgments, which proved to be successful. Specifically, the inclusion of catches from season 4 in season 1 the following year in combination with model modifications that prevented fits or estimation of any catch parameters in S4 improved the variance and CV in the model, as well as resolved some retrospective patterns. The consensus was to incorporate this change into the final model, recognizing its positive impact on model accuracy (WKSPRAT, 2018). A recent change in the fishing pattern in season 3 seems to have caused similar issues as seen for season 4 during WKSPRAT. The catch input data revealed that since 2019 the catches have been low. On average the catches were 0.6% of the total catch in tonnage for the period 2019-2022 (1.2% in 2019, 0.5 % in 2020, 0.6% in 2021 and 0.2% in 2022) compared to 8.6% for the period 2015-2018 (Table 1). In addition, the number of biological samples taken from the fishery used to generate the catch-at-age matrix for the assessment model has also been low compared to before 2019 (Table 2). These sudden changes caused estimation problems for the predicted fishery mortalities in the model, similarly to what found for S4 during WKSPRAT. Therefore, the expert group decided to test the effect of moving the catches from season 3 to season 2 for the period 2019-2022 and configuring the model to not estimate any catches for the season.

1.1.1 Results

The high CV in 2022 for the fishing mortality were corrected by moving the catches to season 2 (Figure 1). The large positive catch residuals for season 3 for all age-groups were removed without causing any drastic changes to the catch residuals in season 2 (Figure 2). The most recent estimated fishing mortalities became less variable. Specifically, the predicted 2022 fishing mortality went from being unrealistic low to being just below the long-time average in 2022 and the record high fishing mortality in 2023 was marginally down-scaled (Figure 3). Furthermore, the AIC were greatly improved from 1062 to 860.

1.1.2 Conclusion

HAWG agreed that the inclusion of season 3 catches for the period in season 2 improved the model significantly without changing the estimated historical dynamics of the stock and exploitation, and concluded that this change should be adopted in the final model. A sensitivity analysis was also conducted only moving the catches from season 3 to season 2 in 2022, which provided comparable improvements to the CV and predicted fishing mortality, but not to the catch residuals. Furthermore, considering that the low number of biological samples extended back to 2019, the group was confident to keep the changes for the period 2019-2022.

1.2 Updating natural mortalities

The current assessment is based on natural mortalities (M) from the 2015 SMS key run. Consequently, a varying M (3-y running means) is implemented up to 2015, and a constant M is used thereafter (2013–2015 average). In 2021, HAWG reviewed the updated Ms from the 2020 SMS key run. Despite no significant changes in recruitment, SSB, F and stock-recruitment relationship, HAWG decided at that time to retain the old M from the 2015 key run, mainly due to the guidelines that necessitated an inter-benchmark process, which was deemed unfeasible because of the tight advisory schedule and the extensive nature of MSE for reference point estimation (HAWG, 2021). After inspecting the updated mortalities from the most recent key run from 2023, HAWG decided that the changes are now so profound that they cannot be ignored and should be implemented from this update assessment. Notably, Ms have increased for all age-groups in all seasons in the most recent time-period (Figure 4).

1.2.1 Results

The inclusion of updated natural mortalities from the most recent SMS 2023 key run changed the perception of the stock, causing an upward shift in both recruitment (s. 1991) and SSB (s. 1982), as well as a downscaling of fishing mortality (s. 1981) (Figure 5). Furthermore, the stock-recruitment relationship showed that the changes in both recruitment and SSB resulted in a down-scaling causing points to be more compact in the early time of the time-series, whereas the period from 1981 and onward became more variable (Figure 6). The median recruitment also increased from being 87849 using the old Ms to 101730 using the updated Ms (Figure 6). There were no drastic changes detected in the CV's and residuals for both the catches and surveys (Figure 7, 8 and 9). The retrospective pattern where improved for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), whereas it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22) (Figure 10). The AIC for the model fit increased with the updated Ms (AIC = 863) compared to a model with the current Ms (AIC = 860), but the difference in delta-AIC were evaluated to be negligible.

1.2.2 Conclusion

The natural mortalities from the 2015 key run are obsolete and do not capture the trophodynamics that characterise the North Sea food web during the last decade. Improvements of the multispecies model since 2015, e.g. incorporating more accurate information on seabird and recent shifts in predator biomass (e.g. whiting and mackerel), have substantial influence on the estimated Ms for sprat. In conclusion, the significant changes in natural mortalities of sprat prompted HAWG to their final decision of updating the Ms for the assessment.

1.3 Reference points

As a result of the change in the stock delimitation and the assessment settings, the reference points were revised and re-estimated. The reference points were revised based on the model run with all revised input data and model configurations (see above). It was decided to follow a similar procedure as WKSPRAT and accordingly all years before 1981 were omitted because they appeared to be in a different regime. It was agreed that the stock-recruitment relationship could be estimated as a type 1 or 2 relationship, which can be estimated by using the R-package *StockRecruitSET* available at https://github.com/mebrooks/StockRecruit. The method for a type 1 gives B_{lim} at the lowest SSB with medium recruitment. The B_{lim} estimate for a type 2 is the break point of a hockey-stick model. The current B_{lim} is based on a hockey-stick breakpoint (WKSPRAT, 2018). The evaluation of B_{lim} is also subjected to expert judgement. Drawing from the experience from the benchmark of sandeel (WKSAND, 2023), it was decided to calculate an alternative B_{lim} based on the average SSB for two years that produced recruitments above the median recruitment.

1.3.1 Results

Using the ICES guidelines for type 1 (spasmodic) stocks, B_{lim} was calculated to be 103464 t (i.e. lowest SSB that gives median recruitment), which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 130728$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The type 2 stock using a hockey-stick model, the breakpoint for Blim was calculated to be 131184 t, which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 167759$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). A calculation of an alternative B_{lim} (mean SSB for two years that have R > median R) yielded 107598 t using the years 1991 and 2013, which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 135952$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The evaluation how the different alternative reference points changed the perception of the stock compared to current perception showed that using type 1 stock method and a simple average of two years gave a similar perception to the current (Figure 11 and Figure 12). On the contrary, using the type 2 stock method would change the historical perception of the stock increasing the number of years under B_{lim} and B_{pa} (Figure 12).

1.3.2 Conclusion

The group had thorough discussions on how to evaluate the estimated reference points and the changed perception of the stock. Considering the stock recruitment relationship as a type 1 or a type 2 did affect the estimation of B_{lim} and perception of the stock substantially. The expert group judged the type 2 estimation method to be risk prone because it included four years of recruitments over the median, where 2008 and 2013 were judged to be higher than expected. Therefore, the group where in doubt whether a type 2 relationship could be supported and worries on a ever-increasing trend causing an overestimation of the hockey-stick break-point were raised. As stated above, the estimation of B_{lim} and perception of the stock where very different depending on method compared to the last benchmark where both type 1 and type 2 relationships gave closely related reference points. As such the expert group preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark. The decision was made to set B_{lim} based on the average SSB of two years with recruitment above the median, deemed to reflect a reasonable and precautionary perception of stock changes. Consequently, the average SSB from 1991 and 2013 was used to establish reference points at B_{lim} = 107598 t and $B_{escapement}$ = B_{pa} = 135952 t. The expert group also wanted to highlight that ICES should be aware that one of the down-sides by discontinuing the inter-benchmark process are very short time frames for these important decisions that are affected by subjective choices to be made, which puts a lot of pressure on the assessment expert groups.

1.4 MSE and F_{cap}

1.4.1 Methods

We used the short-cut method developed for WKspratMSE (ICES 2019). We conditioned the MSE using the assessment from 2024 instead of 2018 and accordingly, we modified the MSE code so that the start year of the MSE was 2023 and so that risk was calculated over years 2038 to 2058.

We ran the MSE for a range of Fcap values from 0.5 to 1.0, and thereafter small increments 1.01-1.05 to include the target risk of 0.05.

1.4.2 Results

Fcap	risk
0.5	0.022
0.6	0.027
0.7	0.032
0.8	0.038
0.9	0.044
1.0	0.049
1.01	0.050
1.02	0.051
1.03	0.051
1.04	0.052
1.05	0.053

Please see supplementary materials for figures and further results.

1.4.3 Conclusion

An Fcap of 1.01 produced risk of 0.05.

1.5. References

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp.

ICES. 2019. Workshop on the management strategy evaluation of the reference point, F_{cap}, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69. 35 pp. https://doi.org/10.17895/ices.pub.19291148

Table 1. Catch in numbers by age (1000's) by season and year (Model year) from 2015 and onward. Note that the time-series used in the model goes back to 1974.

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	2420231	9775216	3342785	163695
2019	2	799272.1	2399200	1041391	139590
2019	3	121303.8	19818	2252.614	237
2019	4	0	0	0	0
2020	1	207574	10153348	3429492	429318
2020	2	69142	2695178	385767	137741
2020	3	28346	78759	8459	1779

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2020	4	0	0	0	0
2021	1	539434	5840604	1505982	255540
2021	2	233795	803968	392200	138805
2021	3	52211	10015	734	8
2021	4	0	0	0	0
2022	1	362805	7103177	813995	99384
2022	2	826841	281637	350919	100995
2022	3	2748	959	67	12
2022	4	0	0	0	0
2023	1	578572	4943797	1984638	98171
2023	2	389454	1497984	618160	68121
2023	3	0	0	0	0
2023	4	0	0	0	0

Table 2. Number of biological samples taken from 2010 and onward. Note that the time-series used in the model goes back to 1974.

Year	S1	S2	S3	S4
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	2	12
2020	27	28	0	0
2021	85	22	0	8
2022	41	29	1	0
2023	78	49	*	*

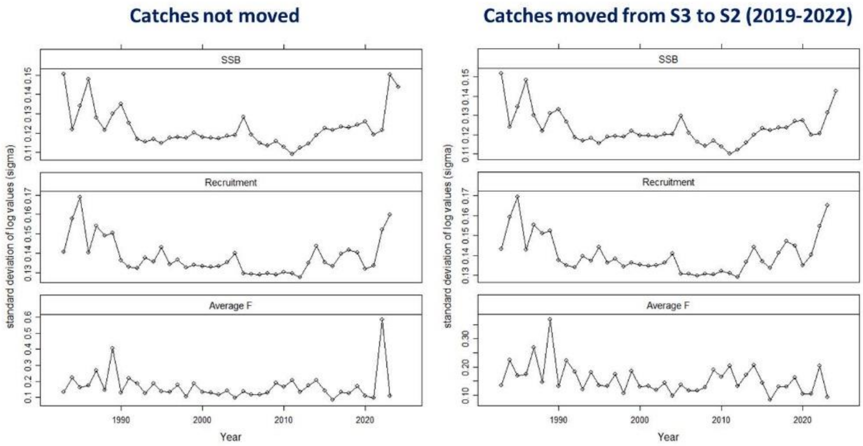

Figure 1. Coefficients of variance (Model year) for recruitment, SSB and fishing mortality for the model without moving catches and a model where catches are moved from S3 to S2.

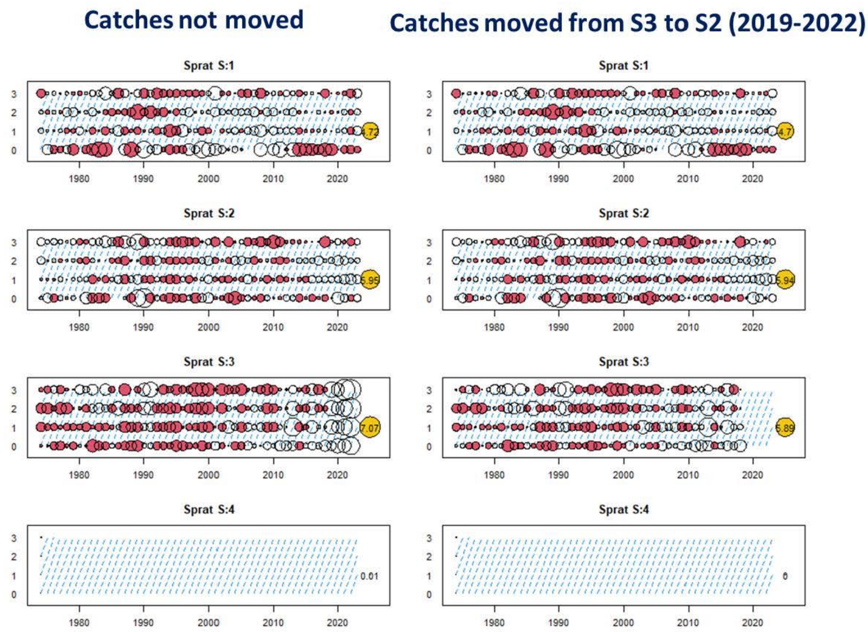

Figure 2. Catch residuals by age and season (Model year) for the model without moving catches and a model where catches are moved from S3 to S2. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

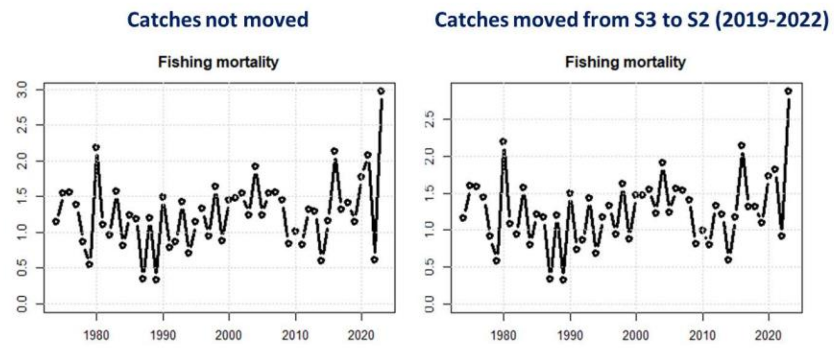

Figure 3. Predicted fishing mortality (Model year) for the model without moving catches and a model where catches are moved from S3 to S2.

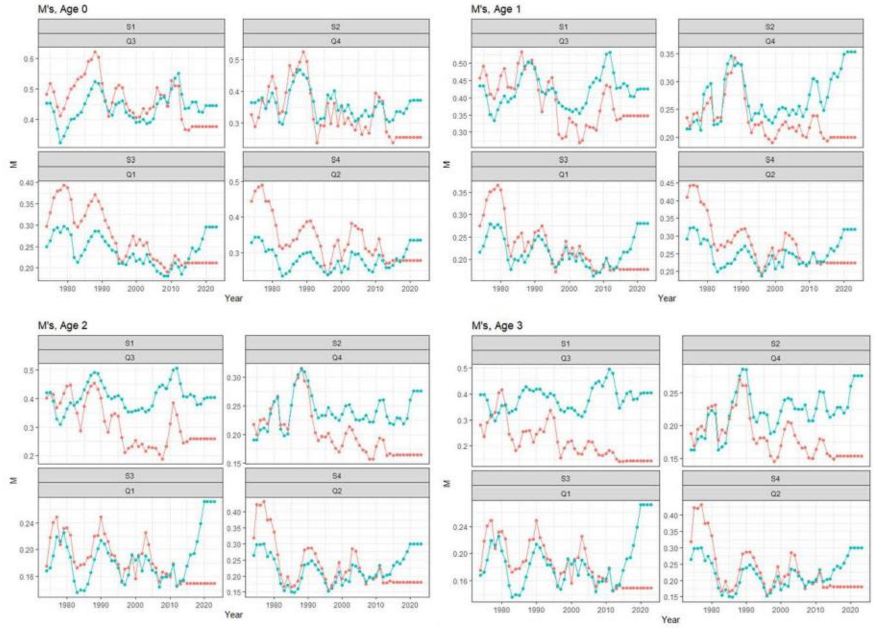

Figure 4. Natural mortalities for sprat for all age-groups, seasons and quarters (Model year). The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

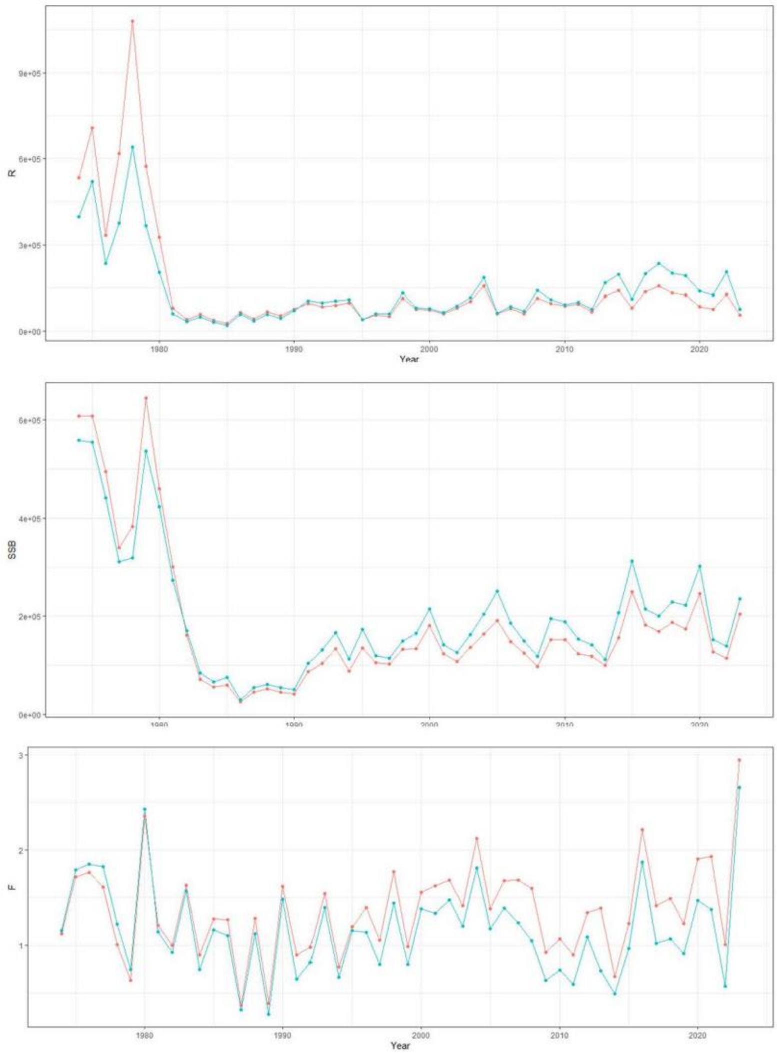

Figure 5. Predicted recruitment, SSB and fishing mortality for models that have old and updated M's. The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

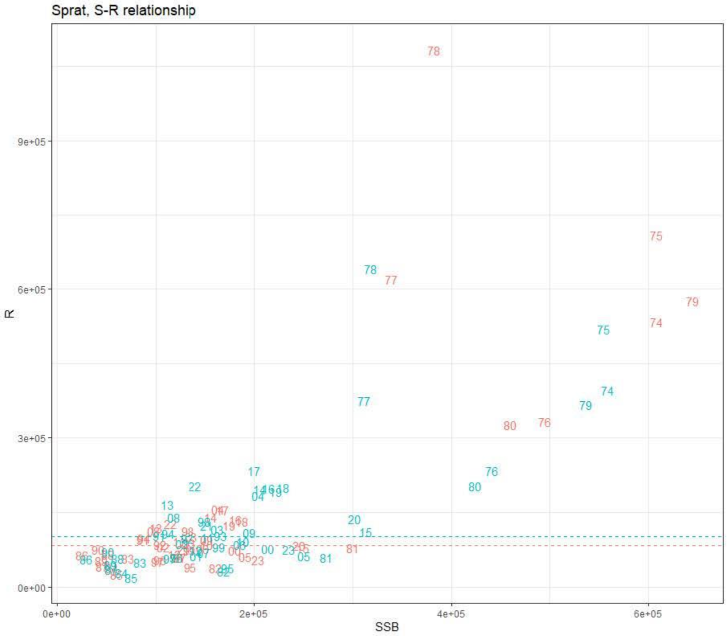

Figure 6. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The red numbers are the current M's from the 2015 SMS key run and the blue numbers is the updated M's from the most recent SMS key run from 2023. The median recruitments are shown (dashed lines).

Old Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.118	0.100
1	0.909	0.877	1.414	0.100
2	0.975	1.048	1.414	0.100
3	0.975	1.048	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.43	0.43	0.43
IBTS Q3		0.54	0.44	0.44
Acoustic		0.44	0.53	0.53

New Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.100	0.100
1	0.864	0.835	1.399	0.100
2	0.950	1.050	1.414	0.100
3	0.950	1.050	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.47	0.47	0.47
IBTS Q3		0.53	0.45	0.45
Acoustic		0.44	0.50	0.50

Figure 7. Catch and survey CVs for models that have old and updated M's.

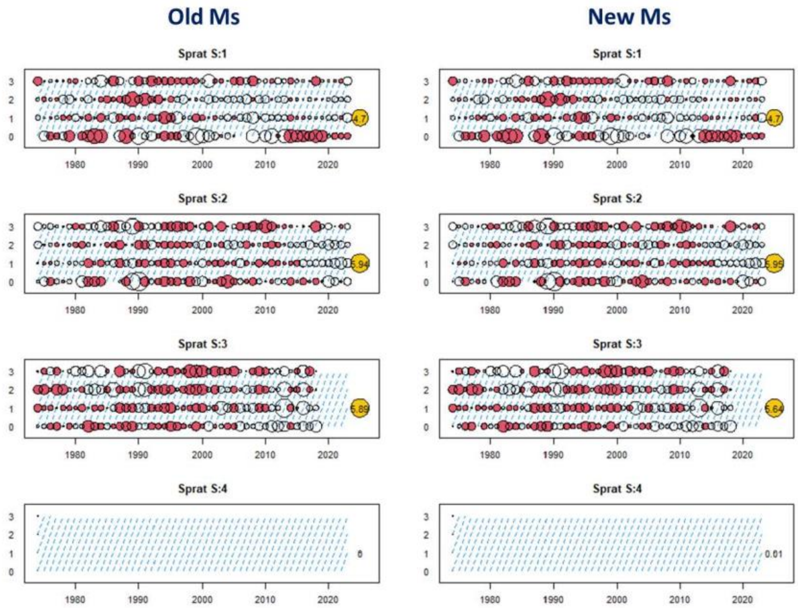

Figure 8. Catch residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

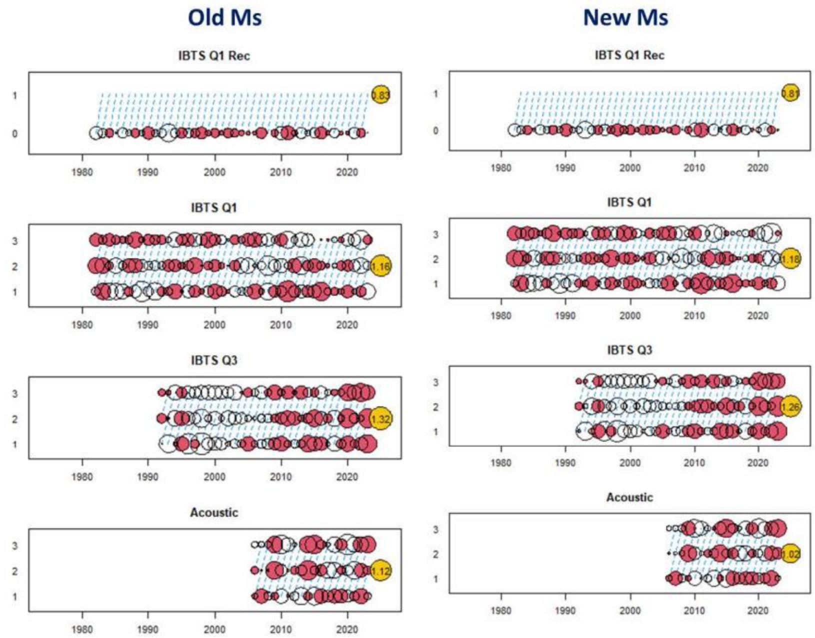

Figure 9. Survey residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

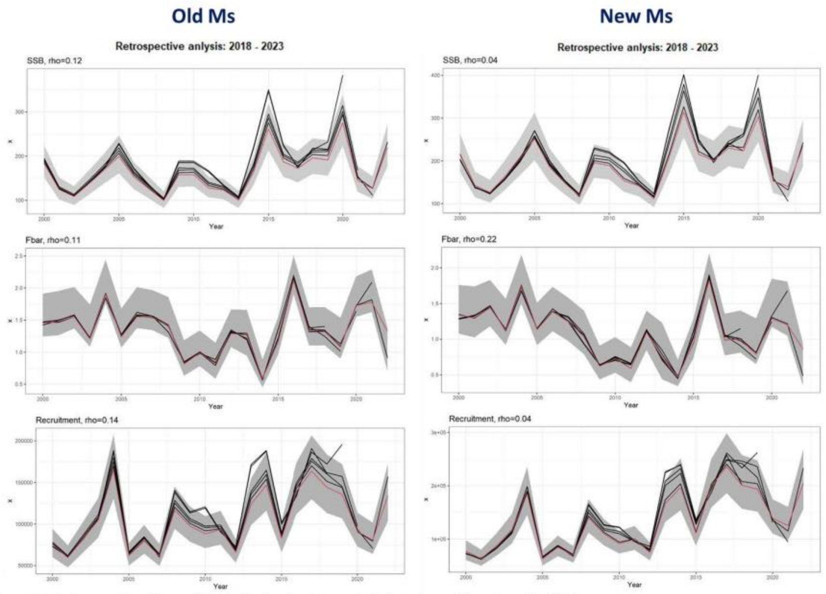

Figure 10. Retrospective bias and Mohn´s rho for the models that have old and updated M's.

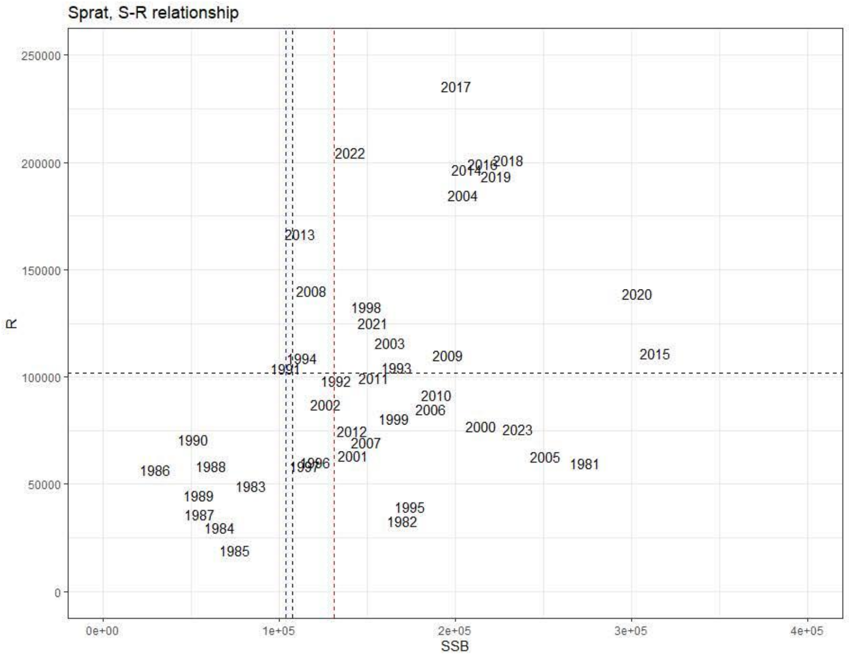

Figure 11. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Lines show type 1 method (minimum SSB that produce above median recruitment, blue dashed line), type 2 method (hockey-stick breakpoint, red dashed line) and an alternative calculation (mean SSB in the two years that produced above recruitment, black dashed vertical line) of B_{lim}. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The median recruitment are also shown (black dashed horizontal line).

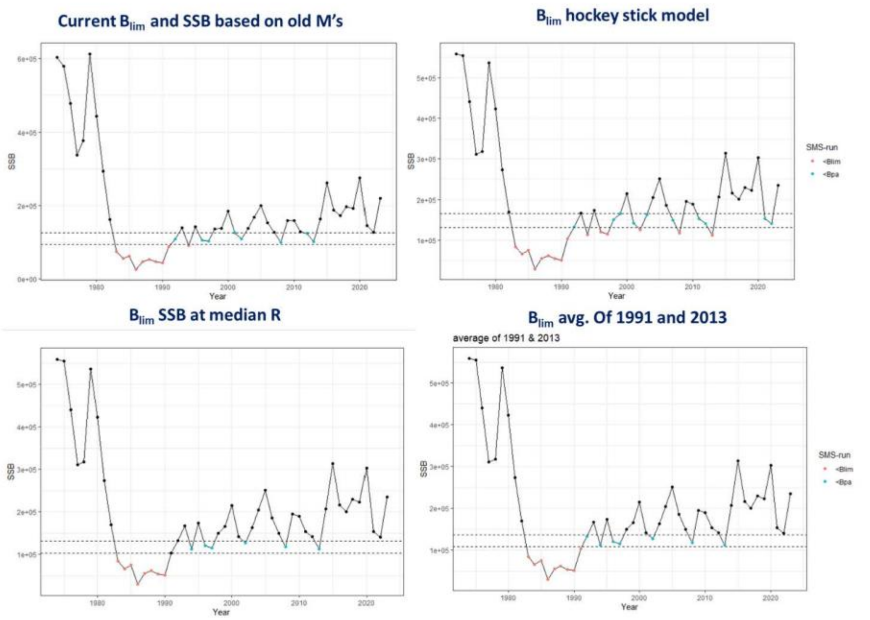

Figure 12. Perception of the stock using the current assessment model and input data (old M's, upper left panel), and a model that include the new M's and biomass reference points calculated as type 1 (lower left panel), tape 2 (upper right panel), and a simple average between two years (lower right panel). Please also see details in Figure 11 for information on the calculation of B_{lim}. The blue points signify years where SSB < B_{pa} and > B_{lim}, and the red points signify years where SSB < B_{lim}.

2 Working documents Reviews

2.1 Review from Mikel Aristegui

The purpose of this external review is to check that the reasoning for the decisions made during the annual meeting of the Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) about the stock assessment and reference points of sprat in Division 3.a and Subarea 4 are in line with ICES guidelines.

HAWG implemented two main changes to the input data and settings of the sprat model: moving catch data from season 3 to season 2 for the period of 2019-2022, and updating the natural mortalities (M's) for all ages. As a result of these changes, reference points were revised and re-estimated.

1. Changes to input data and model settings

a. Catch data input

HAWG identified a change in fishing patterns in recent years (2019-2022), where catches in season 3 have been very low. Subsequently, the number of samples from these catches are also low. HAWG followed the steps and decisions that were made in the last Benchmark Workshop on Sprat (WKSPRAT; ICES 2018), where a similar issue was identified with very low catches in season 4. WKSPRAT decided to move catches from season 4 to season 1, improving the model considerably.

Now, HAWG showed that moving season 3 catches to season 2 (in 2019-2022 period) improved the CV's in the model. Additional efforts were made by the group by also testing that this change removed the large positive catch residuals for season 3, and significantly improved the model's AIC. However, it would be still interesting to know if moving catches from season 3 to season 2 affected the retrospective pattern (WKSPRAT showed that their change reduced Mohn's rho significantly).

HAWG agreed to move catches from season 3 to season 2 between 2019 and 2022, which looks adequate.

b. Natural mortality

The current assessment model uses M's from the 2015 SMS key run. HAWG identified a high increase in M's on the 2023 SMS key run, which significantly changed the perception of the stock (recruitment, SSB and fishing mortality). HAWG tested how applying the new M's would affect CV's, residuals, retrospective patterns and AIC of the model; which in combination were acceptable.

HAWG agreed to update the M's for the assessment, which looks adequate.

2. Reference points

HAWG reviewed the reference points after the changes to input data and model settings mentioned above, and including the most recent data.

a. B_{lim} and $B_{escapement}$ (= B_{pa})

The group followed a methodology similar to that in WKSPRAT, where stock-recruitment relationship types 1 and 2 were considered, and also added an alternative option that WKSANDEEL (ICES 2024) used to improve precaution: to use the average of the two lowest SSB that produced above-median recruitments (modified type 1).

HAWG agreed to use the alternative method, which deviates from the decision made in WKSPRAT; a more thorough justification for this decision would be welcome.

b. F_{cap}

HAWG ran the short-cut MSE method used in WKspratMSE (ICES, 2019) for six F_{cap} values (0.5, 0.6, 0.7, 0.8, 0.9, 1.0) that resulted in risks from 0.022 to 0.049. It would be beneficial to spend more time on this section, exploring higher F_{cap} values to include the target risk of 0.050. For example, WKspratMSE used a finer grid of 0.01 F_{cap} values, getting risks of 0.049, 0.050 and 0.051 (ICES 2019, table 3.4).

General comments

In general, the decisions made by HAWG 2024 were adequate and followed correct methodologies specified by ICES guidelines. However, an optimal review process like the current one, according to ICES most updated guidelines (ICES 2023), is a one-year process. Probably having more time to work on this type of reviews intersessionally decreases the pressure on everyone involved and increases the quality of the job.

Comments on the Working Document draft

The captions in Figures 4, 5 and 6 do not match with the text in the section 1.2 "Updating natural mortalities". The colours (red/blue) seem to be swapped in the captions.

In Figure 12 caption, points are named as "green", but to be consistent with other figures in the document, they should be called "blue", as they all look to use the same colours.

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2.2 Review from Amy Schueller

Two major changes were made in the model. The first change was to move Season 3 catches to Season 2 in the years 2019-2022 to account for the low catch values in Season 3. This change seems to have a favorable effect on the stock assessment, as there was difficulty estimating some parameters with a lack of catch and age data in the latter years. The figures provided suggest that the change was justified and had a small overall effect on the results, yet allowed for better estimation and fitting of the data.

The second change was an update of the natural mortality (M) values from the North Sea multispecies food web model, which has had improvements since it was last used for sprat. M's have increased for all age groups and seasons in the most recent years in the SMS model, so they were incorporated here. The changes in M led to relatively small changes in recruitment estimates in the middle part of the time series, but led to larger differences in the most recent years. However, the stock-recruitment plots look very similar, especially at lower stock sizes between the two runs. The fits to the survey age data were also comparable. These two changes make sense as they updated information to include the best available science and increase the robustness of the model estimation.

The benchmark values were also redetermined using a choice different than the previous assessment. The updated model formulation was appropriate for redetermining the benchmarks. The group discussed using 3 different options for determining B_{lim}: type 1 (spasmodic stocks; median recruitment), type 2 (hockey stick), and a modified type 1 based on the sandeel assessment (spasmodic stocks; mean of two recruitment values above the median recruitment and at the lowest SSB values). The group decided to use the modified type 1 option; however, the justification for this is unclear based on the documentation that was provided. This decision is a deviation from the last assessment where a hockey stick approach was used. While the methods are consistent with what was done in the sandeel assessment, the stock-recruitment plots between the two species do not necessarily have a similar appearance. The sandeel stock-recruitment plots were generally spasmodic with no identifiable area of decreased recruitment at low stock sizes. Based on Figure 11 provided in the documentation, there is a sprat stock size below which there are no recruitment values larger than the median (with 8 years in that region). A hockey stick approach would make more sense here. From the documentation: "The expert group judged the type 2 estimation method to be unsupported and risk prone, and preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark." This last sentence is the justification that was used to make this change. An explanation of how the method is unsupported would be useful. In addition, the statement of the method being more risk prone doesn't make sense without further explanation. The fact that the hockey stick method provides more years with SSB below B_{lim} is not a reason in and of itself to reject this option.

The MSE was updated to reflect the new assessment and used the same methods as were previously used. Very limited information was provided on the MSE; thus, one would infer that the methods were approved during the last assessment and remain consistent.

Comments on the Working Document draft

Figure 4 – The text states that the M values are increasing with the newest SMS model; however, the figure caption states that the red is the updated version (but has lower M values). Is this a caption mistake? This needs some clarity.

Supplementary materials

Sprat Fcap 2024

Mollie Brooks

2024-03-22

Worm plots

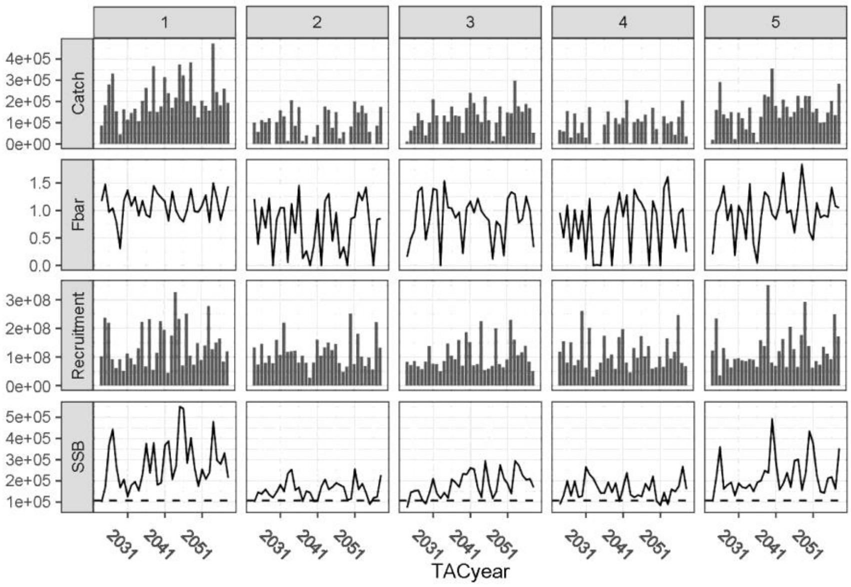

Figure 1: These are 5 simulation trials for one HCR with Fcap = 1

Risk by TACyear by Fcap and TACmin

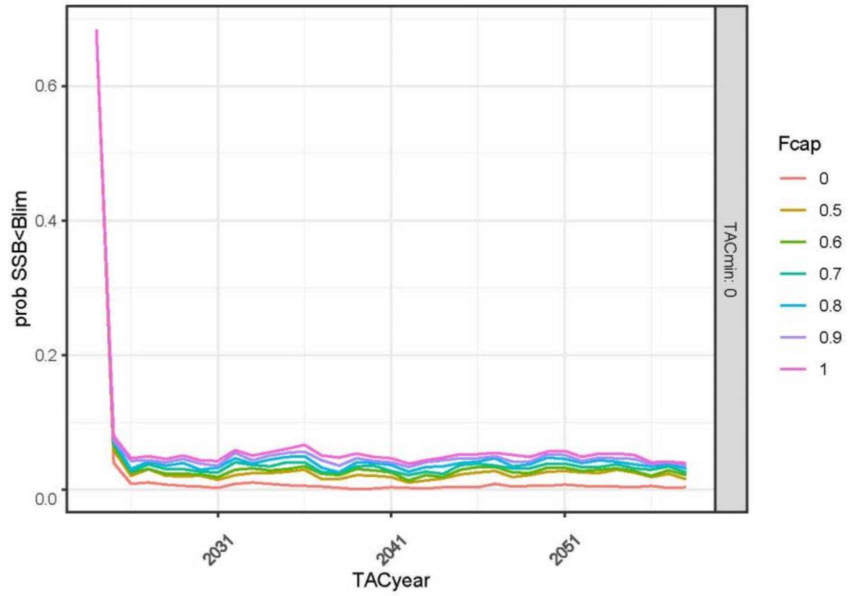

Figure 2: Risk by TACyear for different HCRs.

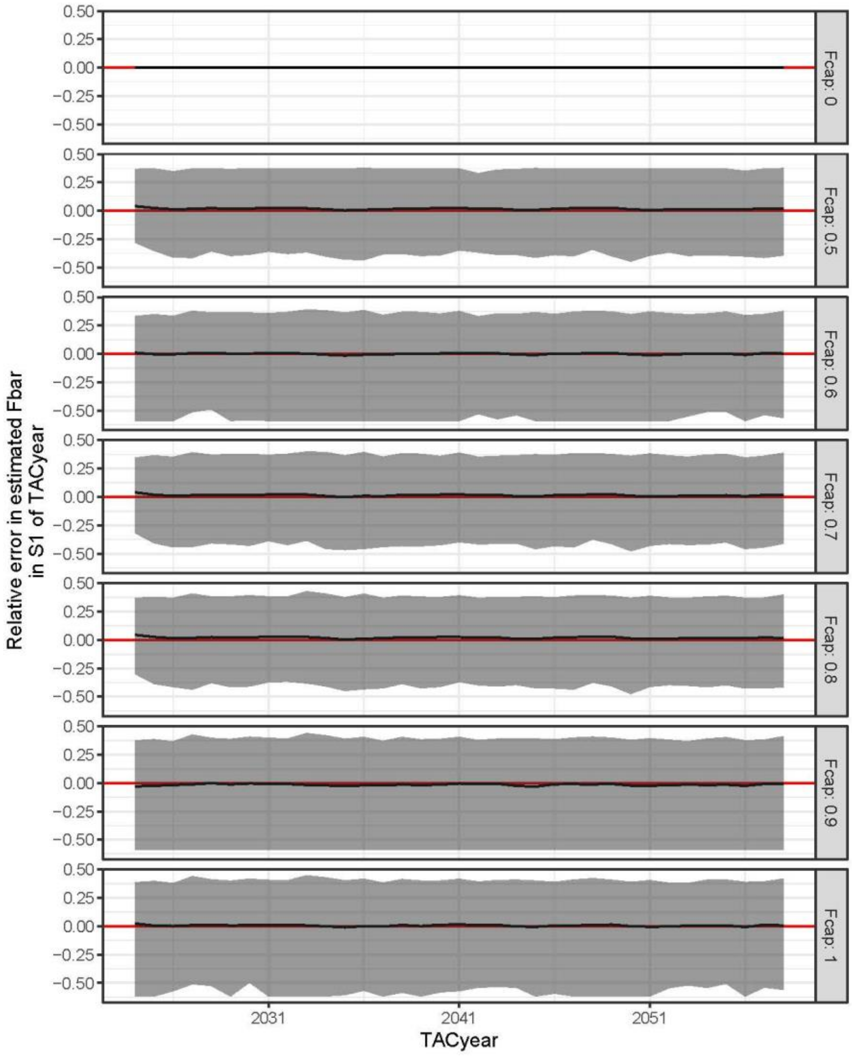

Figure 4: Error rate over time in estimated annual F for ages 1 and 2 (Fbar). The solid black line is the mean. The grey ribbons are 0.025 and 0.975 quantiles. The red line is 0.

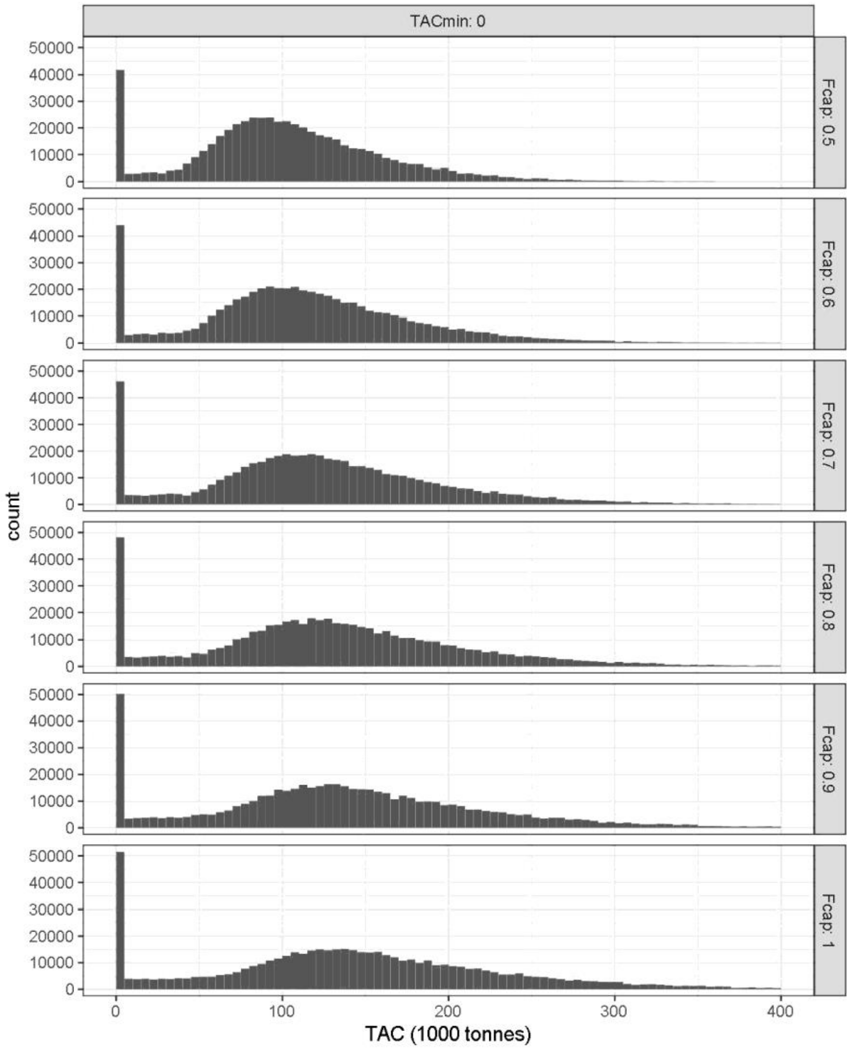

Figure 5: These are the TACs across all years of all simulation trials. The scale of the histogram is too big to see the values near 0.

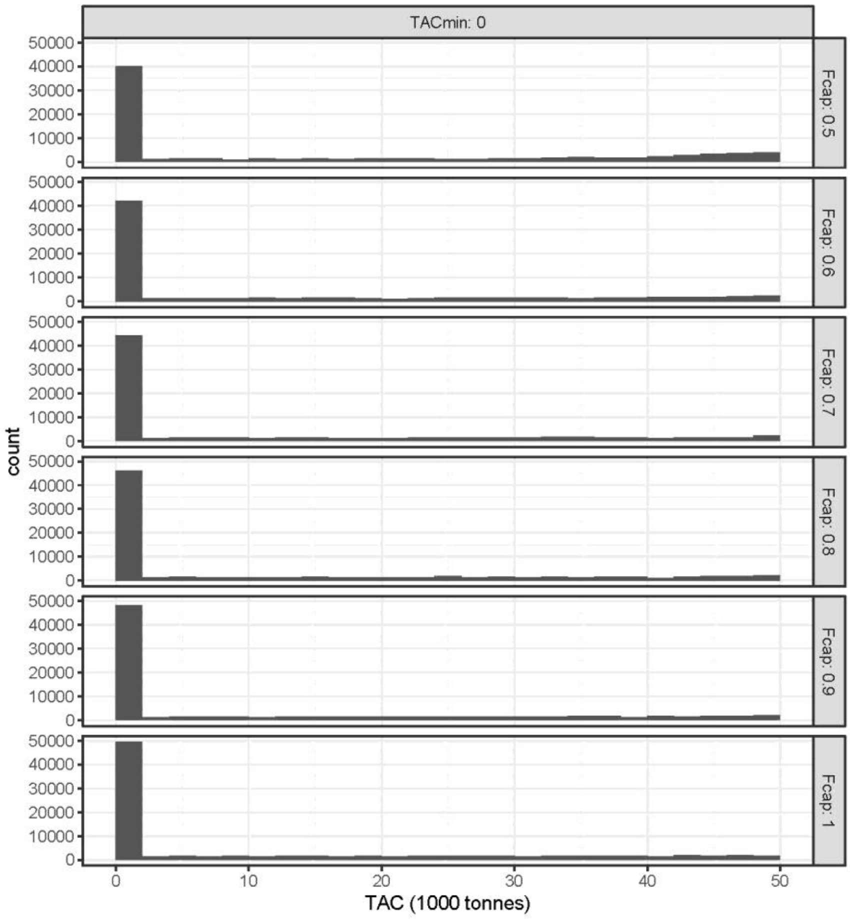

Figure 6: In this zoomed in portion of the histogram (only up to 50,000 tonnes), we can see the stacks at the minimum TAC value.

Summary plots

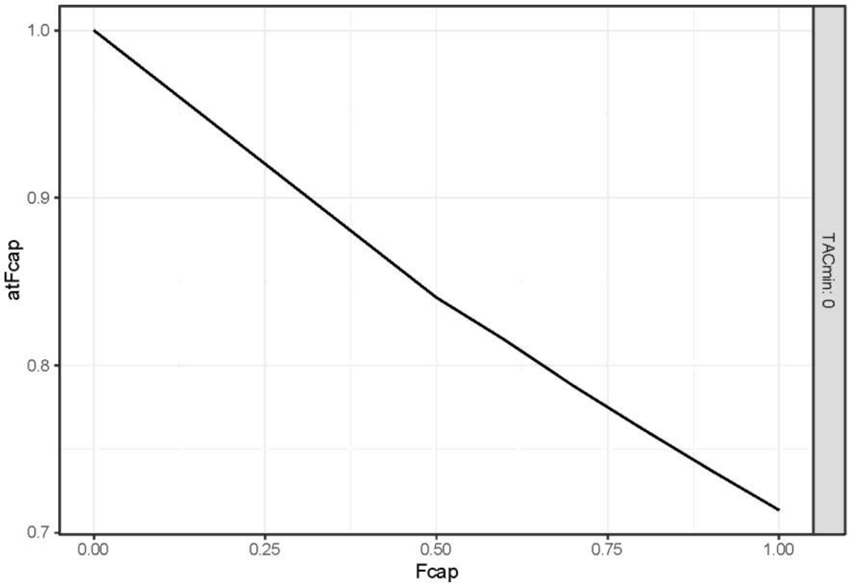

Figure 7: Probability that TAC is based on Fcap in years 2038 to 2058

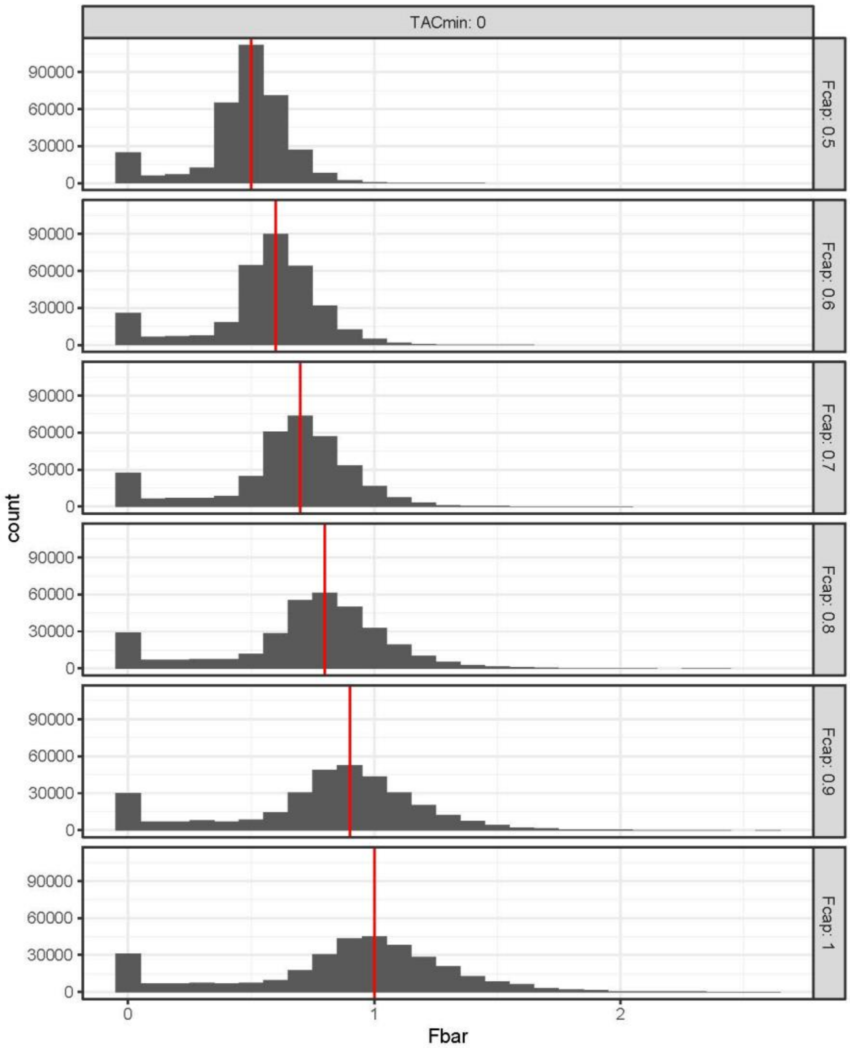

Figure 8: Implemented average F for ages 1 and 2. It can be over Fcap (red vertical line) because there is error in the values going into the forecast (estimated stock numbers, exploitation pattern) that is used to set the TAC. Our implementation model assumes that it will not exceed the highest estimated past effort 2.65.

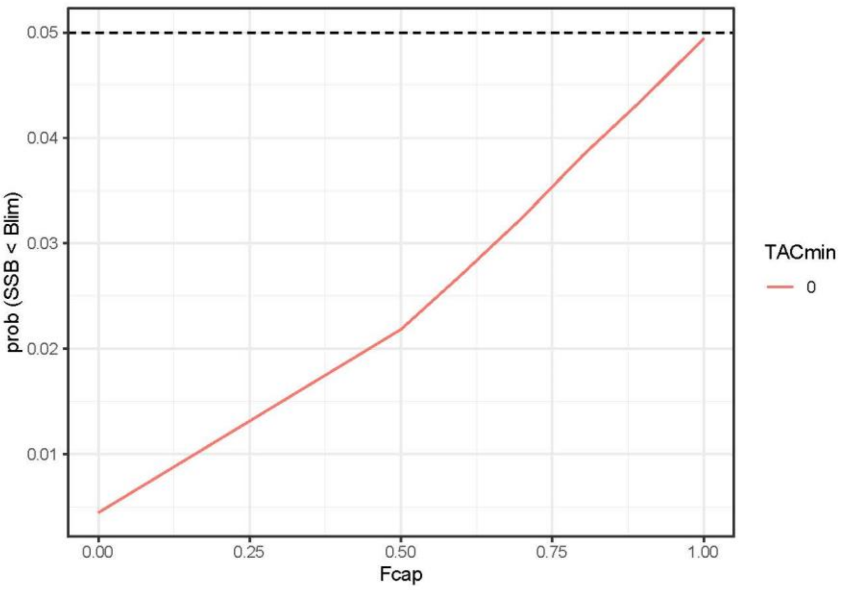

Figure 9: Average risk of SSB<Blim in 2038 to 2058 increases with Fcap. The dashed line is 0.05.

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Contents

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Annex 3: Working Documents

2023 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey

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The waters of Greifswald Bay (ICES area 24) are considered a major spawning area of Western Baltic spring spawning (WBSS) herring. The German Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). It delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. Onboard the research vessel FFS CLUPEA a sampling grid including 35 stations is sampled weekly using ichthyoplankton gear (Bongo-net, mesh size 335 µm) during the main reproduction period from March to June. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design can be found in Polte 2013, ICES WD08). The collected data provide an important baseline for detailed investigations of spawning and recruitment ecology of WBSS herring spawning components. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the assessment of the ICES Herring Assessment Working Group (HAWG).
The rationale for the *N20* recruitment index is based on strong correlations between the amount of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1-wr and 2-wr fish) as determined by acoustic surveys in the Arkona and Belt Seas (GERAS).
This correlation supports the underlying hypotheses that i) major variability of natural mortality occurs at early life stages before larvae reach a total length of 20 mm and ii) larval herring production in Greifswald Bay is an adequate proxy for annual recruitment strength of the WBSS herring stock.
The *N20* recruitment index is calculated every year based on data obtained from the RHLS. This is done by estimating weekly growth of larvae for seasonal temperature change and taking the sum of larvae reaching 20 mm by every survey week until the end of the investigation period. On the spatial scale, the 35 sampling stations are assigned to 5 strata and mean values of stations for each stratum are extrapolated to the strata area (for details see Oeberst et. al 2009).
Calculation procedures have been externally reviewed in 2006 and 2011. Consequently, the survey design was refined in 2007. Accordingly, the recalculated index for the time series from 1992 onwards is used by HAWG since 2008 as 0-group recruitment index for the assessment of Western Baltic Spring Spawning herring.

2023 N20 index results:

The regular Rügen-herring larvae Survey started on February 27th and continued weekly for 17 weeks until June 20th 2023 including a total of 582 stations/hauls. Along the entire Survey period, 13 stations had to be cancelled due to bad weather. However, an adequate coverage of stations (>19) could be sampled every week (minimum 29 stations).

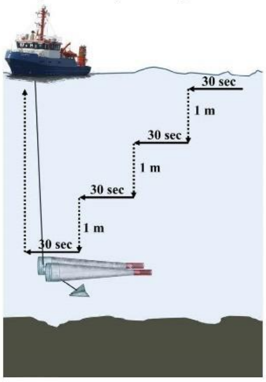

Figure 2. Schematic Bongo net sampling in the RHLS. Note that min. water depth is 4 m (10 m max.). Limit of the haul depth is 1 m above ground. Towing speed is 2 knots.

With an estimated product of **1 516 million** larvae, the 2023 *N20* recruitment index is > 4 times lower than in 2022 (6 603 million) when the index exceeded the time series mean (1992-2022: 6 137 million) for the first time after 11 years. Therefore, after two years of increasing larval production in 2021 and 2022, the 2023 N20 is again lower (Table 1, Figure 2).

Table 1: N20 larval herring index for spring spawning herring of the Western Baltic Sea (WBSS), generated by RHLS data.

Year	N20 (Millions)
1992	660
1993	4542
1994	15158
1995	9327
1996	24540
1997	5290
1998	18782
1999	22342
2000	3404
2001	5670
2002	12452
2003	4775
2004	6818
2005	5118
2006	4173
2007	1986
2008	1903
2009	7989
2010	8004
2011	4493
2012	1340
2013	3588
2014	681
2015	3001
2016	482
2017	1247
2018	1563
2019	1317
2020	239
2021	2751
2022	6603
2023	**1516**

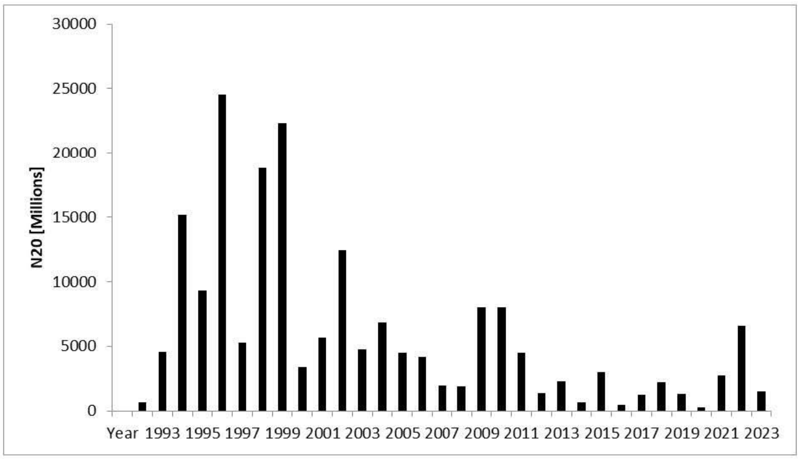

Figure 2 Time series of the N20 index (1992-2023). Time series average: 6095 million.

Correlation between N20 and GERAS 1-wr herring

Figure 3 shows the correlation between the N20 index and the 1-group monitored during the German hydroacoustic survey (GERAS) in October of the following year. After multiple years with the record low N20 (2014, 2016, 2020), the relation with the 1-group juveniles as monitored by the GERAS was re-evaluated to see if recent years with extremely low larvae production are reflected in the abundance of the 1-group juveniles of WBSSH in SDs 21-24. The results reveal that recent years resulted in a lower abundance of 1-wr juveniles detected during the GERAS compared to the period before 2019.

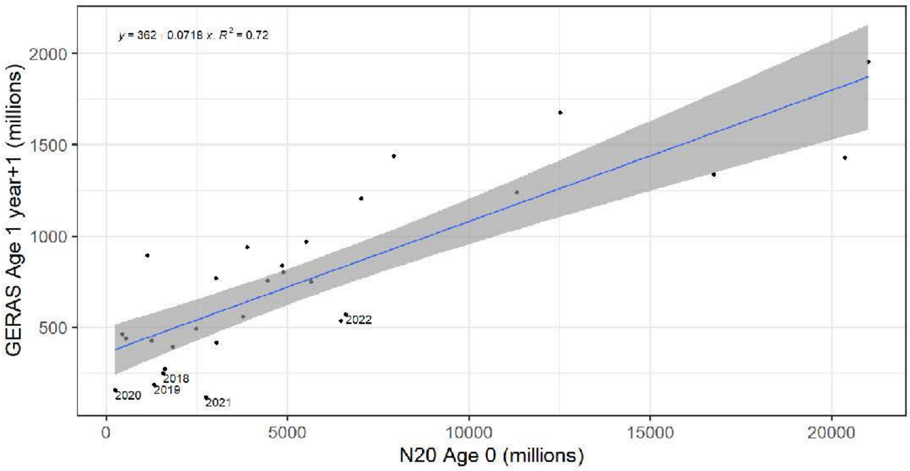

Figure 3 Correlation of N20 larvae index (1993-2022, excl. 2000) with the 1-wr herring from GERAS (1994-2023 excl. 2001 as SD 23 was not covered in that year). Note the one-year lag phase between indices, i.e. the exceptionally low GERAS 1-wr index 2021 is represented by the N20 year 2020 . The years 2018-2023 are labelled.

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PFA self-sampling report for North Sea herring fisheries, 2018-2023

HAWG 2024, Working document 02 / PFA report 2024_04

Including sprat and pilchard

Niels Hintzen and Lina de Nijs, 05/03/2024 15:54:29

1 Executive summary

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 18 freezer trawlers (in 2022) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers aimed at assessing the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions by haul and regularly taking length measurements from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen and Lina de Nijs. The self-sampling program has been incrementally implemented in the fishery and by 2018 all vessels in the PFA fleet participated in the self-sampling.

This report presents an overview of the self-sampling results for the North Sea herring fishery and the fisheries for sprat and pilchard. Vessel-trip-week combinations were selected based on the divisions of the fishery and a minimum amount and proportion of herring, sprat and pilchard.

The North Sea herring fishery takes place in two fishing seasons. The summer fishery is in the northern and central North Sea (ICES divisions 27.4.a and 27.4.b) during the months June – September. The winter fishery for roe-herring takes place in ICES division 27.7.d during December. PFA fisheries for sprat and pilchards are much smaller than the fishery for herring.

Overall, the self-sampling activities for the North Sea herring fisheries during the years 2018 – 2023 covered 502 fishing trips with 12,667 hauls, a total catch of 958,430 tonnes and 422,647 individual length measurements. On average, 64% of the catches are taken in the northern North Sea (ICES division 27.4.a), 18% in the Channel (27.7.d) and 12% in the central North Sea (27.4.b).

The fishery in 2023 was very similar to the fishery in the years before with similar lengths, locations and fat content throughout the season. Fishers have indicated that during the winter months, the fishery had taken place at different spots compared to years before, although this is difficult to visualize at ICES rectangle scale. Furthermore do fishers indicate a stronger presence of flyshoot fishers which may impair the reproductive capacity of herring as herring are being bycaught and discarded in the flyshoot fishery.

Herring is only targeted in the North Sea and English channel, in all other areas, such as 6a and further west, are only taken as bycatch.

Sprat is mostly fished in the central North Sea (27.4.b) and southern North Sea (27.4.c). Catches have been between almost zero and 2,500 tonnes. Median lengths of sprat have been between 10 and 13 cm.

Pilchard is mostly fished in the eastern Channel (27.7.d) and western Channel (27.7.e). Catches have been below 1,000 tonnes per year but in 2023 there were nearly 3000t of catches with some rectangles reporting very high catch rates. Median length of pilchard have been between 19 and 24 cm.

In 2022 a new method of converting length-to-length was implemented, based on the paper by Hansen et al (2018). The method consists of generating simulated length-length-keys similar to the often used age-length-keys. This method is applied in cases when the wrong length metric has been used on the vessel in a particular trip.

The PFA self-sampling program is currently a routine operation on the vessels in freezer-trawler fleet and is yielding consistent information at high temporal and spatial resolution. The information is intended to improve the scientific understanding in relation to the species fishing by the PFA. However, it is also used to inform the skippers and the fleet managers on the development of the fishery and the composition of the catches. Thus, the self-sampling program is providing an effective bridge and communication channel between science and practice.

2 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 18 freezer trawlers (in 2022) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring program is to assess the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Niels Hintzen (PFA chief science officer) and Lina de Nijs (PFA fisheries researcher).

3 Overview of self-sampling methodology

The PFA self-sampling program has been incrementally implemented on freezer-trawler vessels from the Netherlands, UK, Germany, France, Poland and Lithuania during the years 2015-2017. From 2018 onwards, all vessels in the association are covered by the self-sampling program. The program is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers the biological and fisheries information needed for the relevant scientific bodies (e.g. ICES, SPRFMO, CECAF), certification bodies (e.g. MSC) and as a mechanism of feedback for the participating companies.

The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)
- biological information (measuring individual fish)

The self-sampling information was initially collected using standardized Excel worksheets. From 2018 onwards a transition is being made from Excel spreadsheet to dedicated data-recording software (M-Catch) with live synchronization to a shore-based system. The information collected during a trip will be sent for data processing by the end of the trip. The self-sampling data is being checked and added to the database by Floor Quirijns, Lina de Nijs or Martin Pastoors, who also generate standardized trip reports (using RMarkdown) which are being sent back to the vessel and company. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling program.

For this report, the PFA self-sampling data has been filtered for vessel-trip-week combinations using the following criteria:

- hauls in divisions 27.4.a;27.4.b;27.4.c;27.7.d;27.6.a;27.7.b;27.7.c;27.7.g;27.7.e;27.7.h
- catch of her;pil;spr by trip and week at least 10% of the total catch of that trip and week.
- catch of her, pil, spr by trip and week at least 10 tonnes.

The selection resulted in 1097 vessel-trip-week combinations over the years 2018 - 2023.

4 Results

4.1 General

An overview of all the self-sampled trips for her, pil, spr in 27.4.a, 27.4.b, 27.4.c, 27.7.d, 27.6.a, 27.7.b, 27.7.c, 27.7.g, 27.7.e, 27.7.h. The percentage non-target species is defined as the catch of non-pelagic species relative to the catch of pelagic species.

year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nontarget	nlength	nbio
2018	14	79	826	2,158	169,068	205	0.08%	82,790	1,156
2019	13	66	694	1,825	135,794	196	0.12%	65,170	1,034
2020	15	71	712	1,968	154,148	217	0.48%	66,721	2,209
2021	18	77	702	1,730	146,019	208	0.65%	66,439	1,127
2022	16	97	950	2,306	175,452	185	0.71%	51,801	1,010
2023	16	112	1,021	2,680	177,950	174	0.37%	89,727	576
(all)		502	4,905	12,667	958,430			422,648	7,112

Table 3.1.1: PFA fisheries for herring, sprat and pilchard. Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes), catch per day(tonnes/day), percentage non-target species, number of fish measured and number of biological samples

Catch and number of self-sampled hauls by year and division

division	2018	2019	2020	2021	2022	2023	all	perc
27.4.a	99,309	73,854	95,626	107,021	124,496	124,085	624,390	65.1%
27.7.d	31,791	31,259	29,372	24,019	18,199	38,448	173,088	18.1%
27.4.b	31,880	26,835	23,295	2,885	10,015	2,394	97,305	10.2%
27.4.c	1,837	889	3,453	8,646	19,848	6,626	41,299	4.3%
27.6.a	2,904	2,005	2,028	205	1,470	4,296	12,908	1.3%
27.7.e	778	282	0	41	222	1,768	3,091	0.3%
27.7.b	25	481	164	2,106	139	19	2,934	0.3%
27.7.h	358	0	20	1,096	112	0	1,586	0.2%
27.7.g	179	138	191	0	951	0	1,459	0.2%
27.7.c	6	51	0	0	0	314	371	0.0%
(all)	169,068	135,794	154,148	146,019	175,452	177,950	958,430	100.0%

division	2018	2019	2020	2021	2022	2023	all	perc
27.4.a	1,128	925	1,055	1,114	1,381	1,505	7,108	56.1%
27.7.d	583	543	556	459	378	868	3,387	26.7%
27.4.b	323	271	272	30	146	59	1,101	8.7%
27.4.c	28	16	44	90	312	111	601	4.7%
27.6.a	63	41	21	10	20	59	214	1.7%
27.7.e	16	12	0	3	15	72	118	0.9%
27.7.g	5	4	6	0	34	0	49	0.4%
27.7.b	1	12	13	14	7	1	48	0.4%
27.7.h	10	0	1	15	13	0	39	0.3%
27.7.c	1	1	0	0	0	5	7	0.1%
(all)	2,158	1,825	1,968	1,735	2,306	2,680	12,672	100.0%

*Table 3.1.2: PFA fisheries for herring, sprat and pilchard. Self-sampling Summary of catch (top) and number of hauls (bottom) per year and division. * denotes incomplete year*

Catch and number of self-sampled hauls by year and month

month	2018	2019	2020	2021	2022	2023	all	perc
Jan	5,489	2,300	841	751	4,206	4,962	18,550	1.9%
Feb	683	50	156	814	684	3,585	5,972	0.6%
Mar	0	0	0	0	0	1,180	1,180	0.1%
May	0	0	0	411	1,856	528	2,796	0.3%
Jun	16,319	7,312	18,931	11,452	22,045	15,320	91,378	9.5%
Jul	58,674	19,408	35,254	37,989	35,851	45,333	232,511	24.3%
Aug	34,004	35,070	43,581	42,673	36,887	40,855	233,069	24.3%
Sep	18,896	26,252	19,109	8,985	27,112	14,450	114,803	12.0%
Oct	4,416	12,277	1,344	9,186	11,129	6,003	44,356	4.6%
Nov	5,094	8,363	10,956	12,811	6,941	10,645	54,812	5.7%
Dec	25,492	24,762	23,976	20,947	28,740	35,088	159,004	16.6%
(all)	169,068	135,794	154,148	146,019	175,452	177,950	958,430	100.0%

month	2018	2019	2020	2021	2022	2023	all	perc
Jan	88	36	17	14	92	90	337	2.7%
Feb	7	1	1	20	9	114	152	1.2%
Mar	0	0	0	0	0	35	35	0.3%
May	0	0	0	8	21	7	36	0.3%
Jun	249	107	274	213	324	232	1,399	11.0%
Jul	587	242	373	393	367	578	2,540	20.0%
Aug	370	396	417	381	409	437	2,410	19.0%
Sep	210	313	250	107	329	196	1,405	11.1%
Oct	76	156	18	83	124	85	542	4.3%
Nov	94	139	162	154	103	176	828	6.5%
Dec	477	435	456	382	528	730	3,008	23.7%
(all)	2,158	1,825	1,968	1,755	2,306	2,680	12,692	100.0%

Table 3.1.3: PFA fisheries for herring, sprat and pilchard. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch and number of self-sampled hauls by year and country (flag)

flag	2018	2019	2020	2021	2022	2023	all	perc
DEU	27,065	25,086	23,045	18,479	41,523	32,494	167,692	17.5%
FR	25,122	23,107	16,071	23,231	28,476	29,558	145,564	15.2%
LIT	0	0	6,388	1,474	0	9,520	17,381	1.8%
NL	89,637	70,335	87,267	87,422	84,333	84,398	503,393	52.5%
POL	0	0	0	684	0	0	684	0.1%
UK	27,244	17,266	21,377	13,514	19,870	21,980	121,250	12.7%
NA	0	0	0	1,215	1,250	0	2,465	0.3%
(all)	169,068	135,794	154,148	146,019	175,452	177,950	958,430	100.0%

flag	2018	2019	2020	2021	2022	2023	all	perc
DEU	389	369	296	247	509	397	2,207	17.4%
FR	445	438	273	354	444	493	2,447	19.3%
LIT	0	0	71	10	0	116	197	1.6%
NL	988	824	1,087	896	1,039	1,249	6,083	48.0%
POL	0	0	0	5	0	0	5	0.0%
UK	336	194	241	181	312	425	1,689	13.3%
NA	0	0	0	37	2	0	39	0.3%
(all)	2,158	1,825	1,968	1,730	2,306	2,680	12,667	100.0%

Table 3.1.4: PFA fisheries for herring, sprat and pilchard. Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch by species and year

species	english_name	scientific_name	2018	2019	2020	2021	2022	2023	all	perc
her	herring	Clupea harengus	156,569	126,285	136,423	126,811	154,848	152,320	853,255	89.0%
mac	mackerel	Scomber scombrus	6,131	6,492	8,663	11,178	14,150	14,055	60,668	6.3%
hom	horse mackerel	Trachurus trachurus	3,998	2,473	4,201	5,200	3,398	4,272	23,542	2.5%
whb	blue whiting	Micromesistius poutassou	492	219	1,487	895	670	3,267	7,029	0.7%
pil	pilchard	Sardina pilchardus	688	134	49	677	429	2,853	4,831	0.5%
spr	sprat	Sprattus sprattus	1,038	32	2,408	138	507	34	4,157	0.4%
had	haddock	Melanogrammus aeglefinus	10	6	231	288	826	205	1,567	0.2%
arg	argentines	Argentina spp	0	0	171	170	205	475	1,021	0.1%
whg	whiting	Merlangius merlangus	31	47	118	92	147	169	604	0.1%
boc	boarfish	Capros aper	1	22	51	317	12	1	405	0.0%
nop	norway pout	Trisopterus esmarkii	14	10	213	40	118	6	401	0.0%
pok	saithe	Pollachius virens	43	60	73	65	31	119	391	0.0%
brb	black seabream	Spondyliosoma cantharus	27	11	45	101	53	84	321	0.0%
hke	hake	Merluccius merluccius	2	1	5	42	3	5	57	0.0%
squ	various squids nei	Loliginidae, Ommastrephidae	0	0	0	0	1	48	49	0.0%
oth	NA	NA	24	2	9	4	56	35	130	0.0%
(all)	(all)	(all)	169,068	135,794	154,148	146,019	175,452	177,950	958,430	100.0%

Table 3.1.5: PFA fisheries for herring, sprat and pilchard. Self-sampling Summary of total catch (tonnes) by species. OTH refers to all other species that are not the main target species

Haul positions

An overview of all self-sampled hauls in the PFA fisheries for herring, sprat and pilchard..

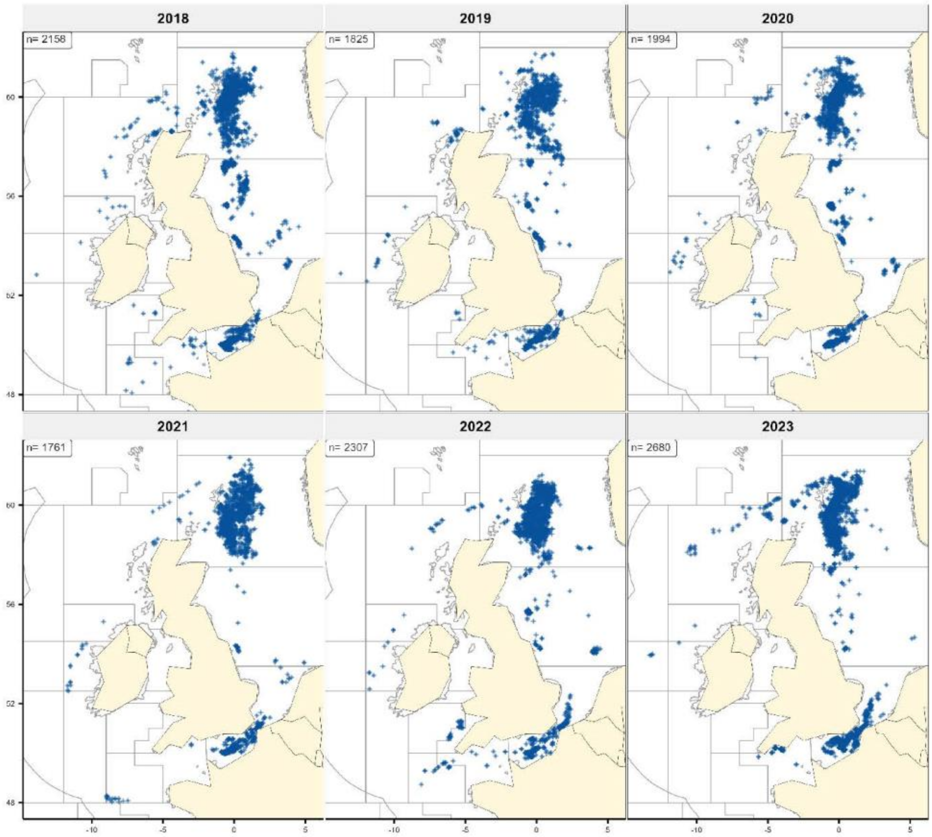

Figure 3.1.1: PFA fisheries for herring, sprat and pilchard. Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

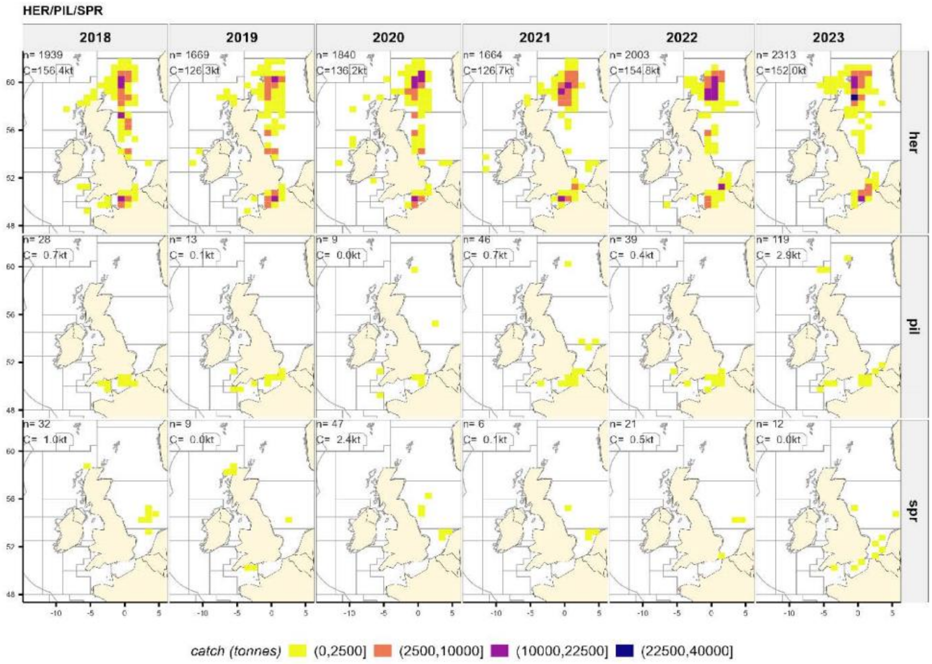

Figure 3.1.2: PFA fisheries for herring, sprat and pilchard. Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

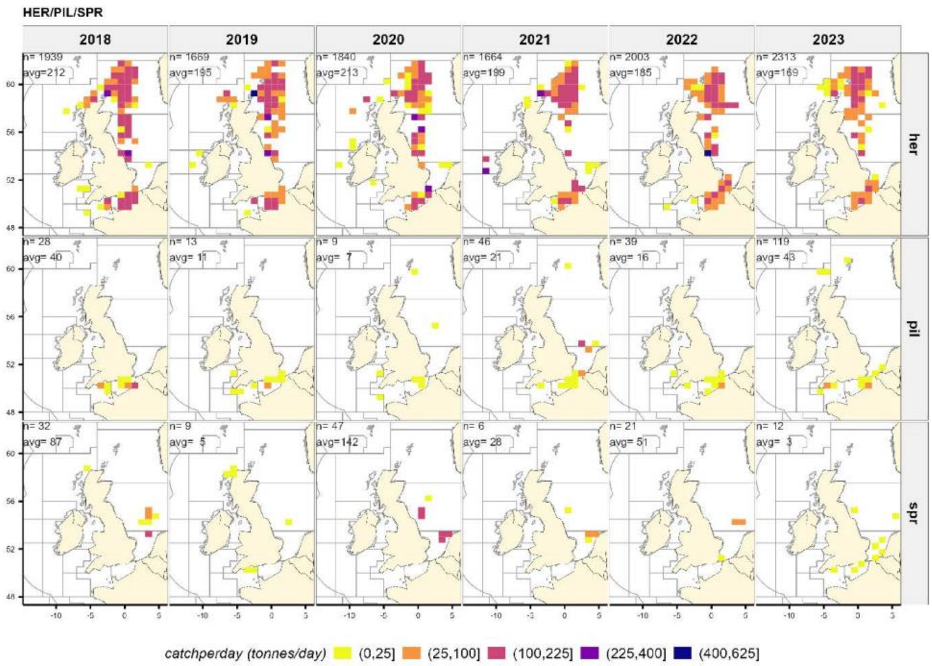

Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

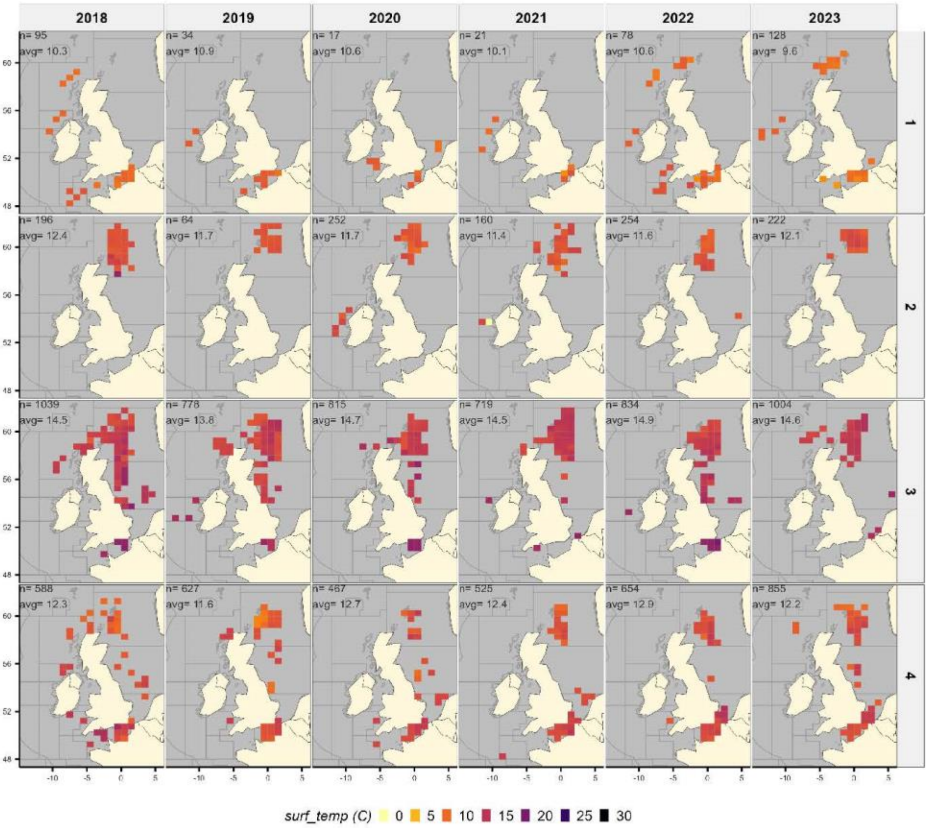

Figure 3.1.4: PFA fisheries for herring, sprat and pilchard. Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

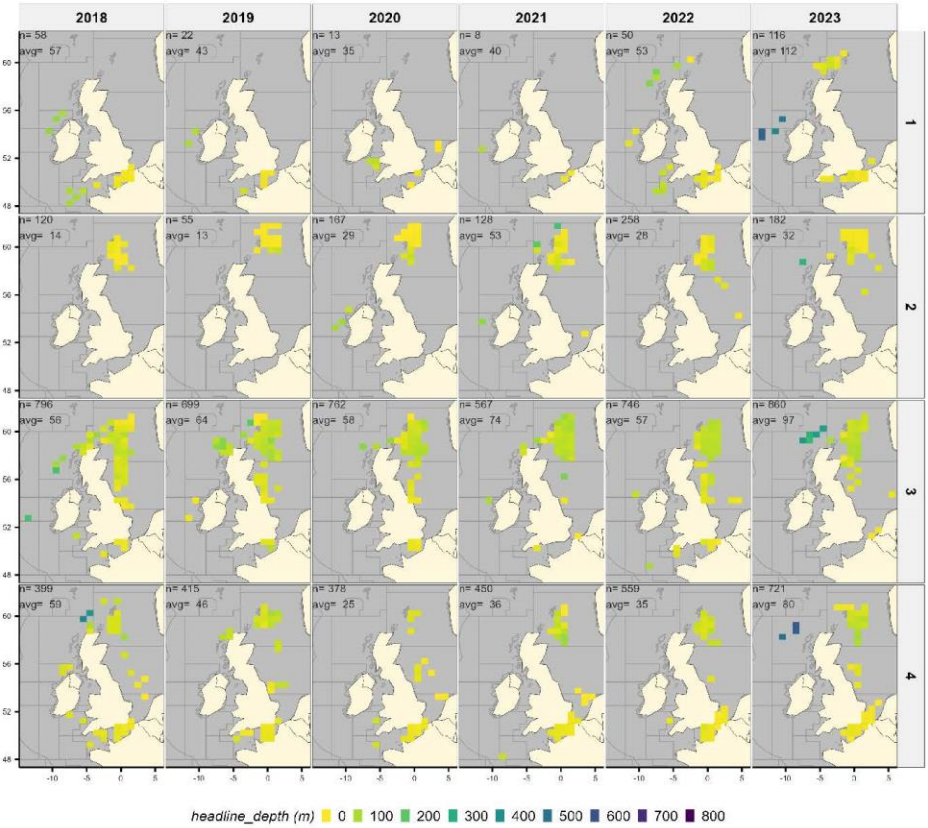

Figure 3.1.5: PFA fisheries for herring, sprat and pilchard. Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

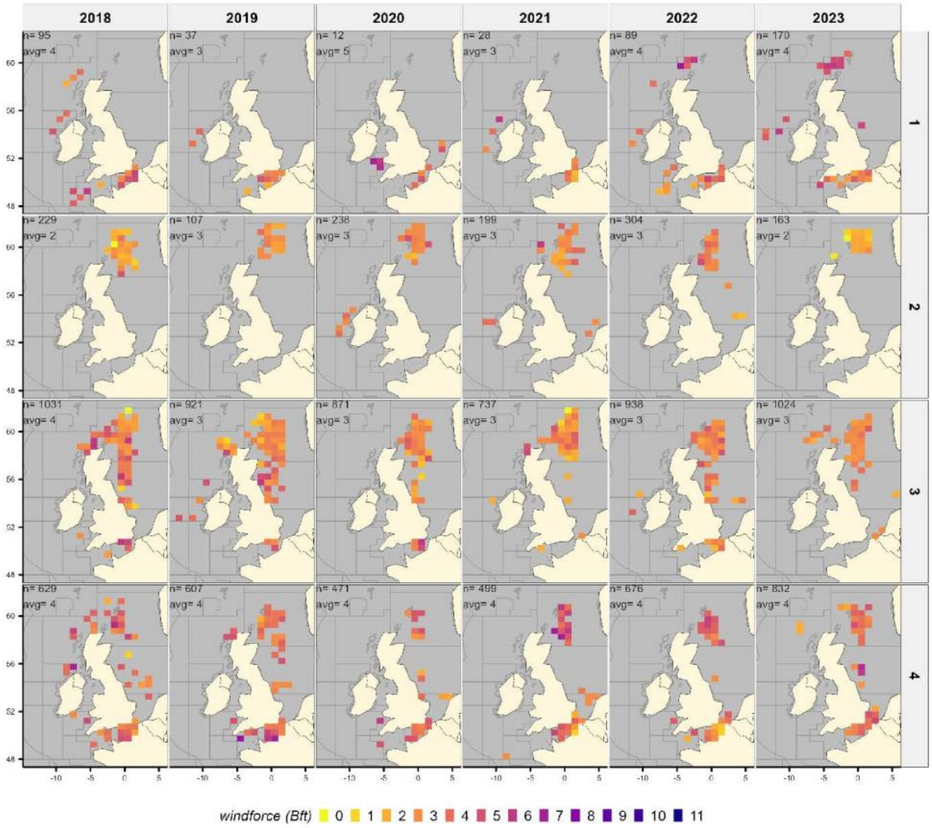

Figure 3.1.6: PFA fisheries for herring, sprat and pilchard. Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

4.2 Herring (North Sea) (HER, Clupea harengus)

Herring (North Sea) self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
her	2018	14	76	714	1,905	154,299	216	66,557	200
her	2019	13	64	631	1,643	124,808	198	48,074	0
her	2020	15	69	632	1,763	136,093	215	51,344	463
her	2021	18	72	633	1,581	125,819	199	55,171	0
her	2022	16	91	838	2,000	154,848	185	41,152	451
her	2023	16	109	895	2,302	152,196	170	67,624	0
(all)	(all)		481	4,343	11,194	848,062		329,922	1,114

Table 3.2.1: Herring (North Sea). Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Herring (North Sea). Catch by division

species	division	2018	2019	2020	2021	2022	2023	all	perc
her	27.4.a	94,154	67,579	86,777	93,553	110,222	110,840	563,124	66.4%
her	27.4.b	31,362	26,521	22,178	2,361	9,151	2,275	93,847	11.1%
her	27.4.c	1,090	746	1,739	8,253	19,506	5,147	36,481	4.3%
her	27.7.d	27,693	29,963	25,400	21,651	15,970	33,934	154,611	18.2%
(all)	(all)	154,299	124,808	136,093	125,819	154,848	152,196	848,062	100.0%

Table 3.2.2: Herring (North Sea). Self-sampling summary with the catch (tonnes) by year and division

Herring (North Sea). Catch by month

species	month	2018	2019	2020	2021	2022	2023	all	perc
her	Jan	3,674	1,311	25	689	2,201	1,487	9,388	1.1%
her	Feb	234	50	156	601	343	906	2,290	0.3%
her	Mar	0	0	0	0	0	233	233	0.0%
her	May	0	0	0	0	965	346	1,311	0.2%
her	Jun	16,086	7,239	17,883	10,883	21,103	14,613	87,808	10.4%
her	Jul	57,934	18,904	34,387	35,476	34,502	43,959	225,161	26.6%
her	Aug	33,367	33,738	41,624	39,124	35,195	39,521	222,568	26.2%
her	Sep	16,287	23,380	14,465	7,183	22,395	11,267	94,977	11.2%
her	Oct	1,376	8,756	164	3,088	4,946	2,103	20,433	2.4%
her	Nov	1,550	7,098	6,459	8,952	5,468	7,005	36,532	4.3%
her	Dec	23,790	24,333	20,930	19,822	27,730	30,756	147,362	17.4%
(all)	(all)	154,299	124,808	136,093	125,819	154,848	152,196	848,062	100.0%

Table 3.2.3: Herring (North Sea). Self-sampling summary with the catch (tonnes) by year and month

Herring (North Sea). Catch by rectangle

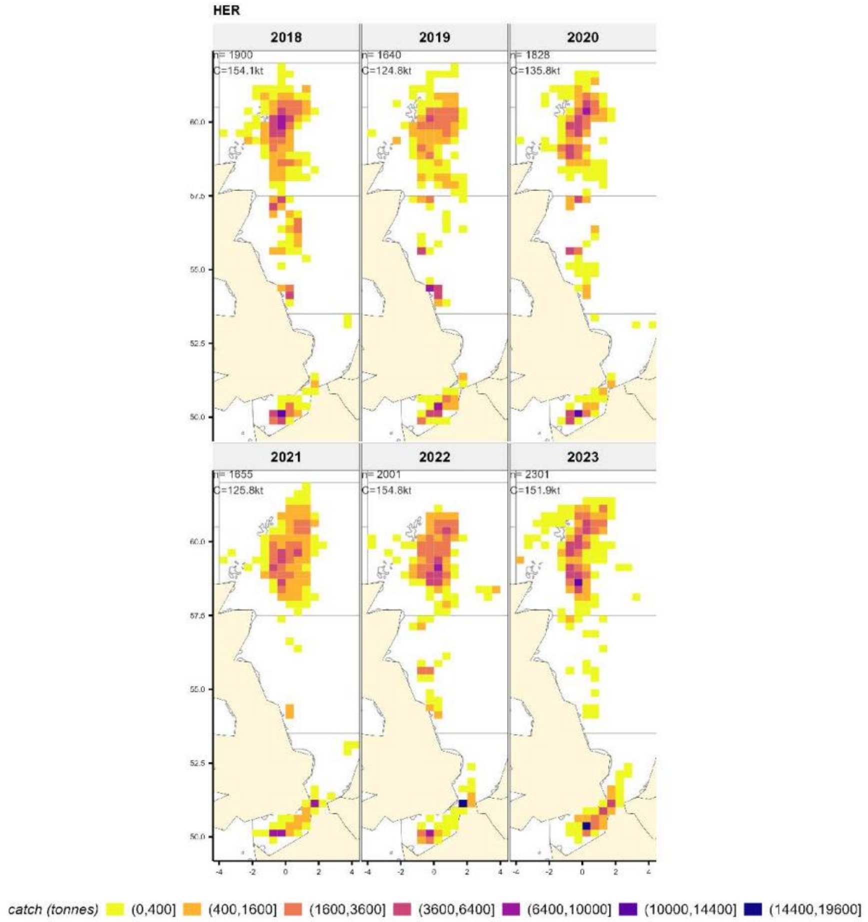

Figure 3.2.1: Herring (North Sea). Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Herring (North Sea). Catchrate (ton/day) by rectangle

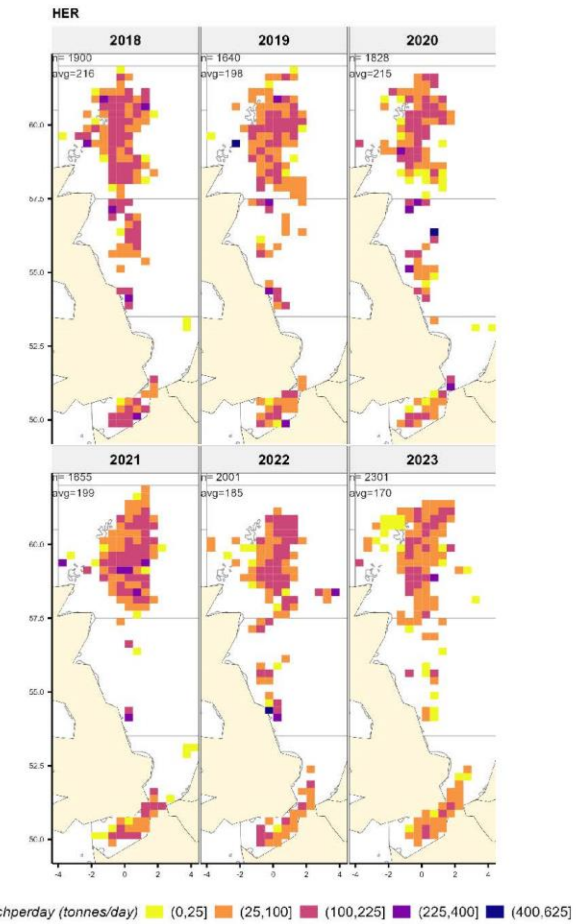

Figure 3.2.2: Herring (North Sea). Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Herring (North Sea). Spatio-temporal evolution of catch by month and rectangle

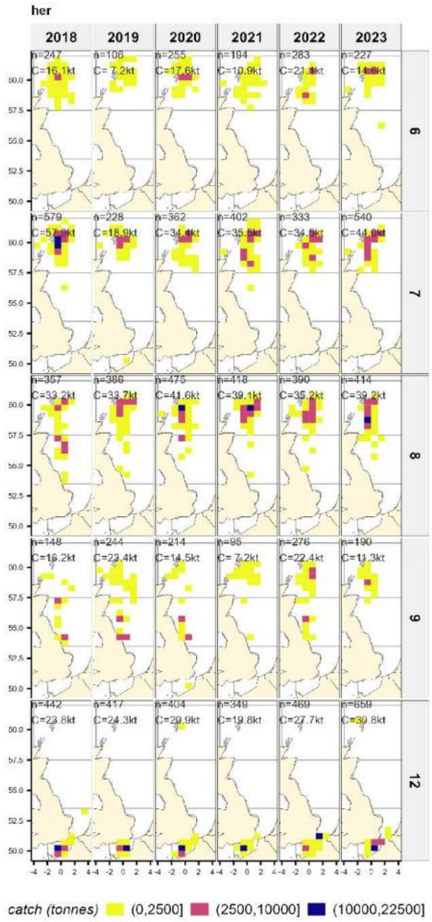

Figure 3.2.3: Herring (North Sea). Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Herring (North Sea). Length distributions of the catch

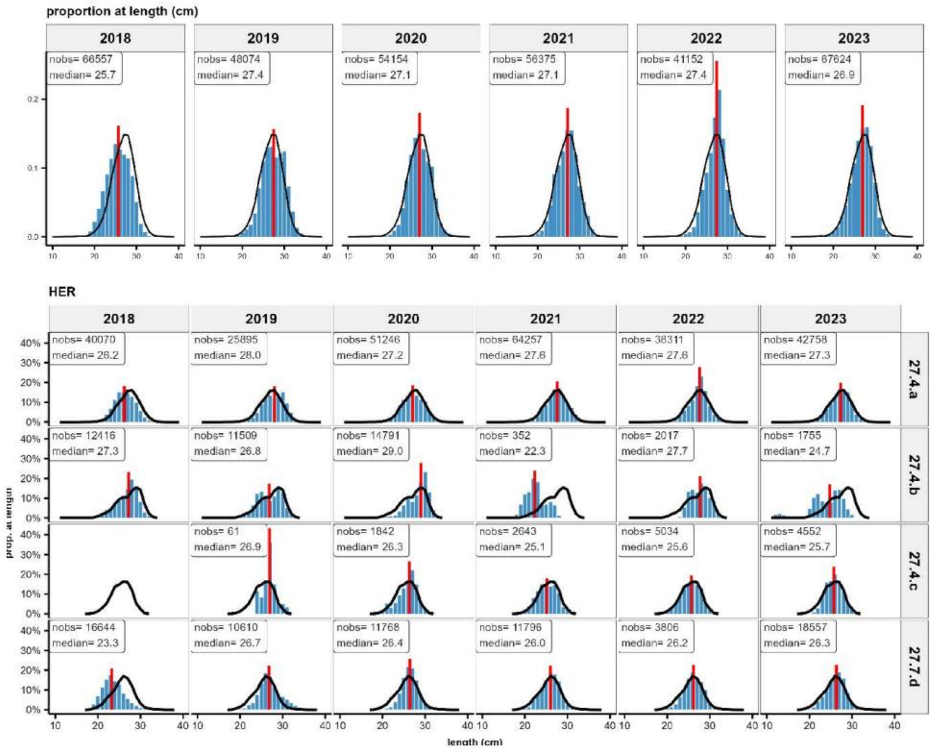

Figure 3.2.4: Herring (North Sea). Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Herring (North Sea). Length distributions as proportions by (large) rectangle

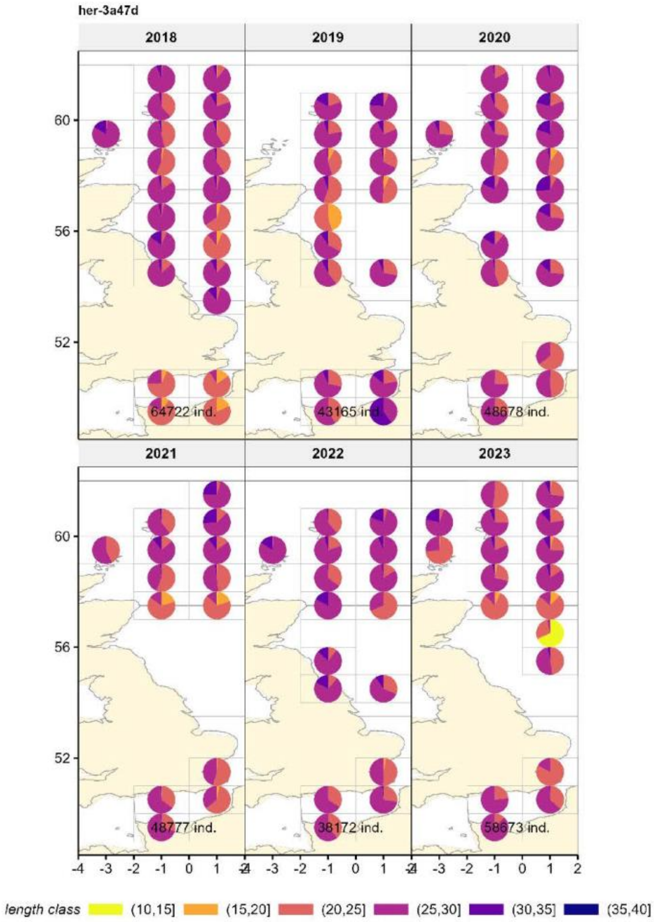

Figure 3.2.5: Herring (North Sea). Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

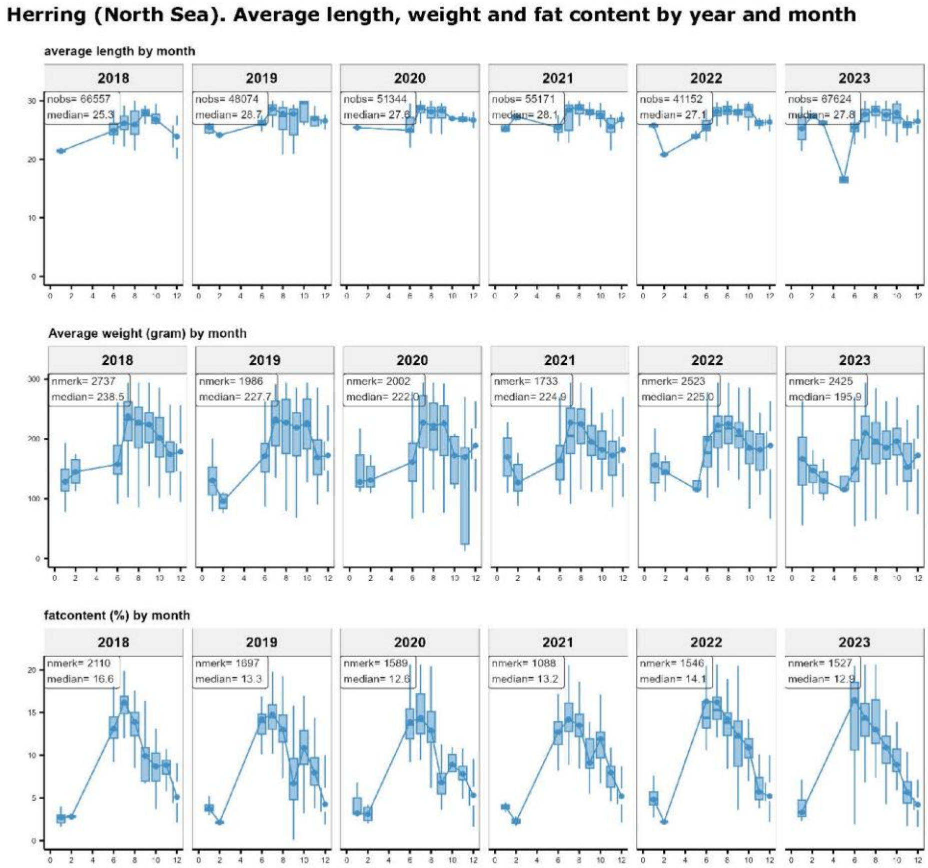

Figure 3.2.6: Herring (North Sea). Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Herring (North Sea) (HER). Standardized CPUE

Standardized CPUE (ton/day) from GAM model with factors year, s(month), GT, division and s(depth) with log(days) or log(hauls) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019). We notice a steady decline in CPUE over the years with the main differences between the days vs hauls as offset in 2020 and 2023 where a dip in CPUE was predicted in 2020 followed by an increase for the haul based models while a steady decline was observed in this period for the models with offset(Days). For 2023 the models differ again suggesting an increase in stock size for the models with days as offset while the models for which hauls were used as an offset suggest a decline. It should be noted that 2023 was ex-ceptional in the number of hauls taken, suggesting that many more smaller hauls were taken compared to years before while catches only showed a small increase. Nominal CPUE dropped from 2022-2023 as well, which is given in Table 3.1.1.

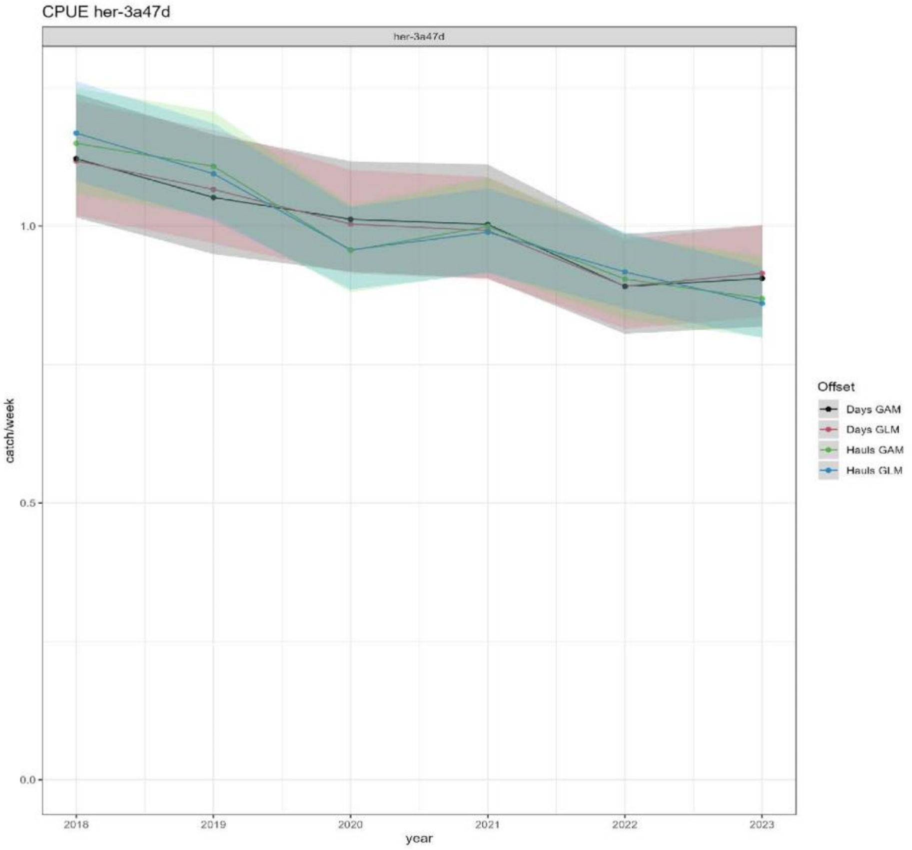

Figure 3.2.7: Herring (North Sea). Standardized CPUE (`per week) from GAM model with factors year, GT, division and with smoother terms for month and depth with log(days) or log(hauls) as offset

Herring (North Sea) (HER). CPUE correlations

Exploration of correlations between year, number of rectangles fished per vessel and year, summed catch per vessel and year, number of fishing days per vessel and year and the average catch per vessel and per day.

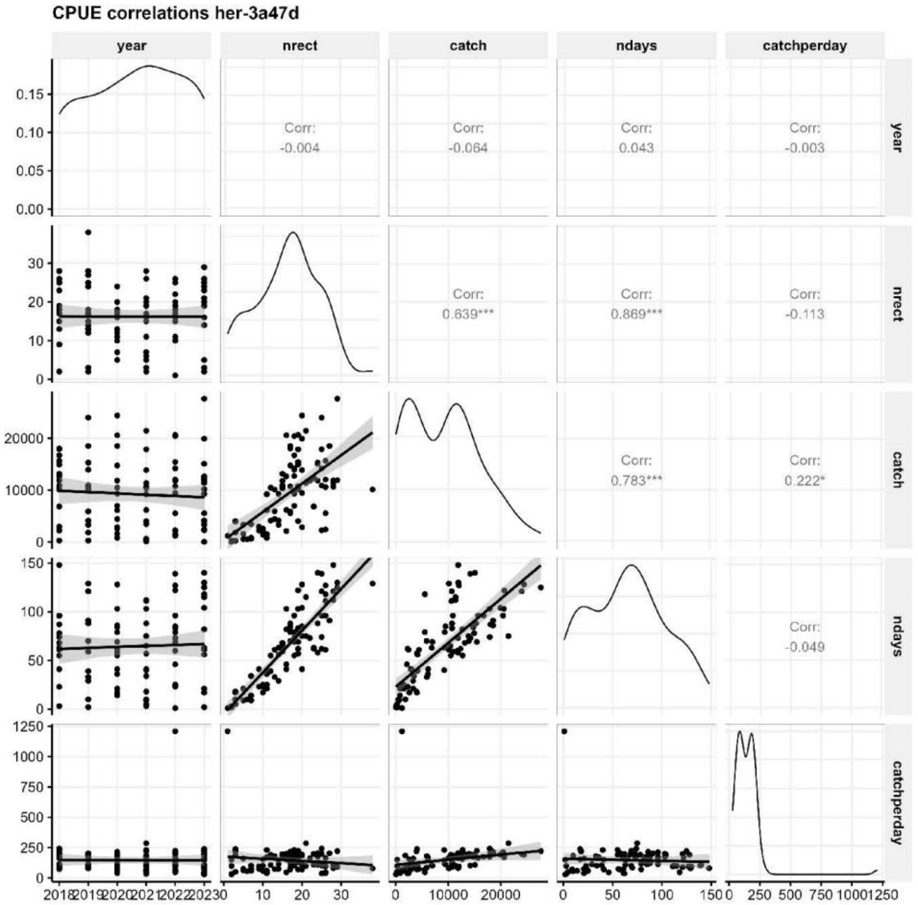

Figure 3.2.8: Herring (North Sea). Correlations between year, number of rectangles, catch, number of days and catch per day

4.3 Herring (4ab) (HER, Clupea harengus)

Herring (4ab) self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
her	2018	14	57	559	1,398	125,515	225	49,913	200
her	2019	11	43	470	1,123	94,099	200	37,403	0
her	2020	15	51	483	1,274	108,954	226	41,609	3
her	2021	17	51	463	1,108	95,914	207	42,821	0
her	2022	15	63	636	1,417	119,372	188	32,312	451
her	2023	14	74	619	1,495	113,115	183	44,515	0
(all)	(all)		339	3,230	7,815	656,970		248,573	654

Table 3.3.1: Herring (4ab). Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Herring (4ab). Catch by division

species	division	2018	2019	2020	2021	2022	2023	all	perc
her	27.4.a	94,154	67,579	86,777	93,553	110,222	110,840	563,124	85.7%
her	27.4.b	31,362	26,521	22,178	2,361	9,151	2,275	93,847	14.3%
(all)	(all)	125,515	94,099	108,954	95,914	119,372	113,115	656,970	100.0%

Table 3.3.2: Herring (4ab). Self-sampling summary with the catch (tonnes) by year and division

Herring (4ab). Catch by month

species	month	2018	2019	2020	2021	2022	2023	all	perc
her	Jan	0	0	0	0	138	486	624	0.1%
her	May	0	0	0	0	965	346	1,311	0.2%
her	Jun	16,086	7,239	17,883	10,883	21,103	14,613	87,808	13.4%
her	Jul	57,934	18,829	34,387	35,476	34,502	43,959	225,086	34.3%
her	Aug	33,367	33,738	41,624	39,124	35,195	39,521	222,568	33.9%
her	Sep	16,287	23,380	14,273	7,183	22,395	11,267	94,785	14.4%
her	Oct	1,376	8,756	69	3,088	4,946	2,103	20,338	3.1%
her	Nov	465	2,158	634	160	129	549	4,095	0.6%
her	Dec	0	0	84	0	0	271	355	0.1%
(all)	(all)	125,515	94,099	108,954	95,914	119,372	113,115	656,970	100.0%

Table 3.3.3: Herring (4ab). Self-sampling summary with the catch (tonnes) by year and month

Herring (4ab). Catch by rectangle

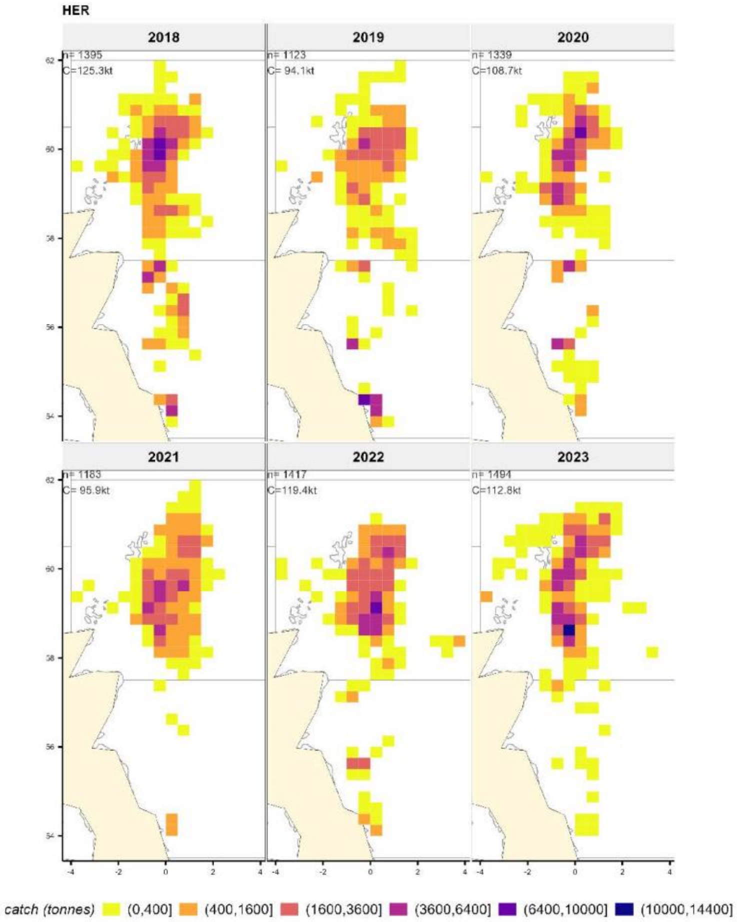

Figure 3.3.1: Herring (4ab). Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Herring (4ab). Catchrate (ton/day) by rectangle

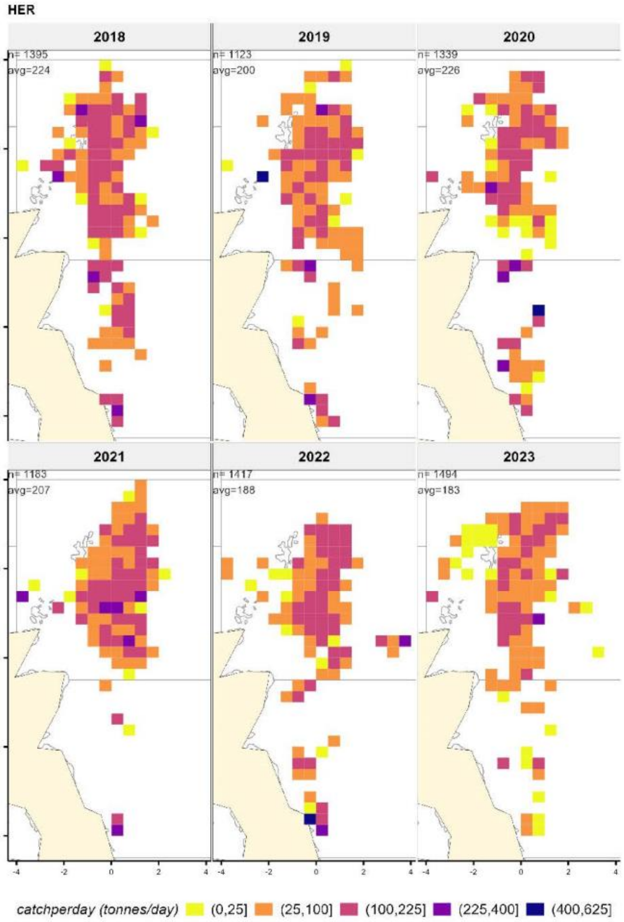

Figure 3.3.2: Herring (4ab). Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Herring (4ab). Spatio-temporal evolution of catch by month and rectangle

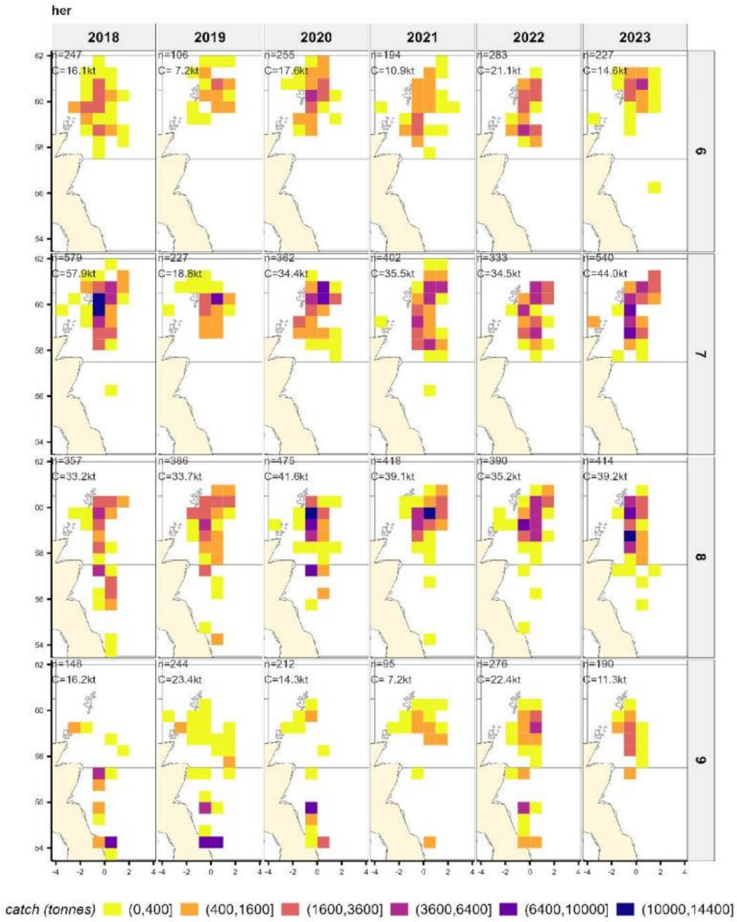

Figure 3.3.3: Herring (4ab). Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Herring (4ab). Length distributions of the catch

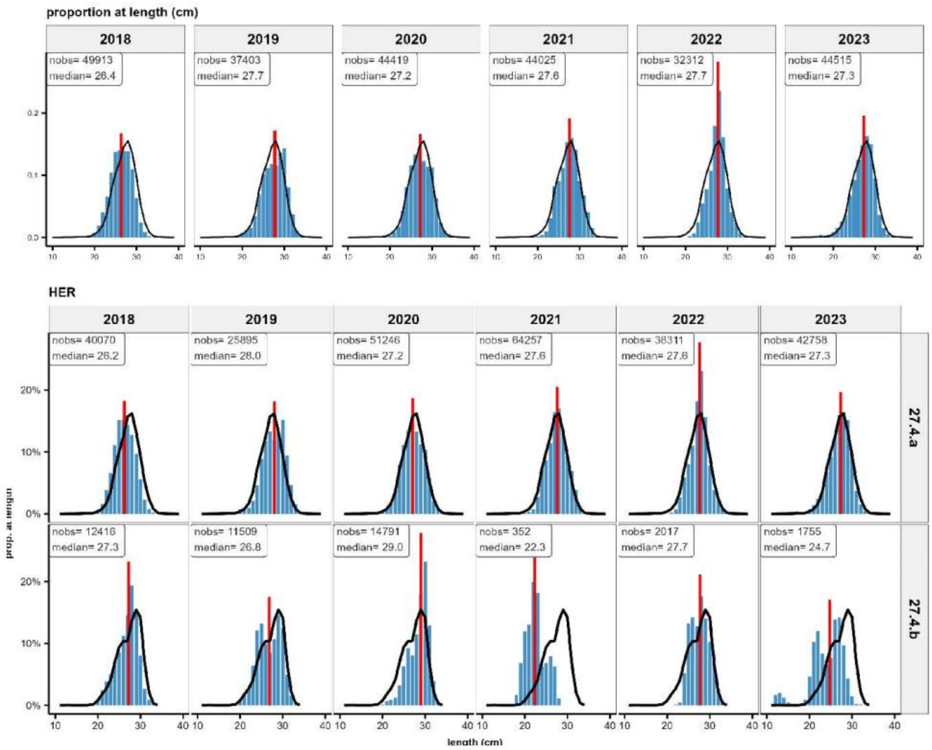

Figure 3.3.4: Herring (4ab). Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Herring (4ab). Length distributions as proportions by (large) rectangle

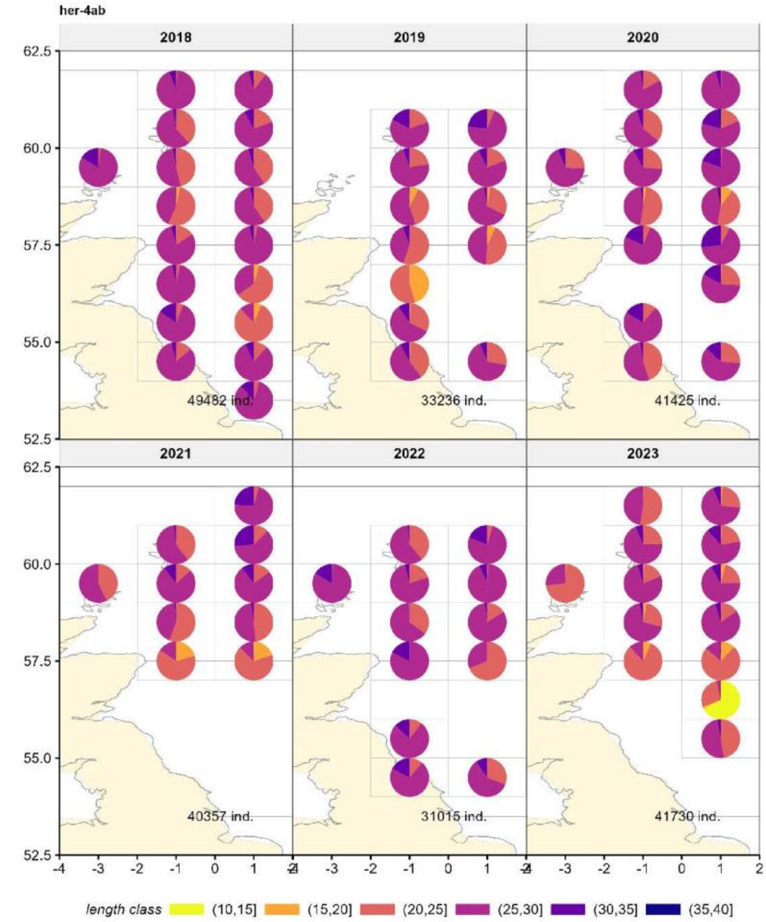

Figure 3.3.5: Herring (4ab). Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

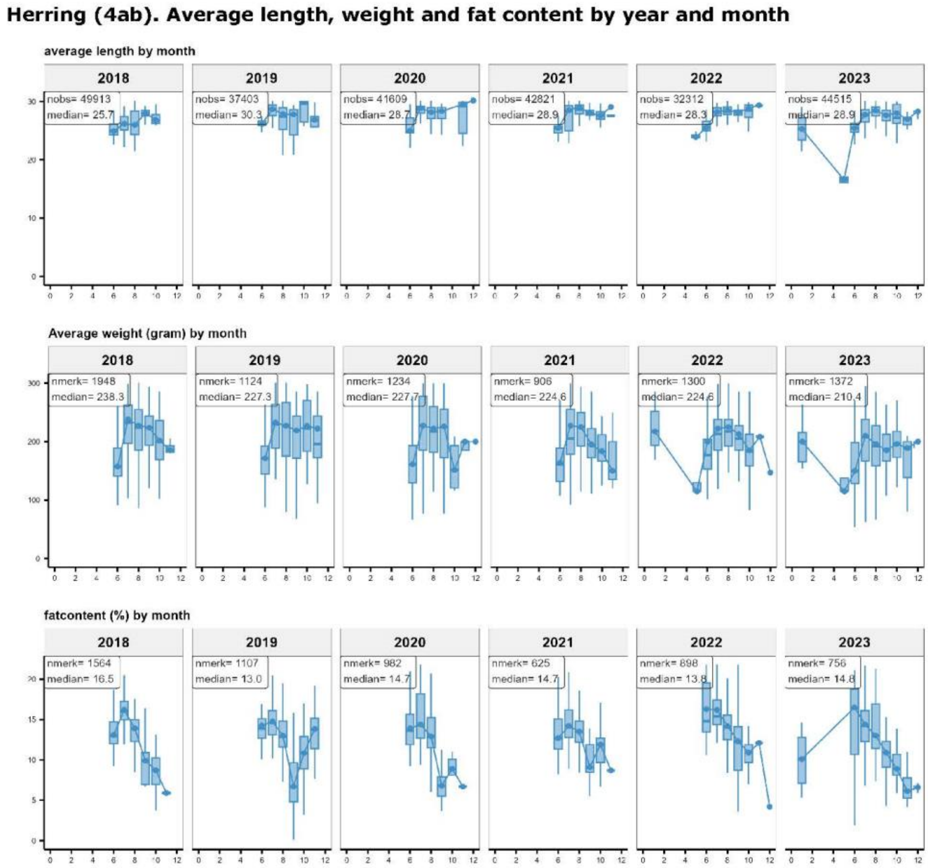

Figure 3.3.6: Herring (4ab). Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Herring (4ab) (HER). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

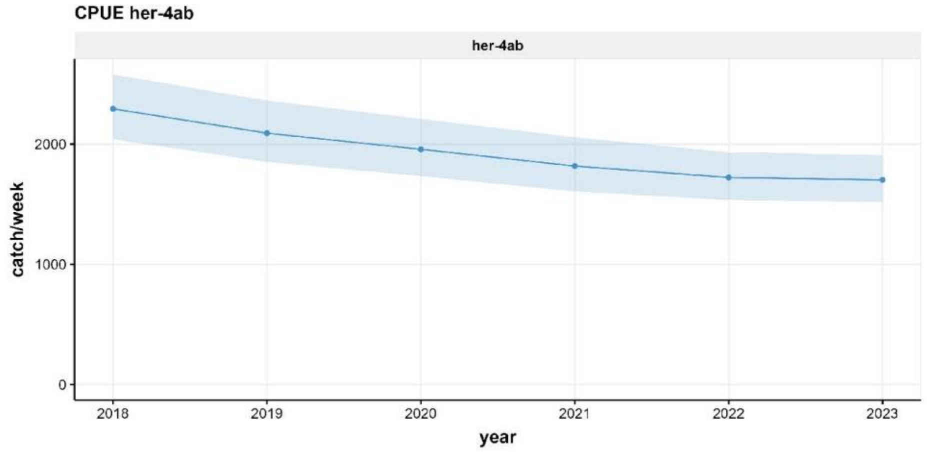

Figure 3.3.7: Herring (4ab). Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

Herring (4ab) (HER). CPUE correlations

Exploration of correlations between year, number of rectangles fished per vessel and year, summed catch per vessel and year, number of fishing days per vessel and year and the average catch per vessel and per day.

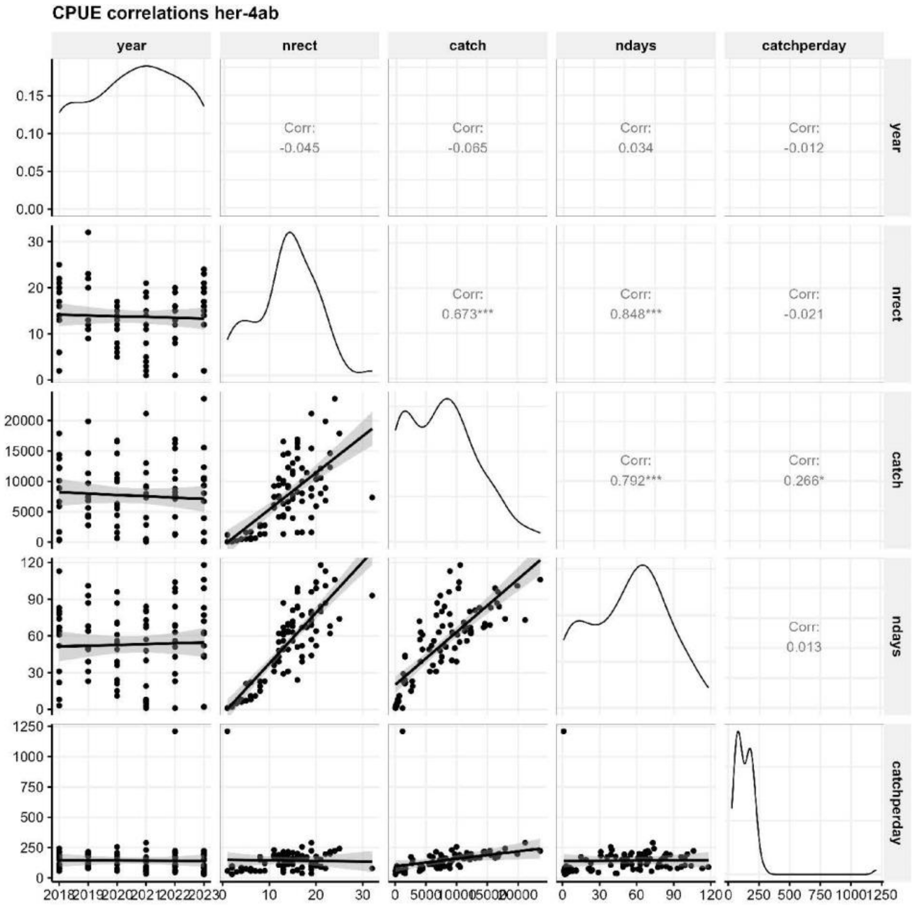

Figure 3.3.8: Herring (4ab). Correlations between year, number of rectangles, catch, number of days and catch per day

4.4 Herring (4c7d Downs) (HER, Clupea harengus)

Herring (4c7d Downs) self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
her	2018	11	20	155	507	28,784	186	16,644	0
her	2019	12	22	162	520	30,709	190	10,671	0
her	2020	11	21	150	489	27,139	181	9,735	460
her	2021	14	24	170	473	29,904	176	12,350	0
her	2022	14	31	202	583	35,475	176	8,840	0
her	2023	13	36	276	807	39,081	142	23,109	0
(all)	(all)		154	1,115	3,379	191,092		81,349	460

Table 3.4.1: Herring (4c7d Downs). Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Herring (4c7d Downs). Catch by division

species	division	2018	2019	2020	2021	2022	2023	all	perc
her	27.4.c	1,090	746	1,739	8,253	19,506	5,147	36,481	19.1%
her	27.7.d	27,693	29,963	25,400	21,651	15,970	33,934	154,611	80.9%
(all)	(all)	28,784	30,709	27,139	29,904	35,475	39,081	191,092	100.0%

Table 3.4.2: Herring (4c7d Downs). Self-sampling summary with the catch (tonnes) by year and division

Herring (4c7d Downs). Catch by month

species	month	2018	2019	2020	2021	2022	2023	all	perc
her	Jan	3,674	1,311	25	689	2,063	1,000	8,764	4.6%
her	Feb	234	50	156	601	343	906	2,290	1.2%
her	Mar	0	0	0	0	0	233	233	0.1%
her	Jul	0	75	0	0	0	0	75	0.0%
her	Sep	0	0	192	0	0	0	192	0.1%
her	Oct	0	0	95	0	0	0	95	0.0%
her	Nov	1,085	4,940	5,825	8,792	5,339	6,456	32,437	17.0%
her	Dec	23,790	24,333	20,845	19,822	27,730	30,486	147,007	76.9%
(all)	(all)	28,784	30,709	27,139	29,904	35,475	39,081	191,092	100.0%

Table 3.4.3: Herring (4c7d Downs). Self-sampling summary with the catch (tonnes) by year and month

Herring (4c7d Downs). Catch by rectangle

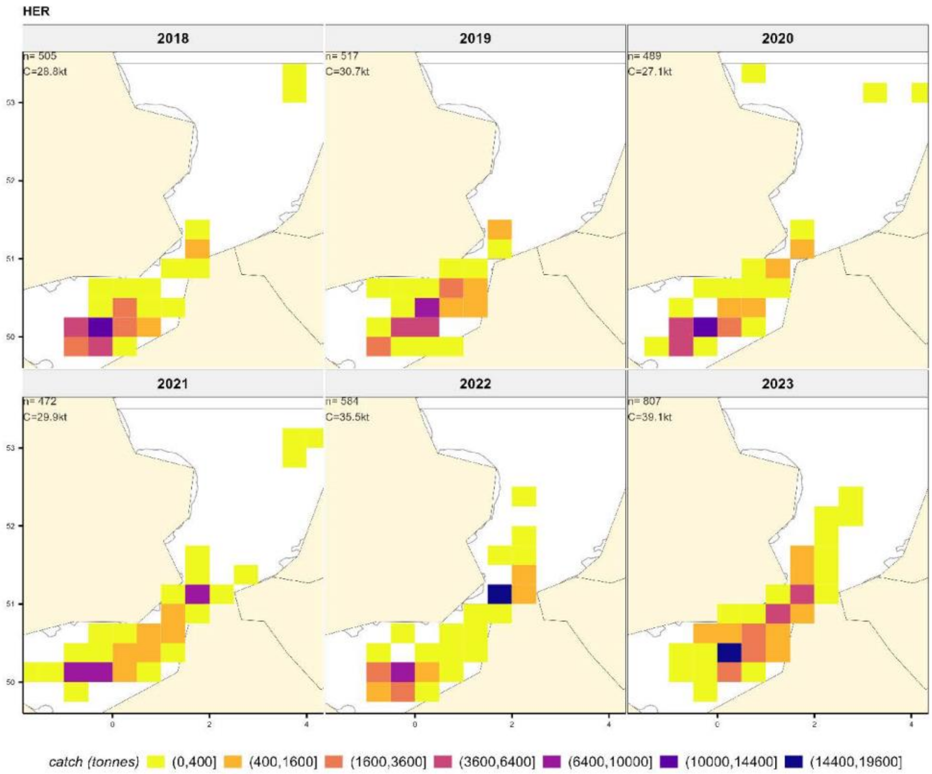

Figure 3.4.1: Herring (4c7d Downs). Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Herring (4c7d Downs). Catchrate (ton/day) by rectangle

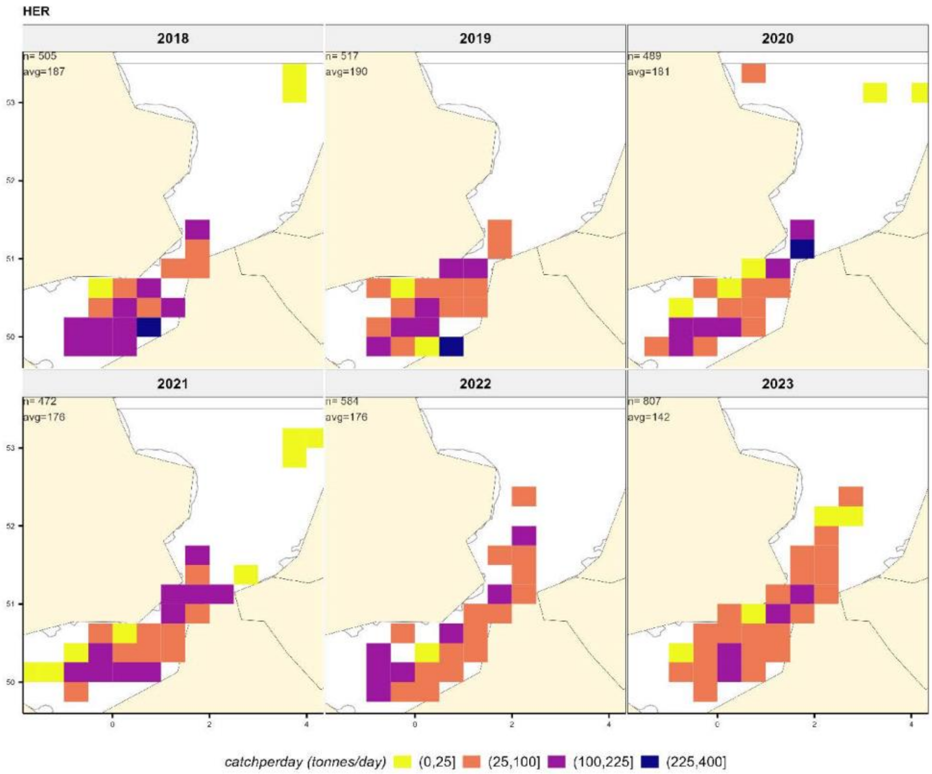

Figure 3.4.2: Herring (4c7d Downs). Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Herring (4c7d Downs). Spatio-temporal evolution of catch by month and rectangle

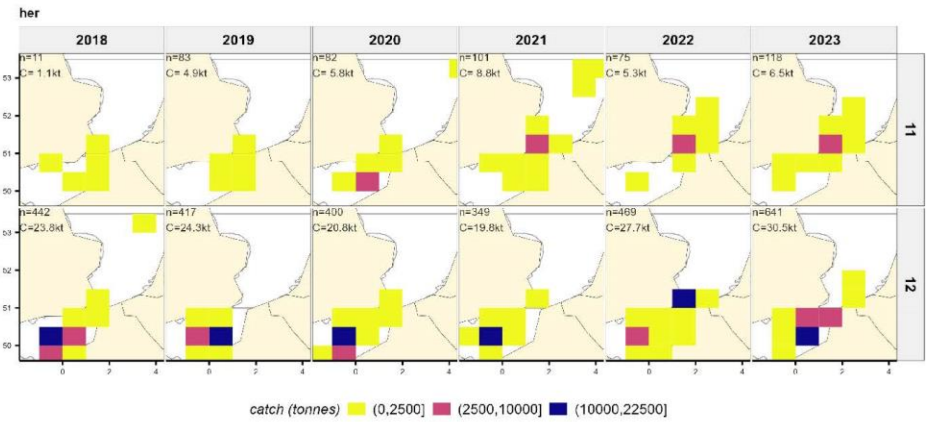

Figure 3.4.3: Herring (4c7d Downs). Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

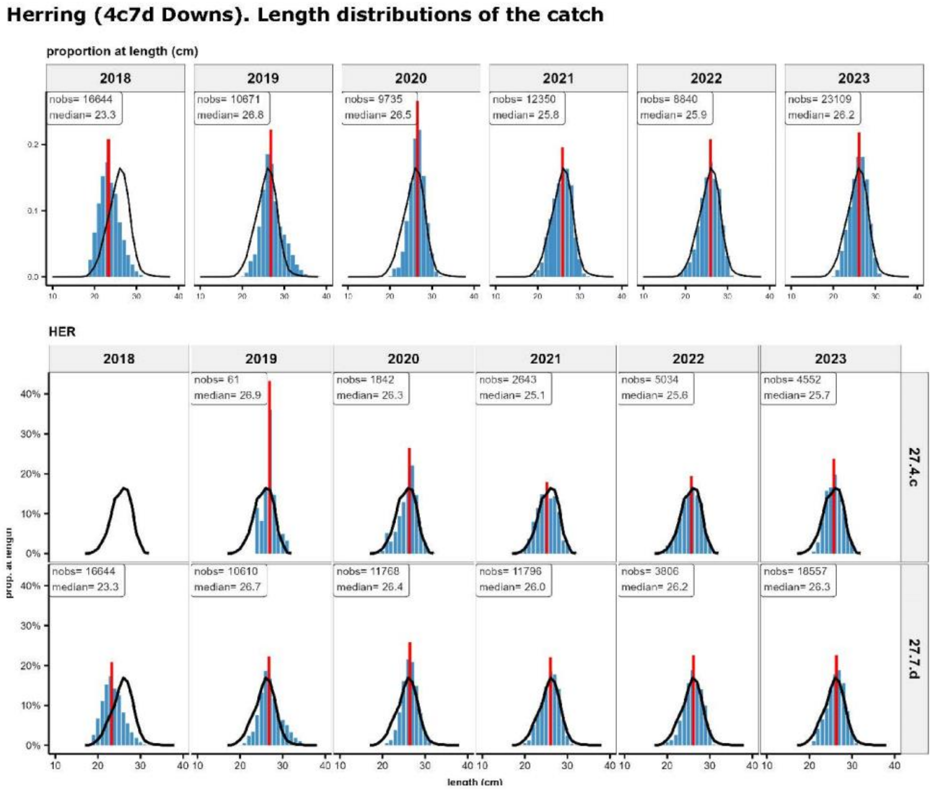

Figure 3.4.4: Herring (4c7d Downs). Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Herring (4c7d Downs). Length distributions as proportions by (large) rectangle

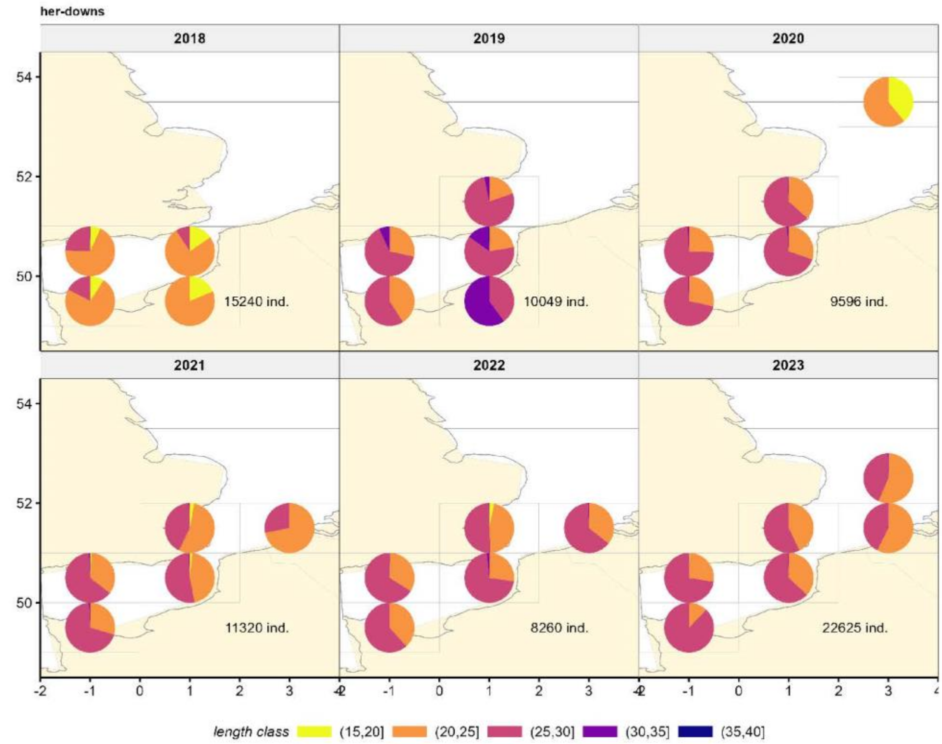

Figure 3.4.5: Herring (4c7d Downs). Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Herring (4c7d Downs). Average length, weight and fat content by year and month

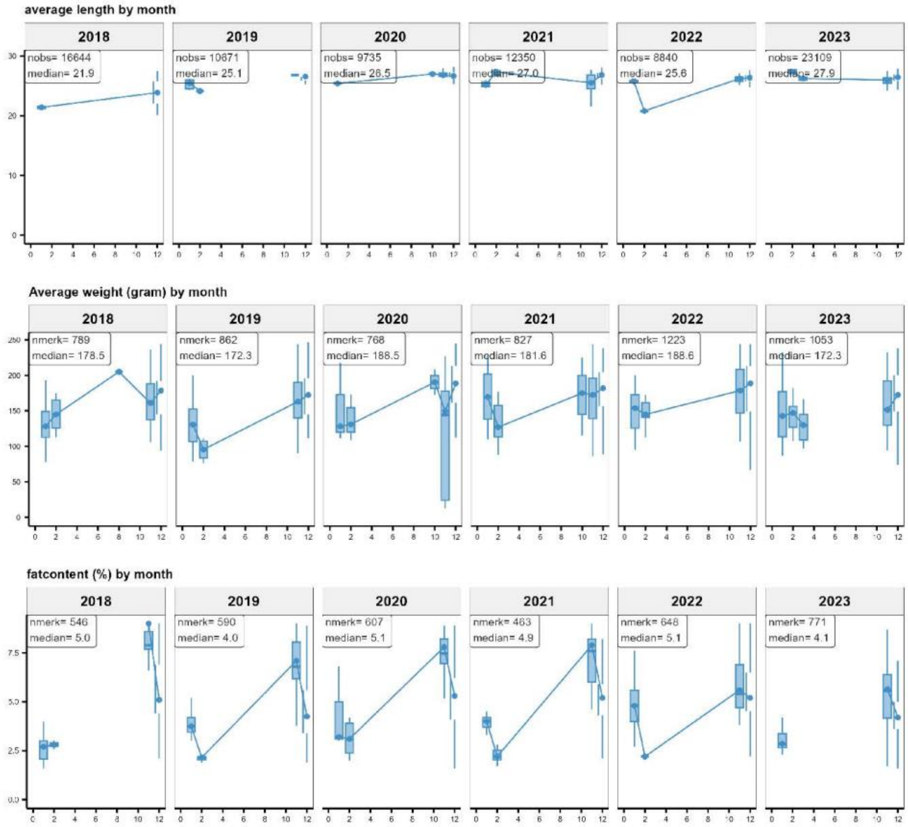

Figure 3.4.6: Herring (4c7d Downs). Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Herring (4c7d Downs) (HER). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

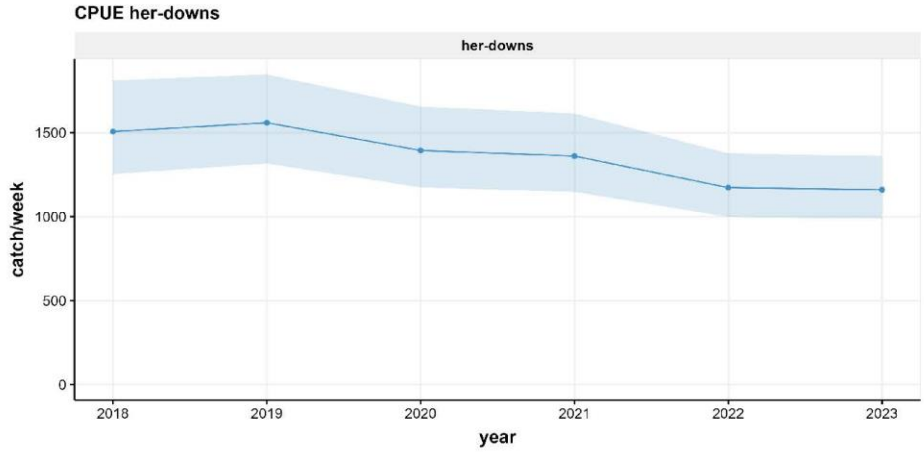

Figure 3.4.7: Herring (4c7d Downs). Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

Herring (4c7d Downs) (HER). CPUE correlations

Exploration of correlations between year, number of rectangles fished per vessel and year, summed catch per vessel and year, number of fishing days per vessel and year and the average catch per vessel and per day.

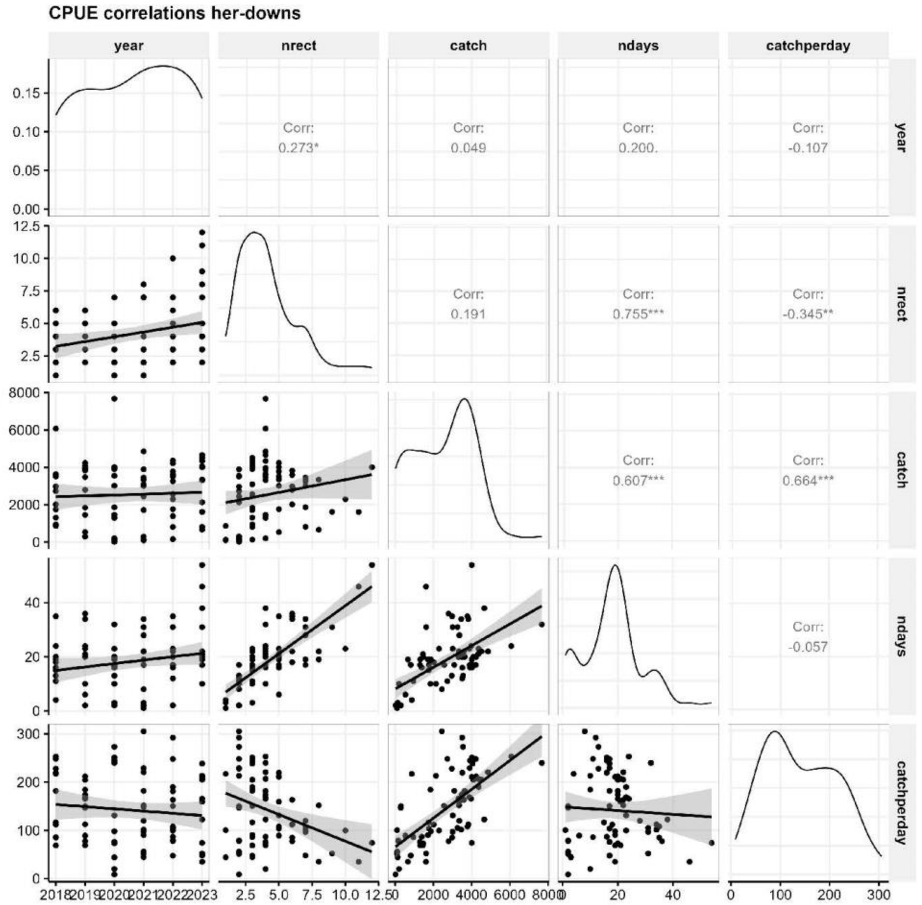

Figure 3.4.8: Herring (4c7d Downs). Correlations between year, number of rectangles, catch, number of days and catch per day

4.5 Herring (western stocks) (HER, Clupea harengus)

Herring (western stocks) self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
her	2018	5	6	19	33	1,866	98	3,463	931
her	2019	3	3	15	26	1,298	87	4,078	596
her	2020	4	6	9	9	330	37	247	300
her	2021	2	2	7	9	992	142	320	217
her	2023	4	4	8	12	124	15	180	0
(all)	(all)		21	58	89	4,609		8,288	2,044

Table 3.5.1: Herring (western stocks). Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Herring (western stocks). Catch by division

species	division	2018	2019	2020	2021	2023	all	perc
her	27.6.a	1,864	1,298	328	5	124	3,618	78.5%
her	27.7.b	0	0	2	987	0	989	21.5%
her	27.7.g	2	0	0	0	0	2	0.0%
(all)	(all)	1,866	1,298	330	992	124	4,609	100.0%

Table 3.5.2: Herring (western stocks). Self-sampling summary with the catch (tonnes) by year and division

Herring (western stocks). Catch by month

species	month	2018	2019	2020	2021	2023	all	perc
her	Jan	0	0	0	0	114	114	2.5%
her	Jun	0	0	4	0	0	4	0.1%
her	Jul	0	0	85	987	10	1,082	23.5%
her	Aug	17	0	222	0	0	240	5.2%
her	Sep	1,661	823	15	5	0	2,504	54.3%
her	Oct	187	475	0	0	0	662	14.4%
her	Nov	0	0	0	0	0	0	0.0%
her	Dec	0	0	3	0	0	3	0.1%
(all)	(all)	1,866	1,298	330	992	124	4,609	100.0%

Table 3.5.3: Herring (western stocks). Self-sampling summary with the catch (tonnes) by year and month

Herring (western stocks). Catch by rectangle

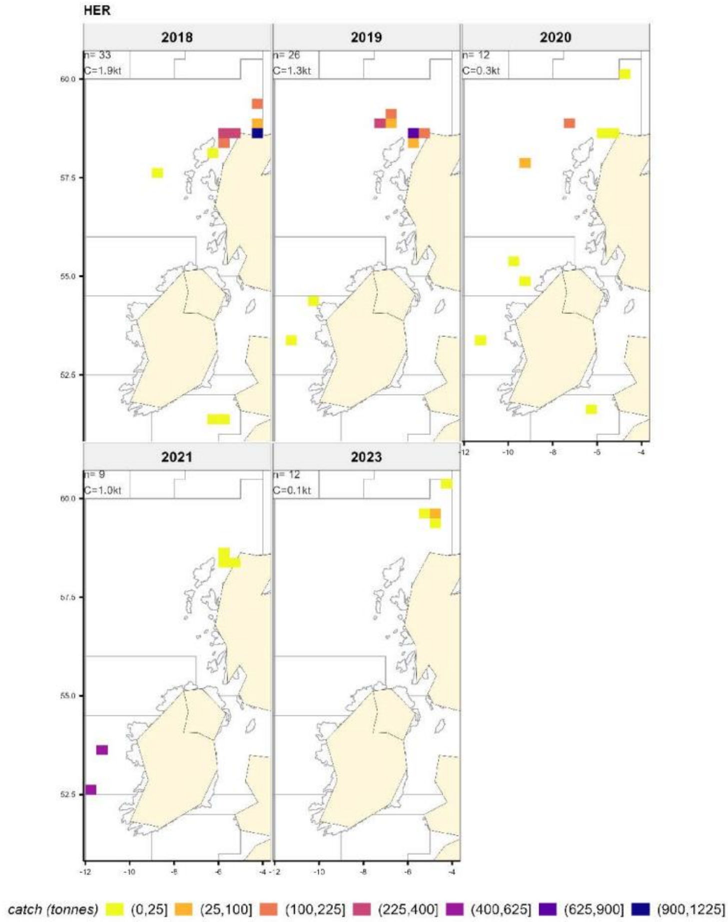

Figure 3.5.1: Herring (western stocks). Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Herring (western stocks). Catchrate (ton/day) by rectangle

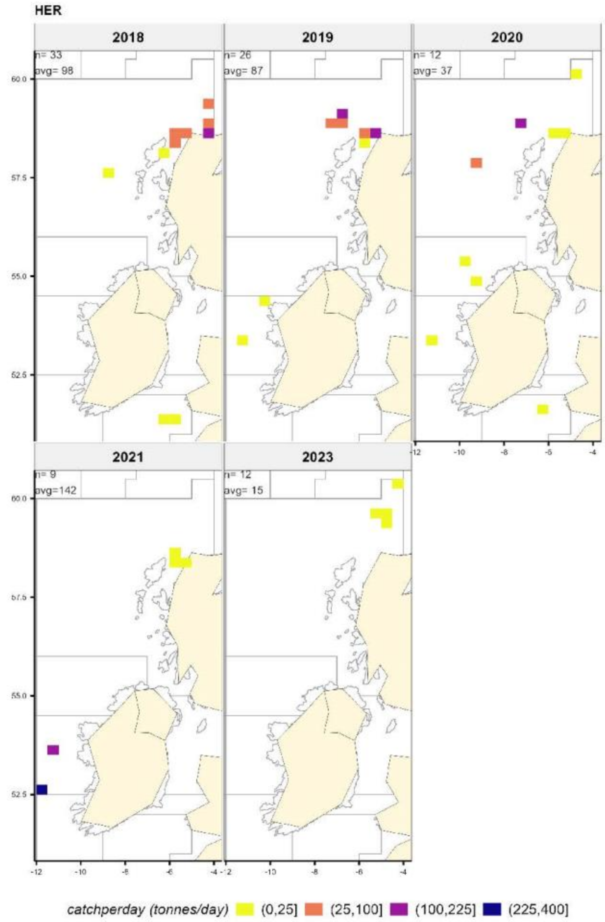

Figure 3.5.2: Herring (western stocks). Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Herring (western stocks). Spatio-temporal evolution of catch by month and rectangle

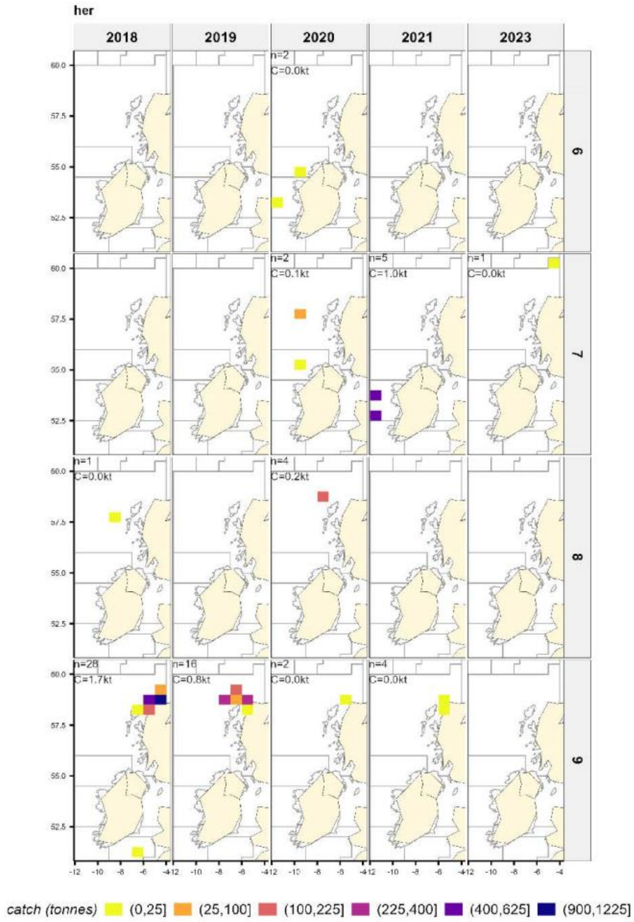

Figure 3.5.3: Herring (western stocks). Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

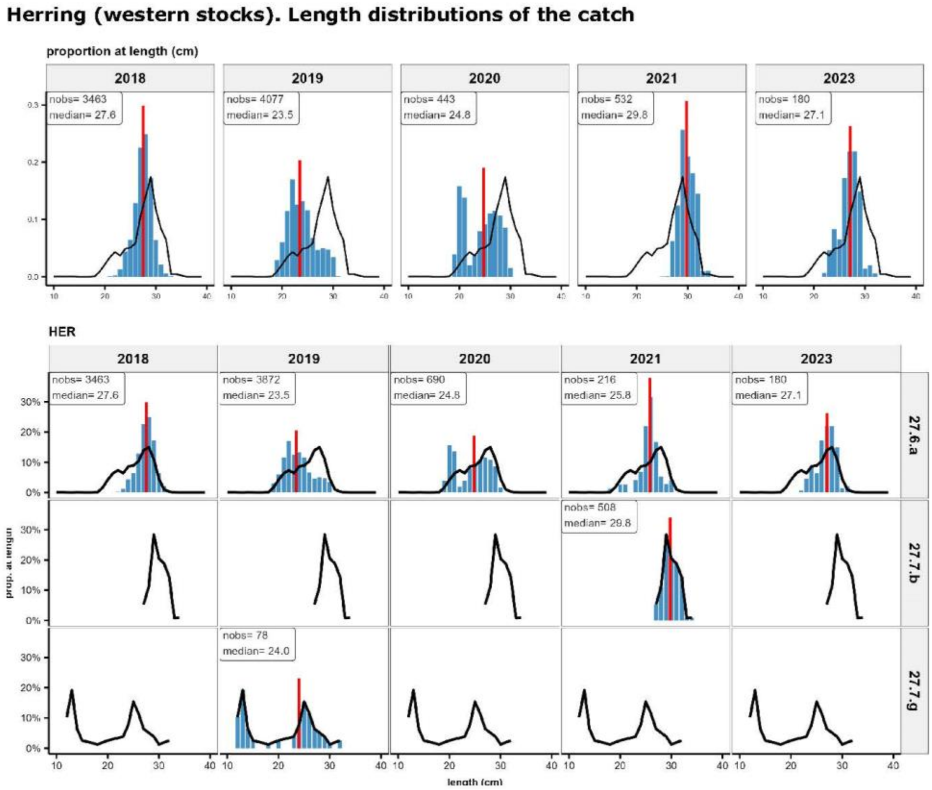

Figure 3.5.4: Herring (western stocks). Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Herring (western stocks). Average length, weight and fat content by year and month

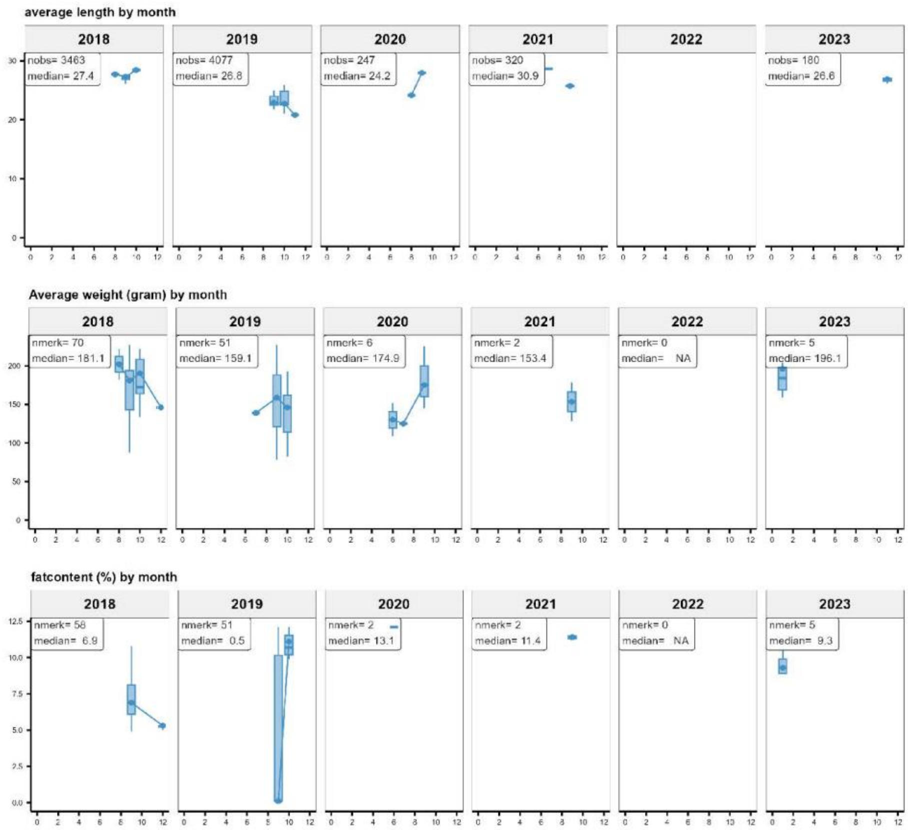

Figure 3.5.5: Herring (western stocks). Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4.6 Pilchard (PIL, Sardina pilchardus)

Pilchard self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength
pil	2018	6	8	17	28	688	40	1,134
pil	2019	6	7	10	11	123	12	385
pil	2020	4	4	5	7	49	10	145
pil	2021	10	14	28	40	577	21	610
pil	2022	7	10	24	36	429	18	346
pil	2023	6	14	60	109	2,846	47	6,325
(all)	(all)		57	144	231	4,713		8,945

Table 3.6.1: Pilchard. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Pilchard. Catch by division

species	division	2018	2019	2020	2021	2022	2023	all	perc
pil	27.4.b	0	0	24	246	0	0	270	5.7%
pil	27.7.d	567	116	6	291	408	1,107	2,495	52.9%
pil	27.7.e	121	7	0	40	21	1,739	1,928	40.9%
pil	27.7.h	0	0	19	0	0	0	19	0.4%
(all)	(all)	688	123	49	577	429	2,846	4,713	100.0%

Table 3.6.2: Pilchard. Self-sampling summary with the catch (tonnes) by year and division

Pilchard. Catch by month

species	month	2018	2019	2020	2021	2022	2023	all	perc
pil	Jan	309	40	0	0	138	598	1,085	23.0%
pil	Feb	0	0	0	34	2	1,716	1,751	37.2%
pil	Mar	0	0	0	0	0	532	532	11.3%
pil	Jun	0	0	0	0	0	0	0	0.0%
pil	Sep	250	3	6	30	183	0	472	10.0%
pil	Oct	110	6	24	76	106	0	322	6.8%
pil	Nov	12	73	0	438	0	0	523	11.1%
pil	Dec	8	0	19	0	0	0	27	0.6%
(all)	(all)	688	123	49	577	429	2,846	4,713	100.0%

Table 3.6.3: Pilchard. Self-sampling summary with the catch (tonnes) by year and month

Pilchard. Catch by rectangle

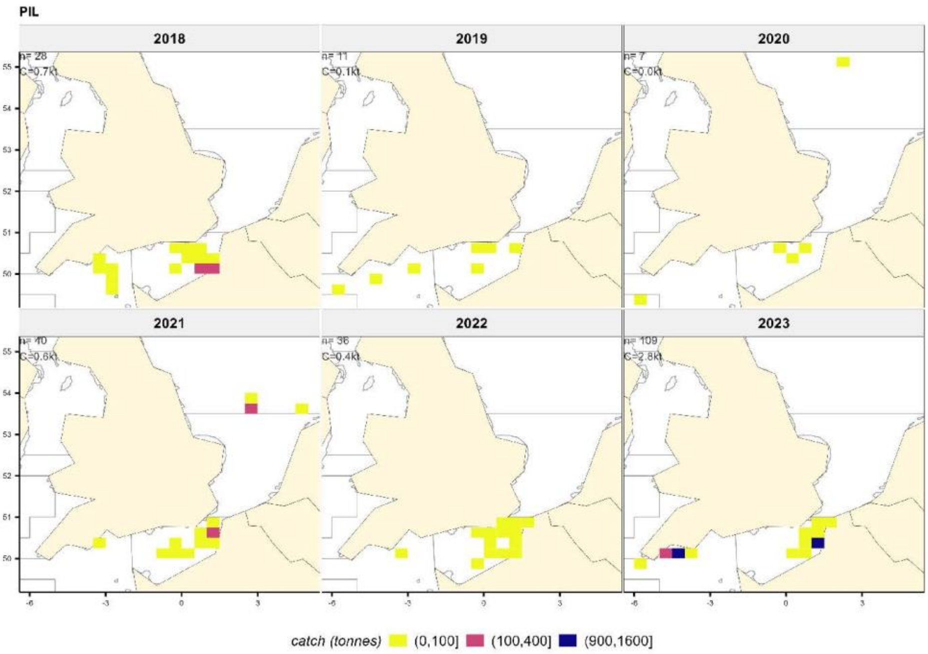

Figure 3.6.1: Pilchard. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Pilchard. Catchrate (ton/day) by rectangle

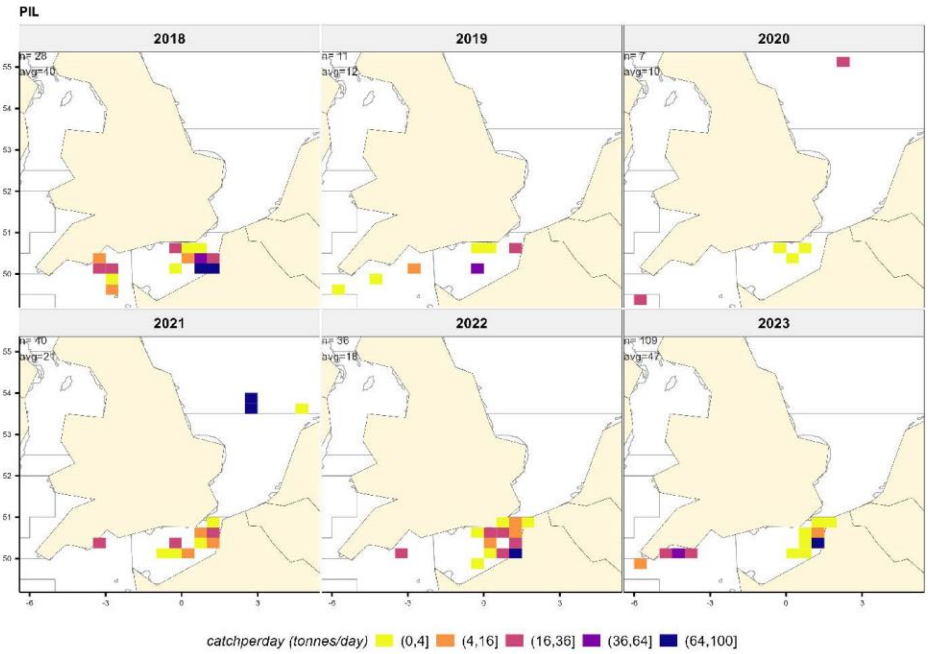

Figure 3.6.2: Pilchard. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Pilchard. Spatio-temporal evolution of catch by month and rectangle

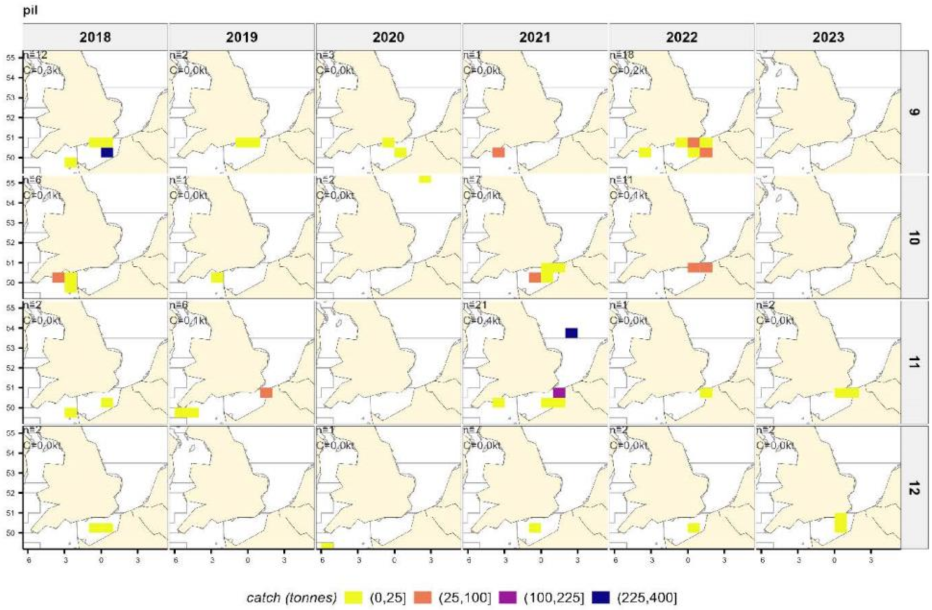

Figure 3.6.3: Pilchard. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Pilchard. Length distributions of the catch

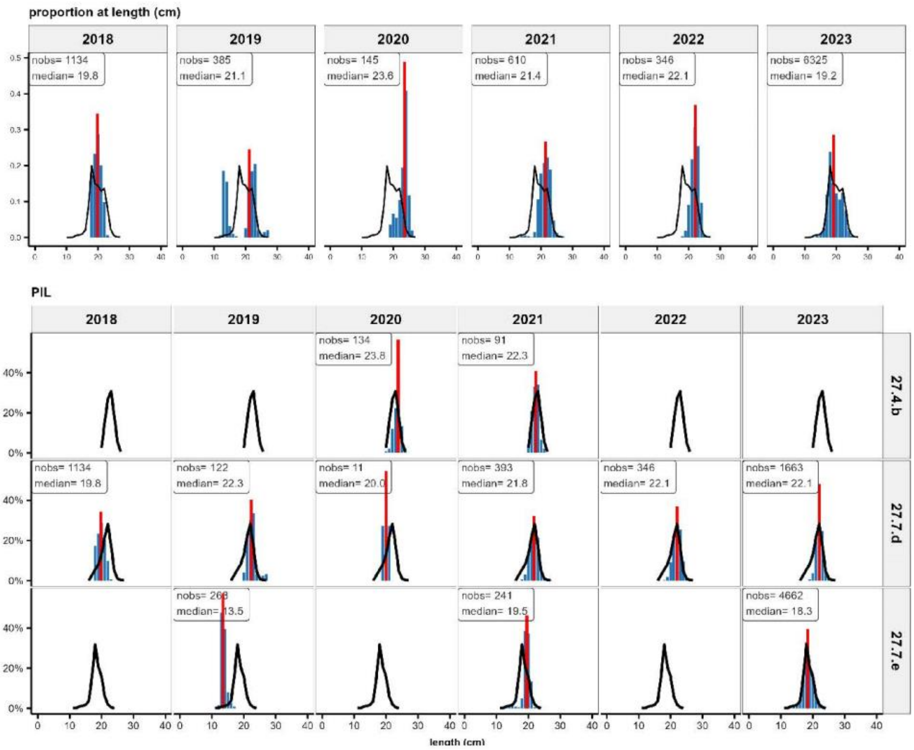

Figure 3.6.4: Pilchard. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Pilchard. Average length, weight and fat content by year and month

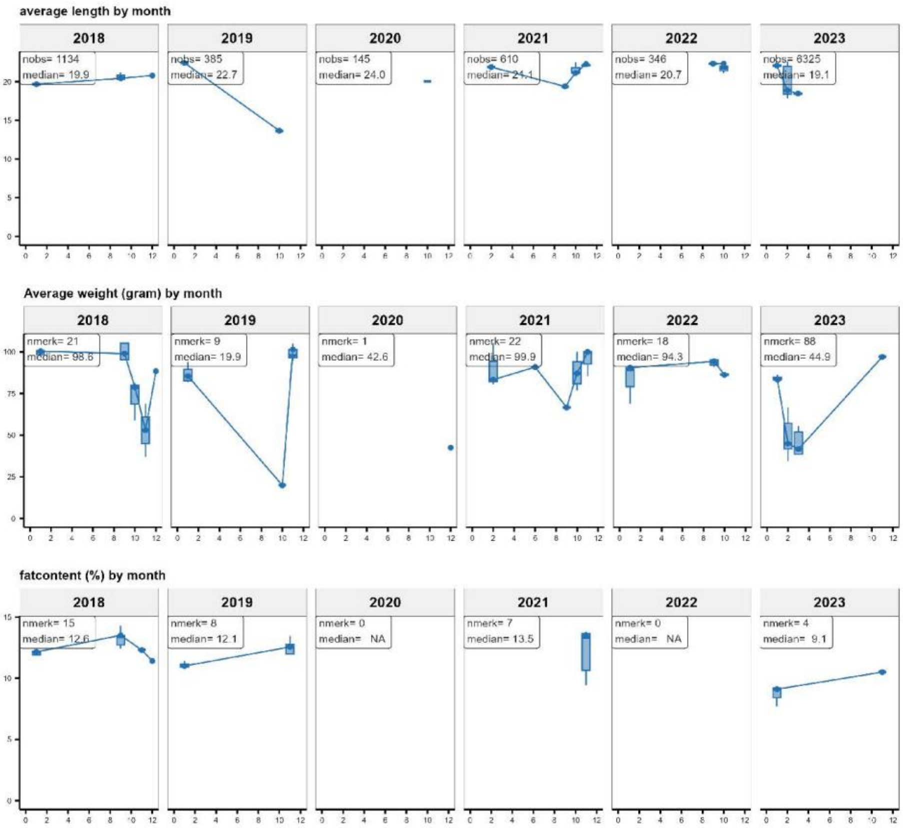

Figure 3.6.5: Pilchard. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4.7 Sprat (SPR, Sprattus sprattus)

Sprat self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength
spr	2018	5	5	11	31	1,038	94	3,395
spr	2019	1	1	3	5	32	11	430
spr	2020	6	9	17	47	2,408	142	1,429
spr	2021	2	3	5	6	138	28	126
spr	2022	4	5	10	21	507	51	208
spr	2023	5	6	9	10	30	3	485
(all)	(all)		29	55	120	4,152		6,073

Table 3.7.1: Sprat. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Sprat. Catch by division

species	division	2018	2019	2020	2021	2022	2023	all	perc
spr	27.4.b	293	7	696	0	506	19	1,521	36.6%
spr	27.4.c	745	0	1,712	138	0	2	2,597	62.5%
spr	27.7.e	0	25	0	0	0	9	34	0.8%
(all)	(all)	1,038	32	2,408	138	507	30	4,152	100.0%

Table 3.7.2: Sprat. Self-sampling summary with the catch (tonnes) by year and division

Sprat. Catch by month

species	month	2018	2019	2020	2021	2022	2023	all	perc
spr	Jan	0	0	653	0	0	0	653	15.7%
spr	Feb	0	0	0	0	0	9	9	0.2%
spr	Jun	0	0	0	0	211	0	211	5.1%
spr	Jul	0	0	0	0	295	0	295	7.1%
spr	Aug	0	0	0	0	0	19	19	0.5%
spr	Sep	259	0	0	0	0	0	259	6.2%
spr	Oct	5	32	12	0	0	0	49	1.2%
spr	Nov	30	0	1,742	138	0	1	1,912	46.0%
spr	Dec	745	0	0	0	0	0	745	17.9%
(all)	(all)	1,038	32	2,408	138	507	30	4,152	100.0%

Table 3.7.3: Sprat. Self-sampling summary with the catch (tonnes) by year and month

Sprat. Catch by rectangle

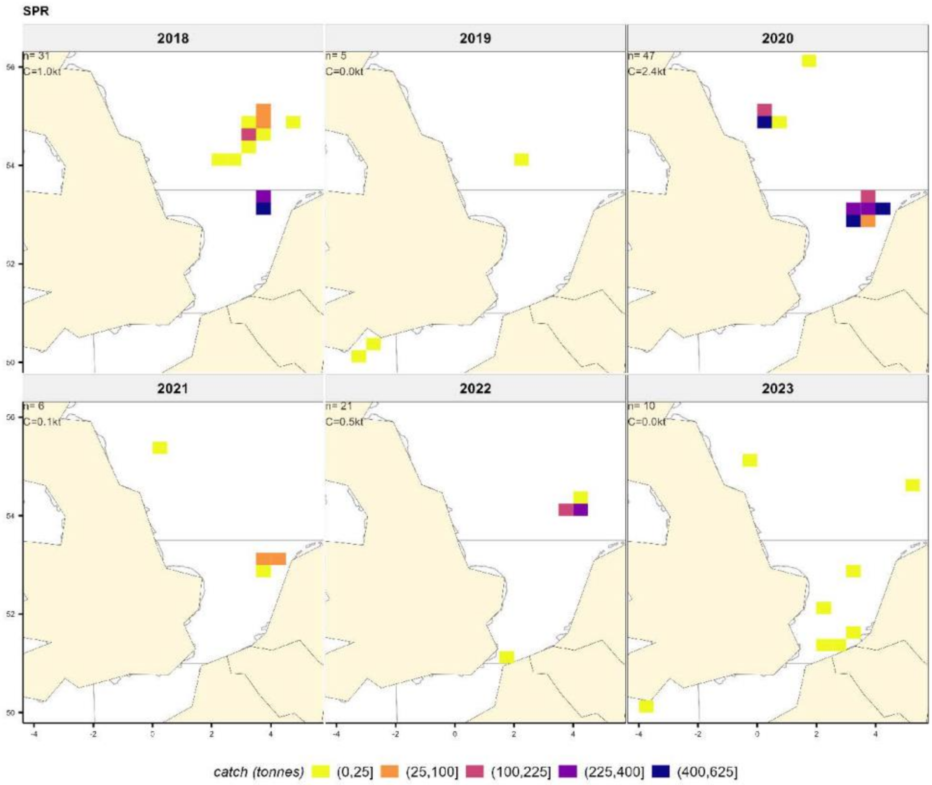

Figure 3.7.1: Sprat. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Sprat. Catchrate (ton/day) by rectangle

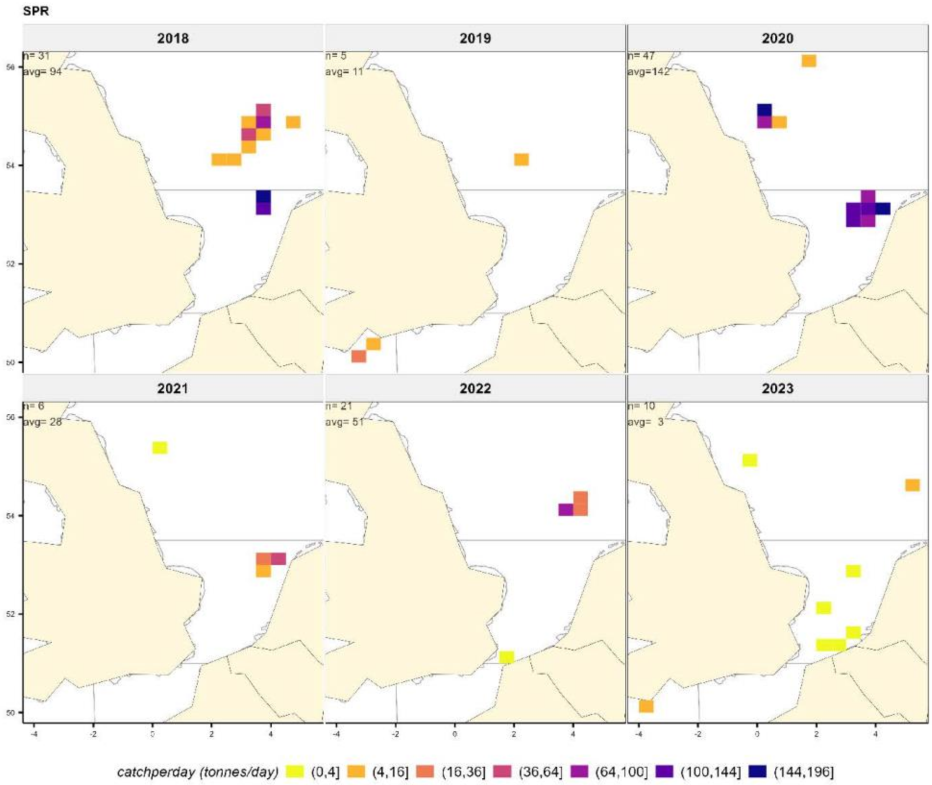

Figure 3.7.2: Sprat. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Sprat. Spatio-temporal evolution of catch by month and rectangle

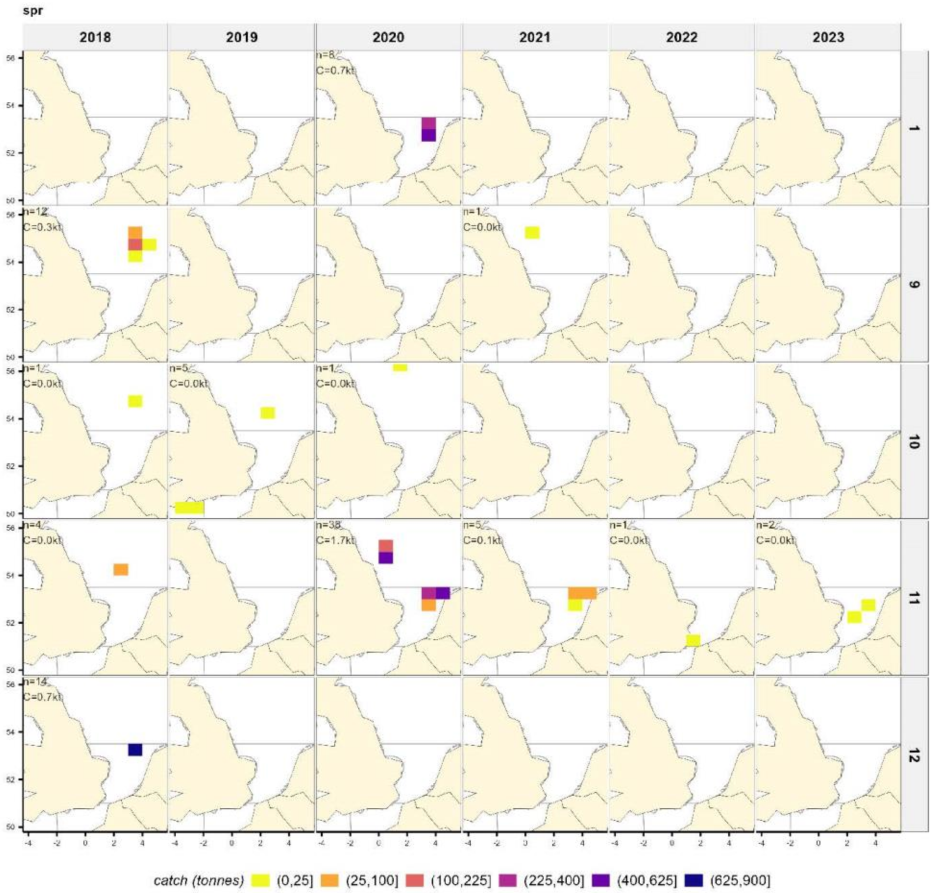

Figure 3.7.3: Sprat. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

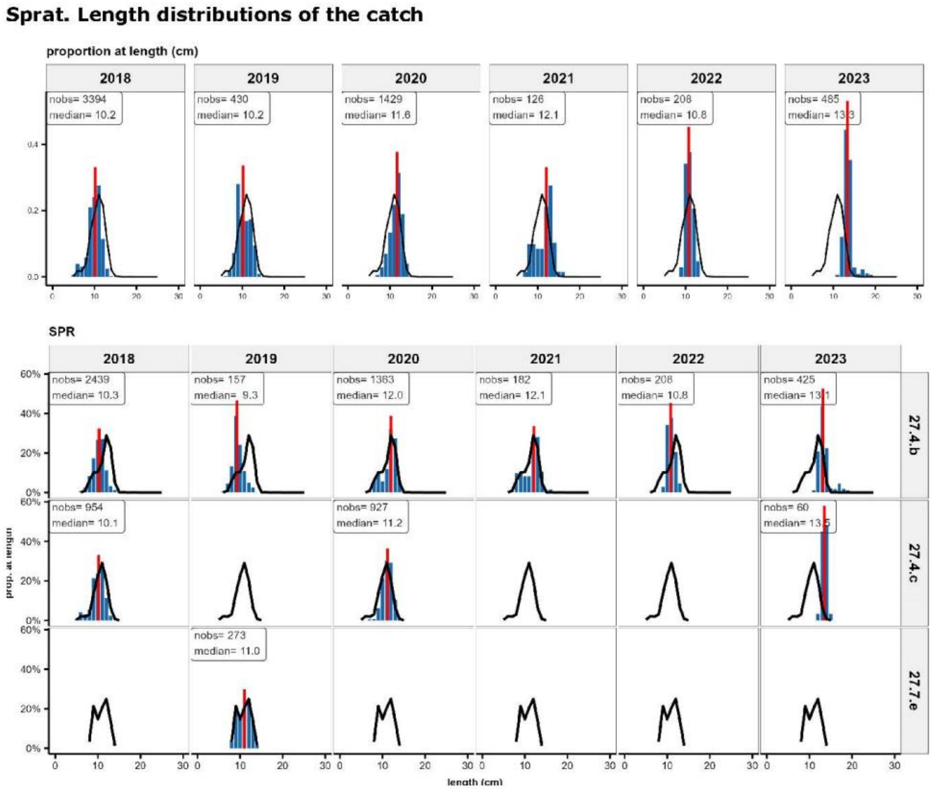

Figure 3.7.4: Sprat. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Sprat. Average length, weight and fat content by year and month

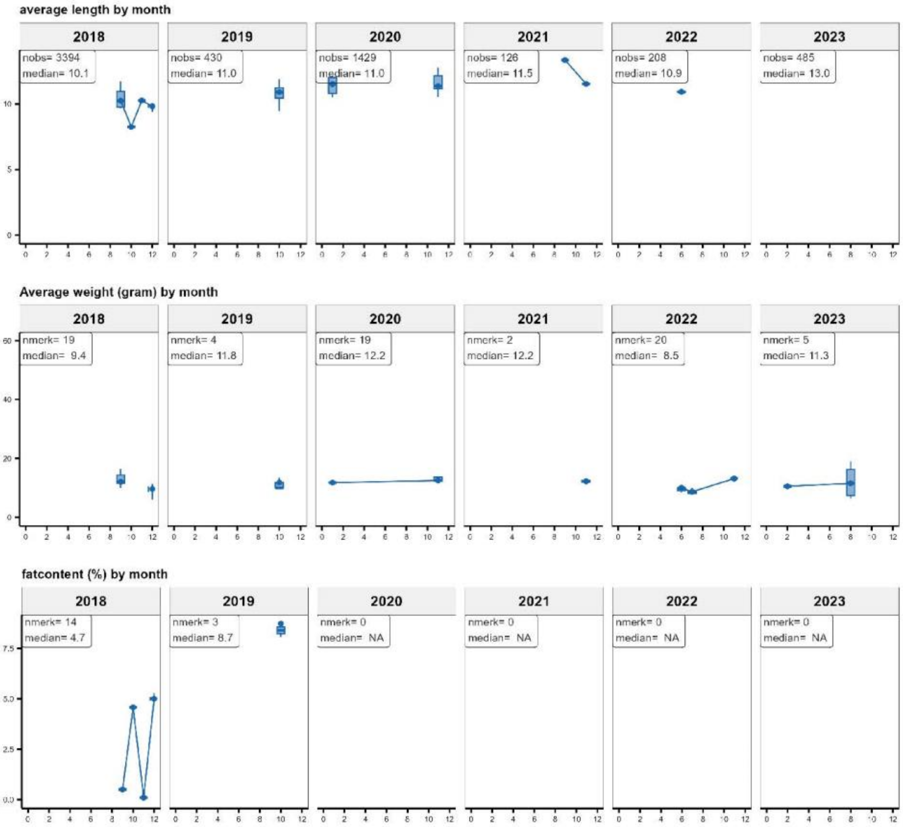

Figure 3.7.5: Sprat. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

5 Discussion and conclusions

From 2018 onwards, all PFA vessels were participating in the PFA self-sampling program. The definition of what constitutes 'a fishery' for a certain species is not straightforward to resolve. In this report we selected all vessel-trip-week combinations with:

- hauls in divisions 27.4.a;27.4.b;27.4.c;27.7.d;27.6.a;27.7.b;27.7.c;27.7.g;27.7.e;27.7.h
- catch of her;pil;spr by trip and week at least 10% of the total catch of that trip and week.
- catch of spr by trip and week at least 10 tonnes.

Since 2020, the measurements of average weight and fat content are included in the self-sampling report. Weights and fat content are routinely being collected for some of the target species (e.g. herring, mackerel) on the basis of production units (batches). The measurements are being carried out both when the species is the main target of the fishery and when it is a bycatch in other fisheries.

A particular challenge in the PFA self-sampling program is dealing with the different length metrics in use. Routinely, on freezer-trawlers, fish will be measured in standard length (SL, until the onset of the tail of the fish). However, for scientific purposes, length is required mostly in total length (TL), or, in the case of the South Pacific RFMO, in fork length (FL). The PFA self-sampling program aims to utilize the appropriate scientific length metric: TL in Europe and Africa, FL in the South Pacific. However, in some instances, the quality managers on board of the vessels have used the wrong length metric for the area they were fishing in. Until 2021, these situations were 'corrected' by applying a direct length-to-length conversion based on data from individual measurements of SL, FL and TL. It was recognized that this approach could lead to holes in the length distributions. In 2022 a new method of converting length-to-length was implemented, based on the paper by Hansen et al (2018). The method consists of generating simulated length-length-keys similar to the often used age-length-keys.

6 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels are putting in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

7 References and publications

Hansen, F. T., F. Burns, S. Post, U. H. Thygesen and T. Jansen (2018). Length measurement methods of Atlantic mackerel (Scomber scombrus) and Atlantic horse mackerel (Trachurus trachurus) – current practice, conversion keys and recommendations. Fisheries Research 205: 57-64.

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8 More information

Please contact Niels Hintzen (nhintzen@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

Working document

1 Revision of data input, model configuration and reference points used for the stock assessment of sprat in the North Sea and 3.a

During the annual meeting for Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) the input data used in the assessment model for sprat in the North Sea and 3.a (Skagerrak-Kattegat) were revised. This included 1) a change in catch input data and associated model adjudgments, 2) an update of natural mortalities from the SMS key run 2023, 3) re-calculation of biomass reference points (Blim and Bpa) and 4) re-calculation of reference point set on fishing mortality (harvest control rule, F_{cap}). In short, the assessment for sprat uses the SMS model (Lewy and Vinther, 2004) with quarterly time steps. The model was benchmarked in 2018 (WKSPRAT, ICES 2018;). Due to the short lifespan and fishery composition of sprat, only in-year advice is viable. To align with sprat's lifecycle, the model is based on TAC years from July to June rather than calendar years, estimating SSB and recruitment on 1 July. Output and input data refer to the adjusted model year, i.e. TAC year (S1-S4; season 1 is quarter 3, season 2 is quarter 4, season 3 is quarter 1, and season 4 is quarter 2). The management of the sprat stock in the North Sea and 3.a employs an escapement strategy ($B_{escapement}$), which involves aiming to fish the stock down to B_{pa} (= $B_{escapement}$). However, it has been demonstrated that this approach is not precautionary for this type of stock without the implementation of a reference point for F as a limit control rule (ICES, 2014). For a more detailed description please see stock annex and report.

The changes were reviewed by external experts Mikel Aristegui and Amy Schueller, and the expert group have revised the working document to accommodate both reviewers by extending the justification and conclusive remarks on the choice of method for the calculation of B_{lim} based on the stock-recruitment relationship, as well as extending the F_{cap} estimation to include the target risk of 0.05.

1.1 Catch data input and model configuration

The SMS-model faces challenges with extended time-series of low catches used as input for the quarterly time-steps. Such catch data can lead to inaccurate estimation of fishing pressure and associated CV's. Historically, catches below a threshold were set to zero to prevent model misfits. During WKSPRAT, a redistribution of low catches from specific seasons provided appropriate model adjudgments, which proved to be successful. Specifically, the inclusion of catches from season 4 in season 1 the following year in combination with model modifications that prevented fits or estimation of any catch parameters in S4 improved the variance and CV in the model, as well as resolved some retrospective patterns. The consensus was to incorporate this change into the final model, recognizing its positive impact on model accuracy (WKSPRAT, 2018). A recent change in the fishing pattern in season 3 seems to have caused similar issues as seen for season 4 during WKSPRAT. The catch input data revealed that since 2019 the catches have been low. On average the catches were 0.6% of the total catch in tonnage for the period 2019-2022 (1.2% in 2019, 0.5 % in 2020, 0.6% in 2021 and 0.2% in 2022) compared to 8.6% for the period 2015-2018 (Table 1). In addition, the number of biological samples taken from the fishery used to generate the catch-at-age matrix for the assessment model has also been low compared to before 2019 (Table 2). These sudden changes caused estimation problems for the predicted fishery mortalities in the model, similarly to what found for S4 during WKSPRAT. Therefore, the expert group decided to test the effect of moving the catches from season 3 to season 2 for the period 2019-2022 and configuring the model to not estimate any catches for the season.

1.1.1 Results

The high CV in 2022 for the fishing mortality were corrected by moving the catches to season 2 (Figure 1). The large positive catch residuals for season 3 for all age-groups were removed without causing any drastic changes to the catch residuals in season 2 (Figure 2). The most recent estimated fishing mortalities became less variable. Specifically, the predicted 2022 fishing mortality went from being unrealistic low to being just below the long-time average in 2022 and the record high fishing mortality in 2023 was marginally down-scaled (Figure 3). Furthermore, the AIC were greatly improved from 1062 to 860.

1.1.2 Conclusion

HAWG agreed that the inclusion of season 3 catches for the period in season 2 improved the model significantly without changing the estimated historical dynamics of the stock and exploitation, and concluded that this change should be adopted in the final model. A sensitivity analysis was also conducted only moving the catches from season 3 to season 2 in 2022, which provided comparable improvements to the CV and predicted fishing mortality, but not to the catch residuals. Furthermore, considering that the low number of biological samples extended back to 2019, the group was confident to keep the changes for the period 2019-2022.

1.2 Updating natural mortalities

The current assessment is based on natural mortalities (M) from the 2015 SMS key run. Consequently, a varying M (3-y running means) is implemented up to 2015, and a constant M is used thereafter (2013–2015 average). In 2021, HAWG reviewed the updated Ms from the 2020 SMS key run. Despite no significant changes in recruitment, SSB, F and stock-recruitment relationship, HAWG decided at that time to retain the old M from the 2015 key run, mainly due to the guidelines that necessitated an inter-benchmark process, which was deemed unfeasible because of the tight advisory schedule and the extensive nature of MSE for reference point estimation (HAWG, 2021). After inspecting the updated mortalities from the most recent key run from 2023, HAWG decided that the changes are now so profound that they cannot be ignored and should be implemented from this update assessment. Notably, Ms have increased for all age-groups in all seasons in the most recent time-period (Figure 4).

1.2.1 Results

The inclusion of updated natural mortalities from the most recent SMS 2023 key run changed the perception of the stock, causing an upward shift in both recruitment (s. 1991) and SSB (s. 1982), as well as a downscaling of fishing mortality (s. 1981) (Figure 5). Furthermore, the stock-recruitment relationship showed that the changes in both recruitment and SSB resulted in a down-scaling causing points to be more compact in the early time of the time-series, whereas the period from 1981 and onward became more variable (Figure 6). The median recruitment also increased from being 87849 using the old Ms to 101730 using the updated Ms (Figure 6). There were no drastic changes detected in the CV's and residuals for both the catches and surveys (Figure 7, 8 and 9). The retrospective pattern where improved for both recruitment (Mohn's rho, from 0.12 to 0.04) and SSB (Mohn's rho, from 0.14 to 0.04), whereas it got worse for the fishing mortality (Mohn's rho, from 0.11 to 0.22) (Figure 10). The AIC for the model fit increased with the updated Ms (AIC = 863) compared to a model with the current Ms (AIC = 860), but the difference in delta-AIC were evaluated to be negligible.

1.2.2 Conclusion

The natural mortalities from the 2015 key run are obsolete and do not capture the trophodynamics that characterise the North Sea food web during the last decade. Improvements of the multispecies model since 2015, e.g. incorporating more accurate information on seabird and recent shifts in predator biomass (e.g. whiting and mackerel), have substantial influence on the estimated Ms for sprat. In conclusion, the significant changes in natural mortalities of sprat prompted HAWG to their final decision of updating the Ms for the assessment.

1.3 Reference points

As a result of the change in the stock delimitation and the assessment settings, the reference points were revised and re-estimated. The reference points were revised based on the model run with all revised input data and model configurations (see above). It was decided to follow a similar procedure as WKSPRAT and accordingly all years before 1981 were omitted because they appeared to be in a different regime. It was agreed that the stock-recruitment relationship could be estimated as a type 1 or 2 relationship, which can be estimated by using the R-package *StockRecruitSET* available at https://github.com/mebrooks/StockRecruit. The method for a type 1 gives B_{lim} at the lowest SSB with medium recruitment. The B_{lim} estimate for a type 2 is the break point of a hockey-stick model. The current B_{lim} is based on a hockey-stick breakpoint (WKSPRAT, 2018). The evaluation of B_{lim} is also subjected to expert judgement. Drawing from the experience from the benchmark of sandeel (WKSAND, 2023), it was decided to calculate an alternative B_{lim} based on the average SSB for two years that produced recruitments above the median recruitment.

1.3.1 Results

Using the ICES guidelines for type 1 (spasmodic) stocks, B_{lim} was calculated to be 103464 t (i.e. lowest SSB that gives median recruitment), which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 130728$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The type 2 stock using a hockey-stick model, the breakpoint for Blim was calculated to be 131184 t, which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 167759$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). A calculation of an alternative B_{lim} (mean SSB for two years that have R > median R) yielded 107598 t using the years 1991 and 2013, which gives the following $B_{escapement} = B_{pa} = B_{lim}*\exp(1.645*\sigma) = 135952$ t, where $\sigma = 0.14219$ (CV for terminal year, 2023). The evaluation how the different alternative reference points changed the perception of the stock compared to current perception showed that using type 1 stock method and a simple average of two years gave a similar perception to the current (Figure 11 and Figure 12). On the contrary, using the type 2 stock method would change the historical perception of the stock increasing the number of years under B_{lim} and B_{pa} (Figure 12).

1.3.2 Conclusion

The group had thorough discussions on how to evaluate the estimated reference points and the changed perception of the stock. Considering the stock recruitment relationship as a type 1 or a type 2 did affect the estimation of B_{lim} and perception of the stock substantially. The expert group judged the type 2 estimation method to be risk prone because it included four years of recruitments over the median, where 2008 and 2013 were judged to be higher than expected. Therefore, the group where in doubt whether a type 2 relationship could be supported and worries on a ever-increasing trend causing an overestimation of the hockey-stick break-point were raised. As stated above, the estimation of B_{lim} and perception of the stock where very different depending on method compared to the last benchmark where both type 1 and type 2 relationships gave closely related reference points. As such the expert group preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark. The decision was made to set B_{lim} based on the average SSB of two years with recruitment above the median, deemed to reflect a reasonable and precautionary perception of stock changes. Consequently, the average SSB from 1991 and 2013 was used to establish reference points at B_{lim} = 107598 t and $B_{escapement}$ = B_{pa} = 135952 t. The expert group also wanted to highlight that ICES should be aware that one of the down-sides by discontinuing the inter-benchmark process are very short time frames for these important decisions that are affected by subjective choices to be made, which puts a lot of pressure on the assessment expert groups.

1.4 MSE and F_{cap}

1.4.1 Methods

We used the short-cut method developed for WKspratMSE (ICES 2019). We conditioned the MSE using the assessment from 2024 instead of 2018 and accordingly, we modified the MSE code so that the start year of the MSE was 2023 and so that risk was calculated over years 2038 to 2058.

We ran the MSE for a range of Fcap values from 0.5 to 1.0, and thereafter small increments 1.01-1.05 to include the target risk of 0.05.

1.4.2 Results

Fcap	risk
0.5	0.022
0.6	0.027
0.7	0.032
0.8	0.038
0.9	0.044
1.0	0.049
1.01	0.050
1.02	0.051
1.03	0.051
1.04	0.052
1.05	0.053

Please see supplementary materials for figures and further results.

1.4.3 Conclusion

An Fcap of 1.01 produced risk of 0.05.

1.5. References

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp.

ICES. 2019. Workshop on the management strategy evaluation of the reference point, F_{cap}, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69. 35 pp. https://doi.org/10.17895/ices.pub.19291148

Table 1. Catch in numbers by age (1000's) by season and year (Model year) from 2015 and onward. Note that the time-series used in the model goes back to 1974.

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	2420231	9775216	3342785	163695
2019	2	799272.1	2399200	1041391	139590
2019	3	121303.8	19818	2252.614	237
2019	4	0	0	0	0
2020	1	207574	10153348	3429492	429318
2020	2	69142	2695178	385767	137741
2020	3	28346	78759	8459	1779

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2020	4	0	0	0	0
2021	1	539434	5840604	1505982	255540
2021	2	233795	803968	392200	138805
2021	3	52211	10015	734	8
2021	4	0	0	0	0
2022	1	362805	7103177	813995	99384
2022	2	826841	281637	350919	100995
2022	3	2748	959	67	12
2022	4	0	0	0	0
2023	1	578572	4943797	1984638	98171
2023	2	389454	1497984	618160	68121
2023	3	0	0	0	0
2023	4	0	0	0	0

Table 2. Number of biological samples taken from 2010 and onward. Note that the time-series used in the model goes back to 1974.

Year	S1	S2	S3	S4
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	2	12
2020	27	28	0	0
2021	85	22	0	8
2022	41	29	1	0
2023	78	49	*	*

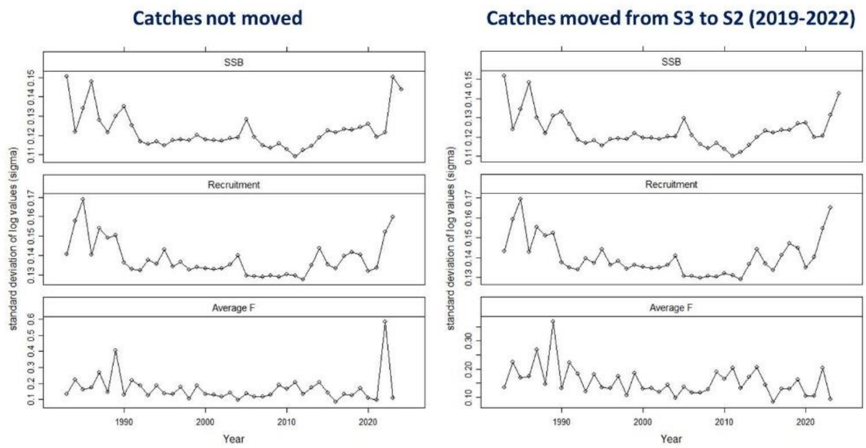

Figure 1. Coefficients of variance (Model year) for recruitment, SSB and fishing mortality for the model without moving catches and a model where catches are moved from S3 to S2.

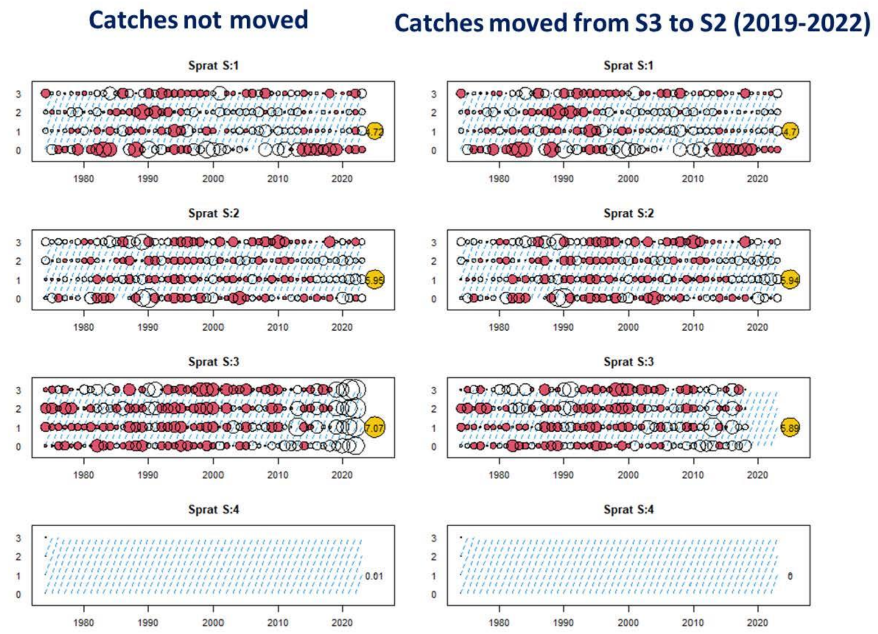

Figure 2. Catch residuals by age and season (Model year) for the model without moving catches and a model where catches are moved from S3 to S2. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

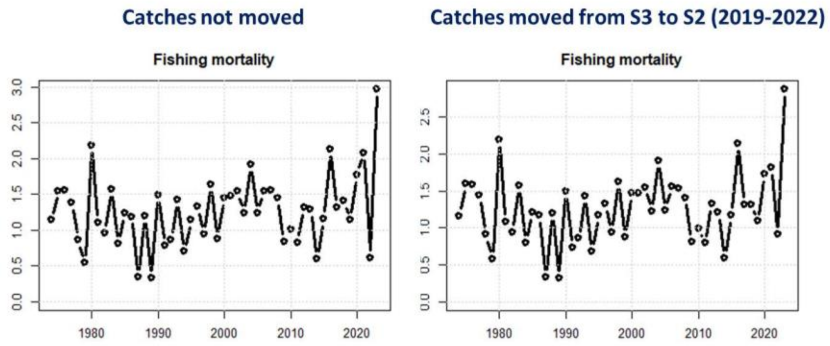

Figure 3. Predicted fishing mortality (Model year) for the model without moving catches and a model where catches are moved from S3 to S2.

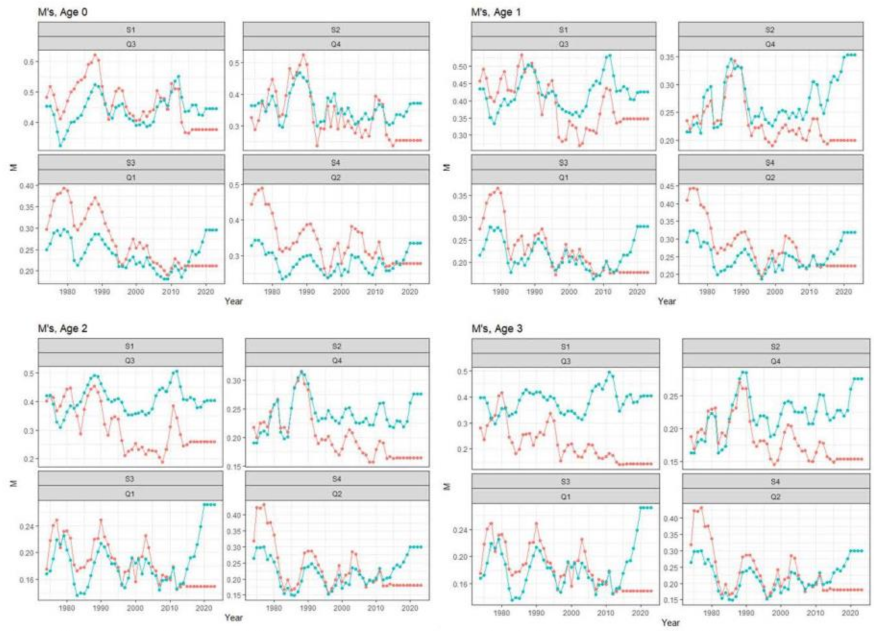

Figure 4. Natural mortalities for sprat for all age-groups, seasons and quarters (Model year). The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

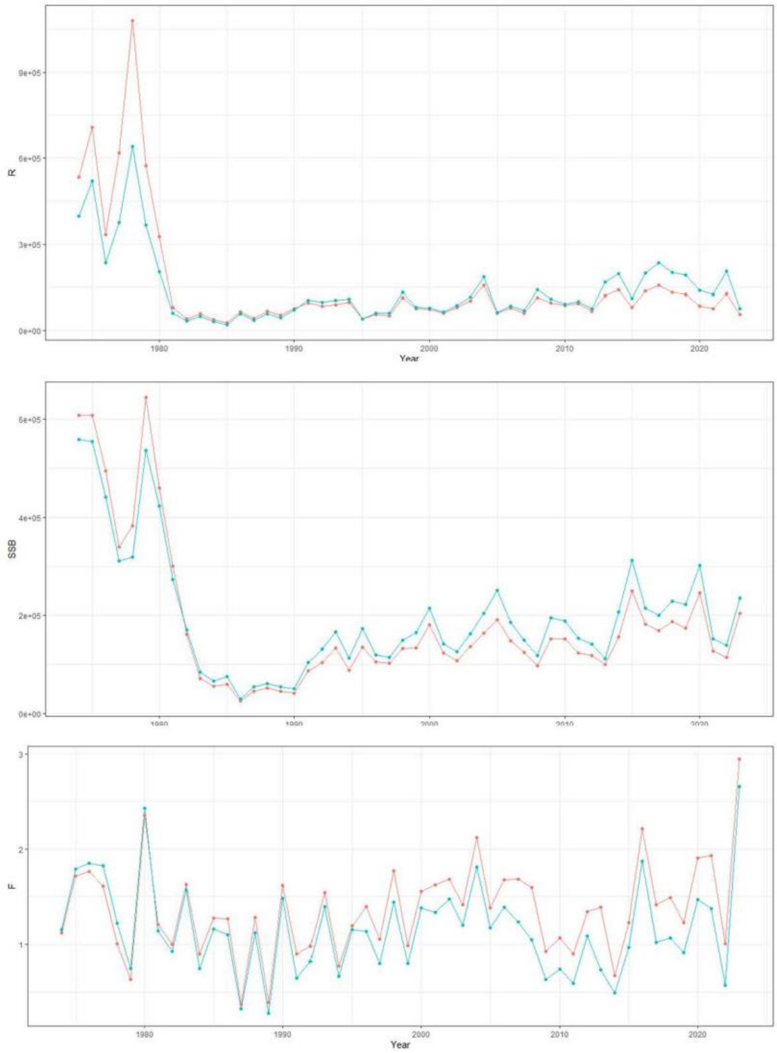

Figure 5. Predicted recruitment, SSB and fishing mortality for models that have old and updated M's. The red line is the current M's from the 2015 SMS key run and the blue line is the updated M's from the most recent SMS key run from 2023.

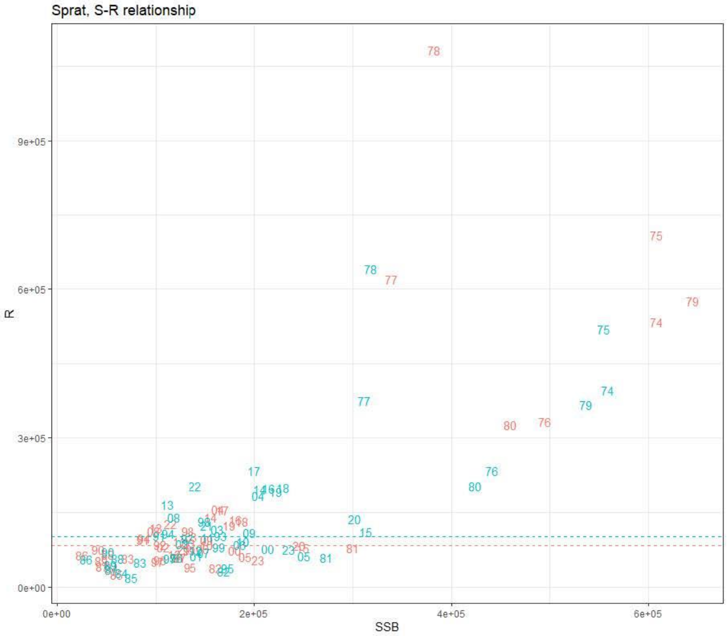

Figure 6. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The red numbers are the current M's from the 2015 SMS key run and the blue numbers is the updated M's from the most recent SMS key run from 2023. The median recruitments are shown (dashed lines).

Old Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.118	0.100
1	0.909	0.877	1.414	0.100
2	0.975	1.048	1.414	0.100
3	0.975	1.048	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.43	0.43	0.43
IBTS Q3		0.54	0.44	0.44
Acoustic		0.44	0.53	0.53

New Ms

sqrt(catch variance) ~ CV:

season

age	1	2	3	4
0	1.414	1.414	1.100	0.100
1	0.864	0.835	1.399	0.100
2	0.950	1.050	1.414	0.100
3	0.950	1.050	1.414	0.100

sqrt(Survey variance) ~ CV:

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.30			
IBTS Q1		0.47	0.47	0.47
IBTS Q3		0.53	0.45	0.45
Acoustic		0.44	0.50	0.50

Figure 7. Catch and survey CVs for models that have old and updated M's.

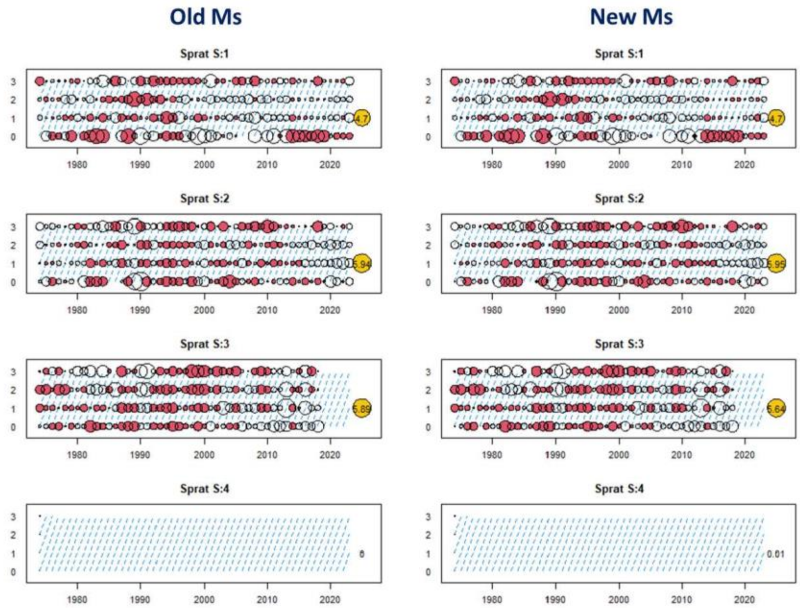

Figure 8. Catch residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

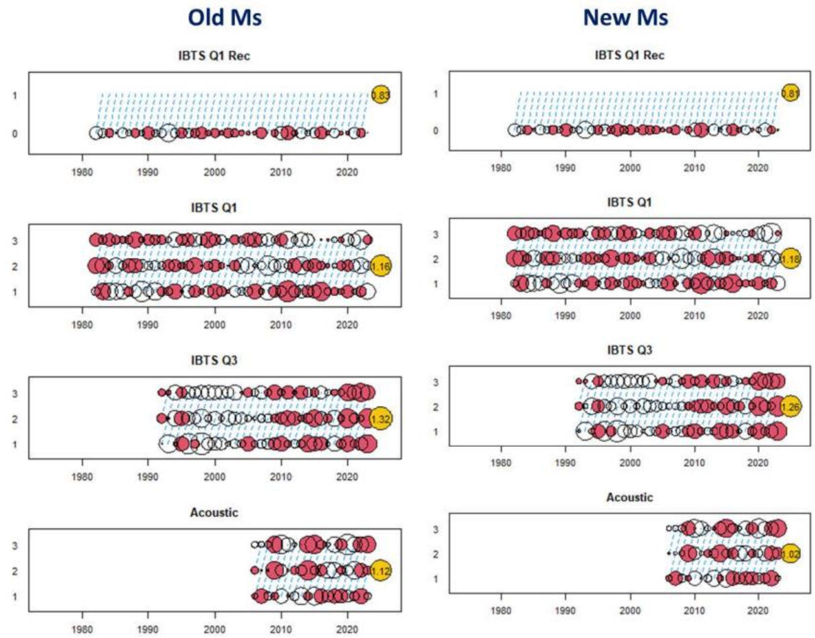

Figure 9. Survey residuals by age and season (Model year) for models that have old and updated M's. A negative catch residual (red) indicates that the estimated quantity is higher than the observed data.

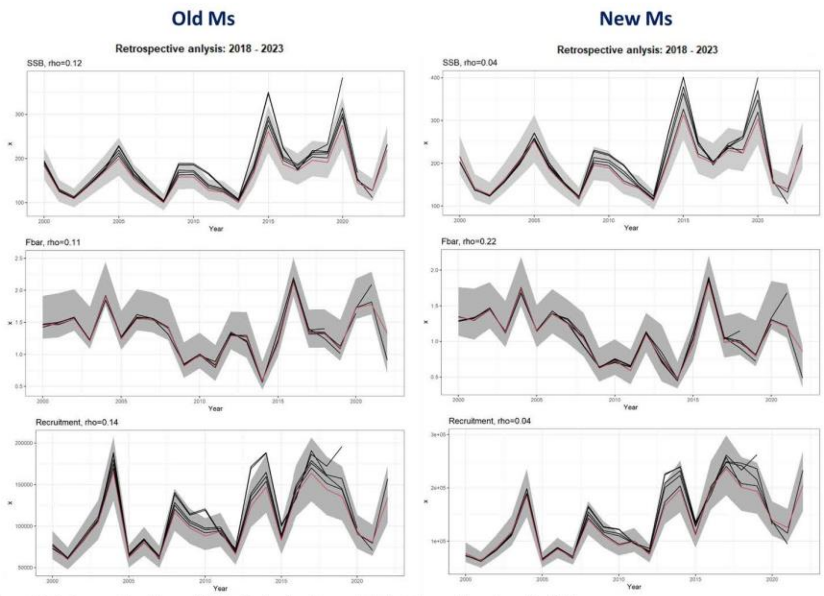

Figure 10. Retrospective bias and Mohn´s rho for the models that have old and updated M's.

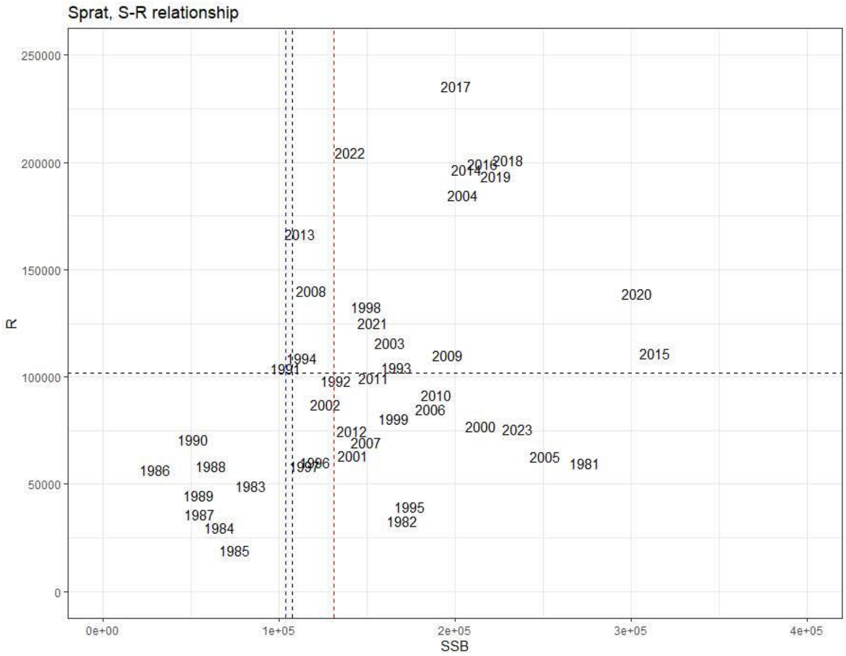

Figure 11. Stock-recruitment relationship using predicted recruitment and SSB for models that have old and updated M's. Lines show type 1 method (minimum SSB that produce above median recruitment, blue dashed line), type 2 method (hockey-stick breakpoint, red dashed line) and an alternative calculation (mean SSB in the two years that produced above recruitment, black dashed vertical line) of B_{lim}. Numbers signify abbreviated years (e.g. 1981 = 81 and 2016 = 16). The median recruitment are also shown (black dashed horizontal line).

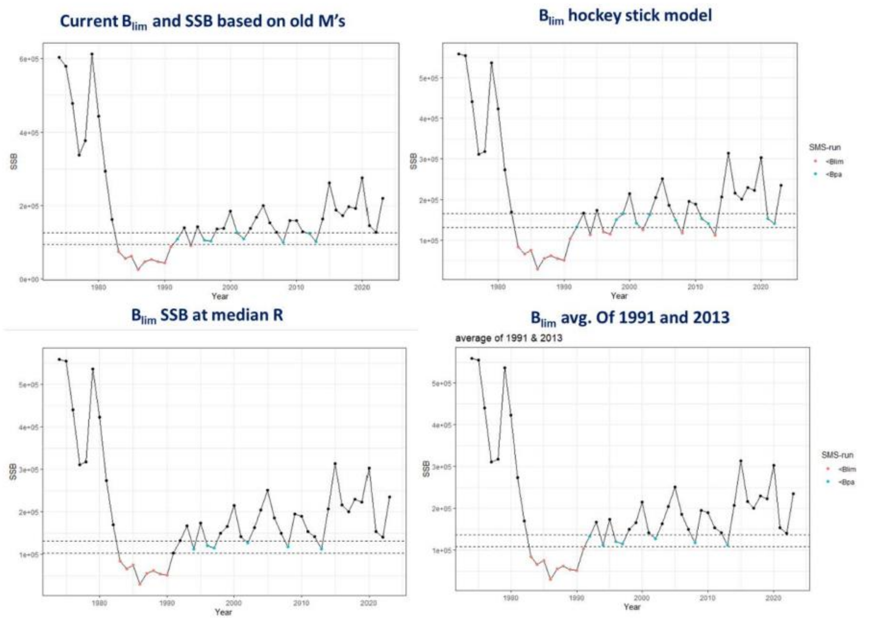

Figure 12. Perception of the stock using the current assessment model and input data (old M's, upper left panel), and a model that include the new M's and biomass reference points calculated as type 1 (lower left panel), tape 2 (upper right panel), and a simple average between two years (lower right panel). Please also see details in Figure 11 for information on the calculation of B_{lim}. The blue points signify years where SSB < B_{pa} and > B_{lim}, and the red points signify years where SSB < B_{lim}.

2 Working documents Reviews

2.1 Review from Mikel Aristegui

The purpose of this external review is to check that the reasoning for the decisions made during the annual meeting of the Herring Assessment Working Group for the Area South of 62ºN (HAWG, 12-21 March 2024 in Aberdeen) about the stock assessment and reference points of sprat in Division 3.a and Subarea 4 are in line with ICES guidelines.

HAWG implemented two main changes to the input data and settings of the sprat model: moving catch data from season 3 to season 2 for the period of 2019-2022, and updating the natural mortalities (M's) for all ages. As a result of these changes, reference points were revised and re-estimated.

1. Changes to input data and model settings

a. Catch data input

HAWG identified a change in fishing patterns in recent years (2019-2022), where catches in season 3 have been very low. Subsequently, the number of samples from these catches are also low. HAWG followed the steps and decisions that were made in the last Benchmark Workshop on Sprat (WKSPRAT; ICES 2018), where a similar issue was identified with very low catches in season 4. WKSPRAT decided to move catches from season 4 to season 1, improving the model considerably.

Now, HAWG showed that moving season 3 catches to season 2 (in 2019-2022 period) improved the CV's in the model. Additional efforts were made by the group by also testing that this change removed the large positive catch residuals for season 3, and significantly improved the model's AIC. However, it would be still interesting to know if moving catches from season 3 to season 2 affected the retrospective pattern (WKSPRAT showed that their change reduced Mohn's rho significantly).

HAWG agreed to move catches from season 3 to season 2 between 2019 and 2022, which looks adequate.

b. Natural mortality

The current assessment model uses M's from the 2015 SMS key run. HAWG identified a high increase in M's on the 2023 SMS key run, which significantly changed the perception of the stock (recruitment, SSB and fishing mortality). HAWG tested how applying the new M's would affect CV's, residuals, retrospective patterns and AIC of the model; which in combination were acceptable.

HAWG agreed to update the M's for the assessment, which looks adequate.

2. Reference points

HAWG reviewed the reference points after the changes to input data and model settings mentioned above, and including the most recent data.

a. B_{lim} and $B_{escapement}$ (= B_{pa})

The group followed a methodology similar to that in WKSPRAT, where stock-recruitment relationship types 1 and 2 were considered, and also added an alternative option that WKSANDEEL (ICES 2024) used to improve precaution: to use the average of the two lowest SSB that produced above-median recruitments (modified type 1).

HAWG agreed to use the alternative method, which deviates from the decision made in WKSPRAT; a more thorough justification for this decision would be welcome.

b. F_{cap}

HAWG ran the short-cut MSE method used in WKspratMSE (ICES, 2019) for six F_{cap} values (0.5, 0.6, 0.7, 0.8, 0.9, 1.0) that resulted in risks from 0.022 to 0.049. It would be beneficial to spend more time on this section, exploring higher F_{cap} values to include the target risk of 0.050. For example, WKspratMSE used a finer grid of 0.01 F_{cap} values, getting risks of 0.049, 0.050 and 0.051 (ICES 2019, table 3.4).

General comments

In general, the decisions made by HAWG 2024 were adequate and followed correct methodologies specified by ICES guidelines. However, an optimal review process like the current one, according to ICES most updated guidelines (ICES 2023), is a one-year process. Probably having more time to work on this type of reviews intersessionally decreases the pressure on everyone involved and increases the quality of the job.

Comments on the Working Document draft

The captions in Figures 4, 5 and 6 do not match with the text in the section 1.2 "Updating natural mortalities". The colours (red/blue) seem to be swapped in the captions.

In Figure 12 caption, points are named as "green", but to be consistent with other figures in the document, they should be called "blue", as they all look to use the same colours.

References

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp. https://doi.org/10.17895/ices.pub.19291145

ICES. 2019. Workshop on the management strategy evaluation of the reference point, F_{cap}, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69. 35 pp. https://doi.org/10.17895/ices.pub.19291148

ICES. 2023. ICES Guidelines for Benchmarks. Version 1. ICES Guidelines and Policies - Advice Technical Guidelines. 26 pp. https://doi.org/10.17895/ices.pub.22316743

ICES. 2024. Benchmark workshop on sandeel (ammodytes spp.) (Outputs from 2022 and 2023 meetings) (WKSANDEEL). ICES Scientific Reports. 6:10. 328 pp. https://doi.org/10.17895/ices.pub.21581151

2.2 Review from Amy Schueller

Two major changes were made in the model. The first change was to move Season 3 catches to Season 2 in the years 2019-2022 to account for the low catch values in Season 3. This change seems to have a favorable effect on the stock assessment, as there was difficulty estimating some parameters with a lack of catch and age data in the latter years. The figures provided suggest that the change was justified and had a small overall effect on the results, yet allowed for better estimation and fitting of the data.

The second change was an update of the natural mortality (M) values from the North Sea multispecies food web model, which has had improvements since it was last used for sprat. M's have increased for all age groups and seasons in the most recent years in the SMS model, so they were incorporated here. The changes in M led to relatively small changes in recruitment estimates in the middle part of the time series, but led to larger differences in the most recent years. However, the stock-recruitment plots look very similar, especially at lower stock sizes between the two runs. The fits to the survey age data were also comparable. These two changes make sense as they updated information to include the best available science and increase the robustness of the model estimation.

The benchmark values were also redetermined using a choice different than the previous assessment. The updated model formulation was appropriate for redetermining the benchmarks. The group discussed using 3 different options for determining B_{lim}: type 1 (spasmodic stocks; median recruitment), type 2 (hockey stick), and a modified type 1 based on the sandeel assessment (spasmodic stocks; mean of two recruitment values above the median recruitment and at the lowest SSB values). The group decided to use the modified type 1 option; however, the justification for this is unclear based on the documentation that was provided. This decision is a deviation from the last assessment where a hockey stick approach was used. While the methods are consistent with what was done in the sandeel assessment, the stock-recruitment plots between the two species do not necessarily have a similar appearance. The sandeel stock-recruitment plots were generally spasmodic with no identifiable area of decreased recruitment at low stock sizes. Based on Figure 11 provided in the documentation, there is a sprat stock size below which there are no recruitment values larger than the median (with 8 years in that region). A hockey stick approach would make more sense here. From the documentation: "The expert group judged the type 2 estimation method to be unsupported and risk prone, and preferred the type 1 estimation which appeared more consistent in terms of outcome with estimations from the last benchmark." This last sentence is the justification that was used to make this change. An explanation of how the method is unsupported would be useful. In addition, the statement of the method being more risk prone doesn't make sense without further explanation. The fact that the hockey stick method provides more years with SSB below B_{lim} is not a reason in and of itself to reject this option.

The MSE was updated to reflect the new assessment and used the same methods as were previously used. Very limited information was provided on the MSE; thus, one would infer that the methods were approved during the last assessment and remain consistent.

Comments on the Working Document draft

Figure 4 – The text states that the M values are increasing with the newest SMS model; however, the figure caption states that the red is the updated version (but has lower M values). Is this a caption mistake? This needs some clarity.

Supplementary materials

Sprat Fcap 2024

Mollie Brooks

2024-03-22

Worm plots

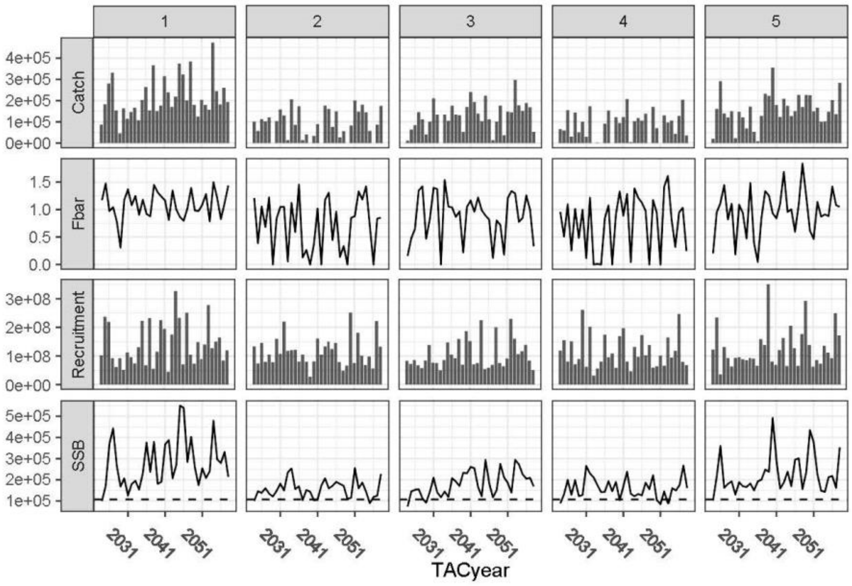

Figure 1: These are 5 simulation trials for one HCR with Fcap = 1

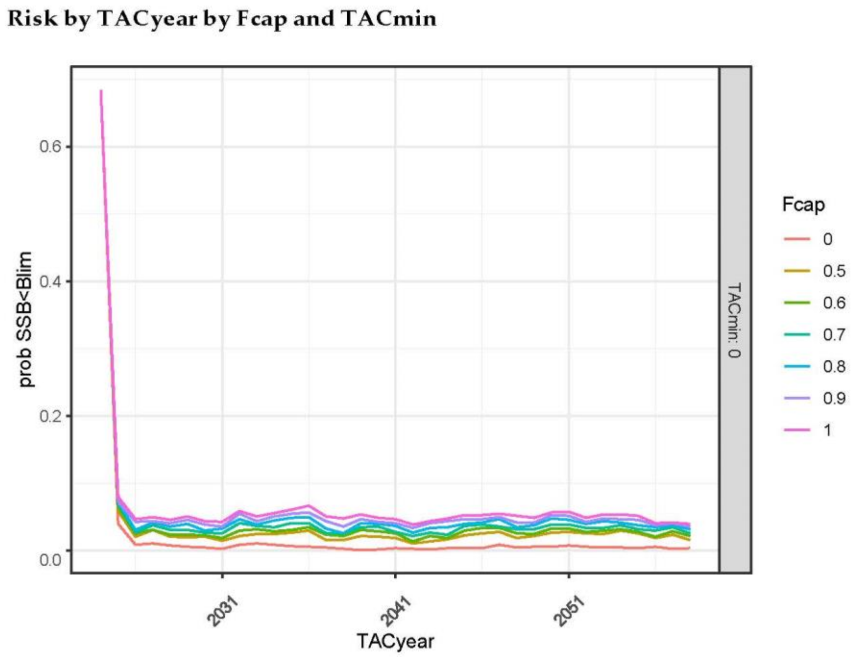

Figure 2: Risk by TACyear for different HCRs.

Error over time

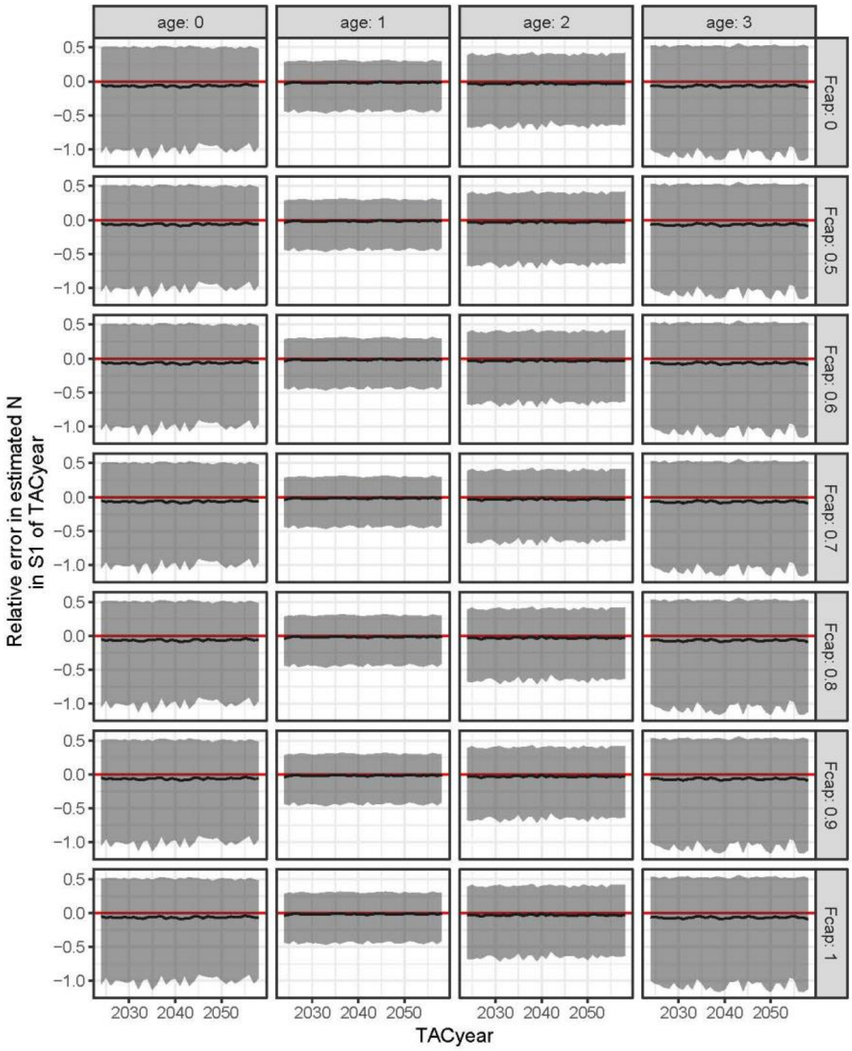

Figure 3: Error rate over time in estimated stock numbers (N). The solid black line is the mean. The grey ribbons are 0.025 and 0.975 quantiles. The red line is 0.

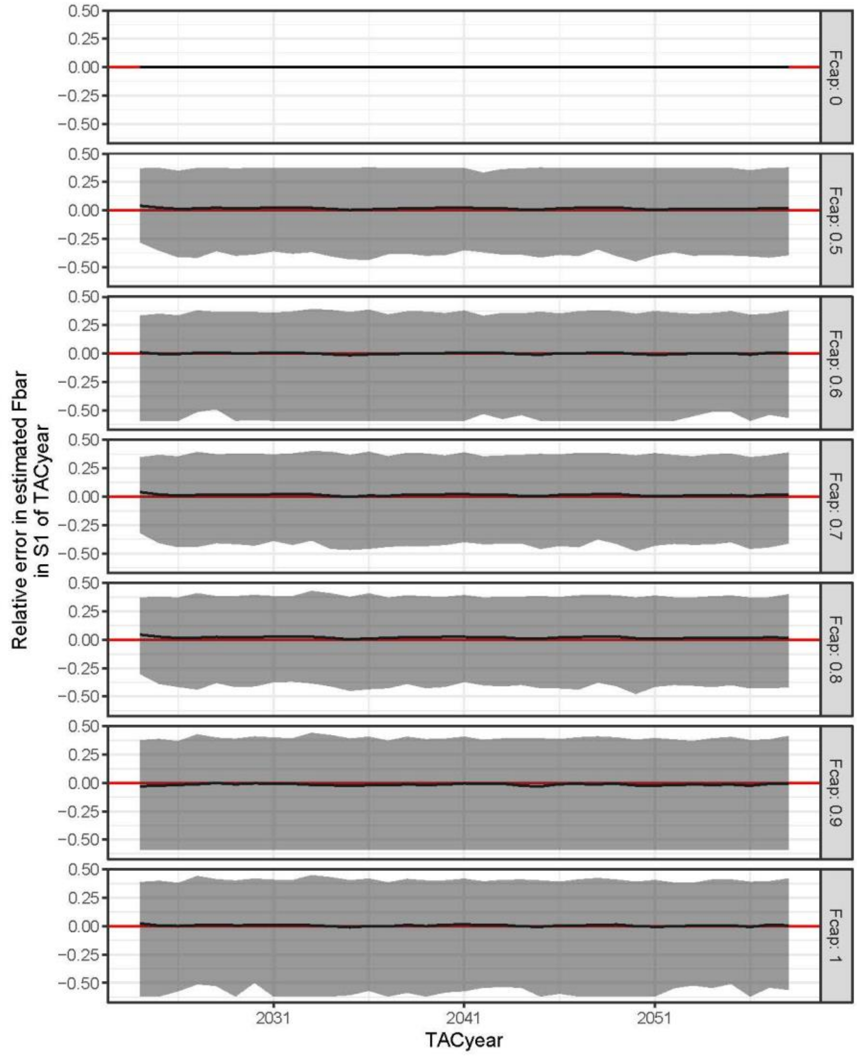

Figure 4: Error rate over time in estimated annual F for ages 1 and 2 (Fbar). The solid black line is the mean. The grey ribbons are 0.025 and 0.975 quantiles. The red line is 0.

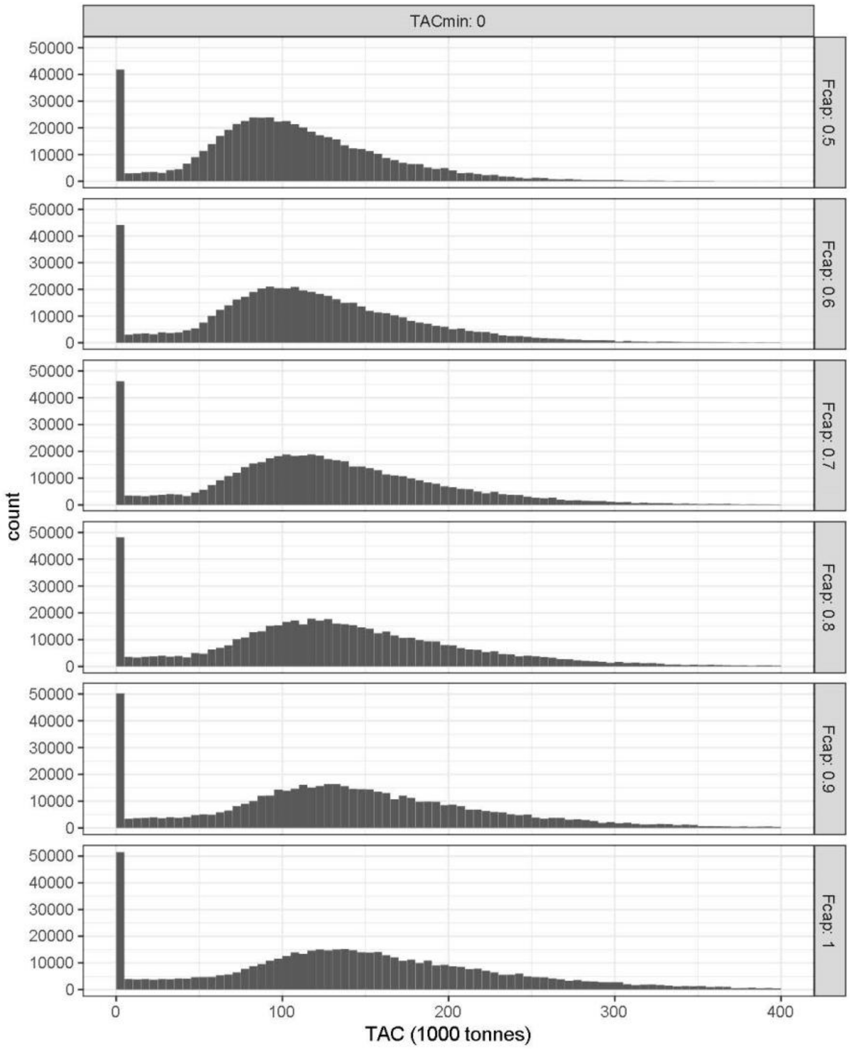

Figure 5: These are the TACs across all years of all simulation trials. The scale of the histogram is too big to see the values near 0.

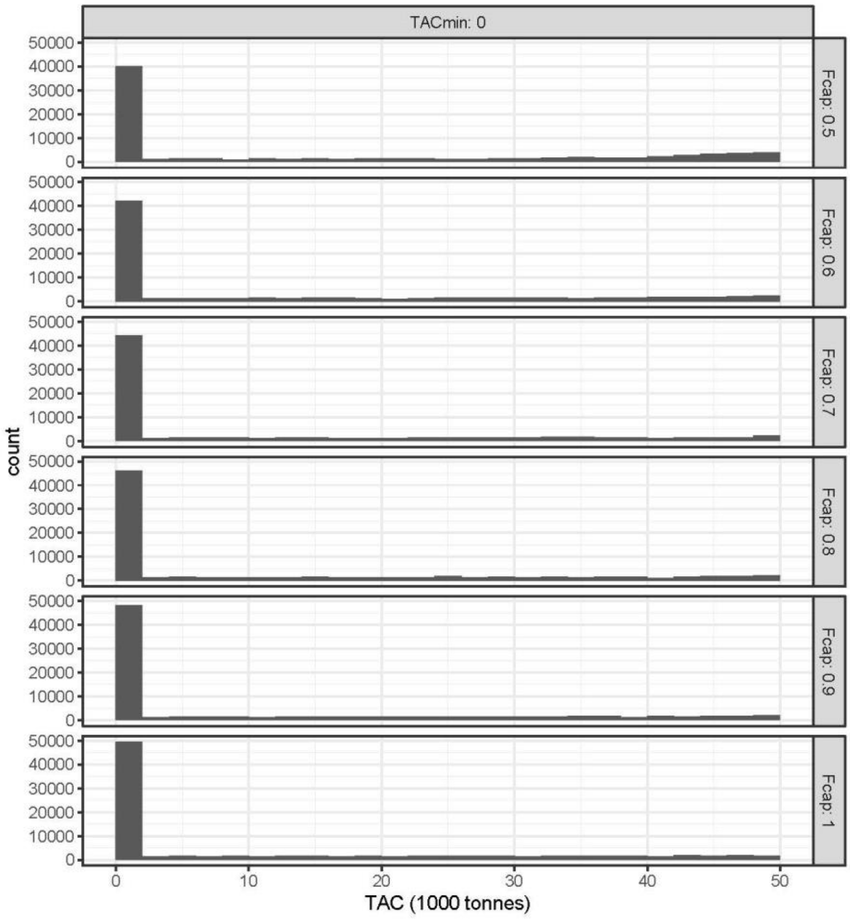

Figure 6: In this zoomed in portion of the histogram (only up to 50,000 tonnes), we can see the stacks at the minimum TAC value.

Summary plots

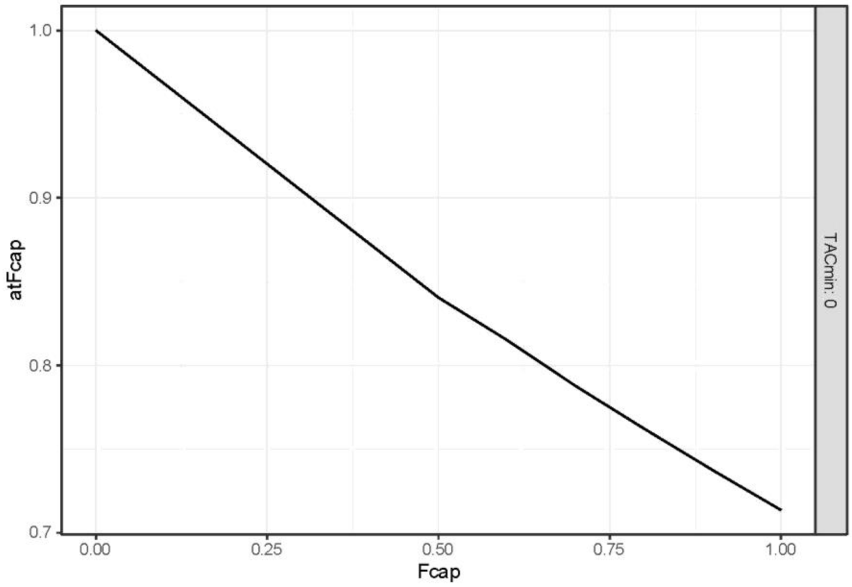

Figure 7: Probability that TAC is based on Fcap in years 2038 to 2058

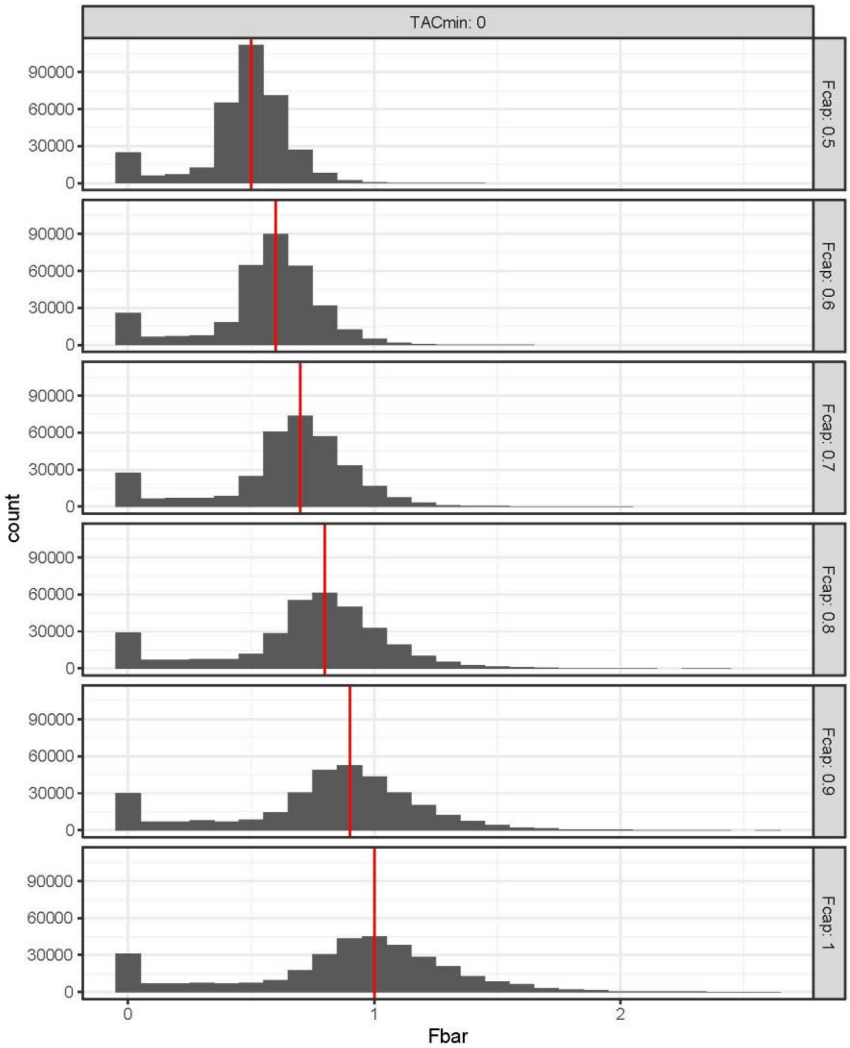

Figure 8: Implemented average F for ages 1 and 2. It can be over Fcap (red vertical line) because there is error in the values going into the forecast (estimated stock numbers, exploitation pattern) that is used to set the TAC. Our implementation model assumes that it will not exceed the highest estimated past effort 2.65.

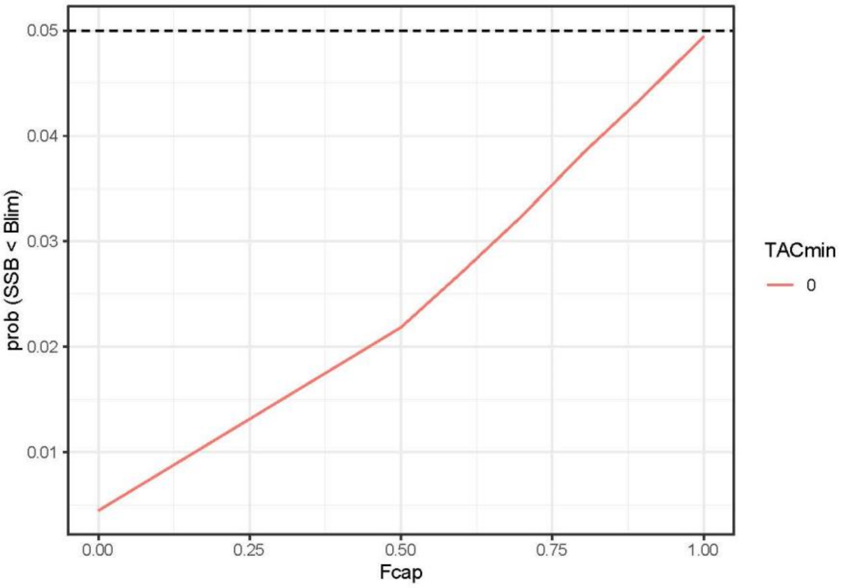

Figure 9: Average risk of SSB<Blim in 2038 to 2058 increases with Fcap. The dashed line is 0.05.

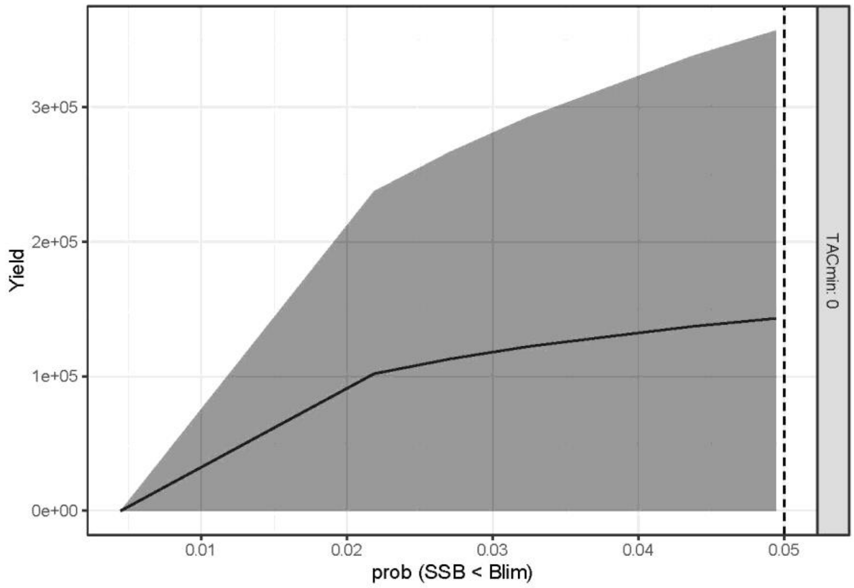

Figure 10: Yield at a given risk level summarized over 2038 to 2058, calculated using the range of Fcap values. The dashed line is 0.05.

Performance statistics

Table 1: For a range of Fcap values with 0 monitoring TAC, the following performance statistics were calculated: atFcap = probability of the advice being Fcap, yield_med = median yield, yield_mean = mean yield, yield.025 = 2.5 percentile, yield0.975 = 97.5 percentile, lowTAC = probabilitity TAC<5000, atFhist = probability implemetation went up to historically maximum F, risk = probability SSB<Blim. These are calculated across 1000 simulaiton trials in years 2038 to 2058.

Fcap	TACmin	atFcap	yield_med	yield_mean	yield.025	yield.975	lowTAC	atFhist	risk
0.0	0	1.00	NA	NA	NA	NA	NA	NA	NA
0.5	0	0.84	101857	106476	7	237388	0.07	0	0.022
0.6	0	0.82	112823	117620	9	266618	0.07	0	0.027
0.7	0	0.79	122096	127136	10	292637	0.08	0	0.032
0.8	0	0.76	129993	135362	6	316429	0.08	0	0.038
0.9	0	0.74	137043	142540	7	338084	0.09	0	0.044
1.0	0	0.71	142976	148859	8	356945	0.09	0	0.049

Acknowledgement

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Stock splitting of North Sea autumn spawners (NSAS) and western Baltic spring spawners (WBSS) for their 2024 assessments

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Abstract

North Sea autumn spawning and western Baltic spring spawning herring are managed separately, but caught together in fisheries and surveys in Kattegat, Skagerrak, and part of the North Sea. Therefore, mixed-stock analysis is needed to allocate catches to the correct assessment. Before the assessment in 2022, the mixed-stock analysis was built on classification from a combination of otolith microstructure, otolith shape analysis, and vertebral count data from Danish, Norwegian, and Swedish samples. Denmark and Norway discontinued their previous sampling and data collection method in favor of stock identification with genetic markers in 2021. Similarly, Sweden has collected genetic samples since 2022. Therefore, it has been necessary to update the procedure for splitting catch data for the her.27.3a47d and her.27.20-24 update assessments in 2022 onwards. To ensure minimal disruption to the update assessments, genetic information suitable to discriminate nine genetic distinct populations was converted to mimic the old stock identification based on spawning time and mean vertebral counts. Further, the mixed-stock analysis was updated to be model based. This working document describes the necessary, but minimally disruptive, changes made to the stock splitting procedure in order to complete the 2024 update assessments of North Sea autumn spawning and western Baltic spring spawning herring. The experiences gained lay out opportunities for improving future assessments.

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Introduction

Several Atlantic herring (*Clupea harengus*) stocks co-occur in the western Baltic Sea, North Sea, and connecting areas Skagerrak and Kattegat. In terms of abundance, the main stocks are the North Sea Autumn Spawners (NSAS) including the Downs winter spawners, and the Western Baltic Spring Spawners (WBSS), respectively. The two stocks mix on feeding grounds in the Kattegat, Skagerrak, and the eastern part of the North Sea.

For the assessment of herring stocks in Subarea 4 and Divisions 3.a and 7.d, autumn spawners (NSAS; North Sea, Skagerrak and Kattegat, eastern English Channel; her.27.3a47d) and in Subdivisions 20–24, spring spawners (WBSS; Skagerrak, Kattegat, and western Baltic, her.27.20-24) catch data and survey estimates have been split between these two stocks in Division 3.a (Skagerrak, Kattegat) and in the so-called 'Transfer area' in the southeastern part of Subarea 4 (Fig. 1). For the HERAS, however, catches from the entire eastern part of Subarea 4.a (4aE) have been split. Any mixing outside these areas has been considered negligible. Likewise, the abundance of other stocks in the assessment areas has been considered negligible, except for the GerAS where Central Baltic herring are filtered out based on growth difference (Gröhsler et al., 2015).

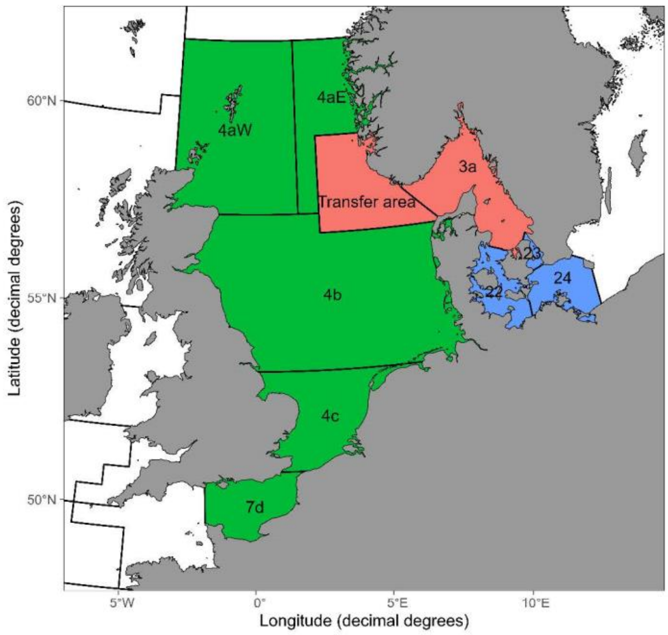

Figure 1: ICES Divisions for the her.27.3a47d (green area) and her.27.20-24 blue area) assessments. The catch data are split by stocks in the 'Transfer area' and Division 3.a (red area).

Historically, the approach for stock splitting in the 'Transfer area' was by vertebral counts in Norwegian samples, whereas splitting in Division 3.a was based on otolith microstructure in

Danish and Swedish data. The microstructure readings were supplemented by otolith shape analysis and a number of other biological parameters (incl. length, weight and maturity) to increase sample sizes. In 2021, Denmark and Norway discontinued the previous sampling methods in favor of genetic marker-based stock identification (hereafter 'genetics'), followed by Sweden in 2022. In this working document, we will report in detail how genetic assignments have been implemented in the splitting of these two stocks for their 2024 update assessment.

Previous method for estimating stock composition

Previously, herring in Division 3.a were mainly split based on otolith microstructure and supplemented by otolith shape analysis (Danish and Swedish data), whereas herring in the 'Transfer area' were split based on mean vertebral counts (VS; Norwegian data).

Using otolith microstructure, it is possible to identify the hatching season of herring, thus fish classified as autumn spawners were assigned as North Sea autumn spawners (NSAS), whereas herring hatched in spring were assigned as western Baltic spring spawners (WBSS). For Danish samples, fish classified as winter spawners were assumed to be Downs herring and assigned as NSAS. In contrast, fish classified as winter spawners from Swedish samples were assumed to be from local coastal populations. Therefore, these were assigned as WBSS.

Using VS, the proportion of NSAS vs. WBSS were estimated per sample assuming that the VS of NSAS = 56.5 and of WBSS = 55.8 as following:

$$\%WBSS = \frac{56.5 - Sample_{VS}}{56.5 - 55.8}$$

where $Sample_{VS}$ represents the mean vertebral count of the specific sample. The value is capped to be between 0 and 1.

These two splitting methods were adjusted to split NSAS and WBSS, whereas observations of other stocks (for example Norwegian spring spawning herring (NSS)) have been noted but not taken into consideration until recently.

Stock compositions were estimated by age (represented by the number of winter rings, wr), quarter, and area. Due to limited samples available, information was 'borrowed' between estimation groups by combining them to ensure at least 10 individuals per age specific estimate, through expert judgement and data patterns. Further, samples from surveys were included to increase the sample sizes. In Division 3.a, stock compositions were estimated for Danish and Swedish commercial catches. In turn, the country-wise estimates were combined to total Division 3.a composition estimates by a weighted average per age and area. The average was weighted by the relevant catches in numbers.

Using genetic information in the update assessments 2024

A detailed description of the applied genetic population identification method is presented in Bekkevold et al. (2023), Seljestad et al. (2024), and ICES (2024). This method has been applied with similar sets of single nucleotide polymorphism (SNP) markers using almost the identical baseline samples across laboratories for Danish, Swedish and Norwegian data. Thus, genetic assignments among different countries are largely comparable. In contrast to the previous splitting methods, the genetics allow for a much more detailed small-scale population identification resulting in nine genetic distinct populations (Table 1).

The shift to a more high-resolution population identification raised several data issues for the transition from previous methods to genetic assignments in the 2024 update assessments of her.27.3a47d and her.27.20-24. The new genetic information revealed that more herring populations are present in the assessment areas than previously accounted for. Further, all populations are found in larger parts of the assessment areas than currently modelled. Two options were considered for transitioning from the meristic/morphometric methods to genetics as the basis for estimating stock compositions.

The first option, which is preferable in the long term, was to split catch and survey samples directly by genetic information into genetic NSAS-Downs, genetic WBSS, and other genetic populations. In the short term, however, this would make the data since 2021 incompatible with previous years, which are based on spawning season and vertebrae counts. For example, genetic WBSS is only a subset of spring spawners present in the area. Moreover, this option would either result in parts of the catches not being allocated to one of the two assessed stocks (her.273a47d or her.27.20-24) or they would be allocated to their original assessed stock which would require changes to herring assessments in several working groups.

Ideally, future work can move the assessments towards corresponding to the biological populations, reflecting the relevant reproductive units. However, such changes would require corrections of data back in time, and close coordination between the assessments of all herring stocks that are part of the regional mixture. This was determined to be outside the scope of an update assessment and should be subject to the thorough peer-review of a benchmark. Instead, it was decided to keep the update assessment as consistent as possible with the procedure decided at the last benchmark (ICES, 2018). The NSAS assessment later went through an inter-benchmark that did not change the stock composition estimation (ICES, 2021). To be consistent with previous assessments, genetic population identification was converted to the assignments that would be expected from the previous methods (Table 1). For microstructure, predominantly spring spawning populations were converted to WBSS while predominantly autumn and winter spawning populations were converted to NSAS. For vertebral counts, genetic populations with VS lower than 56.15 (midpoint between mean VS of NSAS and WBSS) were converted to WBSS while populations with higher VS were converted to NSAS.

We note that this conversion does not fully correspond to what would be obtained with the previous methods. In the previous methods, otolith microstructure (and otolith shape) assignments were made at an individual level. However, in the transformation from genetic assignments (Table 1), all individuals from the same genetic population are transformed to the same expected microstructure assignment, Therefore, differences resulting from inter-stock variability and the risk of misclassification is not accounted for. Likewise, the new method maps genetic populations to NSAS/WBSS based on the mean vertebral count of the stock. For example, all genetic Norwegian spring spawners (NSS) are assigned to NSAS in the new method (Mean VS: 57.2). However, roughly 10% of NSS herring have a VS of 56 or below (Eggers et al., 2014; Berg et al., 2017). In the previous method, these would drag the estimated proportion (slightly) towards WBSS. The remaining 90% would drag the proportion towards NSAS. The impact on the proportions would depend on the individual VS and amount of NSS in each sample. Again, the difference resulting from inter-stock variability is not accounted for.

Table 1: Overview of genetically assigned distinct populations. Mean vertebral counts (VS) for each genetic populations were estimated based on Norwegian catches in 2019-2021, and total number of assigned individuals are presented. For consistency in the assessment, fish were assigned to either North Sea autumn spawners (NSAS) or western Baltic spring spawners (WBSS) based on expected outcome from previously used splitting methods. Norwegian data was split by mean vertebral counts, whereas Danish and Swedish data was split by otolith microstructure into different hatching season. Mismatch between assigned stocks based on Norwegian and Danish/Swedish data is presented in *italic*.

Genetic population	VS	Hatching season	Stock assigned	
			Norwegian data	Danish/Swedish data
North Sea autumn spawners	56.5 (n = 387)	Autumn	NSAS	NSAS
Downs	56.6 (n = 1350)	Winter	NSAS	NSAS
Western Baltic spring spawners	55.7 (n = 553)	Spring	WBSS	WBSS
WBSS-Skagerrak	56.8 (n = 76)	Spring	*NSAS*	*WBSS*
Spring spawners from 6aN	56.9 (n = 268)	Spring	*NSAS*	*WBSS*
Norwegian spring spawners	57.2 (n = 134)	Spring	*NSAS*	*WBSS*
Northeast Atlantic (FASH, ISSH, NASH)	56.5 (n = 8)	Autumn	NSAS	NSAS
Central Baltic herring	55.9 (n = 23)	Spring	WBSS	WBSS
Baltic autumn spawning herring	55.6 (n = 33)	Autumn	*WBSS*	*NSAS*

Updated method for estimating stock compositions

The discontinuation of previous classification methods and subsequent move to genetics, necessitated an update of the method for estimating stock compositions. At the same time, it was decided to change the way information was transferred ('borrowed') between estimation groups. From the 2022 assessment onwards, 'borrowing' of information was implemented in a statistical model with less reliance on expert judgment.

Stock composition in the 'Transfer area'

For the splitting of 2023 catches in the 'Transfer area', 13 Norwegian commercial samples with length-at-age and genetic assignments were available, whereof 10 samples were collected in Q3, but only three samples in Q4. Sweden had one sample in Q1 and three samples in Q3 from the transfer area. Two Danish commercial samples were available: one in Q1 and one in Q3. Thus, the resolution was not optimal, but improved compared to previous years when only two or less samples were available. Similar to the update assessment in 2023, the splitting proportion for quarter 2 and 3 were combined due to lack of samples. To estimate more precise proportions of stocks, we increased the sample size of older fish by 'borrowing' data from the HERAS samples as well as the IBTS samples collected in the 'Transfer area' at similar locations and time as commercial catches. This "borrowing" procedure is in line with previous stock assessments. Proportions for quarter 1 and 4 were calculated from the raw individual genetic classifications. In quarter 4, all age classes were updated. In quarter 1, sufficient data was only available for ages 1-3. For the remaining age classes, the proportions were assumed to be identical to what has been used in the last years. Genetic assignments were converted to NSAS/WBSS to be consistent with previous assessments (Table 1).

For the estimation of proportions, we used a logistic mixed effects model (Albertsen, 2022). The default model included a B-spline with five knots to smooth over ages (wr 1-9+). Further, additional parameters were included for ages 1, 2, and 3 to account for differences in catchability/selectivity/availability between HERAS/IBTS and commercial samples. A parameter was tested for age 4 but did not improve the model fit. For older ages, both stocks were assumed to be fully selected by all gears, and any difference in, e.g., availability was assumed to be negligible. If not, we would not have been able to estimate the difference with the limited number of samples. Finally, a random intercept on trips/hauls was included to account for correlation between samples. Due to the properties of the specific samples available in 2023, it was necessary to reduce the number of spline knots to 3 to ensure that the model was identifiable and converged properly. The estimated proportions of North Sea autumn spawners in the 'Transfer area' are shown in Table 2.

Table 2: Estimated proportion of North Sea autumn spawners (NSAS) by age and quarter in 2023 commercial catches in the 'Transfer area'.

Age	Q1	Q2	Q3	Q4
0	100.00	100.00	100.00	100.00
1	100.00	94.44	94.44	100.00
2	98.15	84.98	84.98	100.00
3	91.67	91.53	91.53	97.78
4	72.53	69.96	69.96	94.44
5	28.57	59.87	59.87	100.00
6	60.32	52.84	52.84	100.00
7	100.00	48.77	48.77	100.00
8	28.57	46.92	46.92	100.00
9+	100.00	46.41	46.41	100.00

The total catch in 2023 in the 'Transfer area' and Division 3.a resulting from the split between NSAS and WBSS is given in Table 3.

Table 3: 2023 catches (tonnes) in the 'Transfer area' and Division 3.a split by stocks.

<table>
<tr><th></th><th colspan="2">NSAS</th><th colspan="2">WBSS</th></tr>
<tr><td>Transfer area (A-fleet)</td><td colspan="2">16 365</td><td colspan="2">2 361</td></tr>
<tr><td rowspan="2">Division 3.a</td><td>C-fleet</td><td>D-fleet</td><td>C-fleet</td><td>D-fleet</td></tr>
<tr><td>563</td><td>169</td><td>194</td><td>61</td></tr>
</table>

Stock composition in Kattegat and Skagerrak

For the splitting of catches in Division 3.a, Danish and Swedish data were available from commercial sampling programs as well as from the IBTS and HERAS surveys (Table 4). Similar to the 'Transfer area', commercial sampling was very limited for some quarters and areas in 2023. Therefore, like in previous years, samples from the IBTS and HERAS were included to inform the estimation of stock compositions.

Table 4: Number of sampled individuals from Danish and Swedish data collected from commercial, IBTS and HERAS catches per quarter and area used for the stock splitting.

Area	Quarter	Denmark (genetics)			Sweden (genetics)		Total
		Commercial	IBTS	HERAS	Commercial	IBTS	
3.a.20	1	0	40	0	22	157	**219**
	2	0	0	0	0	0	**0**
	3	0	29	1064	50	136	**1279**
	4	0	0	0	50	0	**50**
	Total	0	69	1064	122	293	**1548**
3.a.21	1	217	0	0	0	101	**318**
	2	0	0	0	0	0	**0**
	3	106	0	139	0	170	**415**
	4	0	0	0	235	0	**235**
	Total	323	0	139	235	271	**968**
Total		**323**	**69**	**1203**	**357**	**564**	**2516**

Stock compositions of commercial catches were estimated by country, age (0-8+ wr) and area using a logistic mixed effects model (Albertsen, 2022). The default logit-linear model included a B-spline on age with three knots along with additive effects of area, trip type (combining country and commercial/IBTS/HERAS), and quarter. Interactions between the B-spline on age and each area, trip type, and quarter were also included. Further, a factor with a level per quarter for age 0 and a combined level for age 1+ (i.e., the levels: Age0Quarter3, Age0Quarter4, Age1+) was included to allow additional flexibility. There were no observations of age 0 in quarters 1 and 2. Finally, the model included a random intercept varying by trip/haul to account for correlation between observations.

The model allowed the estimation of stock composition in commercial catches for each combination of quarter, area, and country, even when no commercial samples were available. When no commercial samples were available, composition proportions could be extrapolated based on the differences in groups where commercial samples were available. In turn, country-wise stock composition estimates were combined by area, quarter, and age. Similar to previous years, the combined estimates were calculated as a weighted average using commercial catches from Denmark and Sweden (numbers-at-age). For ages without commercial catches from Denmark and Sweden, the sum over ages of Danish/Swedish catches for the same area and quarter were used for the weighted average (i.e. if Danish and Swedish catch for age 2 (A2), quarter 3 (Q3) and Subdivision 20 (SD20) is zero, then the sum over ages in Q3 SD20 = A0Q3SD20 + A1Q3SD20 + … + A8Q3SD20). For ages without commercial catches for any country, no combined estimate was calculated. The estimated proportions of NSAS are shown in Table 5.

The total 2023 catch in Division 3.a resulting from the split between NSAS and WBSS is given in Table 3.

Table 5: Estimated proportion of North Sea autumn spawners (NSAS) per age (wr) and quarter in the Subdivision 3.a.20 Skagerrak and 3.a.21 Kattegat.

Age	Subdivision 3.a.20 Skagerrak				Subdivision 3.a.21 Kattegat			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0		0.85	0.85	0.97		0.71	0.71	0.94

1	0.95	0.80	0.80	0.87	0.86	0.56	0.56	0.68
2	0.92	0.78	0.78	0.61	0.80	0.58	0.58	0.37
3	0.72	0.66	0.66	0.28	0.60	0.53	0.53	0.18
4	0.30	0.44	0.44	0.16	0.29	0.43	0.43	0.16
5	0.07	0.22	0.22	0.31	0.10	0.29	0.29	0.40
6	0.03		0.11	0.91	0.04			0.94
7	0.03		0.07	1.00	0.03			1.00
8+	0.13			1.00	0.05			1.00

Conclusion

With effect from the 2023 update assessments of NSAS and WBSS, Denmark, Sweden and Norway discontinued the sampling of otolith microstructure and vertebral counts in favor of genetics. It was therefore necessary to update the stock splitting procedure. For the update assessment, a minimally disruptive update was chosen to remain consistent with previous years. Changes to the stock splitting that fully utilize the additional information from genetic samples were deferred to a future benchmark.

The updated method consists of a procedure for converting genetic assignments to the expected assignments of otolith microstructure and vertebral counts, respectively. Further, borrowing of information between ages, areas, and cruises was implemented in a model with less reliance on expert judgement than previously. The model was compared to the previous procedure in a re-analysis of data from 2020. The new implementation was found to give stock composition estimates that were overall consistent with the previous method (Berg et al., 2023).

Genetic analyses have revealed that more herring stocks mix in larger areas of the region than accounted for in the assessments. Therefore, it is appropriate to modify the currently applied two-stock procedure into a proper stock-specific composition procedure. Further, neither the previous nor present method accounts for differences in stock weight-at-age in the splitting. Stock compositions are estimated by numbers and used to split the CANUM calculated from average weights. Instead, an integrated model should be used to calculate stock composition, stock-wise catch weights, stock-wise age distributions and stock-wise CANUM. However, such improvements should be part of a benchmark process to ensure that they are thoroughly peer-reviewed, and that the assessment models are built on the best available science. Further, it would require that age samples as well as genotyped samples and baselines are shared between countries, preferably in a standardized format such a GENEPOP (4.0) and with standardized locus names.

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Stock-Specific Simulations to Find Appropriate Proxy Harvest Rates for Herring in 6.a South, 7.b-c and 6.a North for use in the Constant Harvest Rate (*chr*) Method

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Working Document to HAWG, 13rd September 2024

Introduction

Following a benchmark in 2022 (ICES, 2023), advice for the 6.aN and 6.aS,7b-c herring stocks is given on the basis of an implementation of the *chr* rule (Category 3, ICES 2022c). The key advance at the benchmark was made in terms of the Malin Shelf herring acoustic survey (MSHAS) which, following a genetic study, can now be split and provide stock specific biomass estimates. The split survey time series is available from 2014 onwards.

The parameterisation of the *chr* rule involves the identification of a proxy harvest rate that is calculated as the ratio of catch to survey index over an appropriate period. The available time series for estimating these proxies is relatively short with split survey estimates starting in 2014. The catches during this period were limited by either the stock specific TAC or a monitoring TAC which was split (72% 6aN, 28% 6aS,7b-c) between the stocks. This contrasts with the split survey results, which indicate that the southern stock is, on average, 4 times larger than the northern stock. This leads to contrasting proxy harvest rates for the stocks (0.03 for 6.aS,7b-c and 0.34 for 6.aN).

At the HAWG in 2024, the application of the stock-specific *chr* rules led to contrasting advice for neighbouring stocks, which is difficult to reconcile. On the basis of the draft advice, the 6.aN catch advice for 2025 is a (capped) 20% increase, despite a reduction of more than 30% in the survey index. For the southern stock, while the reduction in the survey index leads to a (capped) 25% reduction in advice, the low harvest rate proxy leads to advised catches that correspond to <2% of the estimated biomass from the survey.

After the HAWG 2024 meeting, an alternative proxy harvest rate (0.15) was proposed for both stocks based on values from neighbouring stocks. However, this approach was reviewed unfavourably and was not brought forward to the advice drafting group (ADG Celtic Seas). The justification was that "*Changing the target harvest rate is a substantial change to the method and would likely require stock-specific simulation testing, as recommended in the ICES technical guidelines (ICES, 2022).*"

The issue of the contrasting proxy harvest rates of the two stocks was raised and discussed during ADGCS in June 2024. The final decision was:

"ADGCS suggests that advice for 6aN and 6aS herring be delayed until late 2024 after interim simulation work is conducted to explore how CHR has been applied to the two stocks, its strength, weaknesses for these stocks. MSY proxy harvest rates for each stock will be explored and possibly revised if appropriate, and should be explainable when compared. Advice for the 2025 fishing season will be provided in late 2024."

This document outlines the simulations and results for both stocks. Methods and preliminary results were presented to the HAWG in an online meeting on the 5th of September. This document incorporates comments and suggestions received at that meeting. This document will be sent for external review prior to the ADGNEPH in early October 2024.

The *chr* rule and calculation of the proxy harvest rate ($F_{proxy,MSY}$)

The *chr* rule applies a constant harvest rate ($F_{proxy,MSY}$) that is considered a proxy for an MSY harvest rate, to a survey index. Full explanations of its calculation and use are available in the ICES technical guidelines for category 2 and 3 stocks (ICES, 2022c) and the WKLIFE X report (ICES, 2020). Briefly, the rule states:

$$A_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$$

where A is the advised catch for a given year, I is the survey index, $F_{proxy,MSY}$ is the target harvest rate, b is a biomass safeguard and m is the multiplier which scales the catch advice to a precautionary level. For both herring stocks in 6a the index used is the genetically split MSHAS SSB, and the multiplier, m, is set at 0.5 as outlined in the guidance document

Historical data is used to define the harvest rate ($F_{proxy,MSY}$). $F_{proxy,MSY}$ is the mean ratio of catch to index (C_y/I_y) from those historical years for which the mean length at first capture (L_c) is above the target reference length ($L_{F=M}$). See Table 1 for definitions of terms and Appendix 1 for an example of its calculation in 6.S,7.bc.

Table 1. Definitions of components used in the calculation of the *chr* (from WKLIFE X; ICES, 2020). Note that both 6a herring stocks use a stock specific $L_{F=M}$ equation that differs from the generic in this table.

Component	Definition	Description and use
I_{y-1}		The index in year y−1.
$F_{proxy,MSY}$	$\frac{1}{u}\sum_{y \in U} C_y/I_y$	Is the mean of the ratio C_y/I_y for the set of historical years U for which the quantity $f > 1$, and u is the number of years in the set U. The quantity f is the ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2018b).
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock.
m	[0,1]	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	$min\{max(0.7C_y, C_{y+1}), 1.2C_y\}$	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%; i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's advised catch. The stability clause does not apply when $b < 1$.

Methods for Stock Specific Simulations

The methods followed here were largely informed by Fischer et al. (2022), who used a simulation-based approach "*as an optimisation procedure to tune the parameters of the control rule to meet maximum sustainable yield and precautionary management objectives*." The FLife R package was used to condition operating models (OMs) for both herring stocks in ICES Area 6.a (i.e. 6.aN and 6.aS), simulating FLBRP (equilibrium biological reference point) objects based on life-history parameters. The majority of the life-history parameters used for this simulation exercise were empirically derived, using stock-specific data, or, where appropriate parameters were already available, from stock annexes (Table 2). The only parameter used in generating FLBRP objects that was not estimated directly, steepness (*h*), was tested across a plausible range based around empirical estimates for "Atlantic herring" published in Myers, et al. (1999). Initially, steepness was tested over a range of 0.6 – 0.8, spanning the estimate of 0.74, but following the presentation of preliminary results to the HAWG, values in the range of Myers' estimate and upward were deemed to potentially be implausibly high to a point where stocks would have an unrealistic potential for recovery from heavy exploitation. The final values tested ranged from 0.6 at the lower end up to Myers' estimate of 0.74. Fishery selectivity was described by a sigmoid function, where a_{50} (derived from l_{50}, Table 2) was the first age at full selectivity. Selectivity was explored by estimating selectivity-at-length from commercial catch length sample data (Pauly, 1984). The l_{50} for catch selectivity tended to be close to the maturation l_{50} during the period of commercial fishing (Fig. 1), and so selectivity at maturity (as described above), and selectivity after maturity (e.g. Fischer, *et al.* 2020) were tested in the simulations. Small individuals very rarely appeared in commercial samples. The FLBRP objects were then converted to age-structured OMs. The resulting OMs for the two herring stocks were very similar, as there were only minor disparities in life-history parameters, and some were shared (natural mortality-at-age, steepness) or calculated from pooled data (length-weight relationship) out of necessity.

Table 2. Parameters and settings used to generate FLBRP objects

Parameter/ setting	Description	*her.27.6aN*	*her.27.6aS7bc*	Source
L_{inf}	Von Bertalanffy mean asymptotic length (cm)	30.18	29.47	Re-estimated from data used at WKNSCS (ICES, 2023), fixed t_0
K	VB growth rate coefficient	0.416	0.486	
t_0	VB age at length 0 (WR)	-1.5	-1.5	
h	Steepness	$h \in \{0.6, 0.65, 0.74\}$	$h \in \{0.6, 0.65, 0.74\}$	Myers et al., 1999 (with sensitivity range)
l_{50}	Length at 50% maturity (cm)	23.03	23.53	HERAS survey data (2014-2023)
a; b	Length-weight relationship coefficients	0.00529; 3.155	0.00529; 3.155	
Age	Age range of the stock (years)	0 – 6+	0 – 6+	Age where fish reach 95% L_{inf}
F_{bar} range	Range of ages over which $\bar{F}$ is calculated (years)	2 – 6	2 – 6	Scrutiny of age ranges in commercial sample data
M	Natural mortality-at-age	2020 SMS key run	2020 SMS key run	ICES, 2022a; ICES, 2022b

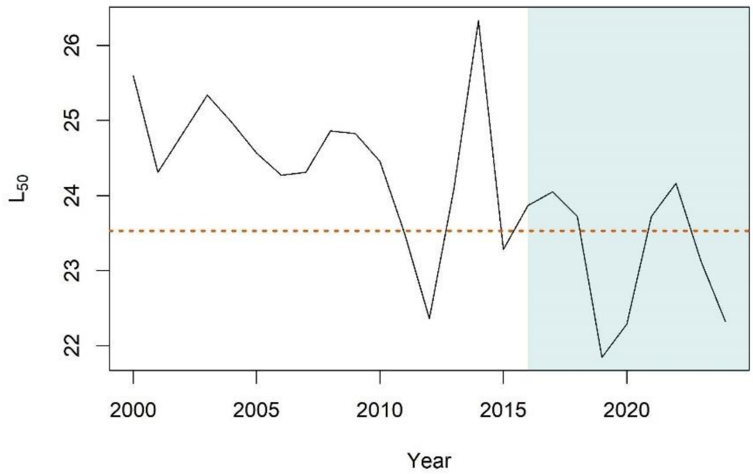

Figure 1. Estimated l_{50} from catch selectivity-at-age analysis (*black line*) over the time-series of commercial sample data for Area 6.a. herring. The *orange* dotted line indicates the maturity l_{50} used to create FLBRP objects. The green area shows the period during which the fishery has been restricted to a monitoring catch advice.

During discussion that followed preliminary presentation of this work to the HAWG, it was agreed that the Von Bertalanffy t_0 values, which were estimated during the benchmark for these stocks (ICES, 2023), were unrealistically low (-3.33 and -2.61 for the 6.aN and 6.aS stocks, respectively). It was decided that the Von Bertalanffy models should be re-fitted to the datasets used in the benchmark process, but with t_0 fixed at a more appropriate value (e.g. -1.5 WR, or -0.5 years; Figures 2 & 3). It was agreed that the benchmark model fits would likely have unreasonably low growth rates, and the estimates of mean asymptotic length would likely be affected as well, which would affect the resulting FLBRP objects leading to inaccurate biological reference points. The resulting fits appeared reasonable, and had comparable L_{inf} estimates to their benchmark approved equivalents. The k values increased in both cases, as expected, and the estimate for 6.aS technically pushes it into Method 3 for Category 3 advice ($k \geq 0.45$; ICES, 2022c). However, the proposed updated method for provision of advice for both stocks more correctly falls under the heading of Method 3.2 (stock-specific MSE process) regardless, and is ultimately a preferable method when compared to the application of a more generic *chr*, as under Method 2.2.

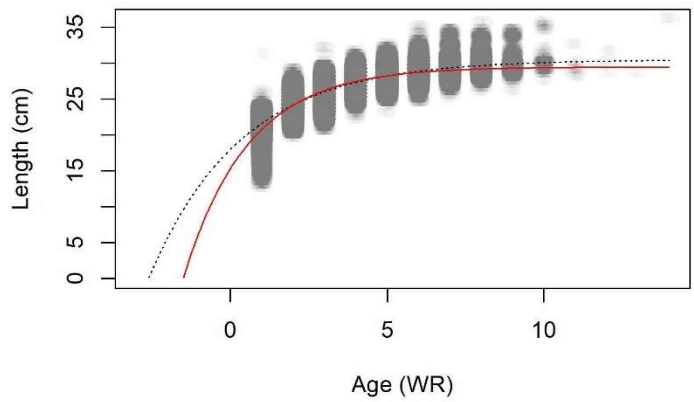

Figure 2. Von Bertalanffy growth model fits to commercial catch-at-age data for 6.aS herring from the WKNSCS benchmark (*black* dotted line), and updated for the current work with t_0 fixed at -1.5 WR (*red* line). The *grey* points are the jittered length-at-age commercial sample data.

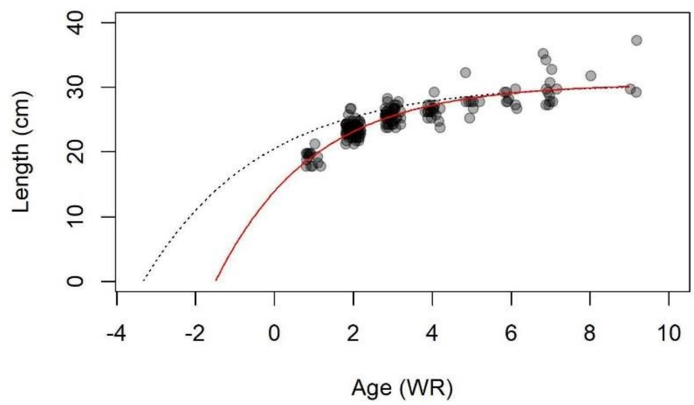

Figure 3. Von Bertalanffy growth model fits to commercial catch-at-age data for 6.aN herring from the WKNSCS benchmark (*black* dotted line, reconstructed from parameters provided by Scottish Marine Directorate), and updated for the current work with t_0 fixed at -1.5 WR (*red* line). The *grey* points are the jittered length-at-age commercial sample data.

In each OM, growth was described by the Von Bertalanffy model. The stock-recruit relationship was assumed to follow the Beverton-Holt function for each steepness scenario tested (Table 2). The maximum age of six reached by both stocks was determined by the age at which individuals would reach 95% of L_{inf}. The maximum age of both stocks also functioned as a plus group. Maturation was described by a sigmoid function centred on l_{50}, which was empirically derived for each stock by fitting GLMs (with a binomial family) to HERAS data. The natural mortality-at-age profiles were taken from the respective stock annexes, which are based on the 2020 SMS key run (ICES 2022a; ICES 2022b).

Unfished spawning stock biomass was set to 1000 units at the beginning of each simulation configuration, then three different 100-year long fishing history trajectories (Fig. 4) were implemented (one-way, random, and rollercoaster; e.g. Fischer et al. 2020). These were designed to reflect a variety of plausible fishery development. A range of maximum historical fishing levels (F_{MAX}) were tested for each historical trajectory; F_{MSY}, 1.5 x F_{MSY}, 2 x F_{MSY}, and 0.8 x F_{CRASH} (i.e. the minimum F that causes a stock collapse). In the random fishing history, F trajectories were generated (based on a random uniform distribution) to give a range of stock depletion levels at the outset of the MSE proper. For the one-way and rollercoaster scenarios, OMs were first fished at 0.5 x F_{MSY} for 75 years, and then diverged for the final 25 years of pre-MSE time. In the one-way scenario, F was increased exponentially from 0.5 x F_{MSY} to F_{MAX} over the final 25 years. For the rollercoaster, F was increased from 0.5 x F_{MSY} to F_{MAX}, sustained at F_{MAX} for 5 years, and then reduced back to F_{MSY}.

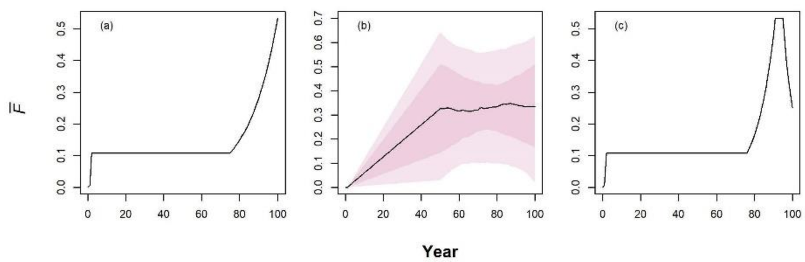

Figure 4. Historical fishing trajectories implemented for herring stock OMs; (*a*) one-way, (*b*) random, and (c) rollercoaster. The *pink* bands in (*b*) indicate the 0.25-0.75 and 0.05-0.95 quantile regions for the 500 randomly generated $\bar{F}$ trajectories.

Each OM was projected forwards by 50 years over 500 iterations. Additional uncertainty was described by a log-normal distribution for the TSB index (SD = 0.2), and recruitment

(SD = 0.6). Management over the 50 year forward-simulated period was applied using the *chr* rule (ICES, 2022c);

$$A_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$$

where A is the advised catch for a given year, I is the survey index, $F_{proxy,MSY}$ is the target harvest rate, b is a biomass safeguard (affecting a reduction in advice if the survey index falls below $I_{trigger}$, and m is the multiplier which scales the catch advice to a precautionary level (see Table 1 for a full description of *chr* components).

The survey index was assumed to be indicative of changes in total stock biomass, without observation uncertainty. During the discussion of preliminary results with the HAWG, it was suggested that incorporation of observation uncertainty might be explored (e.g. including empirically-based survey CV-at-age in the calculation of the index, to be propagated through the simulations). However, the derivation of these age-specific empirical estimates would have been beyond the scope of what could be achieved in the time frame of this work, let alone their incorporation into the simulations (see 'Next Steps' below for details of future plans to address this). As the survey indices being used here are assumed to capture trends in TSB, the simulations are performing a one-dimensional optimisation, moving the catch advice towards a precautionary level by iteratively applying a range of combined scalars (m_s, i.e. ($F_{proxy,MSY}$ x m) ∈ [0,2]) to the survey index. The genetic algorithm was defined by a fitness function aiming to manage the stock towards MSY while following ICES' precautionary approach, and maintaining median probability (PB_{lim}) of SSB dropping below B_{lim} ≤ 5% (ICES, 2016, 2021a), where B_{lim} was set as the SSB where recruitment is impaired by 30% (Fischer, *et al.* 2022). In the event that a precautionary multiplier could not be identified, the algorithm returned the scalar value which maximised the realised catch. Changes to catch advice were restricted to between +20% and -30% from year-to-year.

Results & Discussion

When considering individual simulation scenarios, outcomes were reasonably robust to the assumptions tested around the developmental trajectory of fishing histories. At the starting point for forward-simulation of *chr* management, i.e. year 100, each scenario tended to be at a different SSB level (Fig. 5) due to the different levels of depletion experienced in the historic development. Thus, there were slight differences in the slope and duration of the initial recovery period once *chr* implementation had begun, but when the OMs reached a stable state, the median SSB (and associated uncertainty) tended to be very similar. Even in scenarios where SSB did not recover to a precautionary level, median stabilised values, and associated uncertainty remained consistent across fishing history trajectory options.

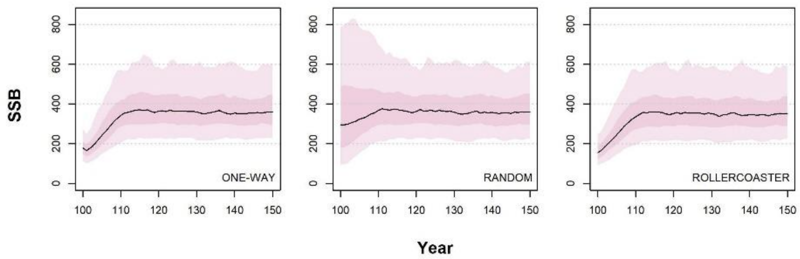

Figure 5. Effect of the fishing history trajectory assumption on a single operating model: 6.aN stock, with selectivity at maturity, m_s = 0.12, h = 0.6, and F_{MAX} = 2 x F_{MSY}. The pink bands indicate the 0.25-0.75 and 0.05-0.95 quantile regions, and the *black* line is the median realised SSB across the forward-simulated period, i.e. the 50 years following the initial fishing history period.

Similarly, sensitivity testing of steepness, *h*, showed that simulations were relatively robust across the agreed plausible range tested (Fig. 6). As *h* was increased, and recruitment became more decoupled from SSB, variability (i.e. uncertainty) in realised SSB increased somewhat, and the stocks' ability to recover from depletion increased accordingly. The median stable-state SSB also increased somewhat with steepness, as expected.

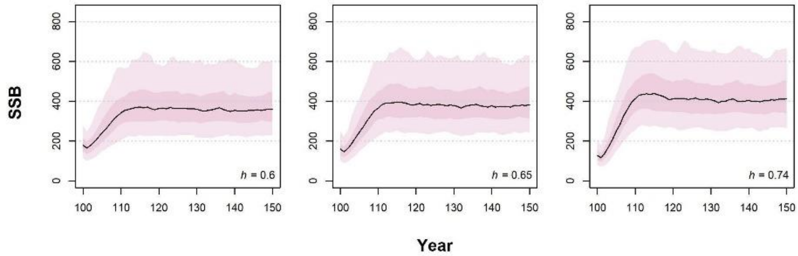

Figure 6. Effect of the steepness assumption, *h*, on a single operating model: 6.aN stock, with selectivity at maturity, m_s = 0.12, a one-way fishing history trajectory, and $F_{MAX} = 2 \times F_{MSY}$. The *pink* bands indicate the 0.25-0.75 and 0.05-0.95 quantile regions, and the *black* line is the median realised SSB across simulations for the forward-simulated period, i.e. the 50 years following the initial fishing history period.

Across OM scenarios, simulated B_{lim} risk profiles behaved similarly (Fig. 7). As m_s values were increased, B_{lim} risk increased. In the majority of scenarios (80% of 6.aN OMS, and 78% of 6.aS OMs), an optimum m_s value was identified which kept B_{lim} risk below the 5% precautionary threshold, after which risk would increase steadily. In others (e.g. red cells in bottom panels of summarised results, historic F_{MAX} at $0.8 \times F_{CRASH}$; Figs. 8 & 9) there was no m_s value that would give precautionary catch advice, and in those cases the optimisation returned the multiplier which maximised the realised catches over the period of simulation. Realised catches would increase once $m_s > 0$, up to some point at which the stocks could no longer sustain that level of fishing, and SSB would decline steadily towards zero thereafter.

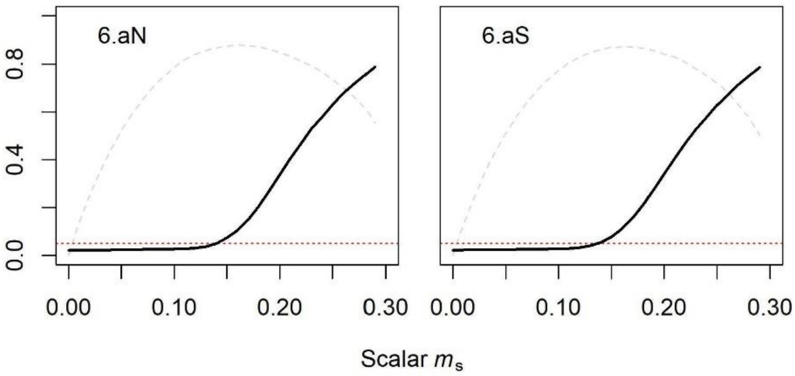

Figure 7. Example optimisation output from operating models for both stocks with selectivity at maturity, a rollercoaster fishing history trajectory, *h* = 0.65, and F_{MAX} = 2 x F_{MSY}. The y-axis shows standardised values [0, 1] for B_{lim} risk profiles (solid *black* line), and realised catch (dashed *grey* line) for m_s values across simulations. The *red* dotted line shows the 5% precautionary risk limit.

Optimised m_s values for the 6.aN and 6.aS herring stocks are presented in Figures 8 and 9, respectively. It should be noted that the historic F_{MAX} of 2 x F_{MSY} scenarios were run on a finer resolution vector of m_s values, as these scenarios were identified as the preferred option for catch advice during preliminary discussions with the HAWG. Both stocks followed similar trend across scenarios. As historic F_{MAX} was increased, multipliers generally decreased slightly, and for the majority of 0.8 x F_{CRASH} scenarios, the genetic algorithm could did not identify a precautionary *chr* implementation. Where F_{MAX} was set at F_{MSY}, the only parameter that the optimisation was slightly sensitive to was the steepness, whereby the highest steepness value yielded a higher optimised m_s in some scenarios. When F_{MAX} was assumed to equal 1.5 x F_{MSY}, all scenarios resulted in an m_s of 0.15 across both stocks. Sensitivity to steepness became more apparent when F_{MAX} was set at 2 x F_{MSY}, with a clearer upwards trend in optimised m_s values as steepness was increased, however insubstantial. The 0.8 x F_{CRASH} scenarios demonstrated the most variability in optimised m_s values, with lower precautionary m_s values identified when compared to the other historic F_{MAX} scenarios. Where precautionary m_s values were not identified, the assumed selectivity affected the optimised m_s in many cases, with selectivity at maturity scenarios fishing down the SSB more quickly in both stocks. Of those non-precautionary m_s values, scenarios with the highest steepness had the highest optimised m_s values as they could withstand higher non-sustainable harvest rates. There were slight disparities between the response of the two herring stocks to the various scenarios tested, particularly for those which were subjected to the two higher historic

F_{MAX} fishing histories. For each of the two higher steepness values tested, the median optimised m_s values were slightly different between stocks (by 0.005).

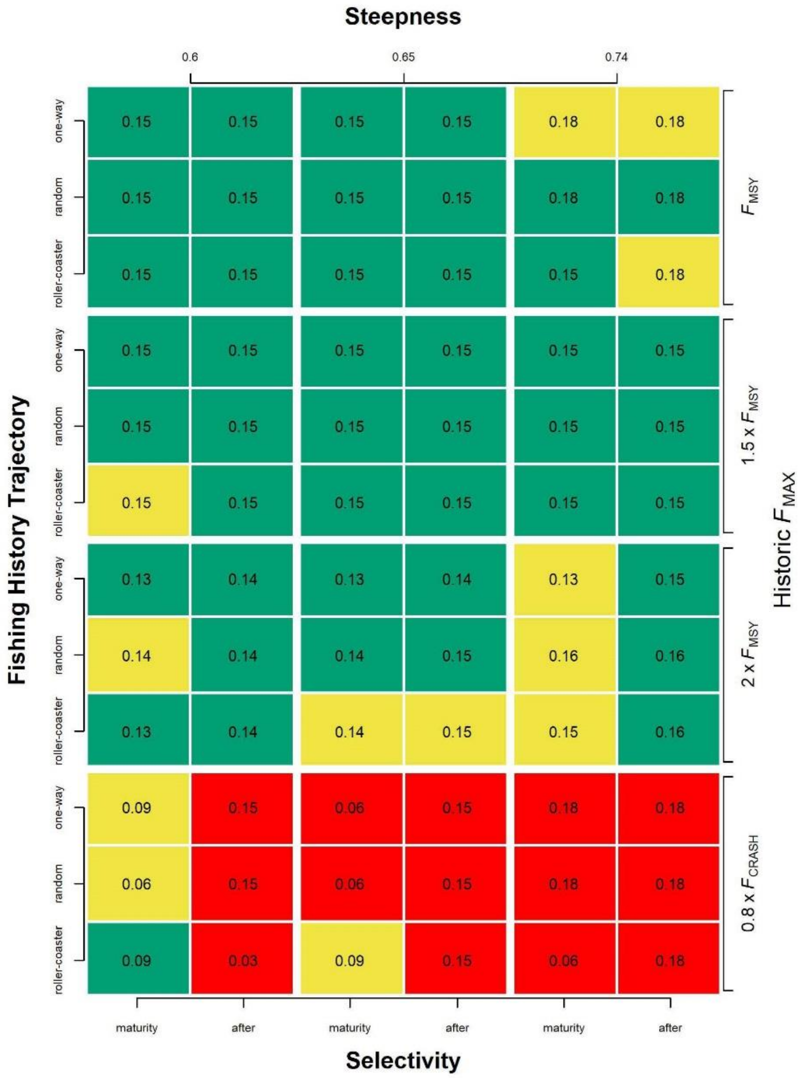

Figure 8. Optimum m_s values for the 6.aN herring OM grid, as identified by the genetic algorithm fitness function. Cell colours indicate optimised m_s risk level: *green* values fall below the 5% precautionary threshold, *yellow* values were at 5% risk when rounded to two decimal places, and *red* values are scenarios where a precautionary m_s value could not be found and the value returned by the algorithm simply maximised realised catch.

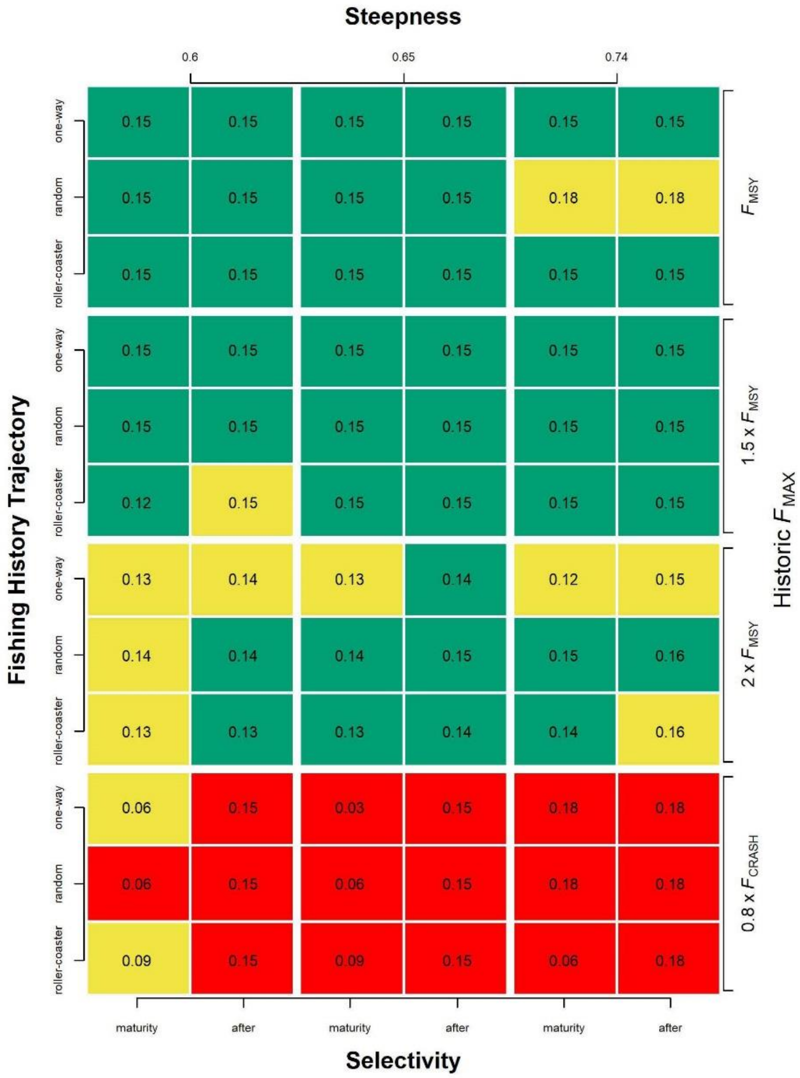

Figure 9. Optimum m_s values for the 6.aS herring OM grid, as identified by the genetic algorithm fitness function. Cell colours indicate optimised m_s risk level: *green* values fall below the 5% precautionary threshold, *yellow* values were at 5% risk when rounded to two decimal places, and *red* values are scenarios where a precautionary m_s value could not be found and the value returned by the algorithm simply maximised realised catch.

Simulations were most sensitive to changes in the relative level of historic fishing, i.e. F_{MAX} applied before application of *chr*. Following discussion of preliminary results with the HAWG, it was agreed that, of the scenarios tested, setting F_{MAX} at twice F_{MSY} was the most realistic option, representing a relatively high and unsustainable level of fishing pressure that would not lead to total stock collapse. It is unlikely that the stocks were fished at or below F_{MSY} for the entire development of the fisheries, as this would be very unlikely to leave them in a depleted state. It also seemed unrealistic that the stocks were fished at levels approaching F_{CRASH}, as they do not appear to have experienced a collapse before the fisheries were closed for monitoring. Simulations demonstrated reasonable robustness to the other assumptions tested (recruitment steepness, *h*, and fishing history trajectory), and where precautionary harvest rates were identified (e.g. Figs. 8 & 9), the values of m_s varied over the relatively small range of 0.06 – 0.18, across all scenarios and both stocks, with 85% of scenarios falling between 0.13 and 0.15. Thus, the most appropriate catch options were identified based on what were considered the most realistic scenarios. Rollercoaster-based scenarios appeared to represent the most realistic historic fishery development trajectory, given that both stocks have experienced relatively high fishing pressure for a period, followed by a reduction in same over the past eight to ten years. Steepness, however, is difficult to measure and estimate in any meaningful empirical sense, and so the median value of h = 0.65 was assumed to be a fair representation of stock dynamics, given its relatively minor influence on outcomes over the ranges tested.

Thus, the proposed m_s values to apply to management for 6.aN and 6.aS (as $F_{proxy,MSY}$ (m_s x 2; Method 2.2) or $HR_{MSYproxy}$ (m_s; Method 3.2)) are 0.14 and 0.13, respectively.

Implications for Advice

As $m_s = F_{proxy,MSY}$ X m, and m = 0.5 (as per method 2.2 guidelines) the **proposed $F_{proxy,MSY}$ values for 6.aN and 6.aS are 0.28 and 0.26 respectively**. Tables 3 and 4 compare the chr calculations for both stocks using the existing and proposed $F_{proxy,MSY}$ values.

Next Steps

This working document will now be sent for external review. If reviewed favourably, a second advice sheet will be produced for each stock using the updated $F_{proxy,MSY}$ values. ADGNEPH would be supplied with both sets of advice sheets, this document, and the reviewers' comments. In the medium term, exploration of the survey index uncertainty issue will be conducted prior to HAWG 2025 in order to fully address HAWG concerns. Any substantial suggestions received from the reviewers could be addressed at this stage as well. In the longer term, it is intended to add herring in 6.aS,7.bc to the benchmark list if interim work on a category 1 model proves successful.

Table 3. Advice calculation with existing and proposed $F_{proxy,MSY}$ values for 6.aN.

	Current Value	**Stock Specific Proposal**
A_y (previous advice)	1,454 t	1,454 t
I_{y-1} (latest survey SSB, t)	22,463 t	22,463 t
$F_{proxy,MSY}$	0.335	0.28
b (biomass safeguard)	1	1
m (multiplier)	0.5	0.5
chr ($I_{y-1} \times F_{proxy,MSY} \times b \times m$)	3,768 t	3,145 t
Change from previous advice	+159%	+116%
Stability clause (-30% or +20%)	Applied	Applied
Advised Catch 2025	**1,745 t**	**1,745 t**

Table 4. Advice calculation with existing and proposed $F_{proxy,MSY}$ values for 6.aS,7.bc.

	Current Value	**Stock Specific Proposal**
A_y (previous advice)	2,270 t	2,270 t
I_{y-1} (latest survey SSB, t)	100,523 t	100,523 t
$F_{proxy,MSY}$	0.030	0.26
b (biomass safeguard)	1	1
m (multiplier)	0.5	0.5
chr ($I_{y-1} \times F_{proxy,MSY} \times b \times m$)	1,508 t	13,068 t
Change from previous advice	-34%	+476%
Stability clause (-30% or +20%)	Applied	Applied
Advised Catch 2025	**1,589 t**	**2,724 t**

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Appendix 2. Example values used in a previous iteration of the *chr* calculation for 6.aS,7.bc, highlighting the calculation of proxy harvest rate.

Year	L_c	L_{mean}	L_{ref}	f	Catch	Index	Catch/Index
2014	235	276	265	1.042	5096	149,270	0.034
2015	235	267	265	1.008	1078	226,293	0.005
2016	235	267	265	1.008	2213	36,707	0.060
2017	235	266	265	1.004	2227	66,342	0.034
2018	235	266	265	1.004	1495	96,138	0.016
2019	235	262	265	0.989	1690	92,364	0.018
2020	235	253	265	0.955	1220	135,335	0.009
2021	235	255	265	0.962	1821	189,856	0.010
2022	235	258	265	0.974	1326	147,199	0.009
2023	235	257	265	0.970	1255	100,523	0.012

$F_{proxy,MSY}$ is the mean ratio of Catch / Index (blue box) where f is above 1 (yellow values).

f is the ratio of Mean length above first capture, L_{Mean} / Target reference length, L_{Ref} (red box).

It can be seen that no matter what years are included in the calculation, $F_{proxy,MSY}$ would always be unusually low.

WD: Revision of input data, model configuration, and reference points used for the assessment of herring in the Irish Sea (her.nirs)

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1. Introduction

The Northern Irish Sea Herring assessment is an assessment on a genetically mixed stock. The stock is an autumn spawning stock and the fishery happens during and after the spawning season. There is considerable commercial data as well as tuning data from a range of surveys. Recent analyses suggest there is a strong mixing component with the Celtic Sea stock from further South. This has been appreciated since a long time, but during the last benchmark it was assumed that the mixing happens largely at a younger age, however it is now evident that it happens across the full age structure.

The stock underwent a full benchmark in 2017 and the assessment is using a SAM model. A review of all commercial and tuning data is available in the benchmark report.

A full benchmark was proposed for 2025 to look into the genetics and the inclusion of other additional data, as well as an issue with a very “flat” fbar and the inability to reproduce the assessment model in another version of SAM to the one used during the benchmark in 2017. The migration to another platform and another version of SAM became very pressing as the benchmarked model was only able to run on a single old laptop. The inability of the model reproduce under a newer package version of SAM was worrying, as all the initial adaptations that had been done during the benchmark in the .tlp file (a file at that time necessary to run an assessment model within the ADMB framework) had one by one been translated into the latest version of SAM.

The assessment is available to review on stockassesment.org, antest002: Assessment link

HAWG still finds it necessary to conduct a full benchmark with a full re-evaluation of data, stock area and mixing, however, this is outside the scope of this report and inter-benchmark.

2. Identification of the issue

The model used for the assessment up to 2023 was incapable to run with an additional year of data during HAWG 2024. An investigation by A. Nielsen identified that a default setting in the FLSAM (2.0.1) wrapper package for SAM used in the assessment provided an erroneous assessment of the stock which was responsible for the incapability to run with the additional data year as well as the non-reproducibility in any other version of. A. Nielsen was able to force the model with the benchmarked settings to run under the latest version of SAM by setting the keyVarLogN parameter to the same setting as in the default setting of the FLSAM version (with an additional slight adjustment to the “keyVarObs” parameter)

The keyVarLogN parameter sets the process variance parameters for the log(N) process for different ages of fish in the model. The first value in the parameter set is the process variance for the recruitment, while the remainder are the survival process variance parameters to the log(N) process at different ages. In general it should be assumed that the recruitment has a very high process variance, while the remainder (survival processes) has a very low one. In the default version all of the ages (including recruitment) had been coupled, which resulted in a range of issues for the model. The setting at the time was an internal setting within the wrapper function and not part of the configuration file and had therefore not been spotted earlier. It had therefore not been discovered until an expert looked at the finer details of the package itself.

HAWG agreed that, even though we could emulate the benchmarked model, it was clearly providing a false assessment, and that the working group would take the assessment through an interbenchmark process rather than grading the stock as a category 3 stock.

The data and model (SAM) are the same used since the last benchmark, no further investigation into data was made except for 2: the setting of Fbar to ages 2-4 to represent the actual fishery and the estimation of catchability q of the VIIaNSpawn survey (Table 1).

Some of the settings necessary to run the previous assessment model (due to the erroneous setting, some settings over the time had to be adjusted, such as keyVarObs for the VIIaNSpawn) were now able to be set appropriately.

The configuration was otherwise kept as close to the previously agreed configuration, while some parameters with regard to coupling of ages were adjusted to improve fit.

2. Input data

All data used in the update assessment were identical to those used in previous years, originally set at the last Benchmark (WKIRISH3 2017) where a full description of the input data can be found. Whilst alterations to input data could be considered, HAWG decided this would be out of the scope of the assessment group and should only be evaluated at the next Benchmark meeting (scheduled for 2025). The data used were updated to use the final data year (2023) and are summarised in Table 1.

Table 1. Summary of input data types and characteristics.

Input data				
Type	**Name**	**Year range**	**Age range**	**Variable between years?**
Caton	Catch in tonnes	1961–2023	NA	Yes
Canum	Catch-at-age in numbers	1961–2023	1–8+	Yes
Weca	Weight-at-age in the commercial catch	1961–1971 1972–1983 1984–2023	1–8+ 1–8+ 1–8+	Yes No Yes
West	Weight-at-age of the spawning stock at spawning time	1961–1971 1972–1983 1984–2023	1–8+ 1–8+ 1–8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961–2023	NA	No
Fprop	Proportion of fishing mortality before spawning	1961–2023	NA	No
Matprop	Proportion mature at age	1961–2023	1–8+	Yes
Natmor	Natural mortality	1961–2023	1–8+	No
Tuning data				
Type	**Name**	**Year range**	**Age range**	
Tuning fleet 1 (acoustic survey on research vessel)	AC_VIIa(N)	1994–2023	1–8+	
Type	**Name**	**Year range**	**Age range**	
Tuning fleet 2 (Biomass indicator, acoustic survey on a commercial vessel)	VIIaNSpawn	2007–2023	NA	

3. Assessment model and configuration

A full configuration file is attached to the report.

3.2 Updates to SAM configuration from HAWG (2024)

Whilst most settings were kept consistent with the previous model configuration, some updates were made at HAWG (2024). All changes are explained in their own sections below.

The agreed assessment model with new settings is available on stockassessment.org named "antest002" (also on TAF). All results and figures are available online.

3.2.1 SAM Version

The default version of the model developed at the 2017 benchmark uses an FLR wrapper (FLSAM 2.0.1) in which the keyVarLogN parameter was set as a default to the same value across all ages. This default setting was hidden from the user. The estimation of all values of recruitment and survival processes to the same value is a paradox with the recruitment (age 1) value generally being very high and the survival down the years very low. The model did (in many years) manage to estimate a value but was forced to estimate a very unrealistic assessment of the stock.

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3.2.2 keyVarLogN

In the previous model settings, recruitment was coupled to the survival process variance parameters to the log(N) process at different ages. The variance of the recruitment process is generally very high, while that of the survival process from one age to the next is supposed to be very low. Coupling the two processes and trying to estimate a single parameter for both has got considerable impacts on the model, i.e. it tries to fit a parameter that it is not able to fit. It is advisable to have at least the first age class (recruitment) separate, because recruitment is a different process than survival. Model changes are shown below:

"Old" model setting	New model setting
0 0 0 0 0 0 0 0	0 1 1 1 1 1 1 1

Decoupling recruitment from survival with the keyVarLogN parameter is essential. It enabled better convergence and stability of the model.

3.2.3 keyLogFpar

There are two acoustic surveys included in the model. The first one (AC_VIIa(N)) has been conducted since the 1994 and has catchability estimated at age, the other one is a survey conducted on a commercial vessel since 2007 and is used as a biomass indicator.

Catchability Q for the biomass survey (VIIaNSpawn) is now estimated rather than fixed to "1". Q is now estimated to be relatively high (5.691, Table 2) but is in line with the estimated q-parameters for the other survey and the commercial catches. Setting Q=1 implies that the survey is an absolute observation of the stock which in the case of the VIIaNSpawn survey is not the case. In general, it is unusual to fix the catchability of the survey in a stock assessment model because such a parameter is difficult to estimate outside the assessment model. It could be turned into a whole area estimates through krieging or some other model standardization, however, this has not happened here as it is just an index and not being estimated as the full population biomass. Instead, catchability is best estimated as part of a stochastic stock assessment model.

Moreover, it is important to note that comparisons with fixing Q to "1" and estimating presented minimal differences in the perception of the stock.

The catchability parameters at age for the AC_VIIa(N) survey have been adjusted to improve the fit of the model. Previously ages 4-8 were estimated as having the same q, now ages 1 to 6 are estimated individually and ages 7 to 8 in combination (row two of the inputs).

Changes in settings are given below, the first row refers to the commercial fleet (at age), the second to the AC_VIIa(N) and the third to the VIIaNSpawn survey:

Old model setting	New model setting
0 0 0 0 0 0 0 0	-1 -1 -1 -1 -1 -1 -1 -1
1 2 3 4 4 4 4 4	0 1 2 3 4 5 6 6
NA NA NA NA NA NA NA NA	7 -1 -1 -1 -1 -1 -1 -1

.

3.2.4 keyVarObs

keyVarObs describes the coupling of the variance parameters for the observations (i.e. c.v.). Previously the value was fixed for the VIIaNSpawn survey, as was q. This was likely to fix the issues caused by the default setting and to enable the model to run. This was no longer necessary with the rectification of the erroneous setting and estimating keyVarObs for VIIaNSpawn is the "correct" way of setting up the assessment.

Changes in settings are given below. First row refers to the variance parameters for the catch data observations by age. Second and further rows refer to the coupling of the variance parameters for the index data observations by age. Some changes in the coupling of the parameters in the commercial and AC_VIIa(N) survey have been adjusted to improve model fit.

Old model setting	New model setting
1 2 2 2 3 3 3 3	0 1 1 1 1 1 1 1
4 5 5 5 5 6 6 6	2 2 2 2 2 2 2 2
0 0 0 0 0 0 0 0	3 -1 -1 -1 -1 -1 -1 -1

3.2.5 Fbar range

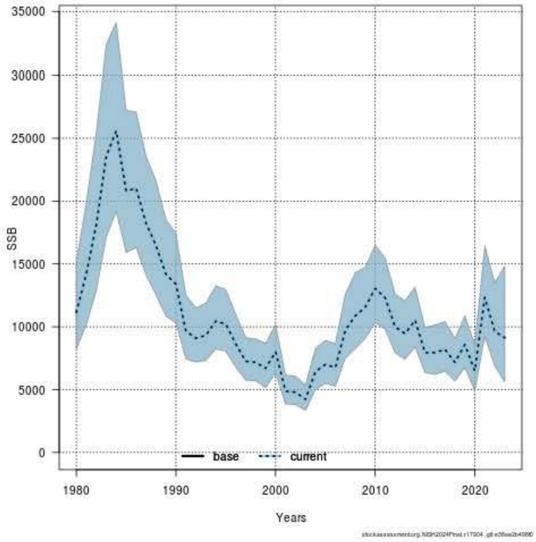
The previous Fbar setting (4–6) has been questioned repeatedly throughout HAWG, although this was accepted at the Benchmark. Following discussions at HAWG (2024), Fbar range was updated together with other model settings. The rationale in 2017 was that the younger ages did experience a higher rate of genetic mixing through the years and hence the ages 4-6 would solely represent the F on the Northern Irish stock rather than the Celtic sea stock. However recent evidence shows that mixing occurs at all length classes and the rationale provided in 2017 is hence no longer valid (Farrel, 2024). Most catches are comprised of ages 2–4, whilst older aged fish only contribute a minor fraction. HAWG is aware of the genetic mixing and this will have to be in a full benchmark.

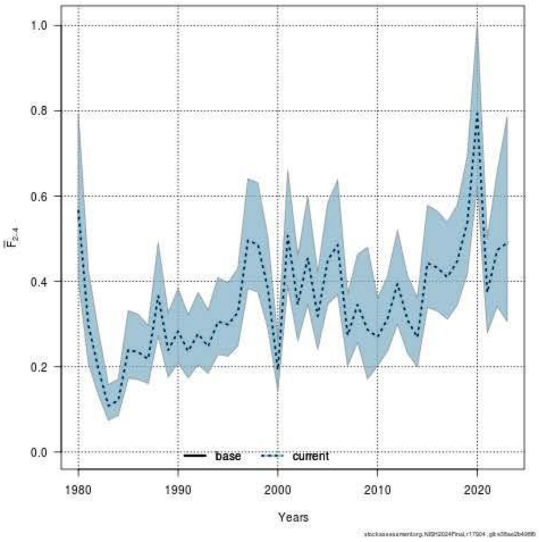
4. Model Fit

Model: SAM within Stockassessment.org

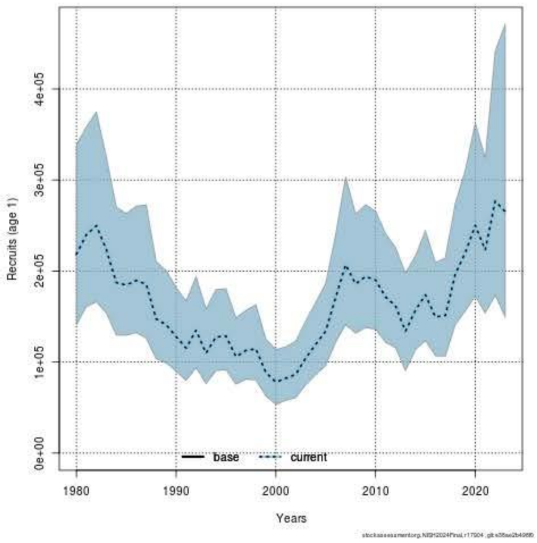
Model fit

Log (L)	-540.77
Number of parameters	17
AIC	1115.54





1.0
0.8
0.6
0.4
0.2
0.0
$\bar{F}_{2-4}$
base
current
1980
1990
2000
2010
2020
Years



4e+05
3e+05
2e+05
1e+05
0e+00
Recruits (age 1)
base
current
1980
1990
2000
2010
2020
Years

8

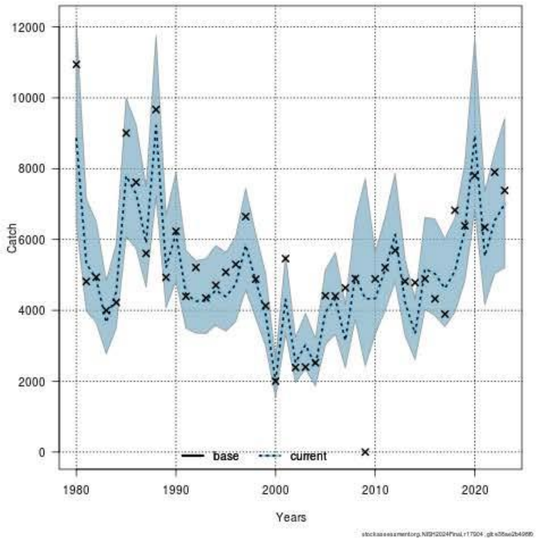


Figure 1: Model outputs, from top to bottom: SSB, Fbar(ages 2-4), recruitment and catches. Estimates from the current run and point wise 95% confidence intervals are shown by line and shaded area.

Table 2: Parameter estimates

Parameter name	**par**	**sd(par)**	**exp(par)**	**Low**	**High**	
logFpar_0	**1.04**	**0.167**	**2.83**	**2.028**	**3.95**	
logFpar_1	**1.412**	**0.165**	**4.102**	**2.948**	**5.708**	
logFpar_2	**1.22**	**0.165**	**3.389**	**2.436**	**4.713**	
logFpar_3	**1.205**	**0.165**	**3.335**	**2.399**	**4.637**	
logFpar_4	**1.254**	**0.165**	**3.505**	**2.522**	**4.872**	

logFpar_5	**1.502**	**0.166**	**4.49**	**3.221**	**6.26**	
logFpar_6	**1.52**	**0.18**	**4.571**	**3.192**	**6.547**	
logFpar_7	**1.739**	**0.11**	**5.691**	**4.563**	**7.097**	
logSdLogFsta_0	**-0.901**	**0.138**	**0.406**	**0.308**	**0.535**	
logSdLogN_0	**-1.524**	**0.341**	**0.218**	**0.11**	**0.431**	
logSdLogN_1	**-1.649**	**0.164**	**0.192**	**0.138**	**0.267**	
logSdLogObs_0	**-0.169**	**0.119**	**0.844**	**0.665**	**1.072**	
logSdLogObs_1	**-1.123**	**0.071**	**0.325**	**0.282**	**0.375**	
logSdLogObs_2	**-0.161**	**0.081**	**0.851**	**0.724**	**1.001**	
logSdLogObs_3	**-1.029**	**0.183**	**0.357**	**0.248**	**0.516**	
transfIRARdist_0	**-0.741**	**0.21**	**0.477**	**0.313**	**0.726**	
itrans_rho_0	**3.109**	**0.768**	**22.407**	**4.821**	**104.13**	

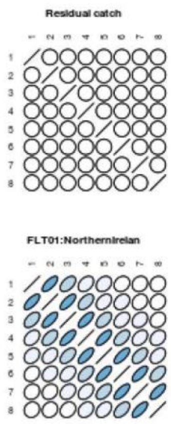


Figure 2: Estimates correlations between age groups for each fleet, top is the commercial fleet, at the bottom the AC_VIIa(N) survey

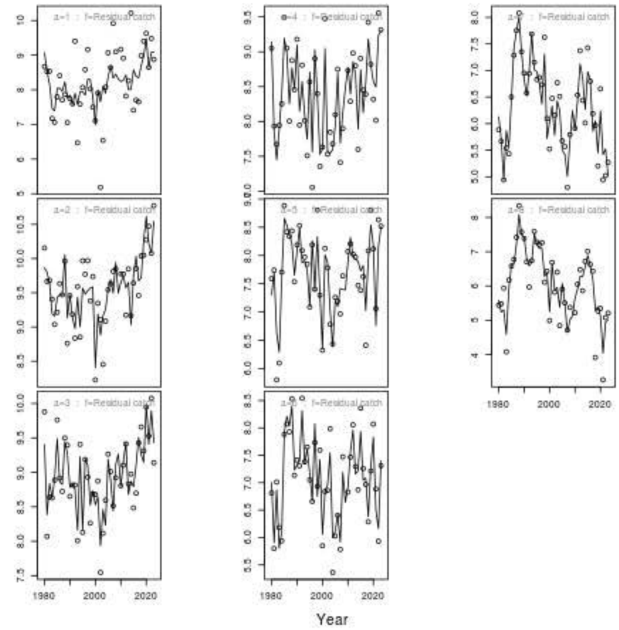


Figure 3 Predicted line and observed points (log scale) for the commercial fleet

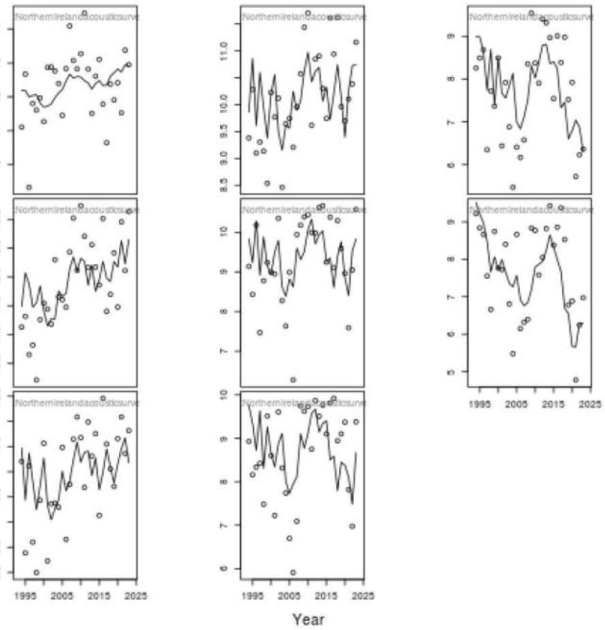


Figure 4 Predicted line and observed points (log scale) for the AC_VIIa(N) survey

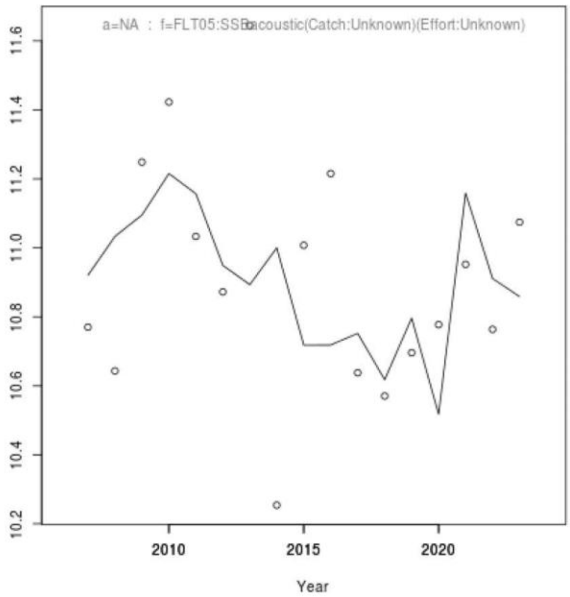


Figure 5 Predicted line and observed points (log scale) for the VIIaNSpawn survey (Biomass only).

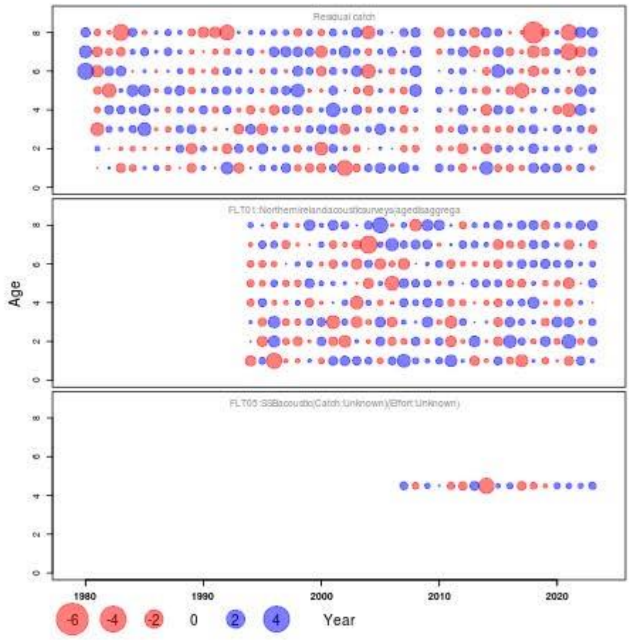


Figure 6 Standardized one-observation-ahead residuals. From top to bottom: commercial catches, AC_VIIa(N) survey and VIIaNSpawn.

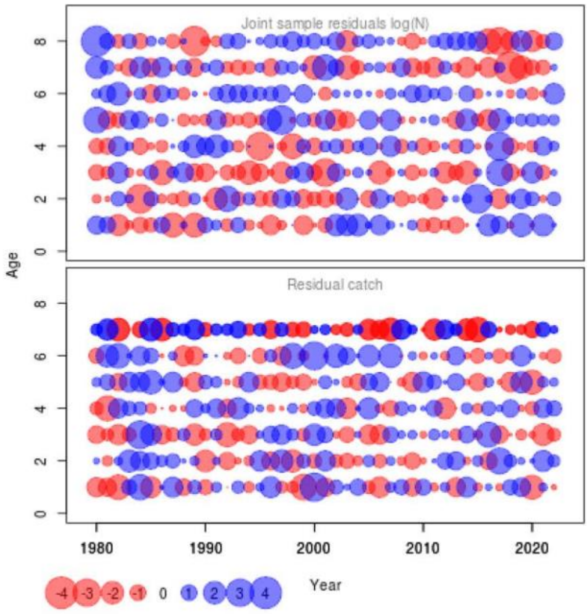
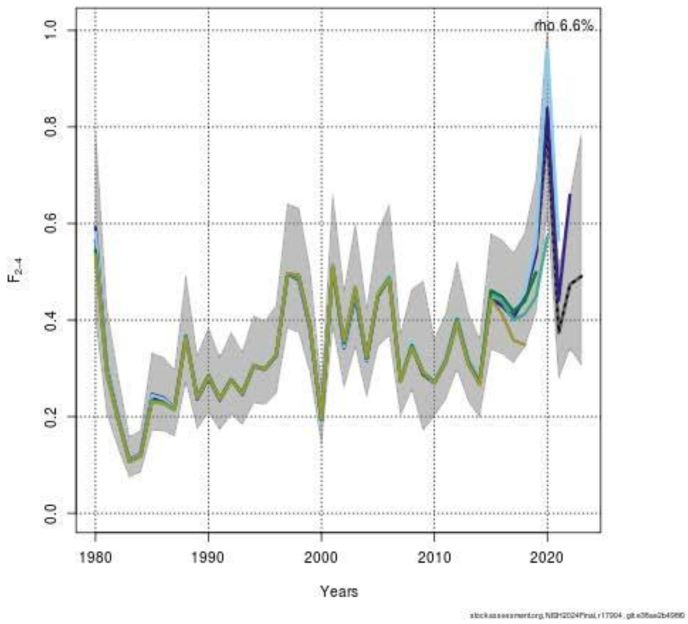
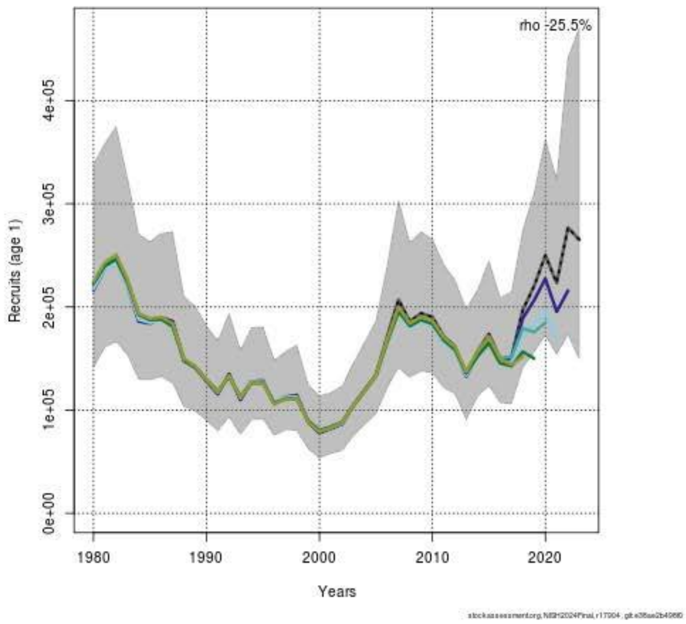


Figure 7 Process residuals; Standardized single-joint-sample residuals of process increments


rho 6.6%
1.0
0.8
0.6
0.4
0.2
0.0
F_{2-4}
1980
1990
2000
2010
2020
Years


rho -25.5%
Recruits (age 1)
0e+00
1e+05
2e+05
3e+05
4e+05
1980
1990
2000
2010
2020
Years

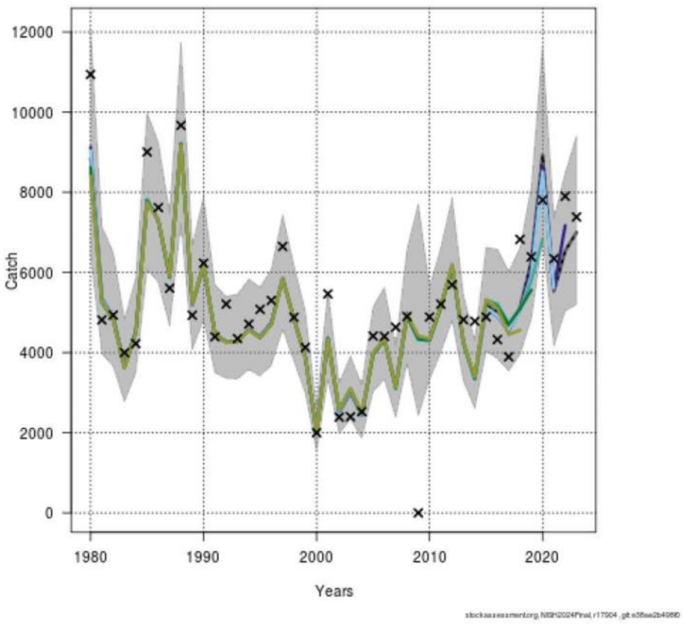


Figure 8 Retrospective plots and Mohns Rho for SSB, Fbar, Recruitment and catches.

5. Updating reference points

Estimation of reference points was done following the ICES guidelines for Category 1 and 2 reference points (ICES, 2021). The standard EQSIM software (ICES, 2014, v0.1.19) was used to fit stock-recruit relationships and conduct the required simulations. Recruitment was shifted by 1 year to account for the autumn-spawning. Table 3 lists the settings used in the EQSIM simulations.

Table 3. EQSIM settings used in simulation to determine reference points

	Setting	Value
	Number of simulations	2000
Assessment uncertainty	sigmaF	0.163
	sigmaSSB	0.242
SRR	SRused	Segreg_Ricker_Bevholt
	SRR year range	1980-2023 (full time series
	Autocorrelation in recruitment	Not used (estimated at 0.82)

Biology	Year Range for resampling biological values (W, M, mat)	2014-2023
Selectivity	Year Range for resampling fishery selectivity	2014-2023
Advice uncertainty	cvF	0.212 (default)
	phiF	0.423 (default)

Blim was estimated as the segmented regression breakpoint at 6080 tonnes and Bpa was hence estimated at 9064 tonnes using the sigmaSSB from the model. Fmsy was estimated at

in constant F simulations. Simulations of Fmsy with a breakpoint at Btrigger lead to a greater than 5% probability of SSB<Blim in the long term, and hence Fmsy was capped by Fpa (0.35).

At the 2017 benchmark, MSY Btrigger was estimated close to Bpa and was consequently setup as MSY Btrigger=Bpa. However, with the derivation of new reference points, Bpa and MSY Btrigger are now different, warranting against setting up MSY Btrigger=Bpa.

Table 4. Reference point values from the EQSIM simulations

Reference points	**Reference points**
Flim	0.45
Fpa	0.35
Fmsy	0.35
Blim	6080
Bpa	9064
MSY Btrigger	11208

5. Short-term Forecast

The forecast settings remain the same as previously, with the intermediate catch (2024) being set to the previously agreed TAC for the stock rather than the new advised catches after the re-issue of the advice.

Initial stock size: Taken from the last year of the assessment.

Recruitment: 1-ring recruits taken from a ten-year geometric mean with the last year being two years prior to the terminal year.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight-at-age in the stock: Mean of the previous three years in the assessment.

Weight-at-age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years (not scaled to the last year, as the terminal estimate of F is not considered more informative)

Intermediate year assumptions: TAC constraint.

Stock–recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

All forecasts are done within the stockassessment.org framework.

References

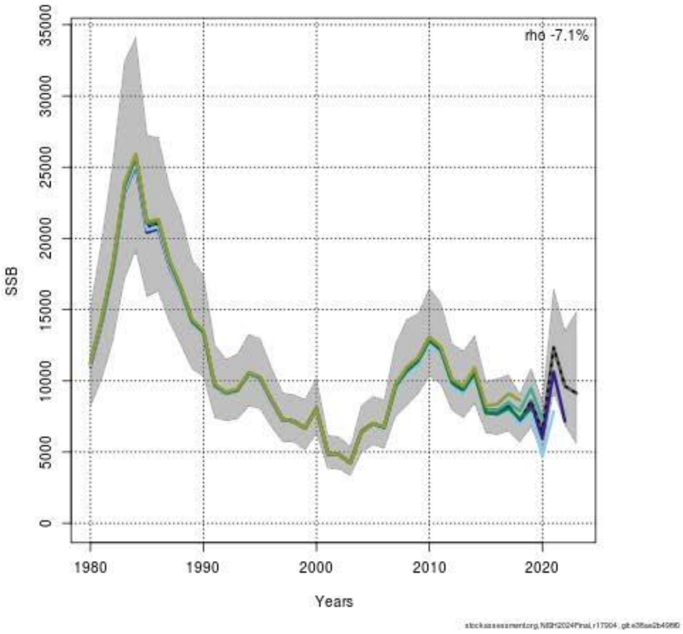
ICES. 2014. Report of the workshop to consider reference points for all stocks (WKMSYREF2), 8–10 January 2014, ICES headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:47, 91pp.

ICES (2017). Report of the Benchmark Workshop on the Irish Sea Ecosystem (WKIRISH3). ICES Expert Group reports (until 2018), Annex 12 and 13. Report. https://doi.org/10.17895/ices.pub.8713

ICES. 2021. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.4.3.1. https://doi.org/10.17895/ices.advice.7891

Annex 1

Configuration of NISH assessment- annex to review report


rho -7.1%
SSB
Years
0
5000
10000
15000
20000
25000
30000
35000
1980
1990
2000
2010
2020

Working document: Proportion of fishing before spawning

Vanessa Trijoulet

Contents

Currently the proportion of fishing mortality (F) before spawning is assumed to be 0.1 for all ages and years. This value only affects the estimates of spawning stock biomass (SSB) and was not investigated at the last benchmark [ICES, 2018]. This value has been used for a relatively long time since the oldest HAWG report found (2014) already reported this value. Here we investigated if this proportion is correct or need updating.

Different data could be used to estimate the proportion of F before spawning. Below we tested different methods.

1 Estimate the proportion of fishing mortality before spawning

1.1 From the total catch in weight per quarter

The total catch in tonnes per quarter could be used to estimate the proportion of F before spawning but this means that potential differences between ages are not accounted for. Figure 1 shows the total catch per quarter in the period 1998-2022 and Figure 2 shows the same information in relative terms. It is clear that the catches at the end of the first quarter represent a higher proportion than the value of 10% previously used. The average proportion over the entire time series is of around 0.36 (0.09-0.54). The increase in the possibility of transfer of human consumption quotas from Division 3.a to the North Sea from 50% to 100% in 2022 has resulted in large changes in the fishery. It is only in 2022 that the proportion equals around 0.1.

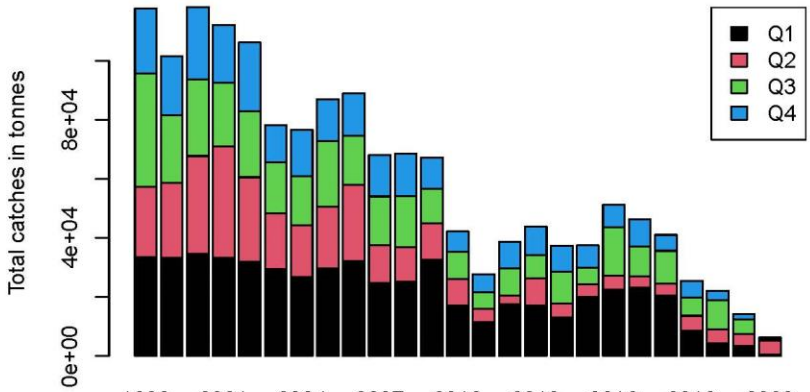


Figure 1: Annual catch (tonnes) per quarter.

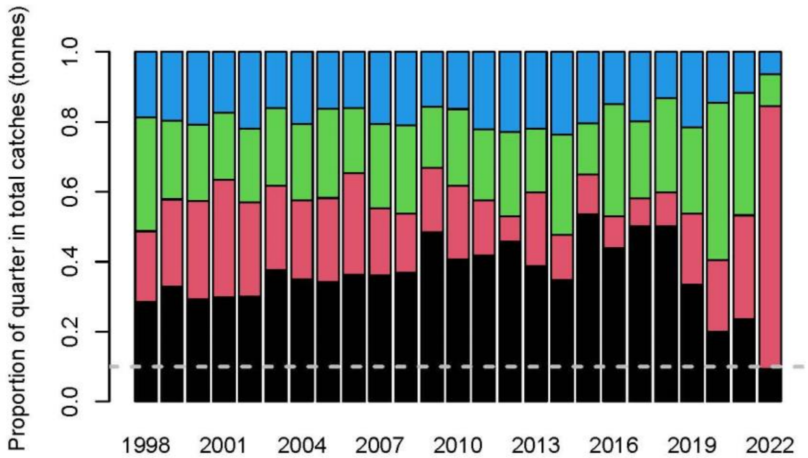


Figure 2: Annual proportion of catch (tonnes) per quarter. The dashed horizontal line shows the value used until now.

1.2 From the catch at age in numbers per quarter

Given that the observed catch in SAM is given as numbers at age, it makes sense to use the same information to estimate the proportion of F before spawning. The value varies over time for all ages. Most ages have a value close to the average estimated above but age 1 shows a very variable proportion. The proportion drops for all ages except age 2 towards the end of the time series. The average proportion across years and ages is of around 0.36 (varying from 0.34 to 0.47 for ages 1 to 8+).

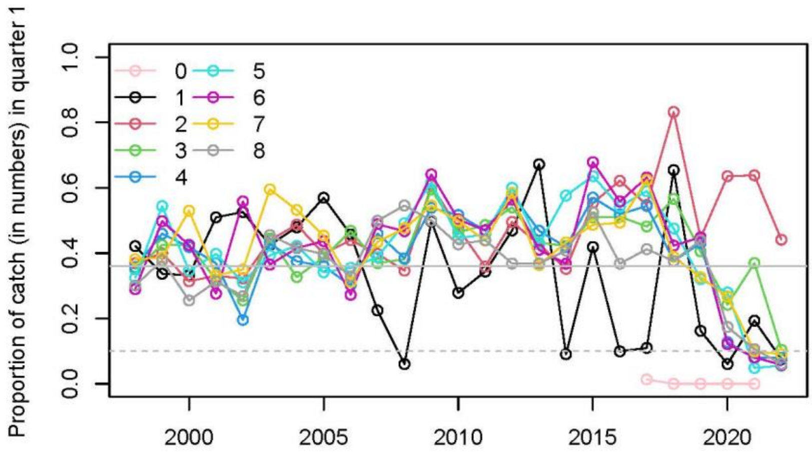


Figure 3: Annual proportion of catch (in numbers) in quarter 1. The dashed horizontal line shows the value used until now. The solid horizontal line shows the averaged calculated from the total catch in tonnes.

1.3 From the catch at age in weight per quarter

Proportion of F before spawning estimated using the catch at age in weight give a similar picture as with the catch in numbers except that the younger ages that weight less are shifted down (Figure 4).

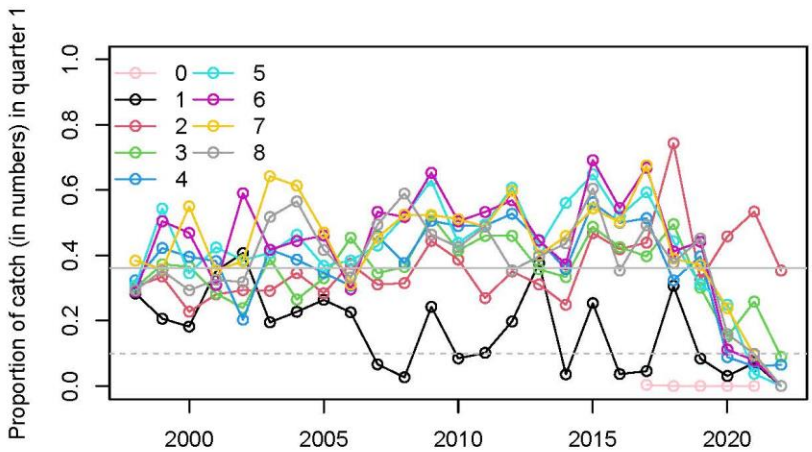


Figure 4: Annual proportion of catch (in weight) in quarter 1. The dashed horizontal line shows the value used until now. The solid horizontal line shows the averaged calculated from the total catch in tonnes.

2 Testing the impact on the assessment

Here we tested the sensitivity of the assessment outputs to the value of the proportion of F before spawning by comparing the current assessment to two sensitivity runs: the assessment using the average value (0.36) calculated from the catch in numbers at age and to the assessment using time and age-varying proportion of F from the catch in numbers at age.

Only the estimates of SSB are affected by a change in the proportion of F before spawning. An increase in the proportion induces a lower SSB back in time but recent SSB is similar between the three runs (Figure 5). The derived SSB for both runs with mean at 0.36 and time- and age-varying proportion lead to very similar estimates of SSB.

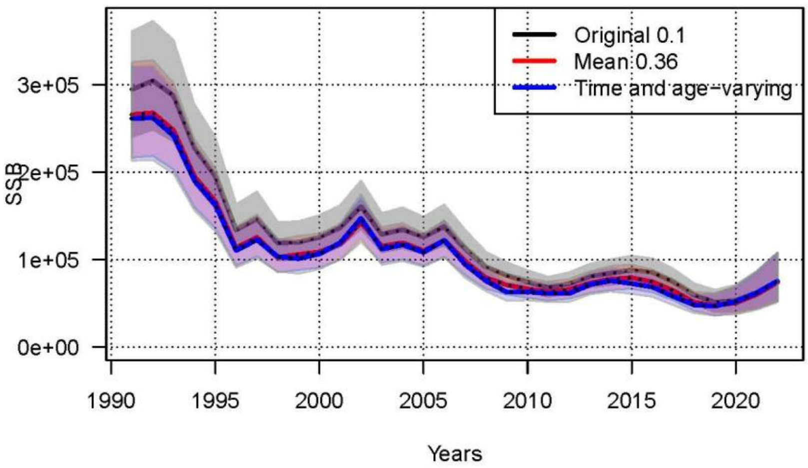


Figure 5: Comparison of SSB estimates between the three fits.

The recruitment pairs are affected by a change in the proportion of F before spawning but the results are very similar in terms of median and confidence intervals for the new runs (Figure 6).

We fitted a segmented regression to the three models keeping the original configuration for all the other variables to test if the proportion of F before spawning can affect the estimation of the stock-recruitment relationship (SRR) for the stock. The three resulting SRRs are similar for the three models (Figure 7). However, it is worth noting that none of the model converged with the original configuration and some tuning is needed to get acceptable fits.

The proportion of F before spawning could be estimated per fleet but this was not done here because the data was not ready in a clear format.

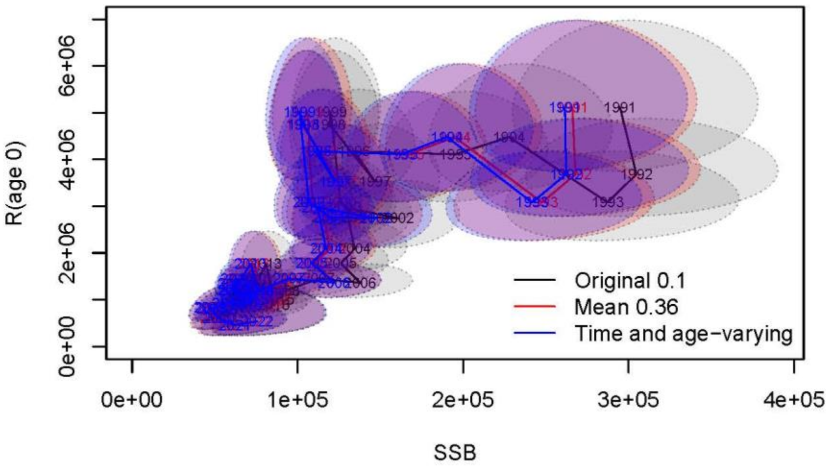


Figure 6: Comparison of stock-recruitment pairs between the three fits.

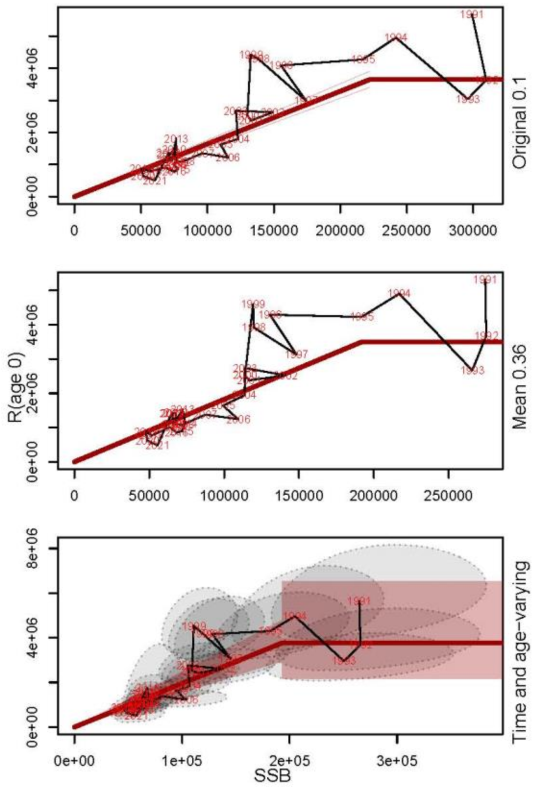


Figure 7: Segmented regression estimated in the models with different proportion of F before spawning.

References

ICES. Report of the benchmark workshop on pelagic stocks (wkpela 2018). Technical Report ICES CM 2018/ACOM:32. 313 pp, ICES HQ, Copenhagen, Denmark, 02 2018.