HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62° N (HAWG)

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i Executive summary

The ICES herring assessment working group (HAWG) met online for nine days in March 2023 to assess the state of six herring (*Clupea harengus*) and three sprat (*Sprattus sprattus*) stocks. 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 2022 was estimated at 1.65 million tonnes while F_{2-6} in 2021 was estimated at 0.23, which is below FMSY. Recruitment in 2022 is at its highest since 2014, 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 2022 was estimated at 75,548 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_{3-6} has been decreasing since 2018 and is now week below F_{MSY} (0.31) at 0.05. The stock has decreased consistently during the second half of the 2000s and given the continued low recruitments, the stock is not able to recover above B_{lim} unless a drastic reduction in fishing effort is applied for several years.

Celtic Sea autumn and winter spawning stock (her.27.irls). SSB in 2022 was estimated at 16,539 tonnes, though is increasing from its lowest level seen in 2018 (6,474 tonnes), but remains below B_{lim} (34,000 tonnes). $F_{(2-5\ rings)}$ in 2022 was estimated at 0.028, 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 2022 was estimated at 25,900 tonnes and is above MSY $B_{trigger}$, B_{pa}, and B_{lim}. Recruitment in 2022 is the highest on record and continues the trend of large incoming year-classes in recent years. F_{4-6} has been stable between 0.22 and 0.24 since 2006 and is below F_{MSY} (0.266).

6aN autumn spawning herring (her.27.6aN). SSB in 2022 was estimated at 33,283 tonnes using the genetically split, Malin Shelf Herring Acoustic Survey (MSHAS). Whilst SSB has increased since its lowest level in 2019, these numbers of herring are low compared to historical estimates. Indicators show that stock size is above MSY $B_{trigger\ proxy}$ and below $F_{MSY\ proxy}$.

Herring in 6.aS/7.b, c (her.27.6aS7bc). SSB in 2022 was estimated at 147,199 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 $F_{MSY\ proxy}$ (0.034) and the stock size index is well above MSY $B_{trigger\ proxy}$ (51 390 t).

Sprat in the North Sea and 3.a (spr.27.3a4). SSB in 2023 was estimated at 206,581 tonnes and is above MSY $B_{escapement}$, B_{pa}, and B_{lim}. F_{1-2} has been decreasing since 2016, however there are high levels of fluctuation throughout the time series. Low recruitment in recent years had contributed to the stock being below MSY $B_{escapement}$, though this has been alleviated by the 2023 year-class.

ii Expert group information

Expert group name	Herring Assessment Working Group for the Area South of 62° N (HAWG)
Expert group cycle	Annual
Year cycle started	2022
Reporting year in cycle	1/1
Chairs	Aaron Brazier, UK
	Cecilie Kvamme, Norway
Meeting venues and dates	24–26 January 2023, Copenhagen, Denmark (12 participants)
	14–22 March 2023, Copenhagen, Denmark (39 participants)

1 Introduction

1.1 HAWG 2023 Terms of Reference

2020/2/FRSG03 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Aaron Brazier, UK, and Cecilie Kvamme, Norway will meet: in ICES and online 24–26 January 2022 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 ICES and online 14–22 March 2023 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 to the meeting must be available to the group on the dates specified in the 2022 ICES data call.

HAWG will report by 6 February (sandeel), 21 April (sprat) and 28 May (herring) 2023 for the attention of ACOM.

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

Stock Name	Stock Coord.	Assess. Coord.	Assessment Method
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
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 2022 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 2022, 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 interbenchmark. 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 Meeting of the Chairs of Assessment Related Expert Groups (WGCHAIRS)

WGCHAIRS met online in January 2023 in preparation for the new year of advice and science working group activities. This was the third year WGCHAIRS was held remotely. The meeting was held over 4 days. The agenda on day 1 was tailored for new chairs. On day 2 the focus was for assessment groups chaired by ACOM leadership. A joint ACOM/SCICOM session was held on the third day and on the final day the focus was for SCICOM groups.

Under the ICES strategy, activities of advisory working groups such as HAWG are conducted under the umbrella of the Fisheries Resources Steering Group (FRSG) which became operational in 2019. Advisory expert groups maintain their prerogative of "closed groups" in the sense that members will be still nominated at a national level. An FRSG meeting was held on the 26th of January to discuss TAF, the application of WKLIFE methods, stock assessment advances and initiatives as well as challenges groups may encounter related to the COVID disruption. The inclusion of conservation aspects on advice sheets were also discussed.

A number of presentations were given which were relevant to HAWG. The benchmark system and the role of the benchmark oversight group was explained. A benchmark is a peer review of data and methods that requires prior development, analysis, and documentation before it can proceed. Benchmark needs should be identified early, and a prioritization process followed. The benchmark oversight group (BOG) provides support and have an overall coordination role. A benchmark planning checklist has been developed to help groups to prioritize issues and agree a timeline for each issue to be completed. If high priority issues are not completed, then the benchmark may be delayed to allow sufficient time to work on these tasks. The distinction between benchmarks and interbenchmarks was also discussed.

Given that the use of the transparent assessment framework has slowed down, the benefits and value of TAF was explained and chairs shared their experiences on this. Work is ongoing towards providing ICES advice online. The new developments and the plan for future work was presented. Furthermore, updates were provided on the development of the ICES Interactive Advice App which has now entered beta testing phase.

WGCHAIRS discussed gender equality, diversity, and inclusion in the ICES community. The gender diversity across several aspects of ICES work was presented, including the ASC participation, chairs of working groups, national representatives at ACOM and SCICOM, council delegates and executive committee members. It was highlighted that we should follow the ICES meeting etiquette and we are all accountable. We treat each other with respect, embrace diversity, include equally, communicate thoughtfully, avoid harassment, and promote wellbeing.

1.3.2 Working Group for International Pelagic Surveys (WGIPS)

The Working Group of International Pelagic Surveys (WGIPS) met in Belfast, Northern Ireland and online on Teams 23rd–2tth January 2023. 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 2023 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2023 pelagic acoustic surveys are available from the WGIPS report (ICES 2023, 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 2022: 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, West of Ireland and Celtic Sea.

The estimate of **North Sea Autumn Spawning herring** spawning-stock biomass is higher than in the previous year at 1.96 million tonnes (2021: 1.50 million tonnes) with an increase in the number of mature fish from 8 170 million fish in 2021 to 10 348 million fish in 2022.

The 2022 estimate of **Western Baltic Spring-spawning herring** 3+ group is 77 000 tonnes and 483 million. Compared to the 2021 estimates of 82 000 tonnes and 639 million fish, this equals a decrease of 24% in biomass.

The **West of Scotland herring** estimate (6.a.N) of SSB in 2022 is 177 000 tonnes and 1 052 million individuals, which is a ~20% increase in both biomass and abundance compared to the 147 000 tonnes and 871 million herring estimate in 2021.

The 2022 SSB estimate for the entire **Malin Shelf area (6.a and 7.b, c combined)** is 233 000 tonnes and 1 442 million individuals. This is lower than the 2021 estimates (278 000 tonnes and 1 827 million herring). There were again small numbers of herring found in the northernmost strata (to the north of Scotland and east to the 4°W line) in 2022, which is similar to recent years. Herring were distributed in only a few discreet areas in 2022, to the north of Lough Swilly (south of

Stanton), to the northwest of Tory island around the 56°N degree line, and south of St Kilda. There were overall less immature herring found in 2022.

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 2022 was estimated at 78 900million individuals and the biomass at 705 000 tonnes. This is an increase from the previous year, and 53% above the long-term average of the time-series, in terms of both abundance and biomass. The estimate is dominated by 1-year-old sprat (70% in biomass). The estimate includes 0-group sprat (2% in numbers, and 1% in biomass), which only occasionally is observed in the HERAS survey.

For **Div. 3.a,** the sprat abundance in 2022 is estimated at 417 million individuals and the biomass at 5 200 tonnes. This is the second lowest estimate of the time-series in terms of biomass, and well below the long-term average both in terms of abundance (78% below) and biomass (79% 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 27th August–11th September 2021 was reported by Northern Ireland. The herring stock estimate in the Irish Sea/North Channel area was estimated to be 99,589 t. The major contribution of ages to the total estimates is from age 1 and age 2 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 1+ herring in 2020 were observed west of the Isle of Man and off the off the east coast of Northern Ireland, with a fairly scattered lesser abundance observed throughout the Irish Sea. The estimate of herring SSB of 64,271t is within the observed range for the time-series and the biomass estimate of 98,277t for 1+ ringers for 2021 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 0 fish by number and 2 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 70,859t for the 2021 acoustic survey is a large increase from 47,933t in 2020. 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 2021 was reported by the Marine Institute, Ireland. Geographical coverage was comparable to 2020. The core distribution areas were comprehensively covered, and the stock was considered contained within the Celtic Sea survey area.

The 2021 total standing stock estimate is 9,877 t and 310 million individuals (CV 0.44) is an increase on the 2020 estimate (4,717 t and a total abundance of 67,368,000 individuals). The standing stock biomass however still remains in a low state. The stock is dominated by 3-wr fish representing 43% of the total biomass (TSB) and 11% of total abundance (TSN). Immature 0-wr fish accounted for 33% of TSB and 81% of TSN.

The biomass of sprat (TSB) was 12,376 t and the TSN 3,018 mill individuals and an increase on the 2020 estimates (4,717 t and 67.3 mill ind.). The nearshore distribution of sprat likely led to the stock not being fully contained within 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 prioritized as this would minimize 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 large 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 2021 GERAS-index was estimated to be 0.87 x 10^9 fish or about 31.1 x 10^3 tonnes in subdivisions 21–24. The biomass index in 2021 represents the lowest in the time-series.

1.3.3 WGQUALITY, WGBIOP and WGCATCH

Operationalizing 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 focuses 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 focuses 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 2022) 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.
- An age reading exchange of North Sea sandeel (*Ammodytes*) was conducted in 2022. The percentage agreement (PA) was 87 % and the CV was 20%. This was an improvement compared to previous exchanges and workshops. From previous calibrations the following age reading issues were apparent; a) incorrect interpretation of the otolith edge in Q4 where some readers were counting an extra year and b) disagreement as to whether or not a faint innermost translucent zone (present in some otoliths) should be counted as a true winter ring or not. The former issue appears to be resolved as a result of repeated calibration of readers and feedback on age reading issues. The latter is a reoccurring issue which needs attention and requires otolith microstructure examination of problematic otoliths from different areas in order to validate whether or not this is a true winter ring. The results of 2022 do not show any indication that a single stock or month of capture (or age) is more difficult to read than others.

Other clupeid stocks

- Otolith exchanges were held for Central Baltic herring and sprat in the Baltic Sea . , For Central Baltic herring in SD 25 PA was 93%, CV was 8%, in SD 26 PA was 85%, CV was 9%, in SD 29 PA was 89%, CV was 12%, and in SD 32 PA was 70%, CV was 7%. For sprat in the Baltic Sea PA was 97% with a CV of 8%. This is an improvement on the results of the 2022 calibration.

Planning of future workshops and exchanges

- An age reading workshop will be held in April 2023 on the comparison between age reading methods of NSSH using scales and otoliths. The focus is on NSSH but results could have implications for NSASH as well.

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.

1.3.4 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 , SA2r, SA3r, and SA4. Predation mortality was updated in the 2021 assessment of these stocks based on the 2020 key run of the North Sea SMS model provided by WGSAM (ICES 2021), except for sandeel in SA2r, SA3r and SA4. The 2020 key run is primarily an update of the 2017 key run by extension of the input data and their update when the single species stock assessment input data were revised through benchmarks or interbenchmarks.

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 parameterized 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 since the 2017 key run 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. The most important changes are:
  - Whiting benchmark with mean weight at age in the sea derived from survey data, whereas mean weights from the catches were used previously. This gives lower mean weight at ages for the youngest ages and higher mean weights for the oldest ages compared to the 2017 key run
  - Sprat benchmark with inclusion of subdivision 3a in the stock area and re-estimation of historical catch data
  - Mackerel benchmark with new stock size estimate
- Re-estimation of the hake stock within the North Sea
- Re-estimation of horse mackerel and their proportion of the stock within the North Sea

Comparison with previous values of predation mortalities suggest:

- **Herring** - the pattern in M is in general consistent between the two key runs but some differences are estimated in the first and last part of the time-series. Differences in most recent years are due to lower stock size of the predators cod and saithe, and by increased predation by whiting and hake.
- **Sprat** - the pattern in M is in general consistent between the two key runs, but the new estimates downscale the absolute values of predations mortality for all ages except age0.
- **Sandeel** – estimates of predation mortality are highly consistent for both the northern and the southern sandeel modelled stocks (i.e. current SMS considers sandeel as two units within the model, approx. corresponding to SA1r and SA3r) between the new and

previous key runs. Some marginal differences are visible for the southern sandeel with an upscale of M in the last part of the time-series for all ages and a downward revision in the first part of the time-series for age3+.

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.

1.3.5 MIK surveys

Down's herring recruitment information

In 2016, WKHERLARS evaluated the North Sea herring larvae surveys (ICES, 2016), and concluded that the current IBTS-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 2018, 2019, 2021 and 2022. Due to COVID-19 measures it was not possible to carry out a DRS in April 2020. As herring larvae need to be caught at the same development stage as the IBTS-MIK, it was not possible to move the survey to a later date in 2020.

The DRS is carried out following the IBTS-MIK protocol, but sampling both day and night, instead of only at night. Comparative fishing trials to check for difference in catchability between day and night were done in 2021 and are planned for April 2023. The preliminary results suggest that night-time catches are much higher, and WGSINS decided to already advice that the DRS will need to be carried out during night-time only. However, with the current survey capacity available it will not be possible to cover the southern North Sea and German Bight when only sampling at night. HAWG supports the search for extra survey participation from 2024 onwards.

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-index for a complete NSAS recruitment index for the advice if the DRS surveys are continued. This became apparent in the 2023 assessment of NSAS. The 0-ringer MIK index of 2022 (corresponding to the 2021 year-class) was one of the lowest in the time-series, but the 1-ringer IBTS index of 2023 (corresponding to the same 2021 year-class) was one of the highest in the time-series. The larval abundances of the DRS 2022 were relatively high, especially compared to the low MIK-index. This supports the high 1-ringer IBTS index of 2023, and indicates that the high recruitment of the 2021 year class may be due to the high Downs production, which is not reflected in the MIK-index. Thus, HAWG supports the continuation of the exploratory surveys in April and have had a positive response from several laboratories.

HAWG recommends that WGSINS investigate calculation of a Downs and combined North Sea herring recruitment index based on the combination of the IBTS-MIK and DRS data. Potential combined indices were presented and discussed at the HAWG meeting. WGSINS will have a subgroup meeting in summer 2023 to prepare the protocol for the combined index calculation and this will be finalized at the WGSINS meeting in November 2023.

1.3.6 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 allowing 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 allow 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 WKMIXHER in 2018 and WKSIDAC in 2017. Another meeting of WKSIDAC is schedule in June2023. 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 – Cormac and Ed

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 2023 include:

Genetic sampling of the commercial catch has begun in 6a South in the 2022/23 fishing season. 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. Two spring-spawning samples have been secured and added to the baseline in the last months.

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). 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 and Danish and Norwegian parts of HERAS, and Danish and Swedish parts of the IBTS/BITS. Currently, information about additionally occurring stocks in 4ab/3a, such as NSS, Baltic Sea Autumn Spawning herring and Baltic Sea spring-spawning herring is currently not used, and these fish has been assigned as either NSAS or WBSS based on previously used methods. Genetic marker-based splitting has thus replaced the methods of vertebral count, otolith shape and microstructure data. Splitting is limited to Danish, Swedish and Norwegian samples from commercial catches and scientific surveys in Skagerrak-Kattegat and the northeastern North Sea. Applied splitting methods will become consistent between labs and countries as of 2022. The benefit of using genetic methods to identify stock components, compared with traditionally implemented phenotyping methods, has been demonstrated for different approaches (Berg et al. 2021; Farrell et al. 2022, Bekkevold et al. 2023).

1.3.7 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 abundance indices (for category 3 stocks). For sprat in 7d,e The effect of seasonal advice schedule (July-June) was investigated. During the stock's interbenchmark, an annual MSE was not able to investigate within-year processes. A novel intra-annual MSE (Mildenberger et al., 2021) was parameterized 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 interbenchmark 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 of 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.

1.3.8 WKNSCS – Benchmark workshop on North Sea and Celtic Sea stocks

The benchmark workshop on North Sea and Celtic Sea stocks (WKNSCS 2022) took place in February 2022 with a data meeting in November 2021. Five stocks were included in this benchmark including herring in 6a, 7b,c. The availability of the genetically split Malin Shelf Acoustic survey data allowed the two stocks to be assessed separately (6aS, 7b,c and 6aN).

For herring in 6aS, 7b,c category 1 assessments were tried using SAM and ASAP. SAM had issues with survey catchability and model convergence as well as with the SSB and F trajectories. ASAP was very sensitive to the assumptions about fishery selectivity. Both models had poor retrospective performance with Mohns Rho values outside acceptable limits. While neither model reached the standard for a category 1 or 2 assessment, significant progress has been made with both approaches showing good promise for the future when more split data (survey and catch) is available. SPiCT was also configured for herring in 6aS, 7b,c but had issues with convergence and poor model diagnostics and was deemed unsuitable to provide category 3 advice.

A SAM assessment was configured for 6aN. The group raised concerns over the catch data and its influence on the assessment presented. Catch data are assumed to be from 6.aN autumn spawning herring, but with a lack of genetic sampling this is not certain. Additionally there are underlying stock identity questions for 6.aN herring relating to the relationship with populations in the North Sea that have not been resolved. The appropriateness of including the IBTS datasets in the SAM model was discussed. The inclusion or exclusion of these indices had an impact on the overall stock trajectory. SPiCT was also tested for 6aN herring. With the short and variable nature of the biomass time-series available, this SPiCT model was not considered to be suitable as a category 3 option.

Given that both stocks did not reach the required standard for a category 1 assessment at this benchmark, the new category 3 guidelines from ICES WKLIFEX (2021) were applied. Both stocks applied method 2.2 constant harvest rate. This method uses that uses length, survey and catch data from 2014-2021.

Significant improvements have been made since the last benchmark that have increased the understanding of the stocks and should lay the groundwork for a higher category assessment in future. Recommendations for future research and data requirements were made for both stocks.

1.3.9 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 2018-2023 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again low: 4.4%, <1%, 1.2%, 0.6%, zero, and 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.

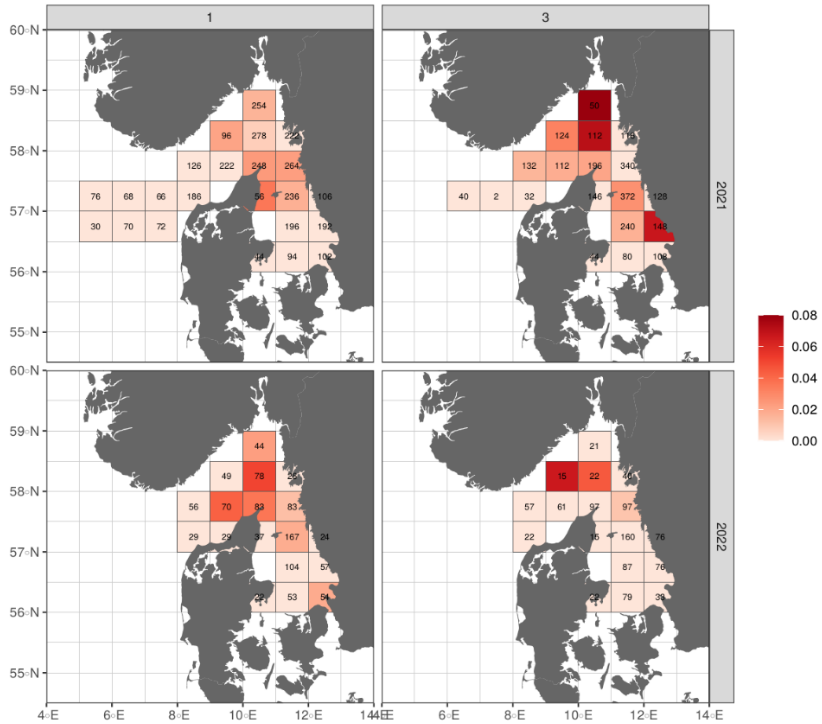


Figure 1.3.9.1 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ1,3 2021-2022. The maps with distribution of the proportion of infested herring and number of samples in each rec- tangle.

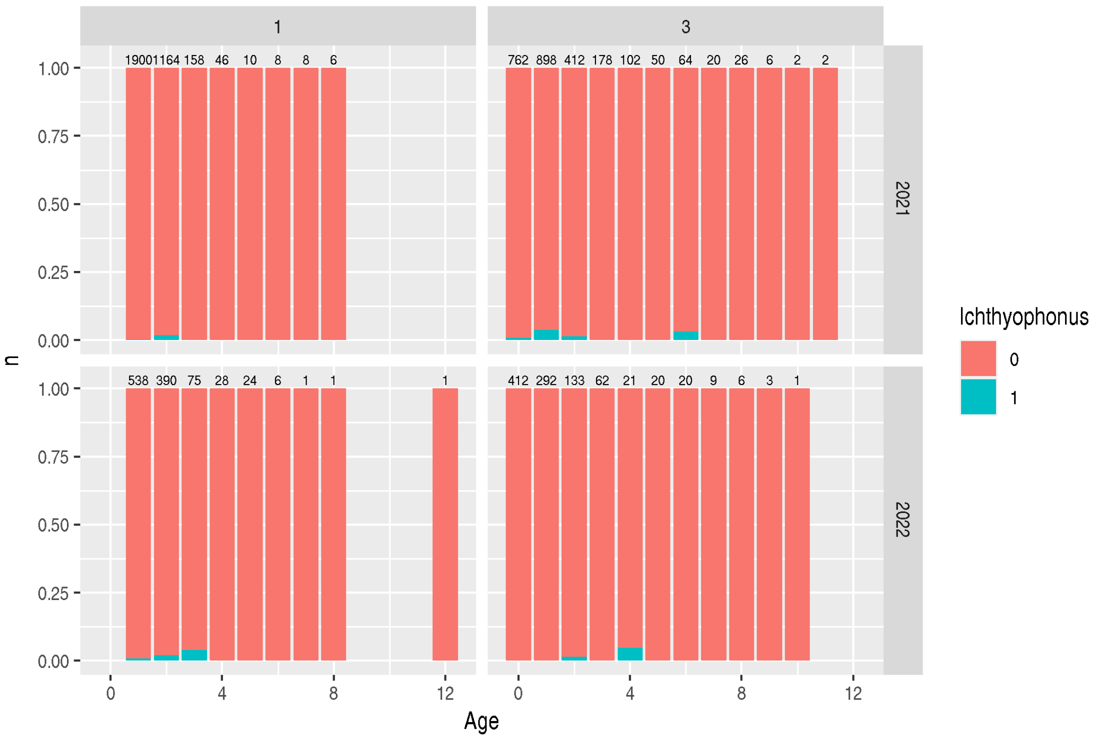


Figure 1.3.9.2 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ1,3 2021-2022. Distribution of infestation among ages.

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.

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 1st March 2023. All but one country 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)	116567	113476	2022	17
4.a(W)	243356	208411	6416	26
4.b	65696	45038	2907	44
4.c	23883	16459	258	11
7.d	17631	9758	257	15
7.a(N)	7208	6329	1680	233
3.a	727	167	149	205
SD22-24	637	470	2056	3228
7g, 7.j, 7aS	350	350	550	1573
6.aN	1115	671	43	39
6.aS, 7.b and 7.c	1326	1326	1701	1283

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 multifleet 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 utilize short-term predictions. The Western Baltic Spring-spawning herring uses an R-based multifleet 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 interbenchmark meeting (ICES, 2021). This resulted in a downward revision of the estimate of B_{lim} and $MSYB_{trigger}$ 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 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 of 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.

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

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.

ICES is reviewing the level of inclusion of ecosystem information into the single-species assessments that provide the base for the current advices to evaluate progresses toward ecosystem-based fisheries management. The intent is to quantify whether and how the ICES assessments incorporated broader system-level considerations, from the inclusion of technical interactions among fisheries (i.e. catch and bycatch of target and non-target species) to interactions with the physical environment (i.e. environmentally-driven recruitment, climate), and biological components (i.e. density-dependence, predation).

Following the ACOM request (March 2019), HAWG collected information and has updated this on where and how change in ecosystem productivity (either annually or over periods) is incorporated in its fish stock assessments, MSE operating models and management advice products for the following six categories (relevant variables in parenthesess) below:

1. Stock assessments (weight-at-age [in stock or catch], length distribution, maturity, sex ratio)
2. Forecasts (recruitment over recent years – reflecting productivity changes, recent weight-at-age, maturity, natural mortality)
3. Natural mortality (predation, diseases, parasites) assessed and included as variable by year (including smoothed)
4. Stock distribution (changes caused by year-class strength, predators, prey, habitat suitability/quality)

5. Mixed fisheries (catch and bycatch of target/non-target species)
6. Climate change (is this considered and how?)

Because the inclusion of system-level information may span from the use of qualitative background considerations to inclusion of quantitative information into analytical assessments, the following scoring system recently proposed by Marshall *et al*. (2019) has been applied:

- Score 0 – information unavailable / not used.
- Score 1 (Background) – productivity is mentioned in the report and/or considered in the output as background information.
- Score 2 (Qualitative) – applicable in two cases: i) when quantitative data/information on productivity change were included in the report, but not used in any analyses/models, or ii) explicit link between the productivity change and assessment parameters or output was established. *For example, including numerical data from diet studies on the target species would receive a score of 2, as would discussing a link between sea surface temperature and recruitment predictions.*
- Score 3 (Quantitative) – productivity-related data were explicitly included in the assessment model through data inputs or estimated parameters.

Stock code	Stock assessment					Short-term forecast				
	variable w@a	length distribution	variable mat@a	estimated variable nat mort	estimated variable sex ratio	environ. driven recruitment	truncating recruitment time-series	recent or trend weight@a	recent or trend mat@a	recent or trend nat mort
her.27.20-24	3	2	3	3	0	1	3	3	3	3
her.27.3a47d	3	2	0	3	0	1	3	3	0	3
her.27.6aS7bc	2	3	2	2	0	0	0	0	0	0
her.27.6aN	2	3	2	2	0	0	0	0	0	0
her.27.irls	3	2	1	2	0	0	3	3	0	0
her.27.nirs	3	2	3	2	0	0	3	3	3	2
san.sa.1r	3	0	1	3	0	0	1	3	1	3
san.sa.2r	3	0	1	1	0	0	3	3	1	1
san.sa.3r	3	0	1	3	0	0	1	3	1	3
san.sa.4	3	0	1	1	0	0	3	3	1	1
san.sa.5r	0	0	0	0	0	0	0	0	0	0
san.sa.6	0	0	0	0	0	0	0	0	0	0
san.sa.7r	0	0	0	0	0	0	0	0	0	0
San.27.6a	0	0	0	0	0	0	0	0	0	0
spr.27.3a4	3	0	1	3	0	0	3	3	1	3
spr.27.67a-cf-k	3	0	0	0	0	0	0	0	0	0
spr.27.7de	3	0	0	0	0	0	0	0	0	0

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 bycatch 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 substock 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 bycatch 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 industrial fishery in Division 3.a and hence a limited bycatch of juvenile herring. The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of bycatch, 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 temperature**s** 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 foodweb 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 foodweb 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 seabird 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 1.7.2–1.7.5.

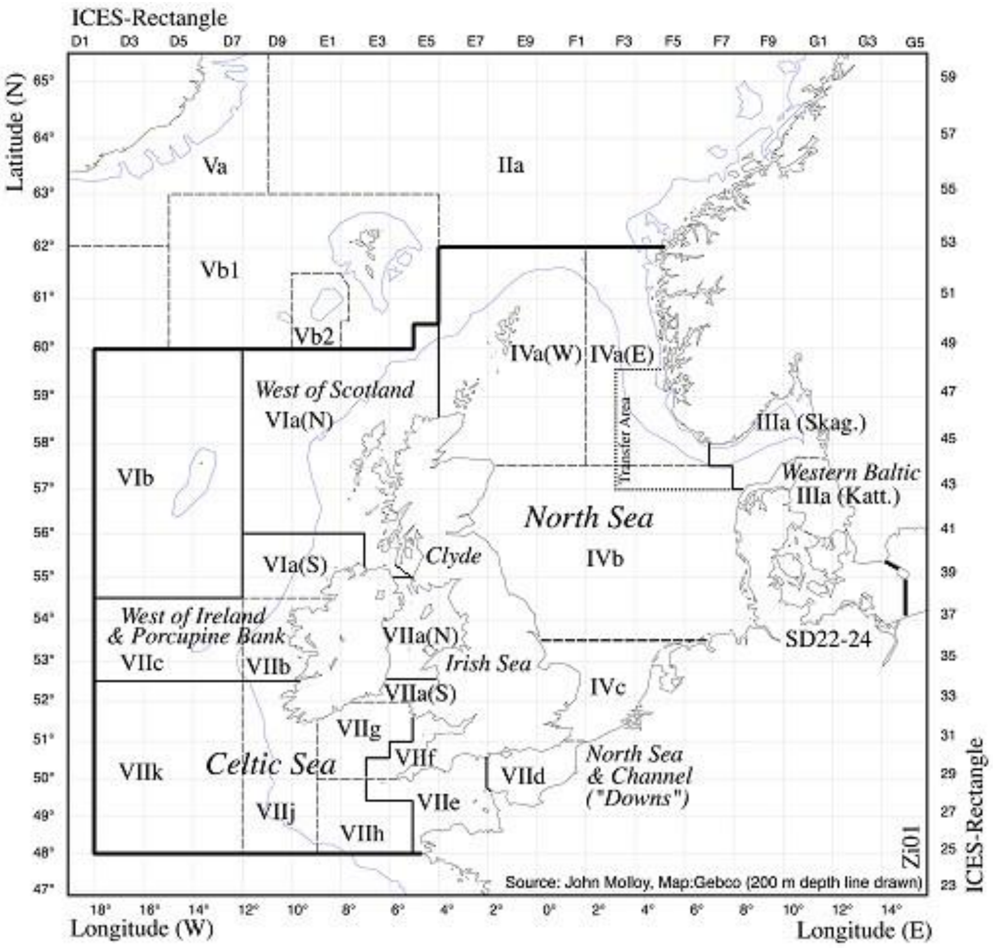


Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long-term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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. Based on the WG assessment, the stock has been harvested at MSY since 1997 (fishing mortality below F_{MSY}=0.31 and SSB above MSY $B_{triggger}$=1 232 828 t). The 2024 advised catch of NSAS herring is increased by 28.3% compared to last year. The SSB in 2022 (1 652 003 t) is estimated to be larger than that predicted in the previous advice (33%). The 2021 year class, contributing to the SSB in the advice year, is now estimated to be larger than that estimated in the previous advice (87%). The SSB in the advice year is forecasted to be above MSY Btrigger, leading to a fishing advice at F_{MSY}) in 2024, rather than below F_{MSY} which was the situation for 2023. The fishing mortality has increased from 0.19 (2019-2021) to 0.23 (2022).

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 that is not currently taken into account in the assessment. The stock has decreased consistently since the late 2000s. The 2019 SSB (51 376 t) and 2021 recruitment (454 304 thousand) are record low. The estimate of SSB in 2022 (75 548 t) is considered low, below both B_{pa} and B_{lim}. Fishing mortality (F_{3-6}) was reduced from 0.57 in 2008 to 0.29 in 2011. It increased and remained above F_{MSY} (0.31) over the period 2012-2018. F_{3-6} then decreased below F_{MSY} from 0.28 in 2019 to 0.05 in 2022, which is the lowest F_{3-6} on records. The 2024 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 85 431 t in 2023 to 92 726 t in 2024. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2025 (103 649 t). A medium-term forecast to 2026 showed that SSB can increase to 115 511 t if F=0 in 2024-2025 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 16 539 t in 2022, 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 22 149 t in 2023. 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 2022 to be 0.028, decreasing from the high of 1.1 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 0.02 and 0.058, are 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 2014-2022 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 2022 is 33 283 tonnes, which represents a decrease compared to 2021. 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 shown an increasing trend since the lowest point in 2016 (36 707 t) and in 2022 was estimated to be 147 199 t. Recent catches are among the lowest in the time-series. Fishing pressure on the stock is at or below $F_{MSY\ proxy}$ (0.034) and the stock size index is above MSY $B_{trigger\ proxy}$ (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 44% of the catch numbers-at-age in 2022.

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 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. A benchmark in 2017 resulted in a substantial revision of SSB perception leading to an increased SSB in the most recent period compared to pre-benchmark perceptions. In 2022, SSB and recruitment have been estimated at 25 900 t and 750 879 thousand respectively. $F_{4–6}$ is estimated at 0.24 in 2022 with estimates of F stable since 2009. Under the MSY approach the stock is expected to show a decrease to 24 273 t in 2024.

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 advice is based on the MSY escapement strategy with an additional precautionary F_{cap}. The F_{cap} of 0.69 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. The estimates for 2023 show an SSB of 206 581 t which is above B_{pa} (125 000 t). The ICES advise for the period 1 July 2022–30 June 2023 is that catches of sprat should not exceed 143 598 t which represents a 109% increase on the last year advice. This large increase is due to a combination of an above average recruitment in 2022 and increases in mean weights for all age groups.

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 survey 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 2022 acoustic survey biomass estimate. The advised catch of 2437 t for 2024 is 73.5% lower 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 advises a catch of no more than 2240 tonnes for 2024 and 2025 in this ecoregion based on the precautionary approach.

Sandeel in 4 (san-nsea): 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.

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} (110 000 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} (85 000 t) in all years except 1984, 1986, 1989 from 1983-1999. 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 only been above B_{lim} (56 000 t) in five years of which only 2001 has been above B_{pa}. SSB increased above B_{lim} in 2018 as the result of the exceptionally high 2016 year-class, but fell below again from 2019-2021. 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 half of B_{lim} (80 000 t) to above B_{pa} (129 000 t) in all years after 2015. SSB had a peak of more than 498 000 t in 2018 and is estimated to 406 000 t in 2022. The recruitments in 2016 and 2019, respectively, were the highest and third highest on record. Forecast indicates an SSB in 2023 of 178 000 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 and 2022.

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 with the exception of 2015 and was close to B_{pa} (102 000 t) in 2023. Recruitment was low in 2018, high in 2019 and around the long-term average in 2020. Recruitment was above average in 2021 and 2022.

Figure 1.7.2 WG estimates of catches of the category 1 herring, sprat and sandeel stocks presented in HAWG 2023

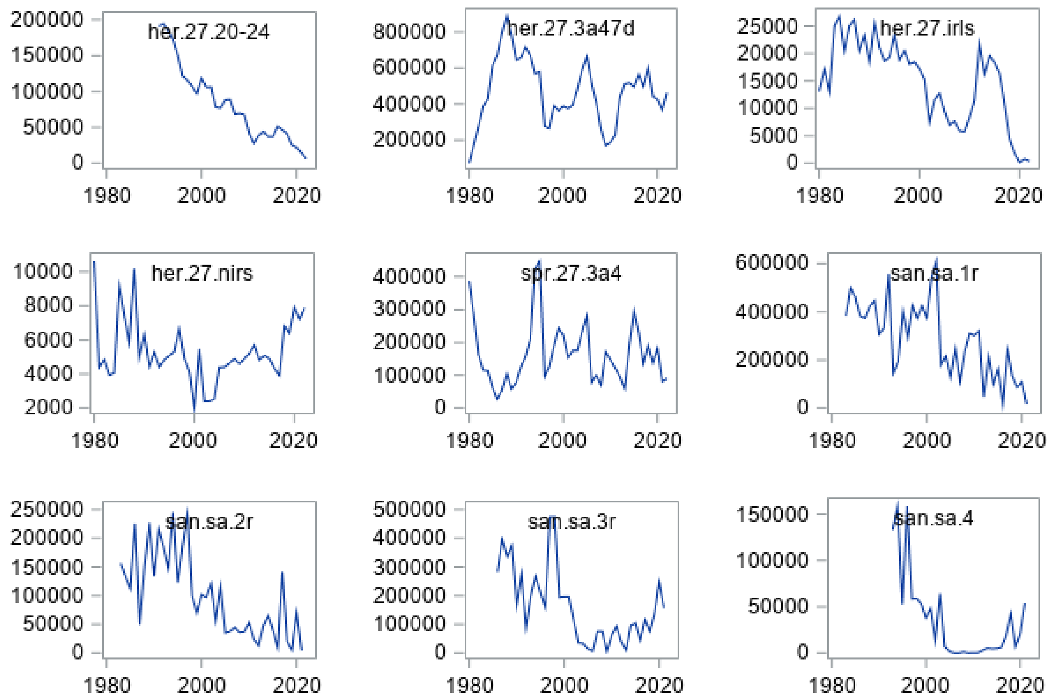


Figure 1.7.3 Spawning-stock biomass estimates for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2023.

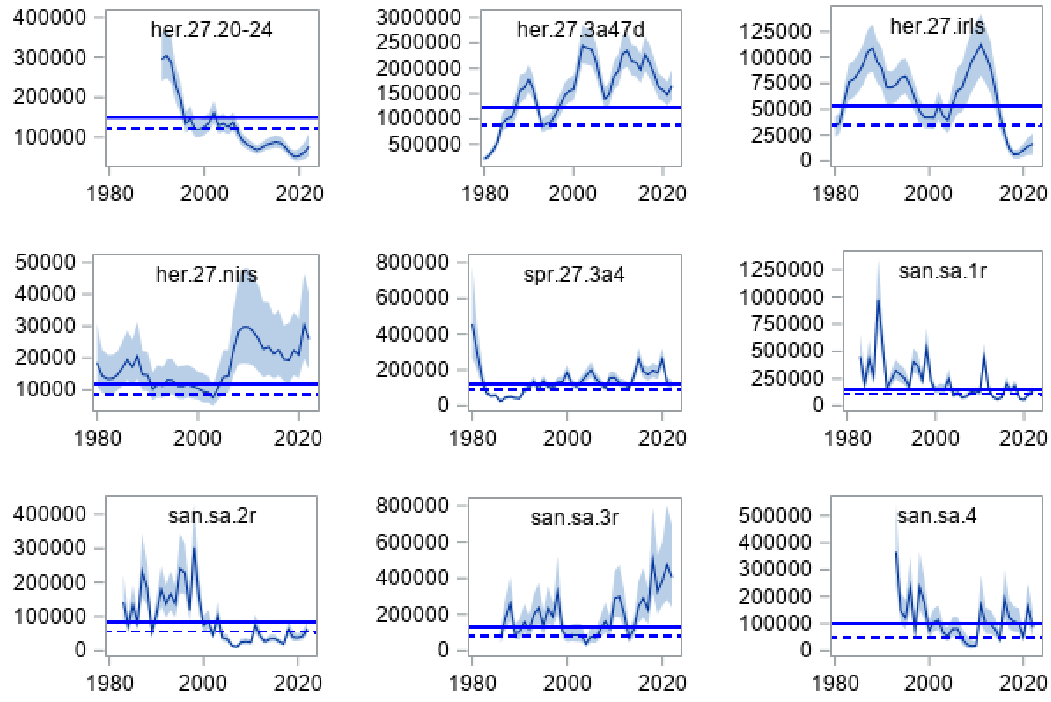


Figure 1.7.4 Estimates of mean F for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2023.

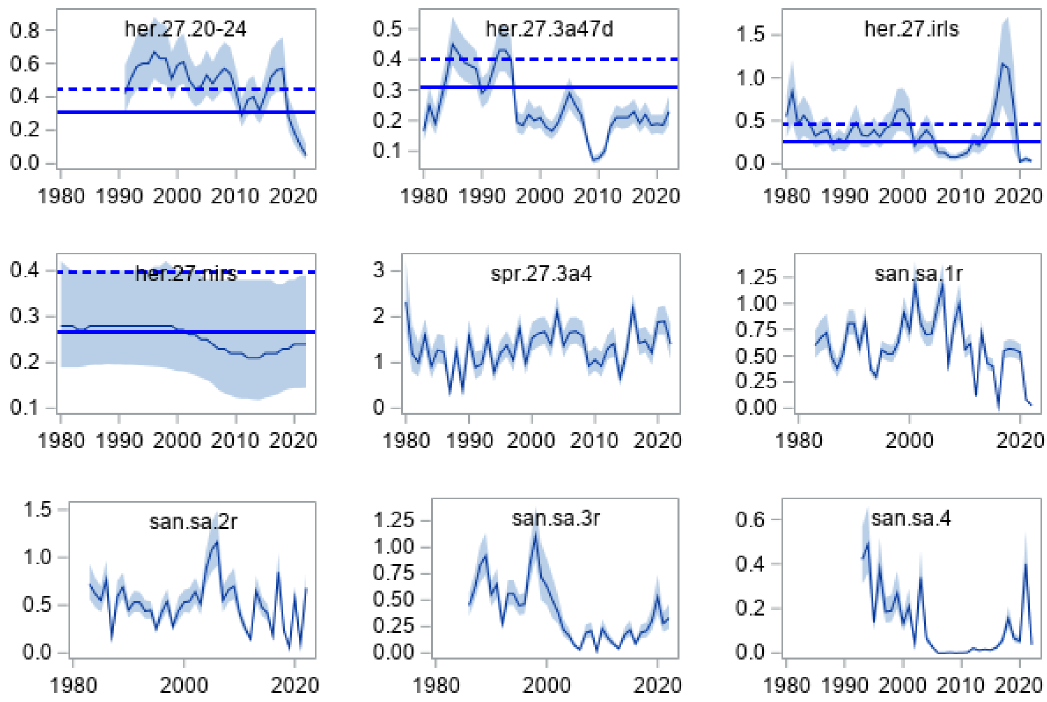
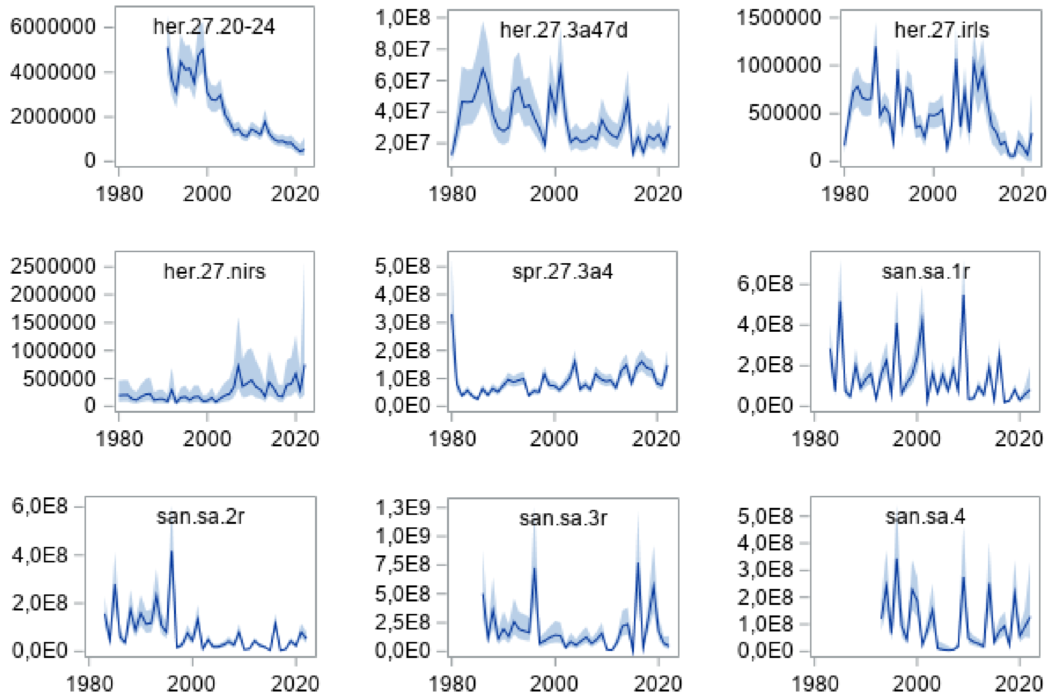


Figure 1.7.5 Estimates of recruitment for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2023.



Given the marked decrease in the weight-at-age of several of the herring stocks assessed by HAWG, the time-series of the relative weight change are presented for comparative reasons (Figure 1.7.6).

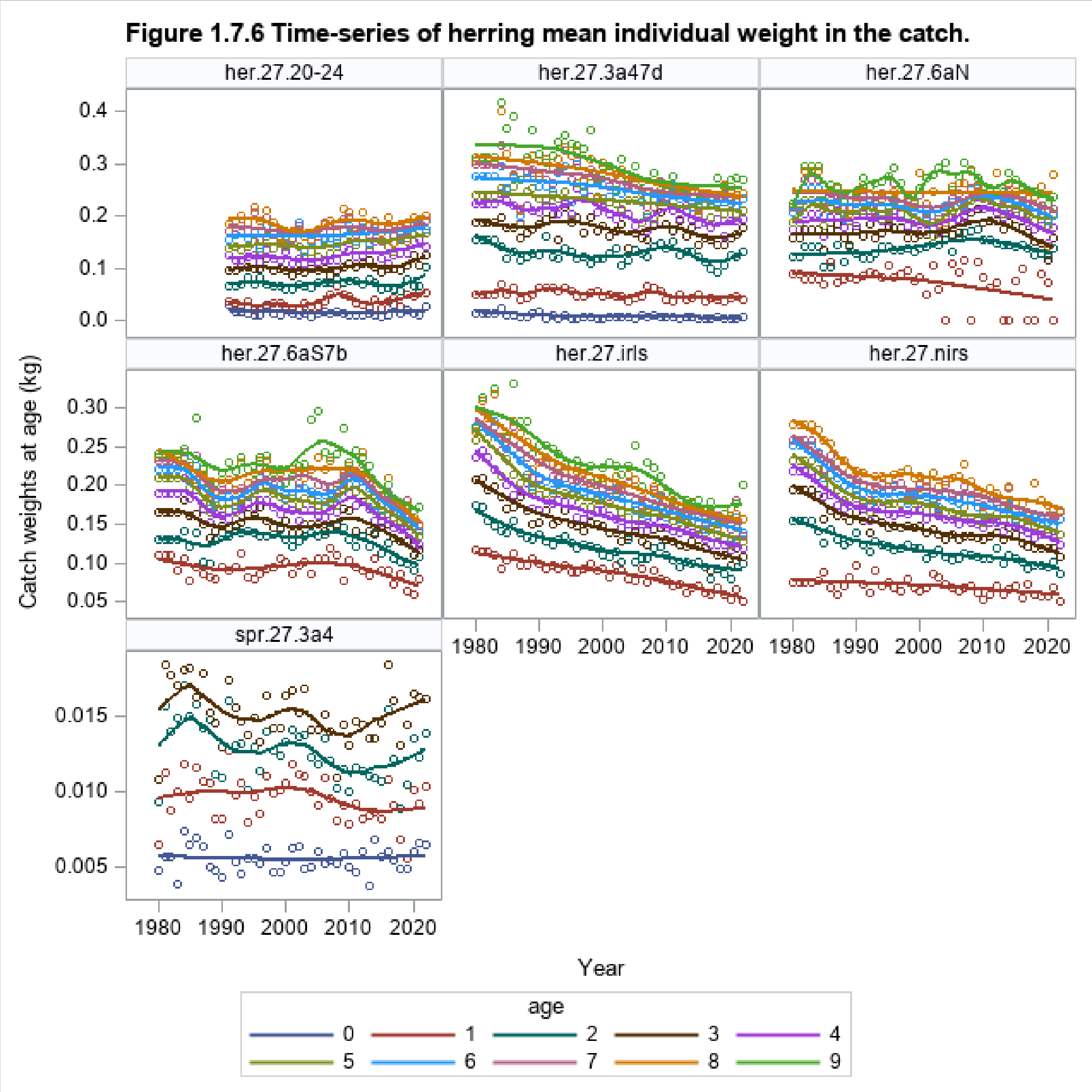


Figure 1.7.6 Time-series of herring mean individual weight in the catch.
her.27.20-24
her.27.3a47d
her.27.6aN
her.27.6aS7b
her.27.irls
her.27.nirs
spr.27.3a4
Catch weights at age (kg)
Year
age
0
1
2
3
4
5
6
7
8
9

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 1.8.1.

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[2] From ICES guidelines

Table 1.8.1 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 retrospective assessments used (n)	F_{bar} rho value	SSB rho: was the inter- mediate year used as the terminal year?	SSB rho value	Recruitment rho: was the intermediate year used as the terminal year?	Recruitment rho value
her.27.20-24	2022	5	-0.04	No	0.16	No	0.06
her.27.3a47d*	2022	5	-0.10	No	0.09	No	-0.04
her.27.irls	2022	5	-0.153	No	0.85	No	2.46
her.27.nirs	2022	5	-0.159	No	0.093	No	-0.309
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	-0.05	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#!/):

7. 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)
8. Herring west of Scotland (her.27.6aN) WKLIFE method 2.2 chr (Updated in 2023)
9. Herring west of Scotland and Ireland (her.27.6aS7bc) WKLIFE method 2.2 *chr* (Updated in 2023)
10. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment (Updated in 2023)
11. Sprat in 7d, e Category 3, biomass trends (Last updated 2018)
12. Sandeel in area 1r (san.sa.1r) SMS assessment (Last updated 2019)
13. Sandeel in area 5r (san.sa.5r) category 5.4 analysis (Last updated 2019)
14. Sandeel in area 6 (san.sa.6) category 5.2 analysis (Last updated 2019)
15. 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 Interbenchmark 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 April 2025 with DEWK in Nov/Dec 2024
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 prep
6.aS, 7.bc herring	3	2022	No	Continue genetic sampling on the survey. Start genetic sampling the catch. Further investigate survey indices. Further work on model development.	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	Update reference points for sandeel area 3 based on the new M estimates	Issue list available

2 Herring (*Clupea harengus*) in Subarea 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 elaboration 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 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.

2.1.1 ICES advice and management applicable to 2022 and 2023

There is currently no agreed EU-Norway 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 management strategies will become available, the MSY approach is used as the basis of ICES advice.

The final TAC adopted by the management bodies for 2022 was 435 802 tonnes for Area 4 and Division 7.d, where no more than 47 039 t should be caught in Division 4.c and 7.d. For 2023, the total TAC is 404 272 t (396 556 t for the A-Fleet), including a TAC of 43 621 t for Division 4.c and 7.d.

The bycatch TAC for the B-Fleet in the North Sea (and Division 2.a) was 8 174 t in 2022 and has decreased by 6% to 7 716 t in 2023. 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 harvesting North Sea herring see the Stock Annex and Section 2.7.2.

2.1.2 Catches in 2022

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 rectangle and quarter are shown in figures 2.1.1 (a–d), the total for the year in Figure 2.1.1(e). Each nation provided 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 467 134 t in 2022. Official catches by the human consumption fishery were 461 007 t, far above the TAC for the human consumption fishery (427 628 t). The effect of 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 41 514 t. The separate TAC for this area was 47 039 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 6 127 tonnes in 2022. The bycatch ceiling for the B-Fleet was 8 174 t. Since the introduction of yearly bycatch ceilings in 1996, these ceilings have fully been taken in 2014, 2016, 2020 and 2021.

The total North Sea TAC and catch estimates for the years 2017 to 2022 are shown in the table below (adapted from Table 2.1.6).

Year	2017	2018	2019	2020	2021	2022
TAC HC (‘000 t)	482	601	385	385	356	428
“Official” landings HC (‘000 t) *	485	594	439	415	356	458
Working Group catch HC (‘000 t)	485	594	440	417	356	461
Excess of landings over TAC HC (‘000 t)	3	-7	55	32	0	33
Bycatch ceiling (‘000 t) **	11	10	13	9	8	8
Reported bycatches (‘000 t) ***	7	8	5	10	9	6
Working Group catch North Sea (‘000 t)	492	602	446	427	365	467

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 2023, the TAC in Division 3.a (HER/03A) is 23 250 tonnes. However, catches in 3.a are limited to 969 tonnes for the Union fleets. Norway stated to transfer at least 90% of their herring quota for Skagerrak into the North Sea.

Half of the EU quota for Division 3a (HER/03A.) can be taken in UK waters of the North Sea (HER/*04-UK) and 50% of the EU quota can be taken in 4b (HER/*4B-EU). In total, the transfer of 3.a quota into the North Sea can be up to 100% for Norway and the EU, depending on access restrictions.

In the North Sea, Norway is currently not allowed to fish in EU or UK waters in Division 4.a and 4.b (Her/*4AB-C). There is currently also no quantity put into place for EU vessels to fish herring in Norwegian waters south of 62°N (HER/*4N-S62).

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

Also 50% of the EU bycatch quota in the small-meshed fishery in 3.a can be fished in EU waters in 4 (HER/*4-EU-BC).

In 2014, an agreed record between EU and Norway was applied, enabling an interannual quota 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 interannual 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 borrowed. Subsequent year, the quota flexibility has been set to 10% again. Since 2021, this interannual quota flexibility is in place also for UK herring quotas.

At HAWG 2023, 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 exemptions 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. In 2022 in the Norwegian fleet, more pelagic trawlers and less purse-seiners have been engaged in fishing.

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.w, in the order of 52% of the total. Subdivision 4.a.e provided 25% of the catches in 2022 and catches in Division 4.b contributed 14%.

In 2022, catches in the transfer area (specific rectangles in Subdivision 4.a.e and 4.b) increased considerably. They amount to 90 861 tonnes, compared to levels of 2 000 - 18 000 tonnes in the preceding 10 years. Reasons for this strong increase may can be the distribution of the fish, the 100% transfer of catches from 3.a into 4.a and, with regards to the Brexit in 2020, a tendency of EU vessels to fish in EU waters.

The bycatch ceiling for the small-meshed fishery (B-Fleet) has not fully been taken in 2022. Reported catches were distributed in 4.a.w (24%) and 4.b (76%).

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

2.2 Biological composition

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 Western 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 procedures 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 2007–2022 (herring 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 2012–2022.

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 3.55 billion fish in 2022. The proportion of 0- and 1-ringers of herring taken in the North Sea is 24.5% of the total catch in numbers (Table 2.2.5), in the same order of magnitude as in 2021. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 67% of the total catch in numbers in 4.b.

The proportion of 3+ winter ring herring is 51% of the total catch in numbers taken in the North Sea (compared to 62% in 2021).

In terms of biomass, the 2- and 3-ringers contributed most to the catches of North Sea herring (25% and 20%, 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 included 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 assessment of Division 3.a/Western Baltic in 2007–2022. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 462 246 tonnes.

Area	Allocated	Unallocated	BMS/Discard	Total
4.a West	242 180		1 177	243 357
4.a East	116 567			116 567
4.b	65 696			65 696
4.c/7.d	39 253		2 261	41 514
	Total catch in the North Sea			467 134
	Autumn spawners caught in Division 3.a (SOP)			515
	Baltic spring spawners caught in the North Sea (SOP)			-5 402
	Total catch NSAS used for the assessment			462 247

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. In 2021 and 2022, 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 2022 was set at 10 tonnes and reported catches amount to only 0.055 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 2022, 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 (below minimum landing size, including any fish lost or damaged during processing procedures) were 13 tonnes in 2022. 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 2022 North Sea herring fishery. However, discards occurred in other fisheries not targeting on herring, mainly in the crustacean fishery. These raised discards sum to 3 438 tonnes in 2022.

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 128 different reported métiers, 40 were sampled in 2022. The sampling level of more than 1 sample per 1000 t catch has been met for 21 métiers. With regards to age readings, 24 métiers appear to be sampled sufficiently (>25 fish aged per 1000 t catch).

However, some of the métiers yielded very little catch. In 78 métiers, the catch is below 1000 t. The total catch in these métiers sums to 14 649t, so the remaining 50 métiers represent 452 485 t of the working group catch (97%). Of these 50 métiers, 32 were sampled. 20 métiers have more than 1 sample per 1000 t catch and 22 métiers more than 25 age readings per 1000 t catch.

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

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).

The estimate of North Sea Autumn Spawning herring spawning stock biomass is higher than in the previous year at 1.96 million tonnes (2021: 1.50 million tonnes) with an increase in the number of mature fish from 8 170 million fish in 2021 to 10 348 million fish in 2022. The mean weight of mature fish is only slightly higher than last year at 189.7g, and the increase in biomass of mature fish is due to higher abundance rather than change in condition of individual fish. The 2012- and 2013- year classes continue to be stronger than the long-term average (especially the 2013- year class). The 2014- year class is also emerging as a stronger than average size year class. These stronger year classes still contribute 17% to the overall biomass in 2022 and it should be noted that all year classes since 2015 are well below the average level since 2010 (and the long-term average). The 2016- year class is particularly weak with abundance at only 56% 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 decreased by 15% from 23 311 million in 2021 to 19 780 million in 2022. While prior to 2020 2 winter ring fish contributed substantially to the abundance of immature fish, the maturity level in this age group was as in the previous year comparatively high (59% mature in 2019, 75% mature in 2020, 74% mature in 2021).

At 70%, the proportion mature at 2 winter rings in 2022 is again at the high end in the time series – compared to e.g., the all-time low of 37% in 2018. Maturities for ages 3 and above were comparable to the long-term average with 95% maturity of 3 winter ringers, 97% of 4-wr and 99% of 5-wr and 100% maturity for all ages 5 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 survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2022–2023. They monitored the abundance and distribution of newly hatched herring larvae in the Orkney/Shetlands area, in the Buchan area and the central North Sea (CNS) in September and in the southern North Sea (SNS) in December 2022 and January 2023 (Figures 2.3.2.1–2.3.2.3). While four survey were conducted as scheduled, the survey in the English Channel in January 2023 struggled with technical problems of the vessel and unfavourable weather condition. Thus, only 50% of the planned stations have been sampled in January 2023.

The survey around the Orkneys revealed lower quantities of newly hatched larvae, and their distribution was different from previous years. Most larvae were not found close to the Orkneys, but much more easterly than usual, on the outer edge of the survey area. These larvae may have drifted here down from the Shetlands, but the actual reason is unknown.

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

The distribution of larvae on the southern North Sea in the December survey was unusual in that manner that highest concentration of larvae was observed in the inner part of the English Channel (around Sandettie Bank), and not at the most westerly stations as in other years. Higher abundance of larvae around Sandettie Bank were also observed during the survey in January, but due to heavy wind speeds and high waves, the western parts of the area were out of reach and could not be sampled.

No survey was planned for the second half of January 2023. Instead, an additional MIK sampling is scheduled for April 2023 in the German Bight and Skagerrak/Kattegat area. This sampling should shade light on the foraging and recruitment of herring larvae originating in the Downs stock component. This survey is described in section 2.11.

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.

In almost all observed area in the North Sea, newly hatched herring larvae at the spawning grounds were less abundant compared to recent years. It is necessary to underpin and verify these findings in the upcoming sampling period.

2.3.3 International Bottom Trawl Survey (IBTS-Q1)

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 2023 survey (corresponding to the 2022 year-class) is 90.8. This corresponds to an average index value and is a bit below the long-term average of 100.7 (in the time-series since 1992).

The previous MIK-IBTS survey in 2022 had been faced with numerous challenges which resulted in poor sampling coverage (see previous HAWG report for details). The 2023 survey was again faced with several challenges, but fortunately considerably fewer than in 2022. Due to technical issues with the steering gear and the trawl winches on RV Walther Herwig III, Germany lost approximately 1.5 weeks of survey time. Scotland also had technical problems with the engine as well as a Covid-19 infection onboard of RV Scotia, resulting in a loss of approximately 1 week of survey time. In addition, several participants had issues with severe weather conditions during parts of the survey period.

A total of 586 MIK hauls were conducted in 2023, which is 153 more than in 2022 but 97 less than in 2021. For the 2023 MIK 0-ringer index (corresponding to the 2022 year-class), all hauls north of 51° N were used, in total 569 hauls (for comparison: 2022 = 410 hauls and 2021 = 663 hauls).

A total of 716 MIK hauls were planned according to the 2023 NSIBTS Q1 program (the target is 4 hauls per ICES rectangle) and 586 were conducted, i.e., 82% of the planned MIK-stations were sampled in 2023. However, there has been a general increase in the number of MIK hauls throughout the time-series, and the 586 MIK hauls achieved in 2023 are above the long-term average of 505 hauls (time-series since 1992). Besides, thanks to coordination between participants during the survey, almost all ICES squares in the survey area were covered. Furthermore, the main distribution area of the herring larvae in the central and southern North Sea was well covered with at least 3 and mostly 4 MIK hauls per ICES square. Thus, the "missing" hauls in relation to the number of planned hauls and the resulting lower coverage with only 1 or 2 hauls per ICES square did mainly occur in the northern part of the survey area, which usually only yields relatively few herring larvae. Overall, the coverage achieved during the 2023 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 MIK larvae in 2023. Herring larvae measured between 6 and 40 mm standard length (SL). Again, and as in most years, the smallest larvae <12 mm were numerous, with a peak at 10 mm. However, while these small larvae <12 mm often accounted for around 50 to 60% of the total number of larvae in other years, they only made up 33% of the total number of larvae in 2023. Instead, larvae in the size range between 13 and 17 mm were also numerous in the 2023 survey, with another peak at 15 mm. This interesting feature in the 2023 length distribution is similar to the length distribution in 2022, which also showed a peak at 15 mm. Larger larvae >18 mm SL were rarer, but their relative share was 20% and thus higher than in the two previous years 2022 and 2021, where the share of these larger larvae >18 mm was only 11 and 12%, respectively.

Figure 2.3.3.1.2 illustrates the spatial distribution of 0-ringers (>18 mm) in 2021, 2022 and 2023. As in previous years, the smallest larvae in 2023 were again chiefly caught in 7.d and in the Southern Bight. The 2023 distribution is partly similar to 2021, with higher abundances east of Scotland and along the UK coast. However, in the south-eastern and eastern part of the North Sea, the potential nurseries, abundance of larger herring larvae in 2023 was lower than in the two previous years. An interesting feature of the 2023 spatial distribution are the few stations with very high abundances in the English channel / Southern Bight area, which have a relatively strong impact on the index value.

As in previous years, sardine larvae were again found in the samples of the 2023 MIK survey. Most sardine larvae occurred in the southern and south-eastern North Sea as well as in the Skagerrak. However, in contrast to previous years, some sardine larvae were also found relatively far north and north-west.

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 2021 is shown in Table 2.3.3.2. The index from the 2023 survey (corresponding to the 2021 year-class) is 5016. This is a record high value in the time series and more than 2.5 times higher than the long-term average of 1969, and considerably higher than the previous 3 highest year-classes in 1986, 1995 and 2013 with index values of 4394, 4403 and 3918, respectively.

Figure 2.3.3.2.1 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2021, 2022, and 2023, corresponding to year-classes 2019, 2020 and 2021. As in previous years, a large part of the 1-ringers of the 2021 year-class were found in the Kattegat/Skagerrak area. However, very high abundances were also found in the entire eastern North Sea, in the area east of 4° East and south of 58° North.

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 but weakened for the 2019 year-class (Fig. 2.3.3.2.2). The 0-ringer and 1-ringer data for the 2020 year-class correspond better than for the 2019 year-class, but the 1-ringer value seemed rather low compared to the 0-ringer value, which may have been related to the severe challenges during the 2022 survey and associated potential catchability issues (see previous HAWG report for details). For the 2021 year-class, the two time-series seem to be highly uncoupled, as the 0-ringer index of 48.0 is one of the lowest in the time series, while the 1-ringer abundance is record high. This may be related to unusually good recruitment of the Downs component, which is not reflected in the 0-ringer index but is included in the 1-ringer abundance (see also section 2.5.1 on the “Relationship between 0-ringer and 1-ringer recruitment indices” for further details).

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 2022 for comparison. The data for 2022 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.

The general trend towards smaller mean weights-at-age observed in recent 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 turned since 2020. This is especially the case for winter ringers 2 and 3. Almost all ages, in both the acoustic survey and the catch, had higher or equal mean weights-at-age compared to 2021, with the only exception of 1-wr fish in both the catch and the survey, and 9+ group in the survey.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2022 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 2022, 2 winter ringers were to 70% 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 (95%) and 4 (97%) are also comparable to the long-term average. 100% maturity was achieved by winter ringers 6.

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).

During the 2018 benchmark (ICES WKPELA, 2018), it was decided to use the new M time-series from the 2017 SMS model key run (ICES WGSAM, 2018). However, because of the substantial impact the absolute level of M has on the assessment, an age and year independent offset is applied. This 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. However, for the profiling performed during WKPELA2018, a benchmark interim model specification was used. In practice, the assessment profiling should have been performed using the WKPELA2018 final model configuration to ensure consistency in the derivation of additive rescaling. This discrepancy was only discovered at HAWG2021 and has consequence in the scaling of the assessment. In order to correct this discrepancy but also update the natural mortality for the NSAS assessment with the latest SMS model key run (ICES WGSAM, 2021), a dedicated inter-benchmark was held (IBPNSherring2021, ICES, 2021).

The latest natural mortality vector from WGSAM (ICES WGSAM, 2021) spans the 1974-2019 period. Values outside this year range is computed using a three-year moving average.

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 Relationship between 0-ringer and 1-ringer recruitment indices

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. 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), but also already for the 1995 year-class, 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). For the 2019 year-class, the relationship between the MIK 0-ringer and the IBTS 1-ringer index decreased again. For the 2020 year-class, the two indices corresponded better, but the 1-ringer value seemed rather low compared to the 0-ringer value, which may have been related to the severe challenges during the 2022 survey and associated potential catchability issues (see previous HAWG report for details).

The most recent data that can be compared between 0-ringers and 1-ringers are for the 2021 year-class, corresponding to the 0-ringers from the 2022 MIK survey and the 1-ringers from the 2023 GOV survey. For this year-class the two time-series seem to be highly uncoupled, as the 0-ringer index of 48.0 is one of the lowest in the time series, while the 1-ringer abundance is record high. This is also reflected in the explained variability of the correlation between 0- and 1-ringers, which was 26% until the last 2020 year-class, but with the large discrepancy between the 0-ringer and 1-ringer indices for the most recent 2021 year-class, this value has now further diminished to 15% (Figure 2.5.1.1).

The high discrepancy may be related to unusually good recruitment of the Downs component, as this component is not reflected in the 0-ringer index but is represented in the 1-ringer index. This is also supported by the index of small (<13 cm) 1-ringers, which are assumed to be of Downs origin and also showed a record high value of 2699 for the 2021 year-class (Table 2.3.3.2). The variable correspondence in the 0-ringer and 1-ringer indices in the later part of the time-series may in general be related to variable but generally increasing contributions of the Downs component. 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.

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.

The proportion mature of 2, 3 and 4-wr individuals are 70%, 95%, and 97% 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 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. Overall, the age composition of the stock sampled by the HERAS acoustic survey in 2022 is similar to previous years. For this survey, the internal consistency of the index remains high, as it has been for a long period (Figure 2.6.1.7). However, as explored at HAWG 2020 (ICES 2020h), the index consistency has decreased in recent years. 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 2022 is estimated at approximately 1.65 million tonnes, a slight increase to 2021. As for recruitment, the 2023 estimates are at similar levels than estimated during 2022. Recruitment of the 2021- and 2022-year classes are estimated to be the highest since 2013. Mean F2–6 in 2022 is estimated at approximately 0.22.

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 2021i), 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: -10.4% (Fbar), -3.5% (rec), and 8.6% (SSB). Figure 2.6.2.10 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and 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 2.6.2.11).

The fishing selectivity at age is presented in Figure 2.6.2.12. 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 2021i). The latest configuration with 2023 data did not allow the model to converge. This was due to the low catches for the B-D fleets, with years associated with 0 catches for some ages. Consequently, model tuning was necessary. A small adaptation of the 2021 inter-benchmark configuration was used and is given in Table 2.6.3.8. The main change is the reduction of ages considered for catches for the fleets B and D (0-6 initially, now ages 0-3).

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.

Whilst the 2023 model converged with the new configuration (Table 2.6.3.8), it failed for all the peels. Consequently, the analytical retrospective could not be performed. The issue in the multi-fleet model convergence requires further investigation at HAWG 2024.

The fishing selectivity for the A fleet are shown in Figure 2.6.3.9 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 2.6.3.10 and 2.6.3.11.

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 (0.31).

The SSB in autumn 2022 was estimated at 1.65 million tonnes, which is above Bpa (0.96 million t) and MSY Btrigger(1.23 million t).

Since the strong 2013-year class, recruitment of herring has been low, but the latest two years are higher than the 10-year rolling average. The 2021-year class is estimated at 123% and the 2022-year class at 124% of the 10-year geometric mean recruitment.

Contrary to recent years' assessments, fishing mortality on older ages is now estimated lower.

2.7 Short-term predictions

Short-term predictions for the years 2023, 2024, and 2025 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 the short-term predictions, recruitment is assumed constant at 23 billion for the years 2024 and 2025 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 2022 year class, obtained from the assessment (informed by the 2023 IBTS0 survey) served as the estimate for 2023.

For the intermediate year (2023). No overshoot for the A fleet was assumed. Negotiations between the EU, Norway, and UK for 2023 resulted in the allowance of 21 970 t of the C-fleet and 50% D-fleet TACs 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 2023 were estimated as follows:

- A-fleet: 413 245 t. Fleet TAC (396 556 t) + C-fleet TAC transfer to the North Sea (21 971 t), scaled by the 3-year average proportion of NSAS in A-fleet catch (98.7%, 2020-2022)
- B-fleet: 8279 t. Fleet TAC (7716 t) + D-fleet TAC transfer (50%) to the North Sea (3330 t), scaled with the fleet uptake in 2022 (75%)
- C-fleet: 331 t. Fleet catches in 3.a of 770 t (310 t agreed maximum Norwegian catch and 47.5% (proportion of C-fleet EU catches in the total EU catches in 3.a in 2022) of 969 t agreed maximum EU catch), scaled by the 3-year average proportion of NSAS in the C-fleet catch (43%, 2020-2022)
- D-fleet: 355 t. Fleet catches based on 52.5% (proportion of D-fleet catches in the total EU catches in 3.a in 2022) of 969 t agreed maximum EU catch, scaled by the 3-year average proportion of NSAS in the D-fleet catch (70%, 2020-2022)
- 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 2024, 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 2024. The catch scenarios with a zero-catch advice for WBSS are presented in Table 2.7.4.

For the catch options with a TAC status quo for the C and D fleets, the fraction of North Sea Autumn Spawning (NSAS) herring caught in 3.a by the C and D fleet was used to derive C and D fleet NSAS catches, based on projected TACs in 3.a for these fleets. The catch scenarios assuming a status quo in C-D fleet catches are presented in Table 2.7.5.

Two additional scenarios with the inclusion of the C-fleet TAC rule were calculated at HAWG2023. The corresponding scenarios (with and without a TAC transfer to the North Sea) are given in Table 2.7.6. 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 2.7.7.

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 at IBPNSherring 2021 (ICES, 2021i), the MSY AR stipulates a fishing mortality of FMSY = 0.31 when the stock is above MSY Btrigger (1 232 828 tonnes) and a linear decline in F when the stock is below MSY Btrigger. With the forecasted values in 2024, the SSB is calculated above MSY Btrigger which results in a target $F_{(wr)\ 2–6}$ =0.31 (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 2024 advice exemplifies a 28.3% increase. The basis for this increase of catch advice is threefold. Firstly, the SSB in 2022 is estimated to be 32.5% larger than that predicted in the previous advice. Secondly, the recruitment in 2022 (2021 year class) is now estimated to be 87.3% larger than that estimated in the previous advice. The contribution of this year class to the SSB in the advice year is 32.6%. Thirdly, the SSB in the advice year is forecasted to be above MSY $B_{trigger}$, leading to a fishing advice at FMSY in 2024, rather than below FMSY which was the situation for 2023.

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 (2023 and 2022) 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.

To explore the sensitivity of the short-term projection to the particular situation for North Sea herring (stock mainly consisting of older fish that are highly selected for), HAWG 2023 again carried out and extended short-term projection using the MSY AR projection, using the same recruitment and the same fishing patterns by fleet for the years 2025–2029 (Figure 2.7.2.4). This projection resulted catch of ~477 269 tonnes by 2027. It should be noted that this does not constitute a real evaluation of the MSY AR rule because the fishing mortality was not adapted according to the rule, but simply kept constant during the years of the projection.

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.

New reference points were calculated during the 2021 interbenchmark meeting (ICES, 2021i) which resulted in a downward estimate of Blim and MSYBtrigger and an upward estimate of Fmsy. 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. Reference points out of the 2018 benchmark and the 2021 interbenchmark are presented in table 2.9.1. The derivation of reference points and the history of the reference points for North Sea herring are further described in the Stock Annex.

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, 2021i). 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.

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).

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 800 000 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 decade (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 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.

2.14 Tables and Figures

Table 2.1.1. Herring caught in the North Sea. Total catch (tonnes) by country, 2018–2022. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2018	2019	2020	2021	2022
Belgium	32	60	119	47	52
Denmark *	132 231	91 680	95 615	62 943	76 168
Faroe Islands	497	614	804	0	212
France	31 505	25 288	19 768	25 070	28 573
Germany	51 636	37 699	29 439	25 741	28 573
Netherlands	111 302	79 465	75 036	66 402	46 986
Norway	162 594	128 614	115 879	95 061	74 376
Lithuania	0	0	0	466	0
Sweden *	19 408	13 184	13 149	18 765	19 813
Ireland	515	3	235	414	306
UK (England)	19 591	12 685	16 241	13 174	15 590
UK (Scotland)	66 005	50 771	49 692	51 194	63 756
UK (N.Ireland)	6 916	3 938	2 681	5 176	3 866
Unallocated landings	0	0	0	0	0
Total landings	602 232	444 001	424 800	364 453	463 696
Discards/BMS	96	1 630	2 522	162	3 438
Total catch	602 328	445 631	427 321	364 615	467 134
Estimates of the parts of the catches which have been allocated to spring-spawning stocks					
WBSS	2 164	8 832	6 802	3 505	5 402
Thames estuary **	0	-	-	2	0
Norw. Spring Spawners ***	310	5	88	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	2018	2019	2020	2021	2022
Denmark *	90 763	54 820	56 676	37 970	43 150
Faroe Islands	496	611	794	0	8
France	14 745	13 344	7 688	13 795	18 055
Germany	35 884	19 851	16 694	16 590	38 182
Lithuania	-	-	2 789	466	-
Netherlands	56 990	44 071	50 363	48 510	49 603
Norway	78 647	53 254	35 674	7 119	14 017
Sweden	14 132	8 557	7 718	11 100	10 412
Ireland	515	3	235	414	306
UK (England)	12 313	5 640	11 439	9 487	10 752
UK (Scotland)	64 424	50 771	42 581	33 416	53 829
UK (N. Ireland)	5 582	3 938	2 681	2 514	3 866
Total Landings	374 491	254 860	235 330	181 381	242 180
Discards/BMS	-	-	284	64	1 177
Total catch	374 491	254 860	235 613	181 445	243 357

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

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	2018	2019	2020	2021	2022
Denmark *	751	0	62	18	618
Faroese	-	-	-	-	204
Netherlands	0	100	0	0	913
Norway	73 452	64 592	58 535	87 756	113 476
Sweden	377	0	0	479	1 356
Total landings	74 580	64 692	58 597	88 253	116 567
Discards/BMS	-	-	-	-	-
Total catch	74 580	64 692	58 597	88 253	116 567
Norw. Spring Spawners **	310	5	88	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	2018	2019	2020	2021	2022
Belgium	0	0	11	1	-
Denmark*	4 067	367 50	38 842	24 903	32 399
Faroe Islands	1	3	10	-	-
France	6 090	1 359	5 092	1 569	1 167
Germany	4 964	8 568	4 197	3 869	838
Netherlands	34 491	20 700	8 814	691	6 124
UK (N. Ireland)	1 334	0	0	2 662	-
Norway	10 495	10 768	21 671	186	6 505
Sweden*	4 899	4 627	5 431	7 166	8 045
UK (England)	3 262	2 750	919	4	695
UK (Scotland)	1 581	-	7 082	17 775	9 923
Unallocated landings	0	0	0	0	0
Total landings	107 794	85 525	95 422	58 826	65 696

Country	2018	2019	2020	2021	2022
Discards	1	800	-	-	-
Total catch	107 795	86 325	95 422	58 826	65696

***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	2018	2019	2020	2021	2022
Belgium	32	60	108	46	52
Denmark*	40	110	36	53	1
France	10 670	10 585	6 988	9 705	9 351
Germany	10 788	9 280	8 548	5 282	7 966
Netherlands	19 821	14 594	15 859	17 202	17 736
Sweden	0	0	0	21	0
UK (England)	4 016	4 295	3 883	3 682	4143
UK (Scotland)	-	-	30	2	4
Unallocated landings	0	0	0	0	0
Total landings	45 367	38 924	35 451	35 992	39 252
Discards/BMS	95	830	2 238	99	2 261
Total catch	45 462	39 754	37 689	36 091	41 514
Coastal spring spawners included above**	10	-	-	2	-

*** 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	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agreed Divisions 4.a,b	173.5	360.4	427.7	418.3	396.3	461.2	428.7	534.5	342.7	342.7	321.6	380.6	352.9
Agreed Div. 4.c, 7.d	26.5	44.6	50.3	51.7	49.0	57.0	53.0	66.0	42.4	42.4	34.8	47.0	43.6
Bycatch ceiling in the small mesh fishery *	16.5	17.9	14.4	13.1	15.7	13.4	11.4	9.7	13.2	9.0	7.8	8.2	7.7
National catch Divisions 4.a,b **	191.7	387.2	453.8	465.9	439	514.0	456.5	556.9	405.1	389.3	328.5	424.4	
Unallocated catch Divisions 4.a,b	0.0	-3.0	0.0	3.3	1.5	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	
Total catch Divisions 4.a,b #	191.7	384.2	453.9	469.2	440.5	514.1	456.5	556.9	405.9	389.6	328.5	425.6	
National catch Divisions 4.c, 7.d **	26.7	37.1	44.7	38.2	41.1	45.8	35.2	45.4	38.9	35.5	36.0	41.5	
Unallocated catch Divisions 4.c,7.d	0.0	3.3	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	
Total catch Divisions 4.c, 7.d	26.7	40.4	44.7	38.2	41.1	45.8	35.2	45.5	39.8	37.7	36.1	41.5	
Total catch 4 and 7.d as used by ICES #	218.4	424.6	498.5	507.5	481.6	559.9	491.7	602.3	445.6	427.3	364.6	467.1	
CATCH BY FLEET/STOCK (4 and 7.d) ##													
North Sea autumn spawners directed fisheries (Fleet A)	209.2	411.8	489.9	490.5	471.5	543.6	484.1	591.7	440.5	417.5	352.3	455.6	
North Sea autumn spawners industrial (Fleet B)	8.9	10.6	8.1	14.0	7.9	14.5	7.0	8.5	5.2	9.9	8.8	6.1	

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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	

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 2022. Catch in numbers (millions) at age (CANUM), by quarter and division.

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	1.2	0.0	0.0	0.0	118.3	598.3	0.0	0.0	716.6	0.0	**717.8**	**716.6**
1	3.3	24.2	0.1	24.1	46.7	90.0	0.1	0.0	160.8	0.1	**164.2**	**161.0**
2	3.8	590.0	6.2	583.	136.2	147.5	4.2	7.0	867.4	11.2	**882.4**	**884.8**
3	0.2	107.4	6.7	100.	362.1	61.2	42.9	26.1	524.0	69.0	**593.2**	**599.7**
4	0.1	25.4	7.2	18.1	274.7	50.9	31.9	25.5	343.8	57.4	**401.3**	**408.4**
5	0.1	17.6	5.1	12.4	89.4	13.3	21.7	14.4	115.2	36.1	**151.3**	**156.4**
6	0.1	32.2	4.5	27.7	122.3	12.7	21.8	15.6	162.8	37.4	**200.3**	**204.7**
7	0.0	6.1	2.5	3.6	69.8	9.7	12.9	6.8	83.2	19.7	**102.9**	**105.4**
8	0.0	18.6	2.5	16.2	132.9	25.9	12.2	12.2	175.0	24.3	**199.3**	**201.7**
9+	0.0	11.0	0.8	10.2	81.4	22.1	17.9	7.3	113.7	25.2	**139.0**	**139.8**
Sum	8.8	832.6	35.6	797.	1433.	1031.	165.5	114.	3262.5	280.	**3551.6**	**3578.4**

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	0.3	0.0	0.0	0.3	0.0	**0.3**	**0.3**
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**
2	2.8	0.0	2.5	0.0	15.4	17.3	0.0	0.0	32.7	0.0	**35.5**	**32.7**
3	0.0	9.4	0.4	9.1	19.2	1.1	5.4	7.3	29.4	12.	**42.2**	**42.5**
4	0.0	1.2	0.3	0.9	15.1	1.0	8.9	12.0	16.9	20.	**37.9**	**38.2**
5	0.0	0.6	0.0	0.6	3.7	0.0	2.3	3.2	4.3	5.5	**9.8**	**9.8**
6	0.0	13.4	0.0	13.4	7.7	0.0	1.8	2.5	21.1	4.3	**25.4**	**25.4**
7	0.0	0.8	0.0	0.8	6.3	0.1	1.5	2.0	7.2	3.5	**10.7**	**10.7**
8	0.0	2.1	0.0	2.1	8.3	0.0	1.0	1.3	10.4	2.3	**12.7**	**12.7**
9+	0.0	2.1	0.0	2.1	5.4	0.0	0.0	0.0	7.5	0.0	**7.5**	**7.5**
Sum	2.9	29.6	3.2	28.9	81.1	19.9	21.0	28.3	129.8	49.	**182.0**	**179.9**

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	0.5	0.0	0.0	0.7	0.0	209.7	0.0	0.0	0.2	0.1	**210.9**	**209.7**
1	1.6	12.3	0.0	12.3	0.0	0.3	0.0	0.0	12.6	0.0	**14.2**	**12.6**
2	0.6	541.0	3.3	537.	57.2	9.5	0.0	0.0	604.5	0.0	**605.0**	**607.7**
3	0.0	85.9	6.0	79.9	42.1	12.3	0.1	0.0	134.4	0.1	**134.5**	**140.4**
4	0.0	15.9	6.1	9.8	50.8	9.9	0.2	0.0	70.6	0.2	**70.7**	**76.8**
5	0.0	8.1	4.7	3.4	11.6	0.7	0.0	0.0	15.8	0.0	**15.8**	**20.5**
6	0.0	7.1	4.0	3.2	9.8	1.3	0.0	0.0	14.3	0.0	**14.3**	**18.3**
7	0.0	4.6	2.5	2.1	6.6	1.4	0.0	0.0	10.1	0.0	**10.1**	**12.6**
8	0.0	7.0	2.2	4.7	10.0	2.7	0.0	0.0	17.5	0.0	**17.5**	**19.7**
9+	0.0	3.6	0.8	2.8	9.0	0.9	0.0	0.0	12.6	0.0	**12.6**	**13.4**
Sum	2.8	685.5	29.5	656.	197.2	248.7	0.4	0.0	892.4	0.5	**1105.8**	**1131.8**

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	0.1	0.0	0.0	0.0	0.4	219.1	0.0	0.0	219.5	0.0	**219.6**	**219.5**
1	0.3	11.9	0.1	0.0	0.0	22.3	0.0	0.0	22.3	0.0	**22.5**	**34.2**
2	0.2	41.9	0.4	0.0	55.8	93.6	0.0	0.0	149.4	0.0	**149.**	**191.3**
3	0.1	9.1	0.4	0.0	281.6	42.5	0.0	0.0	324.1	0.0	**324.2**	**333.2**
4	0.1	6.3	0.7	0.0	183.2	31.9	0.0	0.0	215.1	0.0	**215.2**	**221.4**
5	0.0	7.2	0.4	0.0	60.1	9.4	0.0	0.0	69.5	0.0	**69.5**	**76.7**
6	0.0	9.9	0.5	0.0	91.8	3.7	0.0	0.0	95.5	0.0	**95.6**	**105.4**
7	0.0	0.0	0.0	0.0	53.0	7.4	0.0	0.0	60.4	0.0	**60.4**	**60.4**
8	0.0	2.3	0.2	0.0	101.1	20.4	0.0	0.0	121.5	0.0	**121.5**	**123.8**
9+	0.0	2.1	0.0	0.0	59.1	16.9	0.0	0.0	75.9	0.0	**75.9**	**78.1**
Sum	0.8	90.8	2.8	0.0	886.1	467.0	0.0	0.0	1353.1	0.0	**1353.9**	**1443.9**

Quarter: 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	0.6	0.0	0.0	0.0	117.9	169.3	0.0	0.0	287.1	0.0	**287.7**	**287.1**
1	1.4	0.0	0.0	0.0	46.7	67.5	0.1	0.0	114.2	0.1	**115.6**	**114.2**
2	0.2	7.1	0.0	0.0	7.8	27.1	4.2	7.0	34.9	11.	**46.2**	**53.1**
3	0.1	2.9	0.0	0.0	19.2	5.2	37.4	18.8	24.4	56.2	**80.7**	**83.6**
4	0.1	1.9	0.0	0.0	25.6	8.1	22.8	13.5	33.7	36.3	**70.1**	**71.9**
5	0.0	1.6	0.0	1.6	14.0	3.2	19.3	11.2	18.8	30.5	**49.4**	**49.3**
6	0.0	1.8	0.0	1.8	13.0	7.8	19.9	13.1	22.5	33.1	**55.6**	**55.6**
7	0.0	0.7	0.0	0.7	4.0	0.8	11.4	4.7	5.5	16.	**21.7**	**21.7**
8	0.0	7.4	0.0	7.4	13.4	2.8	11.1	10.	23.6	22.	**45.5**	**45.5**
9+	0.0	3.2	0.0	3.2	8.0	4.3	17.9	7.3	15.6	25.2	**40.8**	**40.8**
Sum	2.3	26.7	0.1	14.7	269.5	296.1	144.1	86.5	580.3	230.	**813.2**	**822.9**

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 2022. 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	0.026	0.000	0.000	0.007	0.007	0.000	0.000	0.007	0.000	**0.007**	**0.007**
1	0.052	0.062	0.068	0.011	0.027	0.094	0.000	0.028	0.094	**0.028**	**0.028**
2	0.061	0.129	0.129	0.133	0.139	0.119	0.122	0.131	0.121	**0.131**	**0.131**
3	0.117	0.140	0.133	0.177	0.164	0.111	0.120	0.168	0.114	**0.162**	**0.162**
4	0.158	0.179	0.144	0.185	0.183	0.121	0.127	0.184	0.124	**0.176**	**0.176**
5	0.170	0.215	0.170	0.194	0.206	0.145	0.163	0.198	0.152	**0.188**	**0.188**
6	0.193	0.250	0.176	0.209	0.196	0.159	0.178	0.216	0.167	**0.208**	**0.207**
7	0.198	0.205	0.192	0.223	0.245	0.173	0.174	0.224	0.173	**0.215**	**0.215**
8	0.205	0.215	0.195	0.229	0.237	0.197	0.202	0.229	0.199	**0.226**	**0.225**
9+	0.000	0.234	0.230	0.242	0.257	0.193	0.211	0.244	0.198	**0.236**	**0.236**
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	**0.004**	**0.004**
1	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.023**	**0.000**
2	0.052	0.081	0.082	0.085	0.083	0.000	0.000	0.084	0.000	**0.081**	**0.084**
3	0.073	0.130	0.105	0.123	0.098	0.083	0.083	0.124	0.083	**0.112**	**0.112**
4	0.113	0.142	0.117	0.137	0.109	0.108	0.108	0.135	0.108	**0.120**	**0.120**
5	0.000	0.238	0.169	0.158	0.000	0.135	0.135	0.168	0.135	**0.150**	**0.150**
6	0.000	0.258	0.174	0.234	0.000	0.145	0.145	0.249	0.145	**0.232**	**0.232**
7	0.000	0.263	0.212	0.192	0.207	0.167	0.167	0.200	0.167	**0.189**	**0.189**
8	0.000	0.218	0.192	0.189	0.000	0.196	0.196	0.194	0.196	**0.195**	**0.195**
9+	0.000	0.241	0.229	0.182	0.000	0.000	0.000	0.199	0.000	**0.199**	**0.199**
Quarter: 2											
0	0.026	0.000	0.004	0.000	0.004	0.000	0.000	0.004	0.000	**0.004**	**0.004**
1	0.052	0.053	0.063	0.000	0.065	0.000	0.000	0.053	0.000	**0.053**	**0.053**
2	0.060	0.129	0.127	0.132	0.149	0.000	0.000	0.130	0.000	**0.130**	**0.130**
3	0.073	0.132	0.130	0.144	0.149	0.083	0.083	0.137	0.083	**0.138**	**0.137**
4	0.113	0.153	0.141	0.162	0.154	0.108	0.108	0.159	0.108	**0.161**	**0.159**
5	0.000	0.170	0.169	0.176	0.194	0.135	0.135	0.174	0.135	**0.176**	**0.174**
6	0.000	0.178	0.174	0.183	0.181	0.145	0.145	0.181	0.145	**0.183**	**0.181**
7	0.000	0.185	0.192	0.186	0.174	0.167	0.167	0.185	0.167	**0.183**	**0.185**
8	0.000	0.192	0.192	0.197	0.195	0.196	0.196	0.195	0.196	**0.196**	**0.195**
9+	0.000	0.208	0.229	0.200	0.225	0.000	0.000	0.203	0.000	**0.202**	**0.203**
Quarter: 3											
0	0.026	0.000	0.025	0.007	0.008	0.000	0.000	0.008	0.000	**0.008**	**0.008**
1	0.053	0.071	0.069	0.028	0.063	0.000	0.000	0.066	0.000	**0.066**	**0.066**
2	0.129	0.121	0.147	0.151	0.154	0.000	0.000	0.146	0.000	**0.146**	**0.146**
3	0.133	0.219	0.172	0.186	0.172	0.000	0.000	0.185	0.000	**0.185**	**0.185**
4	0.159	0.248	0.169	0.196	0.196	0.000	0.000	0.197	0.000	**0.197**	**0.197**
5	0.170	0.259	0.186	0.202	0.207	0.000	0.000	0.208	0.000	**0.208**	**0.208**
6	0.193	0.285	0.186	0.211	0.209	0.000	0.000	0.218	0.000	**0.218**	**0.218**
7	0.198	0.204	0.000	0.232	0.261	0.000	0.000	0.235	0.000	**0.235**	**0.235**
8	0.205	0.279	0.220	0.236	0.245	0.000	0.000	0.238	0.000	**0.238**	**0.238**
9+	0.000	0.292	0.256	0.258	0.268	0.000	0.000	0.261	0.000	**0.261**	**0.261**
Quarter: 4											
0	0.026	0.000	0.000	0.007	0.008	0.000	0.000	0.008	0.000	**0.008**	**0.008**
1	0.052	0.000	0.083	0.011	0.015	0.094	0.000	0.013	0.094	**0.014**	**0.014**
2	0.123	0.149	0.142	0.106	0.120	0.119	0.122	0.122	0.121	**0.122**	**0.122**
3	0.133	0.163	0.165	0.173	0.145	0.115	0.134	0.166	0.121	**0.136**	**0.136**
4	0.159	0.187	0.160	0.183	0.175	0.127	0.144	0.181	0.133	**0.157**	**0.157**
5	0.170	0.233	0.118	0.186	0.204	0.146	0.171	0.193	0.155	**0.170**	**0.170**
6	0.193	0.278	0.248	0.204	0.192	0.161	0.184	0.206	0.170	**0.185**	**0.185**
7	0.198	0.261	0.000	0.218	0.230	0.174	0.177	0.226	0.175	**0.188**	**0.188**
8	0.205	0.216	0.000	0.227	0.214	0.197	0.203	0.222	0.200	**0.212**	**0.212**
9+	0.000	0.219	0.000	0.215	0.221	0.193	0.211	0.218	0.198	**0.206**	**0.206**

Table 2.2.3. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2022. 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.	10.0	9.2	0.0	0.0	9.3	0.0	9.3
1	n.d.	18.8	n.d.	19.0	19.0	22.6	0.0	19.0	22.6	19.0
2	n.d.	23.2	n.d.	24.7	24.6	24.3	24.6	23.7	24.5	23.7
3	n.d.	23.9	n.d.	26.9	25.8	24.6	24.8	26.2	24.7	26.0
4	n.d.	26.2	n.d.	27.3	26.9	24.9	25.5	27.1	25.2	26.9
5	n.d.	28.0	n.d.	27.5	28.0	26.9	27.1	27.7	27.0	27.5
6	n.d.	29.7	n.d.	28.1	27.7	27.3	27.7	28.4	27.5	28.2
7	n.d.	28.2	n.d.	29.0	29.7	27.9	27.5	29.1	27.8	28.8
8	n.d.	29.3	n.d.	29.1	29.4	28.8	28.4	29.1	28.6	29.1
9+	n.d.	29.9	n.d.	29.6	30.2	28.2	28.8	29.7	28.3	29.5
Quarter: 1										
0	n.d.	0.0	n.d.	0.0	7.9	0.0	0.0	7.9	0.0	7.9
1	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	n.d.	22.0	n.d.	22.2	22.6	0.0	0.0	22.4	0.0	22.4
3	n.d.	23.6	n.d.	25.2	23.7	23.5	23.5	24.6	23.5	24.3
4	n.d.	25.5	n.d.	26.1	24.4	25.1	25.1	26.0	25.1	25.5
5	n.d.	30.4	n.d.	27.2	0.0	26.4	26.4	27.7	26.4	27.0
6	n.d.	30.7	n.d.	29.9	0.0	26.7	26.7	30.4	26.7	29.8
7	n.d.	30.8	n.d.	29.3	29.0	27.9	27.9	29.5	27.9	29.0
8	n.d.	30.1	n.d.	29.4	0.0	28.4	28.4	29.5	28.4	29.3
9+	n.d.	31.8	n.d.	29.0	0.0	0.0	0.0	29.8	0.0	29.8
Quarter: 2										
0	n.d.	0.0	n.d.	0.0	7.9	0.0	0.0	7.9	0.0	7.9
1	n.d.	18.0	n.d.	0.0	19.5	0.0	0.0	18.0	0.0	18.0
2	n.d.	23.2	n.d.	24.3	24.7	0.0	0.0	23.3	0.0	23.3
3	n.d.	23.5	n.d.	24.9	24.4	23.5	23.5	24.0	23.5	24.0
4	n.d.	25.1	n.d.	26.0	24.9	25.1	25.1	25.7	25.1	25.7
5	n.d.	26.3	n.d.	26.7	26.4	26.4	26.4	26.5	26.4	26.5
6	n.d.	26.1	n.d.	27.0	26.8	26.7	26.7	26.7	26.7	26.7
7	n.d.	27.3	n.d.	27.2	26.5	27.9	27.9	27.2	27.9	27.2
8	n.d.	27.8	n.d.	27.5	27.0	28.4	28.4	27.5	28.4	27.5
9+	n.d.	28.2	n.d.	27.8	28.9	0.0	0.0	28.0	0.0	28.0
Quarter: 3										
0	n.d.	0.0	n.d.	9.3	9.5	0.0	0.0	9.5	0.0	9.5
1	n.d.	19.7	n.d.	14.8	19.0	0.0	0.0	19.2	0.0	19.2
2	n.d.	22.8	n.d.	25.7	24.9	0.0	0.0	24.7	0.0	24.7
3	n.d.	27.2	n.d.	27.4	26.3	0.0	0.0	27.2	0.0	27.2
4	n.d.	28.3	n.d.	27.7	27.6	0.0	0.0	27.7	0.0	27.7
5	n.d.	29.5	n.d.	27.9	28.1	0.0	0.0	28.1	0.0	28.1
6	n.d.	30.7	n.d.	28.1	28.3	0.0	0.0	28.4	0.0	28.4
7	n.d.	27.6	n.d.	29.2	30.4	0.0	0.0	29.4	0.0	29.4
8	n.d.	30.0	n.d.	29.2	29.8	0.0	0.0	29.3	0.0	29.3
9+	n.d.	29.3	n.d.	30.0	30.6	0.0	0.0	30.1	0.0	30.1
Quarter: 4										
0	n.d.	0.0	n.d.	10.0	10.3	0.0	0.0	10.2	0.0	10.2
1	n.d.	0.0	n.d.	19.0	19.1	22.6	0.0	19.0	22.6	19.0
2	n.d.	25.8	n.d.	25.8	24.8	24.3	24.6	25.2	24.5	25.0
3	n.d.	27.1	n.d.	27.1	25.5	24.8	25.3	26.8	25.0	25.6
4	n.d.	28.1	n.d.	27.2	26.9	24.9	25.8	27.2	25.2	26.2
5	n.d.	29.4	n.d.	26.8	28.1	26.9	27.3	27.2	27.1	27.1
6	n.d.	31.0	n.d.	27.6	27.5	27.4	27.9	27.8	27.6	27.7
7	n.d.	30.6	n.d.	29.0	29.1	27.9	27.3	29.2	27.7	28.1
8	n.d.	30.4	n.d.	29.1	28.6	28.8	28.4	29.4	28.6	29.0
9+	n.d.	30.9	n.d.	28.8	28.7	28.2	28.8	29.2	28.3	28.7

Table 2.2.4. North Sea autumn spawning herring (NSAS), & western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2022. Catches (tonnes) at-age (SOP figures), by quarter & 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	0.8	3.9	0.0	0.0	4.8	0.0	4.8	4.8
1	0.2	1.5	0.0	1.5	0.5	2.5	0.0	0.0	4.5	0.0	4.6	4.5
2	0.2	75.9	0.8	75.1	18.1	20.5	0.5	0.9	113.7	1.3	115.3	115.9
3	0.0	15.1	0.9	14.2	64.1	10.0	4.8	3.1	88.2	7.9	96.1	97.0
4	0.0	4.5	1.0	3.5	50.8	9.3	3.9	3.2	63.6	7.1	70.7	71.7
5	0.0	3.8	0.9	2.9	17.4	2.7	3.1	2.3	23.0	5.5	28.5	29.4
6	0.0	8.0	0.8	7.3	25.6	2.5	3.5	2.8	35.4	6.2	41.6	42.4
7	0.0	1.3	0.5	0.8	15.6	2.4	2.2	1.2	18.7	3.4	22.2	22.6
8	0.0	4.0	0.5	3.5	30.5	6.1	2.4	2.5	40.1	4.8	45.0	45.4
9+	0.0	2.6	0.2	2.4	19.7	5.7	3.4	1.6	27.8	5.0	32.8	33.0
Sum	0.5	116.7	5.5	111.1	243.0	65.7	23.8	17.5	419.8	41.3	461.6	466.7
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1	0.0	0.2	0.0	1.3	1.4	0.0	0.0	2.7	0.0	0.0	2.7
3	0.0	1.2	0.0	1.2	2.4	0.1	0.4	0.6	3.7	1.1	4.7	4.8
4	0.0	0.2	0.0	0.1	2.1	0.1	1.0	1.3	2.3	2.3	4.6	4.6
5	0.0	0.1	0.0	0.1	0.6	0.0	0.3	0.4	0.7	0.7	1.5	1.5
6	0.0	3.5	0.0	3.5	1.8	0.0	0.3	0.4	5.3	0.6	5.9	5.9
7	0.0	0.2	0.0	0.2	1.2	0.0	0.3	0.3	1.4	0.6	2.0	2.0
8	0.0	0.5	0.0	0.5	1.6	0.0	0.2	0.3	2.0	0.5	2.5	2.5
9+	0.0	0.5	0.0	0.5	1.0	0.0	0.0	0.0	1.5	0.0	1.5	1.5
Sum	0.1	6.2	0.3	6.1	11.9	1.7	2.4	3.3	19.6	5.7	22.6	25.5
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8	0.0	0.9	0.8
1	0.1	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.8	0.7
2	0.0	69.8	0.4	69.4	7.5	1.4	0.0	0.0	78.3	0.0	78.4	78.7
3	0.0	11.3	0.8	10.6	6.1	1.8	0.0	0.0	18.5	0.0	18.5	19.3
4	0.0	2.4	0.9	1.6	8.2	1.5	0.0	0.0	11.3	0.0	11.3	12.2
5	0.0	1.4	0.8	0.6	2.0	0.1	0.0	0.0	2.8	0.0	2.8	3.6
6	0.0	1.3	0.7	0.6	1.8	0.2	0.0	0.0	2.6	0.0	2.6	3.3
7	0.0	0.8	0.5	0.4	1.2	0.2	0.0	0.0	1.8	0.0	1.8	2.3
8	0.0	1.3	0.4	0.9	2.0	0.5	0.0	0.0	3.4	0.0	3.4	3.8
9+	0.0	0.7	0.2	0.6	1.8	0.2	0.0	0.0	2.5	0.0	2.5	2.7
Sum	0.1	89.8	4.6	85.2	30.7	7.0	0.0	0.0	122.8	0.0	123.0	127.5
Quarter: 3												
0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	1.7	0.0	1.7	1.7
1	0.0	0.8	0.0	0.0	0.0	1.4	0.0	0.0	1.4	0.0	2.3	2.3
2	0.0	5.1	0.1	0.0	8.4	14.4	0.0	0.0	22.8	0.0	27.9	27.9
3	0.0	2.0	0.1	0.0	52.3	7.3	0.0	0.0	59.6	0.0	61.6	61.6
4	0.0	1.6	0.1	0.0	35.8	6.2	0.0	0.0	42.1	0.0	43.5	43.6
5	0.0	1.9	0.1	1.8	12.1	1.9	0.0	0.0	15.9	0.0	15.9	15.9
6	0.0	2.8	0.1	0.0	19.4	0.8	0.0	0.0	20.1	0.0	22.9	22.9
7	0.0	0.0	0.0	0.0	12.3	1.9	0.0	0.0	14.2	0.0	14.2	14.2
8	0.0	0.6	0.0	0.6	23.9	5.0	0.0	0.0	29.4	0.0	29.4	29.5
9+	0.0	0.6	0.0	0.6	15.2	4.5	0.0	0.0	20.4	0.0	20.4	20.4
Sum	0.1	15.4	0.5	3.0	179.4	45.2	0.0	0.0	227.6	0.0	239.7	240.1
Quarter: 4												
0	0.0	0.0	0.0	0.0	0.8	1.4	0.0	0.0	2.2	0.0	2.2	2.2
1	0.1	0.0	0.0	0.0	0.5	1.0	0.0	0.0	1.5	0.0	1.6	1.5
2	0.0	1.1	0.0	0.0	0.8	3.2	0.5	0.9	4.1	1.3	6.5	6.5
3	0.0	0.5	0.0	0.0	3.3	0.8	4.3	2.5	4.1	6.8	11.4	11.4
4	0.0	0.4	0.0	0.4	4.7	1.4	2.9	1.9	6.5	4.8	11.3	11.3
5	0.0	0.4	0.0	0.4	2.6	0.7	2.8	1.9	3.6	4.7	8.4	8.4
6	0.0	0.5	0.0	0.5	2.6	1.5	3.2	2.4	4.6	5.6	10.3	10.3
7	0.0	0.2	0.0	0.2	0.9	0.2	2.0	0.8	1.2	2.8	4.1	4.1
8	0.0	1.6	0.0	1.6	3.1	0.6	2.2	2.2	5.2	4.4	9.6	9.6
9+	0.0	0.7	0.0	0.7	1.7	1.0	3.4	1.6	3.4	5.0	8.4	8.4
Sum	0.1	5.3	0.0	3.7	21.1	11.7	21.3	14.2	36.5	35.6	73.8	73.6

Table 2.2.5. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2022. Percentage age composition (based on numbers, 3+ group summarized), by quarter and division.

Quarters: 1-4

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
0	13.4%	0.0%	0.0%	0.0%	8.3%	58.0%	0.0%	0.0%	22.0%	0.0%	20.2%	20.0%
1	37.4%	2.9%	0.3%	3.0%	3.3%	8.7%	0.0%	0.0%	4.9%	0.0%	4.6%	4.5%
2	43.0%	70.9%	17.5%	73.3%	9.5%	14.3%	2.5%	6.1%	26.6%	4.0%	24.8%	24.7%
3	2.6%	12.9%	18.8%	12.6%	25.3%	5.9%	25.9%	22.7%	16.1%	24.6%	16.7%	16.8%
4	1.6%	3.0%	20.2%	2.3%	19.2%	4.9%	19.3%	22.2%	10.5%	20.5%	11.3%	11.4%
5	0.7%	2.1%	14.4%	1.6%	6.2%	1.3%	13.1%	12.5%	3.5%	12.9%	4.3%	4.4%
6	0.7%	3.9%	12.5%	3.5%	8.5%	1.2%	13.2%	13.6%	5.0%	13.3%	5.6%	5.7%
7	0.3%	0.7%	7.0%	0.5%	4.9%	0.9%	7.8%	5.9%	2.5%	7.0%	2.9%	2.9%
8	0.4%	2.2%	6.9%	2.0%	9.3%	2.5%	7.3%	10.6	5.4%	8.7%	5.6%	5.6%
9+	0.0%	1.3%	2.2%	1.3%	5.7%	2.1%	10.8%	6.4%	3.5%	9.0%	3.9%	3.9%
Sum 3+	**6.3%**	**26.2%**	**82.2%**	**23.7%**	**79.0%**	**19.0%**	**97.4%**	**93.9%**	**46.5%**	**96.0%**	**50.3%**	**50.7%**

Quarter: 1

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
0	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.0%	0.0%	0.2%	0.0%	0.1%	0.1%
1	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2	97.3%	0.0%	78.7%	0.0%	19.0%	87.3%	0.0%	0.0%	25.2%	0.0%	19.5%	18.2%
3	1.4%	31.8%	10.9%	31.4%	23.7%	5.7%	25.8%	25.8%	22.7%	25.8%	23.2%	23.6%
4	0.0%	4.1%	10.4%	3.0%	18.6%	5.1%	42.4%	42.4%	13.1%	42.4%	20.8%	21.2%
5	0.0%	1.9%	0.0%	2.0%	4.6%	0.0%	11.2%	11.2%	3.3%	11.2%	5.4%	5.5%
6	0.0%	45.2%	0.0%	46.3%	9.5%	0.0%	8.7%	8.7%	16.2%	8.7%	14.0%	14.1%
7	0.0%	2.7%	0.0%	2.8%	7.7%	0.6%	7.2%	7.2%	5.5%	7.2%	5.9%	6.0%
8	0.0%	7.0%	0.0%	7.2%	10.3%	0.0%	4.7%	4.7%	8.0%	4.7%	7.0%	7.1%
9+	0.0%	7.2%	0.0%	7.4%	6.6%	0.0%	0.0%	0.0%	5.8%	0.0%	4.1%	4.2%
Sum 3+	**1.4%**	**100.0%**	**21.3%**	**100.0%**	**81.0%**	**11.4%**	**100.0%**	**100.0%**	**74.6%**	**100.0%**	**80.3%**	**81.7%**

Quarter: 2

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
0	19.7%	0.0%	0.0%	0.1%	0.0%	84.3%	0.0%	0.0%	0.0%	26.3%	19.1%	18.5%
1	58.6%	1.8%	0.0%	1.9%	0.0%	0.1%	0.0%	0.0%	1.4%	0.0%	1.3%	1.1%
2	20.9%	78.9%	11.1%	81.9%	29.0%	3.8%	0.0%	0.0%	67.7%	0.0%	54.7%	53.7%
3	0.7%	12.5%	20.2%	12.2%	21.4%	5.0%	25.8%	25.8%	15.1%	19.0%	12.2%	12.4%
4	0.1%	2.3%	20.6%	1.5%	25.8%	4.0%	42.4%	42.4%	7.9%	31.3%	6.4%	6.8%
5	0.0%	1.2%	16.0%	0.5%	5.9%	0.3%	11.2%	11.2%	1.8%	8.2%	1.4%	1.8%
6	0.0%	1.0%	13.5%	0.5%	5.0%	0.5%	8.7%	8.7%	1.6%	6.4%	1.3%	1.6%
7	0.0%	0.7%	8.5%	0.3%	3.3%	0.6%	7.2%	7.2%	1.1%	5.3%	0.9%	1.1%
8	0.0%	1.0%	7.6%	0.7%	5.1%	1.1%	4.7%	4.8%	2.0%	3.5%	1.6%	1.7%
9+	0.0%	0.5%	2.6%	0.4%	4.5%	0.4%	0.0%	0.0%	1.4%	0.0%	1.1%	1.2%
Sum 3+	**0.8%**	**19.3%**	**88.8%**	**16.1%**	**71.0%**	**11.8%**	**100.0%**	**100.0%**	**30.8%**	**73.7%**	**24.9%**	**26.7%**

Quarter: 3

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
0	9.4%	0.0%	0.0%	0.0%	0.0%	46.9%	0.0%	0.0%	16.2%	0.0%	16.2%	15.2%
1	30.1%	13.1%	3.5%	0.0%	0.0%	4.8%	0.0%	0.0%	1.6%	0.0%	1.7%	2.4%
2	26.5%	46.2%	15.1%	0.0%	6.3%	20.0%	0.0%	0.0%	11.0%	0.0%	11.0%	13.2%
3	11.6%	10.1%	14.2%	0.0%	31.8%	9.1%	0.0%	0.0%	24.0%	0.0%	23.9%	23.1%
4	9.4%	7.0%	26.8%	0.0%	20.7%	6.8%	0.0%	0.0%	15.9%	0.0%	15.9%	15.3%
5	4.6%	8.0%	14.8%	0.0%	6.8%	2.0%	0.0%	0.0%	5.1%	0.0%	5.1%	5.3%
6	4.1%	10.9%	16.8%	0.0%	10.4%	0.8%	0.0%	0.0%	7.1%	0.0%	7.1%	7.3%
7	1.9%	0.0%	0.0%	0.0%	6.0%	1.6%	0.0%	0.0%	4.5%	0.0%	4.5%	4.2%
8	2.4%	2.5%	7.5%	0.0%	11.4%	4.4%	0.0%	0.0%	9.0%	0.0%	9.0%	8.6%
9+	0.0%	2.4%	1.3%	0.0%	6.7%	3.6%	0.0%	0.0%	5.6%	0.0%	5.6%	5.4%
Sum 3+	**34.0%**	**40.7%**	**81.4%**	**0.0%**	**93.7%**	**28.3%**	**0.0%**	**0.0%**	**71.1%**	**0.0%**	**71.1%**	**69.2%**

Quarter: 4

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
0	23.8%	0.0%	0.0%	0.0%	43.7%	57.2%	0.0%	0.0%	49.5%	0.0%	35.4%	34.9%
1	59.1%	0.0%	0.0%	0.0%	17.3%	22.8%	0.1%	0.0%	19.7%	0.0%	14.2	13.9
2	8.3%	26.6%	0.0%	0.0%	2.9%	9.1%	2.9%	8.1%	6.0%	4.8%	5.7%	6.5%
3	3.1%	11.0%	0.0%	0.0%	7.1%	1.8%	25.9%	21.7%	4.2%	24.4%	9.9%	10.2%
4	2.5%	7.2%	65.9%	0.0%	9.5%	2.7%	15.8%	15.6%	5.8%	15.7%	8.6%	8.7%
5	1.2%	6.0%	0.0%	10.9%	5.2%	1.1%	13.4%	13.0%	3.2%	13.2%	6.1%	6.0%
6	1.0%	6.8%	34.1	12.3%	4.8%	2.6%	13.8%	15.2%	3.9%	14.3%	6.8%	6.8%
7	0.5%	2.8%	0.0%	5.1%	1.5%	0.3%	7.9%	5.5%	1.0%	7.0%	2.7%	2.6%
8	0.6%	27.6%	0.0%	50.1%	5.0%	0.9%	7.7%	12.5	4.1%	9.5%	5.6%	5.5%
9+	0.0%	11.9%	0.0%	21.7%	3.0%	1.5%	12.4%	8.5%	2.7%	10.9	5.0%	5.0%
Sum 3+	**8.8%**	**73.4%**	**100.0%**	**100.0%**	**36.1%**	**10.9%**	**97.0%**	**91.9%**	**24.8%**	**95.1%0**	**44.7%**	**44.8%**

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.

2022	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
0	1.7	0.005	701.8	0.007	0.0	0.000	1.2	0.026	704.7	0.007
1	49.2	0.046	110.1	0.011	0.1	0.036	3.2	0.052	162.5	0.023
2	879.9	0.130	6.0	0.039	3.5	0.060	0.2	0.081	889.7	0.129
3	597.9	0.155	0.2	0.113	0.2	0.118	0.0	0.073	598.2	0.155
4	404.4	0.171	0.2	0.113	0.1	0.157	0.0	0.113	404.7	0.171
5	152.5	0.189	0.0	0.000	0.1	0.170	0.0	0.081	152.6	0.189
6	201.9	0.214	0.0	0.000	0.1	0.193	0.0	0.000	202.0	0.214
7	103.8	0.219	0.0	0.000	0.0	0.198	0.0	0.000	103.8	0.219
8	201.0	0.238	0.0	0.000	0.0	0.205	0.0	0.000	201.0	0.238
9+	140.1	0.247	0.0	0.000	0.0	0.000	0.0	0.000	140.1	0.247
TOTAL	2'732.3		818.2		4.1		4.6		3'559.3	
SOP catch		455.6		6.1		0.3		0.2		462.3

Table 2.2.7. Catch-at-age (numbers in millions) of North Sea herring, 2012–2022.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2012	627	110	412	671	403	306	151	104	89	109	2982
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

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, 2012–2022.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2012	0.0	0.0	0.0	0.2	0.4	0.0	1.4	0.0	1.1	6.3	9.4
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

Table 2.2.9. Catch-at-age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2012– 2022.

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

Table 2.2.10. Catch-at-age (numbers in millions) of the total NSAS stock 2012–2022.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2012	773	285	455	673	404	306	150	104	88	102	3341
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

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 2012–2022

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	2012	0.067	0.124	0.169	0.175	0.200	0.221	0.216	-
	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	-
4.a(E)	2012	0.146	0.185	0.195	0.203	0.216	0.225	0.225	0.232
	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
4.a(W)	2012	0.132	0.184	0.186	0.206	0.226	0.240	0.242	0.254
	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

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2017	0.120	0.160	0.177	0.192	0.218	0.226	0.236	0.236
	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
4.b	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.250	0.258
	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

Table 2.2.12. Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2022 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	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish measured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	13	0	0	0	13
	2	3	0	0%	0	0	0	0	0
	3	1	0	0%	0	0	0	0	0
	4	2	0	0%	38	0	0	0	38
total		8	0	0%	52	0	0	0	52
Denmark (A)	1	3	2	100%	9281	9	317	1050	n
	2	3	1	76%	4504	3	67	247	n
	3	3	2	100%	47391	60	1851	5299	y
	4	4	2	100%	9473	6	176	657	n
total		13	7	98%	70648	78	2411	7253	y
Denmark (B)	1	2	1	98%	61	2	6	6	y
	2	1	1	100%	755	9	91	308	y
	3	2	1	100%	1417	41	914	2522	y
	4	2	1	57%	3287	11	163	104	y
total		7	4	74%	5520	63	1174	2940	Y
France	1	3	0	0%	2233	0	0	0	n
	2	4	0	0%	3373	0	0	0	n
	3	3	0	0%	13150	0	0	0	n
	4	4	0	0%	9818	0	0	0	n
total		14	0	0%	28573	0	0	0	n
Germany	1	1	0	0%	133	0	0	0	n
	2	2	1	100%	14465	38	228	12991	y
	3	2	1	97%	23346	47	168	10685	y
	4	4	2	88%	9045	30	390	7930	y
total		9	4	96%	46988	115	786	31606	y

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
Ireland	1	1	1	0	0%	74	0	0	n

Country (fleet)		Q Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish measured	>1 sample per 1 kt catch
	4	1	1	0	0%	232	0	0	n
total		2	2	0	0%	306	0	0	n
Netherlands	1	3	2	100%	1177	4	100	666	y
	2	3	0	0%	3034	0	0	0	n
	3	2	2	100%	49875	47	1531	6776	n
	4	4	2	82%	20290	2	50	360	n
total		12	6	91%	74375	53	1681	7802	n
Norway	1	2	2	100%	7762	8	326	365	y
	2	3	2	94%	96208	32	1566	2553	n
	3	3	2	98%	17555	3	113	138	n
	4	3	2	94%	12473	5	211	266	n
total		11	8	95%	133997	48	2216	3322	n
UK (Scot)	1	3	0	0%	732	0	0	0	n
	2	3	1	100%	2799	5	164	735	y
	3	2	1	83%	58970	22	1088	3495	n
	4	3	0	0%	1256	0	0	0	n
total		11	2	81%	63756	27	1252	4230	n
Sweden (A)	1	3	1	31%	1228	3	225	225	y
	2	3	1	66%	2340	2	142	142	n
	3	3	2	99%	14022	9	622	622	n
	4	3	1	60%	1616	2	150	150	y
total		12	5	87%	19206	16	1139	1139	n
Sweden (B)	2	1	0	0%	43	0	0	0	n
	3	1	0	0%	158	0	0	0	n
	4	1	1	100%	406	5	103	103	y
total		3	1	67%	607	5	103	103	y
UK (NI)	1	1	0	0%	10	0	0	0	n
	3	1	0	0%	3734	0	0	0	n

	4	1	0	0%	122	0	0	0	n
total		3	0	0%	3866	0	0	0	n
UK (E+W)	1	4	1	54%	491	4	100	551	y
	2	3	0	0%	44	0	0	0	n
	3	3	1	100%	9482	39	973	4061	y
	4	4	1	9%	5575	1	25	155	n
total		14	3	66%	15592	44	1098	4767	Y
Faroese	4	2	0	0%	211	0	0	0	n
total		2	0	0%	211	0	0	0	n
Period total	**1**	30	9	74%	25442	30	1074	2863	y
Period total	**2**	30	7	89%	127564	89	2258	16976	n
Period total	**3**	27	12	88%	240261	268	7260	33598	y
Period total	**4**	41	12	67%	73868	62	1268	9725	n
Total 2022		121	40	85%	463696	449	11860	63162	n
Human Cons. Only		111	35	85%	457569	381	10583	60119	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 2022. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata

Celtic Explorer (IRL) EIGB	5 – 20 July	WoS, MSHAS (6.a.N and 6.a.S)	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	29 June – 19 July	MSHAS, WoS, NSAS, Sprat NS	1, 91 (north of 58°30’N), 111, 121
Johan Hjort (NOR) LDGJ	23 June – 15 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NED) PBVO	28 June – 21 July	NSAS, Sprat NS	81, 91 (south of 58°30’N), 101
Solea (GER) DBFH	1 – 19 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	22 June – 08 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 2022. 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	14746	78	0.00	5.3	9.0
1	3711	149	0.00	40.3	16.9
2	3814	503	0.70	132.0	24.2
3	3043	541	0.95	177.8	26.7
4	1743	340	0.97	194.9	27.3
5	822	172	0.99	209.7	27.9
6	662	154	1.00	232.2	29.0
7	718	176	1.00	244.4	29.3
8	619	151	1.00	243.5	29.2
9+	249	67	1.00	268.8	30.4
Immature	19780	367		18.6	11.5
Mature	10348	1963		189.7	26.8
Total	30127	2330	0.34	77.4	16.8

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2022. 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
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
Years / Age (rings)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**	**SSB ('000t)**

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
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

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	

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

Nation:	Vessel:	Dates
Germany	Walther Herwig 3	16 September – 26 September 2022

Netherlands	Tridens 2	19 September – 29 September 2022
Netherlands	Tridens 2	19 December – 23 December 2022
Germany	Walther Herwig 3	04 January – 13 January 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 survey in the English Channel in January 2023 had to face severe weather problems. Thus only 50% of the planned stations have been sampled. The resulting larvae index for this area is therefore most likely an underestimate. Larvae distribution around the Orkneys was different from previous years, as most larvae were found more easterly than usual. In the Buchan and the central North Sea, newly hatched larvae concentrated in two areas. In all survey areas, herring larvae were less abundant compare to last year. The distribution of larvae in December was unusual in that manner that highest concentration of herring larvae was observed in the inner part of the English Channel, and not in the most westerly area as in other years. 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, 373 plankton samples were taken during the IHLS surveys between September 2022 and January 2023. They contained 48,834 herring larvae.

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
4a, 4b	N/A	Gulf	261	261	0	0	100 %	Extra hauls taken when abundance was dense.
4c, 7d	N/A	Gulf	141	112	0	0	79 %	Extra hauls taken when abundance was dense.
total	N/A	Gulf	402	373	0	0	93 %	

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 2022- year classes by areas are density estimates in numbers per square meter according to the new index calculation algorithm. Total abundance is found by multiplying density by area and summing up. Data for the period 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

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995- to 2021- 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
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
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

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
2021	2023	5016	2699	0.54	2470	0.49	0.15

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	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS
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

age	0		1		2		3		4		5		6		7		8		9+	
Year	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS	catch	HERAS
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
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

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 2022. 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
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

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	1972–2022	1973–2022
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2023	1984–2023
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2022	1998–2022
Acoustic (+trawl)	1 wr	1995–2022	1997–2022
	2-9+ wr	1984–2022	1989–2022
IBTS0	0wr	1977–2023	1992–2023

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

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

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

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

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

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

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

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	1070765
1985	1465723
1986	1688359
1987	3199710
1988	1505430
1989	1612781
1990	763223
1991	1094232
1992	1142297
1993	1866527
1994	2748908
1995	2150928
1996	1263540
1997	834462
1998	1482508
1999	722082
2000	2085204
2001	1598455
2002	1770396
2003	1357941
2004	783840
2005	925980
2006	745247
2007	883566
2008	731055
2009	725168
2010	878615
2011	1528358
2012	798515
2013	502558
2014	1658630
2015	1941522
2016	556770
2017	1373951

2018	678384
2019	979984
2020	1145966
2021	1230685
2022	646976
2023	1525725

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	746142	456306	323785	93858	27033	12102
1999	4655800	308088	210339	122567	54784	18836
2000	1769976	741709	295223	120313	73409	17233
2001	1848091	324999	218553	110440	47372	27506
2002	2320620	1921639	476202	340570	83910	32760
2003	912394	473070	571541	152372	117861	19044
2004	2257961	398418	306517	429607	99940	52391
2005	1162862	410220	113336	83132	108262	32967
2006	1056562	297333	192760	77967	47028	52404
2007	2347335	137823	94556	102228	51624	32785
2008	626833	161049	116339	60891	37259	19462
2009	2849593	208455	95989	65858	28517	12250
2010	1513359	495574	171320	85040	38557	16069
2011	896673	348861	177067	104548	52800	22322
2012	801530	210381	92341	70235	40268	23400
2013	1989165	279817	137884	125379	88486	41603
2014	7386892	443236	203907	89768	79279	45667
2015	529316	732079	361702	122806	69235	47888
2016	1797028	178869	374205	213339	74220	43534
2017	880165	280217	78546	2e+05	134319	42174
2018	1867214	321320	119121	51005	89418	40305
2019	1472846	136778	63345	42443	23123	36180
2020	1052911	318606	268824	72360	67119	25947
2021	787374	281442	107626	70668	25161	17101
2022	7455503	201645	263672	136851	86432	18326

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

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

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

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

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	0.4282	0.1272	0.3338	0.5494
catch unique	1	0.4282	0.1272	0.3338	0.5494
catch unique	2	0.1213	0.1755	0.08601	0.1711
catch unique	3	0.1213	0.1755	0.08601	0.1711
catch unique	4	0.1213	0.1755	0.08601	0.1711
catch unique	5	0.1213	0.1755	0.08601	0.1711
catch unique	6	0.1213	0.1755	0.08601	0.1711
catch unique	7	0.1875	0.1958	0.1278	0.2753
catch unique	8	0.1875	0.1958	0.1278	0.2753
HERAS	1	0.464	0.1491	0.3464	0.6215
HERAS	2	0.2641	0.1464	0.1982	0.3519
HERAS	3	0.1643	0.177	0.1161	0.2325
HERAS	4	0.2191	0.09772	0.1809	0.2653
HERAS	5	0.2191	0.09772	0.1809	0.2653

HERAS	6	0.2191	0.09772	0.1809	0.2653
HERAS	7	0.3101	0.1219	0.2442	0.3938
HERAS	8	0.3101	0.1219	0.2442	0.3938
IBTS-Q1	1	0.2718	0.1502	0.2025	0.3648
IBTS0	0	0.3697	0.1575	0.2715	0.5035
IBTS-Q3	0	0.5318	0.1302	0.412	0.6865
IBTS-Q3	1	0.5318	0.1302	0.412	0.6865
IBTS-Q3	2	0.3244	0.09377	0.2699	0.3898
IBTS-Q3	3	0.3244	0.09377	0.2699	0.3898
IBTS-Q3	4	0.3244	0.09377	0.2699	0.3898
IBTS-Q3	5	0.3244	0.09377	0.2699	0.3898
LAI-ORSH	0	1.184	0.04326	1.088	1.289
LAI-BUN	0	1.184	0.04326	1.088	1.289
LAI-CNS	0	1.184	0.04326	1.088	1.289
LAI-SNS	0	1.184	0.04326	1.088	1.289

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.9401	0.06666	0.825	1.071
HERAS	2	0.9401	0.06666	0.825	1.071
HERAS	3	1.075	0.05826	0.9588	1.205
HERAS	4	1.075	0.05826	0.9588	1.205
HERAS	5	1.075	0.05826	0.9588	1.205
HERAS	6	1.075	0.05826	0.9588	1.205
HERAS	7	1.075	0.05826	0.9588	1.205
HERAS	8	1.075	0.05826	0.9588	1.205
IBTS-Q1	1	0.1059	0.06679	0.09294	0.1208
IBTS0	0	3.215e-06	0.09015	2.695e-06	3.837e-06
IBTS-Q3	0	0.1036	0.1257	0.08096	0.1325
IBTS-Q3	1	0.04618	0.1219	0.03637	0.05865
IBTS-Q3	2	0.04158	0.08631	0.03511	0.04924
IBTS-Q3	3	0.03802	0.08584	0.03213	0.04499
IBTS-Q3	4	0.03314	0.08726	0.02793	0.03932
IBTS-Q3	5	0.02481	0.08846	0.02086	0.02951
LAI-ORSH	0	0.01605	0.1069	0.01302	0.01979
LAI-BUN	0	0.01605	0.1069	0.01302	0.01979
LAI-CNS	0	0.01605	0.1069	0.01302	0.01979
LAI-SNS	0	0.01605	0.1069	0.01302	0.01979

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	34843107	16666475	14592167	5407277	7264055	4440840	3912769	2070123	6313607
1948	33204210	16181501	9534969	8641669	3644784	5082805	2940188	2225271	4877291
1949	27923624	15556349	11572065	7226025	4189711	2287343	3243787	1869730	4258186
1950	39551269	12151793	9016049	9345946	5172845	2343749	1449778	1811015	3233889
1951	38374251	19062997	6516386	6049017	6824903	3620847	1475044	841314	2790755
1952	38187357	17642954	10476730	3868830	3576857	3787503	2163612	938806	2269147
1953	43252063	17327703	9216360	5731555	2633236	2114685	2222853	1230487	1764972
1954	40358247	20073032	8858672	5251386	3105424	1713838	1244473	1282427	1706998
1955	34301248	18147174	10527667	5109197	2667527	1790192	1056402	665524	1410434
1956	25467628	16043223	8612241	6055419	2885102	1465175	1045282	582999	1388766
1957	57469609	10830071	8068881	3750345	3535689	1680692	931593	650633	1174883
1958	24929483	32548124	4742779	4542914	1881776	2247417	925005	544476	1011344
1959	28331717	11058168	19138195	2165014	2339195	1102401	1161108	565319	1192960

1960	12552193	14357573	4976624	10533764	1060183	1145048	605690	616115	1088727
1961	52690620	4189313	7282570	2362379	7108365	669800	792664	344557	870697
1962	28485201	27146529	1593856	3196087	1370648	4375518	425469	513429	709615
1963	34232664	13053389	1.6e+07	1009042	1251328	676174	2245795	203160	694024
1964	34357568	14833057	6528560	9346700	663798	734821	506991	1536778	545435
1965	17213841	16503748	6210085	3394650	5403668	389402	425386	320424	1376536
1966	18496083	7916703	7508159	2139560	1362746	2326868	168111	188226	843516
1967	25581791	7847534	3586795	3136850	848279	651293	865360	101071	465311
1968	21939615	11633435	3119983	1877985	1147459	290563	245917	277535	164658
1969	12755372	9855830	4266113	657039	301326	349858	78381	65531	95308
1970	21817686	5820121	4117988	1522153	209995	99146	108168	16300	42983
1971	17158471	10059921	2331552	1206349	371720	51002	31704	30027	17496
1972	12615750	7662338	3287013	757479	313864	95366	13993	1048	6526
1973	6893962	5388537	2652784	1130204	291904	120791	47477	7466	4451
1974	10772641	2769838	1557462	729076	262978	97700	40070	11364	5282
1975	2573246	5323148	926740	432825	232066	81000	26827	11716	5880
1976	3337077	839575	1810962	210300	92974	61398	13516	6298	2457
1977	4403786	1400413	284034	614874	49501	24670	18470	4529	2106
1978	4327905	1874080	706379	222473	249314	30532	11435	10019	3132
1979	7877575	1702345	909388	409014	177215	122259	20572	7006	7224
1980	12639916	3236472	755357	477690	229131	156441	62616	16887	8038
1981	27375323	4678193	1611037	325089	220224	138833	120748	54414	20160
1982	46445060	8097894	1852062	1038911	200208	120572	77139	71073	39265
1983	46151118	14958233	3237207	1057091	504695	126008	103126	52508	82927
1984	46549410	13369781	6158052	1800147	673839	273632	79644	67411	81224
1985	55251332	14932130	5732565	3596705	998515	359510	124580	47172	75364
1986	67358005	19966442	5483377	3e+06	1553044	428929	170027	54620	61493
1987	57782205	26604848	8780676	2620261	1555769	781973	224084	77220	50927
1988	38074870	1.9e+07	10151654	4631942	1345940	813796	393271	113160	67756
1989	29846582	13069401	7000889	5630792	2695651	703681	407168	196541	91457
1990	27756832	9933260	4551829	3978370	3690257	1582458	378498	220919	165033
1991	30285372	10653373	4210989	2376418	2343819	2186812	898056	216844	201851
1992	52786702	10436718	4556140	1810444	1351823	1359405	1319257	533983	248839
1993	55579837	16956715	3799139	2033638	953901	744961	754039	650360	415655
1994	43072895	17190801	5938054	1468651	878873	409834	351952	346030	480817
1995	44203697	14122824	6144059	2644449	737630	379229	203340	176959	386789
1996	35958398	14144266	5262496	3113922	1113623	349902	156709	100130	272117
1997	29160338	13684735	6488721	3011194	1698795	679978	215130	92620	228866
1998	19186559	12120068	9050944	3230497	1512894	913733	447341	132793	179022
1999	55290404	8450077	5600327	5497992	1709313	769806	445855	234442	153849
2000	40457232	22372745	5640786	2949695	3244267	1051521	485515	277632	199837
2001	67636349	16181229	11224247	3648421	1727929	1812566	566391	289903	231348
2002	36318539	28835906	8144674	8156460	1947917	938102	1106339	331337	318713
2003	20507520	14165115	17428976	4571631	5022135	1089305	578736	668465	344760
2004	23685950	7774620	6349044	11062895	3014318	3041947	560153	374060	504464
2005	20842279	9866033	3871523	3880085	6603614	1787980	1633187	278102	415082
2006	21487048	7353034	5030411	2485836	2426252	4169287	874841	736774	293145
2007	24668134	7845506	3238396	2967106	1559892	1395166	2329652	456914	481137
2008	22373022	8853438	4418327	2132420	1730092	1007208	881200	1482315	585283
2009	35013307	8839130	5419499	2634055	1438386	1146203	682761	638555	1632197
2010	28340638	12782070	5563693	3952552	1938063	1072294	1008832	520973	1755764
2011	2.5e+07	11629346	6695592	3615958	2489693	1256525	733720	656509	1494262
2012	23319964	9155391	5954580	5076416	2643228	1742794	812873	482172	1206751
2013	31738726	8655039	4565820	4143107	3465560	1992047	1206047	510235	1045677
2014	47612886	14212065	5440446	3178706	3349911	2330910	1256996	706045	770620
2015	13682022	19235940	9872013	2987687	1961800	2100071	1393879	726823	825980
2016	23844071	5263968	11917987	7014466	1862158	1241790	1182613	706561	733057
2017	14401346	8968411	2560729	8537038	4885576	1234303	638779	561715	612120
2018	24778622	5817443	4300133	1947482	6048389	3472513	813117	425979	713360
2019	22146722	9937479	2453366	2785121	1447492	3817701	2106628	440071	590512
2020	25562864	9216496	5911435	1637139	1910373	1067328	2328132	1111574	533453
2021	18159371	10981001	4816593	3035662	1131440	1329787	737273	1311779	929005
2022	31135028	6329198	7028822	3464781	2158853	782291	876069	477309	1232610
2023	31349395	13787347	3597468	4300806	2023410	1267202	457046	504511	929677

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	0.0001244	0.001054	0.03888	0.09584	0.111	0.1483	0.2442	0.2706	0.2706
1948	0.0001008	0.0008296	0.0331	0.08772	0.1061	0.1403	0.2109	0.2403	0.2403
1949	0.0002486	0.002326	0.04986	0.1098	0.1255	0.159	0.2567	0.3062	0.3062
1950	0.0006014	0.00638	0.07401	0.1365	0.1485	0.164	0.2188	0.2379	0.2379
1951	0.001813	0.0225	0.1301	0.2021	0.2142	0.2099	0.235	0.227	0.227
1952	0.003102	0.04154	0.1604	0.21	0.2195	0.2253	0.2822	0.3078	0.3078
1953	0.00464	0.06581	0.1902	0.2325	0.228	0.2336	0.2821	0.2987	0.2987
1954	0.006552	0.1004	0.2334	0.2746	0.2572	0.2718	0.3639	0.3794	0.3794
1955	0.007046	0.1201	0.2508	0.2663	0.235	0.2402	0.2703	0.2338	0.2338
1956	0.007254	0.1355	0.2761	0.2687	0.2287	0.2307	0.2452	0.2387	0.2387
1957	0.008009	0.1481	0.2856	0.2756	0.2411	0.2612	0.2861	0.2726	0.2726
1958	0.008719	0.1506	0.2953	0.2772	0.231	0.238	0.2041	0.1725	0.1725
1959	0.01467	0.2123	0.3508	0.3146	0.2705	0.271	0.2906	0.2881	0.2881
1960	0.01668	0.1906	0.3088	0.2561	0.2138	0.2104	0.2381	0.2693	0.2693
1961	0.01921	0.1968	0.3276	0.2933	0.2547	0.2401	0.2533	0.2372	0.2372
1962	0.01233	0.1305	0.273	0.3159	0.3023	0.3072	0.3798	0.3501	0.3501

1963	0.01241	0.1173	0.2349	0.225	0.1792	0.1677	0.1307	0.1441	0.1441
1964	0.01853	0.1941	0.3401	0.3394	0.2875	0.2727	0.226	0.2171	0.2171
1965	0.02424	0.2888	0.524	0.584	0.5254	0.5228	0.505	0.5122	0.5122
1966	0.02453	0.2535	0.4915	0.5598	0.4962	0.5137	0.4106	0.5124	0.5124
1967	0.02906	0.2867	0.5643	0.7335	0.6701	0.7111	0.7629	0.9563	0.9563
1968	0.04945	0.5354	0.9964	1.3	1.004	0.9682	1.147	1.215	1.215
1969	0.02798	0.2977	0.6926	0.8799	0.8018	0.8542	1.192	1.07	1.07
1970	0.04705	0.4242	0.8182	1.024	0.9383	0.8547	1.174	0.91	0.91
1971	0.06852	0.561	0.8828	1.082	1.072	1.128	2.928	1.723	1.723
1972	0.06918	0.459	0.6991	0.7286	0.6017	0.5283	0.5394	0.3174	0.3174
1973	0.1017	0.6325	0.9104	1.021	0.8639	0.8634	1.08	0.705	0.705
1974	0.1147	0.543	0.842	0.938	0.8407	0.9428	0.9573	0.8424	0.8424
1975	0.1746	0.6742	1.01	1.242	1.117	1.298	1.284	1.621	1.621
1976	0.1487	0.4456	0.7299	1.015	0.8819	0.9554	0.807	1.156	1.156
1977	0.06793	0.1271	0.2601	0.3879	0.3309	0.4032	0.275	0.4638	0.4638
1978	0.0779	0.1136	0.2139	0.2808	0.2351	0.266	0.1409	0.2563	0.2563
1979	0.1103	0.1309	0.2101	0.2493	0.1942	0.2005	0.08289	0.1542	0.1542
1980	0.1633	0.158	0.215	0.235	0.1729	0.1562	0.05041	0.09152	0.09152
1981	0.324	0.2647	0.2482	0.2776	0.2481	0.2631	0.2122	0.3799	0.3799
1982	0.2982	0.2375	0.2202	0.2509	0.2043	0.1733	0.1065	0.1533	0.1533
1983	0.3022	0.27	0.2411	0.2883	0.2846	0.2756	0.257	0.3379	0.3379
1984	0.2193	0.2611	0.2595	0.3428	0.3876	0.3853	0.3895	0.4928	0.4928
1985	0.1889	0.3262	0.3224	0.4361	0.4986	0.4787	0.5196	0.5842	0.5842
1986	0.1461	0.3018	0.3076	0.3788	0.4341	0.4402	0.5142	0.5787	0.5787
1987	0.1795	0.38	0.3239	0.3559	0.4128	0.4242	0.4527	0.4532	0.4532
1988	0.1656	0.3824	0.3088	0.3234	0.3922	0.4184	0.4506	0.4639	0.4639
1989	0.1619	0.3813	0.3166	0.3198	0.3864	0.4005	0.4115	0.4182	0.4182
1990	0.1179	0.2769	0.2751	0.2611	0.3011	0.3086	0.2822	0.3005	0.3005
1991	0.1581	0.3363	0.3409	0.3041	0.3171	0.3033	0.2806	0.2547	0.2547
1992	0.2267	0.4094	0.3902	0.3536	0.372	0.351	0.3709	0.35	0.35
1993	0.2617	0.4468	0.4397	0.4377	0.4588	0.3968	0.4163	0.3988	0.3988
1994	0.2131	0.3549	0.4104	0.4722	0.4992	0.3926	0.3627	0.3159	0.3159
1995	0.1857	0.2866	0.3365	0.4233	0.4408	0.3958	0.3842	0.3083	0.3083
1996	0.06954	0.1052	0.1693	0.2146	0.2149	0.208	0.1647	0.1121	0.1121
1997	0.03376	0.05958	0.1356	0.1899	0.2048	0.2063	0.182	0.1319	0.1319
1998	0.03784	0.07458	0.1589	0.2263	0.2409	0.2462	0.2368	0.1451	0.1451
1999	0.03814	0.06523	0.1428	0.2203	0.2292	0.228	0.1938	0.1192	0.1192
2000	0.04278	0.06718	0.1347	0.2109	0.2443	0.2494	0.2124	0.1312	0.1312
2001	0.03519	0.04822	0.101	0.1654	0.205	0.2225	0.1952	0.1355	0.1355
2002	0.03184	0.04097	0.08896	0.1453	0.1885	0.2122	0.1961	0.1654	0.1654
2003	0.03563	0.04398	0.08976	0.1478	0.2111	0.264	0.248	0.2058	0.2058
2004	0.04322	0.04728	0.09328	0.1542	0.2357	0.3213	0.3934	0.3339	0.3339
2005	0.06674	0.06854	0.1135	0.173	0.2664	0.363	0.515	0.5497	0.5497
2006	0.05612	0.05289	0.1016	0.1601	0.2434	0.3152	0.41	0.4883	0.4883
2007	0.0498	0.04605	0.09696	0.1564	0.2285	0.2848	0.3575	0.4325	0.4325
2008	0.04827	0.04047	0.08668	0.1084	0.1441	0.1715	0.165	0.2086	0.2086
2009	0.02878	0.02165	0.05555	0.05928	0.07702	0.09295	0.06812	0.09476	0.09476
2010	0.03345	0.02494	0.06244	0.07114	0.08315	0.09695	0.06994	0.07937	0.07937
2011	0.03705	0.02662	0.06844	0.0912	0.1089	0.1268	0.1012	0.1041	0.1041
2012	0.05348	0.04305	0.09659	0.1504	0.1893	0.2226	0.2411	0.2504	0.2504
2013	0.045	0.03744	0.08914	0.1491	0.2109	0.2689	0.3461	0.389	0.389
2014	0.0516	0.03518	0.08418	0.1464	0.2148	0.2678	0.3141	0.3797	0.3797
2015	0.0525	0.02697	0.06629	0.1191	0.1902	0.2758	0.4059	0.5522	0.5522
2016	0.06706	0.02864	0.06705	0.1393	0.2123	0.2925	0.4385	0.6611	0.6611
2017	0.05585	0.02192	0.05869	0.1368	0.2049	0.249	0.3075	0.4624	0.4624
2018	0.05692	0.02009	0.06121	0.1394	0.2244	0.287	0.3777	0.5398	0.5398
2019	0.04706	0.01665	0.06145	0.1299	0.1818	0.2335	0.3173	0.4634	0.4634
2020	0.06963	0.02589	0.09899	0.1672	0.1927	0.2107	0.274	0.4293	0.4293
2021	0.04844	0.02127	0.1048	0.1748	0.1997	0.2213	0.2253	0.3482	0.3482
2022	0.05517	0.03018	0.1425	0.2213	0.239	0.2538	0.2806	0.3433	0.3433
2023	0.05511	0.03015	0.1424	0.2212	0.2389	0.2537	0.2804	0.3431	0.3431

Table 2.6.2.5 North Sea herring single fleet assessment. Analytical retrospective (Mohn's Rho).

year	ssb	fbar	rec
2012	23.54	-30.66	28.75
2013	21.77	-28.17	19.35
2014	14.27	-17.07	3.354
2015	12.97	-14.06	7.284
2016	11.5	-11.83	-19.05
2017	19.77	-27.14	-3.2
2018	12.68	-14.47	-8.542
2019	7.085	-9.155	-9.249
2020	3.874	-4.588	-0.445
2021	8.449	-7.089	0.2181
2022	0	0	0
av_5y	8.643	-10.41	-3.536

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	34843107	19625911	61859146	8574808	6502051	11308329	5288144	3807178	7345197	851339	733014	988764	0.1276	0.08941	0.1822	581760	1.461
1948	33204210	19739073	55854679	7380586	5638212	9661405	4492545	3263477	6184496	661659	578545	756713	0.1156	0.08219	0.1626	502100	1.333
1949	27923624	16775841	46479266	6805979	5272421	8785593	4064846	2986678	5532224	724586	634097	827988	0.1402	0.1008	0.1949	508500	1.45
1950	39551269	24226625	64569573	6430870	5060781	8171879	3813382	2857190	5089575	648221	578906	725836	0.1484	0.1094	0.2012	491700	1.307
1951	38374251	23697892	62139838	6292667	5035285	7864034	3377236	2562141	4451638	777630	699507	864479	0.1983	0.15	0.262	600400	1.324
1952	38187357	23755266	61387410	6044295	4871907	7498809	3195395	2442845	4179780	834373	753448	923989	0.2195	0.1668	0.2888	664400	1.272
1953	43252063	27734115	67452702	5816740	4709363	7184508	2963000	2269315	3868730	835485	754263	925453	0.2333	0.1781	0.3056	698500	1.198
1954	40358247	25972075	62713054	5670943	4606212	6981787	2706632	2060095	3556076	947906	850337	1056671	0.2802	0.2125	0.3695	762900	1.251
1955	34301248	22209401	52976466	5414475	4393798	6672256	2714584	2076479	3548780	843588	750365	948393	0.2525	0.1921	0.332	806400	1.06
1956	25467628	16476565	39365008	5058459	4117056	6215123	2625637	2012614	3425382	833911	742261	936878	0.2499	0.1911	0.3267	675200	1.271
1957	57469609	36856427	89611398	4940708	4034776	6050049	2376964	1821725	3101434	783937	702409	874928	0.2699	0.2061	0.3535	682900	1.158
1958	24929483	16269580	38198842	4950133	4025573	6087038	2018983	1548726	2632028	734843	626486	861941	0.2491	0.1919	0.3233	670500	1.167
1959	28331717	1.8e+07	44585230	5524214	4543279	6716942	2919711	2255993	3778696	1168520	1010934	1350671	0.2995	0.2313	0.3879	784500	1.519
1960	12552193	8045015	19584493	4632019	3808683	5633337	2516069	1949494	3247306	805199	703933	921032	0.2454	0.1911	0.3152		

															696200	1.183
1961	52690620	33900753	81894979	4791135	3976780	5772252	2536810	1993861	3227610	769038	683324	865504	0.2738	0.2167	0.3459	696700	1.135
1962	28485201	18709038	43369771	4470946	3711533	5385741	1771243	1374247	2282924	729409	634130	839003	0.3156	0.2488	0.4004	627800	1.171
1963	34232664	22614627	51819349	5171471	4325637	6182700	2789711	2234012	3483637	595633	512805	691840	0.1875	0.1515	0.2321	716000	0.8602
1964	34357568	22833652	51697489	5109002	4418790	5907026	2516773	2081799	3042632	901056	786199	1032692	0.2931	0.2441	0.3521	871200	1.066
1965	17213841	11433746	25915944	4614594	4076081	5224252	1991409	1676813	2365029	1304893	1149893	1480785	0.5322	0.4504	0.6289	1168800	1.15
1966	18496083	12366304	27664295	3461551	3071762	3900802	1594303	1353527	1877911	934170	833423	1047095	0.4944	0.4219	0.5793	895500	1.071
1967	25581791	17011961	38468702	2676814	2387504	3001181	958349	822953	1116021	833295	742976	934593	0.6884	0.5963	0.7947	695500	1.176
1968	21939615	14715523	32710133	2272975	1996632	2587567	523395	448244	611144	912963	782205	1065580	1.083	0.9554	1.228	717800	1.255
1969	12755372	8440622	19275774	1689713	1460542	1954842	479343	393632	583718	503072	428676	590379	0.884	0.7725	1.012	546700	0.9674
1970	21817686	14441150	32962154	1659738	1441908	1910475	454924	373326	554358	549818	472863	639296	0.9617	0.8456	1.094	563100	0.9657
1971	17158471	11483704	25637470	1465620	1246999	1722570	286581	236803	346824	522484	423282	644937	1.418	1.256	1.602	520100	1.075
1972	12615750	8384612	18982051	1322456	1136433	1538928	329390	271962	398946	393429	319757	484075	0.6194	0.5364	0.7153	497500	0.9197
1973	6893962	4594665	10343889	1106036	968285	1263383	278827	232904	333804	444142	373580	528032	0.9477	0.833	1.078	484000	0.9575
1974	10772641	7059737	16438261	775904	675195	891635	191402	160829	227786	271159	232904	315698	0.9042	0.7923	1.032	275100	0.968
1975	2573246	1673465	3956817	613166	512770	733219	105746	87467	127846	269222	214272	338264	1.19	1.028	1.379	312800	0.9343
1976	3337077	2103457	5294181	453837	379519	542708	144849	109932	190856	159761	135360	188560	0.8779	0.6883	1.12	174800	0.953
1977	4403786	2712103	7150661	319115	251445	404998	110114	80073	151426	52031	44158	61307	0.3314	0.2417	0.4545		

																46000	1.198
1978	4327905	2637275	7102317	379729	290545	496290	137100	100537	186960	45717	26427	79087	0.2273	0.1427	0.3623	11000	.
1979	7877575	4974700	12474357	499450	396269	629498	187117	143407	244149	59567	33833	104874	0.1874	0.1163	0.3018	25100	.
1980	12639916	8462656	18879117	671117	550652	817935	210879	168208	264376	80826	63339	103140	0.1659	0.1315	0.2094	70764	1.094
1981	27375323	18407702	40711671	1093119	892603	1338678	271738	217530	339455	146018	112352	189773	0.2498	0.1993	0.3131	174879	1.008
1982	46445060	31294830	68929712	1710991	1387949	2109220	385735	312760	475737	239532	174365	329056	0.191	0.155	0.2354	275079	0.9786
1983	46151118	31823595	66929135	2352083	1951954	2834236	550510	449858	673682	382595	284543	514435	0.2693	0.2221	0.3267	387202	1.077
1984	46549410	32176197	67343185	3125511	2658237	3674925	906030	739986	1109331	476442	387057	586470	0.3529	0.2939	0.4239	428631	1.054
1985	55251332	38100936	80121644	3567194	3064525	4152314	994586	820715	1205293	639243	545942	748490	0.4511	0.3764	0.5405	613780	1.042
1986	67358005	46278848	98038328	3977599	3396368	4658298	1035062	859198	1246921	717786	579116	889660	0.415	0.3459	0.4979	671488	1.137
1987	57782205	39767737	83957085	3974109	3420178	4617754	1217539	1011865	1465019	766792	630330	932798	0.3939	0.3299	0.4703	792058	1.017
1988	38074870	26264795	55195395	3854891	3356763	4426938	1559333	1300386	1869845	876266	723126	1061837	0.3787	0.319	0.4496	887686	1.164
1989	29846582	20595560	43252937	3509650	3110228	3960366	1620487	1387617	1892439	809747	700747	935701	0.367	0.3128	0.4305	787899	1.034
1990	27756832	19095063	40347692	3507061	3106330	3959489	1773102	1522345	2065162	632348	552039	724340	0.2856	0.2423	0.3367	645229	1.052
1991	30285372	20864782	43959422	3373797	2993222	3802761	1574572	1357488	1826371	686173	590963	796723	0.3092	0.2629	0.3637	658008	1.02
1992	52786702	37776372	73761342	3344843	2959050	3780935	1198109	1029482	1394357	708256	605516	828428	0.3675	0.3121	0.4328	716799	0.995
1993	55579837	39582580	78042369	3113648	2720203	3564000	853988	725955	1004601	708668	597184	840964	0.4298	0.3636	0.5082	671397	1.023
1994	43072895	30558956	60711312	3017170	2602045	3498523	910441	772659	1072792	717553	578711	889705	0.4274	0.3614	0.5056		

```
568234     1.05
  1995   44203697   31280700   62465573   2833567   2449279    3278149    942466    793627   1119219    612450     520482     720669    0.3961    0.3318    0.4729
579371    1.008
  1996   35958398   25499673   50706783   2779770   2387286    3236780   1103450    930869   1308028    266588     232951     305082    0.1943    0.1615    0.2337
275098   0.9987
```

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 ).  Mon Mar 20 08:09:58 2023"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2023         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":
plusgroup
     TRUE

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

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	0.8392	0.1992	0.568	1.24
catch A	2	0.17	0.097	0.1406	0.2056
catch A	3	0.17	0.097	0.1406	0.2056
catch A	4	0.17	0.097	0.1406	0.2056
catch A	5	0.17	0.097	0.1406	0.2056
catch A	6	0.17	0.097	0.1406	0.2056
catch A	7	0.1848	0.2068	0.1232	0.2772
catch A	8	0.1848	0.2068	0.1232	0.2772
catch BD	0	0.5018	0.1449	0.3778	0.6666

catch BD	1	0.4689	0.2038	0.3145	0.6991
catch BD	2	0.6477	0.186	0.4498	0.9327
catch C	1	0.5295	0.1453	0.3983	0.7039
catch C	2	0.5295	0.1453	0.3983	0.7039
catch C	3	0.6488	0.09998	0.5333	0.7892
catch C	4	0.6488	0.09998	0.5333	0.7892
catch C	5	0.6488	0.09998	0.5333	0.7892
catch C	6	0.6488	0.09998	0.5333	0.7892
HERAS	1	0.4625	0.1482	0.3459	0.6184
HERAS	2	0.2616	0.147	0.1961	0.349
HERAS	3	0.1719	0.1744	0.1221	0.2419
HERAS	4	0.2284	0.09712	0.1888	0.2763
HERAS	5	0.2284	0.09712	0.1888	0.2763
HERAS	6	0.2284	0.09712	0.1888	0.2763
HERAS	7	0.326	0.1174	0.259	0.4103
HERAS	8	0.326	0.1174	0.259	0.4103
IBTS-Q1	1	0.2769	0.1445	0.2086	0.3675
IBTS0	0	0.3801	0.1537	0.2812	0.5138
IBTS-Q3	0	0.5335	0.129	0.4143	0.687
IBTS-Q3	1	0.5335	0.129	0.4143	0.687
IBTS-Q3	2	0.3174	0.09437	0.2638	0.3819
IBTS-Q3	3	0.3174	0.09437	0.2638	0.3819
IBTS-Q3	4	0.3174	0.09437	0.2638	0.3819
IBTS-Q3	5	0.3174	0.09437	0.2638	0.3819
LAI-ORSH	0	1.186	0.04331	1.089	1.291
LAI-BUN	0	1.186	0.04331	1.089	1.291
LAI-CNS	0	1.186	0.04331	1.089	1.291
LAI-SNS	0	1.186	0.04331	1.089	1.291

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.9534	0.06378	0.8414	1.08
HERAS	2	0.9534	0.06378	0.8414	1.08
HERAS	3	1.094	0.05562	0.9808	1.22
HERAS	4	1.094	0.05562	0.9808	1.22
HERAS	5	1.094	0.05562	0.9808	1.22
HERAS	6	1.094	0.05562	0.9808	1.22
HERAS	7	1.094	0.05562	0.9808	1.22
HERAS	8	1.094	0.05562	0.9808	1.22
IBTS-Q1	1	0.1074	0.06469	0.09463	0.1219
IBTS0	0	3.29e-06	0.08892	2.764e-06	3.917e-06
IBTS-Q3	0	0.1052	0.1238	0.08251	0.134
IBTS-Q3	1	0.04682	0.1205	0.03697	0.0593
IBTS-Q3	2	0.04215	0.08297	0.03583	0.0496
IBTS-Q3	3	0.0385	0.08262	0.03275	0.04527
IBTS-Q3	4	0.03345	0.08397	0.02838	0.03944
IBTS-Q3	5	0.02526	0.0853	0.02137	0.02985
LAI-ORSH	0	0.01614	0.1062	0.0131	0.01987
LAI-BUN	0	0.01614	0.1062	0.0131	0.01987
LAI-CNS	0	0.01614	0.1062	0.0131	0.01987
LAI-SNS	0	0.01614	0.1062	0.0131	0.01987

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	38197927	14641994	12015645	4995046	6902845	4352893	3838035	2040706	6214738
1948	34933781	17742794	8381938	7352973	3309286	4724442	2873317	2187131	4768084
1949	29878200	16190897	11434149	6589573	3954521	2129154	3043957	1808542	4127397
1950	40090649	13135221	9324594	9076675	4862142	2303192	1349014	1703695	3106775
1951	38623757	19070983	7153012	6274830	6585572	3429229	1451737	786158	2671313
1952	38964890	17676329	10662074	4240472	3681540	3779365	2091316	910461	2169050
1953	42922409	17749061	9482710	5959074	2726420	2149079	2216831	1192762	1710737
1954	38548856	20337162	9304444	5338642	3228564	1728807	1263002	1271102	1665467
1955	34863082	17205520	10899906	5277763	2752236	1837281	1052141	673521	1412897
1956	26292124	16221484	8165716	6177904	2923154	1527548	1075669	590583	1386962
1957	61098438	11014894	8093055	3775900	3536055	1693625	947105	662546	1185371
1958	26427650	33531398	4784688	4448630	1919797	2183644	944472	552576	1031879
1959	27447382	11596365	19308773	2237130	2339138	1108759	1180868	576507	1196039
1960	13060781	13572768	5218478	10841438	1105548	1206347	612383	633747	1099712
1961	53135861	4597428	6755374	2533253	7089264	684081	816557	352239	901997
1962	28741141	27481660	1801614	3080260	1392125	4322257	428557	527045	734600
1963	30866220	13189549	16104483	1059350	1305846	710399	2306489	213327	718555
1964	33675086	13744286	6654159	9534315	676223	760109	509106	1576034	572540
1965	18371597	16195300	5870486	3417911	5287883	393840	429660	321757	1400337
1966	17830172	8268156	7428615	2143497	1381455	2260173	175913	191084	846275
1967	23864634	7645339	3664384	3184956	838056	656388	880757	101258	469558
1968	22813125	10800188	3058655	1689222	1155859	290548	253097	277024	167467
1969	13368585	10220199	4248770	693502	307223	346231	78360	63731	95612
1970	21897578	5976525	4118851	1468889	205133	96351	112709	16370	42855
1971	18626897	10033224	2423644	1250014	379102	55733	29358	29913	17476
1972	12798736	8349590	3280015	758388	306414	95106	14358	1105	6429
1973	7149343	5502704	2647503	1142989	295589	123558	45400	7549	4420
1974	10039938	2854987	1534087	756673	266945	97284	40179	11490	5220
1975	2704422	4770185	918203	439474	229901	79644	28705	11865	5906
1976	3487261	927386	1731820	214889	89981	60646	15020	6454	2598
1977	4046796	1467568	341461	583247	54310	25786	19048	5075	2377
1978	4656229	1687863	725551	246029	247903	33043	12266	10534	3778
1979	8559482	1740441	845939	414453	183850	126259	22295	7579	8194
1980	13221185	3301388	794216	475596	233750	151702	67785	18059	9075
1981	26064880	4851154	1672368	365151	233440	140673	115529	57436	21683
1982	44214530	8030282	2010555	1029667	210213	130838	79212	71315	42279
1983	43417286	14443218	3281277	1128738	521500	131113	103751	54297	84917
1984	45202724	12989492	6041175	1812545	676849	275392	81777	68123	83021
1985	57387293	14537845	5618668	3440901	981763	357972	127952	47599	76044
1986	70354209	20478183	5367269	2901032	1545506	436671	169226	55693	60862
1987	58504757	26878611	8755832	2613701	1521534	774359	223684	77141	51095
1988	38457571	19599420	10290347	4631421	1347807	800051	393725	113486	67486
1989	29986887	13087646	6949915	5612706	2641515	699644	404577	196829	91173
1990	28067349	10031371	4524889	3916084	3587993	1531089	374194	217267	161864
1991	29743046	10425248	4006264	2345387	2305906	2134131	871332	212119	200357
1992	49471609	10091561	4446591	1813361	1331103	1320385	1267293	520793	244721
1993	51161183	16109547	3759266	1997333	942409	719752	722490	626553	404940
1994	41358269	16160366	5900548	1474746	837360	411714	340027	326762	463512
1995	41230862	13882497	6269712	2610068	725358	364098	201620	167735	372566
1996	33551944	13727023	5492475	3043453	1118197	343777	156995	98317	260412
1997	27887113	12931850	6160539	3041647	1601757	653225	207241	97377	213510
1998	19347856	11648351	8527390	3174092	1511069	862880	432595	133032	177020
1999	53808573	8455041	5552495	5154756	1693647	781630	435232	236053	158958
2000	38547655	22296204	5515080	2982279	3032821	978958	483052	266231	223251
2001	67519175	15064836	11246743	3579791	1692238	1658791	508947	277459	290615
2002	35428470	29331568	7922440	7804426	1928269	945425	1012916	307279	318739
2003	19130795	13954259	17317226	4568295	4984963	1073097	584511	627324	334885
2004	23222546	7082507	6262889	10855391	3006721	3034843	573364	368836	491750
2005	20239769	9771276	3655576	3914742	6553921	1794942	1655461	288720	421067
2006	21168571	7177967	4982047	2453239	2435985	4065341	886584	746146	302904
2007	24926578	7761839	3238854	2865989	1544093	1418080	2234474	455547	489525
2008	22857234	8940906	4355279	2123707	1695096	992986	859457	1413101	575202
2009	34427466	9031770	5226837	2641478	1417531	1096096	662545	621939	1529319
2010	28284153	12843961	5573271	3734467	1901478	1041004	894614	495551	1636255
2011	24804130	11300133	6614619	3668813	2446251	1243695	721030	604732	1409145
2012	23680038	9206738	5974199	4889534	2676535	1712527	812801	479820	1167161
2013	32906186	8777507	4485630	4117034	3384893	1960185	1172057	505208	1021232
2014	46804732	14257942	5395495	3118948	3216947	2280079	1237811	686807	763555
2015	13300233	18753339	9660994	3075412	1962960	2092379	1375524	719620	818294
2016	22681856	5056940	11936109	6926735	1935906	1224160	1179266	710993	737836
2017	13952021	8682592	2592439	8307136	4884893	1298831	629779	566556	621861
2018	24172777	5544475	4256154	1971815	5818890	3367895	824952	411643	712687
2019	21678404	9964093	2360141	2763059	1463386	3595230	2034791	445844	582169
2020	25571817	9084027	5835639	1646848	1906961	1082360	2184635	1100365	526074
2021	17223642	11134766	4896007	3062489	1139964	1261075	731259	1250398	906435
2022	31077671	6013021	6791340	3383565	2099472	775725	831622	454891	1181007
2023	30861278	13608120	3439308	4192887	1956564	1221113	449524	473508	866418

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	0.0001263	0.04439	0.1055	0.1202	0.1547	0.2426	0.2748	0.2748
1948	0	0.000107	0.04086	0.1004	0.1164	0.1482	0.2153	0.2465	0.2465
1949	0	0.0001828	0.05123	0.119	0.1368	0.1711	0.2686	0.3169	0.3169
1950	0	0.0003139	0.06454	0.1369	0.1505	0.1714	0.2292	0.2526	0.2526
1951	0	0.0007193	0.09364	0.1808	0.1906	0.1997	0.2375	0.2431	0.2431
1952	0	0.001111	0.1125	0.1959	0.2018	0.2165	0.2825	0.3183	0.3183
1953	0	0.001636	0.1321	0.2142	0.2071	0.2187	0.2739	0.3057	0.3057
1954	0	0.002885	0.1694	0.261	0.2416	0.256	0.3496	0.3853	0.3853
1955	0	0.002984	0.168	0.2391	0.2097	0.2144	0.2383	0.2318	0.2318
1956	0	0.003978	0.1886	0.2504	0.2124	0.2143	0.2288	0.237	0.237
1957	0	0.005121	0.2081	0.2707	0.231	0.2396	0.2629	0.2674	0.2674
1958	0	0.005287	0.2068	0.2589	0.2124	0.2107	0.1855	0.1716	0.1716
1959	0	0.007414	0.2383	0.2963	0.2517	0.2524	0.275	0.2855	0.2855
1960	0	0.005166	0.196	0.2388	0.2043	0.2075	0.2244	0.2586	0.2586
1961	0	0.006324	0.212	0.2644	0.2289	0.2247	0.2265	0.23	0.23
1962	0	0.008144	0.2348	0.3212	0.2897	0.2939	0.3415	0.3416	0.3416
1963	0	0.003907	0.1613	0.2038	0.1712	0.1668	0.1229	0.1367	0.1367
1964	0	0.009683	0.2454	0.3108	0.2648	0.2549	0.2034	0.2077	0.2077
1965	0	0.03578	0.4541	0.5848	0.5059	0.4889	0.4913	0.5129	0.5129
1966	0	0.03169	0.4212	0.553	0.4809	0.4785	0.4231	0.5023	0.5023
1967	0	0.05278	0.5313	0.7392	0.6623	0.6775	0.7858	0.9314	0.9314
1968	0	0.1595	0.9008	1.218	0.9828	0.9381	1.202	1.227	1.227
1969	0	0.09523	0.6861	0.9252	0.8219	0.8411	1.185	1.059	1.059
1970	0	0.1118	0.7267	0.9767	0.8747	0.8486	1.191	0.9184	0.9184
1971	0	0.1585	0.8338	1.138	1.094	1.182	2.78	1.754	1.754
1972	0	0.06406	0.5252	0.6504	0.5504	0.5209	0.5047	0.3154	0.3154
1973	0	0.1547	0.7879	0.9986	0.8467	0.8467	1.02	0.7116	0.7116
1974	0	0.1457	0.7537	0.952	0.8327	0.8796	0.9253	0.8313	0.8313
1975	0	0.247	0.96	1.273	1.105	1.19	1.321	1.576	1.576
1976	0	0.1273	0.689	0.9845	0.8428	0.8799	0.8124	1.082	1.082
1977	0	0.01454	0.237	0.3706	0.3258	0.373	0.251	0.3891	0.3891
1978	0	0.008424	0.1795	0.2646	0.2279	0.2464	0.1288	0.21	0.21
1979	0	0.006851	0.1603	0.2254	0.1846	0.1861	0.0785	0.13	0.13
1980	0	0.006458	0.154	0.2076	0.1624	0.149	0.0518	0.08427	0.08427
1981	0	0.01054	0.1924	0.2757	0.251	0.2623	0.2006	0.3439	0.3439
1982	0	0.006445	0.1499	0.2148	0.1877	0.1734	0.1004	0.1469	0.1469
1983	0	0.01019	0.1851	0.2737	0.2724	0.2708	0.233	0.3222	0.3222
1984	0	0.0157	0.2257	0.3435	0.3698	0.372	0.3722	0.4842	0.4842
1985	0	0.02578	0.2835	0.4295	0.47	0.4613	0.5082	0.5898	0.5898
1986	0	0.02289	0.266	0.3859	0.4322	0.4383	0.5045	0.5792	0.5792
1987	0	0.01924	0.2432	0.3404	0.3915	0.402	0.4276	0.454	0.454
1988	0	0.01677	0.2266	0.3117	0.372	0.3937	0.4285	0.4634	0.4634
1989	0	0.0171	0.2281	0.3047	0.3608	0.3748	0.3939	0.4201	0.4201
1990	0	0.01321	0.2012	0.2578	0.2942	0.2999	0.2795	0.3045	0.3045
1991	0	0.01805	0.2342	0.29	0.3088	0.2961	0.2678	0.2595	0.2595
1992	0	0.02508	0.2746	0.3495	0.372	0.3515	0.3655	0.3569	0.3569
1993	0	0.03578	0.3265	0.4381	0.4587	0.4073	0.4379	0.4181	0.4181
1994	0	0.03395	0.3198	0.4615	0.4796	0.4002	0.3905	0.3411	0.3411
1995	0	0.0222	0.2588	0.4086	0.4318	0.3894	0.3956	0.3299	0.3299
1996	0	0.004572	0.1196	0.1974	0.2083	0.1978	0.1467	0.1123	0.1123
1997	0	0.003259	0.1011	0.1754	0.1886	0.1832	0.1402	0.1077	0.1077
1998	0	0.005428	0.1259	0.222	0.2381	0.236	0.211	0.1387	0.1387
1999	0	0.005196	0.1155	0.2133	0.2278	0.2234	0.1829	0.1143	0.1143
2000	0	0.004942	0.106	0.2028	0.2305	0.2318	0.19	0.1238	0.1238
2001	0	0.003221	0.08161	0.1637	0.2016	0.2202	0.1939	0.1604	0.1604
2002	0	0.002514	0.06852	0.1404	0.1839	0.2103	0.1912	0.167	0.167
2003	0	0.002641	0.06744	0.1441	0.2035	0.2499	0.2454	0.2113	0.2113
2004	0	0.002135	0.06052	0.1397	0.2164	0.29	0.3557	0.3198	0.3198
2005	0	0.00364	0.07347	0.1638	0.2577	0.3492	0.5108	0.5369	0.5369
2006	0	0.004445	0.07757	0.1628	0.2452	0.3184	0.4352	0.4961	0.4961
2007	0	0.00466	0.07455	0.1502	0.2177	0.2754	0.3567	0.4248	0.4248
2008	0	0.004325	0.06691	0.1111	0.1463	0.1758	0.1717	0.2148	0.2148
2009	0	0.002147	0.04632	0.06822	0.08584	0.1031	0.07622	0.1028	0.1028
2010	0	0.002424	0.04848	0.07285	0.08683	0.1012	0.07178	0.08542	0.08542
2011	0	0.002954	0.05436	0.08945	0.1095	0.1281	0.1006	0.1107	0.1107
2012	0	0.006801	0.08007	0.1457	0.1856	0.2194	0.2361	0.2558	0.2558
2013	0	0.006259	0.07537	0.15	0.2099	0.2643	0.3393	0.3926	0.3926
2014	0	0.004657	0.0687	0.144	0.2081	0.2619	0.3222	0.3899	0.3899
2015	0	0.002388	0.05432	0.1232	0.193	0.2694	0.3939	0.5383	0.5383
2016	0	0.002021	0.05371	0.135	0.2104	0.29	0.4447	0.6507	0.6507
2017	0	0.001393	0.04564	0.1228	0.1888	0.2428	0.3129	0.4556	0.4556
2018	0	0.00176	0.05247	0.1373	0.2135	0.2777	0.381	0.5466	0.5466
2019	0	0.001435	0.0491	0.1218	0.1771	0.234	0.317	0.47	0.47
2020	0	0.003909	0.08063	0.1631	0.198	0.2292	0.2902	0.4362	0.4362
2021	0	0.004445	0.09035	0.1722	0.1982	0.2227	0.2391	0.3553	0.3553
2022	0	0.009723	0.1313	0.2311	0.248	0.2619	0.2918	0.3695	0.3695
2023	0	0.009717	0.1313	0.231	0.248	0.2618	0.2917	0.3694	0.3694

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	0.003506	6.666e-05	2.801e-05	0	0	0	0	0	0
1948	0.003446	6.45e-05	2.721e-05	0	0	0	0	0	0
1949	0.003826	7.863e-05	3.24e-05	0	0	0	0	0	0
1950	0.004209	9.423e-05	3.802e-05	0	0	0	0	0	0
1951	0.004619	0.0001124	4.442e-05	0	0	0	0	0	0
1952	0.005063	0.0001337	5.178e-05	0	0	0	0	0	0
1953	0.005543	0.0001588	6.027e-05	0	0	0	0	0	0
1954	0.006305	0.0001994	7.368e-05	0	0	0	0	0	0
1955	0.006477	0.0002155	7.89e-05	0	0	0	0	0	0
1956	0.006539	0.000227	8.26e-05	0	0	0	0	0	0
1957	0.007167	0.0002698	9.62e-05	0	0	0	0	0	0
1958	0.008159	0.0003391	0.0001177	0	0	0	0	0	0
1959	0.01097	0.0005447	0.0001787	0	0	0	0	0	0
1960	0.01479	0.0008781	0.0002723	0	0	0	0	0	0
1961	0.01699	0.001117	0.0003366	0	0	0	0	0	0
1962	0.01496	0.0009606	0.0002944	0	0	0	0	0	0
1963	0.01757	0.001264	0.0003751	0	0	0	0	0	0
1964	0.01931	0.001507	0.0004378	0	0	0	0	0	0
1965	0.02046	0.0017	0.0004869	0	0	0	0	0	0
1966	0.02626	0.002544	0.0006945	0	0	0	0	0	0
1967	0.03162	0.003465	0.0009113	0	0	0	0	0	0
1968	0.03502	0.004165	0.001072	0	0	0	0	0	0
1969	0.03292	0.003933	0.001019	0	0	0	0	0	0
1970	0.0452	0.006484	0.001583	0	0	0	0	0	0
1971	0.05605	0.009205	0.002156	0	0	0	0	0	0
1972	0.07074	0.01339	0.003001	0	0	0	0	0	0
1973	0.08206	0.01716	0.00373	0	0	0	0	0	0
1974	0.1043	0.02509	0.005206	0	0	0	0	0	0
1975	0.1209	0.03192	0.006419	0	0	0	0	0	0
1976	0.1195	0.032	0.0064	0	0	0	0	0	0
1977	0.1256	0.03508	0.006885	0	0	0	0	0	0
1978	0.1516	0.04767	0.009243	0	0	0	0	0	0
1979	0.1768	0.06139	0.01183	0	0	0	0	0	0
1980	0.2048	0.07769	0.01492	0	0	0	0	0	0
1981	0.3007	0.1469	0.02583	0	0	0	0	0	0
1982	0.2999	0.1519	0.02685	0	0	0	0	0	0
1983	0.289	0.1551	0.02794	0	0	0	0	0	0
1984	0.2214	0.1148	0.02208	0	0	0	0	0	0
1985	0.1755	0.09365	0.01934	0	0	0	0	0	0
1986	0.1526	0.08485	0.01871	0	0	0	0	0	0
1987	0.1688	0.1085	0.02446	0	0	0	0	0	0
1988	0.161	0.1101	0.02593	0	0	0	0	0	0
1989	0.1583	0.1151	0.02858	0	0	0	0	0	0
1990	0.1469	0.1093	0.02911	0	0	0	0	0	0
1991	0.1725	0.1442	0.04015	0	0	0	0	0	0
1992	0.2154	0.2058	0.05659	0	0	0	0	0	0
1993	0.2192	0.2153	0.06009	0	0	0	0	0	0
1994	0.1681	0.1431	0.04214	0	0	0	0	0	0
1995	0.1429	0.1182	0.03512	0	0	0	0	0	0
1996	0.09484	0.06951	0.02185	0	0	0	0	0	0
1997	0.05509	0.03242	0.01147	0	0	0	0	0	0
1998	0.04565	0.02595	0.009194	0	0	0	0	0	0
1999	0.04155	0.02153	0.007748	0	0	0	0	0	0
2000	0.04143	0.02127	0.00746	0	0	0	0	0	0
2001	0.03035	0.01173	0.00438	0	0	0	0	0	0
2002	0.04163	0.02225	0.007903	0	0	0	0	0	0
2003	0.04746	0.02883	0.009468	0	0	0	0	0	0
2004	0.0554	0.0364	0.01138	0	0	0	0	0	0
2005	0.06522	0.04509	0.01299	0	0	0	0	0	0
2006	0.05103	0.02666	0.007573	0	0	0	0	0	0
2007	0.04108	0.01732	0.004826	0	0	0	0	0	0
2008	0.04106	0.01666	0.004136	0	0	0	0	0	0
2009	0.03771	0.01407	0.003026	0	0	0	0	0	0
2010	0.03634	0.01237	0.002284	0	0	0	0	0	0
2011	0.03677	0.01186	0.001855	0	0	0	0	0	0
2012	0.04748	0.01898	0.003044	0	0	0	0	0	0
2013	0.04913	0.02026	0.003489	0	0	0	0	0	0
2014	0.05277	0.02019	0.003205	0	0	0	0	0	0
2015	0.06007	0.0216	0.002966	0	0	0	0	0	0
2016	0.0686	0.02355	0.002864	0	0	0	0	0	0
2017	0.063	0.01824	0.002042	0	0	0	0	0	0
2018	0.05153	0.01097	0.001072	0	0	0	0	0	0
2019	0.04063	0.00665	0.0006133	0	0	0	0	0	0
2020	0.0441	0.007269	0.00072	0	0	0	0	0	0
2021	0.05022	0.01023	0.0009639	0	0	0	0	0	0
2022	0.05659	0.01411	0.001262	0	0	0	0	0	0
2023	0.05657	0.0141	0.001262	0	0	0	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	0.0002427	0.001588	0.0001085	0.0004687	0.0004687	0.0004687	0	0
1948	0	0.0002351	0.001541	0.0001042	0.0004536	0.0004536	0.0004536	0	0
1949	0	0.0009431	0.003465	0.0003104	0.001107	0.001107	0.001107	0	0
1950	0	0.00432	0.008554	0.00105	0.003005	0.003005	0.003005	0	0
1951	0	0.02176	0.02266	0.003898	0.008808	0.008808	0.008808	0	0
1952	0	0.04658	0.03536	0.006417	0.01197	0.01197	0.01197	0	0
1953	0	0.07012	0.04407	0.008203	0.01335	0.01335	0.01335	0	0
1954	0	0.09087	0.05068	0.009435	0.01376	0.01376	0.01376	0	0
1955	0	0.1434	0.06888	0.01375	0.01782	0.01782	0.01782	0	0
1956	0	0.1568	0.07622	0.01411	0.01608	0.01608	0.01608	0	0
1957	0	0.1741	0.07907	0.01452	0.0161	0.0161	0.0161	0	0
1958	0	0.1609	0.07997	0.01485	0.01608	0.01608	0.01608	0	0
1959	0	0.1901	0.08724	0.01516	0.01496	0.01496	0.01496	0	0
1960	0	0.1875	0.08518	0.01295	0.01148	0.01148	0.01148	0	0
1961	0	0.1714	0.08414	0.01326	0.01194	0.01194	0.01194	0	0
1962	0	0.1012	0.05207	0.007253	0.007146	0.007146	0.007146	0	0
1963	0	0.135	0.05791	0.008006	0.007073	0.007073	0.007073	0	0
1964	0	0.2395	0.07845	0.01314	0.01141	0.01141	0.01141	0	0
1965	0	0.2375	0.07743	0.01362	0.01203	0.01203	0.01203	0	0
1966	0	0.2229	0.06886	0.01182	0.01048	0.01048	0.01048	0	0
1967	0	0.2425	0.06659	0.0117	0.01037	0.01037	0.01037	0	0
1968	0	0.2383	0.06693	0.01214	0.01045	0.01045	0.01045	0	0
1969	0	0.2511	0.06602	0.01212	0.01035	0.01035	0.01035	0	0
1970	0	0.2569	0.06566	0.01243	0.01038	0.01038	0.01038	0	0
1971	0	0.3947	0.08052	0.0166	0.01282	0.01282	0.01282	0	0
1972	0	0.5193	0.09655	0.02218	0.01604	0.01604	0.01604	0	0
1973	0	0.5244	0.09347	0.02236	0.01619	0.01619	0.01619	0	0
1974	0	0.3914	0.07477	0.01683	0.01276	0.01276	0.01276	0	0
1975	0	0.2548	0.05445	0.01129	0.008963	0.008963	0.008963	0	0
1976	0	0.1429	0.03543	0.006519	0.005552	0.005552	0.005552	0	0
1977	0	0.07771	0.02195	0.00349	0.003216	0.003216	0.003216	0	0
1978	0	0.06279	0.01951	0.003	0.002761	0.002761	0.002761	0	0
1979	0	0.05738	0.01862	0.002835	0.002534	0.002534	0.002534	0	0
1980	0	0.05114	0.01752	0.002616	0.002276	0.002276	0.002276	0	0
1981	0	0.068	0.02005	0.003362	0.002988	0.002988	0.002988	0	0
1982	0	0.07486	0.02127	0.003999	0.003635	0.003635	0.003635	0	0
1983	0	0.0886	0.0236	0.005035	0.004855	0.004855	0.004855	0	0
1984	0	0.105	0.02637	0.006417	0.006459	0.006459	0.006459	0	0
1985	0	0.1862	0.03803	0.0114	0.01102	0.01102	0.01102	0	0
1986	0	0.2054	0.04148	0.01312	0.01267	0.01267	0.01267	0	0
1987	0	0.2531	0.04843	0.01676	0.01616	0.01616	0.01616	0	0
1988	0	0.3339	0.05723	0.02116	0.0196	0.0196	0.0196	0	0
1989	0	0.2837	0.05569	0.02086	0.0188	0.0188	0.0188	0	0
1990	0	0.2397	0.05459	0.02023	0.01679	0.01679	0.01679	0	0
1991	0	0.1776	0.05423	0.0218	0.01687	0.01687	0.01687	0	0
1992	0	0.1478	0.05206	0.02235	0.01634	0.01634	0.01634	0	0
1993	0	0.1217	0.04977	0.02398	0.01647	0.01647	0.01647	0	0
1994	0	0.07712	0.04016	0.02088	0.01418	0.01418	0.01418	0	0
1995	0	0.06875	0.03783	0.02204	0.01421	0.01421	0.01421	0	0
1996	0	0.06087	0.03477	0.02124	0.01281	0.01281	0.01281	0	0
1997	0	0.04118	0.02945	0.01789	0.01021	0.01021	0.01021	0	0
1998	0	0.04676	0.02849	0.0141	0.008171	0.008171	0.008171	0	0
1999	0	0.03511	0.0261	0.01198	0.006798	0.006798	0.006798	0	0
2000	0	0.03418	0.02576	0.01074	0.005789	0.005789	0.005789	0	0
2001	0	0.02115	0.01587	0.003149	0.0009853	0.0009853	0.0009853	0	0
2002	0	0.008822	0.008746	0.0009943	0.0003716	0.0003716	0.0003716	0	0
2003	0	0.01381	0.01537	0.003182	0.002013	0.002013	0.002013	0	0
2004	0	0.009437	0.01486	0.002709	0.00207	0.00207	0.00207	0	0
2005	0	0.02048	0.02238	0.00361	0.001564	0.001564	0.001564	0	0
2006	0	0.01878	0.01795	0.002327	0.0008255	0.0008255	0.0008255	0	0
2007	0	0.01907	0.01548	0.0012	0.0003534	0.0003534	0.0003534	0	0
2008	0	0.01099	0.009976	0.0005904	0.000168	0.000168	0.000168	0	0
2009	0	0.005809	0.005299	0.0002223	9.288e-05	9.288e-05	9.288e-05	0	0
2010	0	0.006637	0.006258	0.0002147	7.302e-05	7.302e-05	7.302e-05	0	0
2011	0	0.00538	0.007986	0.0004994	0.0001627	0.0001627	0.0001627	0	0
2012	0	0.00761	0.009996	0.0007136	0.0002349	0.0002349	0.0002349	0	0
2013	0	0.007761	0.01126	0.0008549	0.0002053	0.0002053	0.0002053	0	0
2014	0	0.005568	0.01067	0.001226	0.000295	0.000295	0.000295	0	0
2015	0	0.005255	0.01149	0.002339	0.0008804	0.0008804	0.0008804	0	0
2016	0	0.003348	0.007032	0.0009424	0.0003172	0.0003172	0.0003172	0	0
2017	0	0.007062	0.01088	0.001527	0.0004604	0.0004604	0.0004604	0	0
2018	0	0.005088	0.008928	0.001126	0.0002837	0.0002837	0.0002837	0	0
2019	0	0.005346	0.009009	0.001008	0.0001304	0.0001304	0.0001304	0	0
2020	0	0.003404	0.009675	0.002155	0.0005325	0.0005325	0.0005325	0	0
2021	0	0.00116	0.005965	0.001431	0.0007752	0.0007752	0.0007752	0	0
2022	0	6.45e-05	0.000946	0.0001086	0.0001083	0.0001083	0.0001083	0	0
2023	0	6.45e-05	0.000946	0.0001086	0.0001083	0.0001083	0.0001083	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	38197927	22290221	65458374	8034897	6296349	10253491	4899103	3648033	6579220	852432	727307	999083	0.1341	0.09737	0.1847	581760
1948	34933781	21421026	56970616	7001338	5523445	8874667	4104753	3082907	5465296	661917	572286	765585	0.1248	0.09173	0.1699	502100
1949	29878200	18468536	48336633	6611595	5269343	8295758	3854908	2930988	5070072	727966	629704	841561	0.1508	0.1117	0.2036	508500
1950	40090649	25038849	64190654	6356589	5121550	7889453	3705057	2859801	4800141	647341	568034	737721	0.1542	0.1163	0.2046	491700
1951	38623757	24376187	61198850	6291123	5127981	7718092	3387421	2640911	4344949	748816	657942	852240	0.191	0.1462	0.2496	600400
1952	38964890	24769335	61296059	6110247	4998387	7469433	3238549	2527921	4148943	835297	736586	947236	0.2174	0.1666	0.2837	664400
1953	42922409	27904152	66023621	5905796	4845015	7198828	3025144	2357292	3882207	833875	732606	949142	0.2277	0.1747	0.2967	698500
1954	38548856	25138435	59113239	5749318	4724798	6995993	2777460	2143930	3598198	947785	828607	1084106	0.2758	0.2105	0.3615	762900
1955	34863082	22900348	53074936	5483668	4498347	6684815	2807308	2172802	3627104	845290	718506	994446	0.2411	0.184	0.3161	806400
1956	26292124	17217892	40148688	5067191	4173473	6152294	2627430	2041990	3380717	833188	710745	976725	0.2466	0.1886	0.3225	675200
1957	61098438	39548353	94391268	5024432	4146796	6087812	2387840	1851868	3078933	804427	692091	934996	0.2709	0.2081	0.3526	682900
1958	26427650	17379874	40185601	5017311	4113817	6119235	2023479	1570565	2607002	745896	594926	935176	0.2435	0.1876	0.316	670500
1959	27447382	17323329	43488106	5584229	4583571	6803344	2980596	2309205	3847190	1131372	925090	1383652	0.2922	0.2251	0.3794	784500
1960	13060781	8394726	20320378	4723706	3905200	5713765	2612996	2037095	3351708	805883	679040	956420	0.2408	0.1867	0.3104	696200
1961	53135861	34406688	82060200	4787085	3994558	5736850	2548959	2023484	3210894	722496	612181	852689	0.258	0.2022	0.3294	696700
1962	28741141	19114042	43217086	4506788	3771016	5386118	1782993	1403816	2264587	711510	601223	842027	0.3124	0.2477	0.3941	627800
1963	30866220	20699327	46026790	5200371	4337355	6235103	2861440	2283979	3584901	592984	484099	726360	0.1827	0.147	0.2271	716000
1964	33675086	22588478	50203090	5128420	4440676	5922678	2595917	2154631	3127584	904084	755922	1081287	0.2811	0.2328	0.3395	871200
1965	18371597	12348602	27332292	4552374	4020000	5155251	1953934	1652422	2310461	1277858	1096903	1488665	0.5305	0.4468	0.6299	1168800
1966	17830172	12023307	26441563	3449638	3051734	3899422	1589454	1350279	1870993	923567	800944	1064962	0.4939	0.4188	0.5825	895500
1967	23864634	16012493	35567276	2666529	2372930	2996455	960748	823851	1120393	855839	743320	985389	0.7013	0.6032	0.8153	695500
1968	22813125	15368327	33864368	2204184	1927391	2520727	517845	442744	605685	828357	700269	979873	1.071	0.9381	1.222	717800
1969	13368585	8925614	20023168	1721258	1477736	2004910	465516	380660	569287	542279	444041	662250	0.9139	0.7951	1.051	546700
1970	21897578	14541840	32974090	1658412	1427061	1927269	458385	373524	562527	529832	442872	633866	0.9457	0.8252	1.084	563100
1971	18626897	12270474	28276110	1510840	1273806	1791982	288045	237056	350002	542112	428167	686380	1.433	1.266	1.622	520100
1972	12798736	8426899	19438662	1357012	1143024	1611062	342103	279836	418226	411840	308804	549255	0.5843	0.4998	0.6831	497500
1973	7149343	4744947	10772115	1118072	963306	1297703	282555	234943	339817	450670	365282	556019	0.9335	0.8143	1.07	484000
1974	10039938	6568380	15346305	771543	666023	893781	192262	160920	229709	273958	228583	328340	0.8957	0.7787	1.03	275100
1975	2704422	1775554	4119222	587169	490511	702874	104971	86732	127046	243113	191752	308232	1.19	1.025	1.381	312800
1976	3487261	2230808	5451384	448730	371319	542279	140977	105949	187586	151594	124793	184152	0.8547	0.6697	1.091	174800
1977	4046796	2563529	6388286	321850	257662	402028	113105	82175	155678	53681	44584	64633	0.3199	0.2332	0.4387	46000
1978	4656229	2919232	7426772	383589	301580	487898	143074	106784	191697	49035	32147	74796	0.2174	0.1336	0.354	11000
1979	8559482	5563545	13168715	506146	408958	626430	186906	145413	240238	61722	40896	93153	0.1752	0.1072	0.2863	25100
1980	13221185	8993259	19436751	690706	571941	834133	218157	175336	271436	81451	63128	105091	0.1534	0.1205	0.1951	70764
1981	26064880	17666667	38455356	1102425	909512	1336257	285288	229988	353886	139511	109581	177615	0.248	0.1981	0.3107	174879
1982	44214530	30061343	65031184	1703246	1398864	2073859	408535	332859	501415	230246	168012	315532	0.1778	0.1438	0.22	275079
1983	43417286	30149787	62523186	2311844	1940981	2753567	570126	468535	693745	362278	276098	475356	0.2612	0.2147	0.3178	387202
1984	45202724	31622388	64615177	3067968	2626583	3583526	895110	735136	1089897	464611	384141	561937	0.3515	0.2922	0.4229	428631
1985	57387293	40048780	82232252	3530626	3044841	4093915	964491	801919	1160021	624116	531577	732764	0.4509	0.376	0.5407	613780
1986	70354209	48975641	101064828	4017615	3446204	4683771	1005533	840566	1202877	744647	595541	931085	0.4276	0.3561	0.5135	671488
1987	58504757	40780529	83932373	3981166	3439738	4607817	1213457	1014004	1452143	757712	619514	926739	0.3886	0.3244	0.4654	792058
1988	38457571	26842187	55099263	3901431	3404785	4470521	1564139	1311992	1864744	934304	754164	1157473	0.3791	0.3183	0.4515	887686
1989	29986887	20981039	42858384	3489774	3100760	3927594	1608047	1384327	1867922	813006	692481	954508	0.3648	0.3086	0.4312	787899
1990	28067349	19648947	40092535	3464410	3084180	3891515	1724688	1489799	1996611	676926	579439	790814	0.2974	0.2505	0.3531	645229
1991	29743046	20867426	42393766	3290550	2933531	3691019	1530703	1327500	1765011	678150	583337	788374	0.3127	0.2631	0.3718	658008
1992	49471609	35712524	68531704	3242668	2882143	3648292	1164147	1006226	1346851	686332	590992	797051	0.3786	0.3191	0.4493	716799
1993	51161183	36612485	71491095	2998495	2635642	3411302	821854	702246	961834	664956	569295	776691	0.4503	0.3781	0.5364	671397
1994	41358269	29596119	57794957	2916317	2529679	3362051	889508	758185	1043577	640183	537208	762897	0.4395	0.3679	0.525	568234
1995	41230862	29429656	57764317	2798034	2423879	3229944	933010	788052	1104631	572251	490903	667081	0.4044	0.3352	0.4878	579371
1996	33551944	24194371	46528713	2753882	2381715	3184205	1099387	930557	1298848	284036	243770	330953	0.1972	0.1621	0.24	275098
1997	27887113	20045424	38796440	2756877	2401794	3164456	1233691	1052083	1446647	265295	231140	304497	0.1756	0.145	0.2126	248023
1998	19347856	14101311	26546435	3052974	2675684	3483463	1408671	1211785	1637547	368039	320559	422551	0.2219	0.1838	0.2677	385577
1999	53808573	39239721	73786522	3131498	2755999	3558159	1507586	1296606	1752896	351524	306620	403003	0.2058	0.1712	0.2474	370877
2000	38547655	28211338	52671083	3737198	3266186	4276133	1543229	1329211	1791706	366240	320484	418529	0.2045	0.1699	0.2461	382794
2001	67519175	48821895	93376937	4178532	3654097	4778234	1930621	1663850	2240165	352723	309970	401374	0.1775	0.1472	0.214	358657
2002	35428470	25883559	48493194	5004317	4362693	5740306	2365262	2038593	2744277	370568	324691	422927	0.1626	0.135	0.1959	371955
2003	19130795	1.4e+07	26134193	5354304	4683599	6121056	2382492	2066349	2747003	476090	418812	541201	0.1889	0.1574	0.2267	480107
2004	23222546	16990702	31740104	4659203	4113607	5277163	2371021	2060926	2727775	552168	485626	627829	0.2195	0.1823	0.2643	570865

2005	20239769	14866839	27554494	3901199	3465642	4391497	2143504	1854310	2477799	653245	574146	743242	0.2797	0.2334	0.3353	666404
2006	21168571	15496944	28915918	3270615	2905884	3681124	1728072	1496200	1995877	514904	453671	584402	0.2539	0.2116	0.3047	524366
2007	24926578	18148081	34236912	2727715	2416379	3079165	1373153	1185796	1590114	385872	339938	438013	0.2194	0.1823	0.2641	408528
2008	22857234	16600099	31472892	2768730	2431914	3152195	1449870	1252177	1678774	251905	223312	284160	0.1374	0.1141	0.1655	259031
2009	34427466	25068755	47279987	3195256	2793518	3654769	1767489	1524041	2049825	172375	152645	194655	0.0777	0.0642	0.09404	172685
2010	28284153	20654624	38731922	3777977	3307389	4315523	1848853	1592262	2146792	178887	158512	201881	0.07803	0.06468	0.09414	187508
2011	24804130	18156267	33886088	3840375	3387223	4354152	2242477	1954046	2573482	222920	197353	251800	0.09858	0.08216	0.1183	224148
2012	23680038	17302246	32408751	3799456	3371223	4282084	2315696	2020289	2654298	417562	369534	471833	0.1762	0.1472	0.211	437236
2013	32906186	23914029	45279576	3686035	3283523	4137888	2103198	1837057	2407896	494334	438097	557791	0.211	0.1765	0.2522	511733
2014	46804732	33806903	64799871	3912295	3477873	4400980	2068339	1805659	2369232	492385	436956	554846	0.2042	0.1706	0.2443	517593
2015	13300233	9639245	18351664	4121335	3632454	4676013	1963949	1711503	2253632	483942	428912	546033	0.2107	0.1755	0.2528	494072
2016	22681856	16576092	31036664	4113554	3613087	4683344	2275739	1969702	2629325	541156	479227	611088	0.2291	0.1904	0.2757	564880
2017	13952021	10143527	19190453	3566742	3139124	4052612	2109847	1818123	2448380	446797	391768	509557	0.1858	0.1547	0.2231	499145
2018	24172777	17629825	33144011	3333144	2946739	3770219	1855787	1597714	2155546	530445	462625	608206	0.2148	0.179	0.2578	604449
2019	21678404	15777301	29786667	2856438	2530060	3224920	1584861	1368585	1835314	418402	365765	478613	0.182	0.1511	0.2193	451542
2020	25571817	18512155	35323703	2834104	2503448	3208434	1535359	1325882	1777932	408261	358776	464572	0.1951	0.1621	0.2347	434000
2021	17223642	12095937	24525081	2766752	2424741	3157004	1459950	1252989	1701096	358702	315845	407375	0.1867	0.1542	0.2259	373167
2022	31077671	20751960	46541225	2996059	2576018	3484590	1591864	1331754	1902777	440436	386742	501585	0.2333	0.1878	0.2899	462596
2023	30861278	16414816	58021878	2946475	2378506	3650069	1404532	1061059	1859189	394927	213998	728827	0.2333	0.1145	0.4752	.

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 ).  Mon Mar 20 08:09:58 2023"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2023         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 sumFleet
       6        6        6        7

Slot "plus.group":
plusgroup
     TRUE

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 -1 -1 -1 -1 -1 -1
  catch C  -1 10 11 12 13 13 13 -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
  sumFleet -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
  sumFleet -1 -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
  sumFleet -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 -1 -1 -1 -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
  sumFleet -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 -1 -1 -1 -1 -1 -1
  catch C  -1  6  6  7  7  7  7 -1 -1
  HERAS    -1  8  9 10 11 11 11 12 12
  IBTS-Q1  -1 13 -1 -1 -1 -1 -1 -1 -1
  IBTS0    14 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  15 15 16 16 16 16 -1 -1 -1
  LAI-ORSH 17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  17 -1 -1 -1 -1 -1 -1 -1 -1
  sumFleet -1 -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
  sumFleet  -1  -1  -1  -1  -1  -1  -1  -1

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

Slot "biomassTreat":
 [1] -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 LN
Levels: LN ALN

Slot "fixVarToWeight":
[1] FALSE

Slot "simulate":
[1] FALSE

Slot "residuals":
[1] TRUE

Slot "sumFleets":
[1] "A"  "BD" "C"
```

Table 2.7.1. North Sea herring. Intermediate year (2023) assumptions for the stock.

Variable	Value	Notes
Fages (wr) 2–6 (2023)	0.238	Based on estimated catch 2022
SSB (2023)	1 480 607	Calculated based on catch constraint (in tonnes)
Rage (wr) 0 (2023)	31 349 395	Estimated by assessment model (in thousands)
Rage (wr) 0 (2024)	23 566 820	Weighted mean over 2012–2021 (in thousands)
Total catch (2023)	422 211	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 (2023), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	396 556	
	B-fleet TAC	7716	
	C-fleet TAC	23 250	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	0.944	Taken from ImY as % of C-fleet TAC
	C-fleet transfer ImY	21 971	Value for the Intermediate year in tonnes
	D-fleet transfer	0.5	Value for the Intermediate year in %
	WBSS/NSAS split in the North Sea	0.0126	Value from terminal year
	B-fleet uptake	0.75	Average over the last 3 years (2019-2021)
	C-fleet NSAS/WBSS split	0.43	Average over the last 3 years (2019-2021)
	D-fleet NSAS/WBSS split	0.7	Average over the last 3 years (2019-2021)
	D-fleet uptake	0.038	Average over the last 3 years (2019-2021)
F by fleet and total	$F_{(wr)\ 2–6}$ A-fleet	0.237	
	$F_{(wr)\ 0–1}$ B-fleet	0.024	
	$F_{(wr)\ 1–3}$ C-fleet	0	
	$F_{(wr)\ 0–1}$ D-fleet	0.001	
	$F_{(wr)\ 2–6}$	0.238	

	$F_{(wr)\ 0\text{–}1}$	0.03	
NSAS catches by fleet	Catches A-fleet	413 245	Fleet TAC (396 556 t) + C-fleet TAC transfer to the North Sea (21 971 t), scaled by the 3-year average proportion of NSAS in A-fleet catch (98.7%, 2020-2022)
	Catches B-fleet	8279	Fleet TAC (7716 t) + D-fleet TAC transfer (50%) to the North Sea (3330 t), scaled with the fleet uptake in 2022 (75%)
	Catches C-fleet	331	Fleet catches in 3.a of 770 t (310 t agreed maximum Norwegian catch and 47.5% (proportion of C-fleet EU catches in the total EU catches in 3.a in 2022) of 969 t agreed maximum EU catch), scaled by the 3-year average proportion of NSAS in the C-fleet catch (43%, 2020-2022)
	Catches D-fleet	335	Fleet catches based on 52.5% (proportion of D-fleet catches in the total EU catches in 3.a in 2022) of 969 t agreed maximum EU catch, scaled by the 3-year average proportion of NSAS in the D-fleet catch (70%, 2020-2022)

Table 2.7.3. North Sea herring. reference points.

wg	fmsy	Fsq	Flim	Fpa	Blim	Bpa	msyBtrigger
IBPNSherring2023	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.

TACs to catches variables.

value	description	basis
0.945	C-fleet transfer forecast year	Value for the forecast year
21971	C-fleet transfer intermediate year	Value for the Intermediate year
0.5	D-fleet transfer intermediate year	Value for the Intermediate year
0.4303	C-fleet NSAS/WBSS split	Average over the last 3 years
0.6976	D-fleet NSAS/WBSS split	Average over the last 3 years
0.01262	WBSS/NSAS split in the north sea	Value from terminal year
0.7496	B-fleet uptake	Average over the last 3 years
0.03774	D-fleet uptake	Average over the last 3 years
0.4745	C-fleet share of EU in 3a	Average over the last 3 years
0.5255	D-fleet share of EU in 3a	Average over the last 3 years

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
intermediate year	0.2373	0.02412	0.0004108	0.001035	0.2378	0.03014	413245	8279	331.3	355.2	1480607	.
fmsyAR_transfer	0.3098	0.03149	1.807e-09	3.373e-07	0.31	0.03795	522833	9334	0.002367	0.1	1482555	1549993
fmsyAR_transfer_Btarget	0.3097	0.04354	1.807e-09	8.927e-09	0.31	0.05	522657	12838	0.002367	0.002632	1482489	1547420
fmsyAR_no_transfer	0.3098	0.03149	3.284e-08	8.879e-09	0.31	0.03795	522832	9334	0.04303	0.002632	1482555	1549993
fmsyAR_transfer_TACrule	0.3094	0.02953	0.0005326	1.176e-07	0.31	0.03604	522179	8762	697.6	0.03488	1482392	1549823
fmsyAR_transfer_TACrule_notransfer	0.3098	0.03149	4.108e-20	2.353e-07	0.31	0.03795	522832	9334	5.383e-14	0.06976	1482555	1549993
fmsyAR_no_transfer_Btarget	0.3097	0.04354	3.285e-08	8.927e-09	0.31	0.05	522657	12838	0.04303	0.002632	1482489	1547420
mpA	0.2297	0.0452	0	0	0.23	0.04999	401862	13345	0	0	1560589	1710328
mpAC	0.2297	0.0452	0	0	0.23	0.04999	401862	13345	0	0	1560589	1710328
mpAD	0.2297	0.0452	0	0	0.23	0.04999	401862	13345	0	0	1560589	1710328
mpB	0.2198	0.04534	0	0	0.2201	0.04993	386288	13388	0	0	1570565	1731995
fmsy	0.3098	0.03149	3.284e-08	8.879e-09	0.31	0.03795	522832	9334	0.04303	0.002632	1482555	1549993
nf	0	0	0	0	0	0	0	0	0	0	1812157	2329793
tacro	0.2262	0.023	3.206e-08	8.828e-09	0.2264	0.02772	396556	6857	0.04303	0.002632	1564316	1723062
-15%	0.189	0.01922	3.172e-08	8.805e-09	0.1892	0.02316	337073	5745	0.04303	0.002632	1602331	1807945
+15%	0.2648	0.02691	3.242e-08	8.852e-09	0.265	0.03244	456039	8004	0.04303	0.002632	1525984	1640331
fsq	0.2376	0.02415	3.217e-08	8.835e-09	0.2378	0.02911	414291	7195	0.04303	0.002632	1552921	1698171
fpa	0.3098	0.03149	3.284e-08	8.879e-09	0.31	0.03795	522832	9334	0.04303	0.002632	1482555	1549993

flim	0.3997	0.04063	3.369e-08	8.935e-09	0.4	0.04897	648316	11969	0.04303	0.002632	1399814	1387573
bpa	1.012	0.1028	3.968e-08	9.311e-09	1.013	0.124	1281303	29074	0.04303	0.002632	956483	711127
blim	1.161	0.118	4.119e-08	9.402e-09	1.161	0.1422	1391641	33025	0.04303	0.002632	874198	616998
MSYBtrigger	0.6008	0.06107	3.561e-08	9.059e-09	0.6012	0.07361	894497	17745	0.04303	0.002632	1232828	1096403

Table 2.7.5. North Sea herring. All scenarios with status quo in C-D fleet catches.

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
intermediate year	0.2373	0.02412	0.0004108	0.001035	0.2378	0.03014	413245	8279	331.3	355.2	1480607	.
fmsyAR_transfer	0.3183	0.04234	0.0004213	3.39e-07	0.3189	0.04902	534986	12489	550.4	0.1	1473968	1530359
fmsyAR_transfer_Btarget	0.3181	0.04437	0.0004214	0.000595	0.3188	0.05164	534809	13071	550.4	175.3	1474045	1529986
fmsyAR_no_transfer	0.3041	0.03091	0.007677	0.0005917	0.31	0.03851	513007	9157	10004	175.3	1480085	1541607
fmsyAR_no_transfer_Btarget	0.304	0.0424	0.007679	0.0005947	0.31	0.05	512838	12496	10004	175.3	1480024	1539182
mpA	0.2438	0.03372	0.0004124	0.00103	0.2443	0.03987	401820	13338	550.3	305.3	1546178	1681319
mpAC	0.2438	0.03372	0.0004124	0.00103	0.2443	0.03987	401820	13338	550.3	305.3	1546178	1681319
mpAD	0.2438	0.03372	0.0004124	0.00103	0.2443	0.03987	401820	13338	550.3	305.3	1546178	1681319
mpB	0.2337	0.03384	0.0004124	0.00103	0.2343	0.03978	386159	13388	551.9	305.4	1556239	1702904
fmsy	0.3041	0.03091	0.007677	0.0005917	0.31	0.03851	513007	9157	10004	175.3	1480085	1541607
nf	0	0	0	0	0	0	0	0	0	0	1812157	2329793
tacro	0.227	0.02307	0.007508	0.0005885	0.2327	0.02905	396556	6872	10004	175.3	1555602	1700867
-15%	0.1897	0.01928	0.007427	0.000587	0.1953	0.02446	337073	5757	10004	175.3	1593700	1785409
+15%	0.2657	0.027	0.007593	0.0005901	0.2715	0.0338	456039	8022	10004	175.3	1517185	1618484
fsq	0.232	0.02358	0.007519	0.0005887	0.2378	0.02967	404428	7022	10004	175.3	1550537	1689840
fpa	0.3041	0.03091	0.007677	0.0005917	0.31	0.03851	513007	9157	10004	175.3	1480085	1541607
flim	0.3939	0.04003	0.007876	0.0005954	0.4	0.04953	638516	11787	10004	175.3	1397246	1379183
bpa	0.9997	0.1016	0.009271	0.0006203	1.007	0.1239	1267111	28717	10004	175.3	956483	707361
blim	1.148	0.1166	0.009624	0.0006263	1.155	0.1421	1377288	32645	10004	175.3	874198	613333
MSYBtrigger	0.5911	0.06008	0.00832	0.0006035	0.5977	0.07374	880693	17450	10004	175.3	1232828	1092620

Table 2.7.6. North Sea herring. All scenarios with the implementation of the C fleet TAC rule for C fleet catches.

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
fmsyAR_transfer_TACrule	0.3093	0.04107	0.0005325	0.007896	0.31	0.05546	521896	12080	697.3	2323	1482286	1545680
fmsyAR_transfer_TACrule_notransfer	0.3022	0.03081	0.01004	0.01579	0.31	0.05377	509768	9064	13059	4645	1479260	1535900

Table 2.7.7. 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_no_transfer	0.31	0.031	0	0	0.31	0.038	522832	9334	0	0	532166	1482555	1549993	0.1	31.8	28.3
fmsy	0.31	0.031	0	0	0.31	0.038	522832	9334	0	0	532166	1482555	1549993	0.1	31.8	28.3
nf	0	0	0	0	0	0	0	0	0	0	0	1812157	2329793	22.4	-100	-100
tacro	0.227	0.023	0.008	0.001	0.233	0.029	396556	6872	10004	175	413607	1555602	1700867	5.1	0	-0.3
fsq	0.238	0.024	0	0	0.238	0.029	414291	7195	0	0	421486	1552921	1698171	4.9	4.5	1.6
fpa	0.31	0.031	0	0	0.31	0.038	522832	9334	0	0	532166	1482555	1549993	0.1	31.8	28.3
flim	0.4	0.041	0	0	0.4	0.049	648316	11969	0	0	660285	1399814	1387573	-5.5	63.5	59.1
bpa	1.012	0.103	0	0	1.013	0.124	1281303	29074	0	0	1310377	956483	711127	-35.4	223.1	215.8
blim	1.161	0.118	0	0	1.161	0.142	1391641	33025	0	0	1424666	874198	616998	-41	250.9	243.4
MSYBtrigger	0.601	0.061	0	0	0.601	0.074	894497	17745	0	0	912242	1232828	1096403	-16.7	125.6	119.9
fmsyAR_no_transfer_Btarget	0.31	0.044	0	0	0.31	0.05	522657	12838	0	0	535495	1482489	1547420	0.1	31.8	29.1
fmsyAR_transfer_TACrule	0.309	0.041	0.001	0.008	0.31	0.055	521896	12080	697	2323	536996	1482286	1545680	0.1	31.6	29.4
fmsyAR_transfer_TACrule_notransfer	0.302	0.031	0.01	0.016	0.31	0.054	509768	9064	13059	4645	536536	1479260	1535900	-0.1	28.5	29.3

Table 2.9.1. North Sea herring. Old and new reference points following WKNSHERRING 2021.

Frame-work ^	Reference point	Old Value	Old Technical basis	Old Source	New value	New basis
MSY approach	MSY $B_{trigger}$	1 400 000	5th percentile of B_{FMSY}	ICES (2018b)	1 232 828	unchanged
	F_{MSY}	0.26	Stochastic simulations with a segmented regression and Ricker stock–recruitment curve from the short time-series (2002–2016).	ICES (2018b)	0.31	Same rationale with extended time series (2002–2020)
Precautionary approach	B_{lim}	800 000	Breakpoint in the segmented regression of the stock–recruitment time-series (1947–2016).	ICES (2018b)	874 198	Breakpoint in the segmented regression of the stock–recruitment time-series (1947–2020, excluding the recovery period 1979-1990).
	B_{pa}	900 000	$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma)$ with $\sigma \approx 0.10$, based on the average *CV* from the terminal assessment year.	ICES (2018b)	956 483	$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma)$ with $\sigma \approx 0.06$, based on the σ from the terminal assessment year.
	F_{lim}	0.34	$F_{P50\%}$ leading to 50% probability of SSB > B_{lim} with a segmented regression and Ricker stock–recruitment curve (2002–2016).	ICES (2018b)	0.39	The F that on average leads to Blim
	F_{pa}	0.30	$F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$ with $\sigma \approx 0.08$, based on the average *CV* from the terminal assessment year.	ICES (2018b)	0.31	The F that provides a 95% probability for SSB to be above Blim (FP05 with AR)

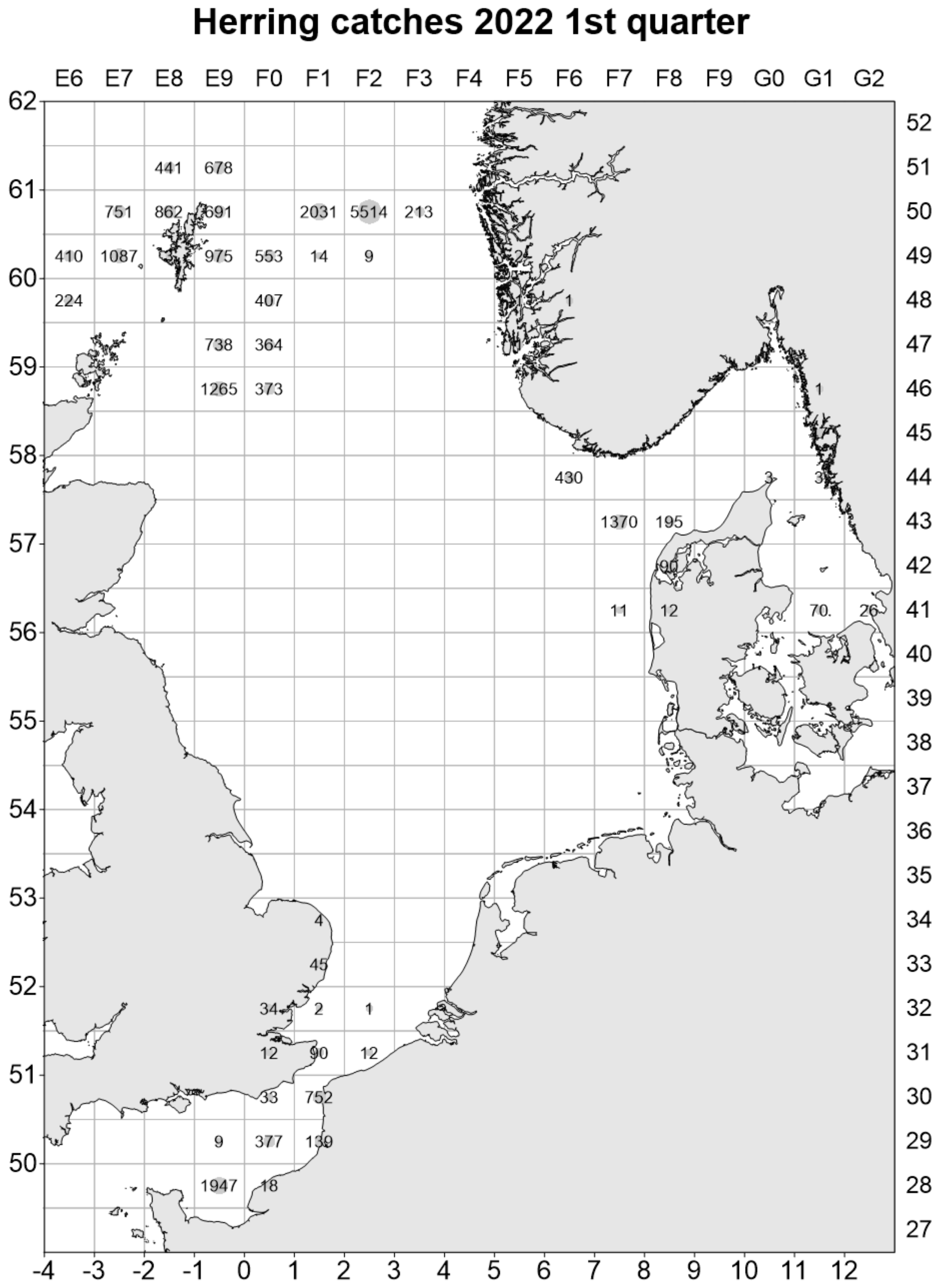


Figure 2.1.1a. Herring catches in the North Sea in the 1st quarter of 2022 (in tonnes) by statistical rectangle.

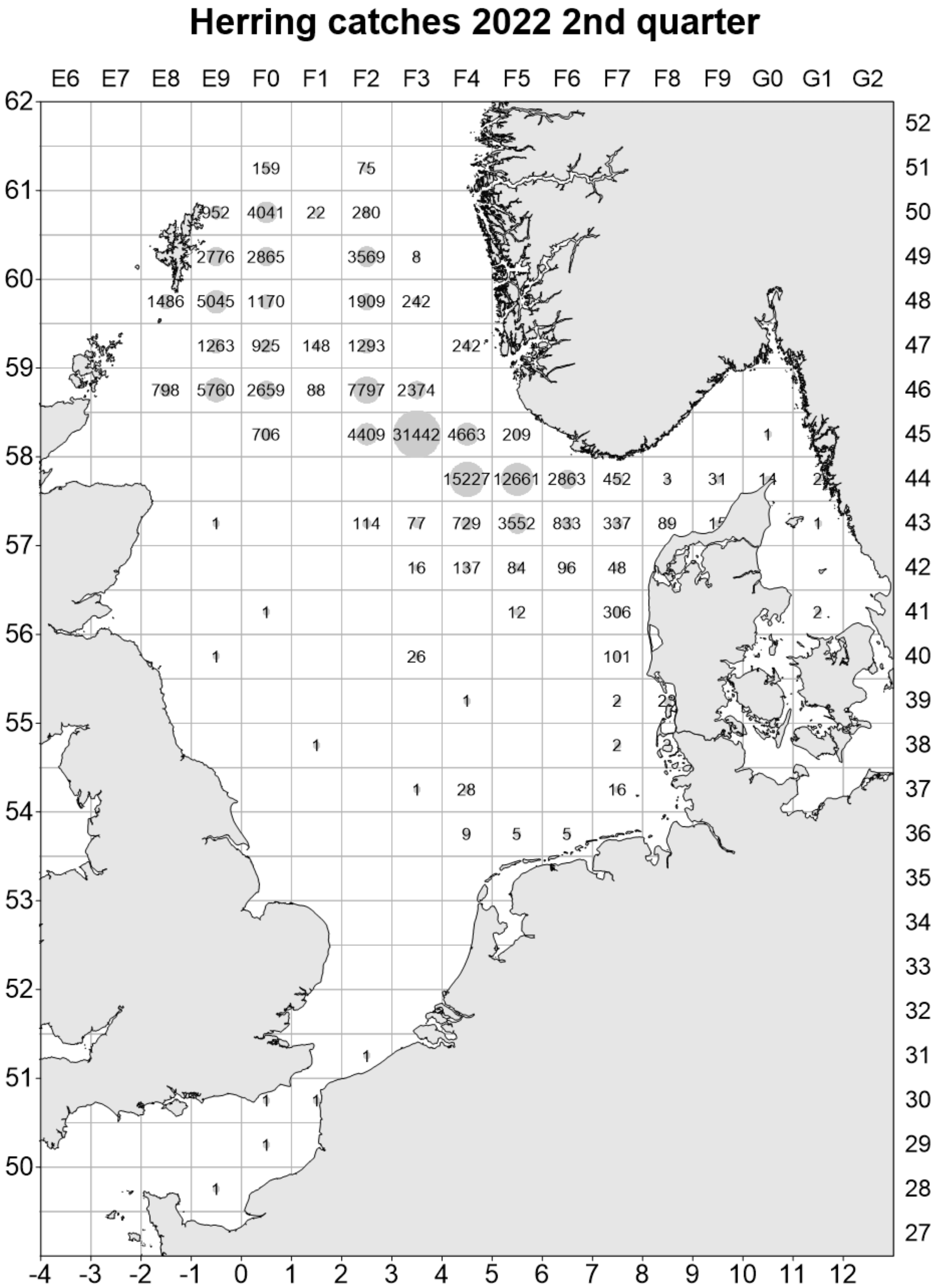


Figure 2.1.1b. Herring catches in the North Sea in the second quarter of 2022 (in tonnes) by statistical rectangle.

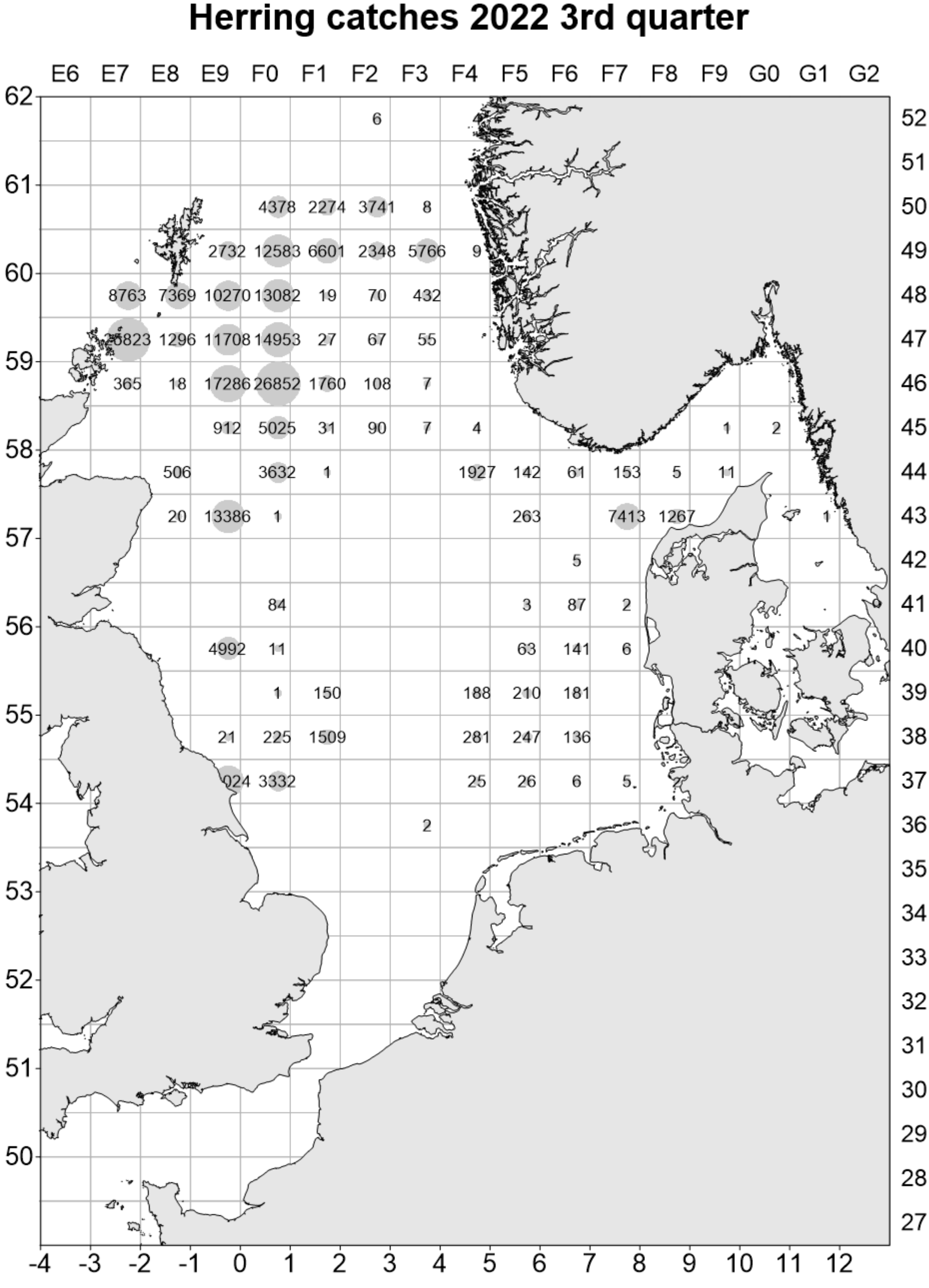


Figure 2.1.1c. Herring catches in the North Sea in the 3rd quarter of 2022 (in tonnes) by statistical rectangle.

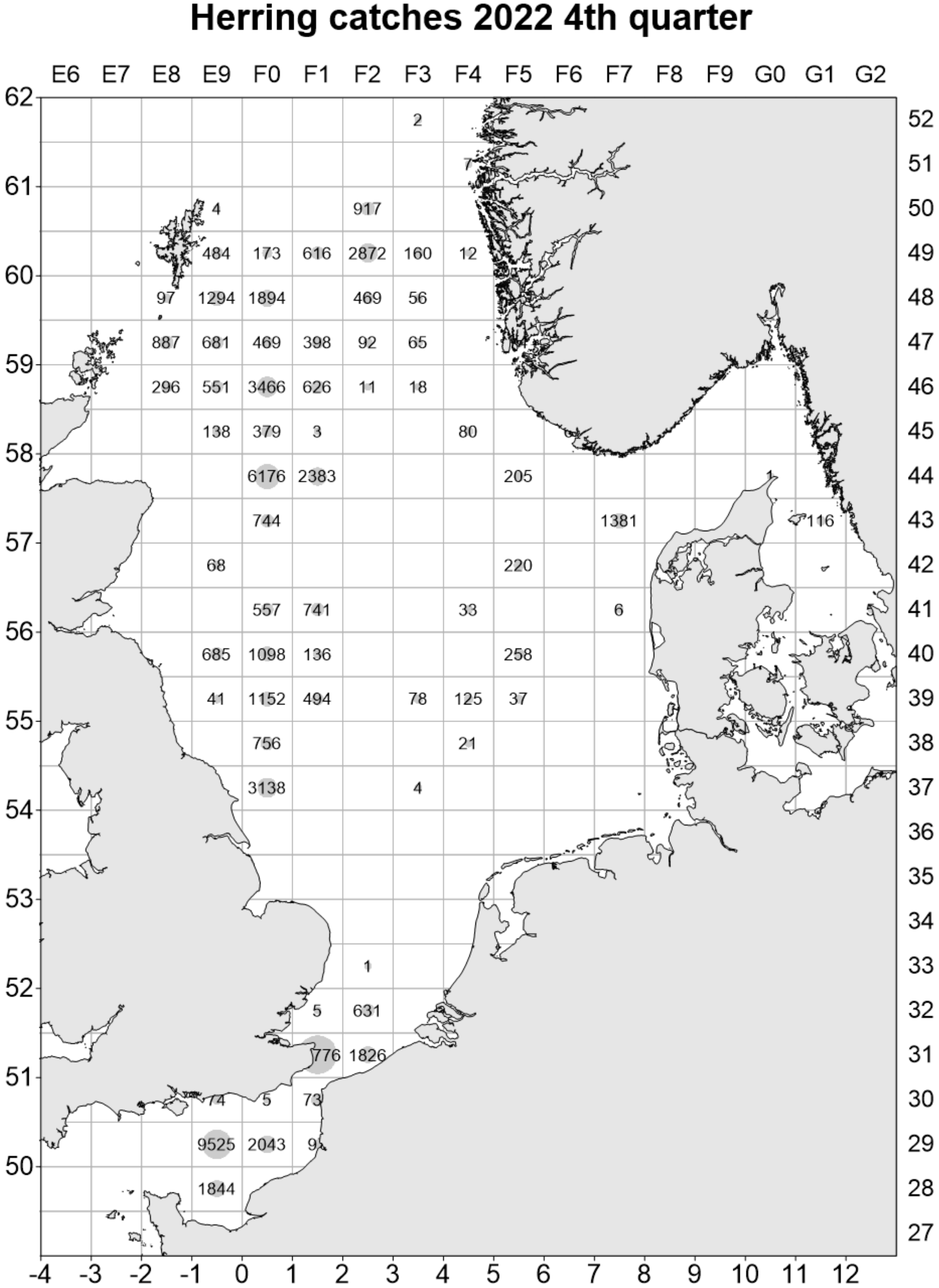


Figure 2.1.1d. Herring catches in the North Sea in the 4th quarter of 2022 (in tonnes) by statistical rectangle.

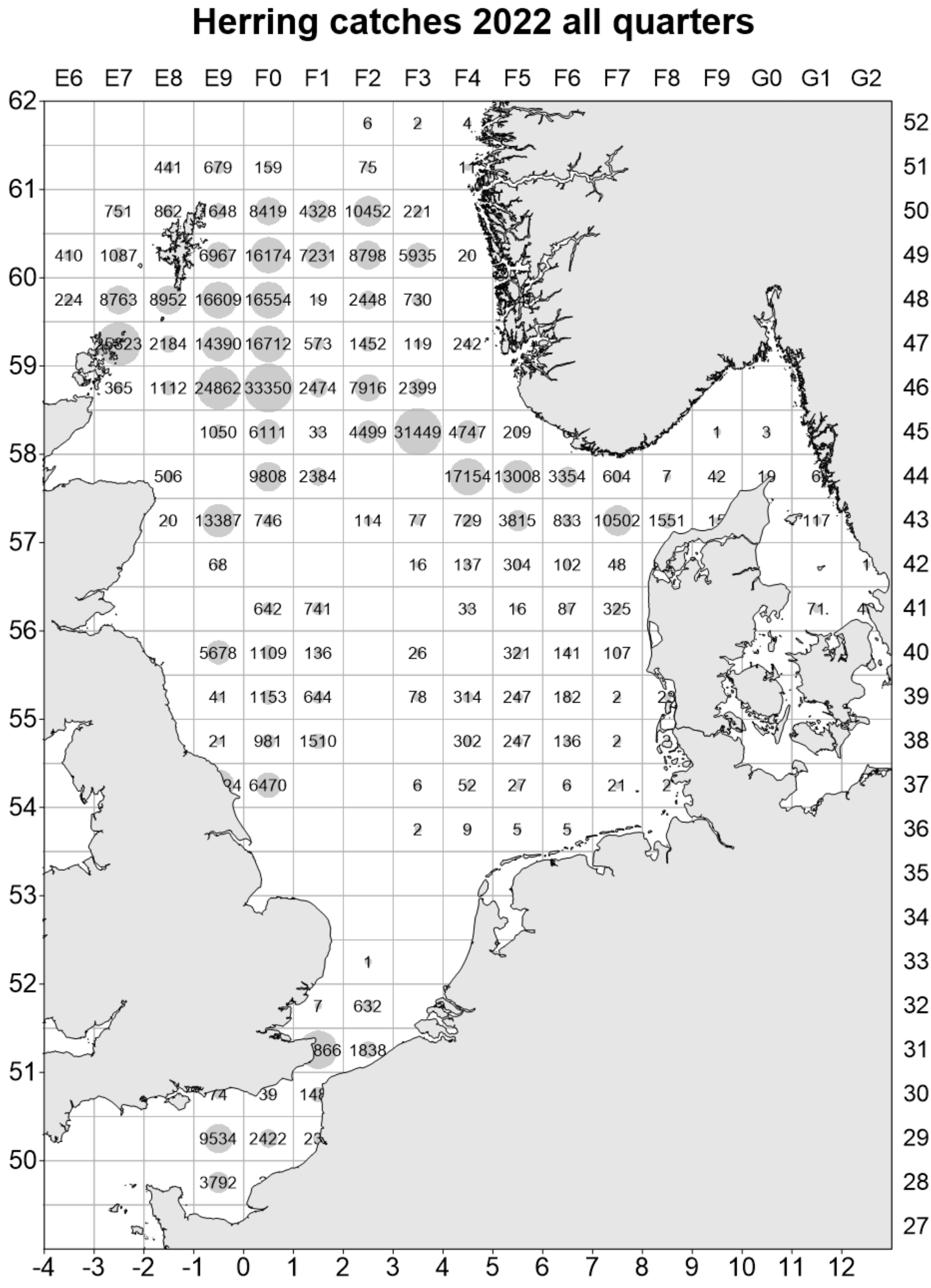


Figure 2.1.1e. Herring catches in the North Sea in all quarters of 2022 (in tonnes) by statistical rectangle.

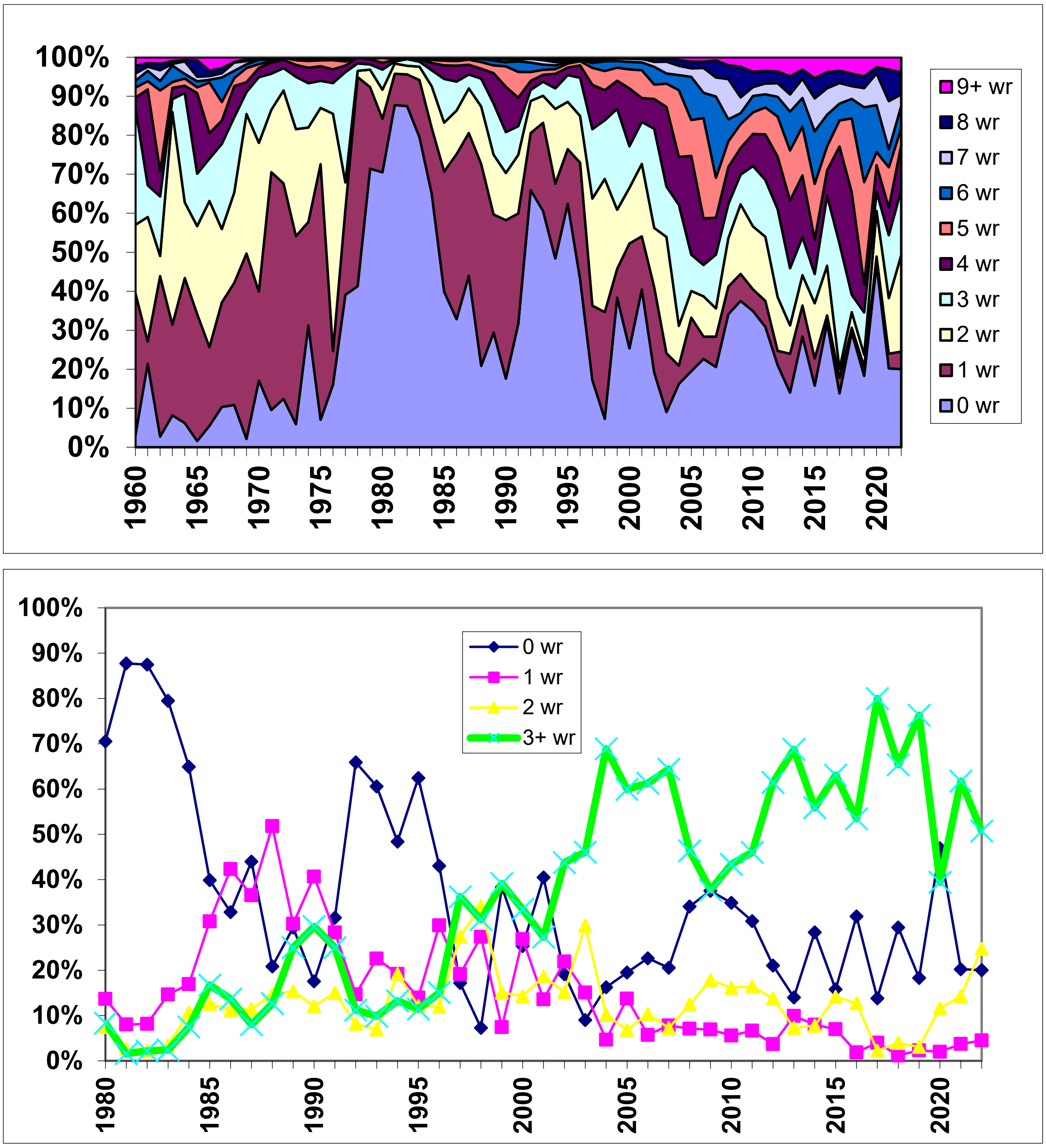


Figure 2.2.1. Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2022, and lower panel, 1980–2022).

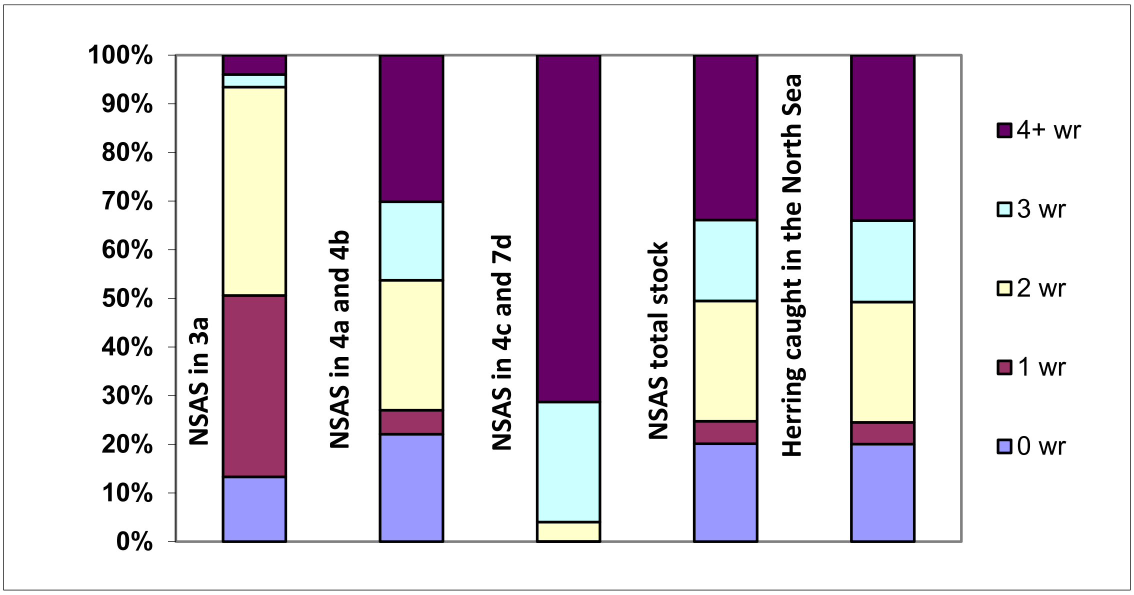


Figure 2.2.2. Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2022.

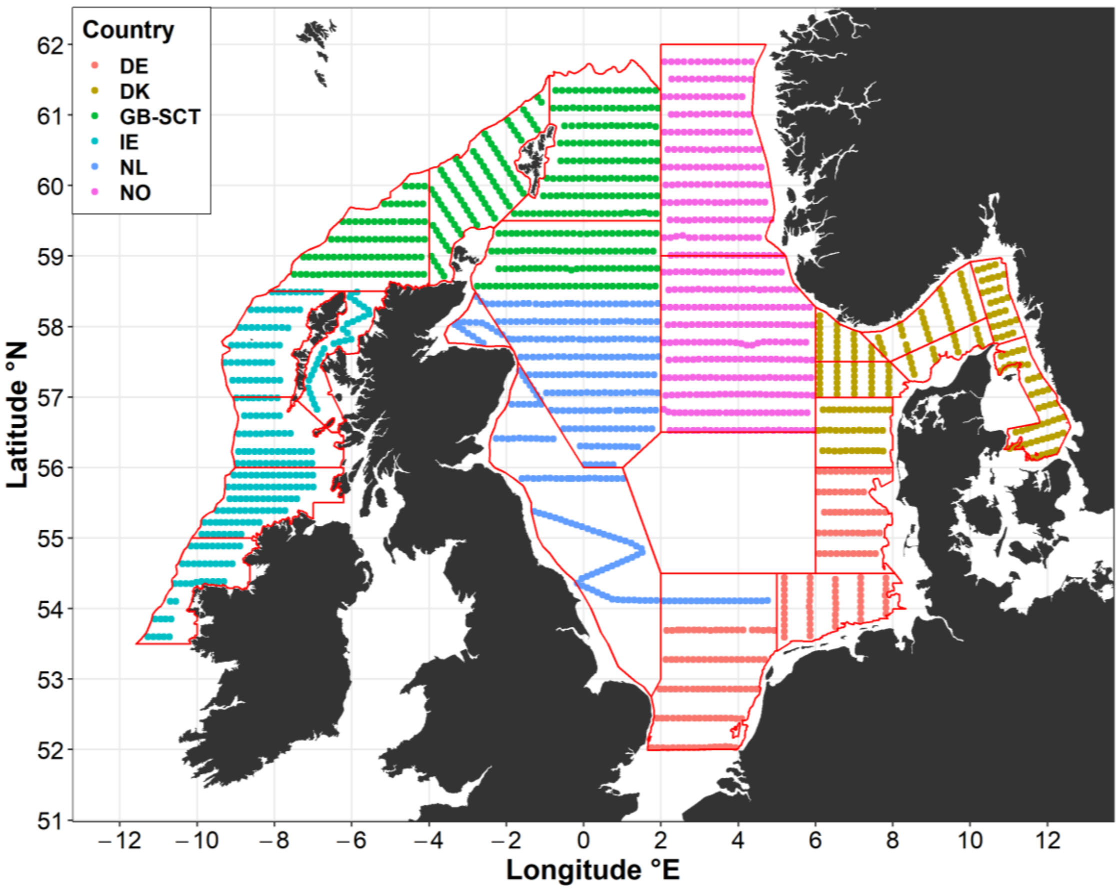


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2022 by nation.

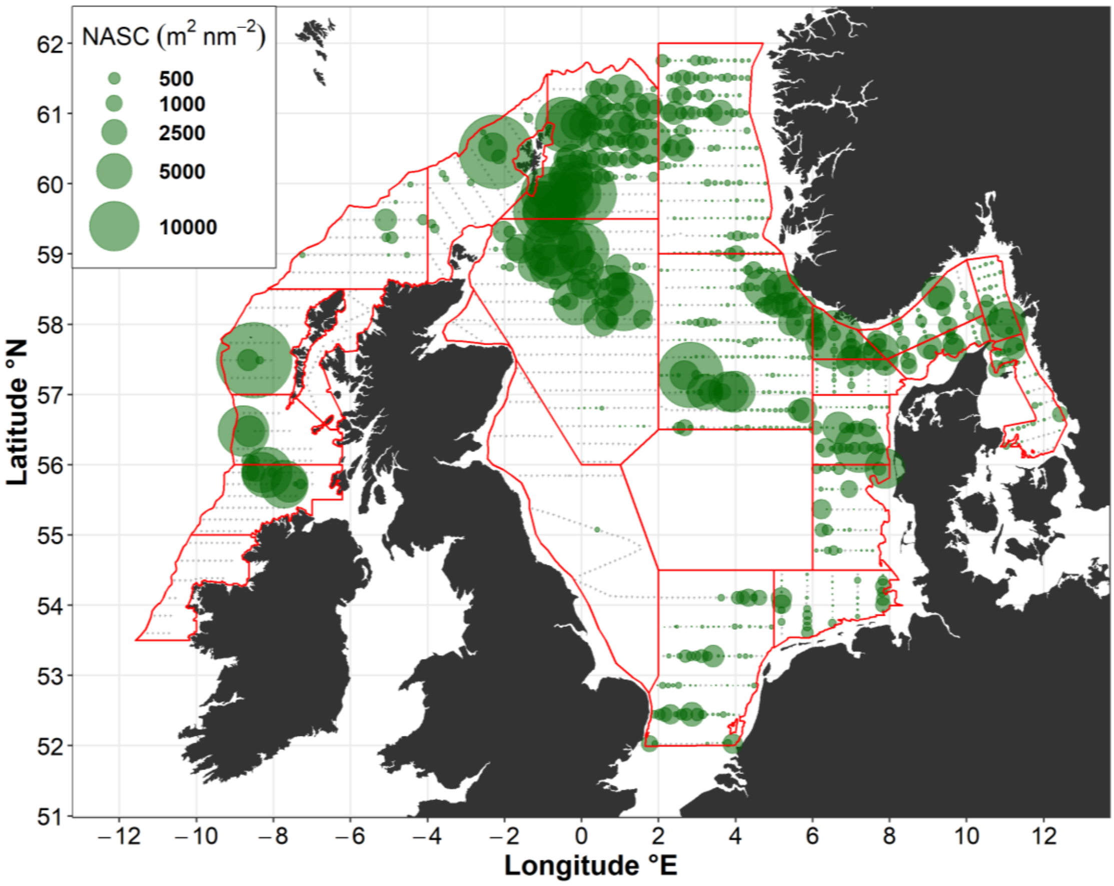


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2022. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

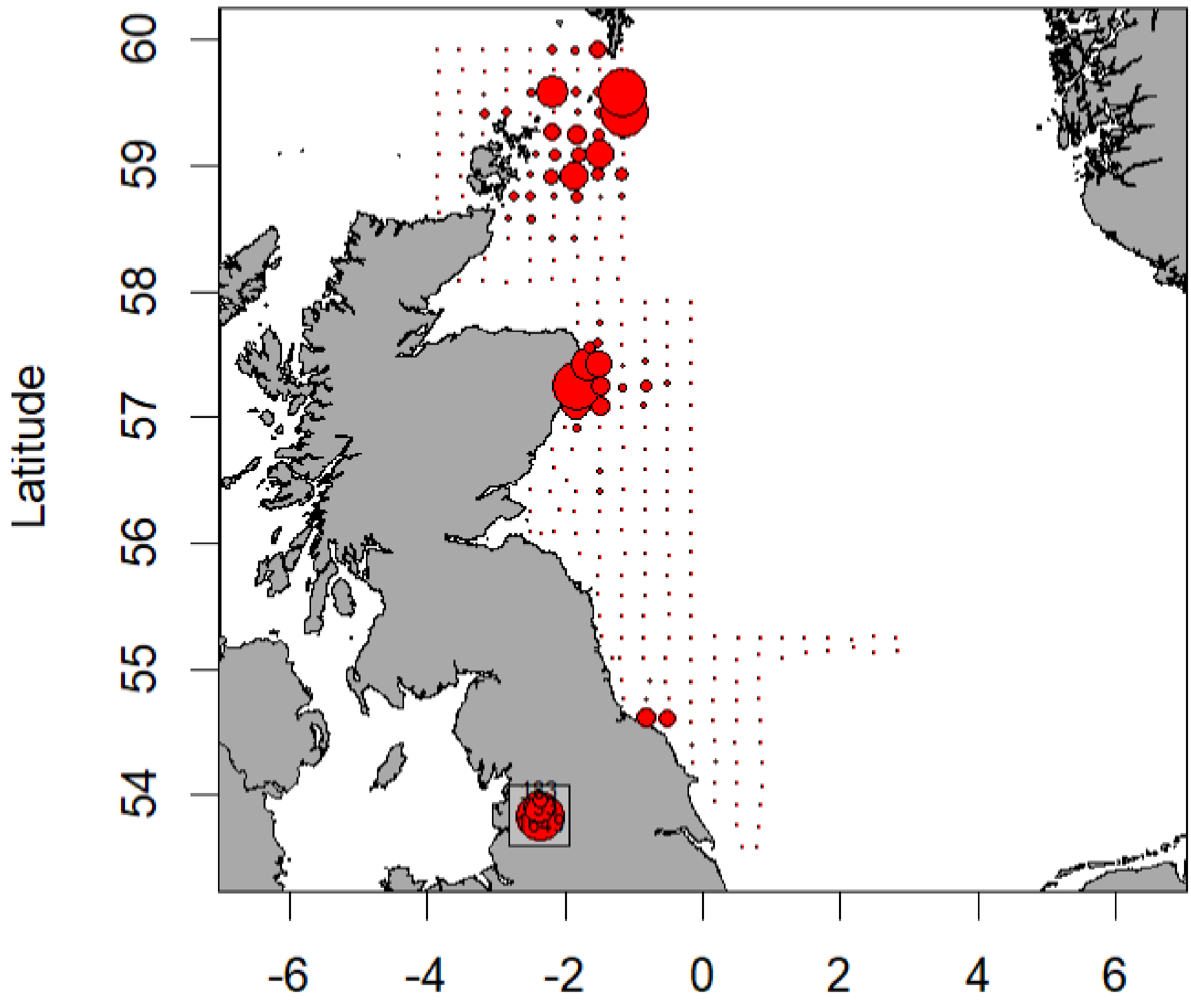


Figure 2.3.2.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands, the Buchan, and the central North Sea area, second half of September 2022 (maximum circle size = 1 650 n/m²).

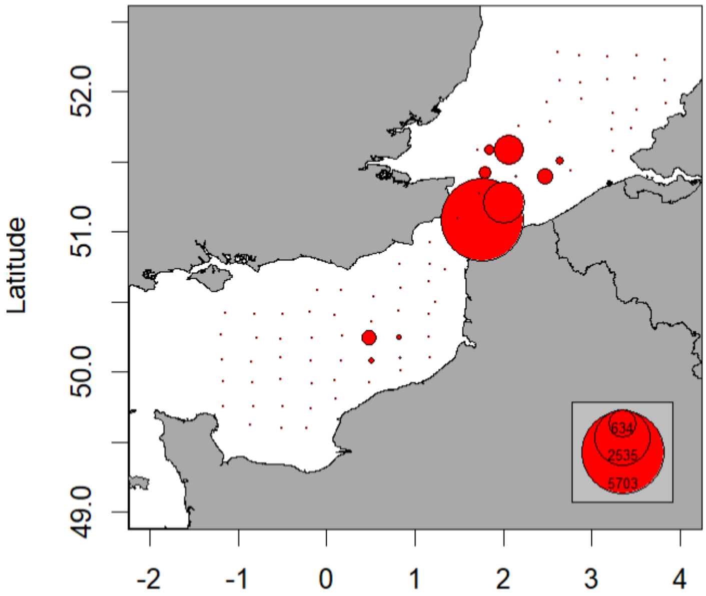


Figure 2.3.2.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2022 (maximum circle size = 5 700 n/m²).

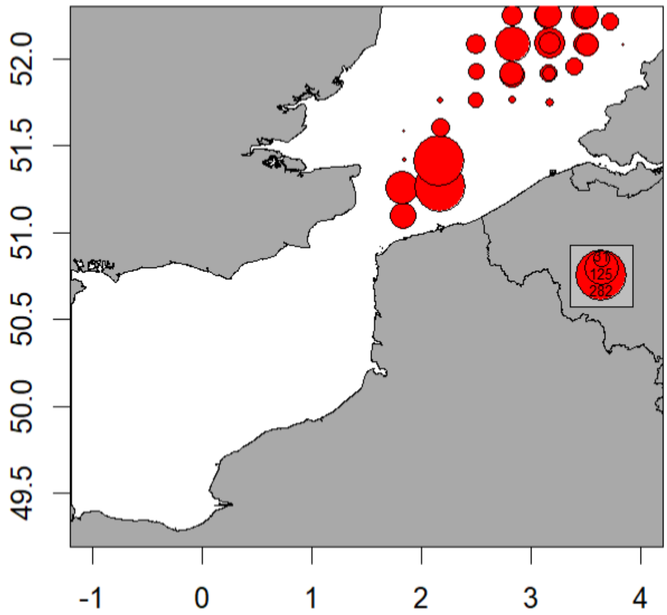


Figure 2.3.2.4. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2023 (maximum circle size = 280 n/m²).

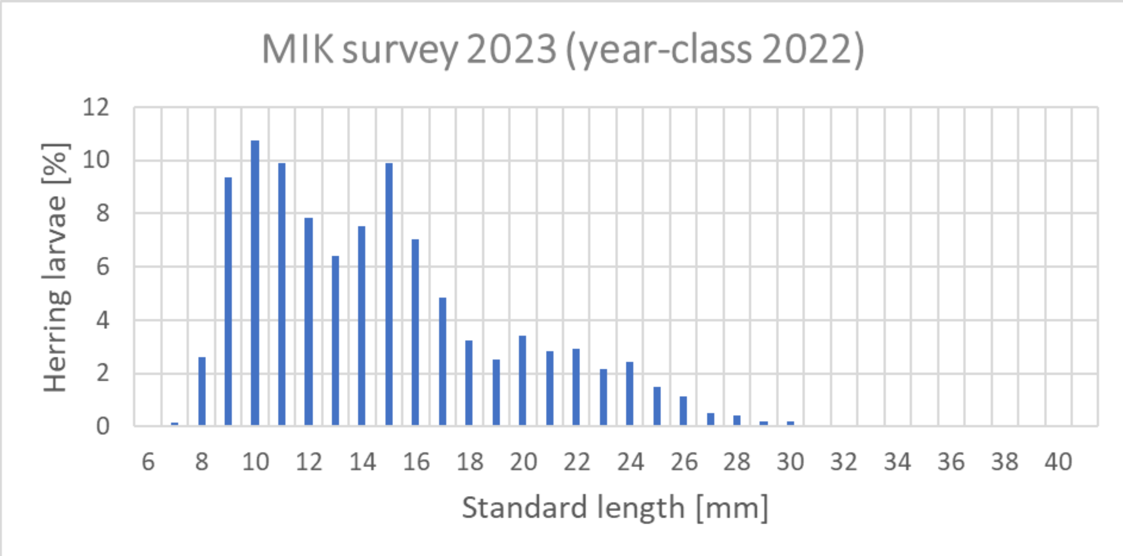


Figure 2.3.3.1.1 North Sea herring. Length distribution of all herring larvae caught in the MIK during the 2023 Q1 IBTS.

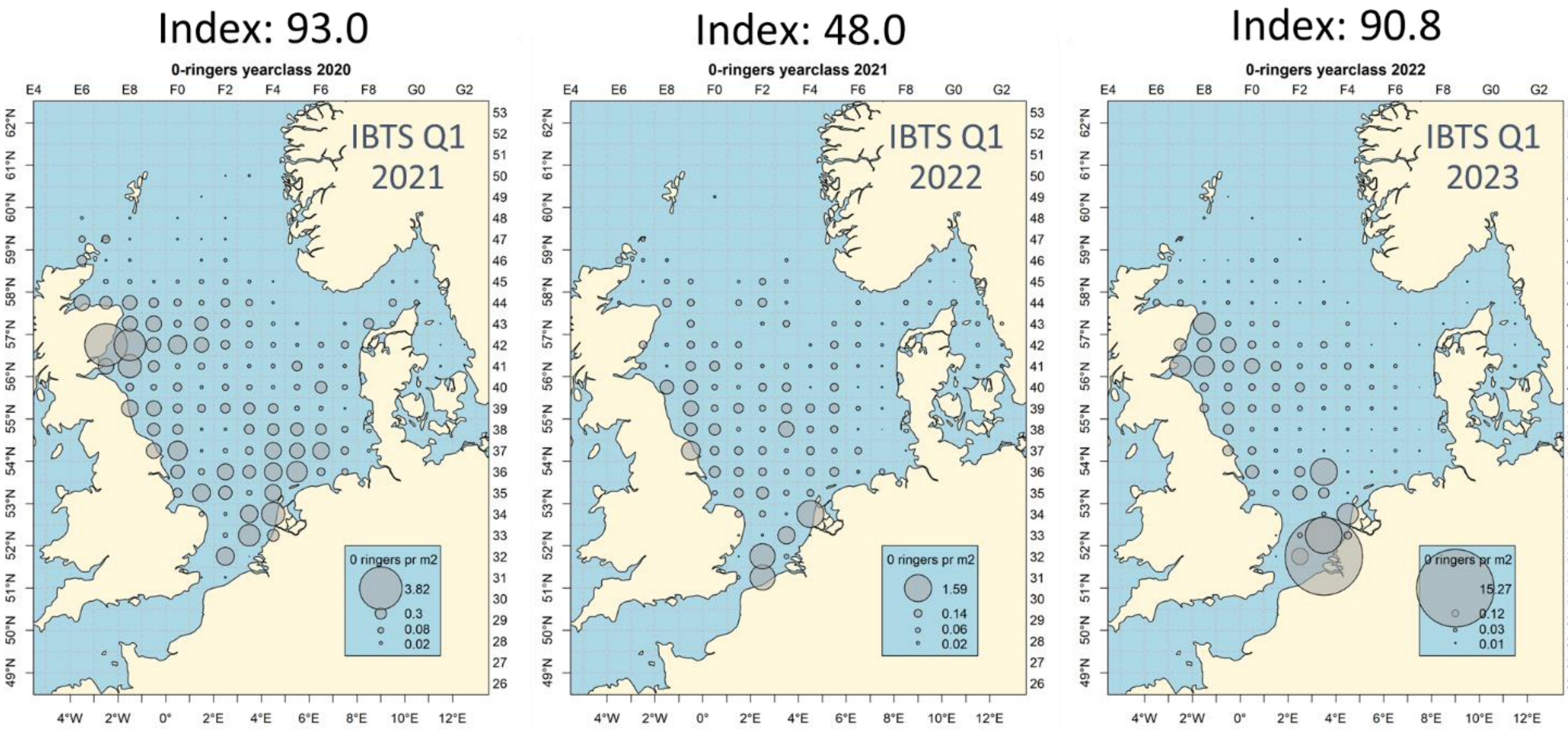


Figure 2.3.3.1.2 North Sea herring. Distribution of 0-ringer herring, year classes 2020–2022. Density estimates of 0-ringers (>18 mm) within each statistical rectangle are based on MIK catches during IBTS in January/February 2021–2023. Areas of filled circles illustrate densities in no m^{-2}.

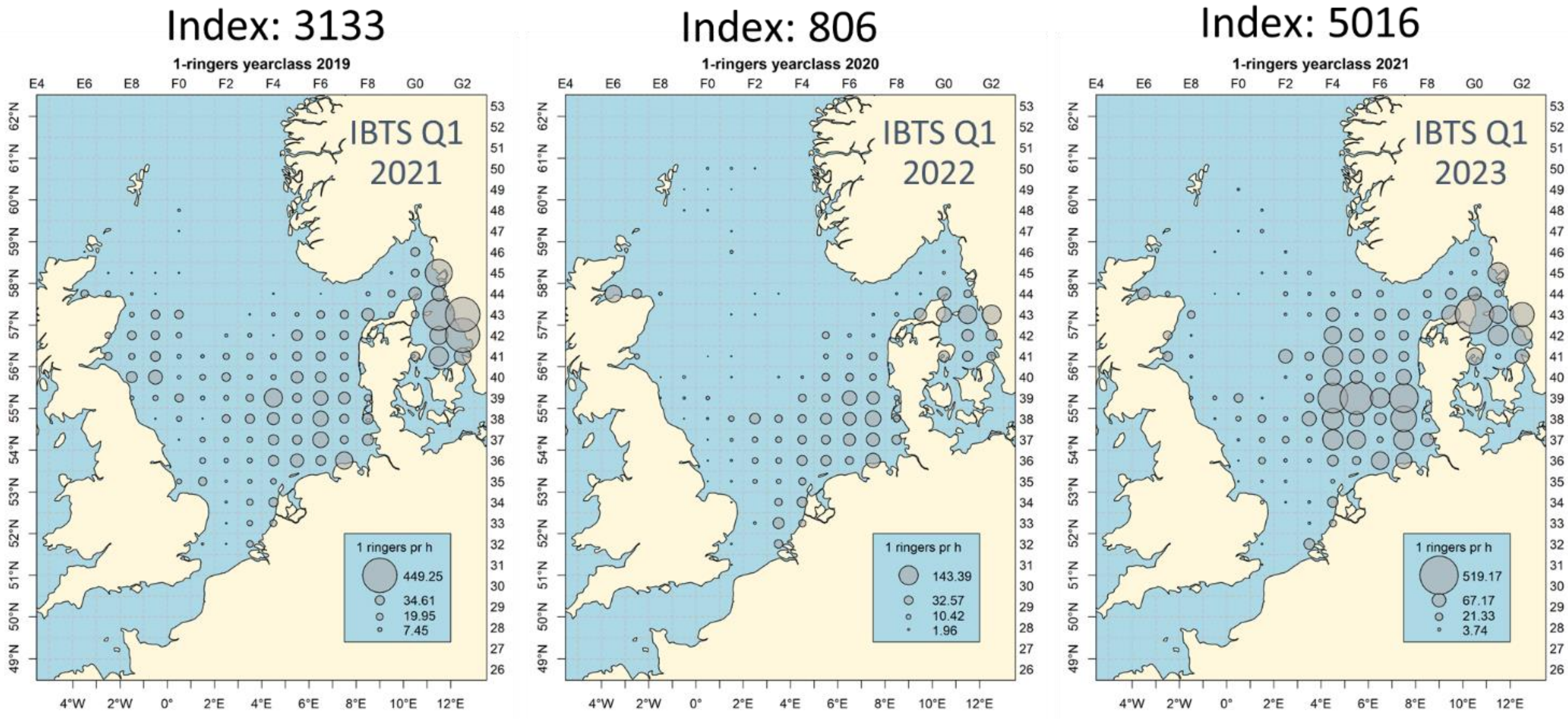


Figure 2.3.3.2.1 North Sea herring. Distribution of 1-ringer herring, year classes 2019–2021. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2021–2023. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data.

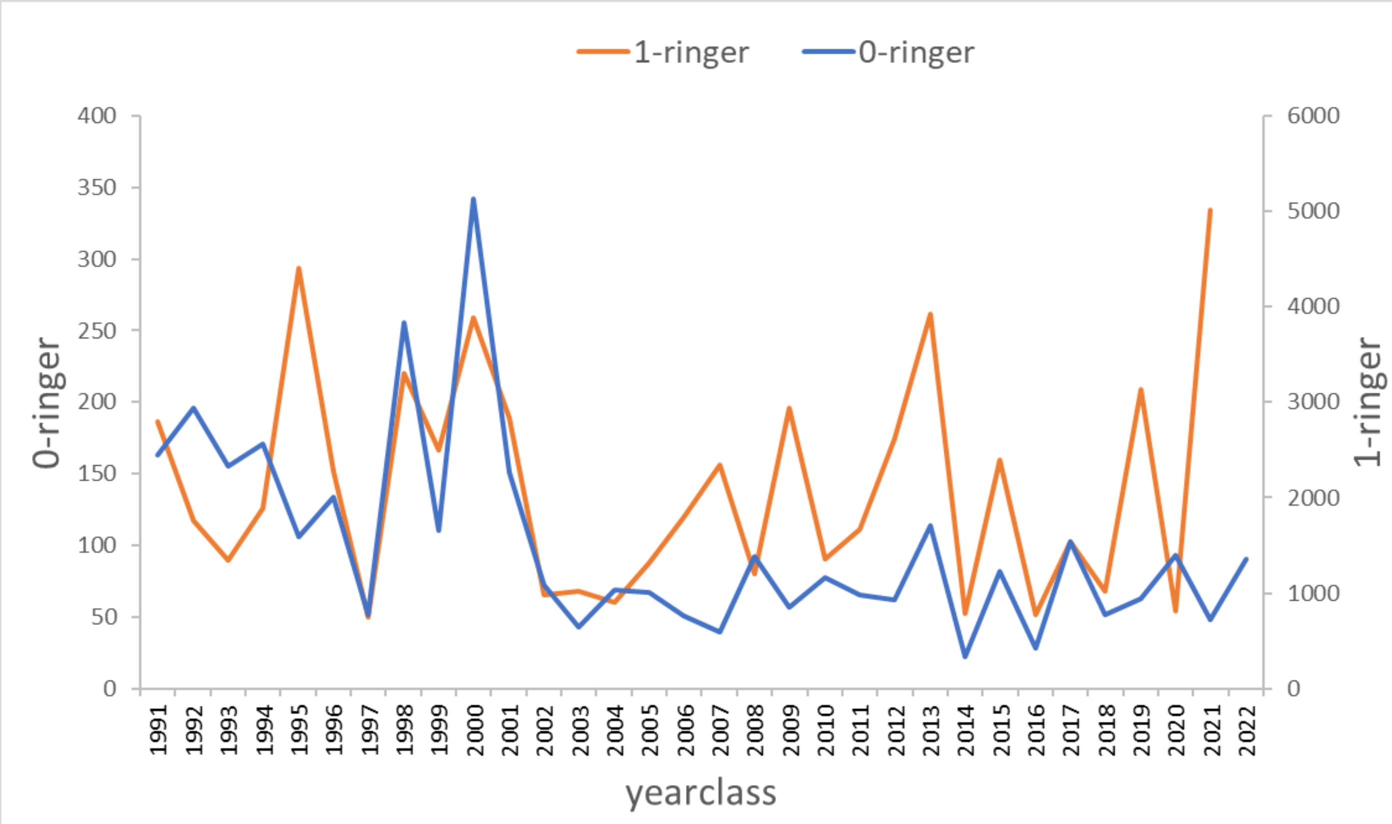


Figure 2.3.3.2.2 North Sea herring. Time series of 0-ringer (blue) and 1-ringer indices (orange). Year-classes 1991 to 2022 for 0-ringers, year-classes 1991–2021 for 1-ringers.

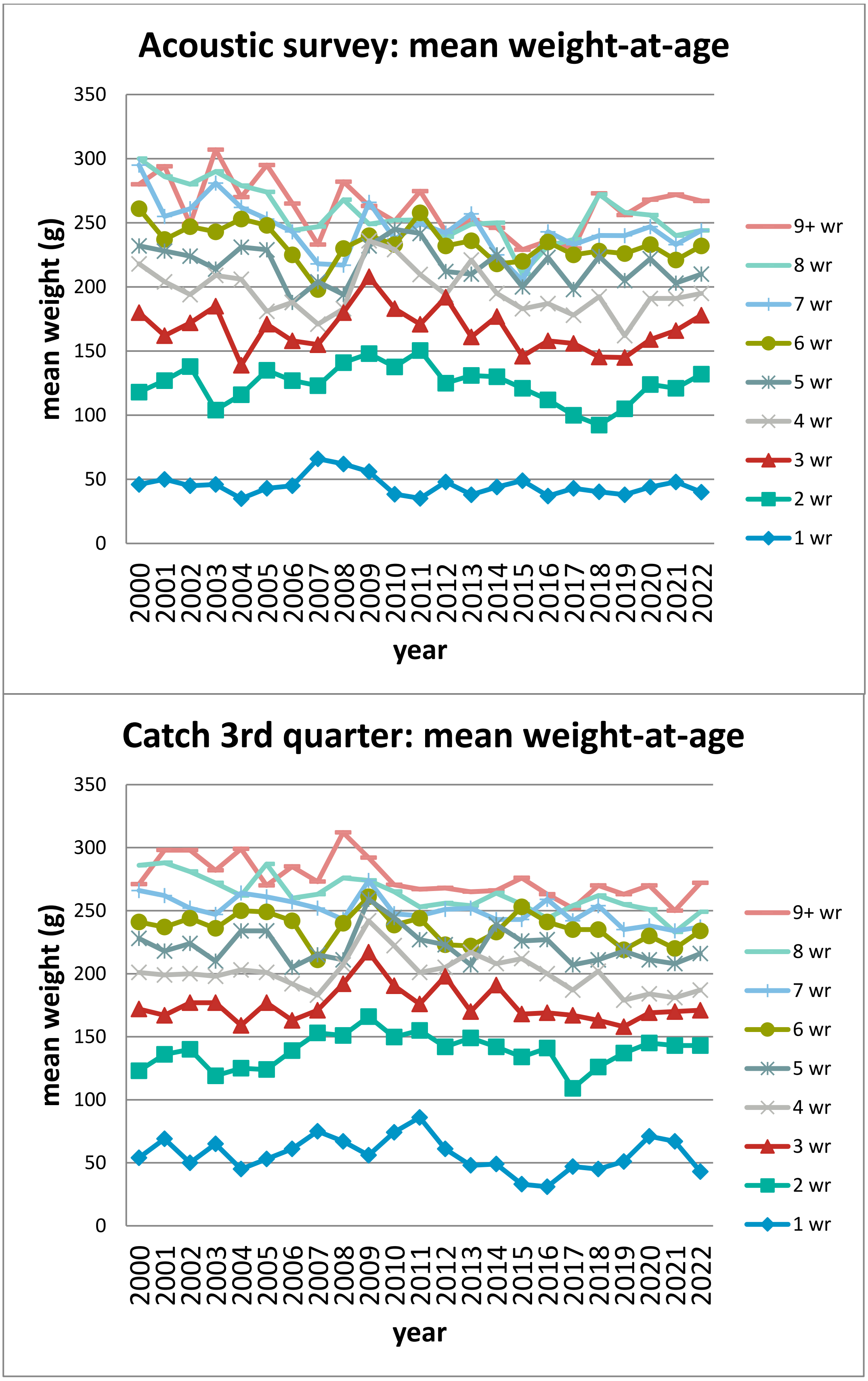


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

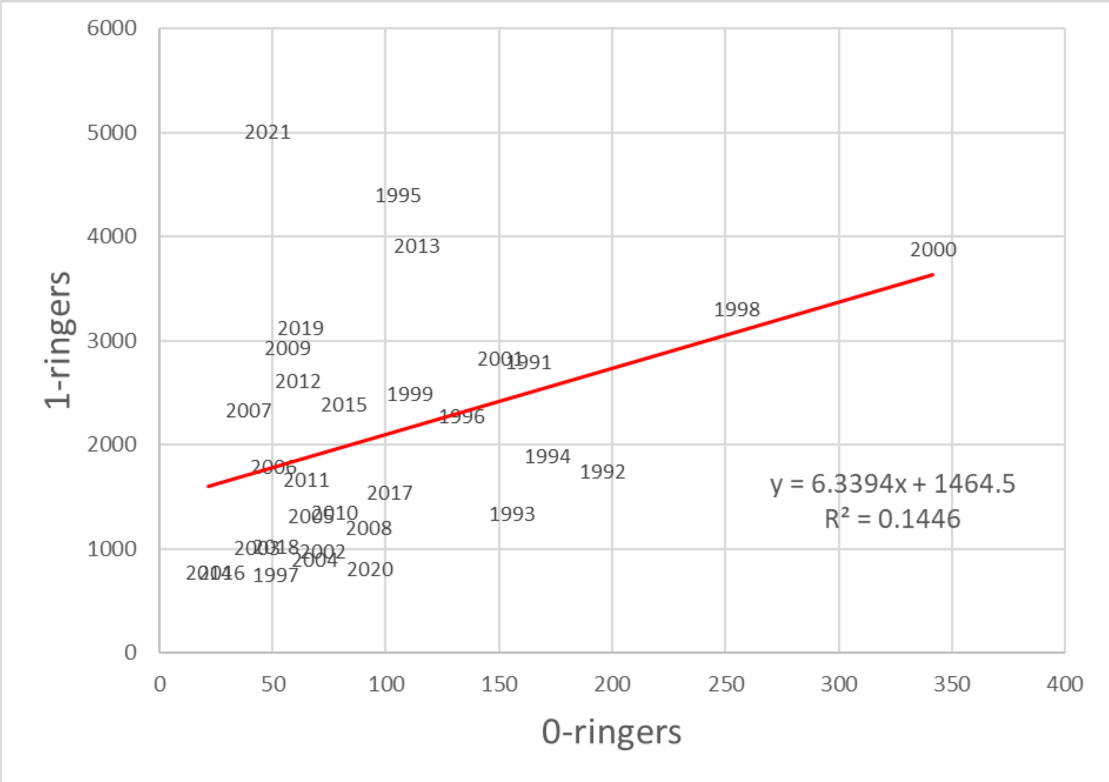


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers, calculated with the new algorithm, and 1-ringers for year-classes 1991 to 2021.

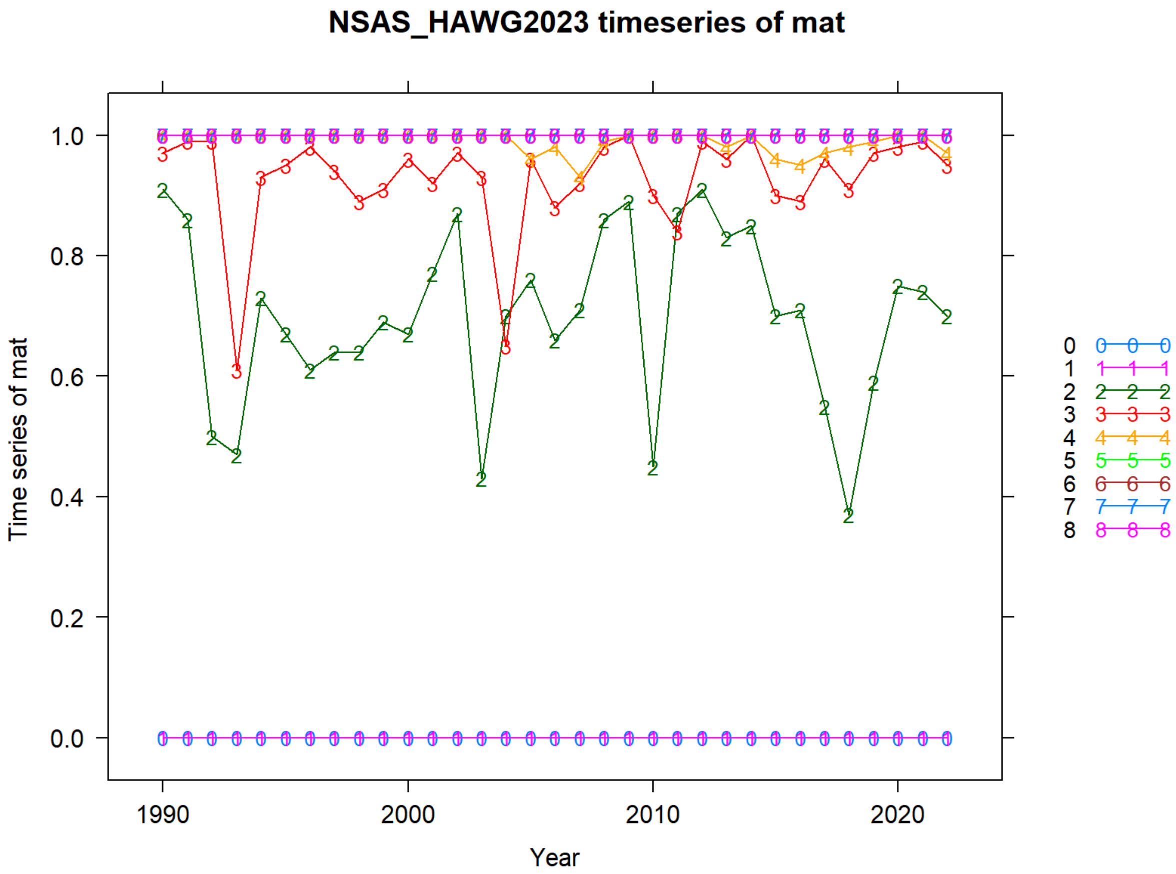


Figure 2.6.1.1. North Sea Herring. Time-series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

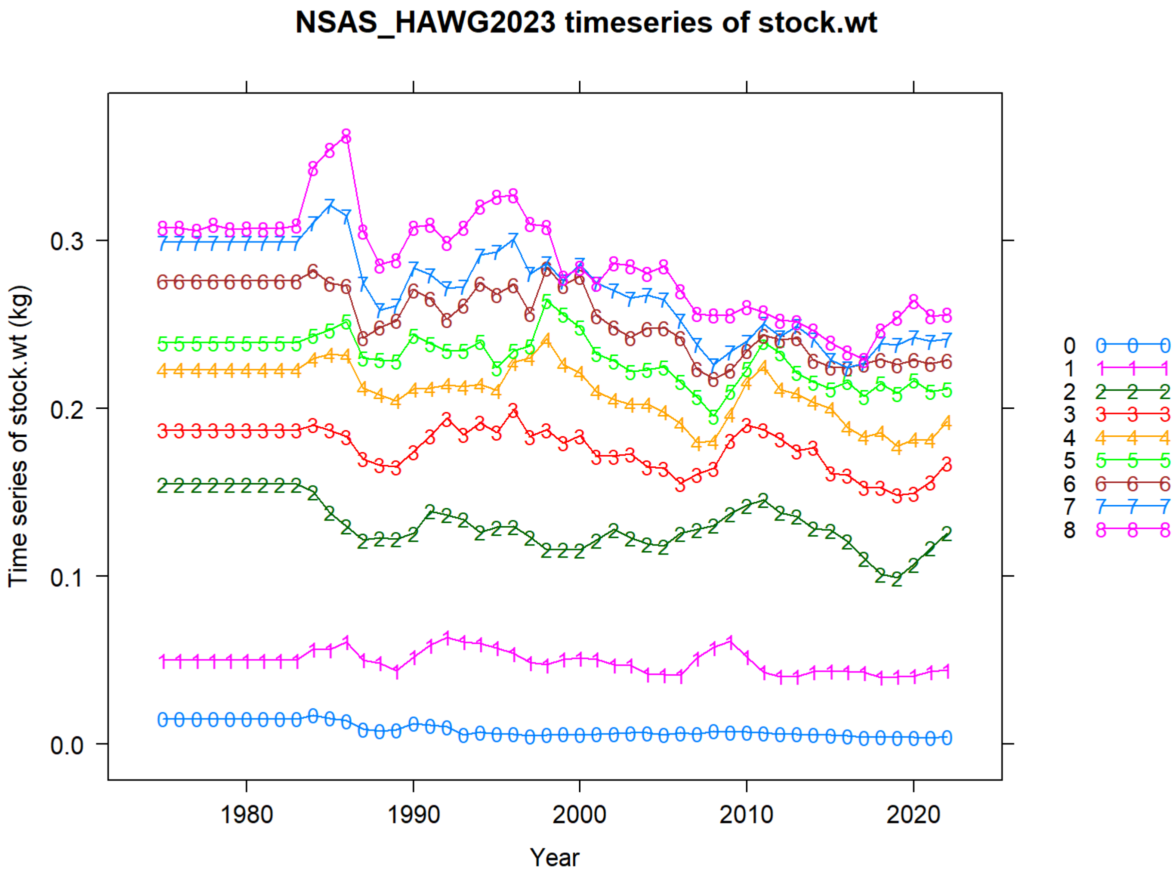


Figure 2.6.1.2. North Sea Herring. Time-series of stock weight at ages 0 to 8+ as used in the North Sea herring assessment.

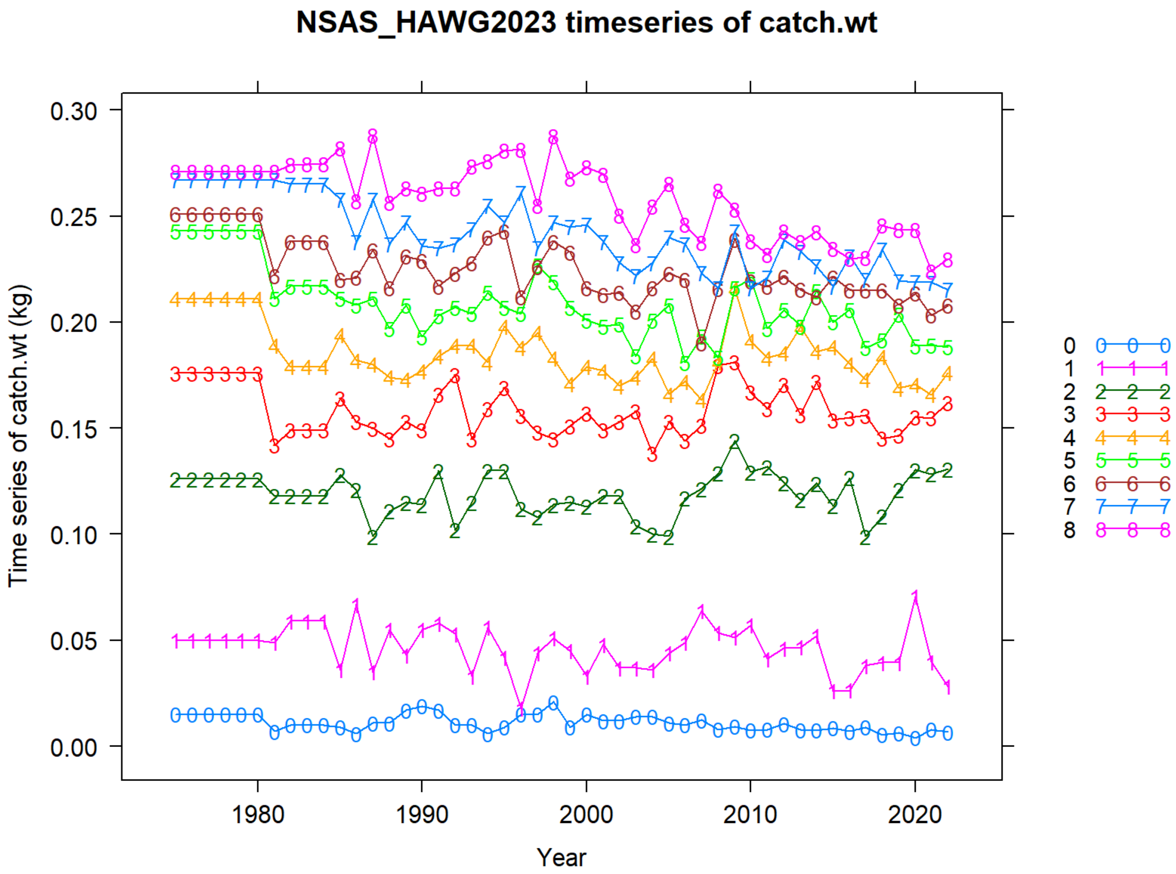


Figure 2.6.1.3. North Sea Herring. Time-series of catch weight at ages 0 to 8+ as used in the North Sea herring assessment.

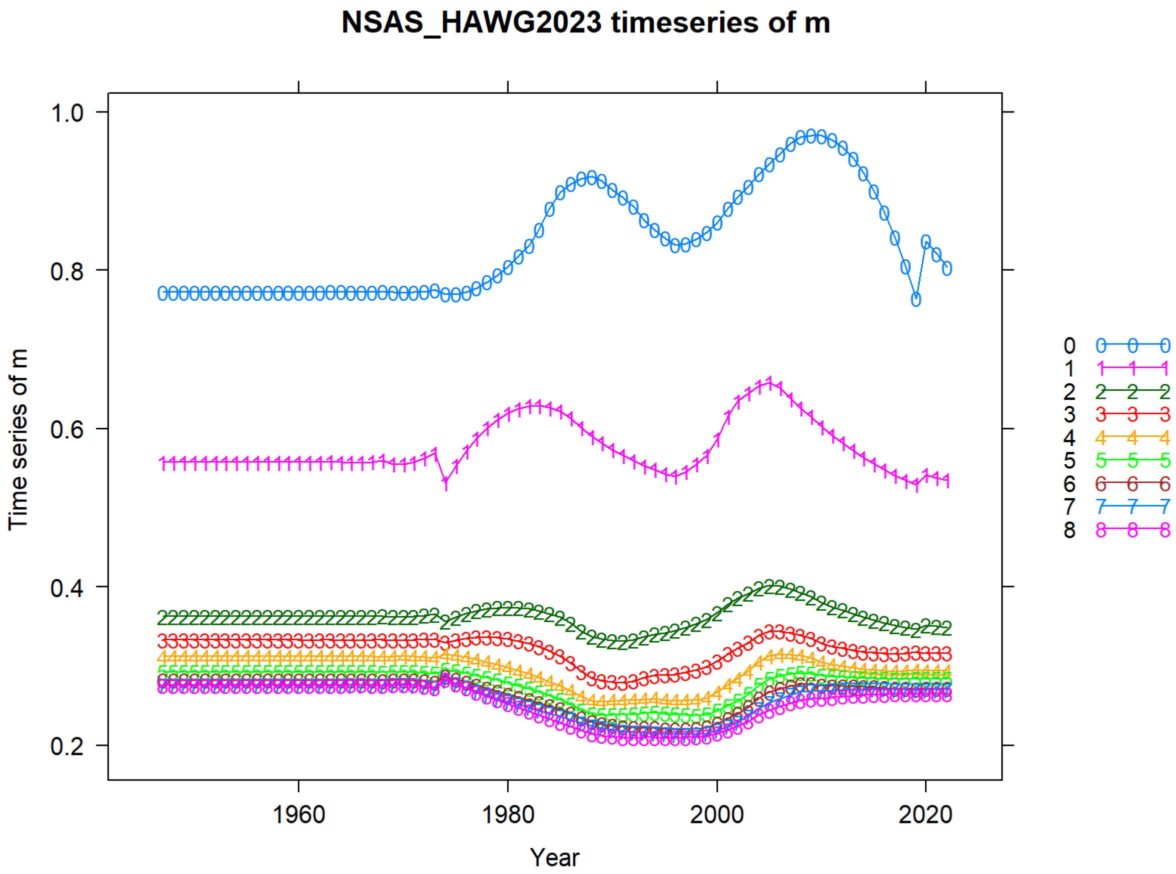


Figure 2.6.1.4. North Sea Herring. Time-series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2019 North Sea key-run (ICES WGSAM, 2021)

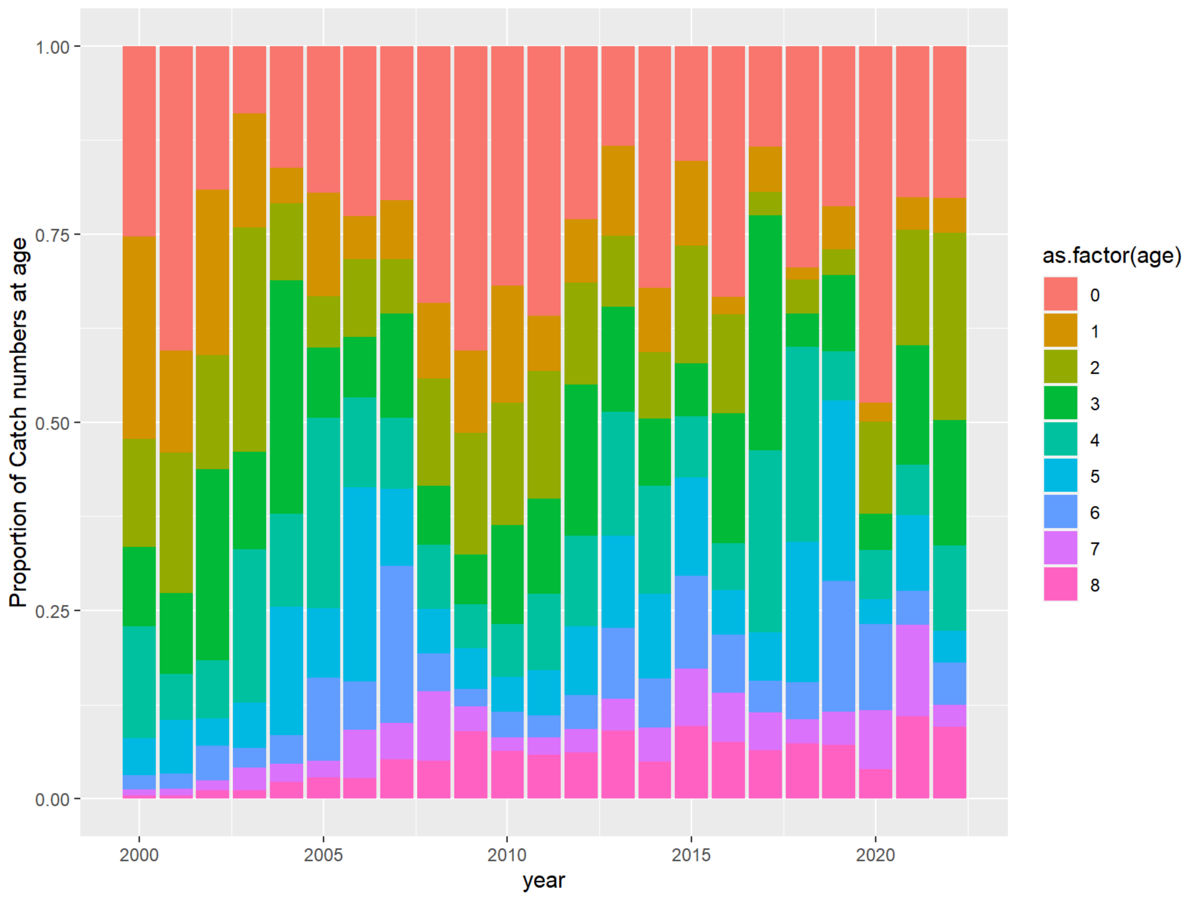


Figure 2.6.1.5. North Sea Herring. Proportion of catch at age since 2000.

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

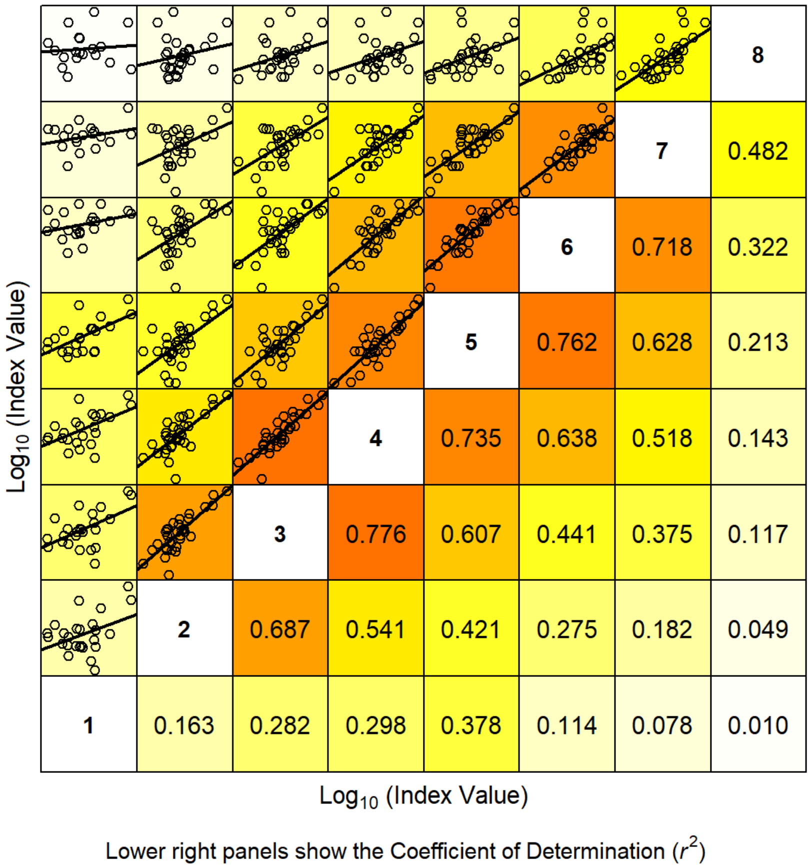


Figure 2.6.1.7. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

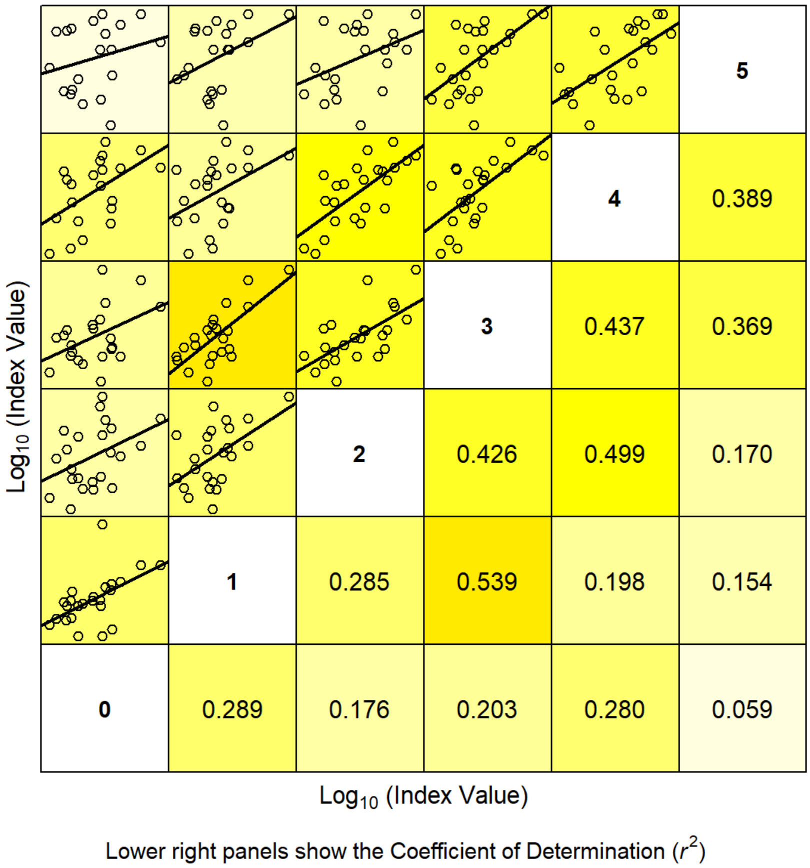


Figure 2.6.1.8. North Sea herring. Internal consistency plot of the IBTS in quarter 3. Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

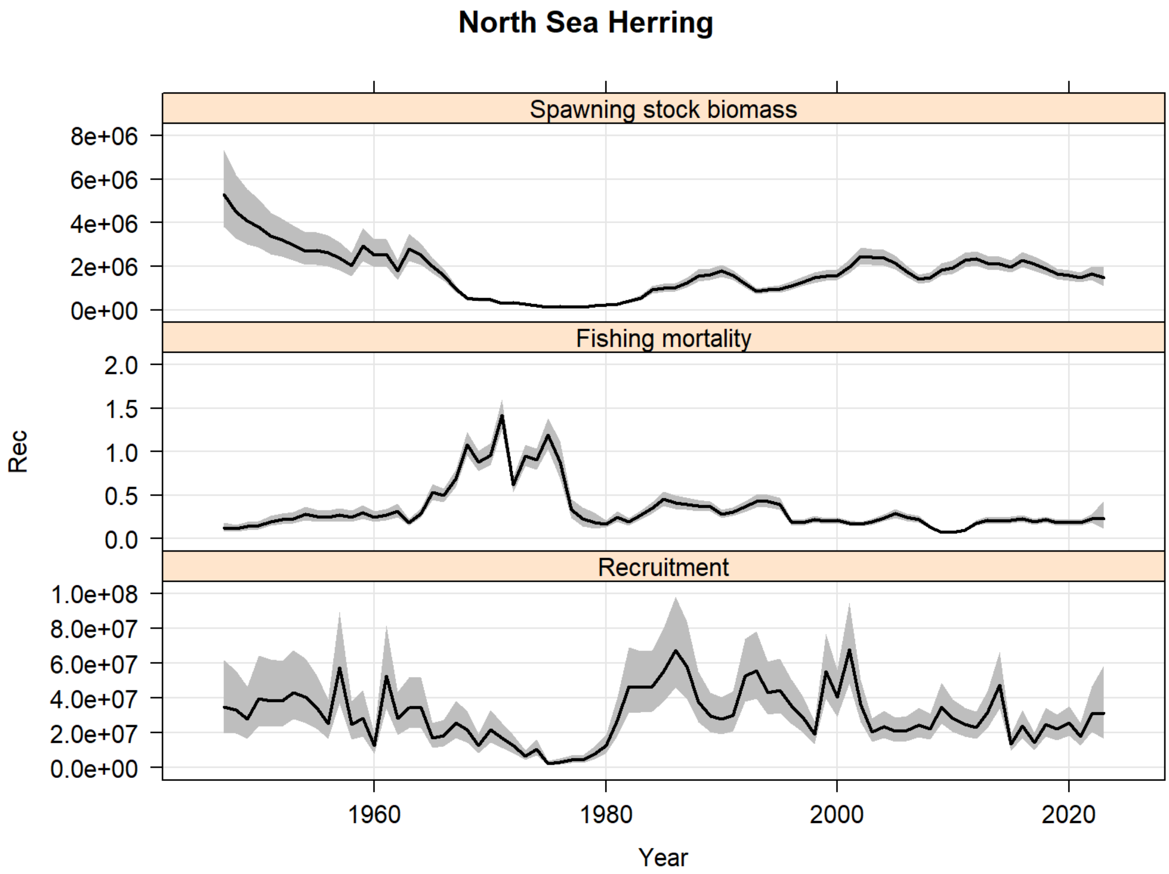


Figure 2.6.2.1. North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

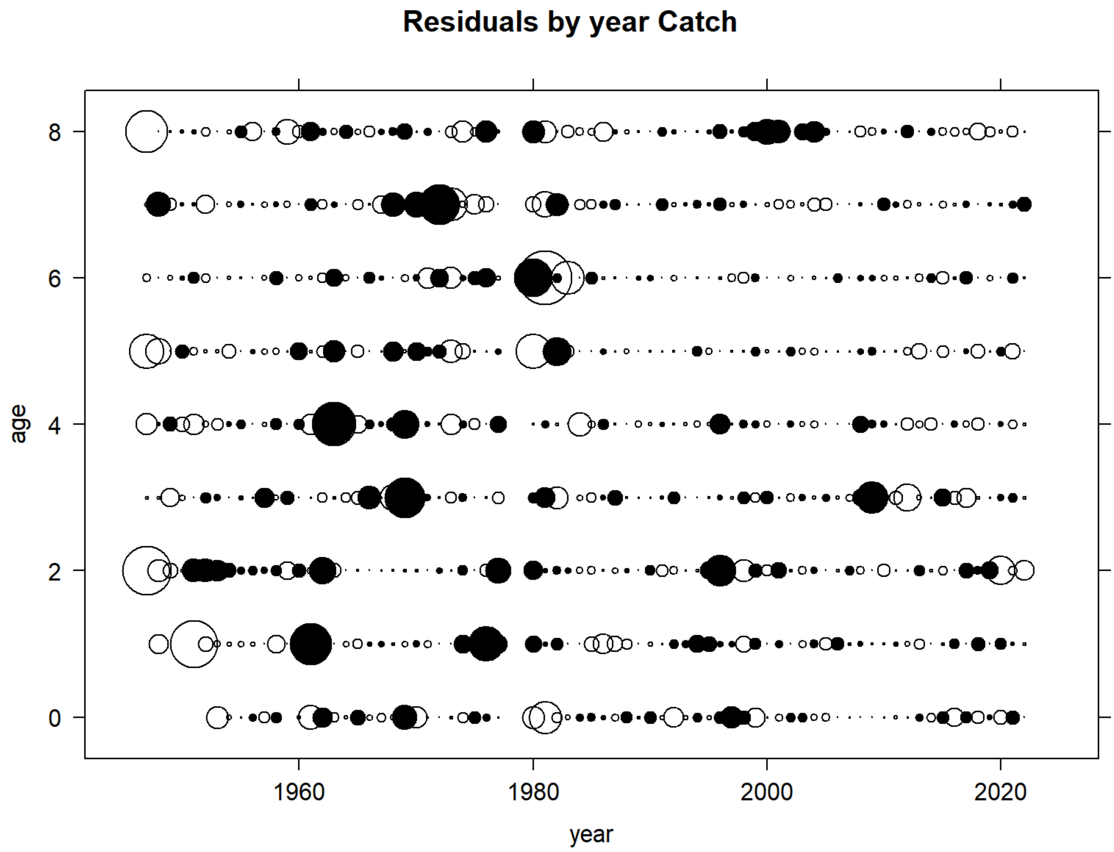


Figure 2.6.2.2. North Sea herring. Bubble plot of standardized catch residual at age.

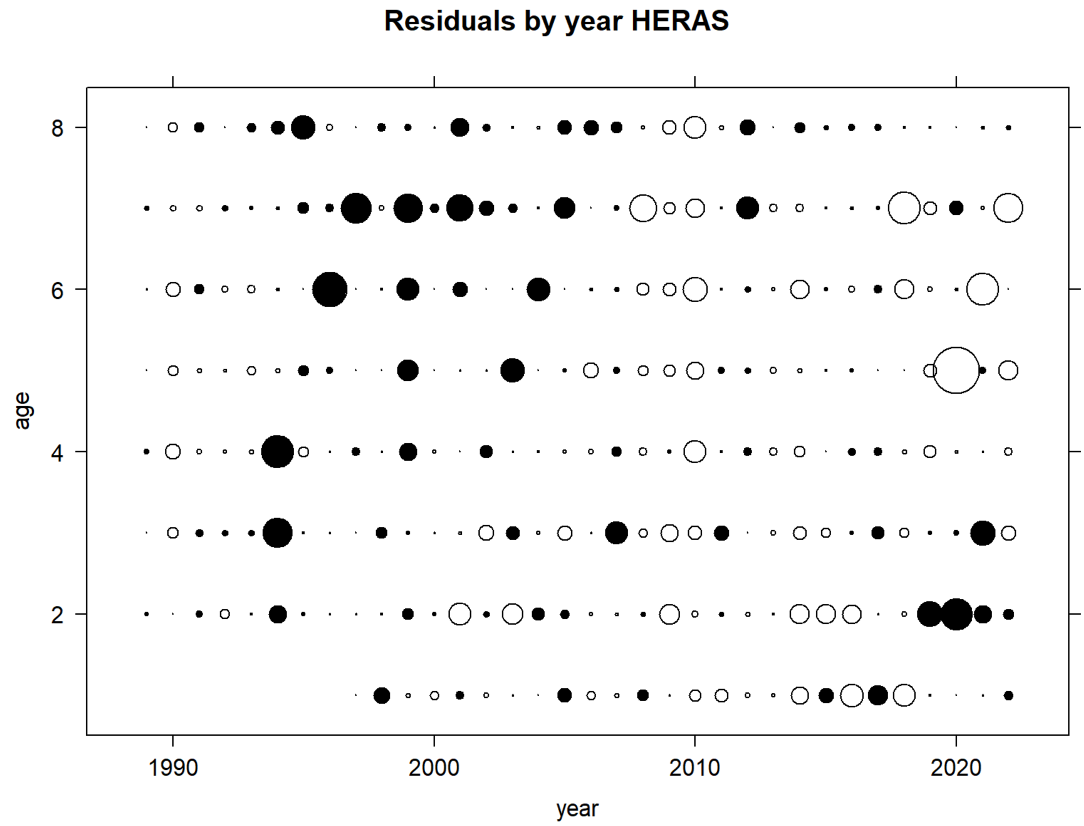


Figure 2.6.2.3. North Sea herring. Bubble plot of standardized acoustic survey residuals at age.

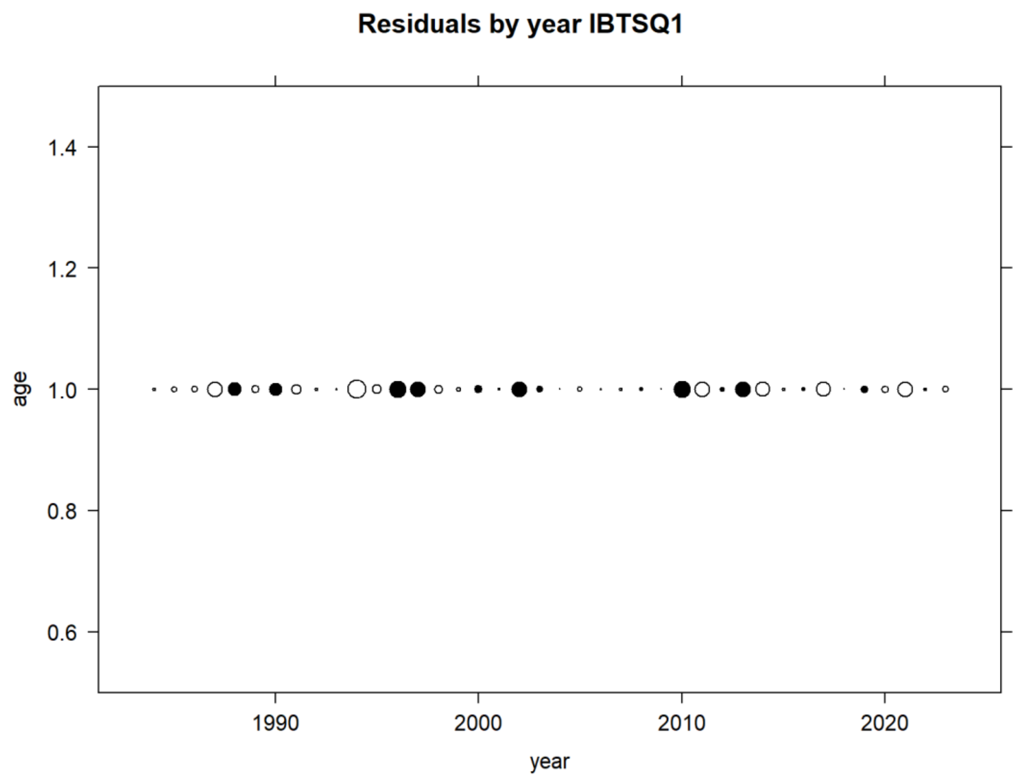


Figure 2.6.2.4. North Sea herring. Bubble plot of standardized IBTSQ1 residuals at age.

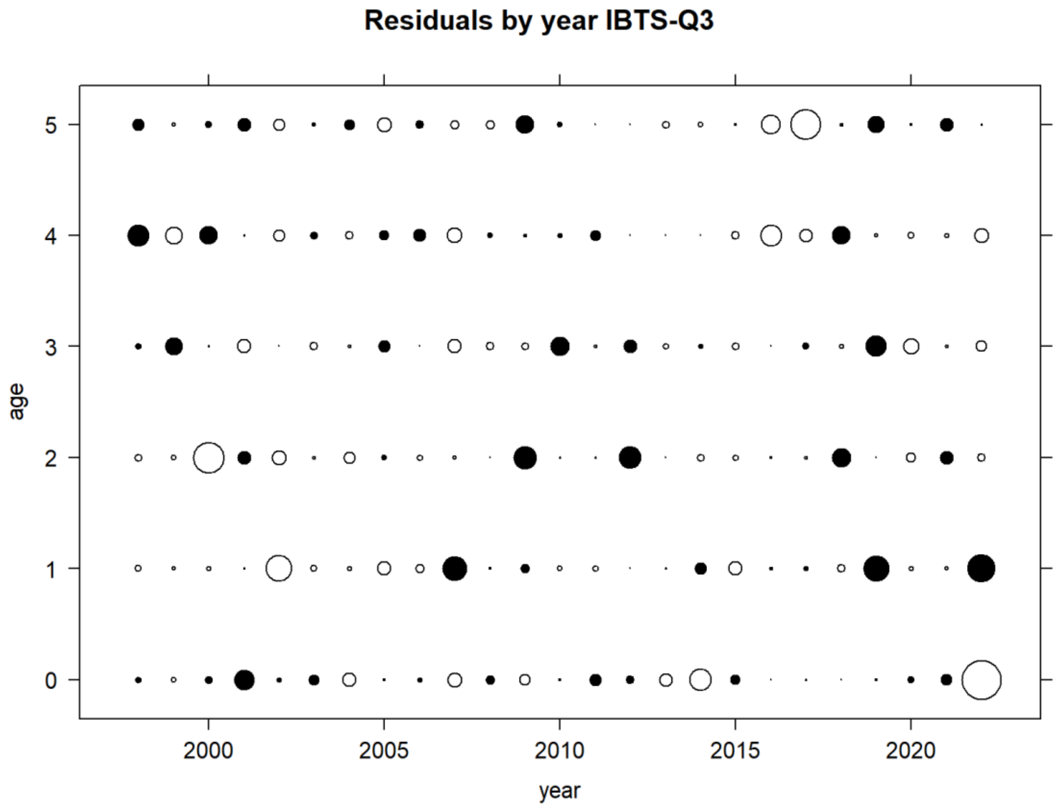


Figure 2.6.2.5. North Sea herring. Bubble plot of standardized IBTSQ3 residuals at age.

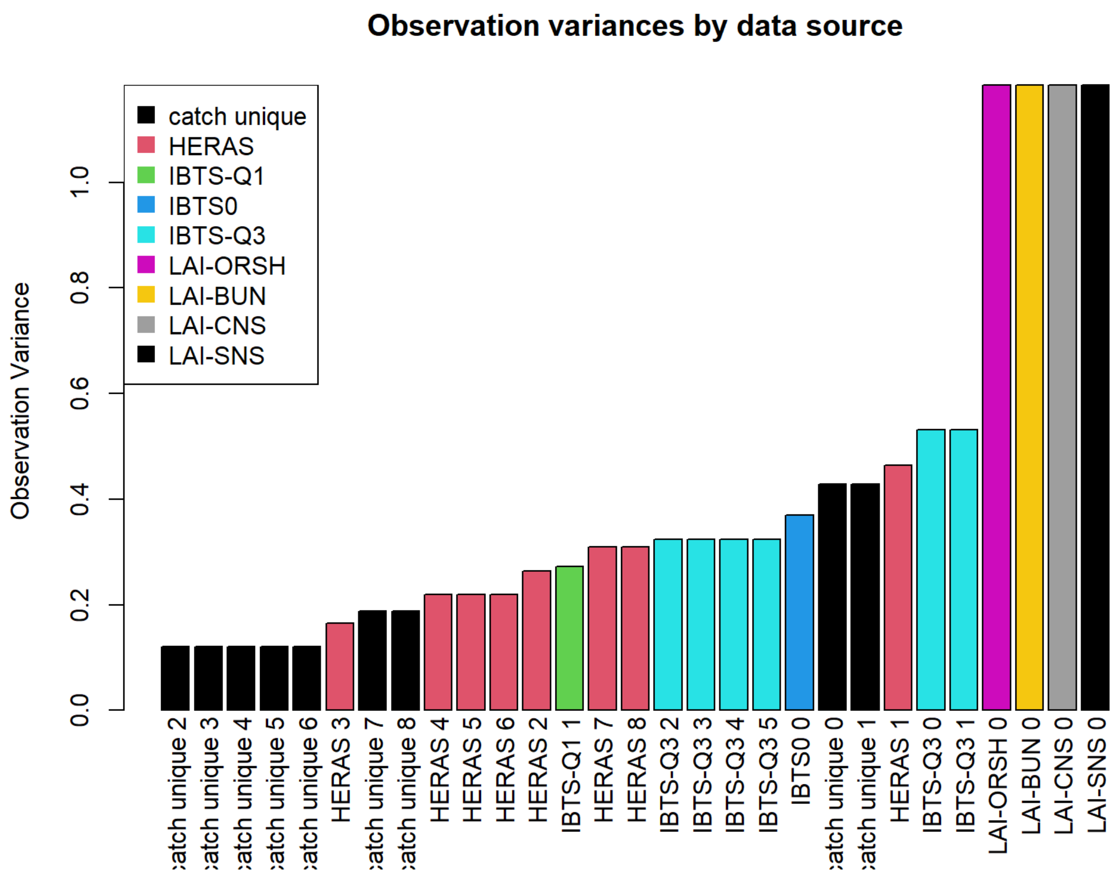


Figure 2.6.2.6. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby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

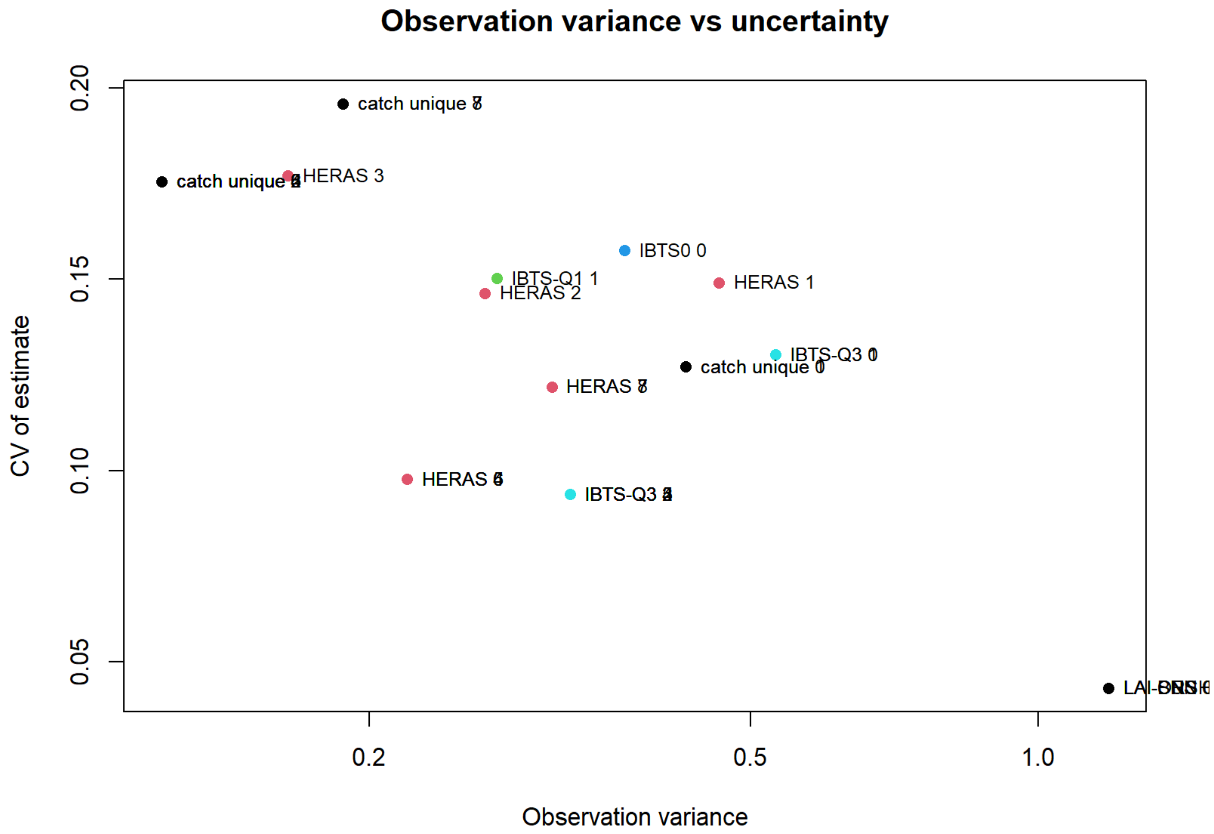


Figure 2.6.2.7. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

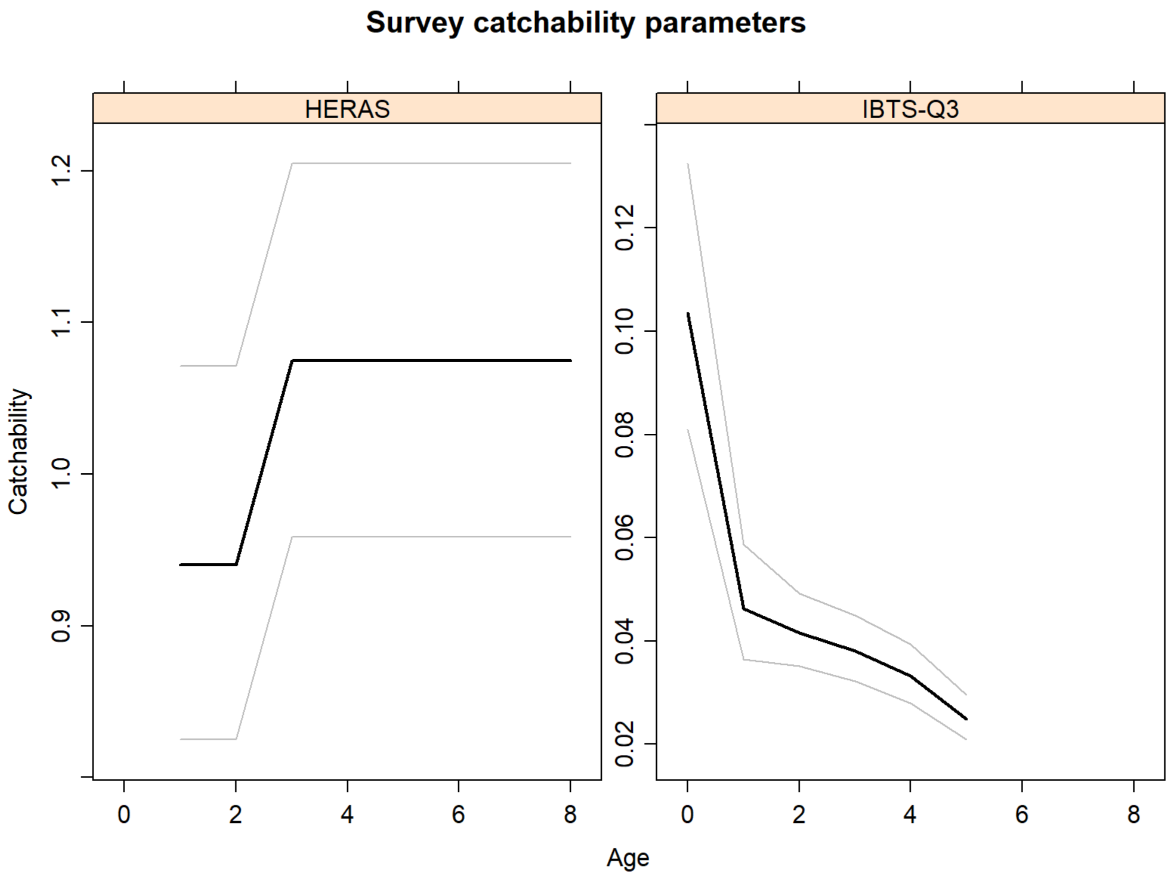


Figure 2.6.2.8. North Sea herring. Catchability at age for the HERAS and IBTSQ3 surveys.

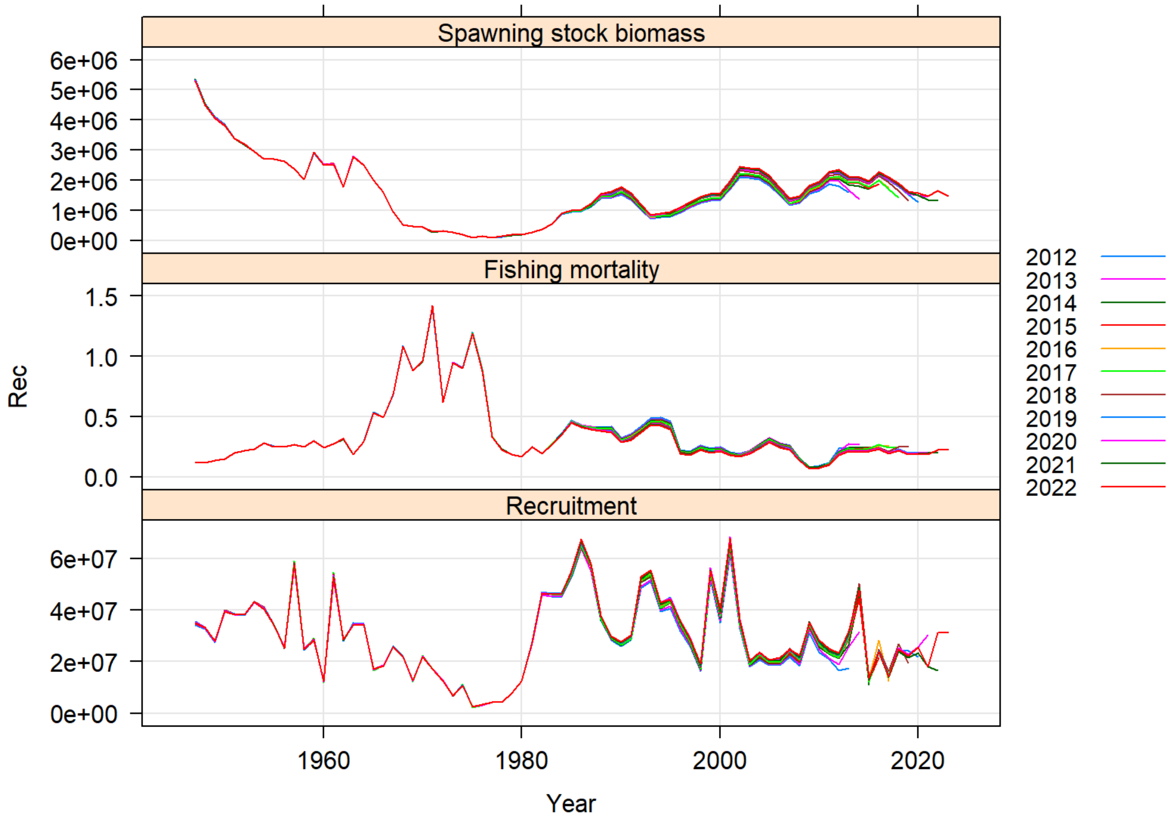


Figure 2.6.2.9. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

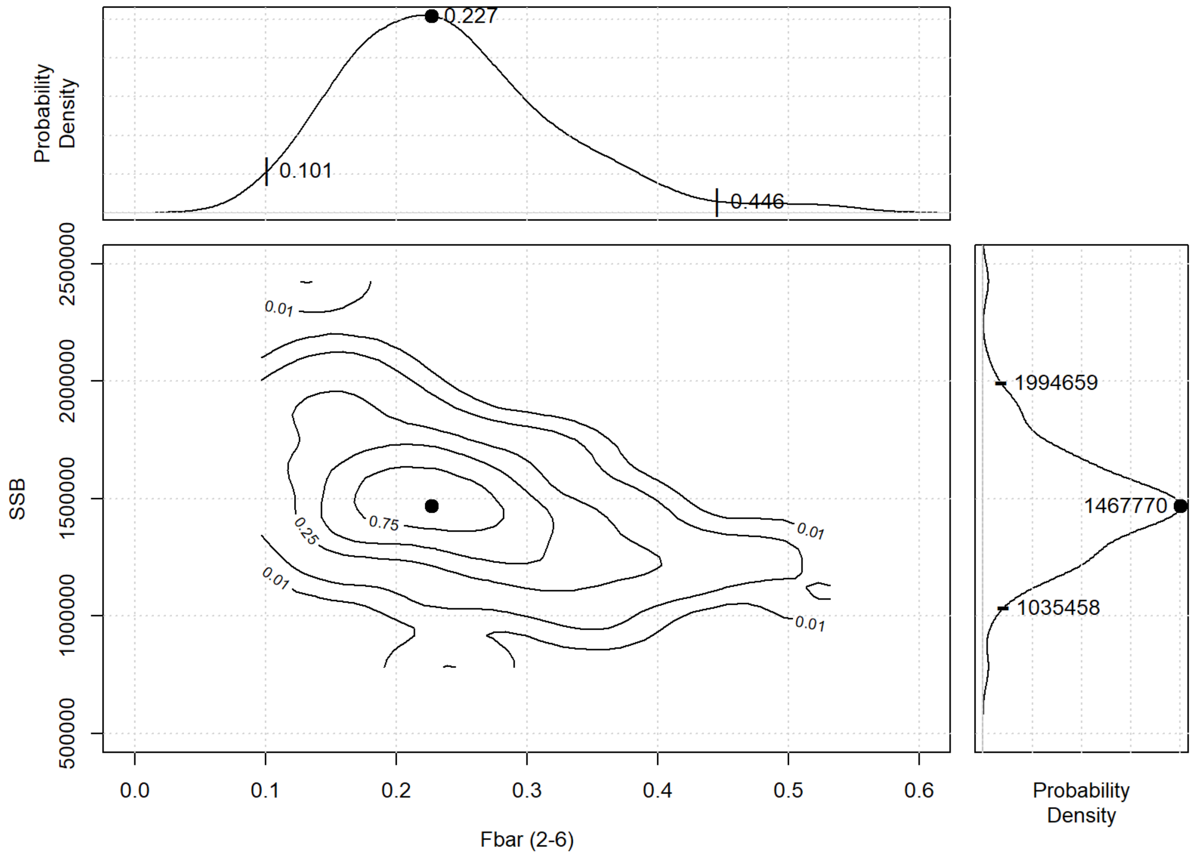


Figure 2.6.2.10. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance/covariance estimates from the model.

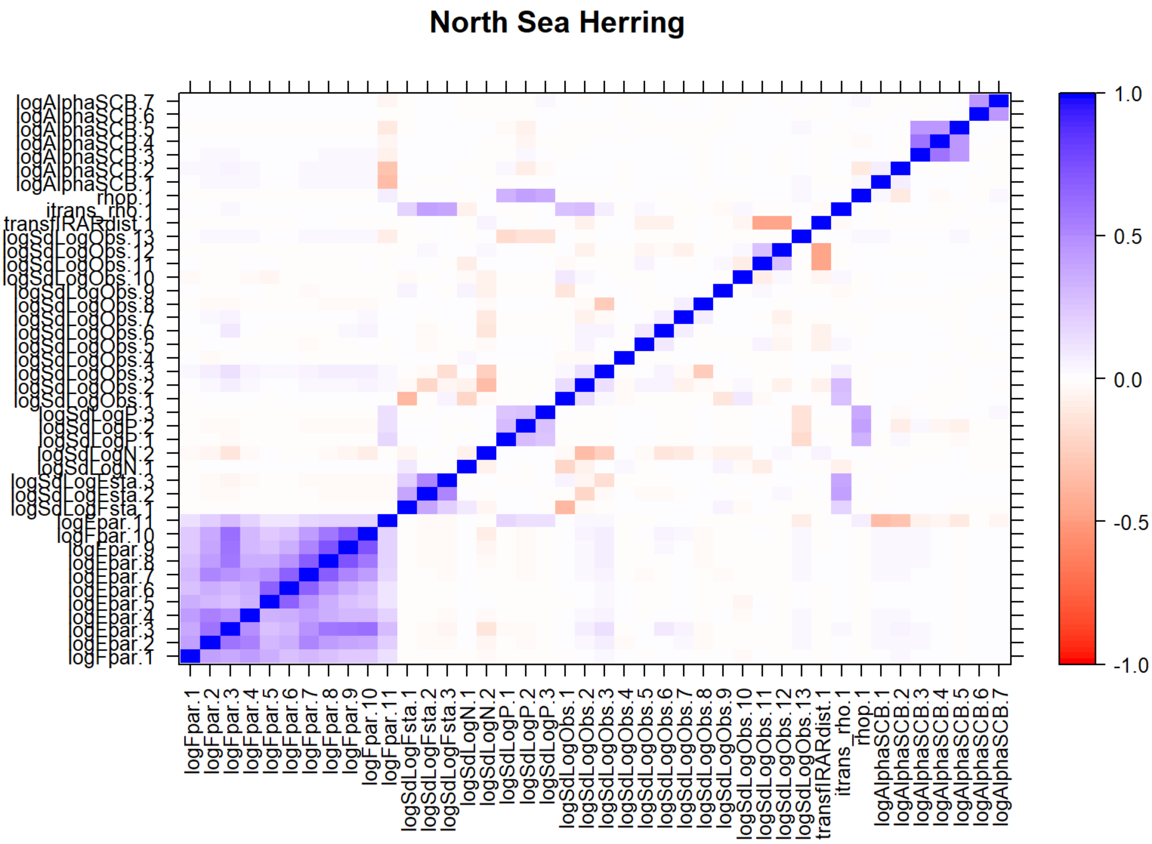


Figure 2.6.2.11. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

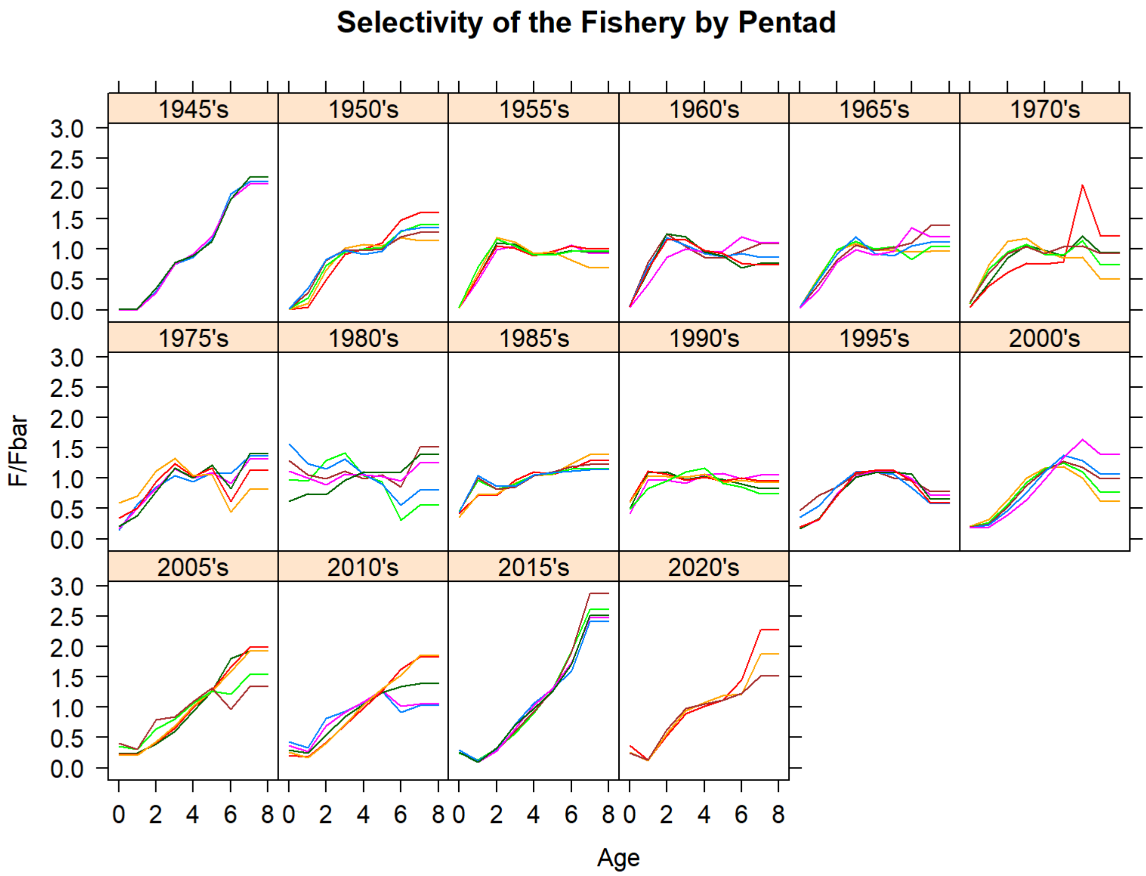


Figure 2.6.2.12. North Sea herring. Fishing selectivity by pentad.

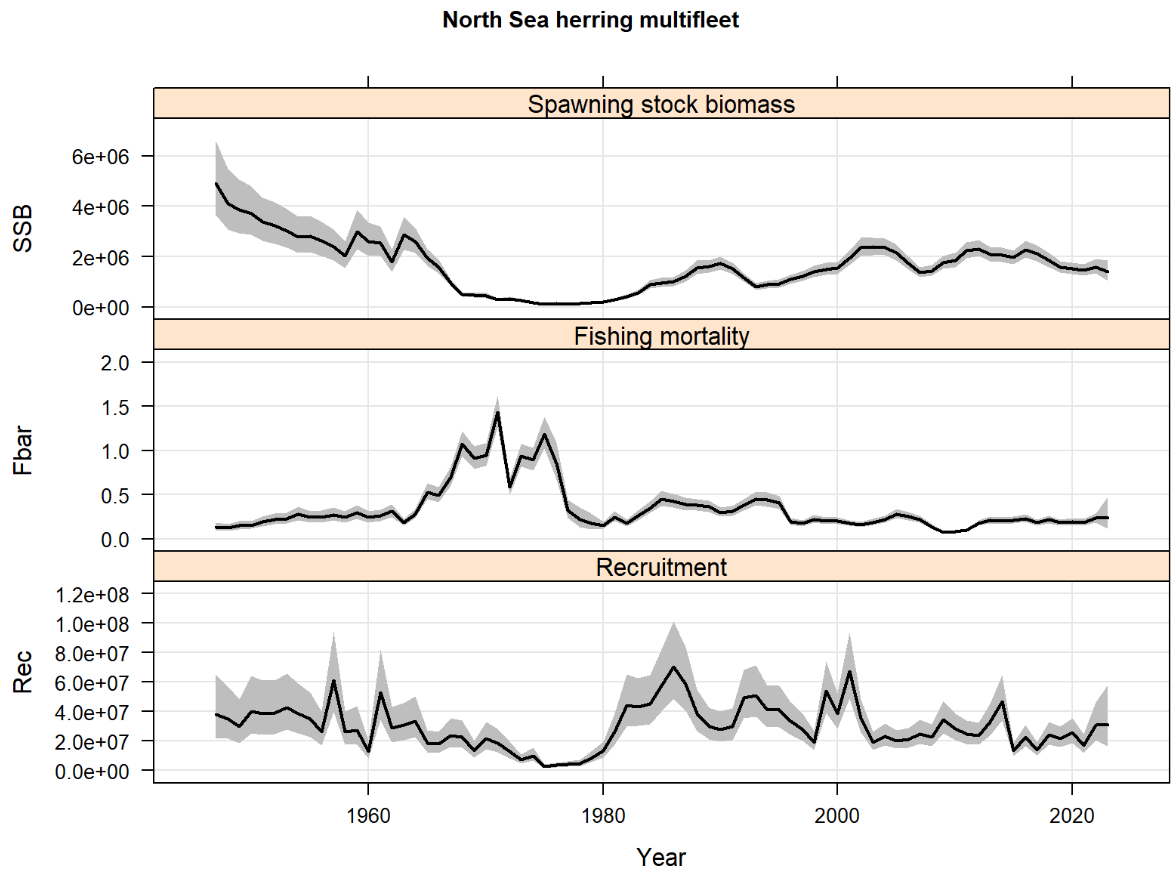


Figure 2.6.3.1 North Sea herring multi-fleet model. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

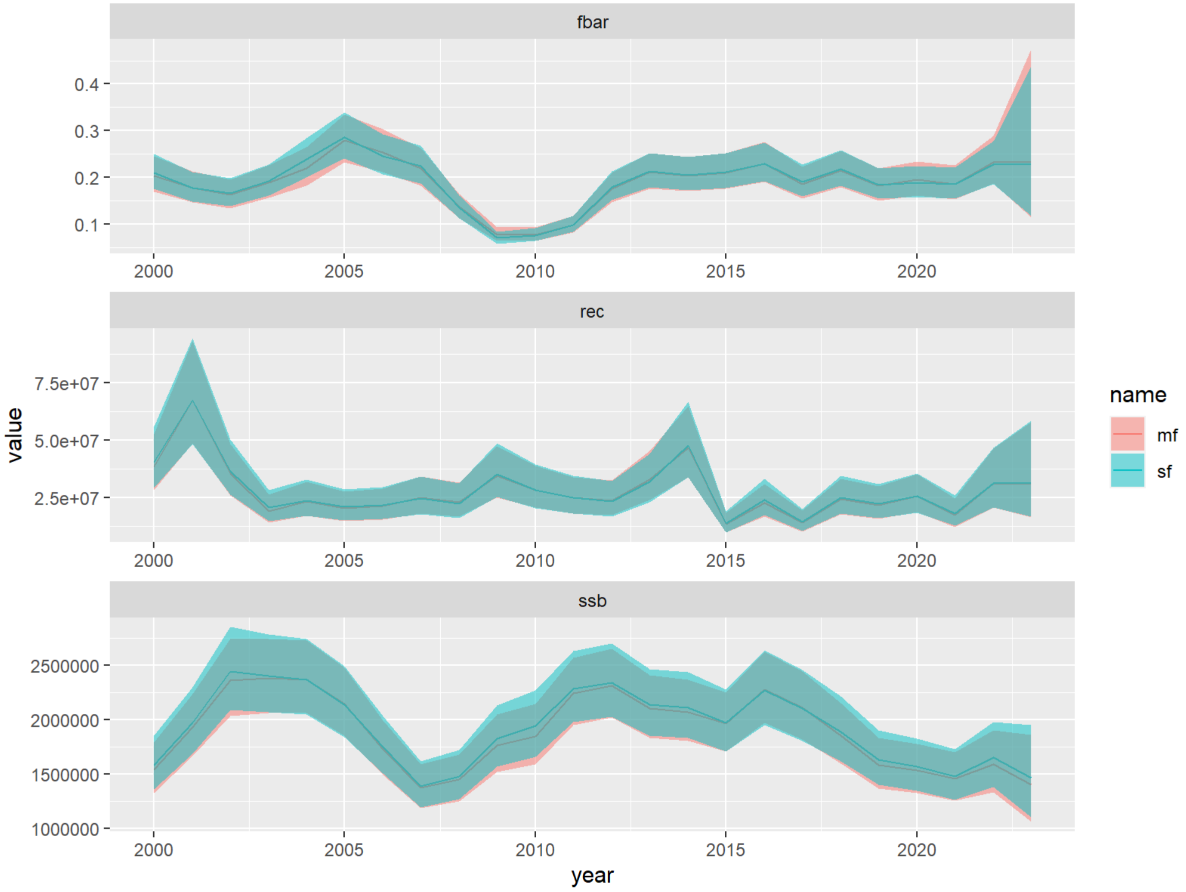


Figure 2.6.3.2 North Sea herring multi-fleet model. Comparison between single fleet and multi-fleet assessment models for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

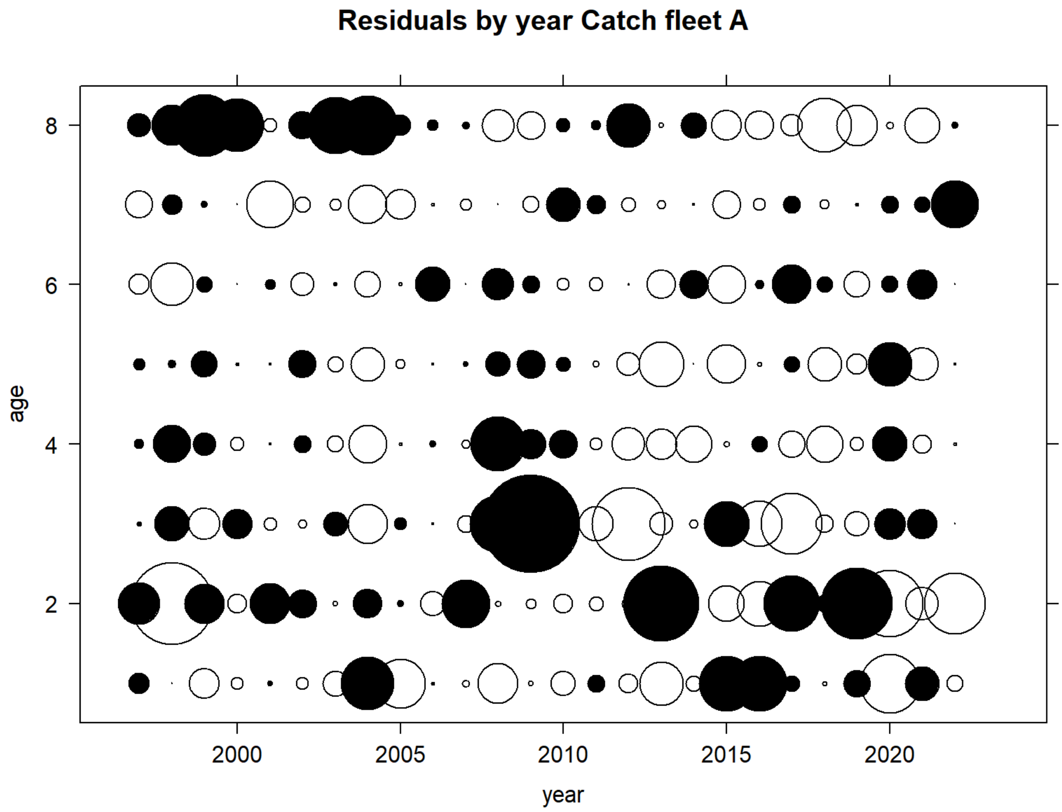


Figure 2.6.3.3. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet A.

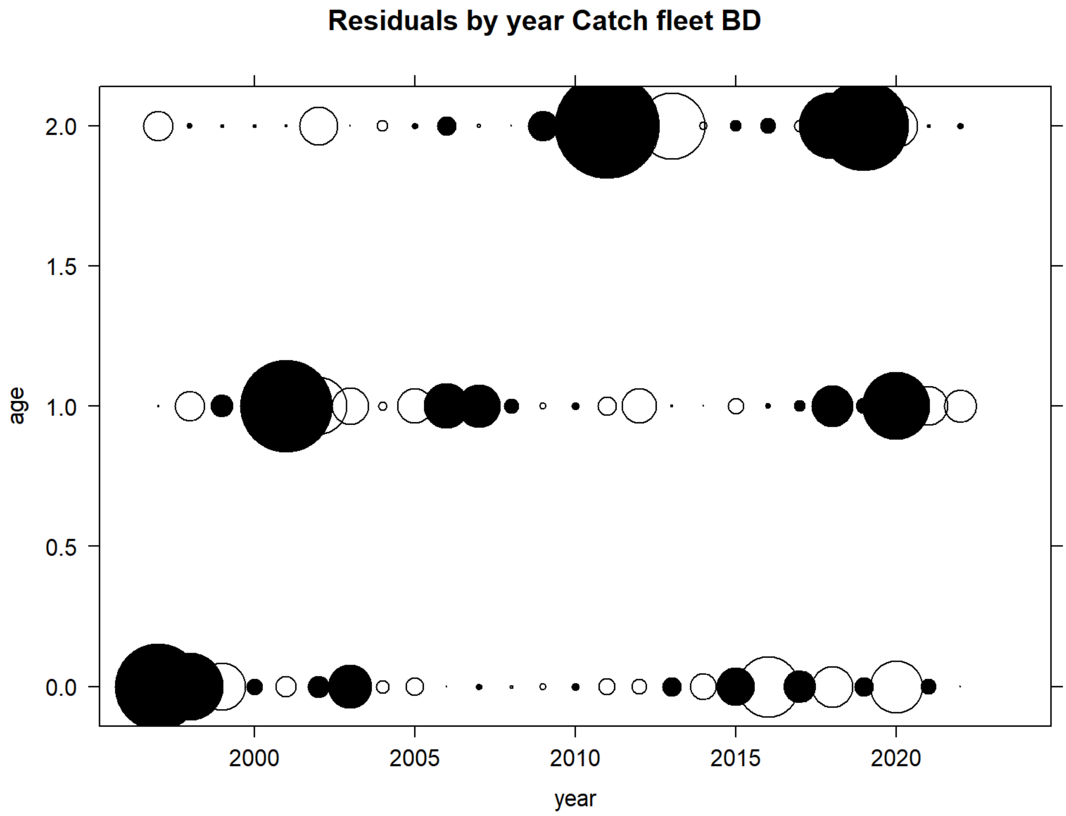


Figure 2.6.3.4. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet B&D.

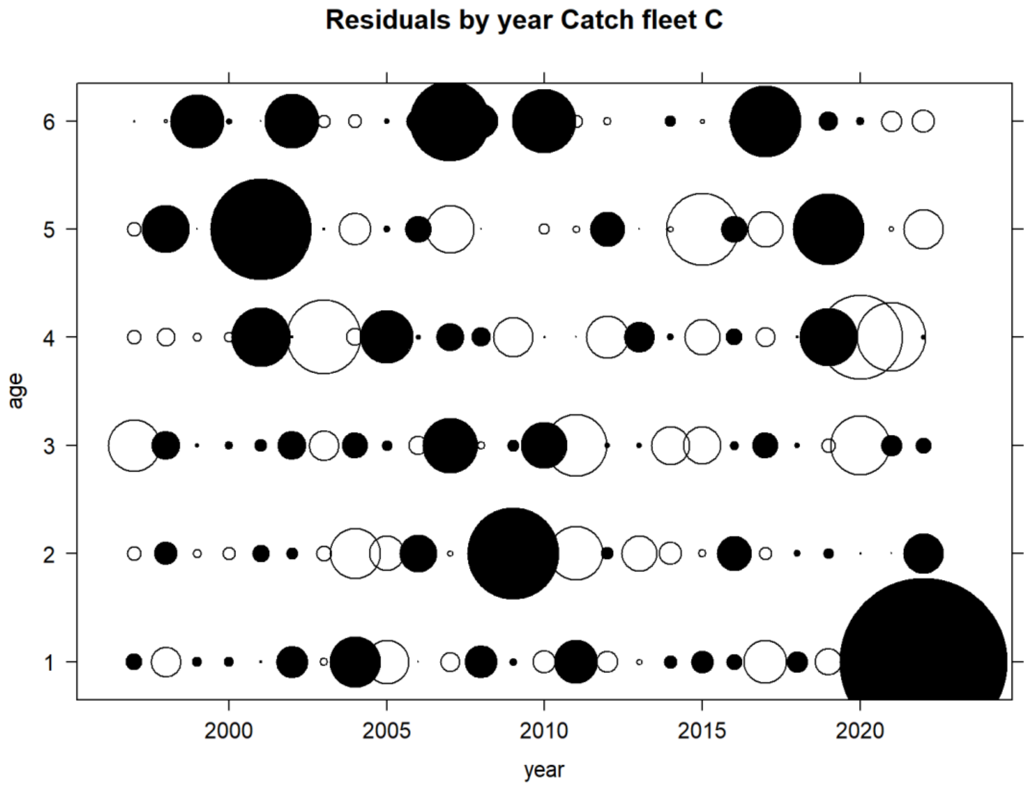


Figure 2.6.3.5. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet C.

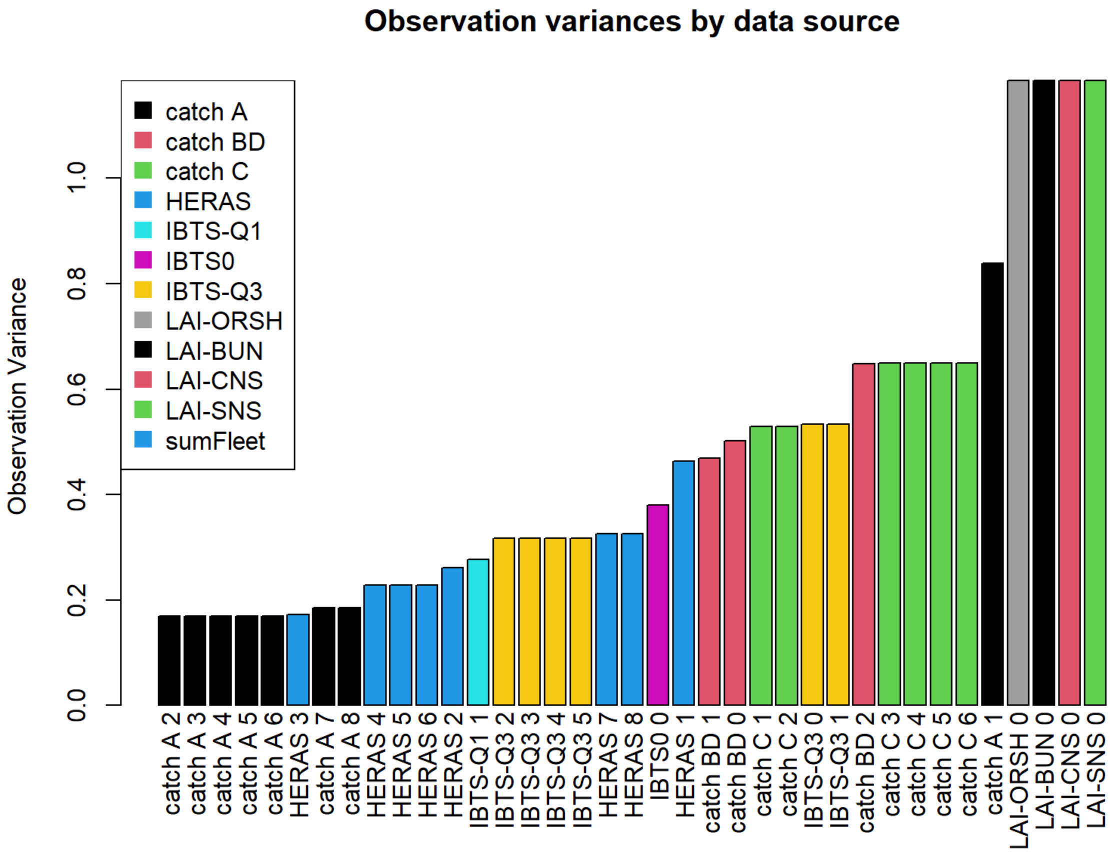


Figure 2.6.3.6. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for 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.

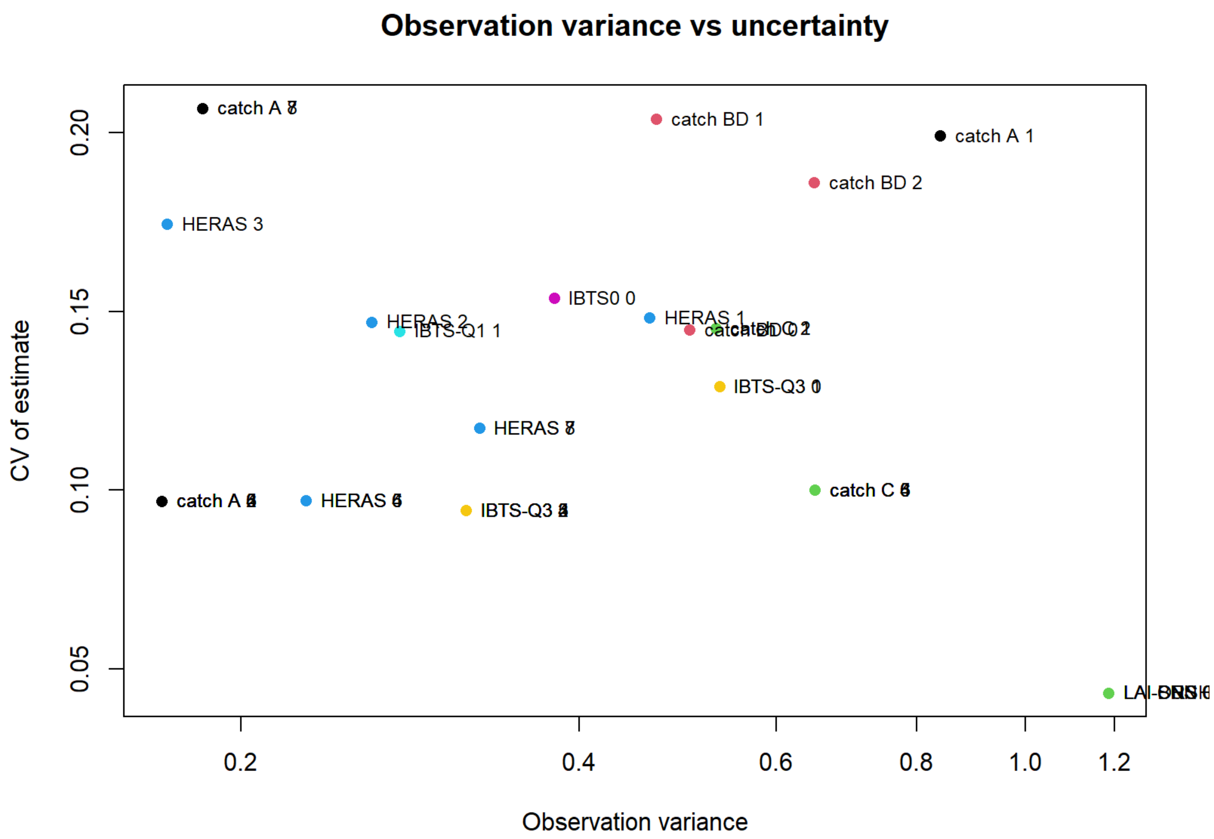


Figure 2.6.3.7. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

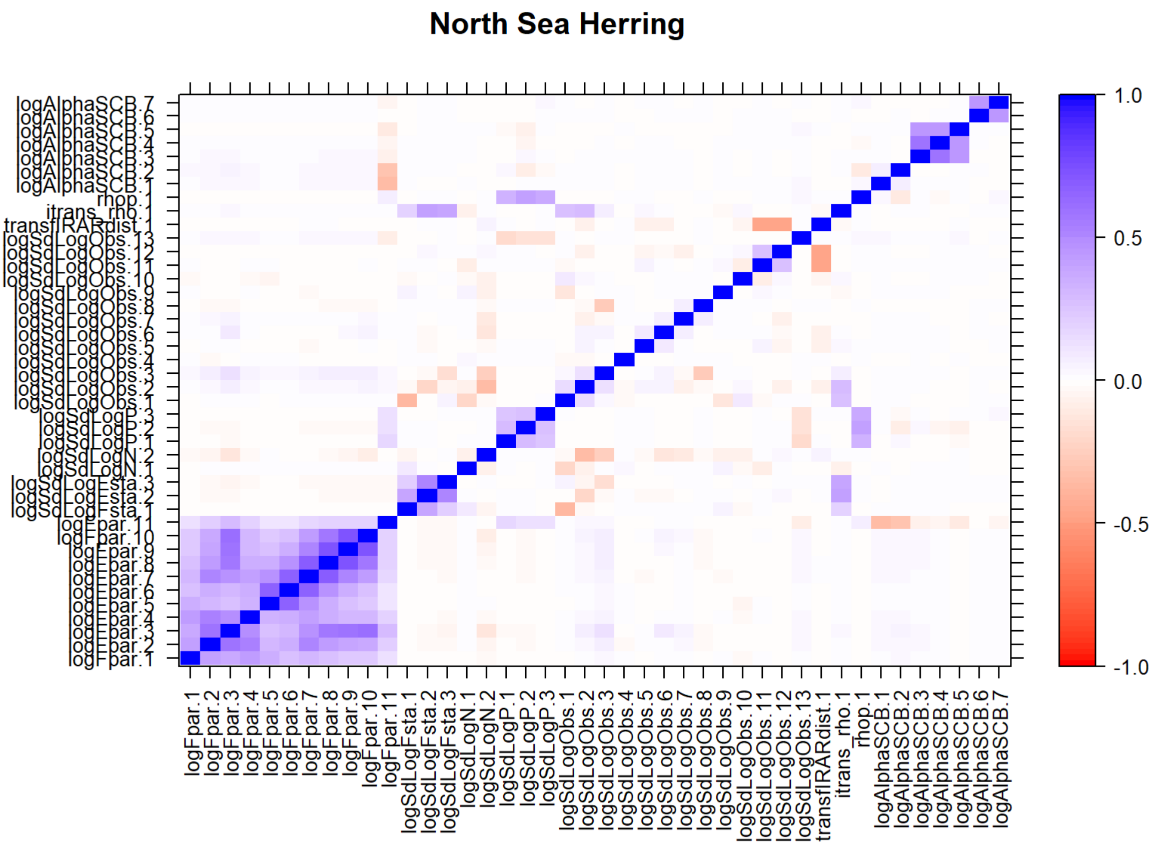


Figure 2.6.3.8. North Sea multifleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

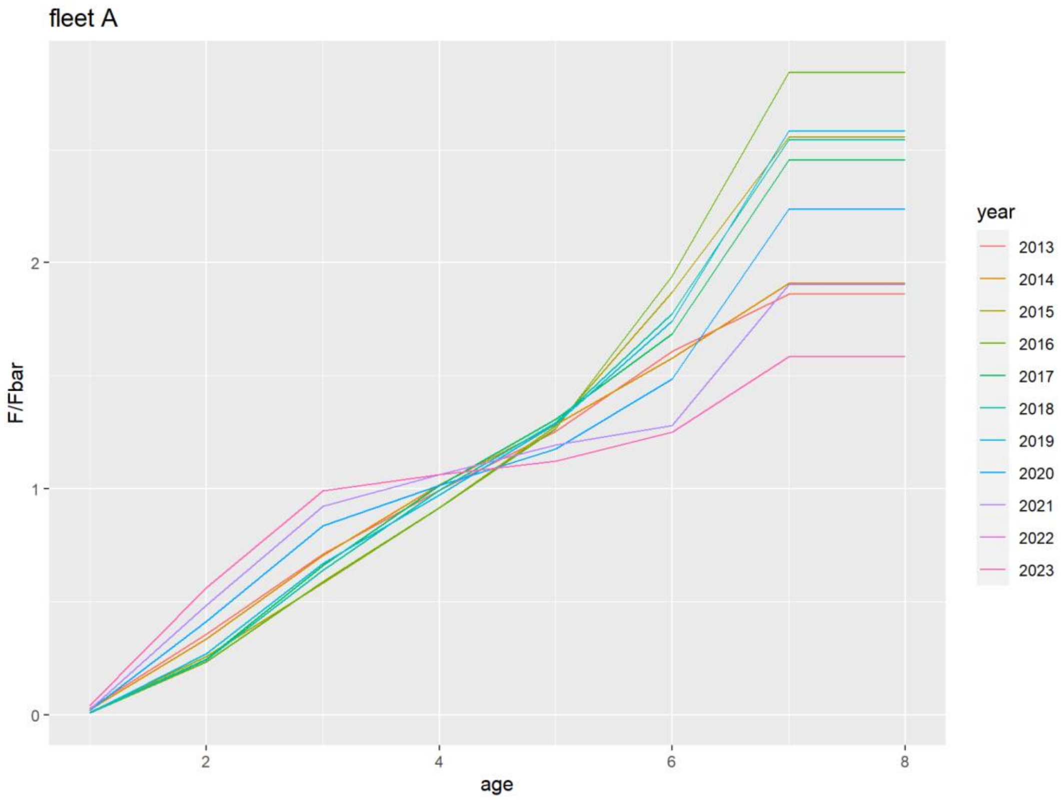


Figure 2.6.3.9. North Sea herring multifleet assessment model. Fishing selectivity fleet A.

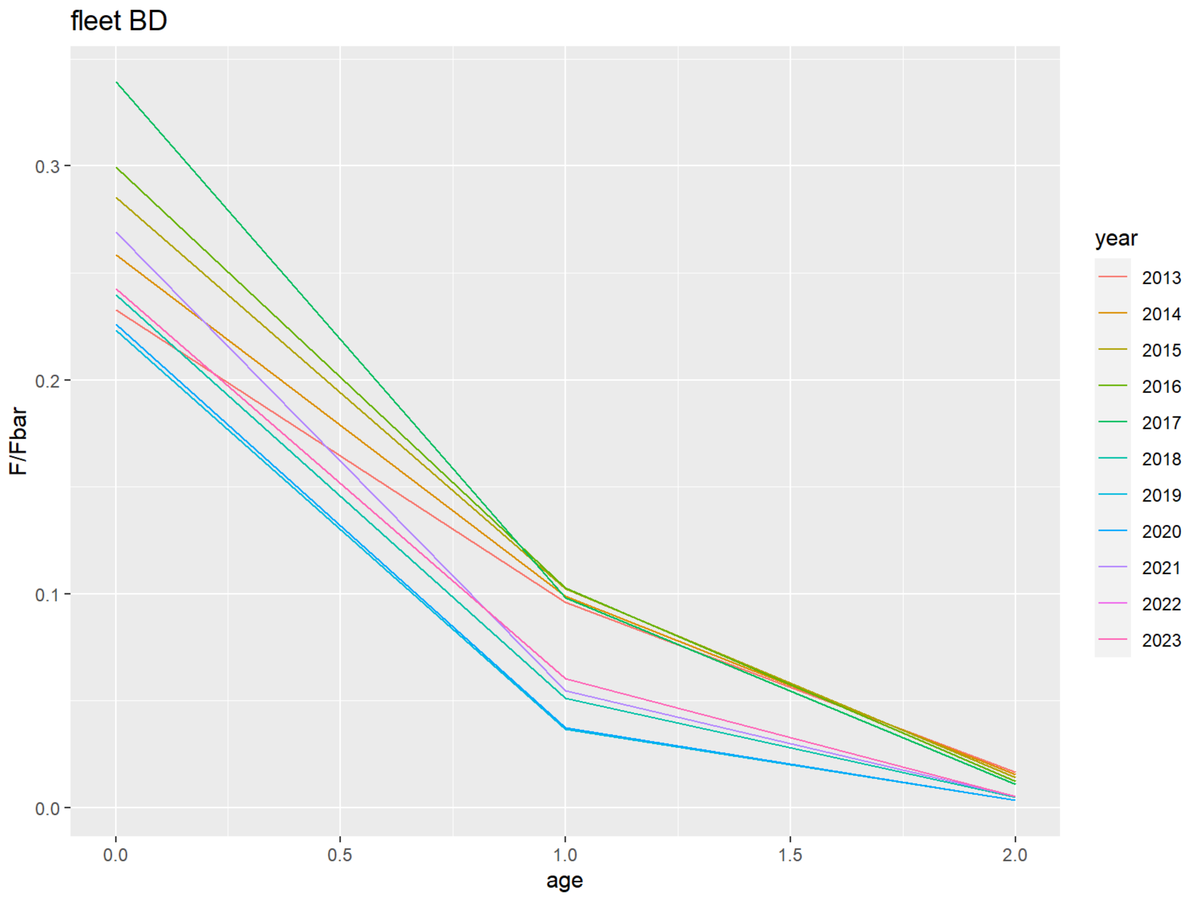


Figure 2.6.3.10. North Sea herring multifleet assessment model. Fishing selectivity fleet B and D combined.

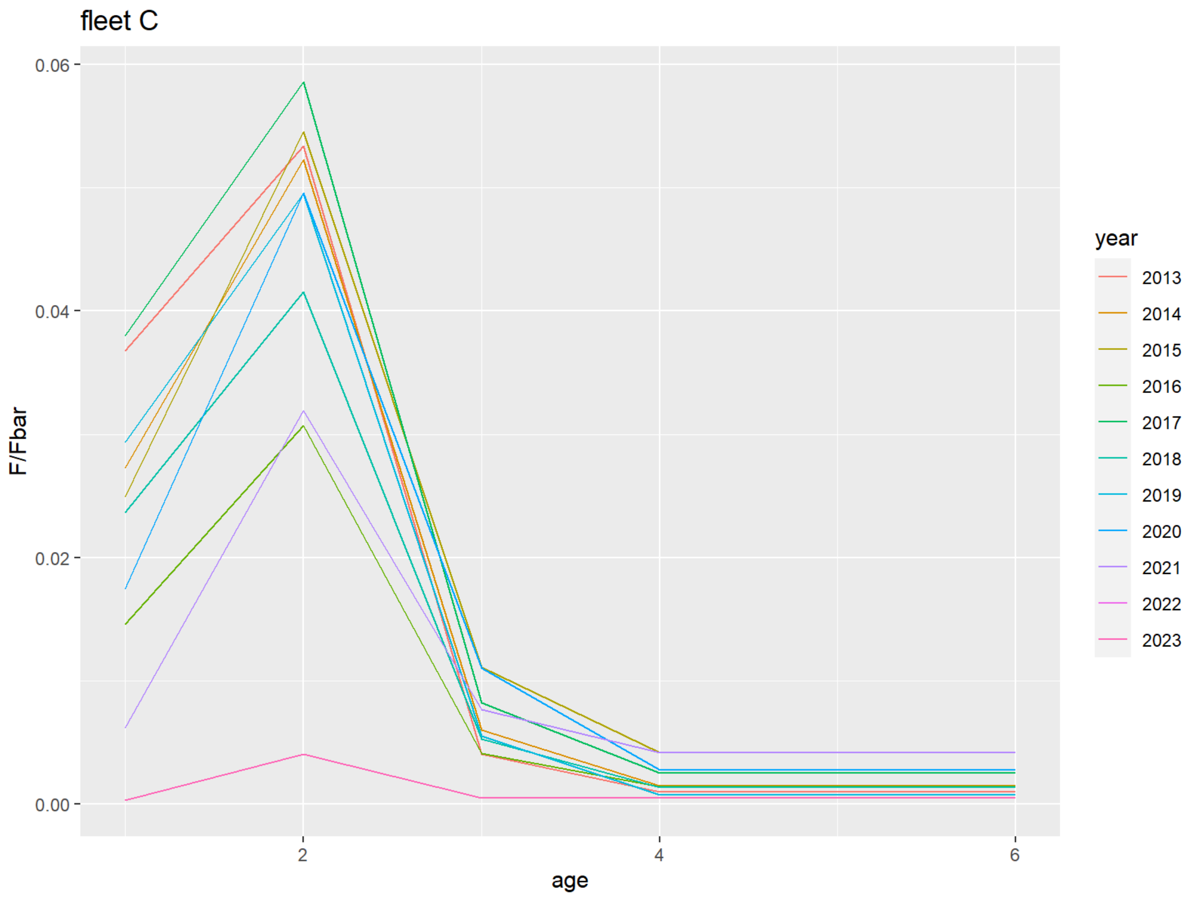


Figure 2.6.3.11. North Sea herring multifleet assessment model. Fishing selectivity fleet C.

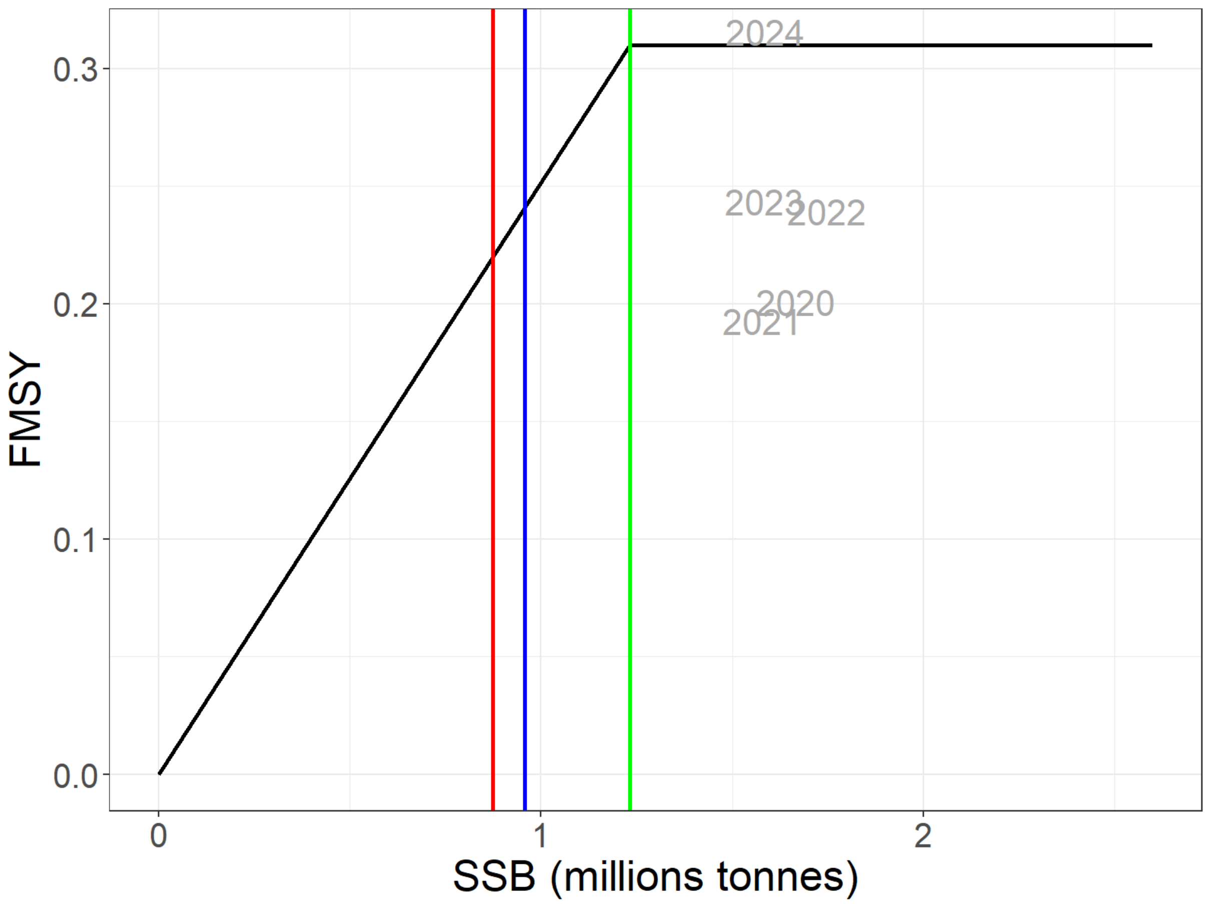


Figure 2.7.1.1. North Sea herring. FMSY advice rule and SSB/Fbar data point since 2020.

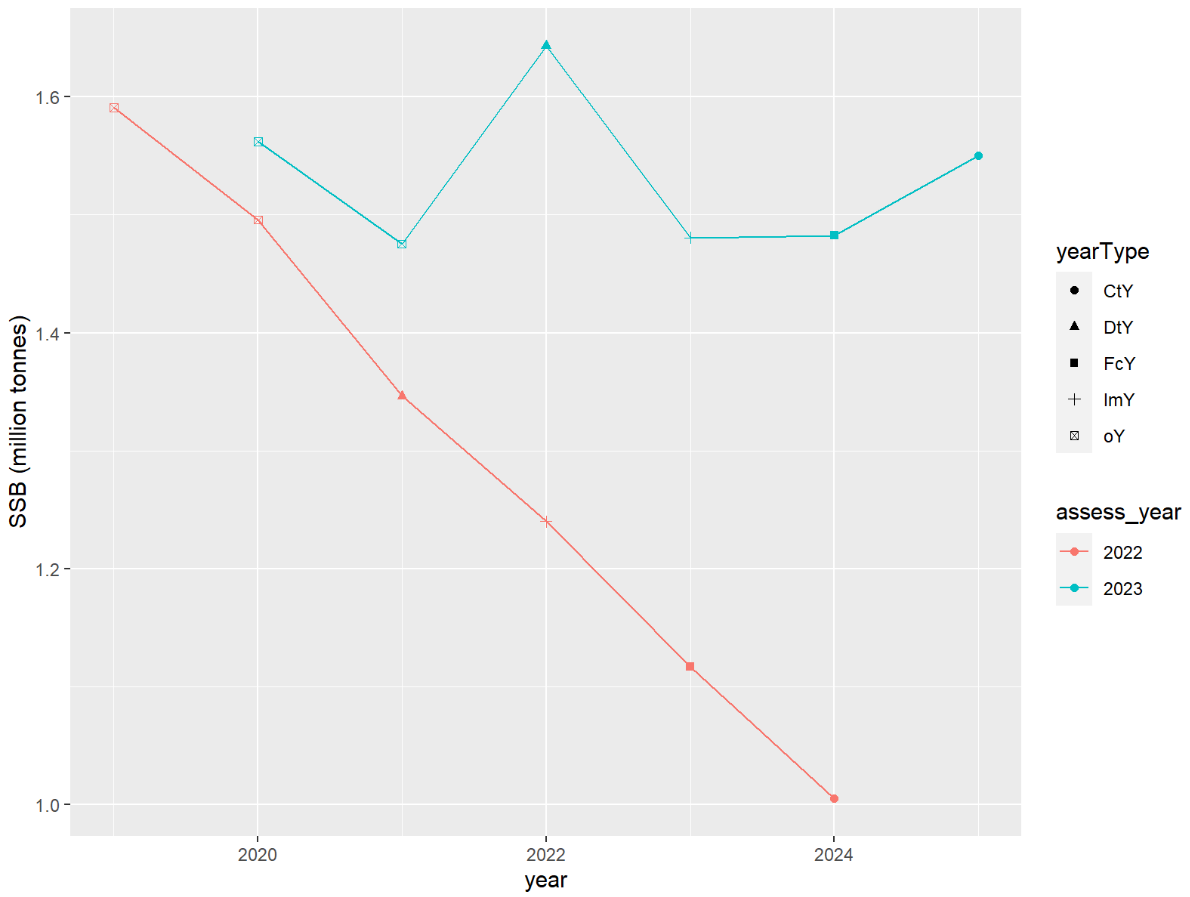


Figure 2.7.2.1. North Sea herring. comparison of SSB trajectory between short term forecasts applied to HAWG2021 and HAWG2022 data. oY: old years (prior to data year). DtY: data year. ImY: intermediate year. FcY: forecast year. CtY: continuation year.

Figure 2.7.2.2. North Sea Herring. Realized and projected catch (in weight) by age (wr) between 2021 assessment (2022 as forecast year), 2022 assessment (2023 as forecast year) and 2023 assessment (2024 as forecast year).

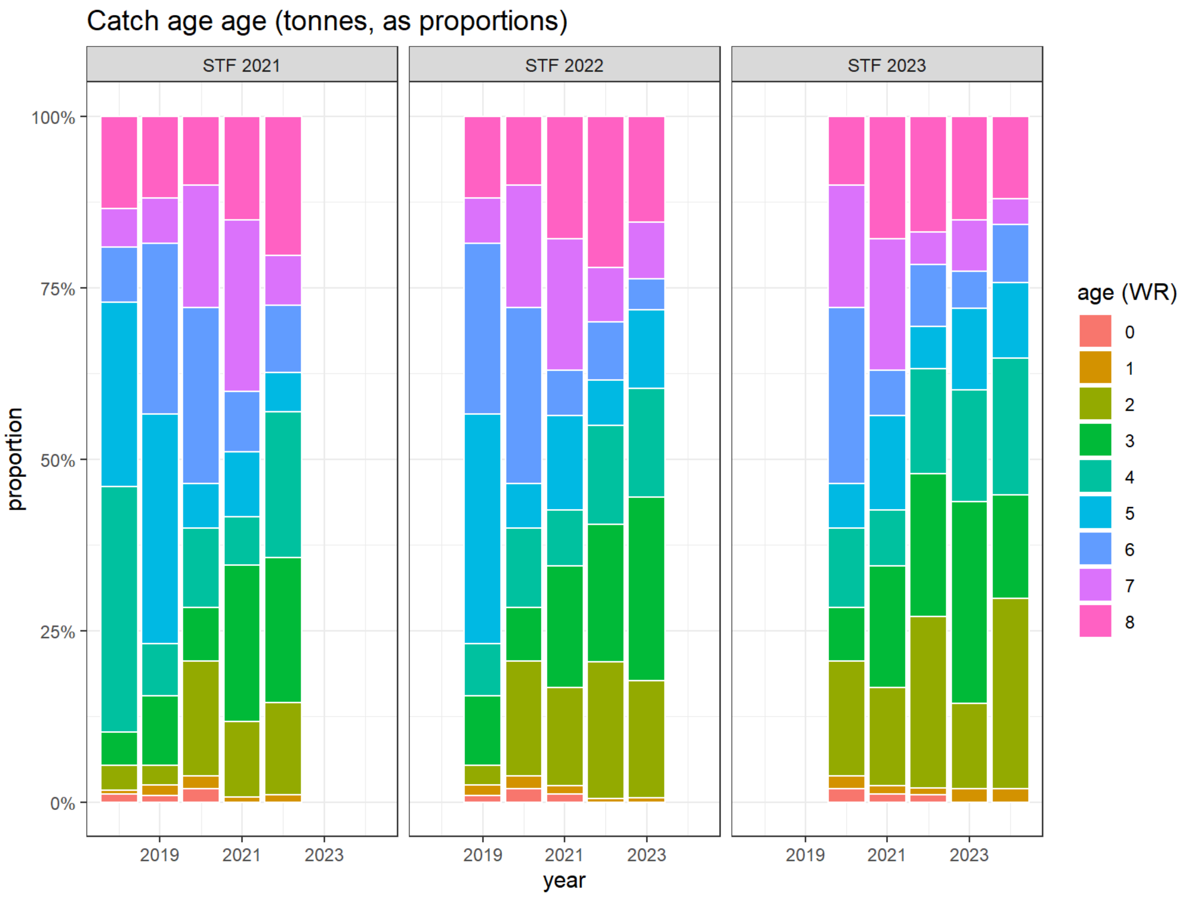


Figure 2.7.2.3. North Sea Herring. Catch proportions for the different ages between the 2021 short-term forecast (2022 as forecast year), 2022 short-term forecast (2023 as forecast year) and 2023 short term forecast (2024 as forecast year).

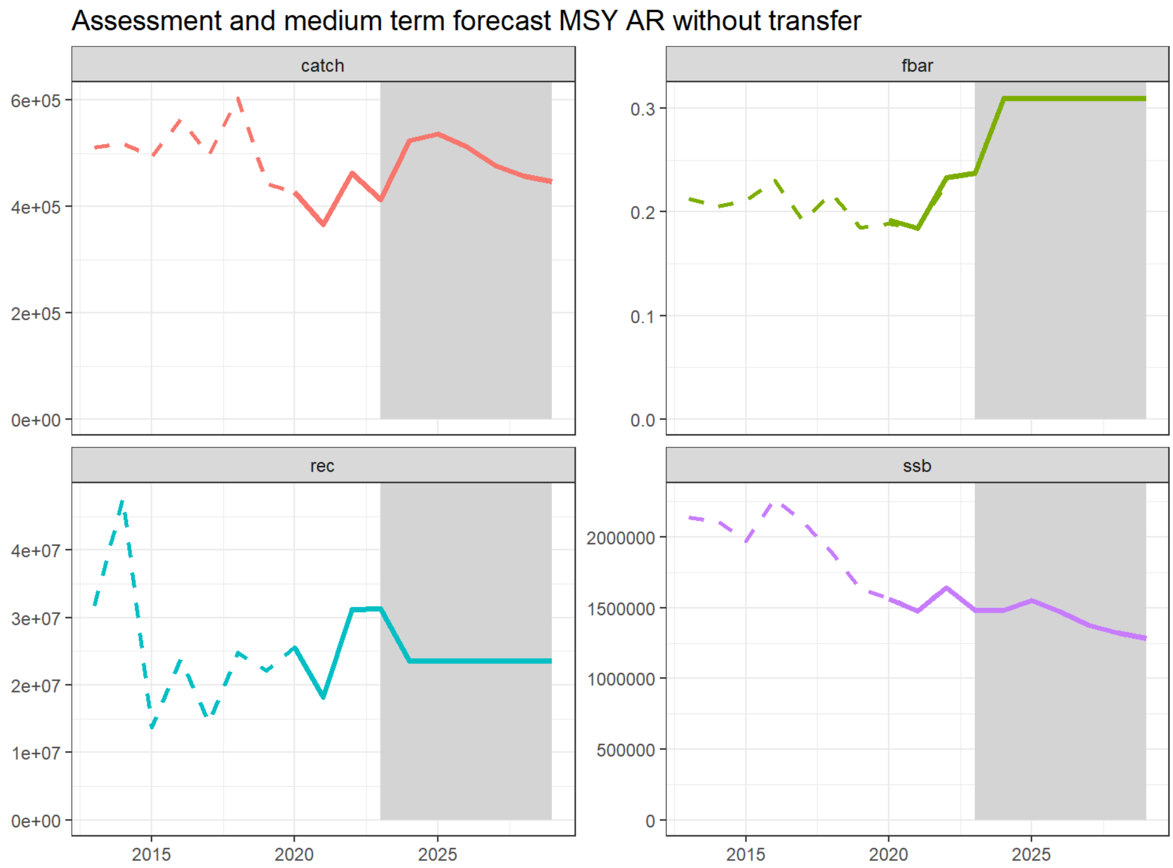
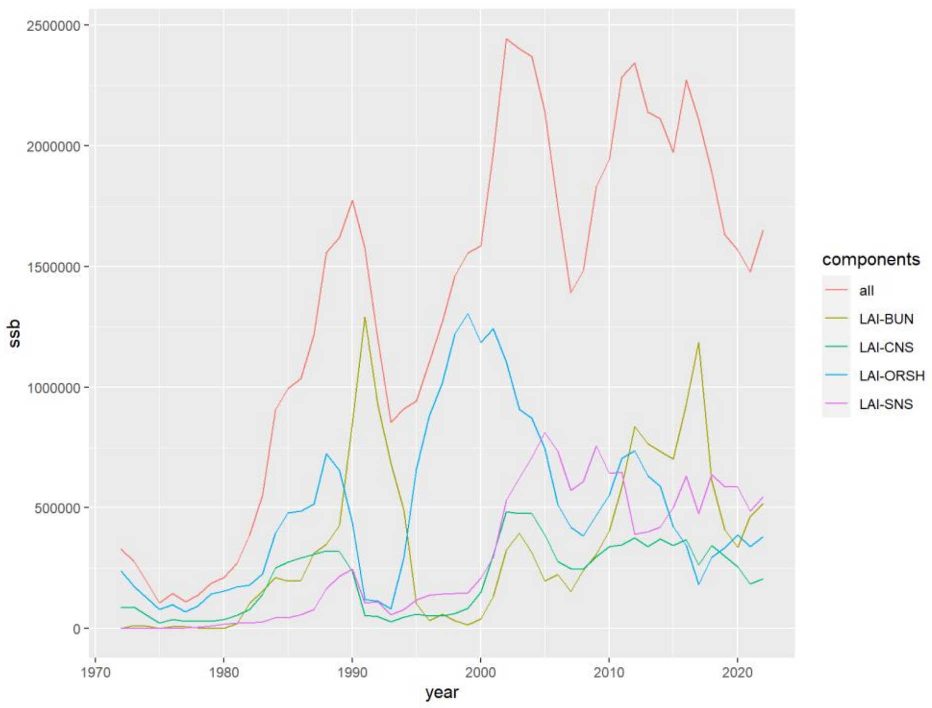


Figure 2.7.2.4. North Sea Herring. Short-term projections using an F status quo from TAC year (i.e., advice year). Intermediate year is in 2023 and the TAC year is 2024.



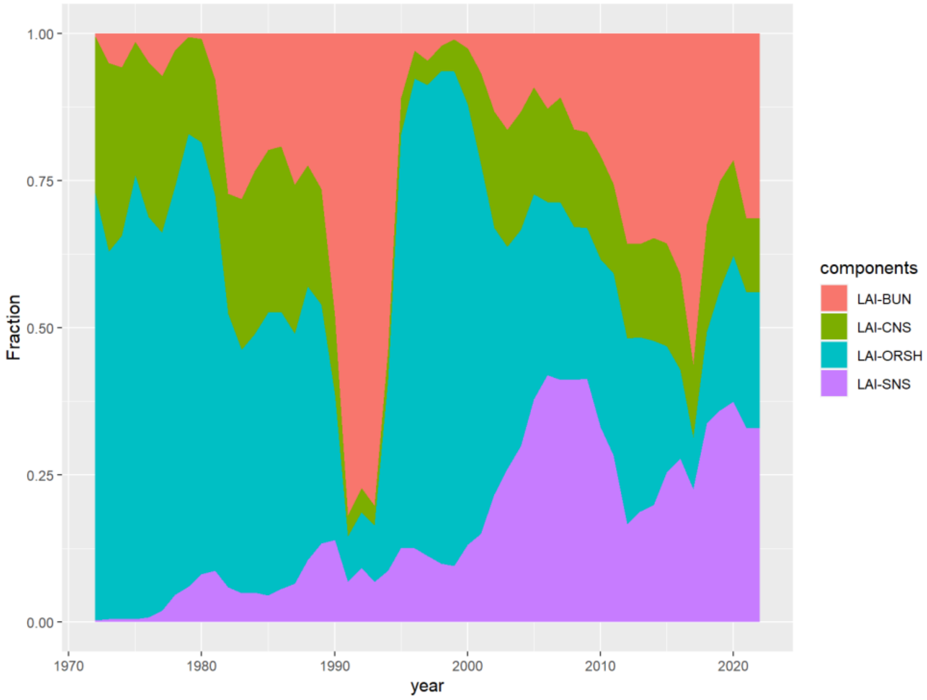


Figure 2.11.1. North Sea herring. Time-series of spawning-stock biomass of each component (top), and contribution of each component to the total stock (bottom; Payne, 2010) as estimated from the LAI index Areas are arranged from top to bottom according to the south-to-north arrangement of the components.

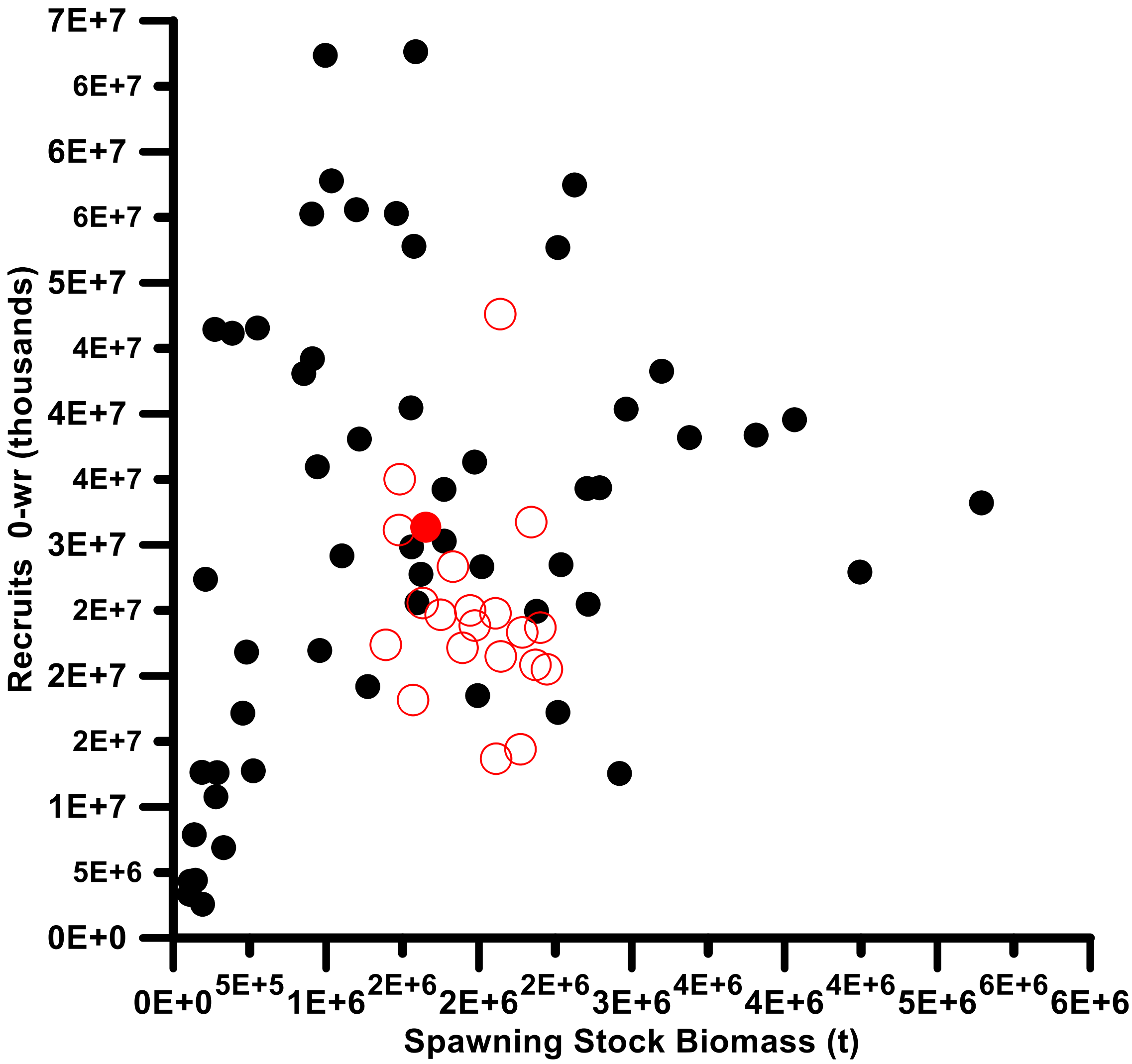


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning-stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent low recruitment. The most recent year class is plotted in solid red.

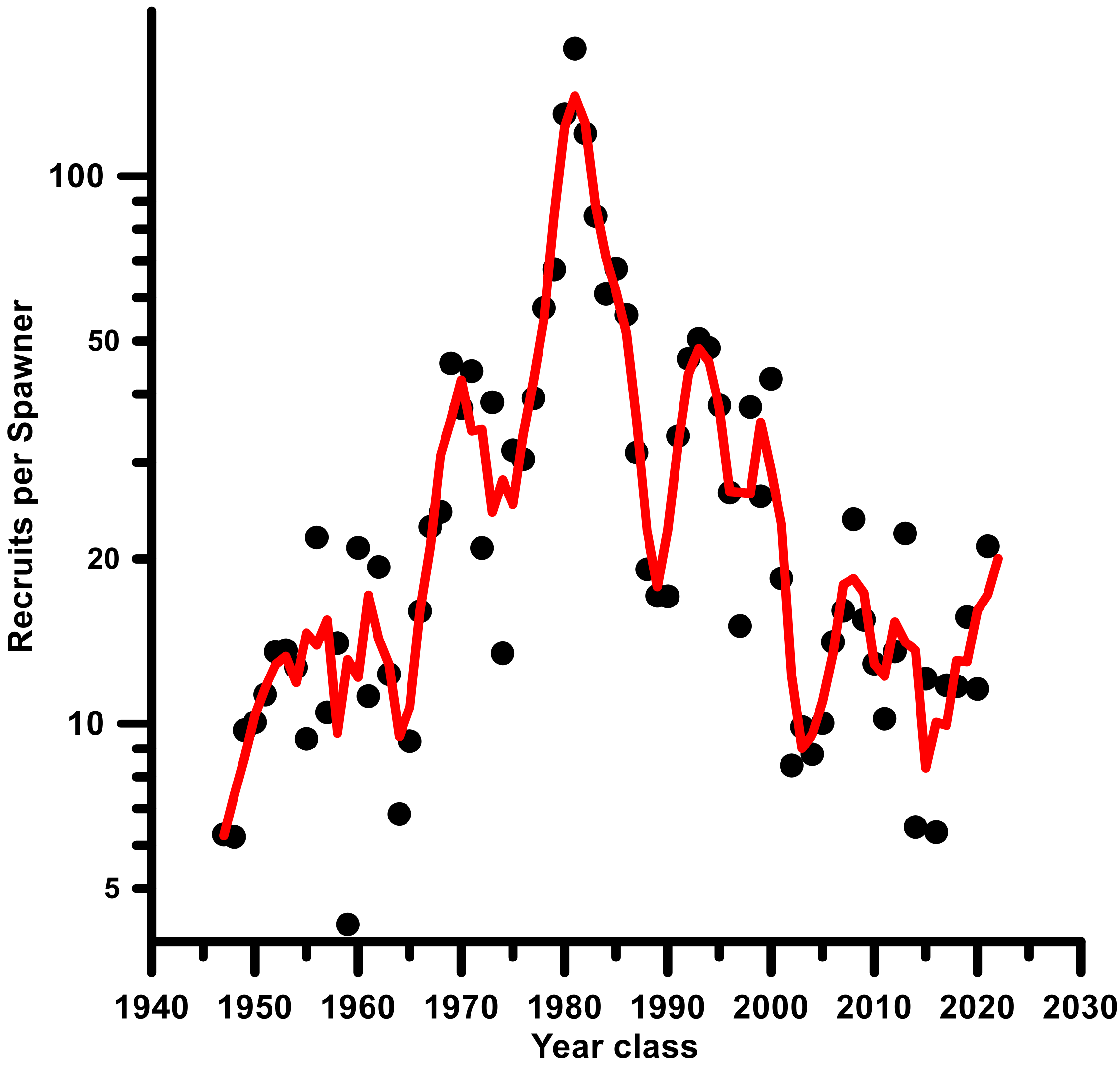


Figure 2.13.2. North Sea Autumn Spawning Herring time-series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawn- ing and is plotted against the year in which spawning occurred. Black points: RPS in a given year. Red line: Smoother to aid visual interpretation. Note the logarithmic scale on the vertical axis.

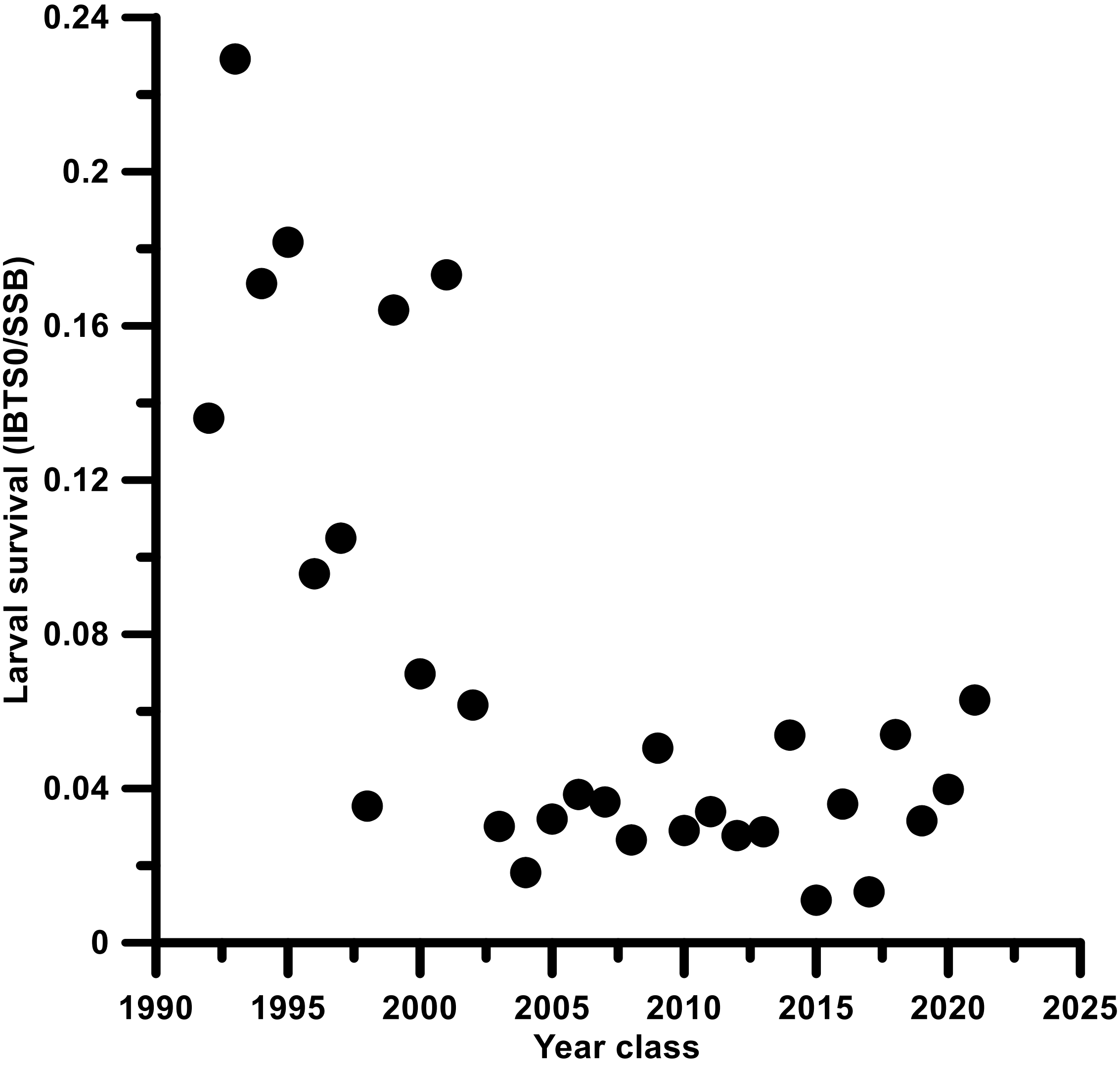


Figure 2.13.3. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is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

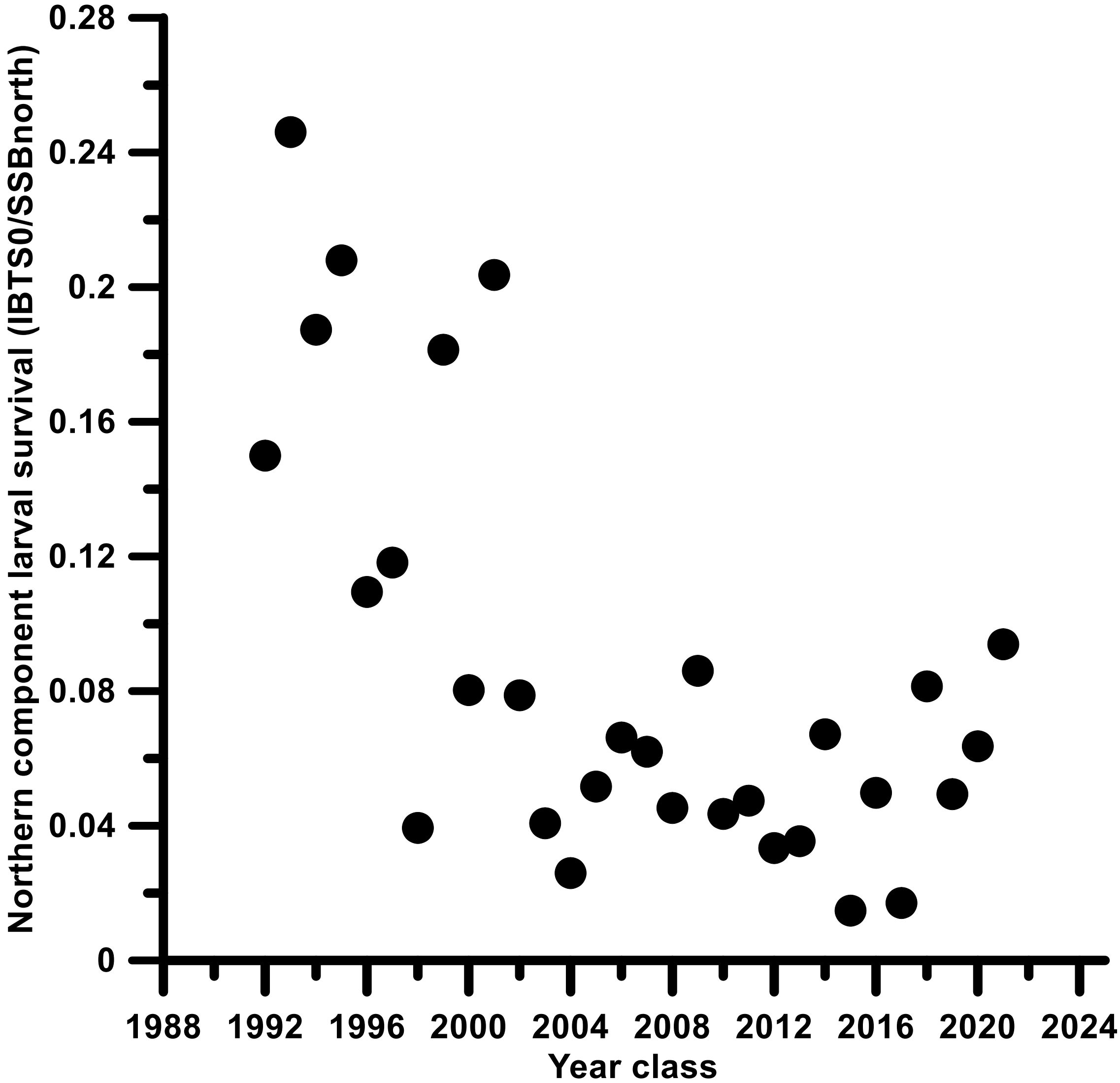


Figure 2.13.4. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the larvae indices for these components (representing larvae less than 10–11 mm) and the IBTS0 index (repre- senting the late larvae, > 18 mm). Survival ratio is plotted against the year in which the larvae are spawned.

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 2022 and 2023

ICES advised in 2022 on the basis of the MSY approach. This corresponds to zero catch in 2023 (ICES 2022).

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. In 2022 and 2023, the agreement states that the possibility to transfer up to 100% of the human consumption TAC from 3.a to the North Sea and up to 50% for the bycatch small mesh fishery (see Council Regulation (EU) 2023/194 + amendment on 17 March 2023 EU 2023b) for more specifics on area limitations on the transfer within the North Sea).

For 2023, the EU, UK and Norway agreed on a maximum catch in Division 3.a for both the human consumption and the industrial fishery of 1 279 t corresponding to 969 t for EU countries and 310 t for Norway (assuming maximum transfer of 90% of 3102 t).

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 was kept constant and set at 788 t.

3.1.2 Landings in 2022

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 2022 are given in Table 3.1.1 and Figure 3.1.1. In 2022, the total landings in Division 3.a and subdivisions 22–24 have decreased to 1 365 t. Landings in 2022 decreased by 95% in the Skagerrak, by 92% in the Kattegat and by 60% in subdivisions 22–24 compared to 2021. As in previous years the 2022 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. This fleet also includes the Swedish fishery with mesh sizes less than 32 mm assuming that there is no difference in age structure of the landings between vessels using different mesh sizes.

Fleet D: Bycatch of herring in Kattegat and Skagerrak in the industrial fleet and only including Danish landings. Covering all fisheries with mesh sizes less than 32 mm e.g., the sprat fishery, but also including other fisheries where herring is landed as bycatch e.g., Norway pout, sandeel and blue whiting fisheries.

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, the Swedish fishery with mesh sizes less than 32 mm was included in the 2022 D-fleet catches together with the Danish landings.

In Table 3.1.2 the landings are given for 2004 to 2022 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

The text table below gives the TACs and Quotas (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**
2022								
Div. 3.a fleet-C	1 136	554	8			407	969	167
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22–24 fleet-F	788	110	435	0	103	140	788	
% of 3.a fleet-C can be taken in 4 EU waters							-100%	
% of 3.a fleet-C can be taken in 4 Norwegian waters								-100%
% of 3.a fleet-D can be taken in 4	50%							
	TAC	DK	GER	FI	PL	SWE	EC	NOR
2023								

	TAC	DK	GER	FI	PL	SWE	EC	NOR
Div. 3.a fleet-C	2 248	559	7			403	969	310
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22–24 fleet-F	788	110	435	0	103	140	788	
% of 3.a fleet-C can be taken in 4 EU waters							-100%	
% of 3.a fleet-C can be taken in 4 Norwegian waters								-100%
% of 3.a fleet-D can be taken in 4	50%							

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 2022.

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, 2022 and 2023, 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 50% has been given to the D-fleet, in order to protect WBSS herring. In addition, in 2022 and 2023, EU committed to limit overall herring catches in Division 3.a to 969 t and Norway to limit those to 167 t in 2022 and 310 t in 2023.

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 quotas for the fleets that exploit these stocks.

3.1.5 Changes in fishing technology and fishing patterns

The amount of WBSS herring taken as bycatch in the D-fleet has been varying between years depending on the utilization of the bycatch TAC and the proportion of WBSS in the catches. In 2022 the amount of WBSS taken was 35 t, which is the lowest recorded catch. However, the TAC utilization was 3.8% being also the lowest recorded utilization. Prediction of TAC utilization is further complicated by the merging of the sprat stocks in 3.a and the North Sea (ICES 2018) with a common management and the optional transfer of 50% of the herring bycatch quota from the D-fleet in 3.a to the B-fleet in the North Sea.

3.1.6 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 1 365 t of landed herring were submitted stratified by area, fleet, and quarter, resulting in 52 strata with landings. 11 of these strata were sampled - accounting for 47% of the landings. Some strata with relatively large amounts of landings were unsampled and only 2 samples were from Skagerrak and Kattegat (Table 3.2.1). Further, it seems like it is getting more and more difficult for countries to sample the trawler landings in the F fleet, most of the samples are from the passive fleet (Table 3.2.2). Unsampled strata accounted in total for 728 t and samples from either other nations or adjacent areas and quarters, and for the first time in recent years, samples from the previous year 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 landed

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 2022, 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 2022 was estimated to be 5 614 t, which represents a decrease of 55% compared to 2021 (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 6 251 for 2022 (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 1993–2022, are presented in table 3.2.7.

The total catch of NSAS in Division 3.a amounted to 515 t in 2021, which represents the 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 2022 were reallocated to the appropriate stocks as shown in the text table below:

Area	WBSS (tonnes)		NSAS (tonnes)	
Subdivision 4.aE (A-fleet)	5 402		85 521	
Division 3.a	C-fleet	D-fleet	C-fleet	D-fleet

	180	32	296	219

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

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. During the 2022 meeting one country checked their estimated discard of herring in the demersal, *Nephrops* and shrimp fisheries in SD 20-24, and for 2020 the estimated discard constituted 1% of the landings, so an insignificant amount. Therefore, 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 2022 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 and the trawlers in area 22-24 are so poorly covered that it was necessarily to use samples from 2021, see section before.

Splitting of 2022 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 2028 (674 Danish and 1354 Swedish) with 70% of the samples in Subdivision 20 (Skagerrak) and 30% 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. Due to the properties of the available samples in 2022, it was necessary to combine commercial and IBTS samples in the Cruise factor as well as wr 0 Quarter 3 and wr 0 Quarter 4 in the wr0Quarter. Total composition estimates per wr, quarter, and subdivision were calculated as a weighted average of the country-wise estimates. Total estimates were

[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.

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 751 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 (1510 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 90 923 tonnes of herring was caught in the transfer area in 2022, with catches constituting 83% in quarter 2 and 12% in quarter 3.

For quarter 2 and 3, the same split was applied based on the combined samples from surveys and the fishery in the transfer area (2043 fish). This was done under the assumption that the 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 2022, 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 2022 the split for quarters 1 and 4 had to be carried over from 2021. 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, 5402 tonnes of WBSS herring were caught in the transfer area in 2022.

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 5–24 October 2022 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 in the recent years 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 2020-2022 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). The applicability of the SF could not be test-ed in 2019 due some higher degree of mixing of CBH/WBSS in the baseline area of WBSS herring in SDs 21 and 23.

Haul 33 (41G2, SD 23) targeting a large aggregation of herring yielded a substantial sample of almost exclusively large herring a high proportion of individuals that were preparing to spawn-ing (maturity 4-6), and already spent (maturity 8). Since the herring could not be allocated to WBSS, both the hydroacoustic data from that aggregation as well as the biological data from haul 33 were removed from the further analysis for producing a biomass and abundance estimate for WBSS. Genetic samples have been taken and are currently being analysed to identify stock origin of that herring.

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 2022 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.

The time-series has been revised in 2008 (ICES 2008/ACOM:02) to include the southern part of SD 21. 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 22 June to 21 July 2022 and covered the Skagerrak and the Kattegat and the North Sea. The 2022 estimate of Western Baltic Spring Spawning herring 3+ group is 77 000 tonnes and 483 million. Compared to the 2021 estimates of 82 000 tonnes and 639 million fish, this equals a decrease of 24% in biomass. In 2021 the stock was dominated by 2 and 3 winter ring fish. In 2022 these same two year-classes, now at 3 and 4 winter rings together still account for 33% of the total stock. The single largest age component in 2022 however was 2 winter ring fish that accounted for 32% despite the almost complete lack of 1 winter ring fish in 2021. The numbers of older herring (3+ group) accounted for 62% of the total stock in 2022. 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 2022 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 **6 603** million larvae, the 2022 N20 re-cruitment index is about 1 200 million higher than the time series mean and more than 25 times higher than that of the record low in 2020. It is the highest value since 2010 (for further details see WD Polte, Kotterba and Haase, HAWG 2022).

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 in 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 2022 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 (R^2 = 0.73, 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. Since 2010, the N20 recruitment index has been below the long-term average (1992–2021: 5 389 million). However, the 2022 N20 is (by 1 200 million) above the time series average. The 2022 N20 recruitment index is more than 25 times higher than that of the record low in 2020 and the highest value since 2010 (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 2022 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 1991–2022. 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_2023) and the single fleet (WBSS_HAWG_2023_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 since 2022 in the multifleet model.

3.6.4 Final run

The results of the assessment are given in Tables 3.6.11–3.6.14. The estimated SSB for 2022 is 75 548 [52 770, 108 157 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.05 [0.022, 0.114 (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 68.1 kt. SSB has only slightly increased in the following period up to 88.2 kt in 2015 and then has declined to 51.4 kt in 2019, which is the lowest SSB of the time-series. A slight increase in SSB was then estimated since 2020 to around 75.5 kt in 2022.

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 0.61. In 2010 and 2011, $F_{3\text{-}6}$ decreased significantly to a value of 0.43 and 0.29 yr-1, respectively. It stabilized between 0.32 and 0.41 yr-1 for few years until it increased again above 0.52 yr-1 from 2016 to 2018. $F_{3\text{-}6}$ then decreased to 0.28 yr-1 in 2019, 0.19 yr-1 in 2020, 0.11 in 2021 and finally 0.05 in 2022, 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 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 2021 estimate of 454 304 thousand is the lowest on record and the estimate in 2022 has slightly increased to 537 470 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 2022 recruitment has varied from about 1.5 billion to less than 0.9 billion at SSB between 51 kt and 113 kt, with a trend of declining recruitment in 2017-2021 and some slight increased recruitment in 2022.

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. Since 2021, the catch of the A-fleet is well fitted.

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 shifting its highest selectivity from age 1 to 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- Q3.4 surveys variance, the IBTS+BITS-Q1 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 (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). 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., 2018-2022 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) 1–4 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 are of the same order of magnitude as last year assessment (Figure 3.6.4.24-27). The SSB has a 5 years Mohn's rho of 16% (compared to 21% in 2022) but the retrospective estimates are considerably improved for the 1- to 3-year peels 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 = -4% compared to -14% in the 2022 assessment, Figure 3.6.4.25). The retrospective for recruitment is acceptable having a Mohn's rho = 6% (11% in 2022, Figure 3.6.4.26). Retrospective is very 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 2022 and continue to show the largest contribution to the estimated SSB level, the small SSB increase in 2022 appear independent from any individual specific survey (Figures 3.6.4.28–31).

Since 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 this year without repeating the sensitivity.

The consideration of the haul with spawning fish (SD23) was discussed in depth this year. 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 this year genetically analysed to be mainly NSAS herring. Two indices were available for 2022, one excluding the haul and the other one including it. 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. It was discussed to maybe look at the entire time series at the next benchmark (planned for 2025) and see if we can agree on a method to handle this haul in the acoustic data.

A haul with spawning fish in SD23 has been seen for a few years during the GERAS survey. The haul was removed from the 2021 index because most of the fish were mature (stage>=6), but in 2020, only the mature fish (stage>=6) were removed. This 2021 sample was this year genetically analysed and found to be mainly NSAS herring. Two indices were available for 2022, one excluding the haul and the other one including it. The baseline model (WBSS_HAWG_2023) uses the index excluding the haul but a sensitivity run is available on stockassessment.org (WBSS_HAWG_2023_GerasInclHaul) where the haul is included, and the plots show the difference between both outputs. The main difference in index is on age 2. Both models give very similar outputs but the number at age 2 are larger for the sensitivity run so the differences might increase in future years when the ages enter the SSB. It was agreed to keep the baseline assessment using the index with exclusion of the haul as final assessment and the GERAS time series will be investigated further for the next WBSS benchmark.

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 2019 (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 2021 is showing a small sign of recovery.

The 2018 benchmark calculated a new F_{MSY} of 0.31. Fishing mortality ($F_{3–6}$) was reduced between 2008 and 2011 from 0.57 to 0.29 (Tables 3.6.11, Figure 3.6.4.2). $F_{3–6}$ has then remained stable above F_{MSY} until 2018 (0.32-0.57). $F_{3–6}$ has decreased since 2019 from 0.28 to 0.05 in 2022, which is the lowest $F_{3–6}$ on records.

Recruitment has been declining since 2014 with a historical low value in 2021 of 454 304 thousand (Tables 3.6.11, Figure 3.6.4.3). Recruitment increased to 537 470 thousand in 2022. Despite the increase in 2022, recruitment is still low compared to the average of the time series and the final recruitment was revised downward this year compared to last year assessment. 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 2022 data resulted in a negative change in the perception of the stock back in time compared to last year assessment of around 0.7-1.8%. The recent estimates of recruitment have however increased by 10 % in the current assessment and F appears to be larger than previously estimated in 2020 (+2.7%) but smaller in 2021 (-34.0%).

Parameter	Assessment in 2022	Assessment in 2023	Difference (2023-2022)/2023
SSB (t) 2020	54 606	53 628	-1.82%
$F_{(3–6)}$ 2020	0.182	0.187	2.67%
Recr. (‘000) 2020	550 822	612 037	10.00%
SSB (t) 2021	62 765	62 343	-0.68%
$F_{(3–6)}$ 2021	0.149	0.111	- 33.96%

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 2023 assessment, recruitment for the forecasts was calculated on the period 2017–2021, 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 (2018–2022). 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 (2023). Predicted 2023 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 Subdivision 4.aE (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 2023 NSAS+WBSS (t)	Predicted 2023 WBSS catch (t)	Predicted 2023 WBSS catch explained (t)
A	396 556	5 282	1.26% (396556+23250-(969+310))
C	23 250	439	57% (0.47x969+310)
D	6 659	154	30% (0.53x969)
F	788	788	100% 2023 TAC
Total	427 253	6 663	

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 advice. This year's assumption results in a total catch of WBSS herring of 5 282 t corresponding to the sum of the A-fleet TAC (396 556 t) and what is transferred from the C-fleet in Division 3.a to the North Sea (23 250 t), scaled by the 3-year average proportion of WBSS in A-fleet catch (1.26%, 2020-2022).

Since 2022, 100% of the human consumption herring quotas for the Division 3.a can be transferred to the North Sea, against 50% the previous years. This results in an important change in the assumed proportion of each fleet in the total WBSS catch compared to what was observed in the past. This is discussed further in part 3.12. The Council Regulation (EU) 2023/194 and the amendment on 17 March 2023 (EU 2023b) stipulate that the catches in Division 3.a should be limited to 1 279 t (969 t of EU catches + 310 t of Norwegian catches) in 2023 as the sum of directed and bycatch fisheries (C- and D-fleets). In 2022, due to difficulties predicted the proportion of each fleet in the total catch in 3.a and given the recent downward trends in the observed D-fleet catches, ICES considered that the bycatch in the D-fleet was negligible in 2022. In 2023, the knowledge acquired in 2022 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 2023 quota in 3.a are split by the proportion of each fleet in the total EU catches in 2022 (47% and 53% for C- and D-fleets, respectively). Additionally, the C-fleet catches also include the maximum agreed Norway catch of 310 t (10% of 3102 t). Both catches in the C- and D-fleets are scaled by the 3-year average proportion of WBSS in the C-fleet catch (57%, 2020-2022) and D-fleet catch (30%, 2020-2022), 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.

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 6 663 t of WBSS herring in 2022.

3.9.3 Catch scenarios for 2024–2026

The inputs and outputs of the short-term predictions are based on a catch constraint in the intermediate year 2023 of 6 663 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 the A-fleet is now catching most WBSS herring, 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 2024 (advice year) to 2026

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because the forecasted SSB in 2025 is below B_{lim} (120 000 t) even when F=0, ICES advises a zero catch for 2024.

None of the catch scenarios for 2024, including zero catch, is expected to bring SSB above B_{lim} in 2025. For the past 3 years, besides requested standard scenarios HAWG also calculated the potential development of the stock projections for an extra year (2026) with different low F scenarios, where F2025 = F2024. None of these scenarios, even when F = 0, can bring the SSB above B_{lim} in 2026.

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 this year 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 last year 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 2022), this can be easily done because SSB in 2024 only depends on F in 2023 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 2024 and the F in 2024 can be estimated to obtain a SSB in 2025 equal to 2024. 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 2024 is in fact the result of catches assumed (agreed TACs) for the intermediate year (2023) and some catches in the first months of 2024. In other words, the SSB in 2024 depends on F in 2023 but also on a fraction of the F in 2024, which is the advice year. What to assume for the first months of 2024 is the real issue here. For instance, if a zero catch is assumed in 2024 according to the advice, it will be uninformative because the table of advice would still only show the average F in 2024 (so F = 0). If an F that makes SSB 2024 = SSB 2023 is assumed for 2024, it will be an unrealistic high F needed to compensate for the low catches assumed in 2023. Given the reasons described above, the constant SSB between 2024 and 2025 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 (2024)	$F_{3–6}$ (2024)	SSB* (2024)	SSB* (2025)	% SSB change **	% advice change ***
ICES advice basis							
3.9.2	MSY approach: zero catch	0	0	92 726	103 649	12	0
Other scenarios							
3.9.3	EU Baltic Sea multiannual plan (MAP): F = F_{MSY} × SSB_{2023}/MSY $B_{trigger}$ ^	27 346	0.177	90 148	80 228	-11	
3.9.4	MAP: F = $F_{MSY\ lower}$ × SSB_{2023}/MSY $B_{trigger}$ ^	19 958	0.123	90 919	86 404	-5	
3.9.5	F = F_{MSY}	43 103	0.310	88 265	67 575	-23	
3.9.6	F = F_{pa}	52 915	0.410	86 889	59 887	-31	
3.9.7	F = F_{lim}	56 452	0.450	86 347	57 171	-34	
	SSB (2025) = B_{lim} ^^						
	SSB (2025) = B_{pa} ^^						
	SSB (2025) = MSY $B_{trigger}$ ^^						
3.9.8	F = F_{2023}	7669	0.044	92 074	96 985	5	
3.9.9	Catch of WBSS by A- and D-fleets only^^^	5436	0.028	92 275	99 119	7	

* For spring-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries and natural mortality between 1 January and spawning time (April).
** SSB (2025) relative to SSB (2024).
*** The advised catch in 2022 was 0 tonnes.
^ Because SSB_{2023} is below MSY $B_{trigger}$, the F_{MSY} and $F_{MSY\ lower}$ values in the MAP are adjusted by the SSB_{2023}/MSY $B_{trigger}$ ratio.
^^ B_{lim} and B_{pa} cannot be achieved in 2025, 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 2023 (C- and F-fleets are directed WBSS fisheries so have zero catch in this scenario).

Table number	Basis	Total catch (2024)	Total catch (2025)	$F_{3–6}$ (2024)	SSB* (2024)	SSB* (2025)	SSB* (2026)	% SSB change (2024–2025)	% SSB change (2025–2026
Medium-term catch scenarios									
3.9.10	F = 0	0	0	0	92 726	103 649	115 511	12	11
3.9.11	F = 0.010	1800	2134	0.010	92 577	102 077	112 390	10	10
3.9.12	F = 0.025	4436	5125	0.025	92 355	99 783	107 946	8	8
3.9.13	F = 0.050	8667	9603	0.050	91 986	96 126	101 124	5	5
3.9.14	F = 0.100	16 559	16 944	0.100	91 254	89 386	89 360	-2	0
3.9.15	F = 0.150	23 768	22 576	0.150	90 529	83 326	79 630	-8	-4
3.9.16	Constant catch 2023–2025 **	6663	6663	0.038	92 162	97 926	105 128	6	7

* For spring-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries and natural mortality between 1 January and spawning time (April).
** It is assumed that the fleets' 2023 catches (as defined in Table 1) are kept constant for 2024–2025.

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 FMSY 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. Similarly to the past two year, the 2023 assessment is very consistent with the 2022 assessment.

The herring assessed in subdivisions 20–24 is a complex mixture of 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 divisions 3.a and 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 2023 advice

This year assessment shows an SSB consistent with last year's assessment. Recruitment is still low but has slightly increased in 2022 (537 470thousands). However, this increase in recruitment can shift after updating the data, for example the increase in recruitment was in 2021 in last year assessment but is shifted to 2022 this year. Under these conditions the stock is not expected to increase above B_{lim} in the short-term (2025) nor in the medium-term (2026) for any level of fishing mortality (SSB_{2026} = 115 511 t assuming F = 0).

To explore the potential development of the stock, projections until 2026 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.

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 overexploitation of the WBSS stock.

This stock is caught across three different management areas, and recovery will be impaired if catches of this stock are not minimized in all areas. Based on agreed catches for 2023 and assumptions on stock mixing, it is predicted that around 79% of the total WBSS catches will be taken in the eastern parts of Division 4.a and 4.b in 2023. For the other two areas, catch shares in 2023 are predicted to be around 9% for subdivisions 20–21 and 12% for subdivisions 22–24.

The catch of WBSS in the North Sea in recent years has been substantial (estimated at 5236 t based on the average over the 2020–2022 period). The catches of WBSS in 2023 are expected to continue to be larger in the North Sea than in subdivisions 20-24. Without additional area and seasonal restrictions on the herring fishery in the North Sea in 2024, catches of WBSS in the North Sea will be unavoidable, an aspect that would delay the recovery of the WBSS stock.

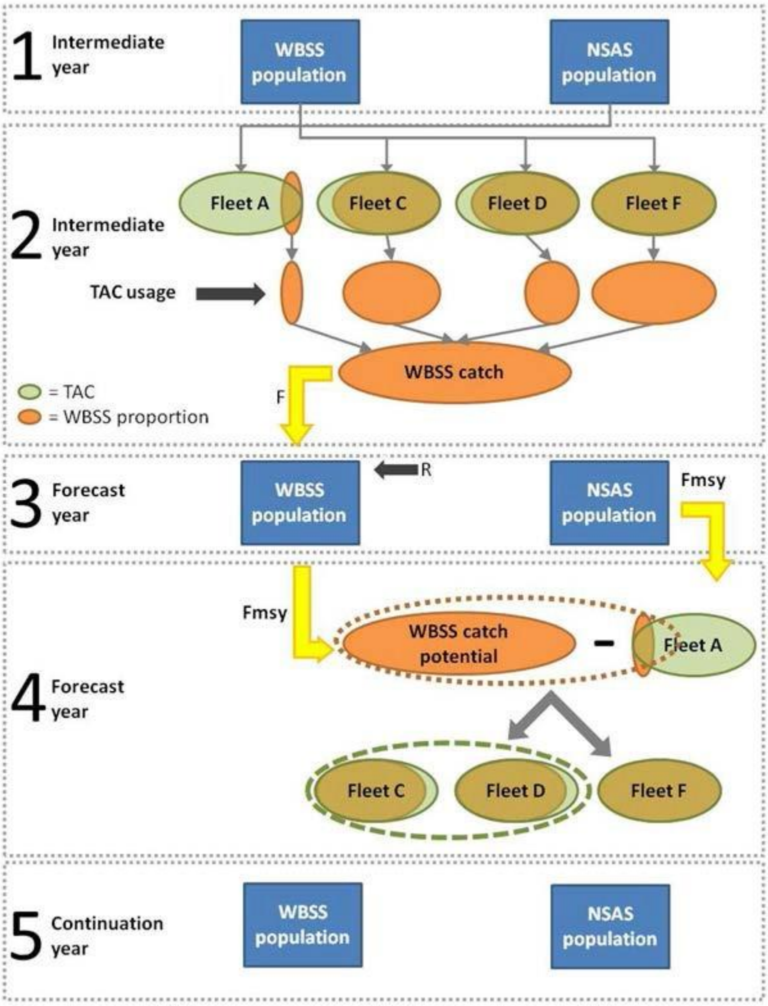
3.13 Management Considerations

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 North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) together (see Section 2.7). Since 2011, 50% of the EU and Norwegian quotas for human consumption can optionally be transferred from Division 3.a and taken in Subarea 4. In 2021, the transfer was increased to 100%, effective in 2022. Since then, 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 1 279 t (969 t of EU catches + 310 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 2023:



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 taking into account a fleet share of the total TAC. Only part of this TAC is WBSS catches and not all fleets utilize their full TAC fleet share. 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. The calculation of the stock size January 1st in the forecast year is needed to project catches in the forecast year.

Box 4: The management rule for the C-fleet TAC uses the potential WBSS catches calculated from the FMSY 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 the C-fleet to the A- fleet the realized WBSS catches may deviate from the predictions based on FMSY.

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, 3.9.2 and updated stock annex).

3.14 Ecosystem 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. in review).

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 o 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). 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 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)

3.15 Changes in the Environment

3.15.1 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.

3.16 Tables and Figures

Table 3.1.1 WESTERN BALTIC HERRING. Both WBSS and NSAS. Total catch in 1989-2022 (1000 tonnes) (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**
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**
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**

year	area	Denmark	Faroe Islands	Finland	Germany	Lithuania	Netherlands	Norway	Poland	Sweden	Total
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**
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**
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**

year	area	Denmark	Faroe Islands	Finland	Germany	Lithuania	Netherlands	Norway	Poland	Sweden	Total
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**
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**
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**

year	area	Denmark	Faroe Islands	Finland	Germany	Lithuania	Netherlands	Norway	Poland	Sweden	Total
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**

*Preliminary

**2,000 t of Danish catches are missing (HAWG 2007)

***3,103 t officially reported catches (HAWG 2011)

Table 3.1.2 WESTERN BALTIC HERRING. Both WBSS and NSAS. Catch (SOP) in 2004-2022 by fleet and quarter (1000 t)

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**
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**

year	area	fleet	1	2	3	4	Total
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**
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**

*Preliminary

Table 3.2.1 WESTERN BALTIC HERRING. Both WBSS and NSAS. Samples of commercial catch by quarter, fleet, and area for 2022 available to the Working Group

year	area	quarter	country	fleet	landings (t)	number of samples	number of fish measured	number of fish aged
2022	27.3.a.20	1	Denmark	C	0.1	-	-	-
2022	27.3.a.20	2	Denmark	C	0.0	-	-	-
2022	27.3.a.20	3	Denmark	C	1.4	-	-	-
2022	27.3.a.20	4	Denmark	C	0.2	-	-	-
2022	27.3.a.20	1	Germany	C	0.0	-	-	-
2022	27.3.a.20	2	Germany	C	0.0	-	-	-
2022	27.3.a.20	3	Germany	C	0.1	-	-	-
2022	27.3.a.20	4	Germany	C	0.0	-	-	-
2022	27.3.a.20	1	Norway	C	49.4	-	-	-
2022	27.3.a.20	2	Norway	C	0.5	-	-	-
2022	27.3.a.20	3	Norway	C	120.4	-	-	-
2022	27.3.a.20	4	Norway	C	78.5	-	-	-
2022	27.3.a.20	1	Sweden	C	51.4	1	75	75
2022	27.3.a.20	2	Sweden	C	12.5	-	-	-
2022	27.3.a.20	3	Sweden	C	14.1	-	-	-
2022	27.3.a.20	4	Sweden	C	20.6	-	-	-
2022	27.3.a.20	1	Denmark	D	0.0	-	-	-
2022	27.3.a.20	2	Denmark	D	111.7	-	-	-
2022	27.3.a.20	3	Denmark	D	17.6	-	-	-
2022	27.3.a.20	4	Denmark	D	0.0	-	-	-
2022	27.3.a.20	1	Germany	D	0.0	-	-	-

year	area	quar-ter	country	fleet	landings (t)	number of samples	number of fish measured	number of fish aged
2022	27.3.a.20	2	Germany	D	0.0	-	-	-
2022	27.3.a.20	3	Germany	D	0.0	-	-	-
2022	27.3.a.20	4	Germany	D	0.0	-	-	-
2022	27.3.a.20	1	Norway	D	0.0	-	-	-
2022	27.3.a.20	2	Norway	D	0.0	-	-	-
2022	27.3.a.20	3	Norway	D	0.0	-	-	-
2022	27.3.a.20	4	Norway	D	0.0	-	-	-
2022	27.3.a.20	1	Sweden	D	0.0	-	-	-
2022	27.3.a.20	2	Sweden	D	0.0	-	-	-
2022	27.3.a.20	3	Sweden	D	0.0	-	-	-
2022	27.3.a.20	4	Sweden	D	0.0	-	-	-
2022	27.3.a.21	1	Denmark	C	84.1	-	-	-
2022	27.3.a.21	2	Denmark	C	15.7	-	-	-
2022	27.3.a.21	3	Denmark	C	0.5	-	-	-
2022	27.3.a.21	4	Denmark	C	1.4	-	-	-
2022	27.3.a.21	1	Germany	C	0.0	-	-	-
2022	27.3.a.21	2	Germany	C	0.0	-	-	-
2022	27.3.a.21	3	Germany	C	0.0	-	-	-
2022	27.3.a.21	4	Germany	C	0.0	-	-	-
2022	27.3.a.21	1	Sweden	C	8.5	-	-	-
2022	27.3.a.21	2	Sweden	C	0.6	-	-	-
2022	27.3.a.21	3	Sweden	C	10.8	-	-	-
2022	27.3.a.21	4	Sweden	C	4.9	-	-	-
2022	27.3.a.21	1	Denmark	D	6.6	-	-	-
2022	27.3.a.21	2	Denmark	D	0.0	-	-	-
2022	27.3.a.21	3	Denmark	D	0.0	-	-	-
2022	27.3.a.21	4	Denmark	D	0.0	-	-	-
2022	27.3.a.21	1	Germany	D	0.0	-	-	-
2022	27.3.a.21	2	Germany	D	0.0	-	-	-
2022	27.3.a.21	3	Germany	D	0.0	-	-	-
2022	27.3.a.21	4	Germany	D	0.0	-	-	-
2022	27.3.a.21	1	Sweden	D	0.0	-	-	-
2022	27.3.a.21	2	Sweden	D	0.0	-	-	-
2022	27.3.a.21	3	Sweden	D	0.0	-	-	-
2022	27.3.a.21	4	Sweden	D	115.5	1	74	74
2022	27.3.b.23	1	Denmark	F	0.0	-	-	-
2022	27.3.b.23	2	Denmark	F	0.0	-	-	-
2022	27.3.b.23	3	Denmark	F	0.0	-	-	-
2022	27.3.b.23	4	Denmark	F	0.4	-	-	-
2022	27.3.b.23	1	Sweden	F	45.2	-	-	-
2022	27.3.b.23	2	Sweden	F	0.0	-	-	-
2022	27.3.b.23	3	Sweden	F	12.6	-	-	-
2022	27.3.b.23	4	Sweden	F	187.0	10	668	668
2022	27.3.c.22	1	Denmark	F	0.9	-	-	-

year	area	quarter	country	fleet	landings (t)	number of samples	number of fish measured	number of fish aged
2022	27.3.c.22	2	Denmark	F	6.1	-	-	-
2022	27.3.c.22	3	Denmark	F	0.0	-	-	-
2022	27.3.c.22	4	Denmark	F	1.0	-	-	-
2022	27.3.c.22	1	Germany	F	8.4	2	498	107
2022	27.3.c.22	2	Germany	F	1.2	2	743	139
2022	27.3.c.22	3	Germany	F	0.0	-	-	-
2022	27.3.c.22	4	Germany	F	5.4	1	343	78
2022	27.3.c.22	1	Poland	F	0.0	-	-	-
2022	27.3.c.22	2	Poland	F	0.0	-	-	-
2022	27.3.c.22	3	Poland	F	0.0	-	-	-
2022	27.3.c.22	4	Poland	F	0.0	-	-	-
2022	27.3.c.22	1	Sweden	F	0.0	-	-	-
2022	27.3.c.22	2	Sweden	F	0.0	-	-	-
2022	27.3.c.22	3	Sweden	F	0.0	-	-	-
2022	27.3.c.22	4	Sweden	F	0.0	-	-	-
2022	27.3.d.24	1	Denmark	F	0.0	-	-	-
2022	27.3.d.24	2	Denmark	F	0.0	-	-	-
2022	27.3.d.24	3	Denmark	F	0.0	-	-	-
2022	27.3.d.24	4	Denmark	F	0.8	-	-	-
2022	27.3.d.24	1	Germany	F	155.5	8	1751	415
2022	27.3.d.24	2	Germany	F	33.1	4	1128	220
2022	27.3.d.24	3	Germany	F	3.3	-	-	-
2022	27.3.d.24	4	Germany	F	18.3	2	342	118
2022	27.3.d.24	1	Poland	F	36.9	6	892	262
2022	27.3.d.24	2	Poland	F	24.4	1	226	49
2022	27.3.d.24	3	Poland	F	1.8	-	-	-
2022	27.3.d.24	4	Poland	F	87.7	-	-	-
2022	27.3.d.24	1	Sweden	F	1.2	-	-	-
2022	27.3.d.24	2	Sweden	F	0.0	-	-	-
2022	27.3.d.24	3	Sweden	F	0.0	-	-	-
2022	27.3.d.24	4	Sweden	F	5.9	-	-	-
2022	**Total**	**Total**	**Total**	**Total**	**1364.2**	**38**	**6740**	**2205**

Table 3.2.2 WESTERN BALTIC HERRING. Both WBSS and NSAS. Samples of commercial catch by quarter, fleet, and area for 2022 used to estimate catch in numbers and mean weight at age as W-ringers for 2022

year	area	quarter	ctry	fleet	landings (t)	sampling
2022	27.3.a.20	1	Denmark	C	0.1	2022 Sweden 27.3.a.20 fleetC Q1
2022	27.3.a.20	2	Denmark	C	0.0	2022 Sweden 27.3.a.20 fleetC Q1
2022	27.3.a.20	3	Denmark	C	1.4	2021 Denmark 27.3.a.20 fleetC Q3
2022	27.3.a.20	4	Denmark	C	0.3	2021 Denmark 27.3.a.20 fleetC Q3
2022	27.3.a.20	1	Denmark	D	0.0	No landings
2022	27.3.a.20	2	Denmark	D	111.6	2022 Sweden 27.3.a.21 fleetD Q4
2022	27.3.a.20	3	Denmark	D	17.6	2022 Sweden 27.3.a.21 fleetD Q4
2022	27.3.a.20	4	Denmark	D	0.0	No landings
2022	27.3.a.20	1	Germany	C	0.0	No landings
2022	27.3.a.20	2	Germany	C	0.0	No landings
2022	27.3.a.20	3	Germany	C	0.2	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.20	4	Germany	C	0.0	No landings
2022	27.3.a.20	1	Germany	D	0.0	No landings
2022	27.3.a.20	2	Germany	D	0.0	No landings

year	area	quarter	ctry	fleet	landings (t)	sampling
2022	27.3.a.20	3	Germany	D	0.0	No landings
2022	27.3.a.20	4	Germany	D	0.0	No landings
2022	27.3.a.20	1	Norway	C	49.4	2022 Sweden 27.3.a.20 fleetC Q1
2022	27.3.a.20	2	Norway	C	0.5	2022 Sweden 27.3.a.20 fleetC Q1
2022	27.3.a.20	3	Norway	C	120.3	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.20	4	Norway	C	78.5	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.20	1	Norway	D	0.0	No landings
2022	27.3.a.20	2	Norway	D	0.0	No landings
2022	27.3.a.20	3	Norway	D	0.0	No landings
2022	27.3.a.20	4	Norway	D	0.0	No landings
2022	27.3.a.20	1	Sweden	C	51.4	Sampling
2022	27.3.a.20	2	Sweden	C	12.5	2022 Sweden 27.3.a.20 fleetC Q1
2022	27.3.a.20	3	Sweden	C	14.1	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.20	4	Sweden	C	20.6	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.20	1	Sweden	D	0.0	No landings
2022	27.3.a.20	2	Sweden	D	0.0	No landings
2022	27.3.a.20	3	Sweden	D	0.0	No landings
2022	27.3.a.20	4	Sweden	D	0.0	No landings
2022	27.3.a.21	1	Denmark	C	84.0	2021 Sweden 27.3.a.21 fleetC Q1
2022	27.3.a.21	2	Denmark	C	15.7	2021 Sweden 27.3.a.21 fleetC Q1
2022	27.3.a.21	3	Denmark	C	0.5	2021 Denmark 27.3.a.20 fleetC Q3
2022	27.3.a.21	4	Denmark	C	1.4	2021 Denmark 27.3.a.20 fleetC Q3
2022	27.3.a.21	1	Denmark	D	6.6	2021 Sweden 27.3.a.21 fleetC Q1
2022	27.3.a.21	2	Denmark	D	0.0	No landings
2022	27.3.a.21	3	Denmark	D	0.0	No landings
2022	27.3.a.21	4	Denmark	D	0.0	No landings
2022	27.3.a.21	1	Germany	C	0.0	No landings
2022	27.3.a.21	2	Germany	C	0.0	No landings
2022	27.3.a.21	3	Germany	C	0.0	No landings
2022	27.3.a.21	4	Germany	C	0.0	No landings
2022	27.3.a.21	1	Germany	D	0.0	No landings
2022	27.3.a.21	2	Germany	D	0.0	No landings
2022	27.3.a.21	3	Germany	D	0.0	No landings
2022	27.3.a.21	4	Germany	D	0.0	No landings
2022	27.3.a.21	1	Sweden	C	8.5	2021 Sweden 27.3.a.21 fleetC Q1
2022	27.3.a.21	2	Sweden	C	0.6	2021 Sweden 27.3.a.21 fleetC Q1
2022	27.3.a.21	3	Sweden	C	10.9	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.21	4	Sweden	C	5.0	2021 Sweden 27.3.a.20 fleetC Q3
2022	27.3.a.21	1	Sweden	D	0.0	No landings
2022	27.3.a.21	2	Sweden	D	0.0	No landings
2022	27.3.a.21	3	Sweden	D	0.0	No landings
2022	27.3.a.21	4	Sweden	D	115.5	Sampling
2022	27.3.b.23	1	Denmark	F - active	0.0	No landings
2022	27.3.b.23	2	Denmark	F - active	0.0	No landings
2022	27.3.b.23	3	Denmark	F - active	0.0	No landings
2022	27.3.b.23	4	Denmark	F - active	0.0	No landings
2022	27.3.b.23	1	Denmark	F - passive	0.0	No landings
2022	27.3.b.23	2	Denmark	F - passive	0.0	No landings
2022	27.3.b.23	3	Denmark	F - passive	0.0	2022 Sweden 27.3.b.23 fleetF - passive Q4
2022	27.3.b.23	4	Denmark	F - passive	0.5	2022 Sweden 27.3.b.23 fleetF - passive Q4
2022	27.3.b.23	1	Sweden	F - active	0.0	No landings
2022	27.3.b.23	2	Sweden	F - active	0.0	No landings
2022	27.3.b.23	3	Sweden	F - active	0.0	No landings
2022	27.3.b.23	4	Sweden	F - active	0.0	No landings
2022	27.3.b.23	1	Sweden	F - passive	45.1	2022 Sweden 27.3.b.23 fleetF - passive Q4
2022	27.3.b.23	2	Sweden	F - passive	0.0	No landings
2022	27.3.b.23	3	Sweden	F - passive	12.5	2022 Sweden 27.3.b.23 fleetF - passive Q4
2022	27.3.b.23	4	Sweden	F - passive	186.9	Sampling
2022	27.3.c.22	1	Denmark	F - active	0.0	No landings
2022	27.3.c.22	2	Denmark	F - active	0.0	No landings
2022	27.3.c.22	3	Denmark	F - active	0.0	No landings
2022	27.3.c.22	4	Denmark	F - active	0.0	No landings
2022	27.3.c.22	1	Denmark	F - passive	0.9	2022 Germany 27.3.c.22 fleetF - passive Q1
2022	27.3.c.22	2	Denmark	F - passive	6.1	2022 Germany 27.3.c.22 fleetF - passive Q2
2022	27.3.c.22	3	Denmark	F - passive	0.2	2022 Germany 27.3.c.22 fleetF - passive Q4
2022	27.3.c.22	4	Denmark	F - passive	1.0	2022 Germany 27.3.c.22 fleetF - passive Q4
2022	27.3.c.22	1	Germany	F - active	0.0	No landings

year	area	quarter	ctry	fleet	landings (t)	sampling
2022	27.3.c.22	2	Germany	F - active	0.0	2021 Denmark 27.3.d.24 fleetF - active Q1
2022	27.3.c.22	3	Germany	F - active	0.0	2021 Germany 27.3.c.22 fleetF - active Q3
2022	27.3.c.22	4	Germany	F - active	0.1	2021 Germany 27.3.c.22 fleetF - active Q3
2022	27.3.c.22	1	Germany	F - passive	8.3	Sampling
2022	27.3.c.22	2	Germany	F - passive	1.2	Sampling
2022	27.3.c.22	3	Germany	F - passive	0.1	2022 Germany 27.3.c.22 fleetF - passive Q4
2022	27.3.c.22	4	Germany	F - passive	5.3	Sampling
2022	27.3.c.22	1	Poland	F - active	0.0	No landings
2022	27.3.c.22	2	Poland	F - active	0.0	No landings
2022	27.3.c.22	3	Poland	F - active	0.0	No landings
2022	27.3.c.22	4	Poland	F - active	0.0	No landings
2022	27.3.c.22	1	Poland	F - passive	0.0	No landings
2022	27.3.c.22	2	Poland	F - passive	0.0	No landings
2022	27.3.c.22	3	Poland	F - passive	0.0	No landings
2022	27.3.c.22	4	Poland	F - passive	0.0	No landings
2022	27.3.c.22	1	Sweden	F - active	0.0	No landings
2022	27.3.c.22	2	Sweden	F - active	0.0	No landings
2022	27.3.c.22	3	Sweden	F - active	0.0	No landings
2022	27.3.c.22	4	Sweden	F - active	0.0	No landings
2022	27.3.c.22	1	Sweden	F - passive	0.0	No landings
2022	27.3.c.22	2	Sweden	F - passive	0.0	No landings
2022	27.3.c.22	3	Sweden	F - passive	0.0	No landings
2022	27.3.c.22	4	Sweden	F - passive	0.0	No landings
2022	27.3.d.24	1	Denmark	F - active	0.0	No landings
2022	27.3.d.24	2	Denmark	F - active	0.1	2021 Denmark 27.3.d.24 fleetF - active Q1
2022	27.3.d.24	3	Denmark	F - active	0.0	2021 Germany 27.3.d.24 fleetF - active Q4
2022	27.3.d.24	4	Denmark	F - active	0.1	2021 Denmark 27.3.d.24 fleetF - active Q4
2022	27.3.d.24	1	Denmark	F - passive	0.0	No landings
2022	27.3.d.24	2	Denmark	F - passive	0.0	No landings
2022	27.3.d.24	3	Denmark	F - passive	0.0	2022 Germany 27.3.d.24 fleetF - passive Q4
2022	27.3.d.24	4	Denmark	F - passive	0.7	2022 Germany 27.3.d.24 fleetF - passive Q4
2022	27.3.d.24	1	Germany	F - active	21.8	2021 Denmark 27.3.d.24 fleetF - active Q1
2022	27.3.d.24	2	Germany	F - active	9.2	2021 Denmark 27.3.d.24 fleetF - active Q1
2022	27.3.d.24	3	Germany	F - active	0.0	No landings
2022	27.3.d.24	4	Germany	F - active	2.0	2021 Germany 27.3.d.24 fleetF - active Q4
2022	27.3.d.24	1	Germany	F - passive	133.7	Sampling
2022	27.3.d.24	2	Germany	F - passive	23.9	Sampling
2022	27.3.d.24	3	Germany	F - passive	3.4	2022 Germany 27.3.d.24 fleetF - passive Q4
2022	27.3.d.24	4	Germany	F - passive	16.4	Sampling
2022	27.3.d.24	1	Poland	F - active	0.0	No landings
2022	27.3.d.24	2	Poland	F - active	0.0	No landings
2022	27.3.d.24	3	Poland	F - active	1.8	2021 Germany 27.3.d.24 fleetF - active Q4
2022	27.3.d.24	4	Poland	F - active	87.6	2021 Germany 27.3.d.24 fleetF - active Q4
2022	27.3.d.24	1	Poland	F - passive	36.9	Sampling
2022	27.3.d.24	2	Poland	F - passive	24.5	Sampling
2022	27.3.d.24	3	Poland	F - passive	0.0	No landings
2022	27.3.d.24	4	Poland	F - passive	0.0	No landings
2022	27.3.d.24	1	Sweden	F - active	0.0	No landings
2022	27.3.d.24	2	Sweden	F - active	0.0	No landings
2022	27.3.d.24	3	Sweden	F - active	0.0	No landings
2022	27.3.d.24	4	Sweden	F - active	0.0	No landings
2022	27.3.d.24	1	Sweden	F - passive	1.2	2022 Germany 27.3.d.24 fleetF - passive Q2
2022	27.3.d.24	2	Sweden	F - passive	0.1	2022 Germany 27.3.d.24 fleetF - passive Q2
2022	27.3.d.24	3	Sweden	F - passive	0.0	No landings
2022	27.3.d.24	4	Sweden	F - passive	5.8	2022 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 2022

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.20	C	1	CANUM	-	-	1.96	-	-	-	-	-	-	**1.96**
2022	27.3.a.20	C	2	CANUM	-	-	0.25	-	-	-	-	-	-	**0.25**
2022	27.3.a.20	C	3	CANUM	-	0.01	0.28	0.19	0.19	0.09	0.07	0.03	0.04	**0.90**
2022	27.3.a.20	C	4	CANUM	-	0.01	0.20	0.14	0.14	0.07	0.05	0.02	0.03	**0.66**
2022	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	CANUM	0.56	1.63	0.13	-	-	-	-	-	-	**2.32**
2022	27.3.a.20	D	3	CANUM	0.09	0.26	0.02	-	-	-	-	-	-	**0.37**
2022	27.3.a.20	D	4	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	CANUM	-	0.04	1.47	0.18	0.03	0.00	-	-	-	**1.71**
2022	27.3.a.21	C	2	CANUM	-	0.01	0.26	0.03	0.00	0.00	-	-	-	**0.30**
2022	27.3.a.21	C	3	CANUM	-	0.00	0.02	0.02	0.02	0.01	0.01	0.00	0.00	**0.08**
2022	27.3.a.21	C	4	CANUM	-	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	**0.05**
2022	27.3.a.21	D	1	CANUM	-	0.00	0.10	0.01	0.00	0.00	-	-	-	**0.12**
2022	27.3.a.21	D	2	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	CANUM	0.58	1.69	0.13	-	-	-	-	-	-	**2.40**
2022	27.3.b.23	F	1	CANUM	-	0.00	0.02	0.03	0.07	0.06	0.04	0.01	0.01	**0.25**
2022	27.3.b.23	F	2	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	CANUM	-	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.00	**0.07**
2022	27.3.b.23	F	4	CANUM	-	0.00	0.08	0.14	0.28	0.26	0.15	0.06	0.04	**1.02**
2022	27.3.c.22	F	1	CANUM	-	-	-	0.00	0.00	0.01	0.02	0.02	0.02	**0.05**
2022	27.3.c.22	F	2	CANUM	-	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	**0.06**
2022	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	**0.00**
2022	27.3.c.22	F	4	CANUM	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	**0.07**
2022	27.3.d.24	F	1	CANUM	-	0.04	0.08	0.30	0.23	0.27	0.24	0.24	0.19	**1.60**
2022	27.3.d.24	F	2	CANUM	-	0.02	0.04	0.18	0.13	0.11	0.07	0.05	0.04	**0.65**
2022	27.3.d.24	F	3	CANUM	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	**0.03**
2022	27.3.d.24	F	4	CANUM	0.00	0.01	0.12	0.24	0.19	0.13	0.08	0.05	0.02	**0.85**
2022	27.3.a.20	C	1	SOP	-	-	100.94	-	-	-	-	-	-	**100.94**
2022	27.3.a.20	C	2	SOP	-	-	13.00	-	-	-	-	-	-	**13.00**
2022	27.3.a.20	C	3	SOP	-	0.71	36.63	25.08	29.56	15.51	14.06	6.15	8.37	**136.06**
2022	27.3.a.20	C	4	SOP	-	0.35	26.70	18.36	21.64	11.35	10.28	4.49	6.14	**99.32**
2022	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	SOP	14.65	85.46	11.50	-	-	-	-	-	-	**111.62**
2022	27.3.a.20	D	3	SOP	2.31	13.49	1.82	-	-	-	-	-	-	**17.62**
2022	27.3.a.20	D	4	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	SOP	-	0.87	75.43	12.86	3.03	0.31	-	-	-	**92.50**
2022	27.3.a.21	C	2	SOP	-	0.15	13.28	2.26	0.53	0.05	-	-	-	**16.28**
2022	27.3.a.21	C	3	SOP	-	0.14	3.08	2.08	2.44	1.29	1.17	0.51	0.69	**11.39**
2022	27.3.a.21	C	4	SOP	-	0.31	1.78	1.09	1.27	0.69	0.64	0.28	0.34	**6.40**
2022	27.3.a.21	D	1	SOP	-	0.06	5.35	0.91	0.22	0.02	-	-	-	**6.57**

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.21	D	2	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	SOP	15.16	88.42	11.90	-	-	-	-	-	-	**115.48**
2022	27.3.b.23	F	1	SOP	-	0.05	2.88	5.63	11.91	12.17	7.56	2.77	2.12	**45.10**
2022	27.3.b.23	F	2	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	SOP	-	0.01	0.80	1.56	3.31	3.38	2.10	0.77	0.59	**12.53**
2022	27.3.b.23	F	4	SOP	-	0.21	11.96	23.42	49.53	50.59	31.41	11.51	8.83	**187.46**
2022	27.3.c.22	F	1	SOP	-	-	-	0.07	0.22	1.00	2.51	2.65	2.76	**9.21**
2022	27.3.c.22	F	2	SOP	-	0.00	0.03	0.72	0.64	1.29	2.26	1.14	1.17	**7.27**
2022	27.3.c.22	F	3	SOP	0.00	0.01	0.04	0.09	0.06	0.07	0.04	0.01	0.02	**0.33**
2022	27.3.c.22	F	4	SOP	0.00	0.12	0.76	1.67	1.06	1.30	0.81	0.19	0.49	**6.40**
2022	27.3.d.24	F	1	SOP	-	0.68	4.33	18.68	19.57	31.93	39.00	43.14	36.32	**193.66**
2022	27.3.d.24	F	2	SOP	-	0.29	1.93	11.15	10.26	9.79	9.78	7.88	6.68	**57.76**
2022	27.3.d.24	F	3	SOP	0.00	0.01	0.24	0.78	0.94	1.63	0.78	0.49	0.35	**5.22**
2022	27.3.d.24	F	4	SOP	0.07	0.50	9.91	25.92	26.88	21.64	13.63	9.56	4.55	**112.66**
2022	27.3.a.20	C	1	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	2	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	3	WECA	-	59.30	131.35	133.02	158.52	170.43	193.09	197.52	204.53	**150.90**
2022	27.3.a.20	C	4	WECA	-	61.69	131.46	133.01	158.51	170.41	193.02	197.36	204.58	**151.39**
2022	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**48.06**
2022	27.3.a.20	D	3	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**48.06**
2022	27.3.a.20	D	4	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**54.04**
2022	27.3.a.21	C	2	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**54.04**
2022	27.3.a.21	C	3	WECA	-	56.60	130.87	133.09	158.59	170.52	193.36	198.23	204.31	**148.88**
2022	27.3.a.21	C	4	WECA	-	55.17	128.43	133.49	158.98	171.02	194.91	202.24	202.96	**138.95**
2022	27.3.a.21	D	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**54.04**
2022	27.3.a.21	D	2	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**48.06**
2022	27.3.b.23	F	1	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.b.23	F	2	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.b.23	F	4	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.c.22	F	1	WECA	-	-	-	152.29	145.43	161.22	163.20	170.16	179.87	**169.08**
2022	27.3.c.22	F	2	WECA	-	16.17	61.11	68.50	104.96	115.29	127.23	146.05	157.91	**118.21**
2022	27.3.c.22	F	3	WECA	20.10	60.63	74.25	88.63	98.87	105.55	106.08	143.78	103.75	**94.57**
2022	27.3.c.22	F	4	WECA	20.10	61.36	73.76	87.58	96.03	104.13	103.77	138.39	102.62	**93.06**
2022	27.3.d.24	F	1	WECA	-	16.17	51.82	62.41	86.71	116.23	159.27	180.37	186.72	**120.75**
2022	27.3.d.24	F	2	WECA	-	16.17	51.39	61.10	78.65	85.88	131.31	156.98	163.95	**89.17**
2022	27.3.d.24	F	3	WECA	20.10	38.38	89.00	122.70	153.31	186.65	188.20	198.22	204.43	**160.37**
2022	27.3.d.24	F	4	WECA	20.04	38.40	84.06	109.66	139.09	166.75	177.32	187.32	195.92	**133.32**

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 sampling schemes.

year	area	quarter	type	0	1	2	3	4	5	6	7	8+
2022	27.3.a.20	1	n	0	38	106	18	7	11	4	0	1
2022	27.3.a.20	1	NSAS	-	-	0.9038	-	-	-	-	-	-
2022	27.3.a.20	1	WBSS	-	-	0.0962	-	-	-	-	-	-
2022	27.3.a.20	2	n	0	17	122	16	10	8	8	2	1
2022	27.3.a.20	2	NSAS	0.9672	0.9925	0.9638	-	-	-	-	-	-
2022	27.3.a.20	2	WBSS	0.0328	0.0075	0.0362	-	-	-	-	-	-
2022	27.3.a.20	3	n	91	198	221	102	89	56	27	9	12
2022	27.3.a.20	3	NSAS	0.8740	0.9229	0.7130	0.4987	0.3976	0.3840	0.4186	0.4664	0.4892
2022	27.3.a.20	3	WBSS	0.1260	0.0771	0.2870	0.5013	0.6024	0.6160	0.5814	0.5336	0.5108
2022	27.3.a.20	4	n	0	0	0	0	0	0	0	0	0
2022	27.3.a.20	4	NSAS	-	0.9229	0.7130	0.4987	0.3976	0.3840	0.4186	0.4664	0.4892
2022	27.3.a.20	4	WBSS	-	0.0771	0.2870	0.5013	0.6024	0.6160	0.5814	0.5336	0.5108
2022	27.3.a.21	1	n	0	63	19	14	4	0	0	0	0
2022	27.3.a.21	1	NSAS	-	0.8794	0.6472	0.2105	0.0379	0.0103	-	-	-
2022	27.3.a.21	1	WBSS	-	0.1206	0.3528	0.7895	0.9621	0.9897	-	-	-
2022	27.3.a.21	2	n	0	0	0	0	0	0	0	0	0
2022	27.3.a.21	2	NSAS	-	0.9788	0.8386	0.6162	0.5316	0.6043	-	-	-
2022	27.3.a.21	2	WBSS	-	0.0212	0.1614	0.3838	0.4684	0.3957	-	-	-
2022	27.3.a.21	3	n	144	303	127	52	14	10	13	4	2
2022	27.3.a.21	3	NSAS	-	0.8069	0.3266	0.2132	0.2832	0.4493	0.5641	0.4609	0.1132
2022	27.3.a.21	3	WBSS	-	0.1931	0.6734	0.7868	0.7168	0.5507	0.4359	0.5391	0.8868
2022	27.3.a.21	4	n	0	0	0	0	0	0	0	0	0
2022	27.3.a.21	4	NSAS	0.9448	0.8069	0.3266	0.2132	0.2832	0.4493	0.5641	0.4609	0.1132
2022	27.3.a.21	4	WBSS	0.0552	0.1931	0.6734	0.7868	0.7168	0.5507	0.4359	0.5391	0.8868

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 2022

year	area	fleet	quarter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.20	C	1	CANUM	-	-	1.77	-	-	-	-	-	-	**1.77**
2022	27.3.a.20	C	2	CANUM	-	-	0.24	-	-	-	-	-	-	**0.24**
2022	27.3.a.20	C	3	CANUM	-	0.01	0.20	0.09	0.07	0.03	0.03	0.01	0.02	**0.48**
2022	27.3.a.20	C	4	CANUM	-	0.01	0.14	0.07	0.05	0.03	0.02	0.01	0.01	**0.35**
2022	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	CANUM	0.55	1.62	0.12	-	-	-	-	-	-	**2.29**
2022	27.3.a.20	D	3	CANUM	0.08	0.24	0.01	-	-	-	-	-	-	**0.33**
2022	27.3.a.20	D	4	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	CANUM	-	0.03	0.95	0.04	0.00	0.00	-	-	-	**1.02**
2022	27.3.a.21	C	2	CANUM	-	0.01	0.22	0.02	0.00	0.00	-	-	-	**0.25**
2022	27.3.a.21	C	3	CANUM	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
2022	27.3.a.21	C	4	CANUM	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**
2022	27.3.a.21	D	1	CANUM	-	0.00	0.07	0.00	0.00	0.00	-	-	-	**0.07**
2022	27.3.a.21	D	2	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	CANUM	0.55	1.36	0.04	-	-	-	-	-	-	**1.96**
2022	27.3.a.20	C	1	SOP	-	-	91.24	-	-	-	-	-	-	**91.24**

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.20	C	2	SOP	-	-	12.53	-	-	-	-	-	-	**12.53**
2022	27.3.a.20	C	3	SOP	-	0.65	26.12	12.51	11.75	5.96	5.89	2.87	4.09	**69.83**
2022	27.3.a.20	C	4	SOP	-	0.33	19.04	9.16	8.61	4.36	4.30	2.09	3.00	**50.88**
2022	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	SOP	14.17	84.82	11.09	-	-	-	-	-	-	**110.08**
2022	27.3.a.20	D	3	SOP	2.02	12.45	1.29	-	-	-	-	-	-	**15.77**
2022	27.3.a.20	D	4	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	SOP	-	0.77	48.82	2.71	0.11	0.00	-	-	-	**52.42**
2022	27.3.a.21	C	2	SOP	-	0.15	11.13	1.40	0.28	0.03	-	-	-	**13.00**
2022	27.3.a.21	C	3	SOP	-	0.11	1.01	0.44	0.69	0.58	0.66	0.24	0.08	**3.80**
2022	27.3.a.21	C	4	SOP	-	0.25	0.58	0.23	0.36	0.31	0.36	0.13	0.04	**2.26**
2022	27.3.a.21	D	1	SOP	-	0.05	3.46	0.19	0.01	0.00	-	-	-	**3.72**
2022	27.3.a.21	D	2	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	SOP	14.32	71.34	3.89	-	-	-	-	-	-	**89.55**
2022	27.3.a.20	C	1	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	2	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	3	WECA	-	59.30	131.35	133.02	158.52	170.43	193.09	197.52	204.53	**146.10**
2022	27.3.a.20	C	4	WECA	-	61.69	131.46	133.01	158.51	170.41	193.02	197.36	204.58	**146.90**
2022	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**48.13**
2022	27.3.a.20	D	3	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**47.81**
2022	27.3.a.20	D	4	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**51.31**
2022	27.3.a.21	C	2	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**53.01**
2022	27.3.a.21	C	3	WECA	-	56.60	130.87	133.09	158.59	170.52	193.36	198.23	204.31	**147.90**
2022	27.3.a.21	C	4	WECA	-	55.17	128.43	133.49	158.98	171.02	194.91	202.24	202.96	**128.54**
2022	27.3.a.21	D	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**51.31**
2022	27.3.a.21	D	2	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**45.76**

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 2022

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.20	C	1	CANUM	-	-	0.19	-	-	-	-	-	-	**0.19**
2022	27.3.a.20	C	2	CANUM	-	-	0.01	-	-	-	-	-	-	**0.01**
2022	27.3.a.20	C	3	CANUM	-	0.00	0.08	0.09	0.11	0.06	0.04	0.02	0.02	**0.42**
2022	27.3.a.20	C	4	CANUM	-	0.00	0.06	0.07	0.08	0.04	0.03	0.01	0.02	**0.31**
2022	27.3.a.20	D	1	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	CANUM	0.02	0.01	0.00	-	-	-	-	-	-	**0.04**
2022	27.3.a.20	D	3	CANUM	0.01	0.02	0.01	-	-	-	-	-	-	**0.04**
2022	27.3.a.20	D	4	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	CANUM	-	0.00	0.52	0.14	0.03	0.00	-	-	-	**0.69**
2022	27.3.a.21	C	2	CANUM	-	0.00	0.04	0.01	0.00	0.00	-	-	-	**0.06**
2022	27.3.a.21	C	3	CANUM	-	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	**0.05**
2022	27.3.a.21	C	4	CANUM	-	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	**0.03**
2022	27.3.a.21	D	1	CANUM	-	0.00	0.04	0.01	0.00	0.00	-	-	-	**0.05**
2022	27.3.a.21	D	2	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	CANUM	0.03	0.33	0.09	-	-	-	-	-	-	**0.45**
2022	27.3.b.23	F	1	CANUM	-	0.00	0.02	0.03	0.07	0.06	0.04	0.01	0.01	**0.25**
2022	27.3.b.23	F	2	CANUM	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	CANUM	-	0.00	0.01	0.01	0.02	0.02	0.01	0.00	0.00	**0.07**
2022	27.3.b.23	F	4	CANUM	-	0.00	0.08	0.14	0.28	0.26	0.15	0.06	0.04	**1.02**
2022	27.3.c.22	F	1	CANUM	-	-	-	0.00	0.00	0.01	0.02	0.02	0.02	**0.05**
2022	27.3.c.22	F	2	CANUM	-	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	**0.06**
2022	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	**0.00**
2022	27.3.c.22	F	4	CANUM	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	**0.07**
2022	27.3.d.24	F	1	CANUM	-	0.04	0.08	0.30	0.23	0.27	0.24	0.24	0.19	**1.60**
2022	27.3.d.24	F	2	CANUM	-	0.02	0.04	0.18	0.13	0.11	0.07	0.05	0.04	**0.65**
2022	27.3.d.24	F	3	CANUM	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	**0.03**
2022	27.3.d.24	F	4	CANUM	0.00	0.01	0.12	0.24	0.19	0.13	0.08	0.05	0.02	**0.85**
2022	27.4.a.e	A	1	CANUM	-	-	2.54	0.35	0.34	-	-	-	-	**3.22**
2022	27.4.a.e	A	2	CANUM	-	0.00	3.29	5.96	6.09	4.72	3.98	2.51	3.00	**29.54**
2022	27.4.a.e	A	3	CANUM	-	0.10	0.42	0.39	0.74	0.41	0.47	-	0.25	**2.78**
2022	27.4.a.e	A	4	CANUM	-	-	-	-	0.04	-	0.02	-	-	**0.06**
2022	27.3.a.20	C	1	SOP	-	-	9.71	-	-	-	-	-	-	**9.71**
2022	27.3.a.20	C	2	SOP	-	-	0.47	-	-	-	-	-	-	**0.47**
2022	27.3.a.20	C	3	SOP	-	0.05	10.51	12.57	17.81	9.56	8.18	3.28	4.27	**66.23**

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.20	C	4	SOP	-	0.03	7.66	9.20	13.04	6.99	5.98	2.40	3.13	**48.43**
2022	27.3.a.20	D	1	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	SOP	0.48	0.64	0.42	-	-	-	-	-	-	**1.54**
2022	27.3.a.20	D	3	SOP	0.29	1.04	0.52	-	-	-	-	-	-	**1.85**
2022	27.3.a.20	D	4	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	C	1	SOP	-	0.11	26.61	10.16	2.92	0.30	-	-	-	**40.09**
2022	27.3.a.21	C	2	SOP	-	0.00	2.14	0.87	0.25	0.02	-	-	-	**3.29**
2022	27.3.a.21	C	3	SOP	-	0.03	2.08	1.63	1.75	0.71	0.51	0.28	0.61	**7.59**
2022	27.3.a.21	C	4	SOP	-	0.06	1.20	0.86	0.91	0.38	0.28	0.15	0.30	**4.14**
2022	27.3.a.21	D	1	SOP	-	0.01	1.89	0.72	0.21	0.02	-	-	-	**2.85**
2022	27.3.a.21	D	2	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	SOP	0.84	17.08	8.01	-	-	-	-	-	-	**25.93**
2022	27.3.b.23	F	1	SOP	-	0.05	2.88	5.63	11.91	12.17	7.56	2.77	2.12	**45.10**
2022	27.3.b.23	F	2	SOP	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	SOP	-	0.01	0.80	1.56	3.31	3.38	2.10	0.77	0.59	**12.53**
2022	27.3.b.23	F	4	SOP	-	0.21	11.96	23.42	49.53	50.59	31.41	11.51	8.83	**187.46**
2022	27.3.c.22	F	1	SOP	-	-	-	0.07	0.22	1.00	2.51	2.65	2.76	**9.21**
2022	27.3.c.22	F	2	SOP	-	0.00	0.03	0.72	0.64	1.29	2.26	1.14	1.17	**7.27**
2022	27.3.c.22	F	3	SOP	0.00	0.01	0.04	0.09	0.06	0.07	0.04	0.01	0.02	**0.33**
2022	27.3.c.22	F	4	SOP	0.00	0.12	0.76	1.67	1.06	1.30	0.81	0.19	0.49	**6.40**
2022	27.3.d.24	F	1	SOP	-	0.68	4.33	18.68	19.57	31.93	39.00	43.14	36.32	**193.66**
2022	27.3.d.24	F	2	SOP	-	0.29	1.93	11.15	10.26	9.79	9.78	7.88	6.68	**57.76**
2022	27.3.d.24	F	3	SOP	0.00	0.01	0.24	0.78	0.94	1.63	0.78	0.49	0.35	**5.22**
2022	27.3.d.24	F	4	SOP	0.07	0.50	9.91	25.92	26.88	21.64	13.63	9.56	4.55	**112.66**
2022	27.4.a.e	A	1	SOP	-	-	207.91	36.92	39.34	-	-	-	-	**284.18**
2022	27.4.a.e	A	2	SOP	-	0.21	417.97	774.80	858.21	797.68	692.06	481.84	603.24	**4626.00**
2022	27.4.a.e	A	3	SOP	-	6.71	61.49	67.65	125.60	76.56	86.94	-	55.78	**480.74**
2022	27.4.a.e	A	4	SOP	-	-	-	-	5.90	-	4.74	-	-	**10.63**
2022	27.3.a.20	C	1	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	2	WECA	-	-	51.61	-	-	-	-	-	-	**51.61**
2022	27.3.a.20	C	3	WECA	-	59.30	131.35	133.02	158.52	170.43	193.09	197.52	204.53	**156.31**
2022	27.3.a.20	C	4	WECA	-	61.69	131.46	133.01	158.51	170.41	193.02	197.36	204.58	**156.41**
2022	27.3.a.20	D	1	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.20	D	2	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**43.56**
2022	27.3.a.20	D	3	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**50.37**
2022	27.3.a.20	D	4	WECA	-	-	-	-	-	-	-	-	-	**-**

year	area	fleet	quar-ter	type	0	1	2	3	4	5	6	7	8+	Total
2022	27.3.a.21	C	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**58.08**
2022	27.3.a.21	C	2	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**58.53**
2022	27.3.a.21	C	3	WECA	-	56.60	130.87	133.09	158.59	170.52	193.36	198.23	204.31	**149.38**
2022	27.3.a.21	C	4	WECA	-	55.17	128.43	133.49	158.98	171.02	194.91	202.24	202.96	**145.39**
2022	27.3.a.21	D	1	WECA	-	22.80	51.40	73.40	112.90	81.10	-	-	-	**58.08**
2022	27.3.a.21	D	2	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	3	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.a.21	D	4	WECA	25.94	52.37	91.63	-	-	-	-	-	-	**58.16**
2022	27.3.b.23	F	1	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.b.23	F	2	WECA	-	-	-	-	-	-	-	-	-	**-**
2022	27.3.b.23	F	3	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.b.23	F	4	WECA	-	140.82	153.78	161.60	178.38	191.71	203.86	203.93	206.67	**183.97**
2022	27.3.c.22	F	1	WECA	-	-	-	152.29	145.43	161.22	163.20	170.16	179.87	**169.08**
2022	27.3.c.22	F	2	WECA	-	16.17	61.11	68.50	104.96	115.29	127.23	146.05	157.91	**118.21**
2022	27.3.c.22	F	3	WECA	20.10	60.63	74.25	88.63	98.87	105.55	106.08	143.78	103.75	**94.57**
2022	27.3.c.22	F	4	WECA	20.10	61.36	73.76	87.58	96.03	104.13	103.77	138.39	102.62	**93.06**
2022	27.3.d.24	F	1	WECA	-	16.17	51.82	62.41	86.71	116.23	159.27	180.37	186.72	**120.75**
2022	27.3.d.24	F	2	WECA	-	16.17	51.39	61.10	78.65	85.88	131.31	156.98	163.95	**89.17**
2022	27.3.d.24	F	3	WECA	20.10	38.38	89.00	122.70	153.31	186.65	188.20	198.22	204.43	**160.37**
2022	27.3.d.24	F	4	WECA	20.04	38.40	84.06	109.66	139.09	166.75	177.32	187.32	195.92	**133.32**
2022	27.4.a.e	A	1	WECA	-	-	82.00	105.00	117.00	-	-	-	-	**88.16**
2022	27.4.a.e	A	2	WECA	-	63.00	127.00	130.00	141.00	169.00	174.00	192.00	201.31	**156.58**
2022	27.4.a.e	A	3	WECA	-	69.00	147.00	172.00	169.00	186.00	186.00	-	225.45	**173.02**
2022	27.4.a.e	A	4	WECA	-	-	-	-	160.00	-	248.00	-	-	**190.05**

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 1993-2022

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**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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 & 27.3.d.24	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
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**
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**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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 & 27.3.d.24	SOP	157.26	2943.82	5595.72	7513.20	7456.75	5928.01	7782.71	4439.22	1908.12	**43724.81**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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**
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**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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 & 27.3.d.24	WECA	11.09	26.90	50.36	81.61	112.04	148.38	151.43	167.81	160.98	**36.84**
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**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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**

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 1993-2022

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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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**
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**
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**

year	area	type	0	1	2	3	4	5	6	7	8+	Total
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**
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**
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**
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**

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	443.730	353.850	295.170	162.430	236.830	155.950	201.590	366.841	341.120	260.350	163.150	142.778	212.201	76.782	102.018
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

small revision in 2015

small revision in 2017

(<0.5 %)

*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

small revision in 2018

***** 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 1991–2022 (July).

Year	1991	* 1992	* 1993	* 1994	* 1995	* 1996	1997	1998	** 1999	2000	2001	2002	2003	2004	2005	2006
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	2,081
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	2,217
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1
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	6,786
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	2,487
W-rings/Biomass ('000 tonnes)																
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	112.6
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	160.5
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	158.6
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	56.3
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	23.7
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	4.1
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	1.6
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	0.0
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	517.5
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	244.4
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	54.1
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	72.4
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	89.1
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	114.8
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	131.6
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	153.2
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	169.2
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	178.0
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	76.3

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
W-rings/Numbers in millions																
0		112				1		314	2	203	1		2	9	0	0
1	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106	418	815	26	45
2	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224	591	274	245	246
3	933	843	205	254	259	236	525	176	446	381	661	271	315	225	275	129
4	499	333	161	115	163	87	53	248	224	99	401	175	109	180	203	124
5	154	274	82	65	70	76	30	28	171	40	94	169	67	74	52	100
6	34	176	86	24	53	33	12	37	82	40	53	50	52	77	49	58
7	26	45	39	28	22	14	8	26	89	12	52	35	19	64	22	36
8+	14	44	65	34	46	60	15	42	115	28	92	44	13	46	39	37
Total	**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**	**911**	**775**
3+ group	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**	**1,353**	**744**	**575**	**666**	**640**	**484**
W-rings/Biomass ('000 tonnes)																
0						0.0		1.0	0.03	1.0	0.0		0.0	0.0	0.0	0.0
1	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	1.0	2.0
2	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	21.0	28.0
3	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	30.0	17.0
4	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	23.0	17.0
5	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	9.0	16.0
6	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	8.0	11.0
7	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	5.0	7.0
8+	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	8.0	9.0
Total	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	105.0	107.0
3+ group	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	83.0	77.0
W-rings/Mean weight (g)																
0		6.3				3.0		4.3	14.2	4.0	23.0		4.0	4.6		
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	54.4	40.2
2	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	86.9	115.6
3	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	107.4	132.6
4	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	112.5	137.2
5	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	168.8	163.1
6	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	169.1	183.2
7	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	212.0	198.5
8+	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	209.0	230.2
Total	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	115.2	115.2

* 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

TABLE 3.6.1.a - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet - Fleet A
Catch in number (CANUM, thousands)

	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
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	2.858	46.79	2368	1013	245.2	90.16	108.3	136.3
2018	0	28.6	329.8	900.6	2277	4270	1744	860.9	623.1
2019	0	7599	6239	4857	2750	7257	9687	2650	2583
2020	0	1812	3204	5845	7536	1219	10720	5325	4587
2021	0	393.8	1096	2794	7339	4469	1887	1100	2250
2022	0	100.5	6245	6705	7203	5132	4464	2510	3244

TABLE 3.6.1.b - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet - Fleet C
Catch in number (CANUM, thousands)

	0	1	2	3	4	5	6	7	8
2000	59181	209579	294752	99060	55666	20361	7311	978	772
2001	2924	22479	184831	97597	25224	12059	5979	1672	882
2002	1207	108742	133960	118066	40768	8532	4442	1459	1345
2003	4704	27998	155177	57513	54639	16425	4427	2786	1051
2004	6559	78442	56286	42645	9927	7987	2586	671	290
2005	5318	62322	175515	53573	30534	6613	7336	2142	692
2006	2105	41760	91008	86554	29334	26306	4849	4390	1833
2007	230	90083	79527	31939	26596	11189	7371	5701	1931
2008	824	92818	60484	34255	12424	14454	7281	4175	1121
2009	442	91310	119936	41373	20153	9000	5845	3043	1921
2010	230	41741	96890	42943	17084	7087	4177	2768	2739
2011	89	41858	28489	19924	12990	5756	2913	915	822
2012	0	15350	81497	20357	9152	7091	2774	2230	1166
2013	0	6260	40605	68642	10640	3858	1085	409	372
2014	49	23096	16886	18895	39169	6795	2439	1283	1329
2015	115	17357	47337	19590	12579	10401	3016	1232	1727
2016	0	13761	146136	38528	12298	10290	12066	2906	5340
2017	1427	47128	36117	40438	33155	10000	10792	7246	2762
2018	2.36	18967	176762	16634	12912	18031	5096	3041	2511
2019	5231	29648	52720	16127	5473	2488	1414	326	54.23
2020	10315	32689	49813	16558	9210	6368	2864	3022	1071
2021	1482	1370	62429	14535	8234	4939	3907	1594	1811
2022	0	7.689	920.1	332.6	239.4	107.5	77.36	30.89	40.7

TABLE 3.6.1.c - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet - Fleet D
Catch in number (CANUM, thousands)

	0	1	2	3	4	5	6	7	8
2000	58480	109337	13888	5033	555	156	87	18	10
2001	118759	13695	11926	3256	711	460	1197	938	1130
2002	68427	468952	26715	1707	1742	169	160	0	53
2003	47410	35021	27318	4810	3741	1543	665	263	158
2004	19111	130900	24598	23435	4794	4746	918	387	156
2005	90002	35287	21250	4344	3718	149	377	238	0
2006	1551	47777	17551	14152	3926	5720	652	428	234
2007	1395	13772	11277	2346	2960	997	1270	161	133
2008	4079	8946	10511	4583	888	598	366	141	148
2009	14358	58292	11338	2404	913	457	224	164	219
2010	8879	6826	8183	202	310	83	0	0	0
2011	6080	41200	1317	590	0	0	0	0	0
2012	1521	15193	12792	138	0	0	0	0	0
2013	0	5770	11071	2313	444	0	0	0	0
2014	25267	8397	3039	1979	0	0	0	0	0
2015	3195	40377	12506	526	121	313	0	0	0
2016	23879	13397	14390	391	0	674	0	0	0
2017	0	1294	6017	18.3	0	0	0	0	0
2018	285.3	1471	2047	85.05	0	0	0	0	0
2019	75.4	985.6	279.9	61.46	0	0	0	0	0
2020	462.8	2107	1881	944.4	384.9	190.1	40.66	0	6.787
2021	0	434.9	226.5	0	0	0	0	0	0
2022	62.04	358.5	134.4	9.819	1.833	0.2657	0	0	0

TABLE 3.6.1.d - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet - Fleet F
Catch in number (CANUM, thousands)

	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
2015	26670	46242	72781	38506	48439	29846	14860	7857	9120
2016	20012	22342	37247	93863	45681	30535	17423	10455	8256
2017	51.79	9435	32839	38541	78328	38496	26936	13463	10170
2018	367.8	48383	18459	34635	23065	51273	16259	8843	4507
2019	270.3	6881	20667	15565	13301	10333	15868	6034	3517
2020	30.67	1690	2487	4580	4673	6707	4148	5326	1579
2021	42.55	591.9	1772	3192	2531	1501	1331	926.2	923.2
2022	3.743	76.78	354.8	945.1	937.8	902.9	643.1	441.5	343.9

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
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

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
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

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
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

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

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
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

	0	1	2	3	4	5	6	7	8
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

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
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

	0	1	2	3	4	5	6	7	8
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

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	0.75	0.9	1	1	1	1
1992	0	0	0.2	0.75	0.9	1	1	1	1
1993	0	0	0.2	0.75	0.9	1	1	1	1
1994	0	0	0.2	0.75	0.9	1	1	1	1
1995	0	0	0.2	0.75	0.9	1	1	1	1
1996	0	0	0.2	0.75	0.9	1	1	1	1
1997	0	0	0.2	0.75	0.9	1	1	1	1
1998	0	0	0.2	0.75	0.9	1	1	1	1
1999	0	0	0.2	0.75	0.9	1	1	1	1
2000	0	0	0.2	0.75	0.9	1	1	1	1
2001	0	0	0.2	0.75	0.9	1	1	1	1
2002	0	0	0.2	0.75	0.9	1	1	1	1
2003	0	0	0.2	0.75	0.9	1	1	1	1
2004	0	0	0.2	0.75	0.9	1	1	1	1
2005	0	0	0.2	0.75	0.9	1	1	1	1
2006	0	0	0.2	0.75	0.9	1	1	1	1

	0	1	2	3	4	5	6	7	8
2007	0	0	0.2	0.75	0.9	1	1	1	1
2008	0	0	0.2	0.75	0.9	1	1	1	1
2009	0	0	0.2	0.75	0.9	1	1	1	1
2010	0	0	0.2	0.75	0.9	1	1	1	1
2011	0	0	0.2	0.75	0.9	1	1	1	1
2012	0	0	0.2	0.75	0.9	1	1	1	1
2013	0	0	0.2	0.75	0.9	1	1	1	1
2014	0	0	0.2	0.75	0.9	1	1	1	1
2015	0	0	0.2	0.75	0.9	1	1	1	1
2016	0	0	0.2	0.75	0.9	1	1	1	1
2017	0	0	0.2	0.75	0.9	1	1	1	1
2018	0	0	0.2	0.75	0.9	1	1	1	1
2019	0	0	0.2	0.75	0.9	1	1	1	1
2020	0	0	0.2	0.75	0.9	1	1	1	1
2021	0	0	0.2	0.75	0.9	1	1	1	1
2022	0	0	0.2	0.75	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
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

	0	1	2	3	4	5	6	7	8
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

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	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

	0	1	2	3	4	5	6	7	8
1992	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1993	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1994	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1995	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1996	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1997	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1998	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1999	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2000	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2001	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2002	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2003	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2004	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2005	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2006	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2007	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2008	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2009	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2010	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2011	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2012	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2013	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2014	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2015	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2016	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2017	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2018	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2019	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2020	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

	0	1	2	3	4	5	6	7	8
2021	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2022	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

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	NA	NA	NA	NA
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
2012	236000	87000	76000	33000
2013	525000	53000	30000	12000
2014	176000	248000	28000	37000

	3	4	5	6
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

TABLE 3.6.8.b - WESTERN BALTIC SPRING SPAWNING HERRING, continued
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	NA	NA	NA	NA
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
2008	392737	165347	166301	102018
2009	270959	95866	43553	17761
2010	534633	305540	214539	107364
2011	1206762	360354	210455	115984

	1	2	3	4
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

TABLE 3.6.8.c - WESTERN BALTIC SPRING SPAWNING HERRING, continued
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
2002	11324000
2003	5507000
2004	5640000
2005	3887000
2006	3774000

	0
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

TABLE 3.6.8.d - WESTERN BALTIC SPRING SPAWNING HERRING, continued
Multi fleet
Survey indices: IBTS Q1 + BITS Q1 (number in thousands)

	1	2	3
2002	1012698	57144	11439
2003	679132	131493	3395
2004	289327	72938	12960
2005	178201	113465	7044

2006	143497	32836	6406
2007	237369	36605	3262
2008	162723	32322	3946
2009	533986	38010	1120
2010	301646	78811	9377
2011	159743	68881	12912
2012	267873	74418	3626
2013	170436	73289	13112
2014	150560	21317	2742
2015	260080	61794	2046
2016	190864	92649	5407
2017	465661	71591	11029
2018	106439	67129	2736
2019	417826	39068	5625
2020	326622	79385	5288
2021	325379	127912	6423
2022	182473	75620	7168

TABLE 3.6.8.e - WESTERN BALTIC SPRING SPAWNING HERRING, continued
Multi fleet
Survey indices: IBTS Q3 + BITS Q4 (number in thousands)

	2	**3**
2002	3416	1487
2003	7071	1519
2004	3530	1270
2005	3573	634

2006	2805	1162
2007	3932	688.8
2008	2377	1241
2009	3346	621.1
2010	4349	1260
2011	2817	705.1
2012	5435	806.5
2013	4832	1468
2014	1242	1442
2015	9964	1402
2016	8592	2125
2017	5824	1723
2018	6675	1165
2019	9767	3318
2020	8749	2299
2021	9096	1780
2022	2314	1214

TABLE 3.6.9 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
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

Configuration saved: Tue Feb 13 12:34:28 2018

```
#
# Where a matrix is specified, rows correspond to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
#
$minAge
# The minimum age class in the assessment
 0

$maxAge
# The maximum age class in the assessment
 8

$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1

$keyLogFsta
# Coupling of the fishing mortality states (normally 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 (normally 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
 -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 (normally 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
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 highest 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)	Low	High	SSB	Low	High	Fbar(3-6)	Low	High	TSB	Low	High
1991	5116963	3971062	6593528	294773	240510	361280	0.422	0.302	0.590	591253	498894	700711
1992	3684550	2929011	4634981	304636	248867	372902	0.510	0.386	0.673	524980	442517	622810
1993	3078506	2396940	3953874	287341	235433	350693	0.582	0.440	0.769	457006	383148	545100
1994	4479773	3505922	5724135	227748	186895	277532	0.603	0.461	0.790	375889	316051	447057

Year	R(age 0)	Low	High	SSB	Low	High	Fbar(3-6)	Low	High	TSB	Low	High
1995	4110015	3260314	5181165	195407	159074	240038	0.596	0.444	0.799	316364	265035	377633
1996	4171325	3326114	5231316	134244	110260	163444	0.668	0.508	0.878	277990	236393	326906
1997	3527199	2762275	4503943	146775	121087	177913	0.634	0.481	0.837	277244	235011	327068
1998	4744073	3747772	6005230	119220	99355	143057	0.626	0.473	0.829	264982	226547	309939
1999	5018116	4011841	6276791	120005	100006	144003	0.507	0.383	0.671	271356	232689	316450
2000	3086006	2460397	3870691	125841	104976	150854	0.589	0.460	0.754	263828	225949	308058
2001	2764627	2227871	3430703	136767	115236	162319	0.610	0.476	0.783	280857	241020	327278
2002	2740867	2217827	3387256	160622	135519	190376	0.500	0.387	0.647	288864	247633	336959
2003	2971033	2389890	3693490	129048	108627	153308	0.446	0.344	0.579	222004	191124	257874
2004	2088989	1683176	2592645	134457	113177	159739	0.464	0.358	0.601	228238	196581	264993
2005	1780760	1441341	2200108	126104	106721	149007	0.528	0.412	0.677	220173	189455	255872
2006	1361488	1099249	1686286	137834	116489	163090	0.476	0.370	0.614	233249	200441	271427
2007	1451383	1166312	1806132	112660	94616	134144	0.529	0.411	0.680	181938	155613	212715
2008	1180250	944293	1475167	91780	77241	109057	0.575	0.450	0.733	159665	137057	186003
2009	1109111	892922	1377642	82061	69293	97181	0.542	0.420	0.699	143240	123181	166566
2010	1444975	1167671	1788134	74567	63284	87861	0.432	0.329	0.568	124213	106794	144473
2011	1335731	1086848	1641608	68146	57744	80422	0.291	0.217	0.389	111275	95942	129059
2012	1198209	969739	1480507	72629	61598	85635	0.377	0.286	0.497	124011	107092	143602
2013	1765082	1343427	2319080	80901	68627	95371	0.399	0.303	0.525	136923	118062	158798
2014	1233676	971998	1565800	84593	71265	100414	0.320	0.242	0.424	143429	123716	166282
2015	998672	785133	1270290	88247	74449	104601	0.407	0.309	0.537	150321	129082	175056
2016	893169	689301	1157332	85406	71847	101523	0.522	0.401	0.679	133590	113623	157066
2017	915592	699274	1198826	74730	62341	89581	0.561	0.430	0.731	118867	100253	140937
2018	813788	598428	1106650	59805	48982	73019	0.572	0.429	0.763	95426	79074	115158
2019	830255	584427	1179485	51376	40213	65638	0.279	0.196	0.399	93027	74067	116841
2020	612037	403824	927607	53628	40296	71370	0.187	0.114	0.308	92039	70375	120373
2021	454304	267107	772694	62343	44764	86824	0.111	0.063	0.195	97293	70982	133356
2022	537470	268327	1076573	75548	52770	108157	0.050	0.022	0.114	109946	77649	155677

TABLE 3.6.12.a - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated fishing mortality - Sum all fleets

Year Age	0	1	2	3	4	5	6	7	8
1991	0.027	0.203	0.313	0.349	0.400	0.444	0.495	0.537	0.537
1992	0.027	0.222	0.349	0.402	0.476	0.540	0.621	0.688	0.688
1993	0.034	0.261	0.375	0.446	0.541	0.618	0.723	0.805	0.805
1994	0.041	0.286	0.413	0.470	0.564	0.634	0.745	0.826	0.826
1995	0.065	0.360	0.457	0.484	0.557	0.619	0.723	0.793	0.793
1996	0.047	0.321	0.431	0.504	0.618	0.710	0.840	0.932	0.932
1997	0.048	0.307	0.396	0.468	0.580	0.674	0.815	0.939	0.939
1998	0.050	0.316	0.426	0.476	0.574	0.664	0.792	0.940	0.940
1999	0.034	0.235	0.395	0.411	0.467	0.531	0.619	0.740	0.740
2000	0.028	0.238	0.441	0.463	0.541	0.619	0.731	0.876	0.876
2001	0.032	0.248	0.415	0.455	0.557	0.646	0.784	0.924	0.924
2002	0.025	0.199	0.382	0.391	0.457	0.524	0.628	0.740	0.740
2003	0.023	0.182	0.336	0.346	0.407	0.467	0.563	0.667	0.667
2004	0.024	0.187	0.284	0.330	0.422	0.493	0.611	0.729	0.729
2005	0.016	0.171	0.328	0.381	0.488	0.557	0.687	0.819	0.819
2006	0.015	0.170	0.364	0.376	0.446	0.494	0.590	0.695	0.695
2007	0.013	0.160	0.360	0.401	0.497	0.555	0.662	0.761	0.761
2008	0.013	0.166	0.380	0.427	0.538	0.609	0.725	0.817	0.817
2009	0.014	0.186	0.425	0.422	0.505	0.566	0.675	0.755	0.755
2010	0.007	0.123	0.355	0.347	0.406	0.445	0.531	0.594	0.594
2011	0.004	0.075	0.206	0.217	0.271	0.303	0.372	0.420	0.420
2012	0.005	0.087	0.226	0.264	0.351	0.400	0.493	0.552	0.552
2013	0.005	0.091	0.222	0.269	0.369	0.427	0.530	0.599	0.599
2014	0.004	0.074	0.198	0.226	0.295	0.341	0.421	0.487	0.487
2015	0.006	0.102	0.242	0.275	0.368	0.441	0.545	0.659	0.659
2016	0.006	0.120	0.376	0.387	0.467	0.554	0.678	0.842	0.842
2017	0.004	0.109	0.395	0.415	0.491	0.596	0.741	0.954	0.954

Year Age	0	1	2	3	4	5	6	7	8
2018	0.004	0.106	0.386	0.413	0.495	0.612	0.768	1.043	1.043
2019	0.002	0.046	0.166	0.190	0.238	0.297	0.393	0.592	0.592
2020	0.001	0.049	0.192	0.164	0.176	0.176	0.234	0.362	0.362
2021	0.001	0.022	0.098	0.092	0.112	0.103	0.138	0.239	0.239
2022	0.000	0.003	0.013	0.027	0.054	0.046	0.073	0.164	0.164

TABLE 3.6.12.b - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated fishing mortality - Fleet A

Year Age	0	1	2	3	4	5	6	7	8
1991	0.000	0.000	0.004	0.021	0.016	0.019	0.017	0.017	0.017
1992	0.000	0.000	0.004	0.020	0.016	0.018	0.018	0.018	0.018
1993	0.000	0.000	0.004	0.020	0.017	0.018	0.019	0.020	0.020
1994	0.000	0.000	0.004	0.020	0.018	0.018	0.021	0.021	0.021
1995	0.000	0.000	0.004	0.020	0.018	0.019	0.022	0.023	0.023
1996	0.000	0.000	0.004	0.020	0.019	0.020	0.024	0.026	0.026
1997	0.000	0.000	0.004	0.020	0.019	0.021	0.024	0.032	0.032
1998	0.000	0.000	0.004	0.019	0.019	0.024	0.024	0.040	0.040
1999	0.000	0.000	0.004	0.020	0.020	0.027	0.025	0.046	0.046
2000	0.000	0.000	0.004	0.019	0.022	0.029	0.030	0.049	0.049
2001	0.000	0.000	0.004	0.017	0.023	0.030	0.033	0.049	0.049
2002	0.000	0.000	0.003	0.016	0.021	0.028	0.031	0.048	0.048
2003	0.000	0.000	0.002	0.015	0.019	0.023	0.027	0.043	0.043
2004	0.000	0.000	0.002	0.016	0.018	0.021	0.024	0.036	0.036
2005	0.000	0.000	0.002	0.014	0.018	0.018	0.024	0.039	0.039
2006	0.000	0.000	0.001	0.010	0.015	0.016	0.022	0.042	0.042
2007	0.000	0.000	0.001	0.007	0.010	0.009	0.017	0.028	0.028
2008	0.000	0.000	0.001	0.004	0.007	0.006	0.013	0.022	0.022
2009	0.000	0.000	0.001	0.004	0.008	0.006	0.014	0.031	0.031
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	0.017	0.017

Year Age	0	1	2	3	4	5	6	7	8
2012	0.000	0.000	0.000	0.003	0.006	0.002	0.016	0.015	0.015
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	0.023	0.032	0.032
2015	0.000	0.000	0.001	0.006	0.009	0.010	0.026	0.043	0.043
2016	0.000	0.000	0.001	0.008	0.010	0.012	0.026	0.048	0.048
2017	0.000	0.000	0.001	0.010	0.012	0.013	0.025	0.054	0.054
2018	0.000	0.000	0.002	0.011	0.019	0.020	0.036	0.098	0.098
2019	0.000	0.000	0.004	0.015	0.026	0.027	0.053	0.142	0.142
2020	0.000	0.000	0.005	0.018	0.038	0.028	0.066	0.160	0.160
2021	0.000	0.000	0.005	0.019	0.045	0.033	0.061	0.148	0.148
2022	0.000	0.000	0.007	0.021	0.046	0.036	0.060	0.147	0.147

TABLE 3.6.12.c - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated fishing mortality - Fleet C

Year Age	0	1	2	3	4	5	6	7	8
1991	0.001	0.029	0.132	0.095	0.076	0.068	0.066	0.066	0.066
1992	0.001	0.030	0.135	0.098	0.078	0.070	0.068	0.068	0.068
1993	0.001	0.027	0.122	0.088	0.071	0.063	0.061	0.061	0.061
1994	0.001	0.034	0.154	0.111	0.089	0.079	0.077	0.077	0.077
1995	0.001	0.041	0.185	0.134	0.108	0.096	0.093	0.093	0.093
1996	0.001	0.029	0.134	0.097	0.078	0.069	0.067	0.067	0.067
1997	0.000	0.025	0.112	0.081	0.065	0.058	0.056	0.056	0.056
1998	0.001	0.033	0.151	0.109	0.087	0.078	0.075	0.076	0.076
1999	0.001	0.044	0.201	0.145	0.116	0.103	0.100	0.101	0.101
2000	0.001	0.050	0.229	0.166	0.133	0.118	0.115	0.115	0.115
2001	0.001	0.040	0.184	0.133	0.107	0.095	0.092	0.092	0.092
2002	0.001	0.048	0.218	0.158	0.127	0.112	0.109	0.110	0.110
2003	0.001	0.040	0.182	0.131	0.105	0.094	0.091	0.091	0.091
2004	0.000	0.020	0.092	0.066	0.053	0.047	0.046	0.046	0.046
2005	0.001	0.031	0.141	0.102	0.082	0.073	0.071	0.071	0.071

Year Age	0	1	2	3	4	5	6	7	8
2006	0.001	0.042	0.194	0.140	0.112	0.100	0.097	0.098	0.098
2007	0.001	0.038	0.176	0.127	0.102	0.091	0.088	0.089	0.089
2008	0.001	0.040	0.182	0.131	0.105	0.094	0.091	0.092	0.092
2009	0.001	0.052	0.239	0.172	0.138	0.123	0.120	0.121	0.121
2010	0.001	0.054	0.248	0.178	0.143	0.128	0.124	0.126	0.126
2011	0.001	0.029	0.134	0.096	0.077	0.069	0.067	0.068	0.068
2012	0.001	0.027	0.123	0.089	0.071	0.064	0.062	0.063	0.063
2013	0.000	0.022	0.101	0.073	0.059	0.052	0.051	0.052	0.052
2014	0.000	0.024	0.110	0.079	0.064	0.057	0.055	0.056	0.056
2015	0.000	0.025	0.116	0.083	0.067	0.060	0.059	0.059	0.059
2016	0.001	0.056	0.258	0.185	0.149	0.134	0.131	0.132	0.132
2017	0.001	0.064	0.295	0.212	0.170	0.152	0.149	0.151	0.151
2018	0.001	0.062	0.285	0.205	0.165	0.147	0.144	0.146	0.146
2019	0.000	0.025	0.117	0.084	0.067	0.060	0.059	0.059	0.059
2020	0.001	0.036	0.166	0.119	0.096	0.086	0.084	0.085	0.085
2021	0.000	0.019	0.087	0.062	0.050	0.045	0.044	0.044	0.044
2022	0.000	0.001	0.004	0.003	0.002	0.002	0.002	0.002	0.002

TABLE 3.6.12.d - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated fishing mortality - Fleet D

Year Age	0	1	2	3	4	5	6	7	8
1991	0.015	0.043	0.016	0.008	0.004	0.003	0.004	0.004	0.004
1992	0.012	0.033	0.013	0.007	0.003	0.003	0.004	0.003	0.003
1993	0.017	0.047	0.017	0.009	0.004	0.003	0.004	0.004	0.004
1994	0.024	0.066	0.024	0.011	0.006	0.004	0.006	0.005	0.005
1995	0.049	0.141	0.048	0.021	0.010	0.007	0.009	0.007	0.007
1996	0.028	0.075	0.025	0.011	0.005	0.004	0.005	0.005	0.005
1997	0.029	0.076	0.025	0.011	0.005	0.004	0.005	0.004	0.004
1998	0.033	0.087	0.029	0.012	0.005	0.004	0.005	0.005	0.005
1999	0.021	0.054	0.019	0.008	0.004	0.003	0.004	0.003	0.003

Year Age	0	1	2	3	4	5	6	7	8
2000	0.014	0.035	0.013	0.005	0.002	0.002	0.003	0.003	0.003
2001	0.018	0.051	0.021	0.009	0.005	0.005	0.009	0.010	0.010
2002	0.016	0.050	0.020	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.059	0.032	0.015	0.009	0.008	0.009	0.008	0.008
2004	0.016	0.068	0.044	0.023	0.014	0.012	0.012	0.009	0.009
2005	0.007	0.034	0.023	0.011	0.006	0.004	0.004	0.003	0.003
2006	0.008	0.050	0.043	0.022	0.012	0.012	0.011	0.009	0.009
2007	0.005	0.031	0.029	0.014	0.007	0.008	0.007	0.007	0.007
2008	0.005	0.033	0.032	0.013	0.005	0.006	0.005	0.005	0.005
2009	0.008	0.061	0.051	0.015	0.004	0.004	0.003	0.003	0.003
2010	0.002	0.020	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	0.011	0.008	0.001	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.015	0.015	0.002	0.000	0.000	0.000	0.000	0.000
2014	0.001	0.013	0.012	0.001	0.000	0.000	0.000	0.000	0.000
2015	0.002	0.031	0.028	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.019	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	0.003	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2019	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.000	0.008	0.010	0.001	0.000	0.000	0.000	0.000	0.000
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

TABLE 3.6.12.e - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated fishing mortality - Fleet F

Year Age	0	1	2	3	4	5	6	7	8
1991	0.011	0.131	0.161	0.225	0.303	0.354	0.408	0.451	0.451
1992	0.014	0.159	0.197	0.278	0.378	0.449	0.532	0.599	0.599
1993	0.016	0.187	0.232	0.329	0.449	0.533	0.638	0.720	0.720

Year Age	0	1	2	3	4	5	6	7	8
1994	0.016	0.187	0.231	0.328	0.451	0.533	0.642	0.723	0.723
1995	0.015	0.178	0.219	0.309	0.422	0.498	0.599	0.670	0.670
1996	0.019	0.217	0.267	0.376	0.516	0.616	0.744	0.835	0.835
1997	0.018	0.207	0.255	0.357	0.491	0.592	0.730	0.846	0.846
1998	0.017	0.196	0.242	0.336	0.462	0.559	0.687	0.820	0.820
1999	0.012	0.137	0.171	0.239	0.328	0.398	0.489	0.590	0.590
2000	0.013	0.153	0.194	0.274	0.383	0.470	0.584	0.709	0.709
2001	0.013	0.157	0.206	0.296	0.422	0.517	0.650	0.774	0.774
2002	0.008	0.101	0.141	0.210	0.306	0.382	0.484	0.580	0.580
2003	0.007	0.083	0.120	0.185	0.274	0.342	0.436	0.525	0.525
2004	0.008	0.098	0.145	0.225	0.336	0.413	0.529	0.638	0.638
2005	0.008	0.105	0.162	0.255	0.382	0.461	0.589	0.706	0.706
2006	0.006	0.078	0.127	0.205	0.307	0.365	0.460	0.546	0.546
2007	0.007	0.090	0.154	0.253	0.378	0.447	0.550	0.637	0.637
2008	0.007	0.093	0.166	0.278	0.420	0.503	0.617	0.698	0.698
2009	0.006	0.073	0.135	0.231	0.355	0.433	0.538	0.600	0.600
2010	0.004	0.049	0.093	0.163	0.255	0.313	0.393	0.444	0.444
2011	0.003	0.033	0.065	0.117	0.187	0.231	0.292	0.335	0.335
2012	0.004	0.048	0.094	0.171	0.273	0.334	0.416	0.475	0.475
2013	0.004	0.053	0.105	0.190	0.304	0.371	0.461	0.528	0.528
2014	0.003	0.037	0.076	0.141	0.223	0.277	0.342	0.399	0.399
2015	0.003	0.046	0.097	0.183	0.292	0.371	0.461	0.556	0.556
2016	0.003	0.044	0.099	0.193	0.308	0.409	0.521	0.661	0.661
2017	0.003	0.041	0.096	0.193	0.308	0.430	0.566	0.749	0.749
2018	0.003	0.041	0.096	0.197	0.311	0.445	0.588	0.800	0.800
2019	0.001	0.018	0.043	0.091	0.144	0.209	0.282	0.390	0.390
2020	0.000	0.005	0.012	0.026	0.042	0.062	0.084	0.118	0.118
2021	0.000	0.002	0.005	0.011	0.017	0.025	0.034	0.047	0.047
2022	0.000	0.001	0.002	0.003	0.005	0.008	0.011	0.015	0.015

TABLE 3.6.13 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Estimated stock numbers (1000) at age

Year Age	0	1	2	3	4	5	6	7	8
1991	5116963	4122924	2246492	1868970	912099	551866	162679	48647	17493
1992	3684550	3724986	2032424	1347850	1077384	497917	288437	81767	31957
1993	3078506	2657326	1836150	1163842	743742	546329	236380	126922	46855
1994	4479773	2171413	1239962	1050432	601950	359298	239713	93775	63492
1995	4110015	3221895	993598	662571	551260	273342	158147	92522	56203
1996	4171325	2841926	1369150	517817	331744	257352	120258	62936	55096
1997	3527199	2955983	1244119	737268	256595	145205	102040	42433	38452
1998	4744073	2459235	1318275	685884	380052	117813	61070	36282	25960
1999	5018116	3356038	1077173	700956	349774	176488	49391	22925	19619
2000	3086006	3637957	1614152	590018	377595	180650	85003	21850	16616
2001	2764627	2202123	1743758	862519	300315	179843	79037	33849	13092
2002	2740867	1974032	1022498	948433	458460	138978	77669	29013	15395
2003	2971033	1968178	982551	565762	524811	240177	66788	34017	17334
2004	2088989	2177660	995187	578229	327846	284020	123565	31205	21495
2005	1780760	1497932	1106839	619893	338542	176259	141501	55206	20779
2006	1361488	1300362	754532	656535	353852	168236	84023	57724	27522
2007	1451383	984515	669130	427801	366123	188429	81583	39370	34440
2008	1180250	1072280	502311	383468	233639	181462	89964	34276	28415
2009	1109111	861040	558253	280755	202720	112933	79724	36040	22702
2010	1444975	800250	434020	298258	151820	100911	52814	32389	22848
2011	1335731	1070880	424331	248103	172111	82789	53375	25609	24742
2012	1198209	983916	612334	281654	162145	107306	50089	30176	27047
2013	1765082	873794	540704	408364	176521	93621	58346	25229	26989
2014	1233676	1334182	473332	352391	258359	98528	50171	28116	23835
2015	998672	909022	774443	317014	229196	153120	57946	26829	26546
2016	893169	732268	495210	510106	197613	129228	78419	27582	22860
2017	915592	656006	393307	272324	292050	102253	60963	31911	17870
2018	813788	681086	357534	217378	142182	151180	46864	23624	15462

Year Age	0	1	2	3	4	5	6	7	8
2019	830255	600180	367595	197654	119111	70626	67455	18126	11053
2020	612037	619775	347061	250692	130665	78773	42827	37534	13201
2021	454304	454322	362378	233320	172339	88793	54311	27633	28795
2022	537470	330972	272534	265572	173991	125009	66370	38486	36122

TABLE 3.6.14.a - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Predicted catch in numbers - Sum fleets

	0	1	2	3	4	5	6	7	8
1991	117613.57	629969.45	596163.16	545280.90	294832.05	193779.95	62205.55	19820.79	7127.31
1992	84795.35	615213.07	594869.30	443922.98	402347.01	204229.49	131488.04	40161.95	15696.70
1993	90740.19	511044.05	572439.81	416773.48	305868.90	247192.37	119875.94	69285.83	25577.68
1994	156769.86	459472.93	424659.96	397034.50	258992.32	167719.50	125783.18	52749.46	35714.80
1995	228109.28	852944.82	376703.06	260176.44	238086.02	126871.60	82379.03	51347.59	31191.09
1996	167109.59	666951.07	484646.20	205942.14	152041.55	129633.55	68143.48	38167.63	33413.14
1997	143431.09	664482.66	406660.45	273918.41	111073.62	69965.70	56235.63	25755.87	23339.33
1998	204231.14	571305.11	464243.59	261624.03	165771.81	57008.50	33442.25	22490.92	16092.30
1999	145152.65	593473.18	354570.30	238424.54	131273.83	73239.40	23036.31	12342.68	10562.76
2000	73414.03	648601.87	584747.28	223238.74	160717.67	85157.81	45226.54	13331.29	10137.61
2001	75759.89	408244.77	600265.02	318813.05	129498.21	86722.58	43870.79	21201.70	8200.47
2002	59215.24	298599.94	325361.15	308907.03	169643.91	57415.29	36935.29	15722.43	8343.03
2003	59933.17	273634.13	279704.79	165156.83	175408.71	89687.65	28998.11	16940.80	8632.65
2004	43531.50	308771.20	242917.43	159884.30	110186.77	108012.92	55430.11	16013.03	11029.92
2005	25172.59	194089.04	307511.70	195006.35	129392.60	74316.54	69929.25	31124.30	11714.96
2006	18116.59	168933.49	231779.35	207051.29	127801.03	65823.60	37813.80	29715.00	14167.67
2007	15772.42	120365.69	202675.85	141341.83	142963.89	79744.93	39586.16	21268.44	18605.18
2008	12865.91	135918.92	160270.11	133567.09	96952.25	82232.33	46438.35	19368.91	16056.89
2009	13479.26	122194.42	197264.82	97920.38	81194.00	49078.13	39735.85	19716.83	12419.94
2010	8994.76	75908.06	127238.25	86610.02	50517.38	36102.15	21899.94	14786.27	10430.58
2011	5049.91	61987.70	75321.38	46376.07	39269.86	20799.65	16055.17	8567.59	8277.74
2012	5305.10	66057.66	119232.23	62916.10	46293.64	34018.42	18992.54	12480.88	11186.68

	0	1	2	3	4	5	6	7	8
2013	8213.92	61190.26	103721.00	92366.05	52266.16	31134.22	23251.94	11049.37	11820.42
2014	4428.24	76778.21	81479.19	68217.15	63345.13	27246.84	16749.36	10631.05	9012.12
2015	5009.31	71508.01	162187.32	73752.86	68286.16	52753.55	23871.38	12907.56	12771.42
2016	4243.82	67712.98	153473.66	163859.57	74438.69	55610.16	39683.36	16508.17	13681.55
2017	3487.59	54971.80	125744.92	93133.04	115405.81	47005.34	33167.77	21022.79	11772.38
2018	3023.23	55697.53	112204.96	74149.37	56686.32	71099.40	26279.58	16858.30	11033.76
2019	1349.80	21321.03	52840.98	32731.76	24361.27	17590.38	21720.04	8473.95	5167.39
2020	771.50	23814.37	56522.42	35690.40	20148.68	12170.53	8732.17	11595.27	4078.29
2021	215.84	7732.63	30928.00	18969.00	17078.70	8120.66	6643.02	5690.44	5929.88
2022	49.02	668.47	3240.43	6430.57	8353.62	5096.17	4265.81	5378.99	5048.48

TABLE 3.6.14.b - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Predicted catch in numbers - Fleet A

	0	1	2	3	4	5	6	7	8
1991	0.00	9.96	8627.26	34513.20	13425.49	9496.65	2491.33	724.96	260.69
1992	0.00	9.00	7821.97	24266.65	15830.02	8259.16	4670.04	1338.60	523.17
1993	0.00	6.42	6971.57	21388.46	11246.44	8960.04	4078.81	2243.33	828.15
1994	0.00	5.25	4706.45	18568.36	9796.10	5860.09	4454.39	1778.70	1204.29
1995	0.00	7.79	3750.65	11896.85	9096.05	4648.74	3162.07	1882.30	1143.40
1996	0.00	6.87	5107.33	9205.47	5539.44	4712.42	2542.61	1455.59	1274.27
1997	0.00	7.14	4618.34	13001.34	4310.71	2747.95	2220.89	1220.69	1106.16
1998	0.00	5.94	4928.90	11729.74	6610.96	2481.97	1306.04	1295.38	926.85
1999	0.00	8.11	4027.25	12306.41	6234.40	4212.77	1126.23	934.66	799.87
2000	0.00	8.79	5980.37	9945.89	7582.75	4728.72	2245.73	944.78	718.44
2001	0.00	6.08	5897.37	13211.06	6109.31	4789.35	2318.45	1459.99	564.70
2002	0.00	4.68	2743.55	14026.67	8608.40	3432.74	2157.68	1233.76	654.69
2003	0.00	4.40	1696.94	7806.51	9071.87	5039.09	1632.26	1306.93	665.98
2004	0.00	5.03	2133.05	8392.56	5386.33	5318.26	2658.92	992.30	683.50
2005	0.00	3.95	2071.01	7549.34	5506.04	2911.91	3065.69	1909.91	718.88
2006	0.00	4.25	990.47	5848.09	4633.44	2475.66	1636.05	2176.73	1037.83

	0	1	2	3	4	5	6	7	8
2007	0.00	3.18	481.81	2520.47	3247.31	1552.70	1225.56	989.73	865.80
2008	0.00	3.68	265.11	1430.32	1564.44	965.77	1013.59	677.57	561.70
2009	0.00	3.39	262.37	1028.45	1441.05	562.51	1006.05	992.10	624.94
2010	0.00	3.90	139.69	925.54	948.11	387.62	618.11	700.89	494.42
2011	0.00	5.69	116.72	698.67	913.10	238.19	580.26	395.48	382.10
2012	0.00	6.36	157.12	761.07	820.23	226.27	711.00	402.23	360.52
2013	0.00	7.73	187.36	1283.11	949.56	350.37	937.32	441.04	471.82
2014	0.00	18.40	269.38	1541.26	1901.06	598.43	1036.08	796.91	675.55
2015	0.00	18.74	489.12	1655.11	1882.57	1390.04	1323.78	1031.67	1020.79
2016	0.00	22.40	450.96	3478.93	1832.89	1358.95	1857.76	1183.29	980.68
2017	0.00	29.88	423.02	2374.67	3277.22	1225.38	1383.26	1532.73	858.30
2018	0.00	53.62	639.36	2239.64	2420.06	2660.59	1504.43	2006.75	1313.42
2019	0.00	84.79	1184.43	2755.11	2794.34	1706.46	3142.15	2179.01	1328.75
2020	0.00	117.26	1490.68	4074.31	4444.44	1976.76	2463.97	5034.23	1770.64
2021	0.00	96.32	1790.59	3954.93	6808.16	2629.39	2905.49	3462.90	3608.61
2022	0.00	71.75	1673.83	4886.50	7118.58	3964.59	3498.02	4790.44	4496.09

TABLE 3.6.14.c - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Predicted catch in numbers - Fleet C

	0	1	2	3	4	5	6	7	8
1991	2506.98	92137.45	251461.88	153787.49	60836.93	32844.11	9406.68	2820.01	1014.04
1992	1853.21	85430.03	233178.19	113722.96	73704.10	30397.83	17111.26	4863.33	1900.76
1993	1396.72	55045.07	191205.15	88978.44	46062.35	30183.43	12690.07	6831.89	2522.07
1994	2562.55	56536.26	160391.00	100154.66	46591.11	24829.90	16101.08	6315.23	4275.82
1995	2839.44	101001.28	152925.67	75465.69	51070.12	22629.70	12728.06	7465.61	4534.99
1996	2087.49	64855.95	156331.26	43465.75	22572.46	15624.41	7095.31	3723.18	3259.39
1997	1471.99	56377.77	119710.25	51993.70	14644.63	7389.28	5045.69	2104.07	1906.66
1998	2663.79	62871.44	167597.11	64216.72	28866.96	7987.66	4024.07	2397.45	1715.38
1999	3748.45	113592.24	178012.81	85841.09	34858.19	15722.29	4277.43	1990.84	1703.74
2000	2637.09	140470.72	301118.85	81854.64	42711.91	18281.03	8364.42	2156.01	1639.51

	0	1	2	3	4	5	6	7	8
2001	1893.34	68452.04	266302.41	97379.73	27564.69	14749.60	6302.96	2708.19	1047.48
2002	2228.51	72614.41	182473.72	125641.02	49481.21	13418.27	7293.89	2735.30	1451.47
2003	2013.87	60575.27	148689.27	63249.60	47687.35	19505.49	5274.97	2699.31	1375.51
2004	716.45	34212.11	79491.75	33718.37	15445.28	11931.54	5045.41	1281.10	882.43
2005	934.75	35853.13	132274.97	54415.50	24091.17	11206.17	8749.72	3434.12	1292.58
2006	981.35	42527.68	120857.47	77757.17	34096.39	14520.32	7056.38	4880.47	2326.94
2007	950.00	29294.99	98174.12	46298.22	32205.96	14845.97	6258.30	3042.48	2661.50
2008	798.80	32976.68	76024.52	42835.59	21224.76	14775.12	7134.90	2739.42	2270.99
2009	982.95	34490.44	107837.79	40311.51	23764.39	11887.97	8180.44	3726.69	2347.50
2010	1327.89	33213.89	86627.10	44293.97	18423.02	11001.44	5614.77	3470.31	2448.04
2011	662.48	24255.56	48220.98	20674.25	11635.17	5014.07	3150.68	1523.72	1472.17
2012	547.86	20566.23	64499.02	21721.57	10140.69	6013.64	2736.76	1662.33	1489.96
2013	663.97	15058.34	47364.45	26111.02	9141.85	4343.27	2639.75	1150.94	1231.25
2014	501.49	24827.29	44654.17	24285.71	14436.34	4936.34	2454.20	1387.23	1175.98
2015	428.86	17858.26	76985.58	23028.03	13506.54	8100.45	2996.91	1400.02	1385.25
2016	852.30	31530.52	102448.22	78470.36	24887.41	14677.72	8725.17	3096.21	2566.06
2017	997.65	32138.77	91390.10	47248.19	41568.81	13140.01	7679.66	4056.82	2271.75
2018	857.41	32293.04	80716.70	36573.32	19609.18	18816.75	5716.80	2908.08	1903.34
2019	358.22	11841.91	36746.51	14403.02	7035.29	3745.53	3502.11	949.53	579.02
2020	375.00	17281.37	48161.39	25517.83	10816.82	5863.75	3122.86	2760.91	971.07
2021	145.67	6679.92	27321.30	12768.14	7630.89	3527.39	2113.59	1084.73	1130.38
2022	8.38	238.35	1038.50	726.28	382.91	246.20	128.04	74.90	70.30

TABLE 3.6.14.d - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Predicted catch in numbers - Fleet D

	0	1	2	3	4	5	6	7	8
1991	64614.27	138230.52	33146.74	14044.34	3419.57	1531.43	621.49	156.61	56.32
1992	38917.82	96707.28	23711.50	8079.50	3285.05	1149.26	943.10	230.21	89.98
1993	46116.08	96091.81	28571.11	9061.41	2884.96	1576.58	957.75	437.74	161.60
1994	91722.45	109836.32	26478.56	10719.81	2998.16	1301.46	1203.73	394.97	267.42

	0	1	2	3	4	5	6	7	8
1995	170748.23	335552.45	41925.59	12479.72	4765.80	1638.35	1261.32	595.95	362.01
1996	98054.84	161838.43	31066.43	5305.47	1619.18	915.04	593.88	262.62	229.91
1997	88242.12	169831.65	27876.73	7153.41	1169.49	483.85	475.42	170.28	154.30
1998	133626.91	161863.26	34105.24	7225.63	1835.96	412.52	295.10	152.43	109.06
1999	91172.08	139799.25	18442.46	4884.53	1131.68	426.37	168.65	70.36	60.21
2000	36646.65	99788.79	18529.35	2734.55	832.33	306.50	209.89	50.07	38.07
2001	42704.64	86314.71	32465.60	7016.45	1473.74	854.97	655.21	292.21	113.02
2002	37237.19	76300.02	18286.28	6042.76	1517.71	356.18	249.01	74.41	39.49
2003	40504.94	89258.82	28115.72	7396.29	4154.86	1672.83	559.76	232.96	118.71
2004	28533.24	113772.05	39011.15	11777.29	4033.73	3022.09	1330.27	259.80	178.95
2005	11343.67	39707.64	22722.95	5955.82	1737.23	712.91	495.91	139.97	52.68
2006	9951.72	49756.34	28483.46	12942.81	3953.60	1891.91	821.91	459.16	218.92
2007	6022.01	23936.72	17240.36	5360.40	2384.29	1356.03	542.51	244.89	214.22
2008	4783.97	27806.12	14197.71	4444.71	1073.28	902.21	383.12	163.84	135.83
2009	7180.26	40067.15	24995.91	3795.91	745.91	399.02	199.96	112.44	70.83
2010	3053.55	12675.87	5631.79	717.71	54.28	25.82	6.93	5.37	3.79
2011	1478.85	9948.54	2845.20	214.47	11.67	3.82	1.43	1.09	1.05
2012	1037.97	8766.16	4611.25	232.67	8.01	3.58	0.97	1.02	0.91
2013	1618.78	10535.26	7400.99	695.63	17.32	5.96	1.80	1.30	1.39
2014	1021.37	13487.82	5000.08	387.31	13.94	4.74	1.11	1.06	0.90
2015	1712.08	21531.48	19610.09	762.06	32.33	26.22	3.54	2.39	2.36
2016	925.33	11064.29	8359.80	645.74	14.66	16.22	4.06	2.28	1.89
2017	161.13	1822.83	1342.70	65.56	4.63	3.01	1.18	1.27	0.71
2018	132.50	1771.50	1146.60	54.62	2.70	4.98	1.24	1.31	0.86
2019	93.62	1101.26	821.38	42.12	2.63	2.73	2.27	1.18	0.72
2020	215.37	4077.07	3102.11	259.89	20.82	21.29	9.50	11.88	4.18
2021	17.09	283.09	231.51	12.96	1.59	1.47	1.01	0.96	1.00
2022	21.16	207.39	155.35	11.90	1.20	1.35	0.87	1.00	0.94

TABLE 3.6.14.e - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Predicted catch in numbers - Fleet F

	0	1	2	3	4	5	6	7	8
1991	50492.32	399591.52	302927.28	342935.87	217150.06	149907.76	49686.05	16119.21	5796.26
1992	44024.32	433066.76	330157.64	297853.87	309527.84	164423.24	108763.64	33729.81	13182.79
1993	43227.39	359900.75	345691.98	297345.17	245675.15	206472.32	102149.31	59772.87	22065.86
1994	62484.86	293095.10	233083.95	267591.67	199606.95	135728.05	104023.98	44260.56	29967.27
1995	54521.61	416383.30	178101.15	160334.18	173154.05	97954.81	65227.58	41403.73	25150.69
1996	66967.26	440249.82	292141.18	147965.45	122310.47	108381.68	57911.68	32726.24	28649.57
1997	53716.98	438266.10	254455.13	201769.96	90948.79	59344.62	48493.63	22260.83	20172.21
1998	67940.44	346564.47	257612.34	178451.94	128457.93	46126.35	27817.04	18645.66	13341.01
1999	50232.12	340073.58	154087.78	135392.51	89049.56	52877.97	17464.00	9346.82	7998.94
2000	34130.29	408333.57	259118.71	128703.66	109590.68	61841.56	34406.50	10180.43	7741.59
2001	31161.91	253471.94	295599.64	201205.81	94350.47	66328.66	34594.17	16741.31	6475.27
2002	19749.54	149680.83	121857.60	163196.58	110036.59	40208.10	27234.71	11678.96	6197.38
2003	17414.36	123795.64	101202.86	86704.43	114494.63	63470.24	21531.12	12701.60	6472.45
2004	14281.81	160782.01	122281.48	105996.08	85321.43	87741.03	46395.51	13479.83	9285.04
2005	12894.17	118524.32	150442.77	127085.69	98058.16	59485.55	57617.93	25640.30	9650.82
2006	7183.52	76645.22	81447.95	110503.22	85117.60	46935.71	28299.46	22198.64	10583.98
2007	8800.41	67130.80	86779.56	87162.74	105126.33	61990.23	31559.79	16991.34	14863.66
2008	7283.14	75132.44	69782.77	84856.47	73089.77	65589.23	37906.74	15788.08	13088.37
2009	5316.05	47633.44	64168.75	52784.51	55242.65	36228.63	30349.40	14885.60	9376.67
2010	4613.32	30014.40	34839.67	40672.80	31091.97	24687.27	15660.13	10609.70	7484.33
2011	2908.58	27777.91	24138.48	24788.68	26709.92	15543.57	12322.80	6647.30	6422.42
2012	3719.27	36718.91	49964.84	40200.79	35324.71	27774.93	15543.81	10415.30	9335.29
2013	5931.17	35588.93	48768.20	64276.29	42157.43	26434.62	19673.07	9456.09	10115.96
2014	2905.38	38444.70	31555.56	42002.87	46993.79	21707.33	13257.97	8445.85	7159.69
2015	2868.37	32099.53	65102.53	48307.66	52864.72	43236.84	19547.15	10473.48	10363.02
2016	2466.19	25095.77	42214.68	81264.54	47703.73	39557.27	29096.37	12226.39	10132.92
2017	2328.81	20980.32	32589.10	43444.62	70555.15	32636.94	24103.67	15431.97	8641.62
2018	2033.32	21579.37	29702.30	35281.79	34654.38	49617.08	19057.11	11942.16	7816.14

	0	1	2	3	4	5	6	7	8
2019	897.96	8293.07	14088.66	15531.51	14529.01	12135.66	15073.51	5344.23	3258.90
2020	181.13	2338.67	3768.24	5838.37	4866.60	4308.73	3135.84	3788.25	1332.40
2021	53.08	673.30	1584.60	2232.97	2638.06	1962.41	1622.93	1141.85	1189.89
2022	19.48	150.98	372.75	805.89	850.93	884.03	638.88	512.65	481.15

TABLE 3.9.1 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Input table for short term predictions

2022						
wr	N	M	Mat	PM	PF	SWt
0	537470	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0178
2		0.2	0.20	0.25	0.1	0.0749
3		0.2	0.75	0.25	0.1	0.0865
4		0.2	0.90	0.25	0.1	0.1127
5		0.2	1.00	0.25	0.1	0.1304
6		0.2	1.00	0.25	0.1	0.1650
7		0.2	1.00	0.25	0.1	0.1810
8+		0.2	1.00	0.25	0.1	0.1872

2023						
wr	N	M	Mat	PM	PF	SWt
0	725195	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0198
2		0.2	0.20	0.25	0.1	0.0567
3		0.2	0.75	0.25	0.1	0.0798
4		0.2	0.90	0.25	0.1	0.1123
5		0.2	1.00	0.25	0.1	0.1395
6		0.2	1.00	0.25	0.1	0.1663
7		0.2	1.00	0.25	0.1	0.1757
8+		0.2	1.00	0.25	0.1	0.1845

2024						
wr	N	M	Mat	PM	PF	SWt
0	725195	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0198
2		0.2	0.20	0.25	0.1	0.0567

3	0.2	0.75	0.25	0.1	0.0798
4	0.2	0.90	0.25	0.1	0.1123
5	0.2	1.00	0.25	0.1	0.1395
6	0.2	1.00	0.25	0.1	0.1663
7	0.2	1.00	0.25	0.1	0.1757
8+	0.2	1.00	0.25	0.1	0.1845

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_{2022} wr 0-8+: Populations numbers from the assessment
$N_{2023/2024}$ wr 0: Average of wr 0 for the years 2017-2021
Natural Mortality (M): Constant
Weight in the Stock 2023-2024 (SWt): Average for 2018-2022

TABLE 3.9.2 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. MSY approach (zero catch, F=0)

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.000	0.000	0.000
fbar:low	0.050	0.044	0.000	0.000	0.000
fbar:high	0.050	0.044	0.000	0.000	0.000
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92726	103649	115511
ssb:low	75548	85431	92726	103649	115511
ssb:high	75548	85431	92726	103649	115511
catch:Estimate	5898	6663	0	0	0
catch:low	5898	6663	0	0	0
catch:high	5898	6663	0	0	0

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	0	0	0
Fleet C	301	439	0	0	0
Fleet D	25	154	0	0	0
Fleet F	630	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

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.177	0.186	0.166
fbar:low	0.050	0.044	0.177	0.186	0.166
fbar:high	0.050	0.044	0.177	0.186	0.166
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	90148	80228	74422
ssb:low	75548	85431	90148	80228	74422
ssb:high	75548	85431	90148	80228	74422
catch:Estimate	5898	6663	27346	26182	22426
catch:low	5898	6663	27346	26182	22426
catch:high	5898	6663	27346	26182	22426

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	21630	20463	17555
Fleet C	301	439	1707	1749	1559
Fleet D	25	154	764	896	803
Fleet F	630	788	3245	3073	2510

TABLE 3.9.4 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. MAP 2018: F=FMSYlower(0.216)*SSBy-1/MSYBtrigger

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.123	0.131	0.124
fbar:low	0.050	0.044	0.123	0.131	0.124
fbar:high	0.050	0.044	0.123	0.131	0.124
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	90919	86404	83816
ssb:low	75548	85431	90919	86404	83816
ssb:high	75548	85431	90919	86404	83816
catch:Estimate	5898	6663	19958	20839	19932
catch:low	5898	6663	19958	20839	19932
catch:high	5898	6663	19958	20839	19932

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	15835	16448	15821
Fleet C	301	439	1223	1317	1276
Fleet D	25	154	536	638	610
Fleet F	630	788	2363	2435	2225

TABLE 3.9.6 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=Fpa=0.41

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.410	0.410	0.410
fbar:low	0.050	0.044	0.410	0.410	0.410
fbar:high	0.050	0.044	0.410	0.410	0.410
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	86889	59887	48447
ssb:low	75548	85431	86889	59887	48447
ssb:high	75548	85431	86889	59887	48447
catch:Estimate	5898	6663	52915	36646	30142
catch:low	5898	6663	52915	36646	30142
catch:high	5898	6663	52915	36646	30142

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	41324	27452	22121
Fleet C	301	439	3541	2994	2810
Fleet D	25	154	1720	1870	1872
Fleet F	630	788	6330	4331	3338

TABLE 3.9.7 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=Flim=0.45

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.450	0.450	0.450
fbar:low	0.050	0.044	0.450	0.450	0.450
fbar:high	0.050	0.044	0.450	0.450	0.450
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	86347	57171	45396
ssb:low	75548	85431	86347	57171	45396
ssb:high	75548	85431	86347	57171	45396
catch:Estimate	5898	6663	56452	37572	30407
catch:low	5898	6663	56452	37572	30407
catch:high	5898	6663	56452	37572	30407

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	43996	27940	22072
Fleet C	301	439	3818	3161	2949
Fleet D	25	154	1878	2033	2036
Fleet F	630	788	6760	4437	3351

TABLE 3.9.8 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=F2023=0.044

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.044	0.044	0.044
fbar:low	0.050	0.044	0.044	0.044	0.044
fbar:high	0.050	0.044	0.044	0.044	0.044
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92074	96985	102699
ssb:low	75548	85431	92074	96985	102699
ssb:high	75548	85431	92074	96985	102699
catch:Estimate	5898	6663	7669	8582	9589
catch:low	5898	6663	7669	8582	9589
catch:high	5898	6663	7669	8582	9589

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	6114	6873	7776
Fleet C	301	439	457	496	531
Fleet D	25	154	194	219	221
Fleet F	630	788	905	994	1062

TABLE 3.9.9 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. Catch for bycatch fleets only

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.028	0.024	0.021
fbar:low	0.050	0.044	0.028	0.024	0.021
fbar:high	0.050	0.044	0.028	0.024	0.021
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92275	99119	107337
ssb:low	75548	85431	92275	99119	107337
ssb:high	75548	85431	92275	99119	107337
catch:Estimate	5898	6663	5436	5436	5436
catch:low	5898	6663	5436	5436	5436
catch:high	5898	6663	5436	5436	5436

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	5282	5282	5282
Fleet C	301	439	0	0	0
Fleet D	25	154	154	154	154
Fleet F	630	788	0	0	0

TABLE 3.9.10 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.000	0.000	0.000
fbar:low	0.050	0.044	0.000	0.000	0.000
fbar:high	0.050	0.044	0.000	0.000	0.000
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92726	103649	115511
ssb:low	75548	85431	92726	103649	115511
ssb:high	75548	85431	92726	103649	115511
catch:Estimate	5898	6663	0	0	0
catch:low	5898	6663	0	0	0
catch:high	5898	6663	0	0	0

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	0	0	0
Fleet C	301	439	0	0	0
Fleet D	25	154	0	0	0
Fleet F	630	788	0	0	0

TABLE 3.9.11 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0.01

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.010	0.010	0.010
fbar:low	0.050	0.044	0.010	0.010	0.010
fbar:high	0.050	0.044	0.010	0.010	0.010
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92577	102077	112390
ssb:low	75548	85431	92577	102077	112390
ssb:high	75548	85431	92577	102077	112390
catch:Estimate	5898	6663	1800	2134	2506
catch:low	5898	6663	1800	2134	2506
catch:high	5898	6663	1800	2134	2506

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	1438	1719	2049
Fleet C	301	439	106	119	130
Fleet D	25	154	44	50	51
Fleet F	630	788	212	246	276

TABLE 3.9.12 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0.025

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.025	0.025	0.025
fbar:low	0.050	0.044	0.025	0.025	0.025
fbar:high	0.050	0.044	0.025	0.025	0.025
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92355	99783	107946
ssb:low	75548	85431	92355	99783	107946
ssb:high	75548	85431	92355	99783	107946
catch:Estimate	5898	6663	4436	5125	5884
catch:low	5898	6663	4436	5125	5884
catch:high	5898	6663	4436	5125	5884

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	3541	4118	4794
Fleet C	301	439	262	290	314
Fleet D	25	154	110	125	126
Fleet F	630	788	523	592	650

TABLE 3.9.13 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0.05

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.050	0.050	0.050
fbar:low	0.050	0.044	0.050	0.050	0.050
fbar:high	0.050	0.044	0.050	0.050	0.050
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	91986	96126	101124
ssb:low	75548	85431	91986	96126	101124
ssb:high	75548	85431	91986	96126	101124
catch:Estimate	5898	6663	8667	9603	10641
catch:low	5898	6663	8667	9603	10641
catch:high	5898	6663	8667	9603	10641

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	6907	7682	8616
Fleet C	301	439	517	559	596
Fleet D	25	154	220	249	250
Fleet F	630	788	1023	1113	1179

TABLE 3.9.14 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0.1

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.100	0.100	0.100
fbar:low	0.050	0.044	0.100	0.100	0.100
fbar:high	0.050	0.044	0.100	0.100	0.100
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	91254	89386	89360
ssb:low	75548	85431	91254	89386	89360
ssb:high	75548	85431	91254	89386	89360
catch:Estimate	5898	6663	16559	16944	17612
catch:low	5898	6663	16559	16944	17612
catch:high	5898	6663	16559	16944	17612

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	13157	13436	14079
Fleet C	301	439	1007	1042	1078
Fleet D	25	154	437	491	494
Fleet F	630	788	1958	1975	1962

TABLE 3.9.15 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. F=0.15

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.150	0.150	0.150
fbar:low	0.050	0.044	0.150	0.150	0.150
fbar:high	0.050	0.044	0.150	0.150	0.150
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	90529	83326	79630
ssb:low	75548	85431	90529	83326	79630
ssb:high	75548	85431	90529	83326	79630
catch:Estimate	5898	6663	23768	22576	22207
catch:low	5898	6663	23768	22576	22207
catch:high	5898	6663	23768	22576	22207

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	18829	17741	17516
Fleet C	301	439	1470	1463	1477
Fleet D	25	154	651	727	731
Fleet F	630	788	2818	2644	2483

TABLE 3.9.17 - WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet
Forecast table. Constant 2023 TAC

	2022	2023	2024	2025	2026
fbar:Estimate	0.050	0.044	0.038	0.034	0.030
fbar:low	0.050	0.044	0.038	0.034	0.030
fbar:high	0.050	0.044	0.038	0.034	0.030
rec:Estimate	537470	725195	725195	725195	725195
rec:low	537470	725195	725195	725195	725195
rec:high	537470	725195	725195	725195	725195
ssb:Estimate	75548	85431	92162	97926	105128
ssb:low	75548	85431	92162	97926	105128
ssb:high	75548	85431	92162	97926	105128
catch:Estimate	5898	6663	6663	6663	6663
catch:low	5898	6663	6663	6663	6663
catch:high	5898	6663	6663	6663	6663

Per fleet	2022	2023	2024	2025	2026
Fleet A	4942	5282	5282	5282	5282
Fleet C	301	439	439	439	439
Fleet D	25	154	154	154	154
Fleet F	630	788	788	788	788

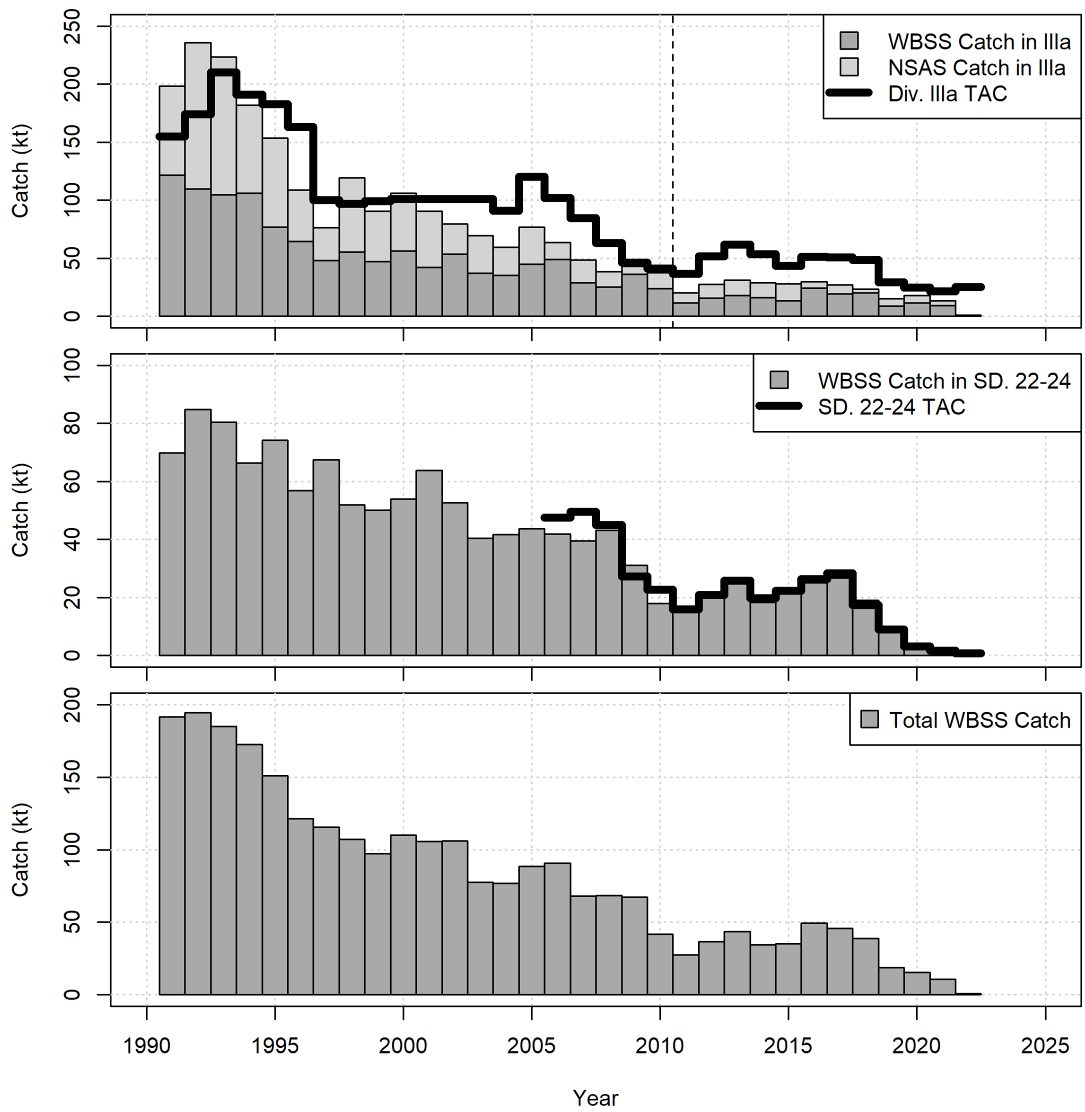


Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for IIIa excludes the by-catch TAC, while the CATCH includes the by-catch

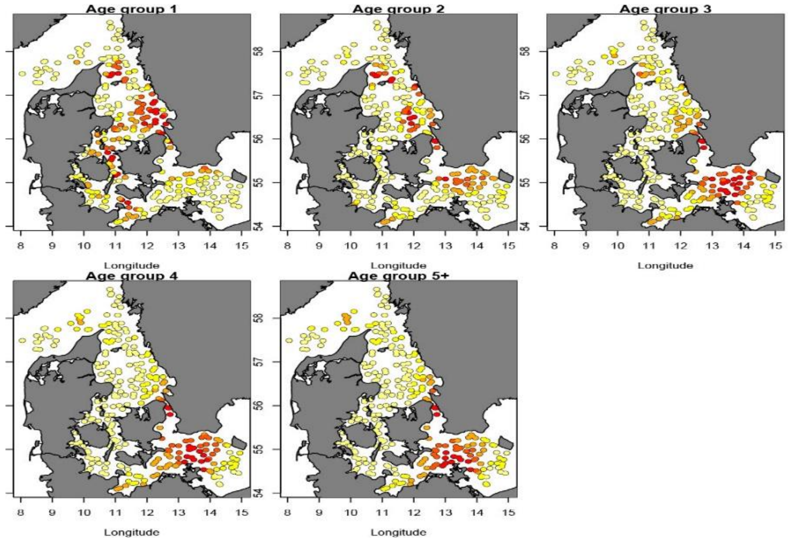


Figure 3.3.1 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q1 survey.

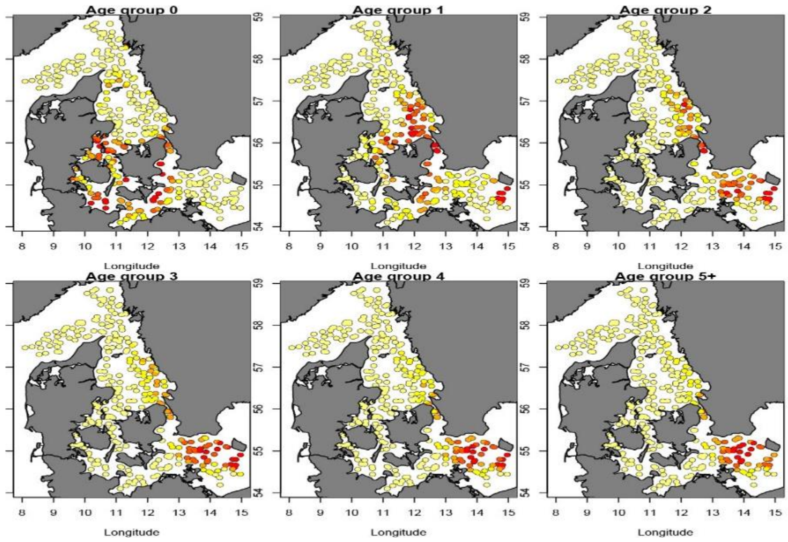


Figure 3.3.2 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q3.4 survey.

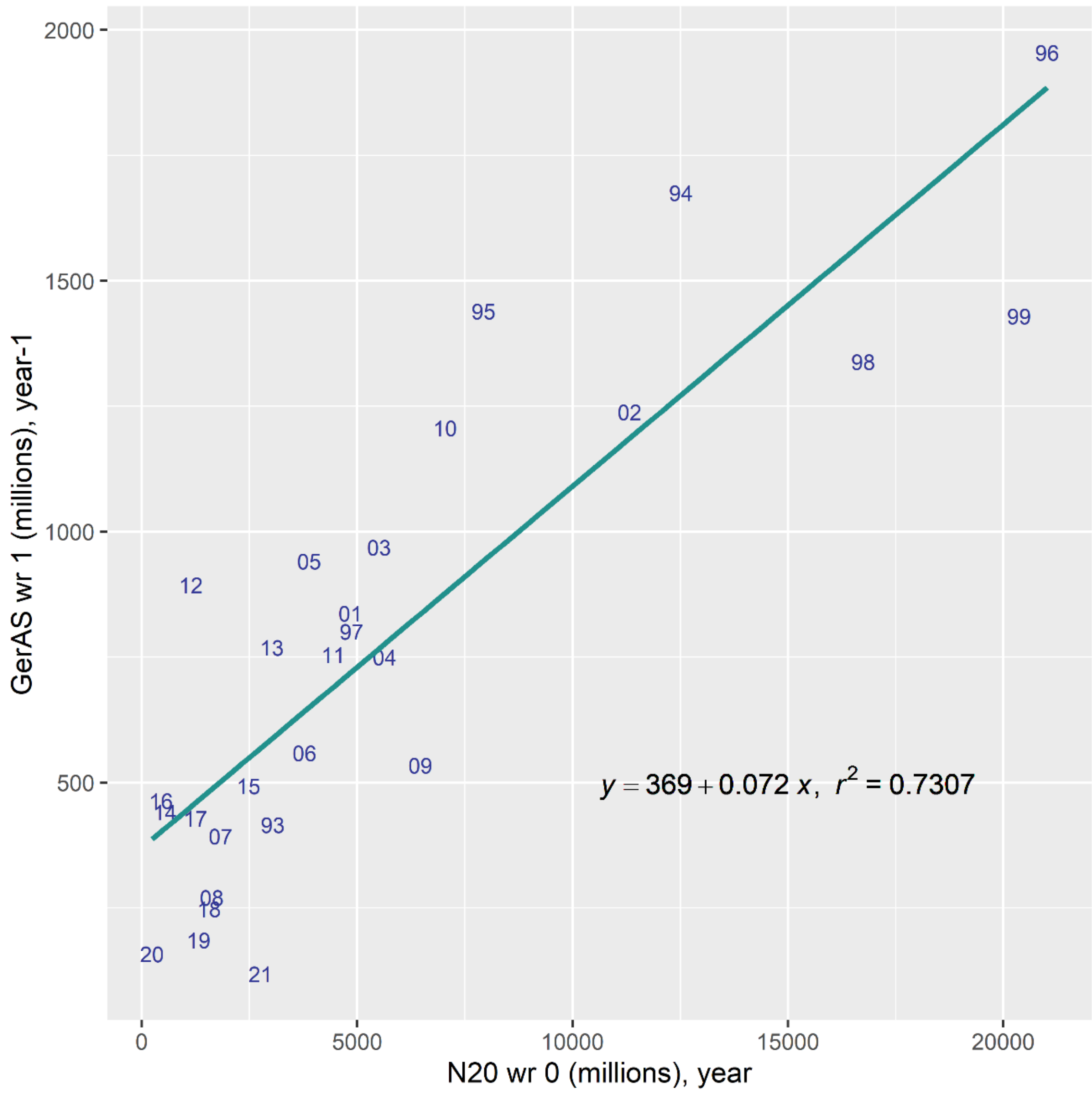


Figure 3.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N20.

Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WECA).

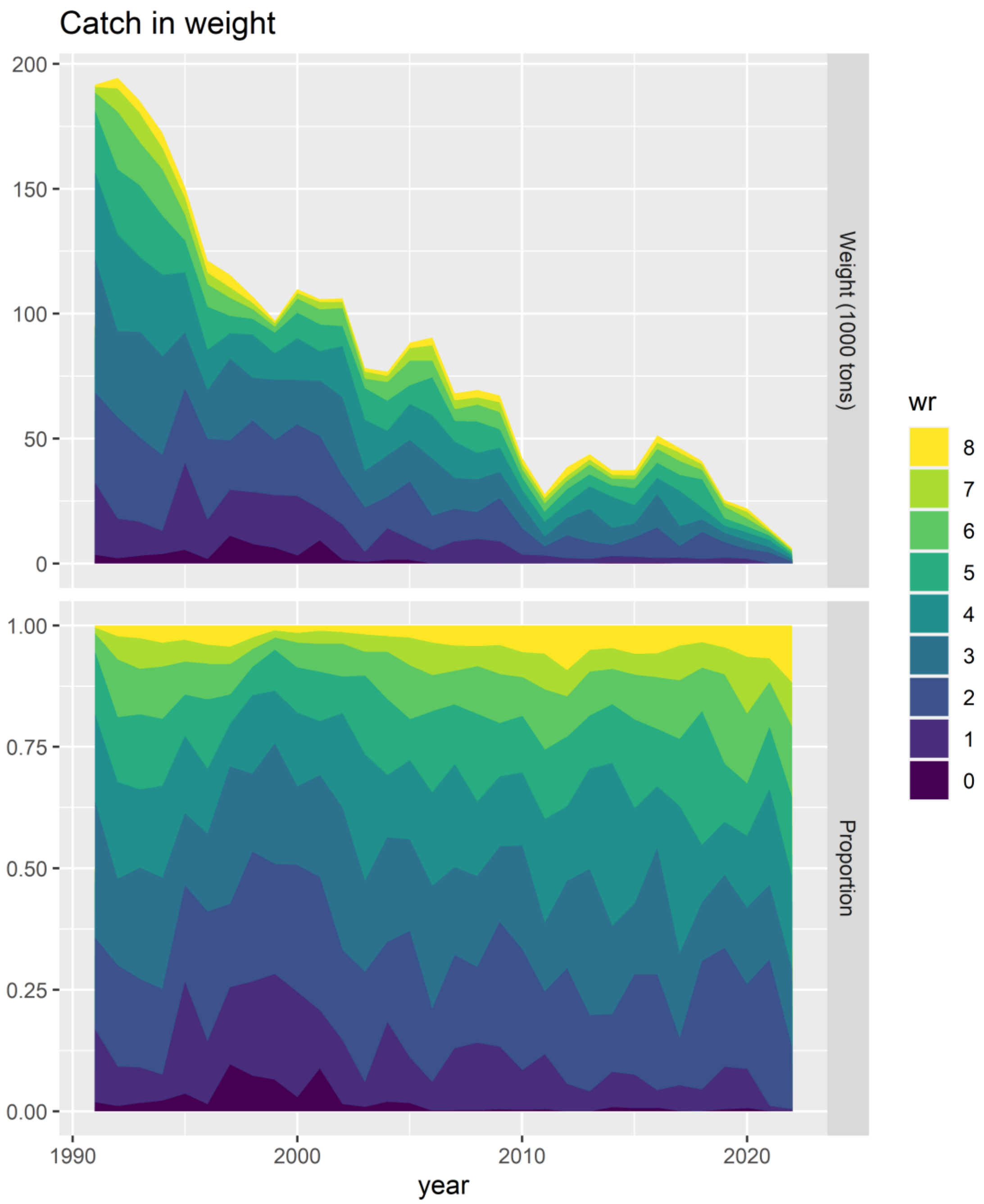


Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in weight. Upper panel: Catch in weight (1000 tons) at age as W-ringers (wr). Lower panel: Proportion (by weight) of a given age as W-ringers (wr) in the catch.

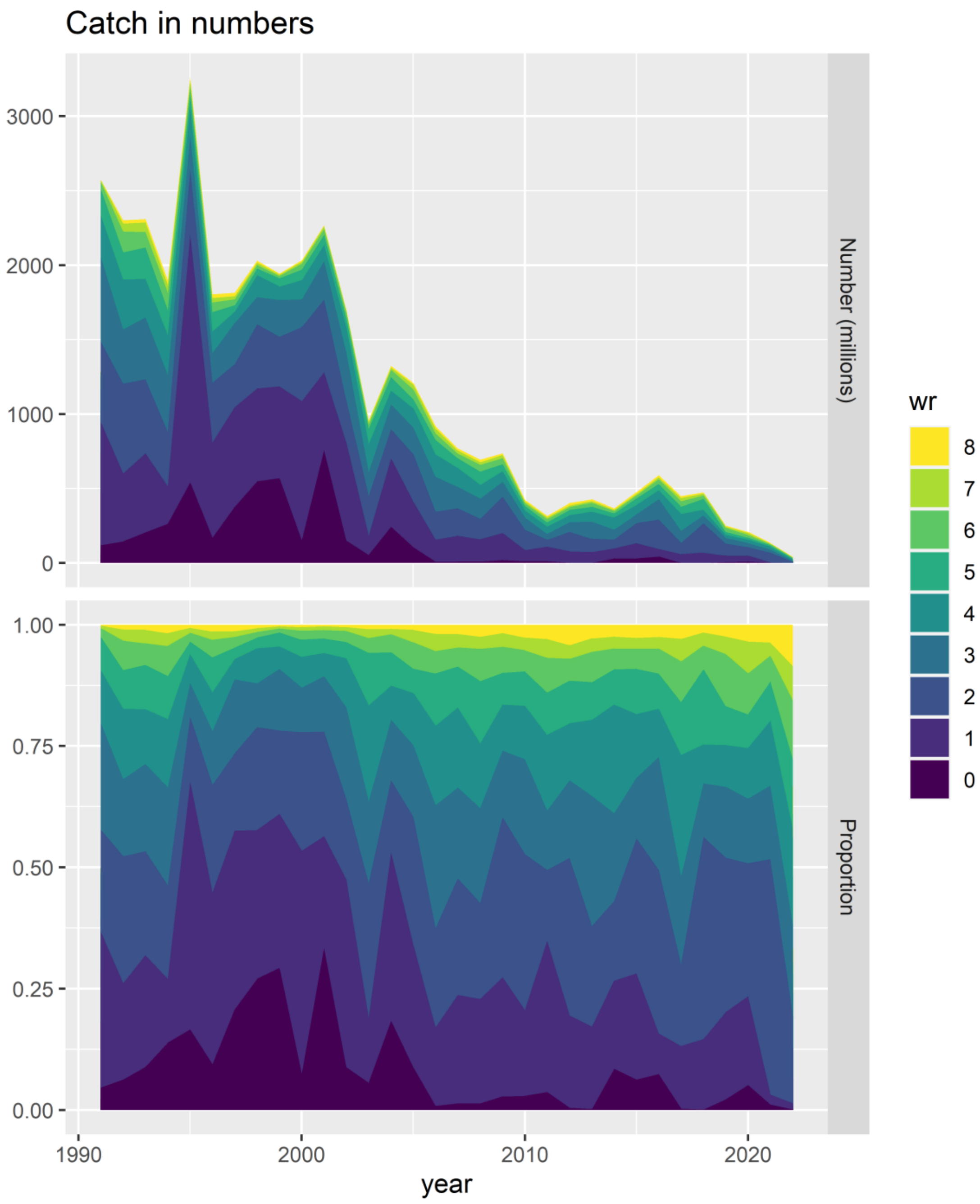


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in Numbers. Upper panel: Catch in numbers (millions) at age as W-ringers (wr). Lower panel: Proportion (by number) of a given age as W-ringers (wr) in the catch.

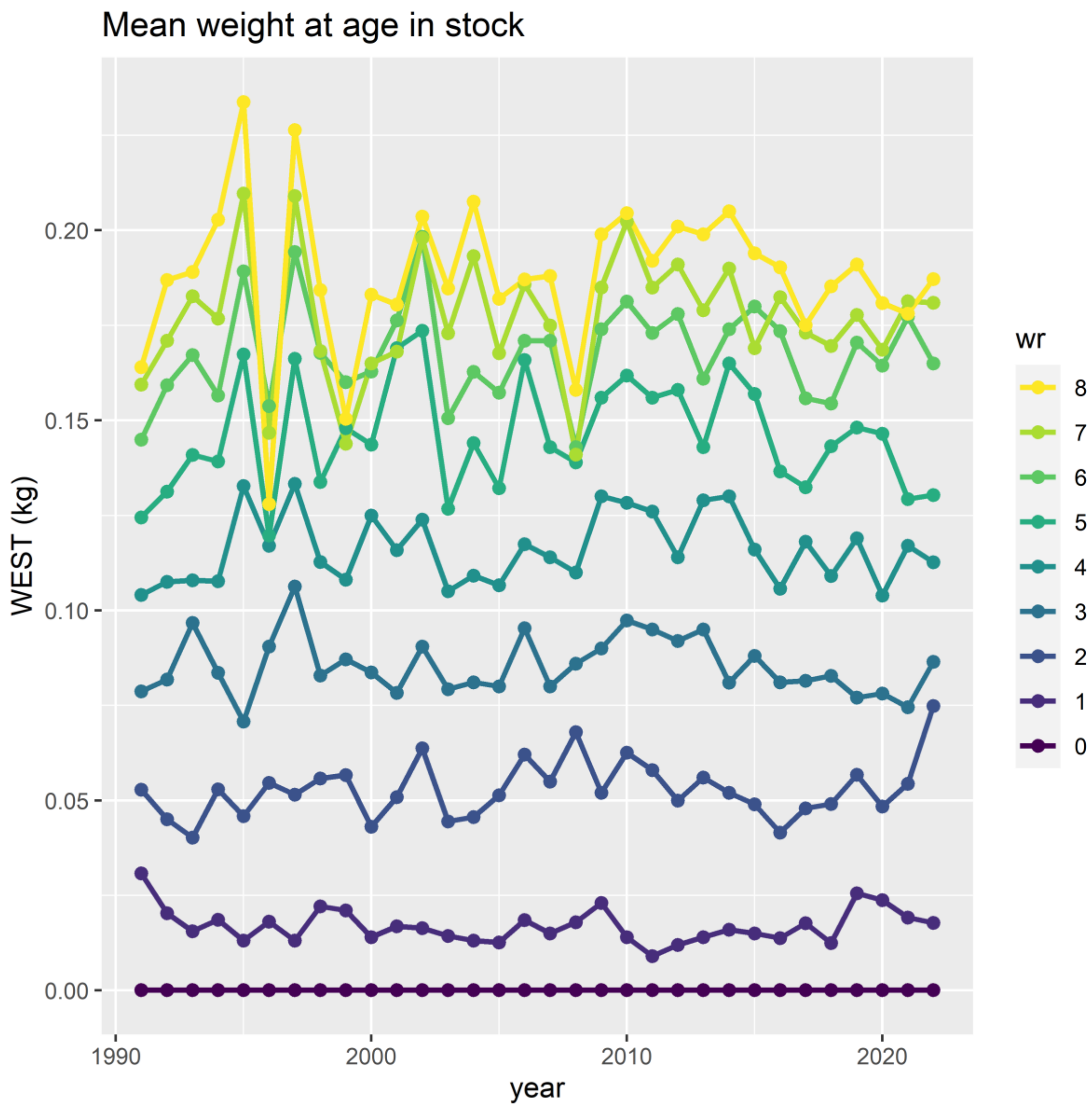


Figure 3.6.1.4 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the stock (WEST), coming from the catch Q1 WECA.

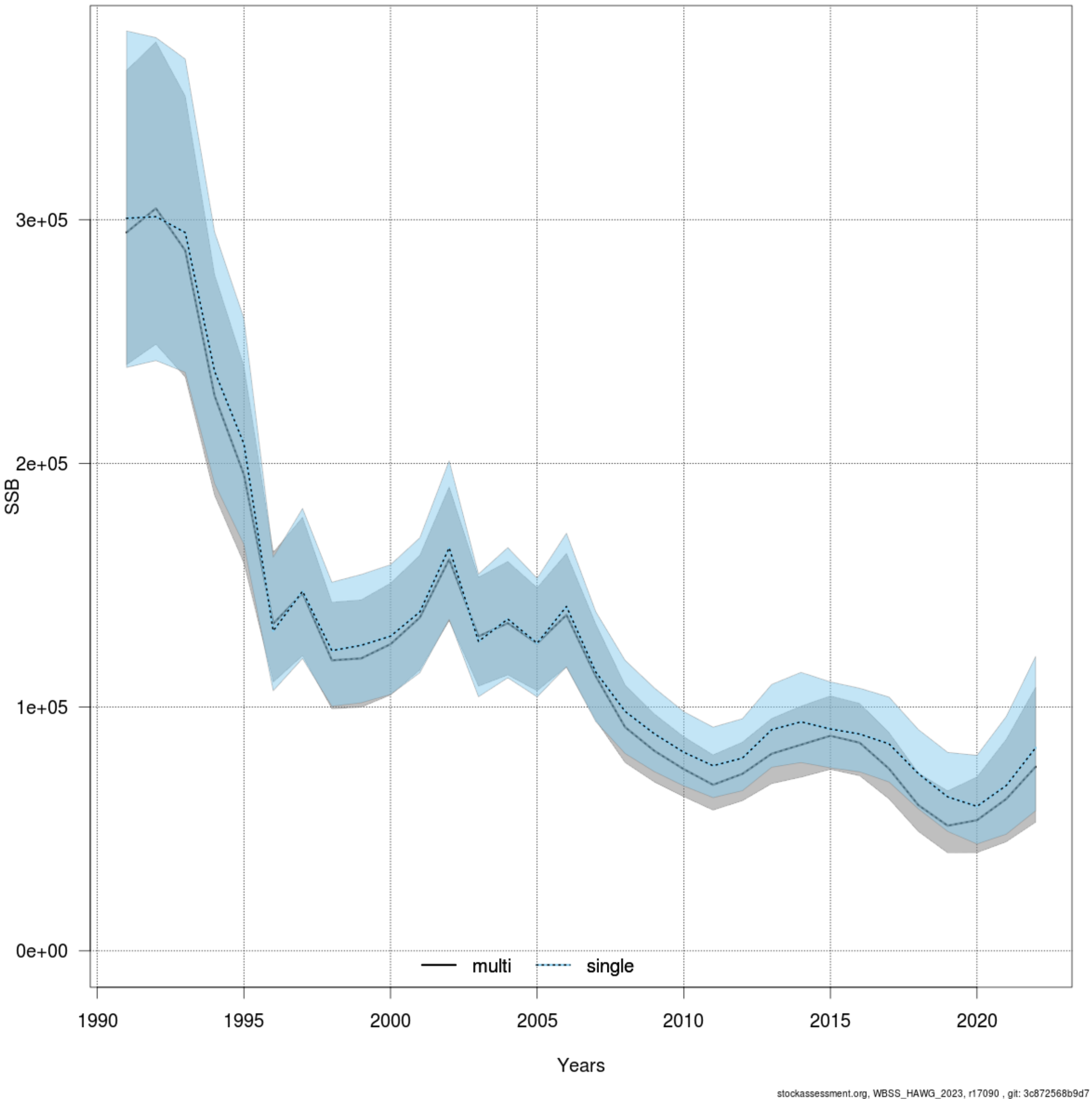


Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Spawning stock biomass (SSB). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

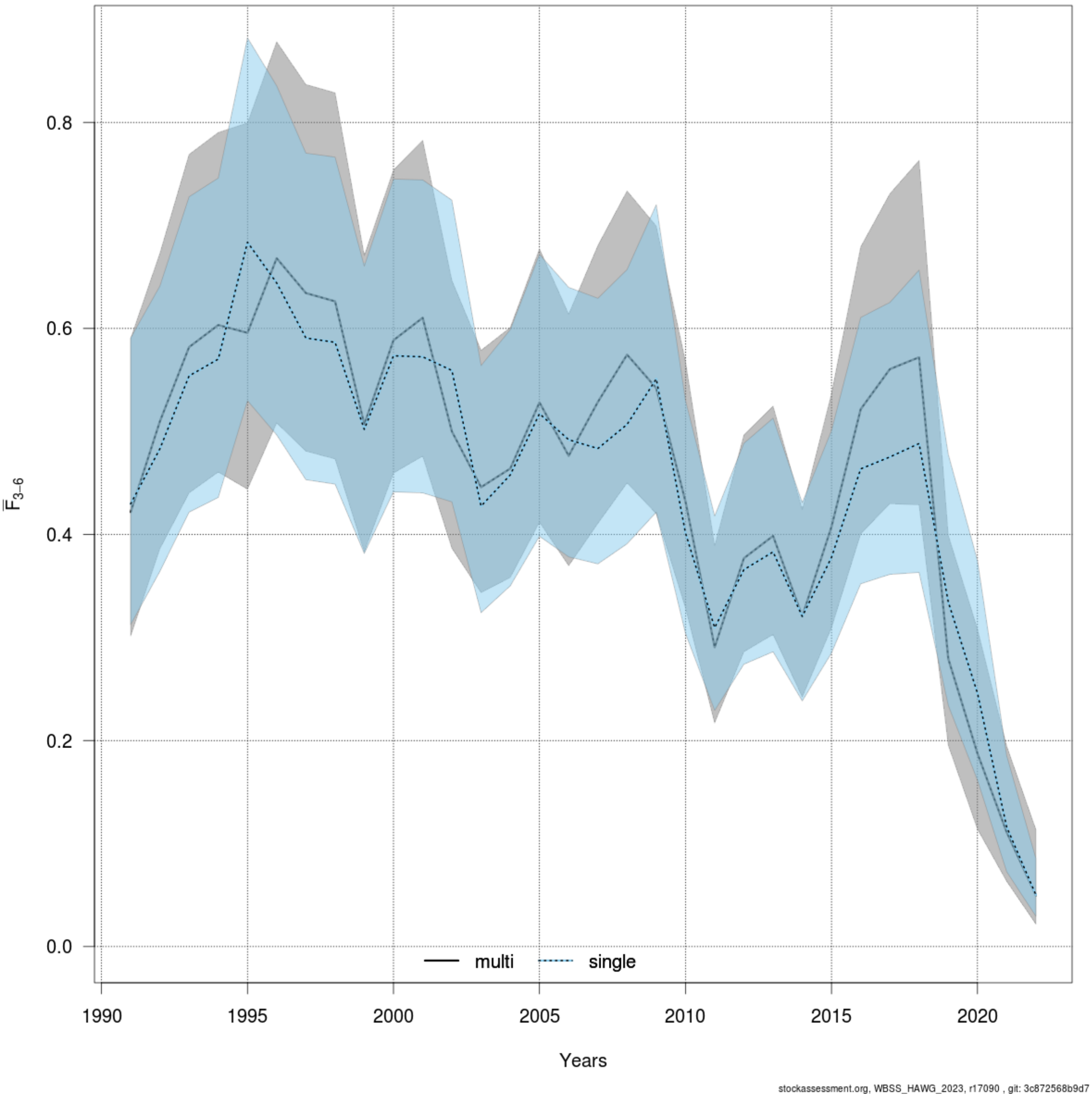


Figure 3.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Average fishing mortality (F) for the shown age range. Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

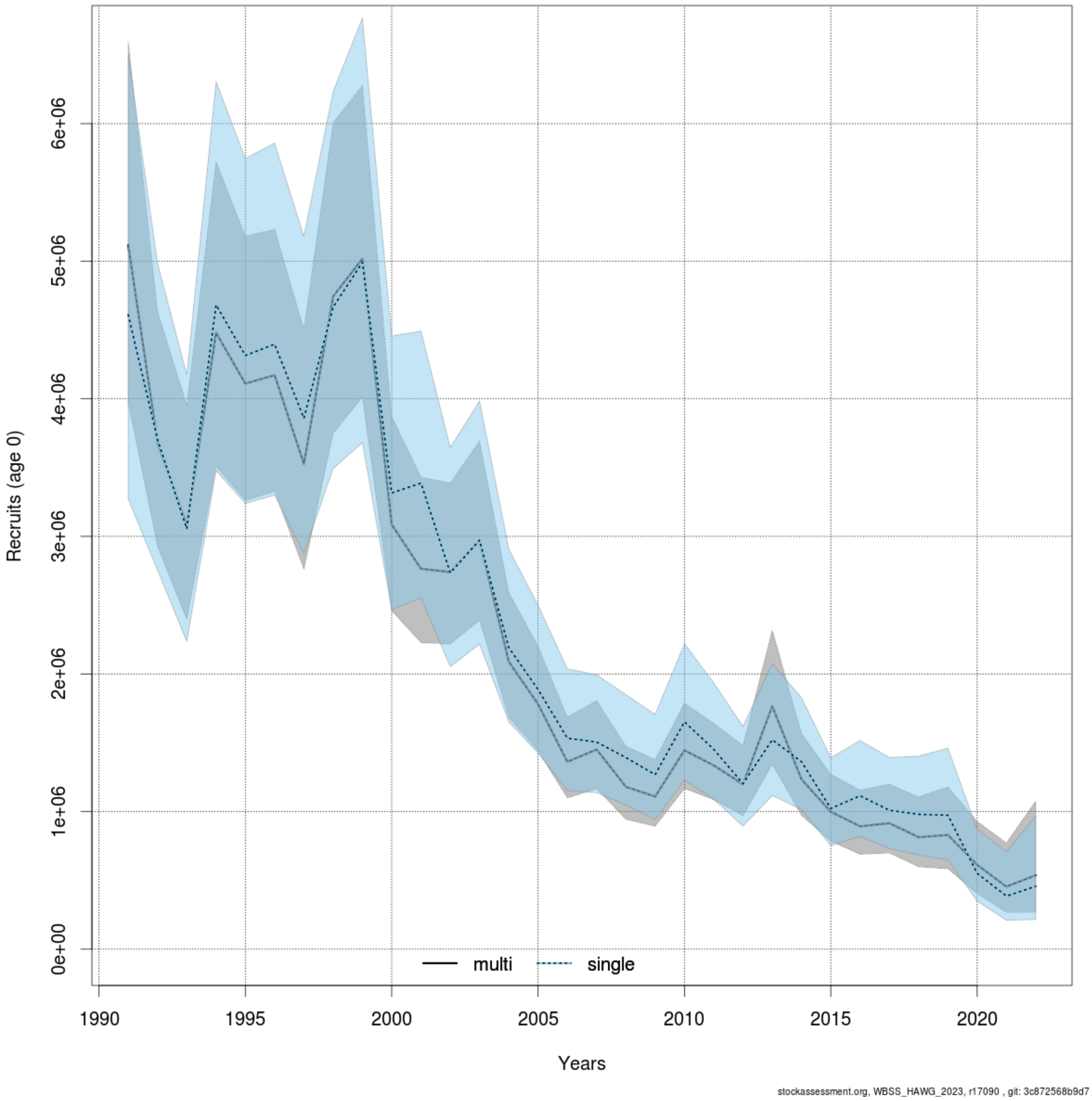


Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

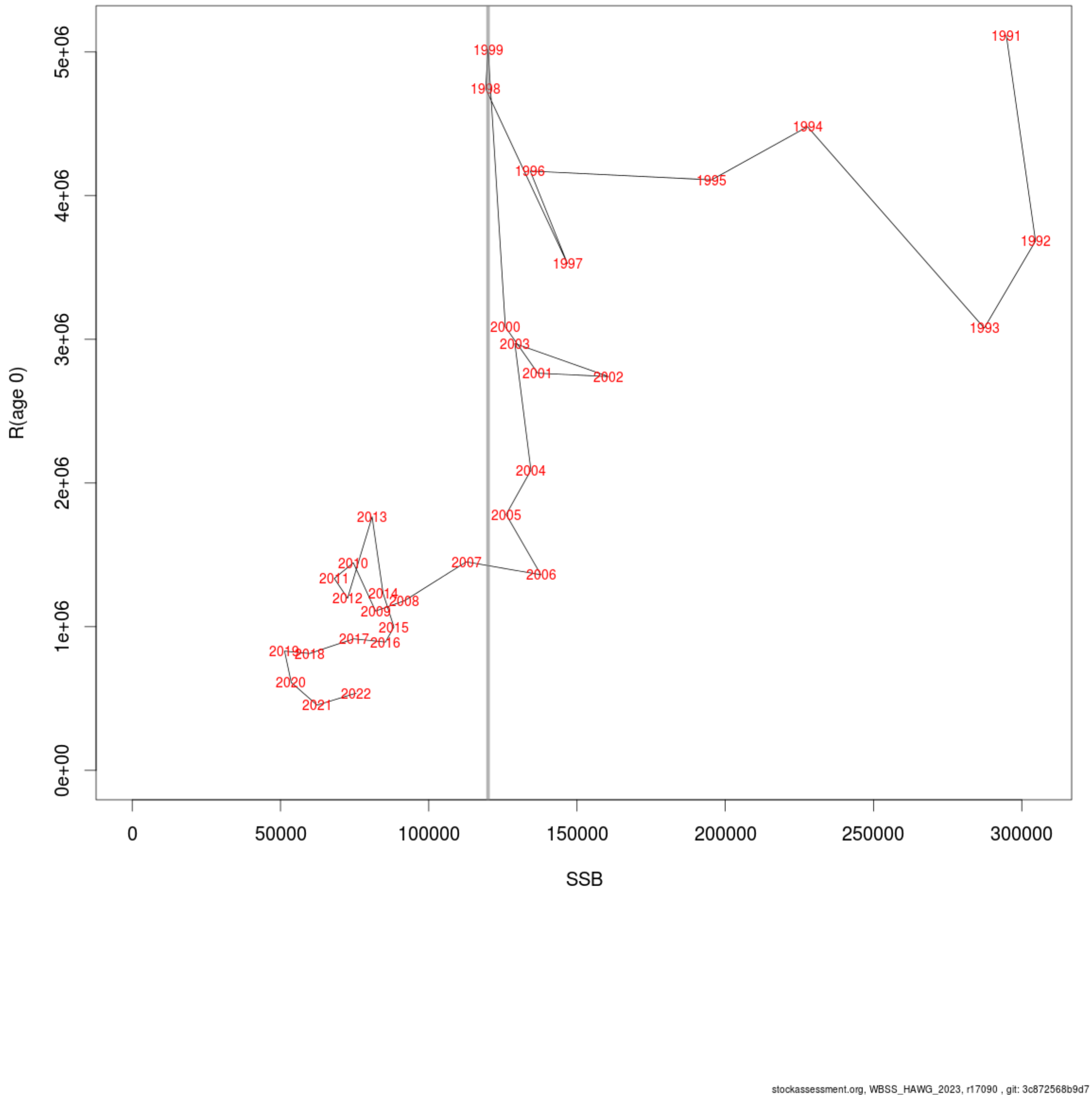


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

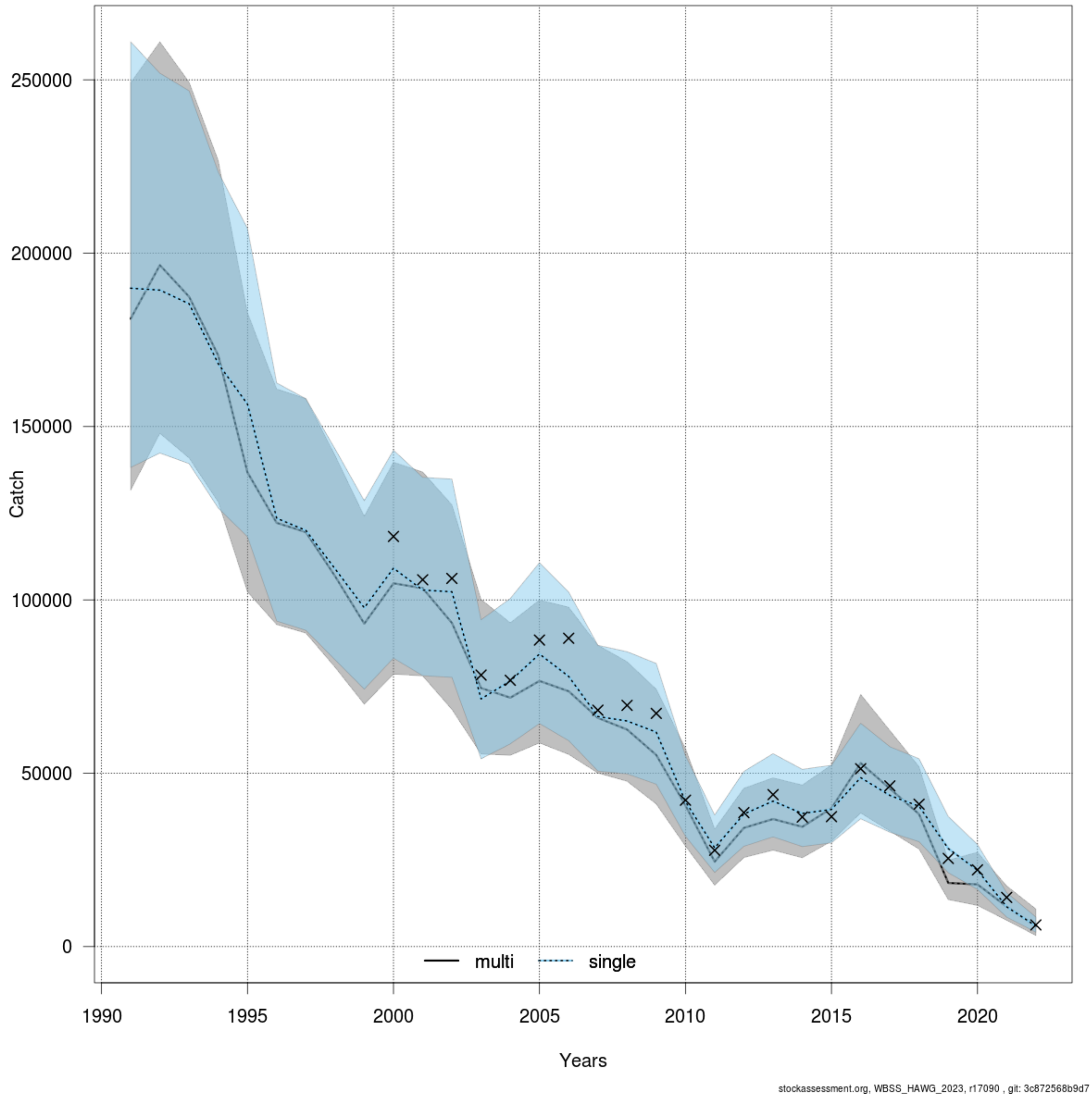


Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tons). Prediction from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area. The yearly observed total catch weight (crosses) are calculated sum of catch per fleet.

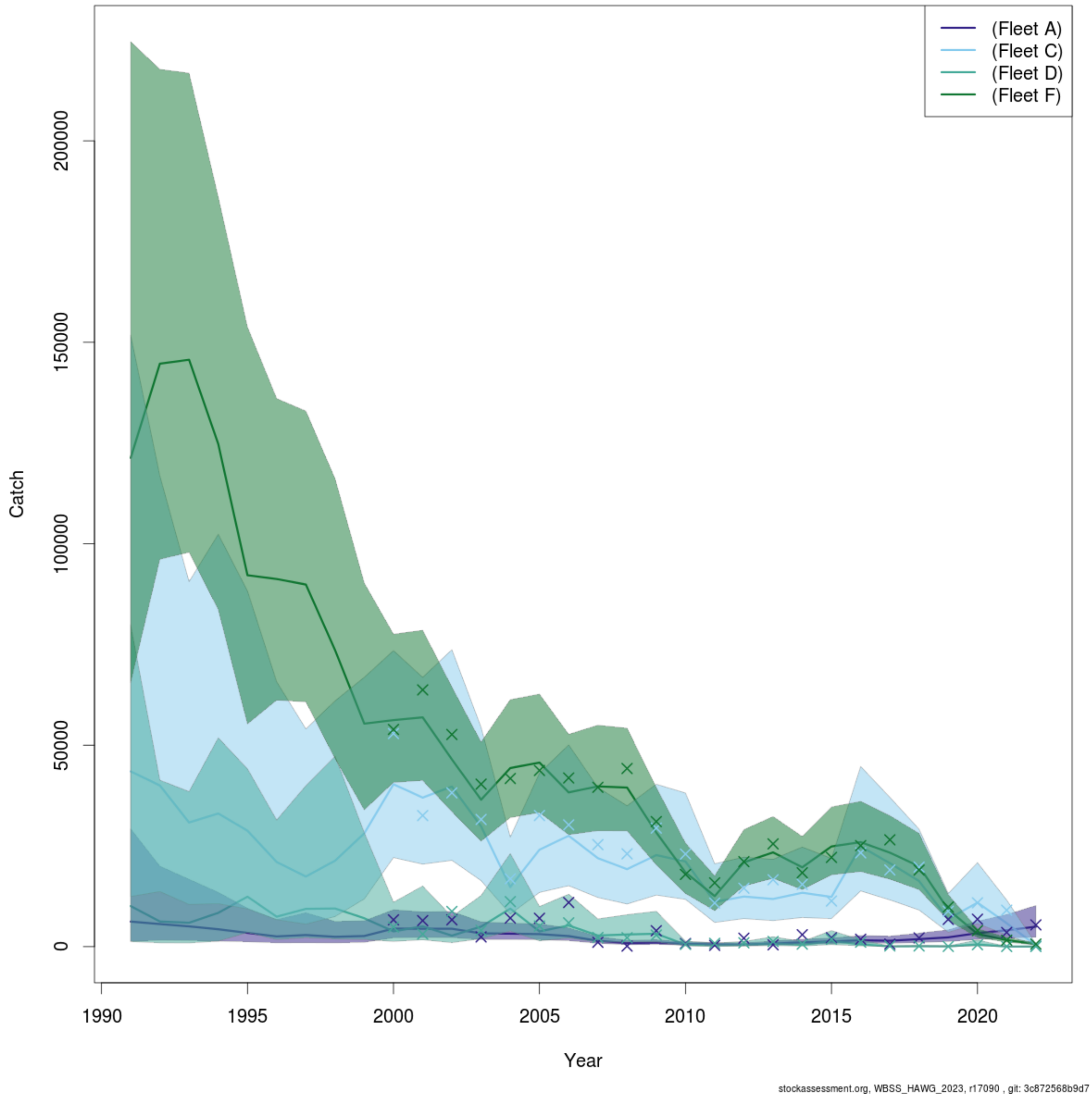


Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tons) by fleet. Prediction from the WBSS multi fleet assessment run and point wise 95% confidence intervals are shown by line and shaded area. The plot also shows the observed total catch weight per fleet (crosses)

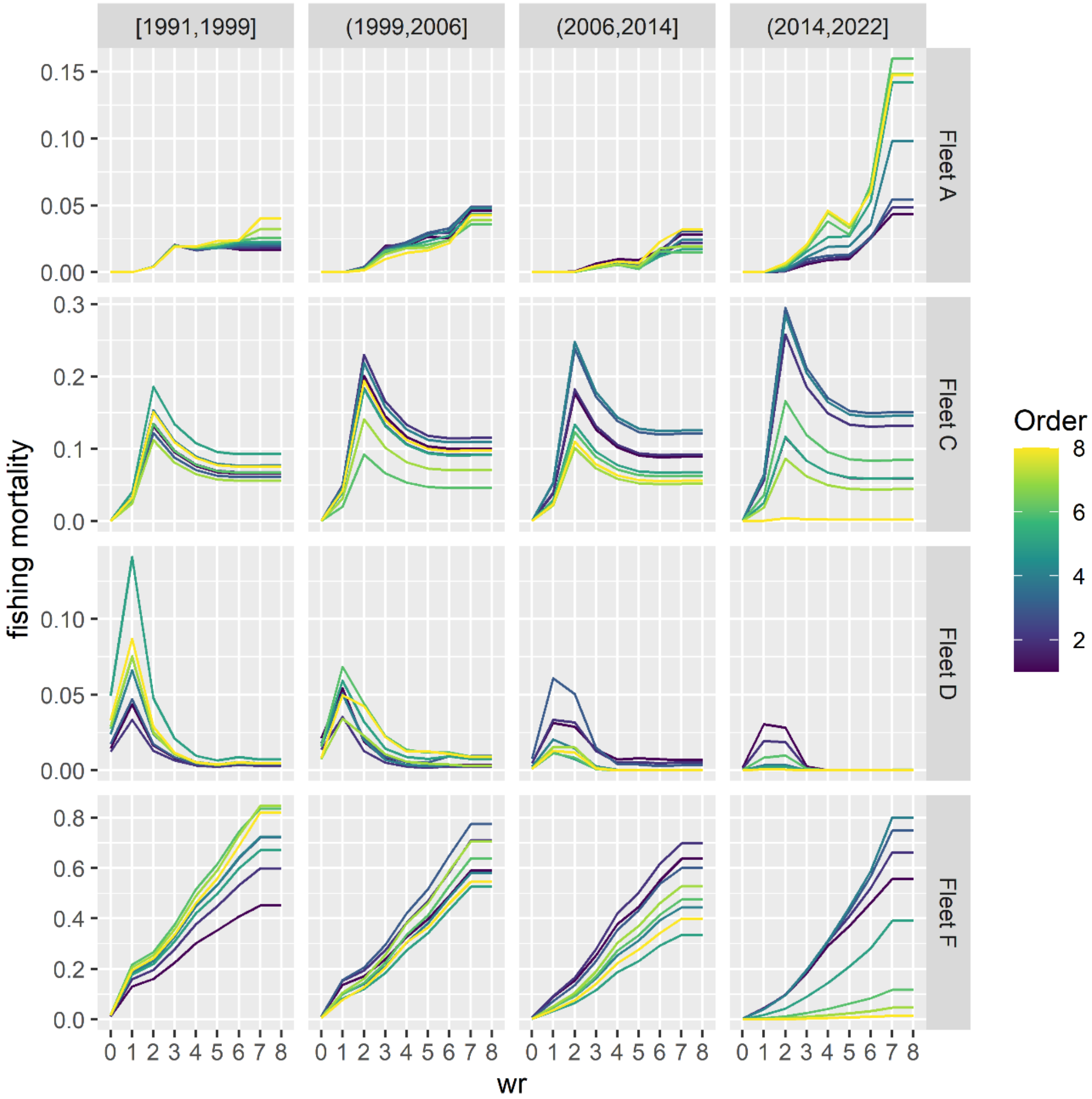


Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated partial fishing mortalities at age as W-ringers (wr) per fleet and year. Order: 1 equal 1st year in the respective time span.

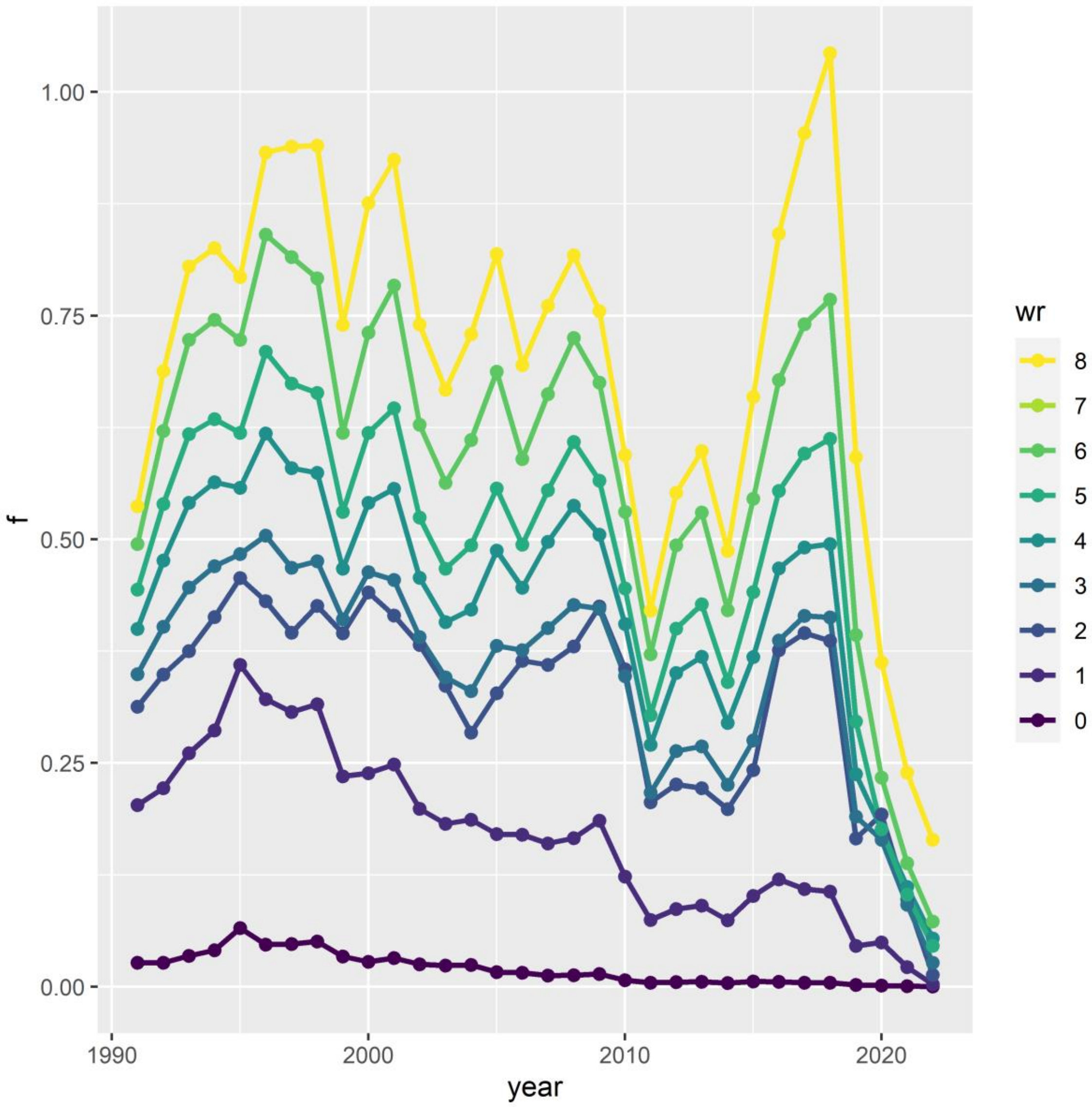


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr)

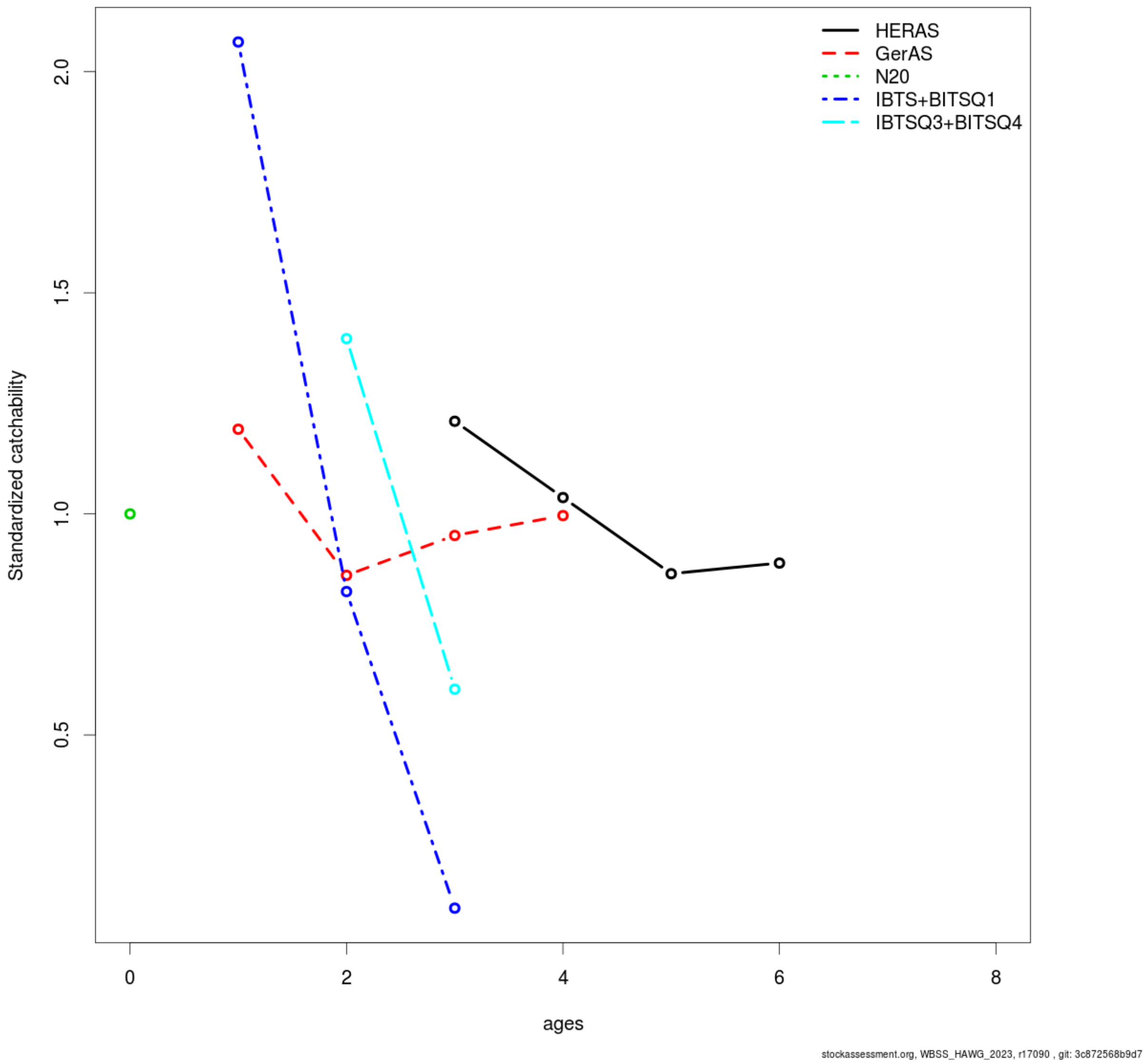


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Estimated survey catchabilities. N20 only covers age 0 and therefore no line

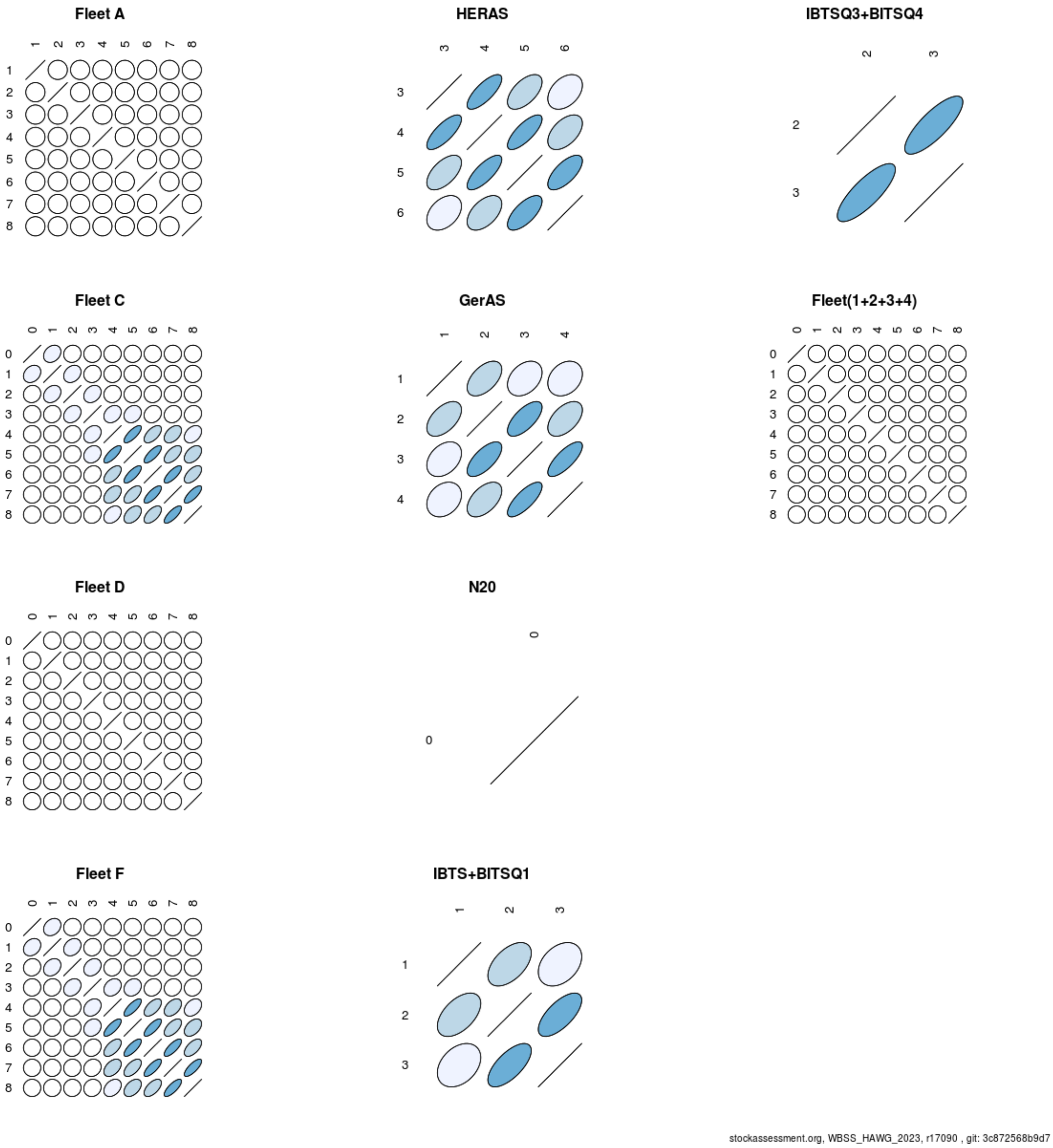


Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. Estimates correlations between age groups for each fleet.

Figure 3.6.4.11 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated age distribution in the stock. Colours represent a cohort

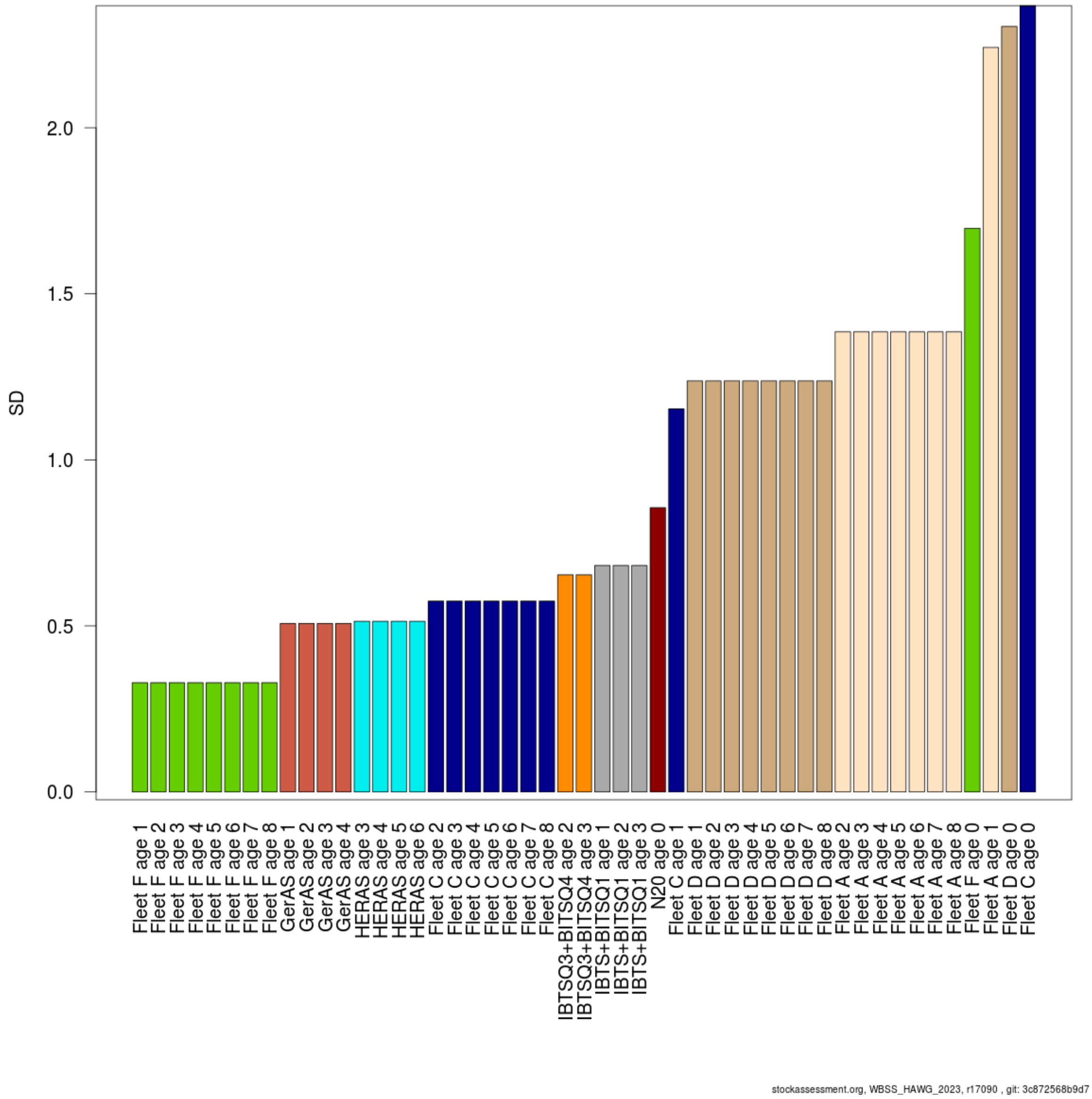


Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated observation variance in the WBSS multi fleet assessment run.

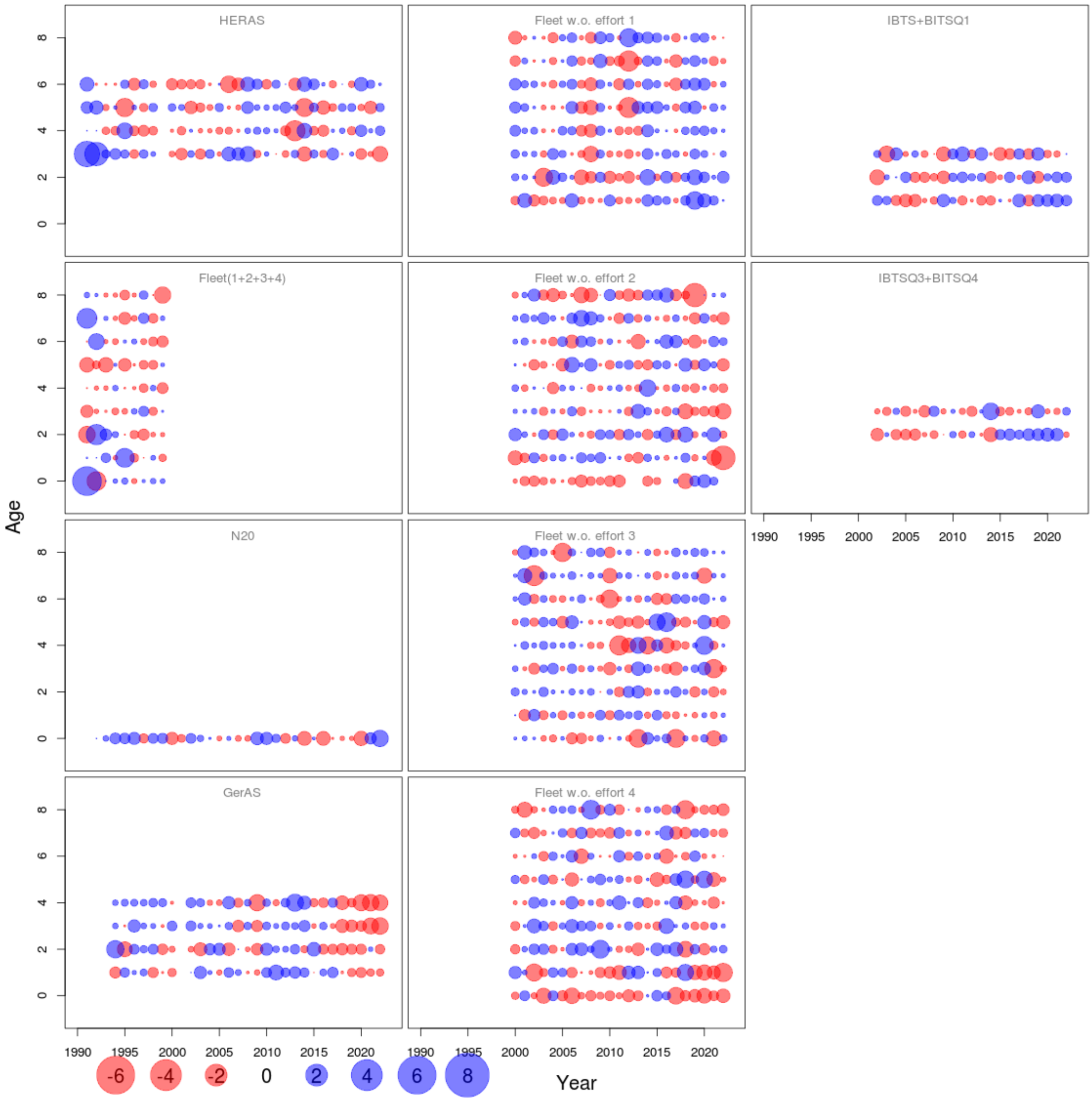


Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. BUBBLE PLOT. Standardized one-observation-ahead residuals from multi fleet run.

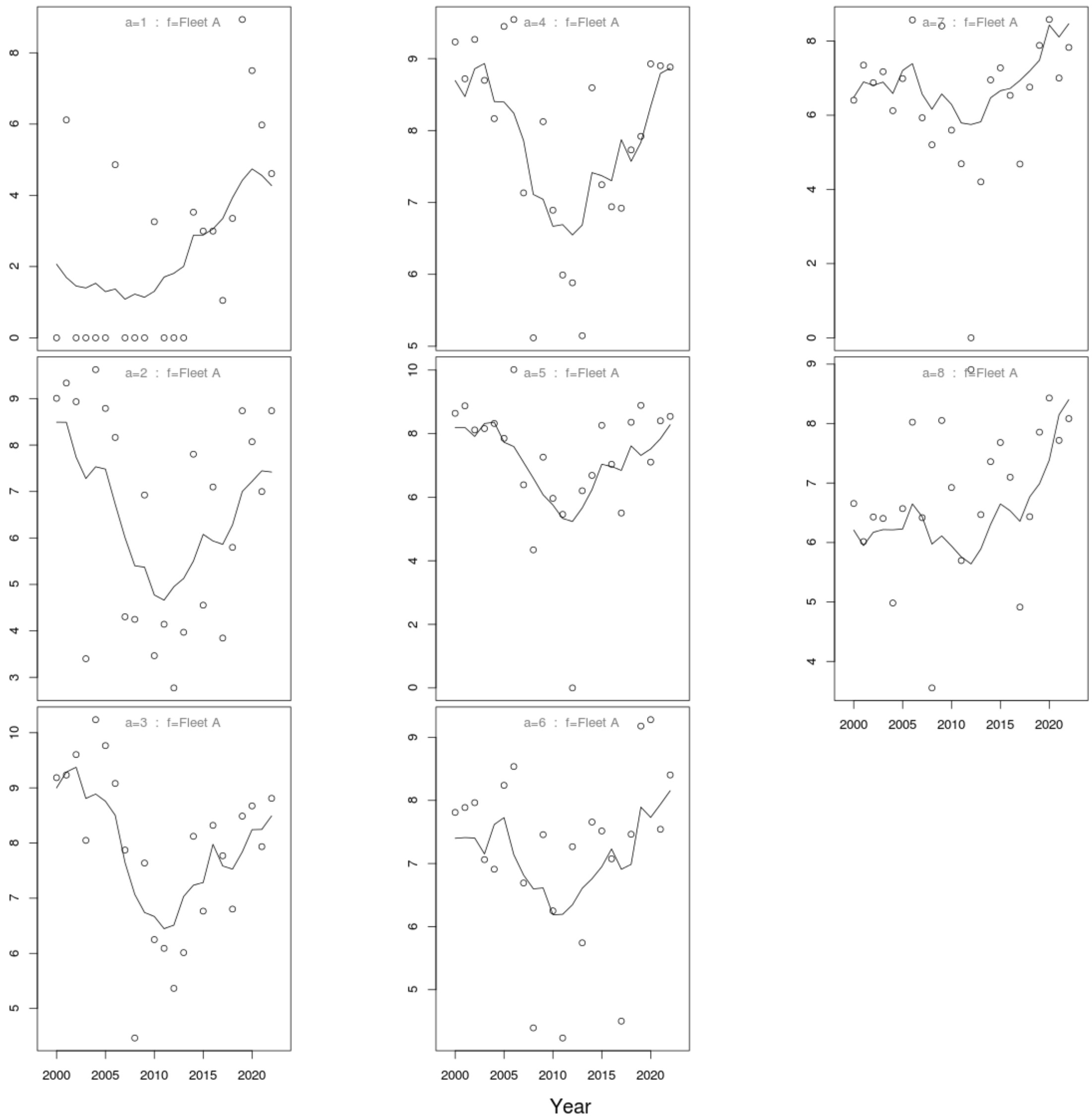


Figure 3.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet A. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

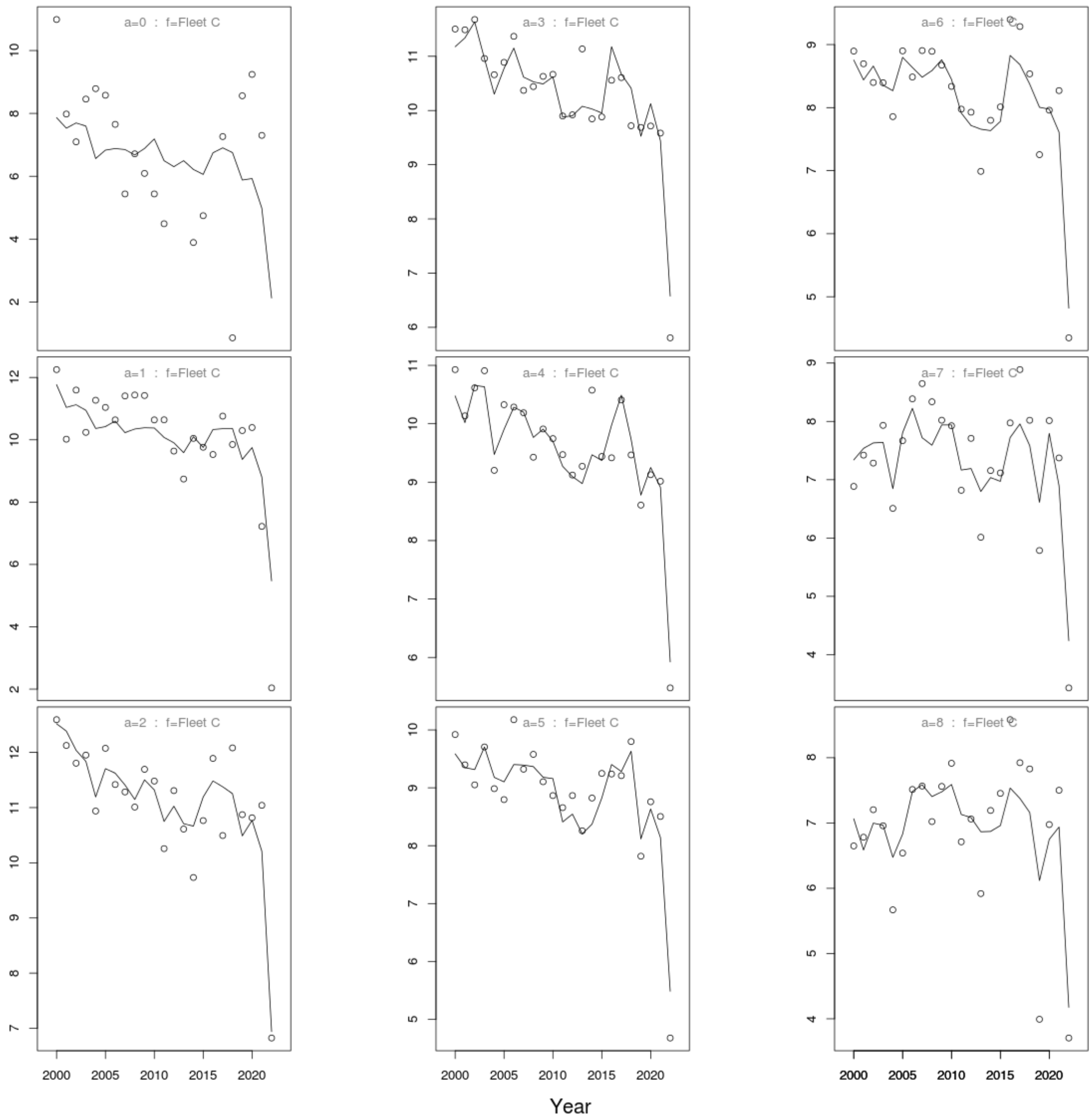


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

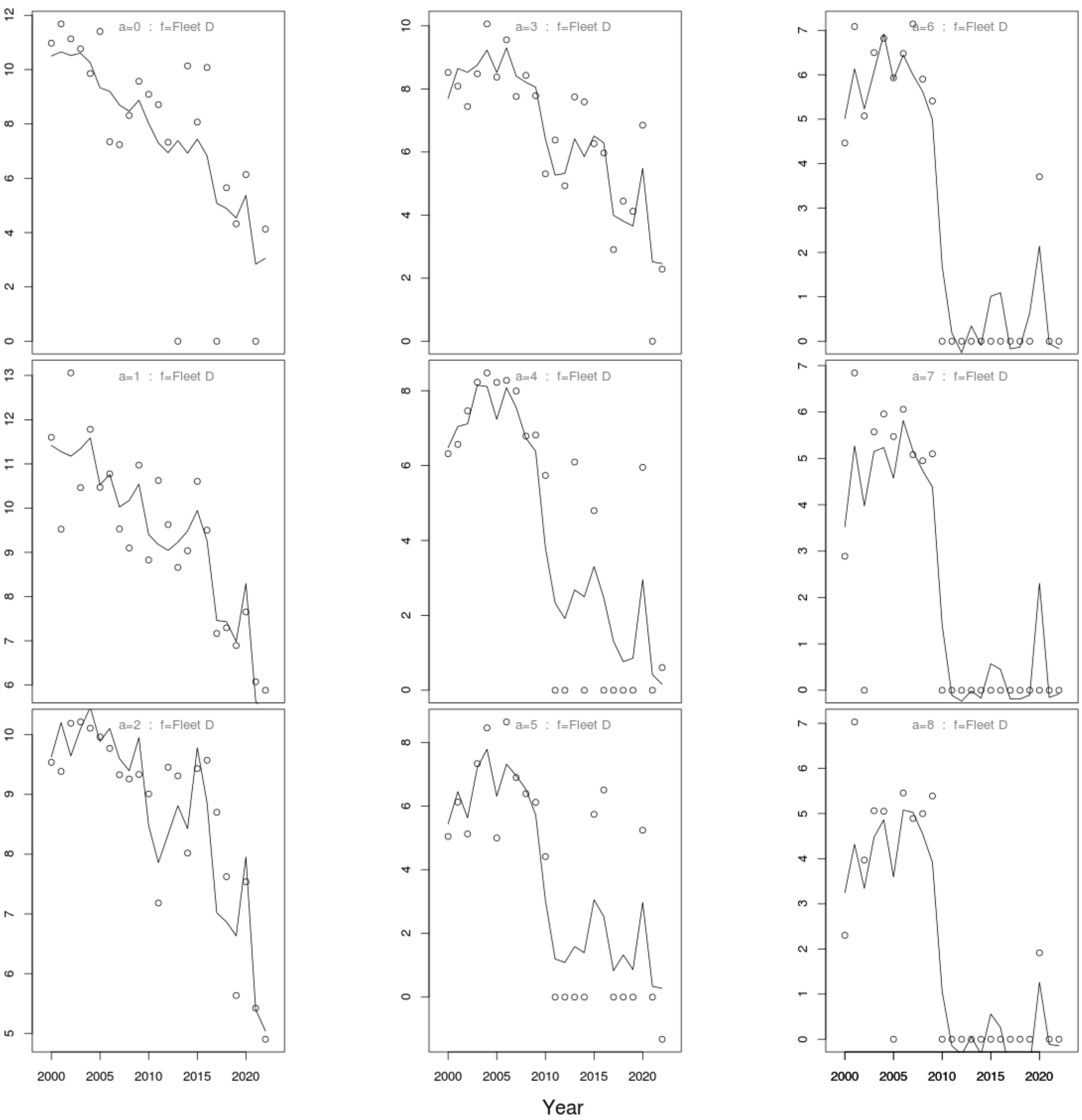


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

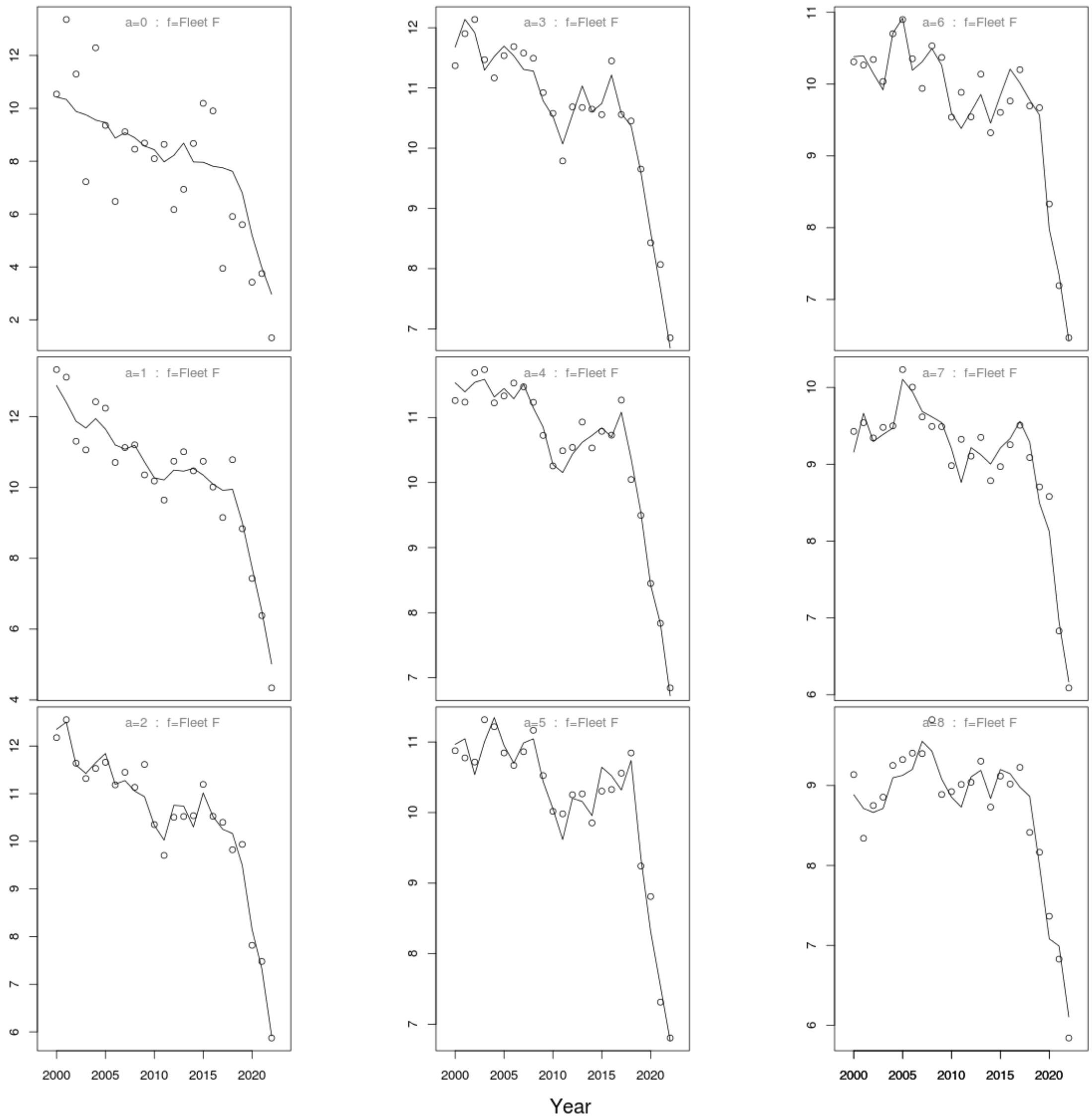


Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet F. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

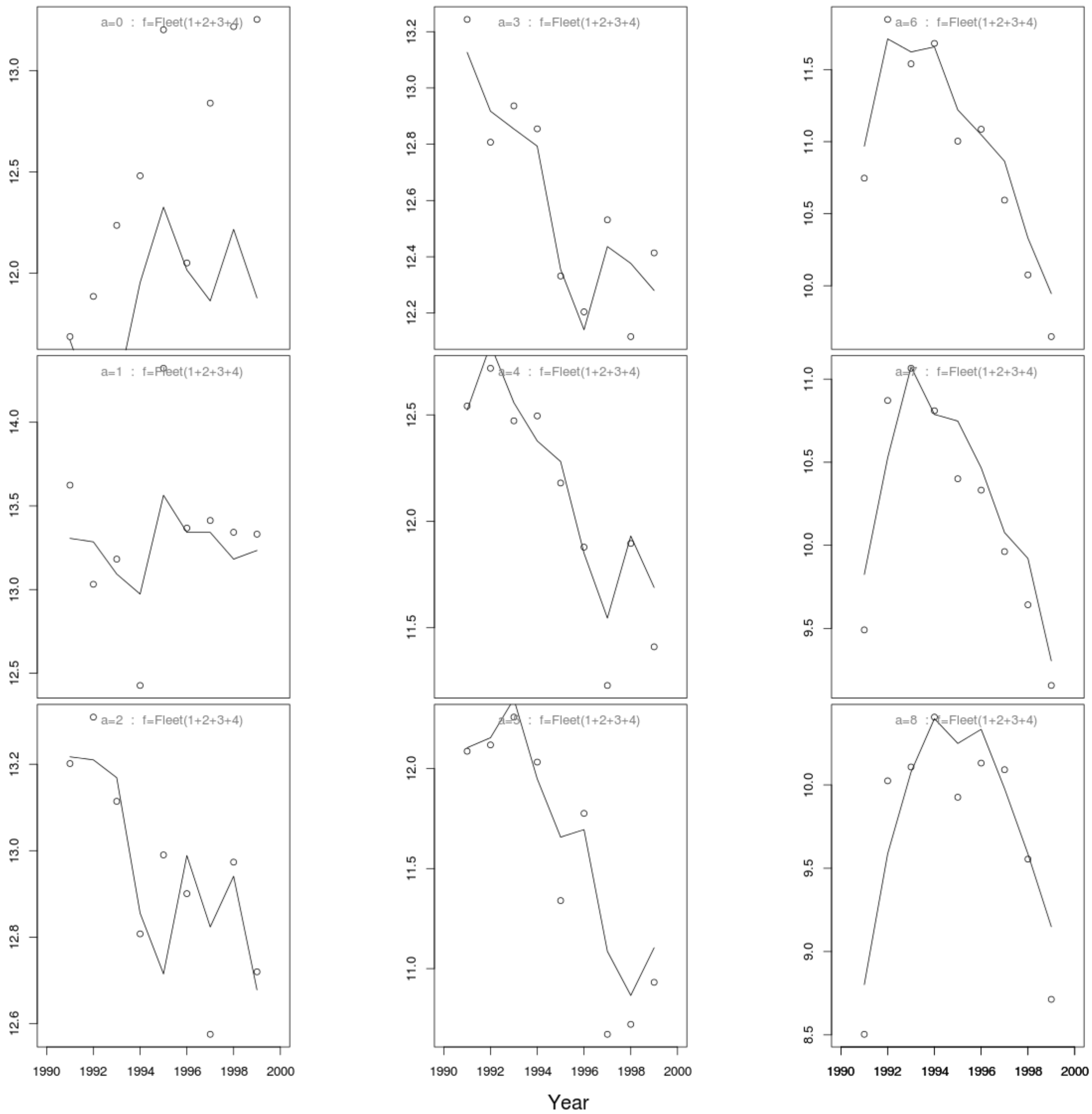


Figure 3.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit. Sum of fleets. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

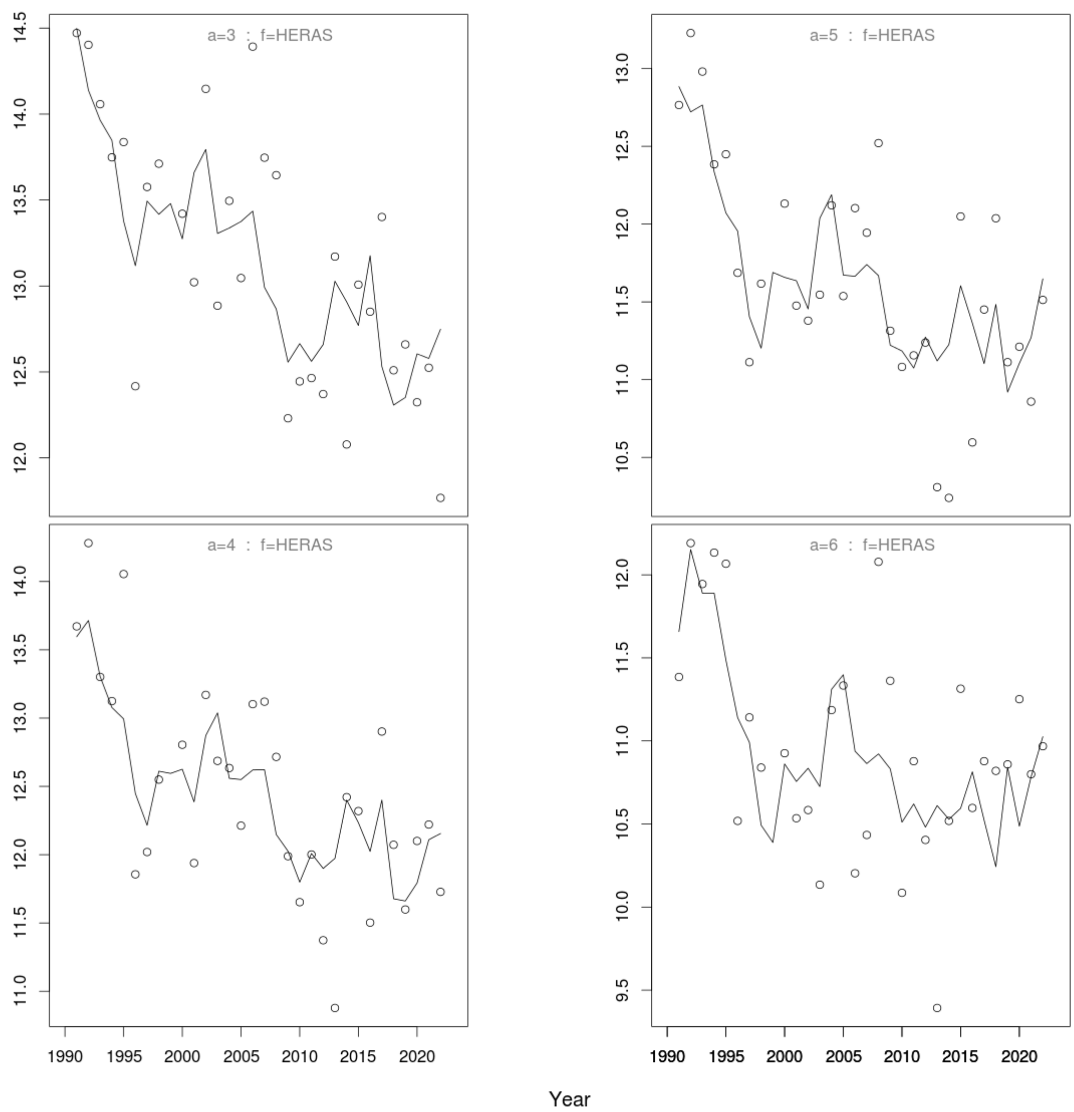


Figure 3.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the HERAS index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

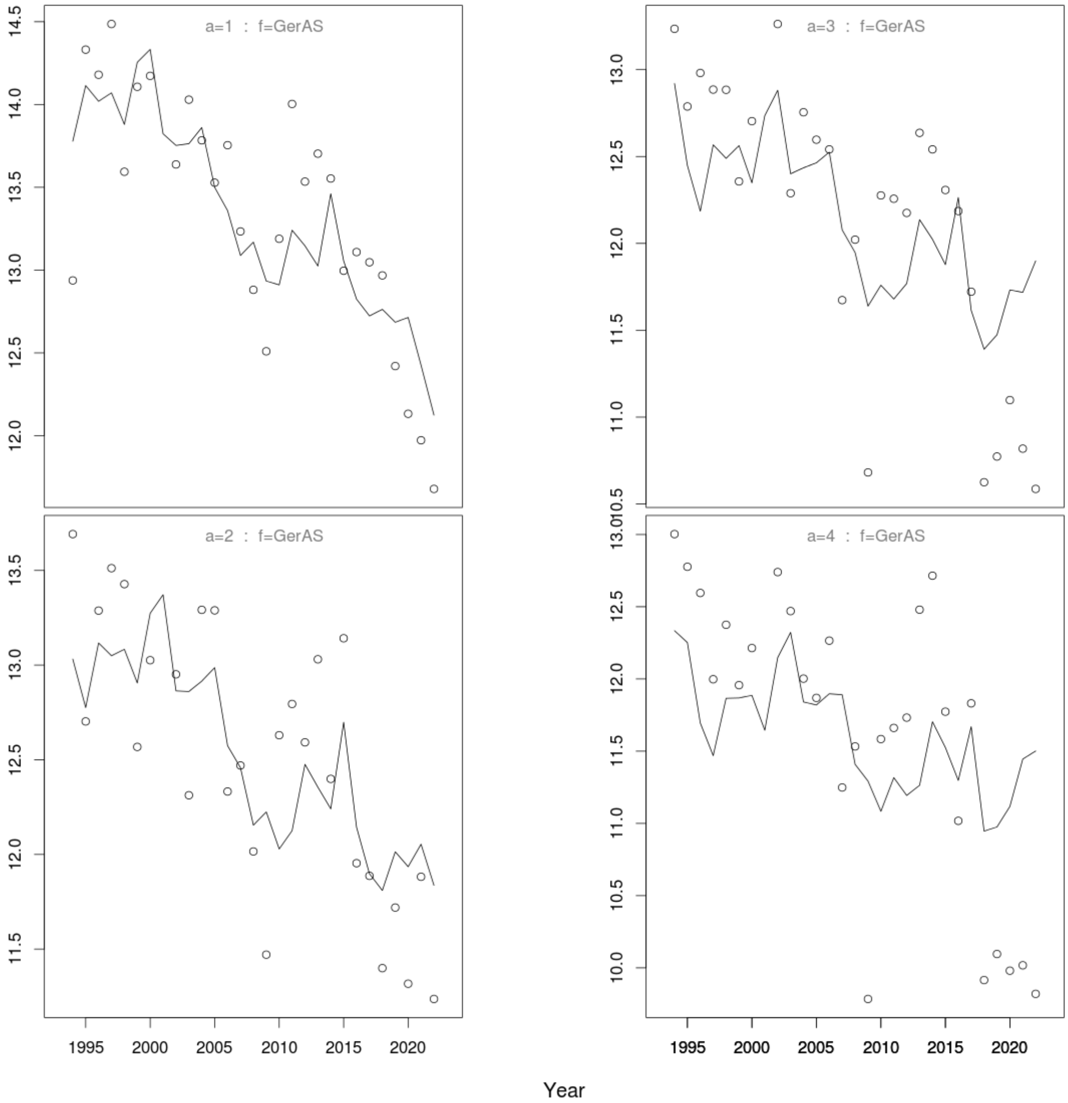


Figure 3.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the GerAs index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

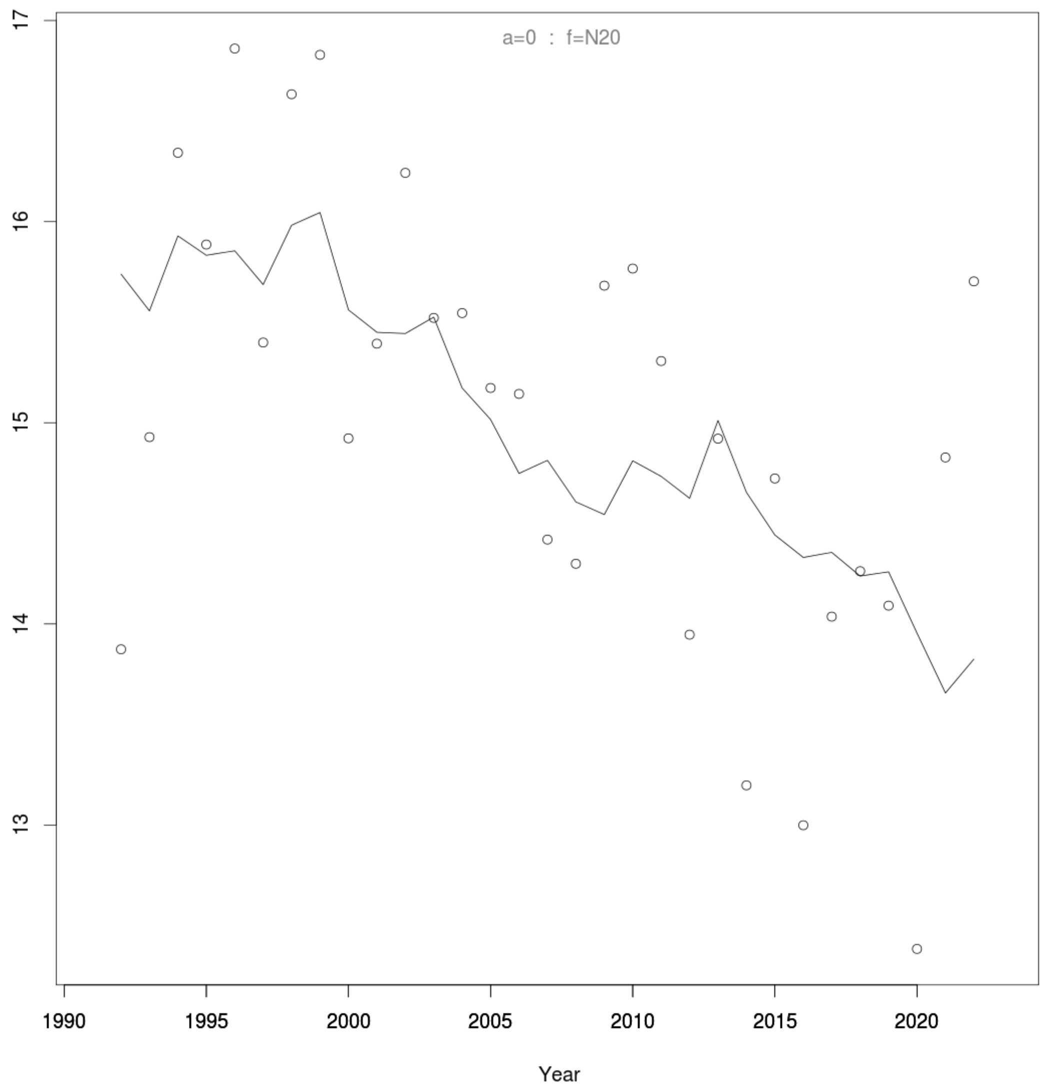


Figure 3.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the N20 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

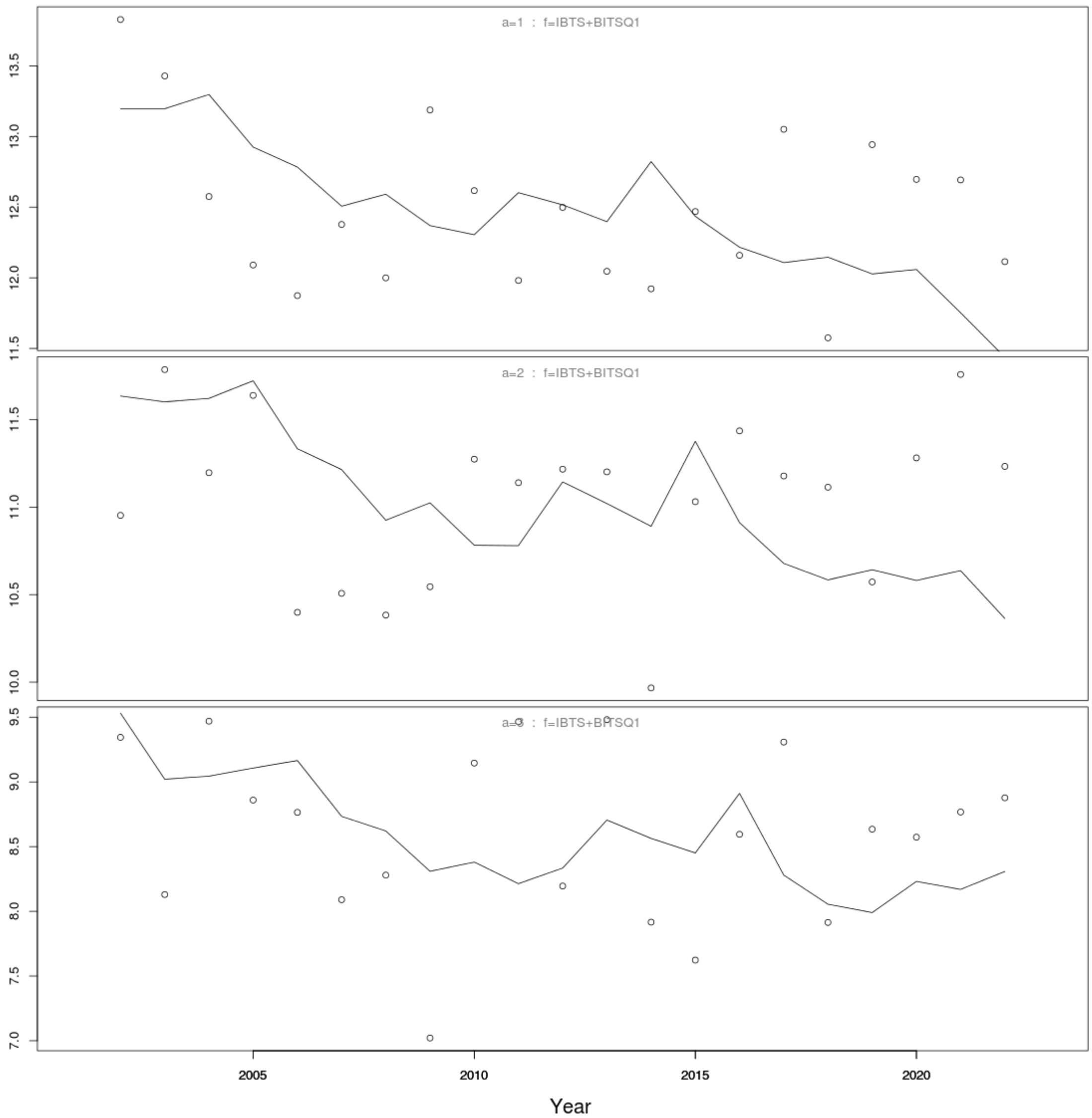


Figure 3.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q1 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

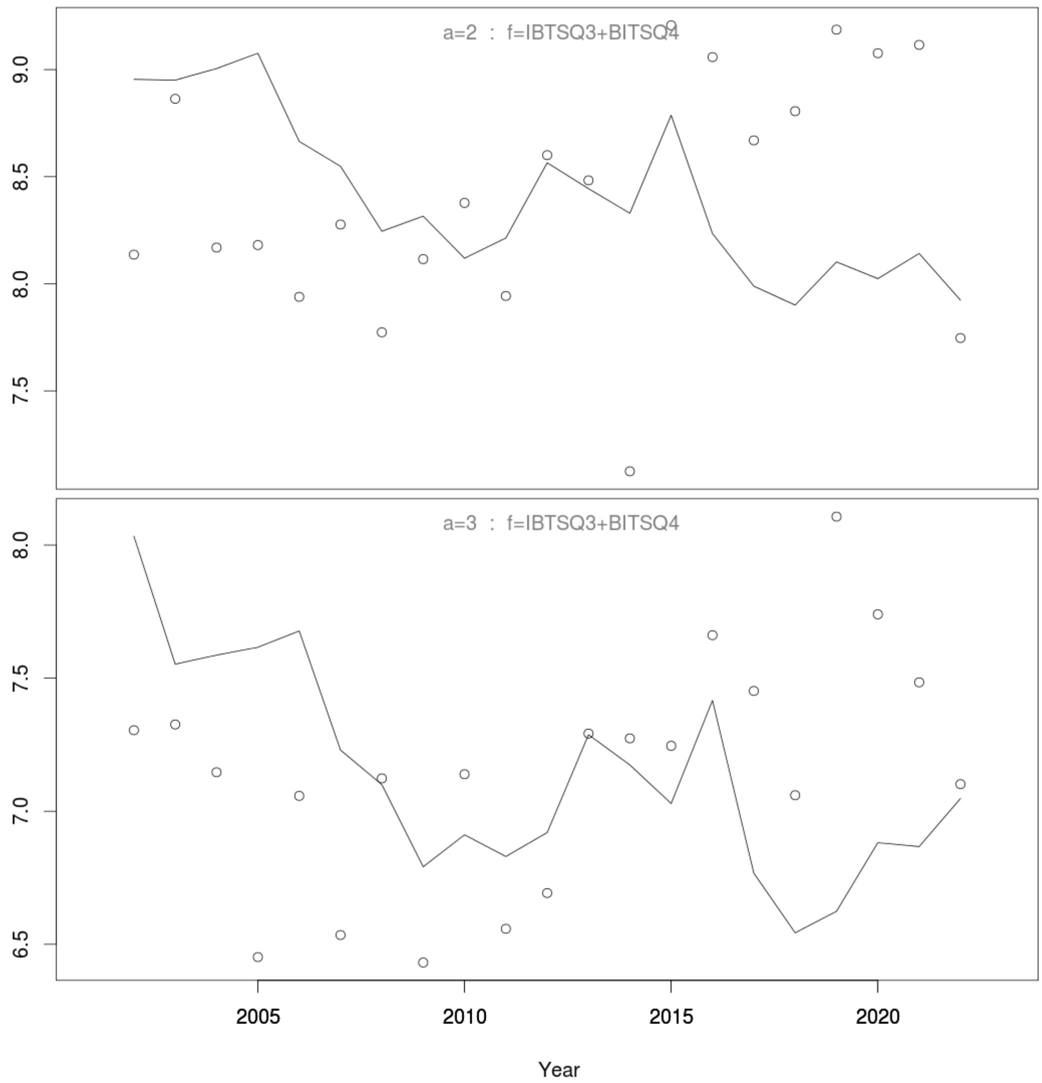


Figure 3.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q3.4 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

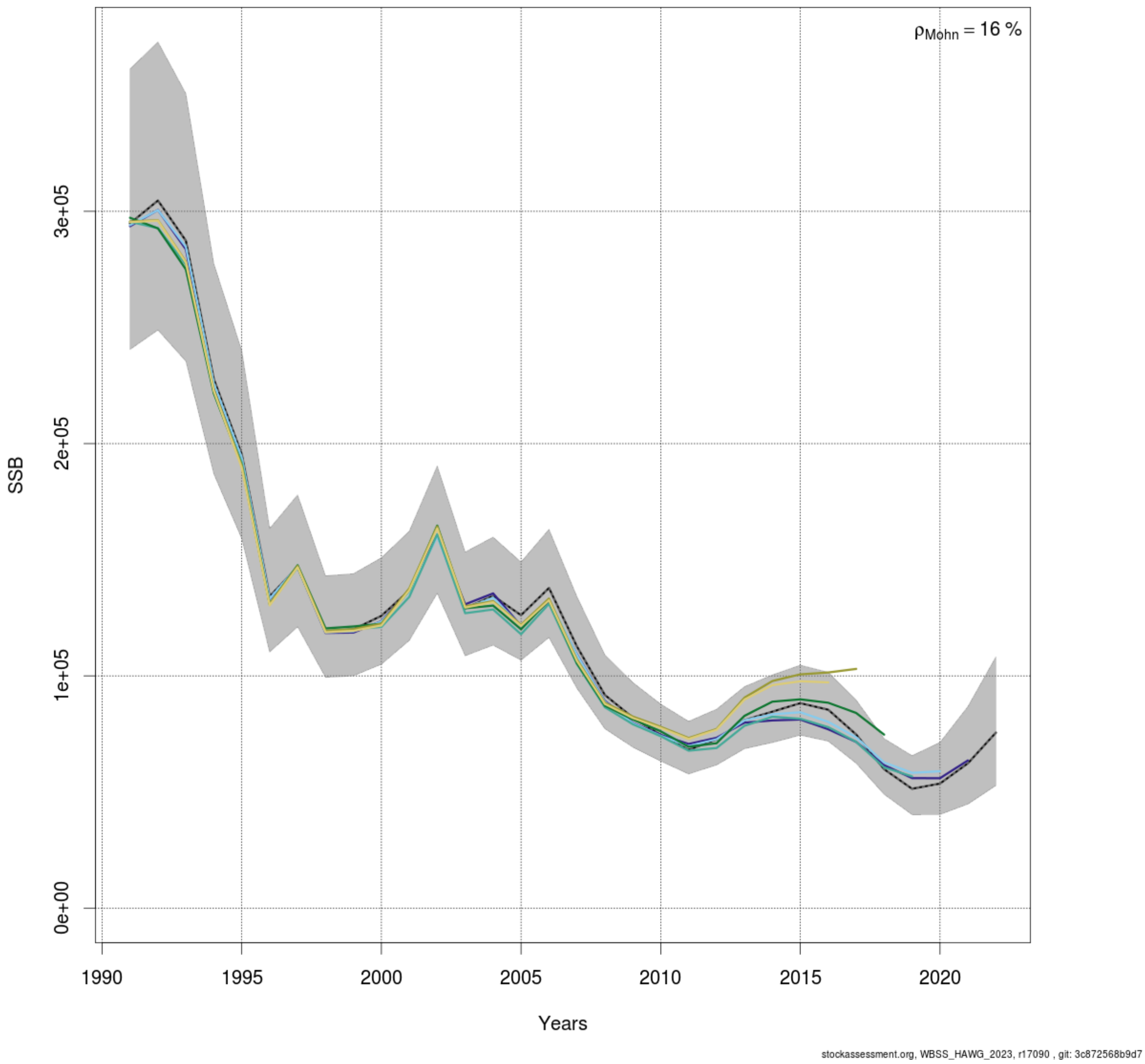


Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Spawning stock biomass.

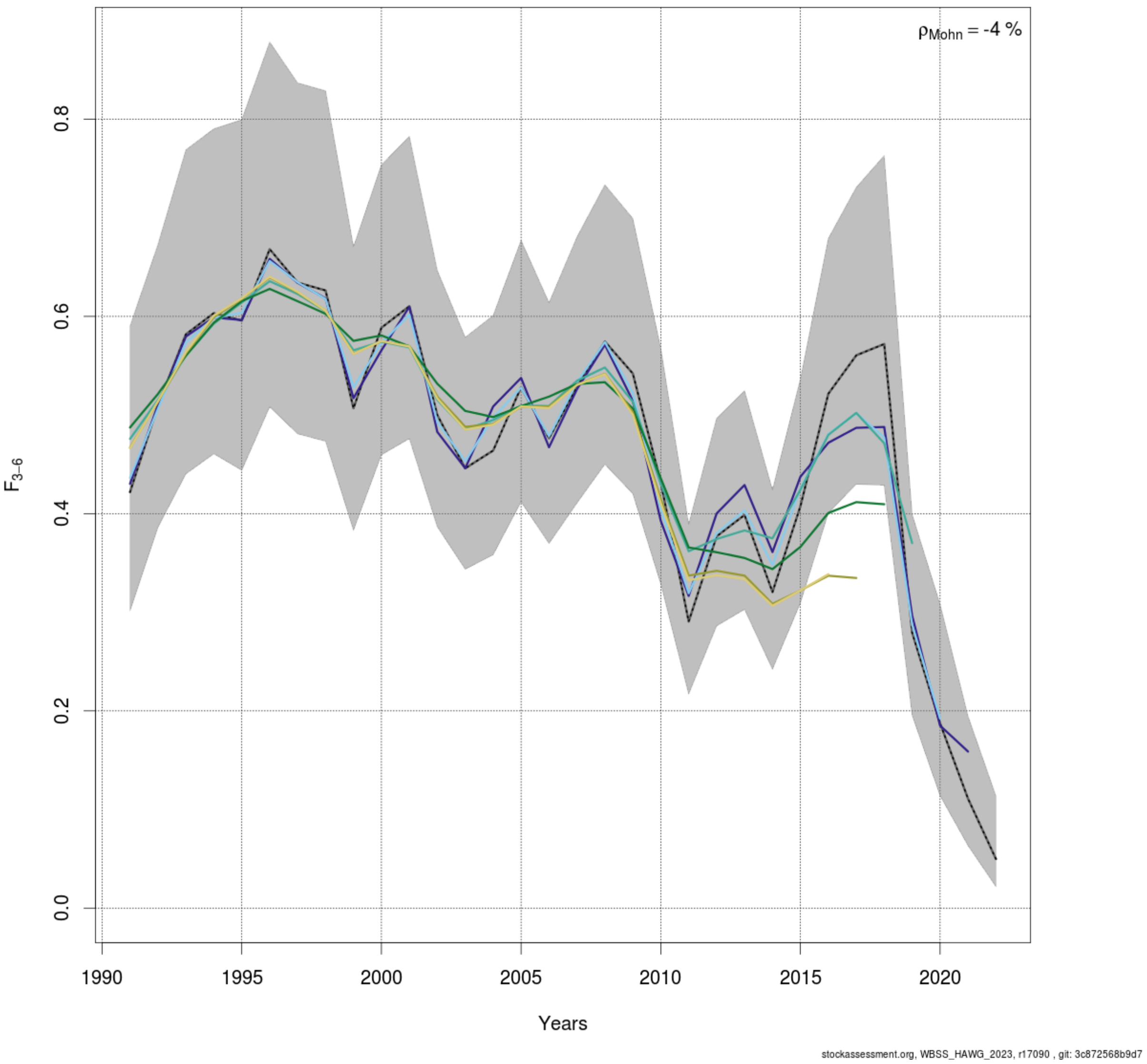


Figure 3.6.4.25 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Average fishing mortality for the shown age range.

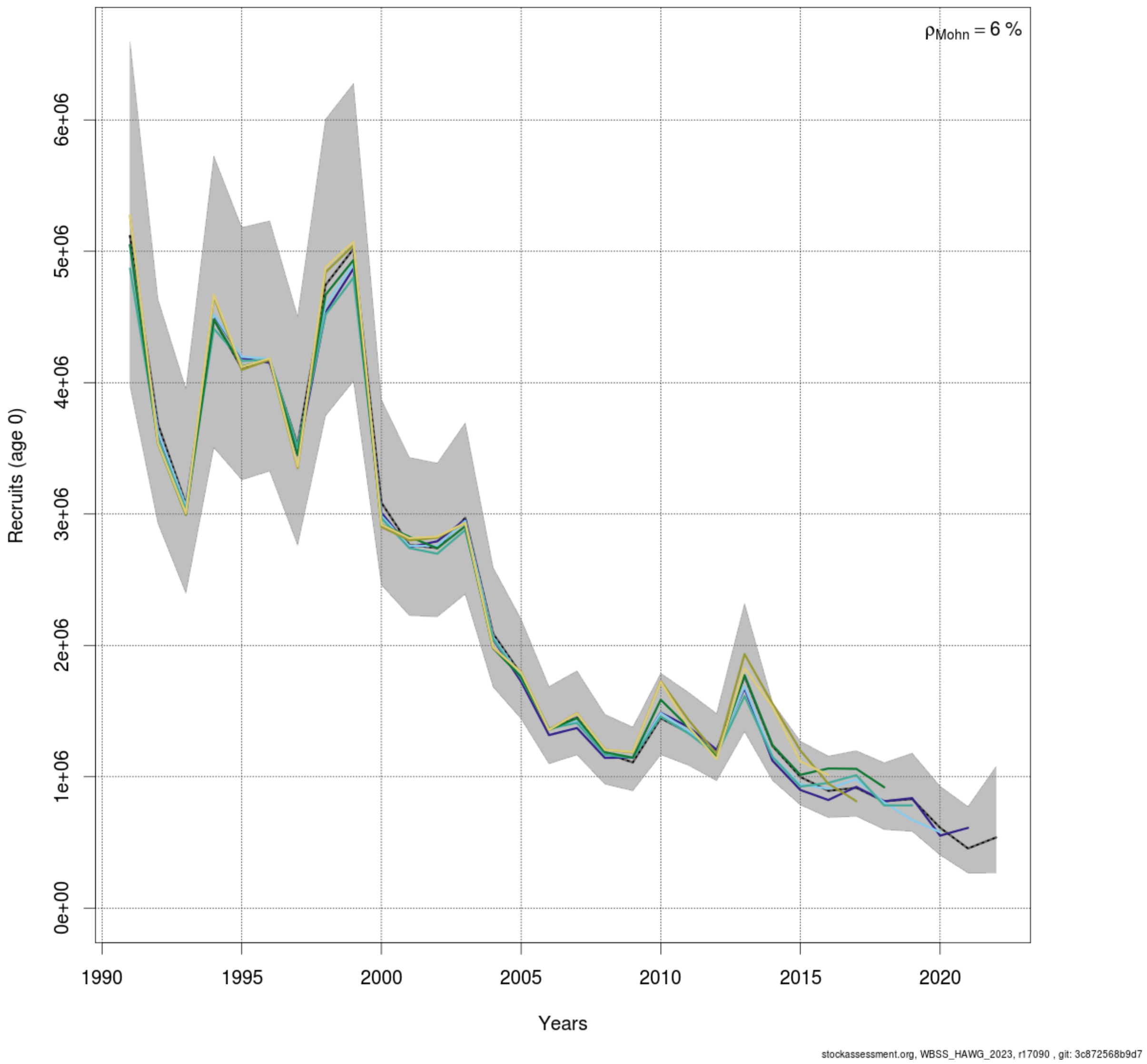


Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Catch.

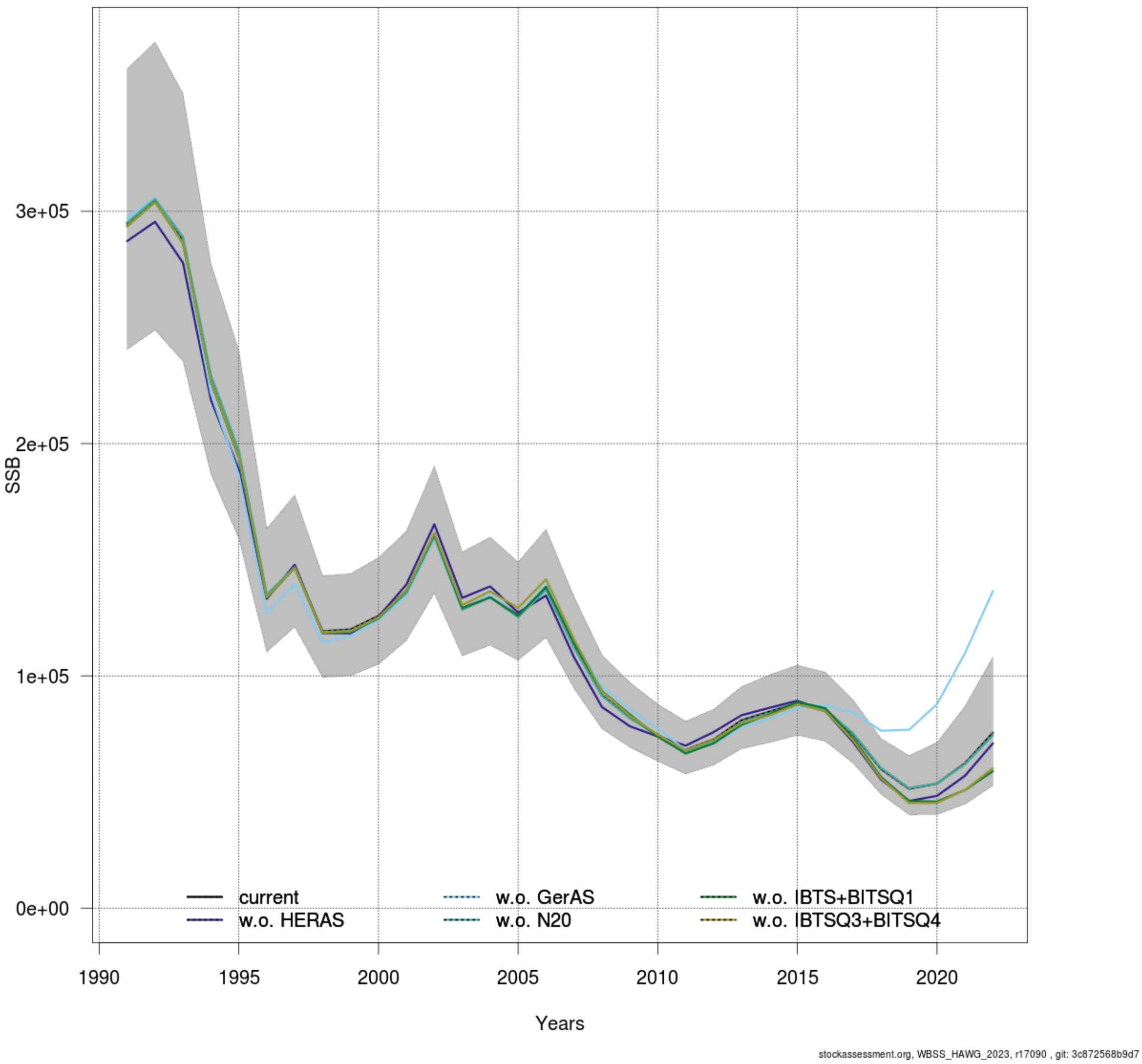


Figure 3.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Spawning stock biomass.

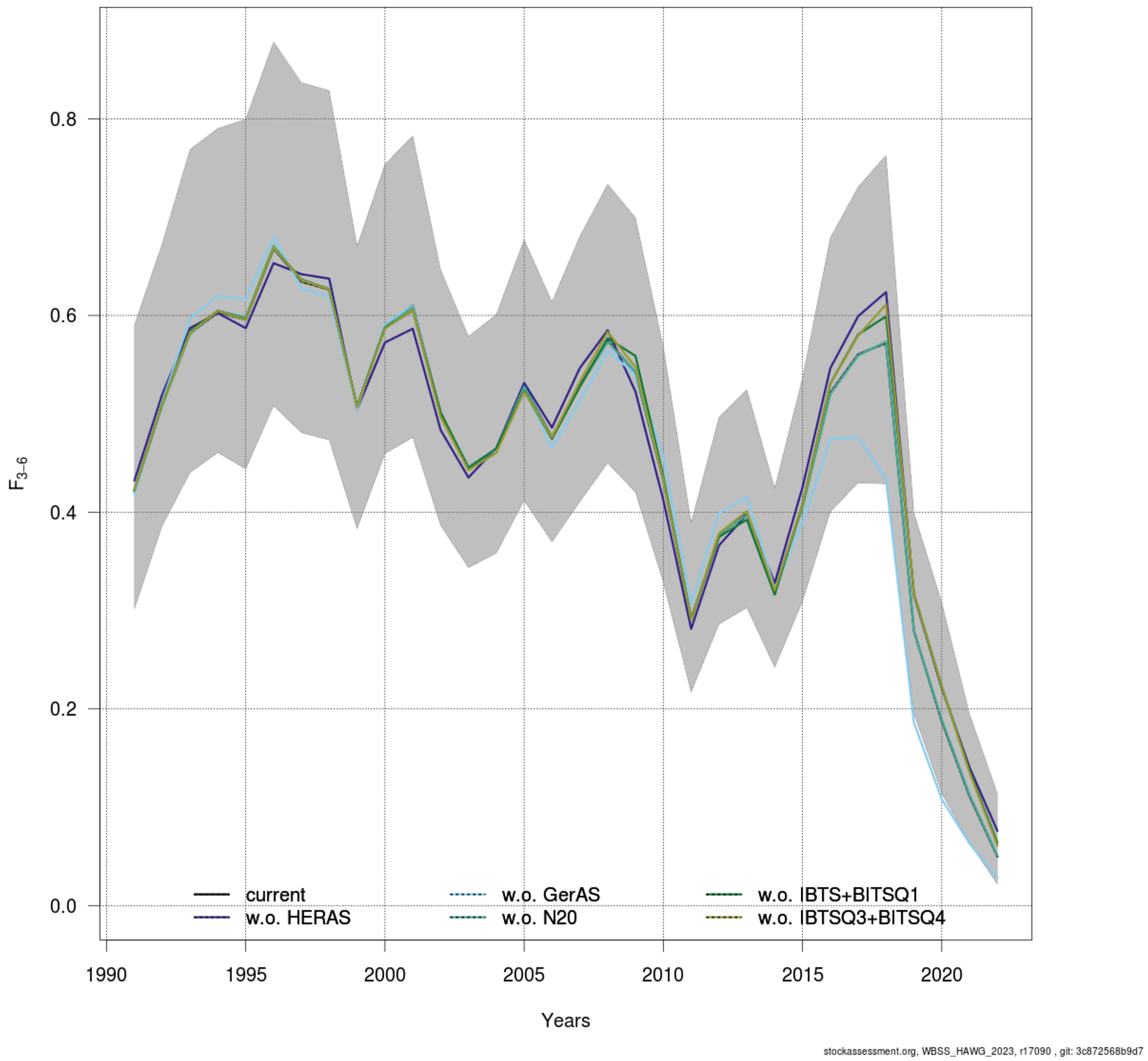


Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

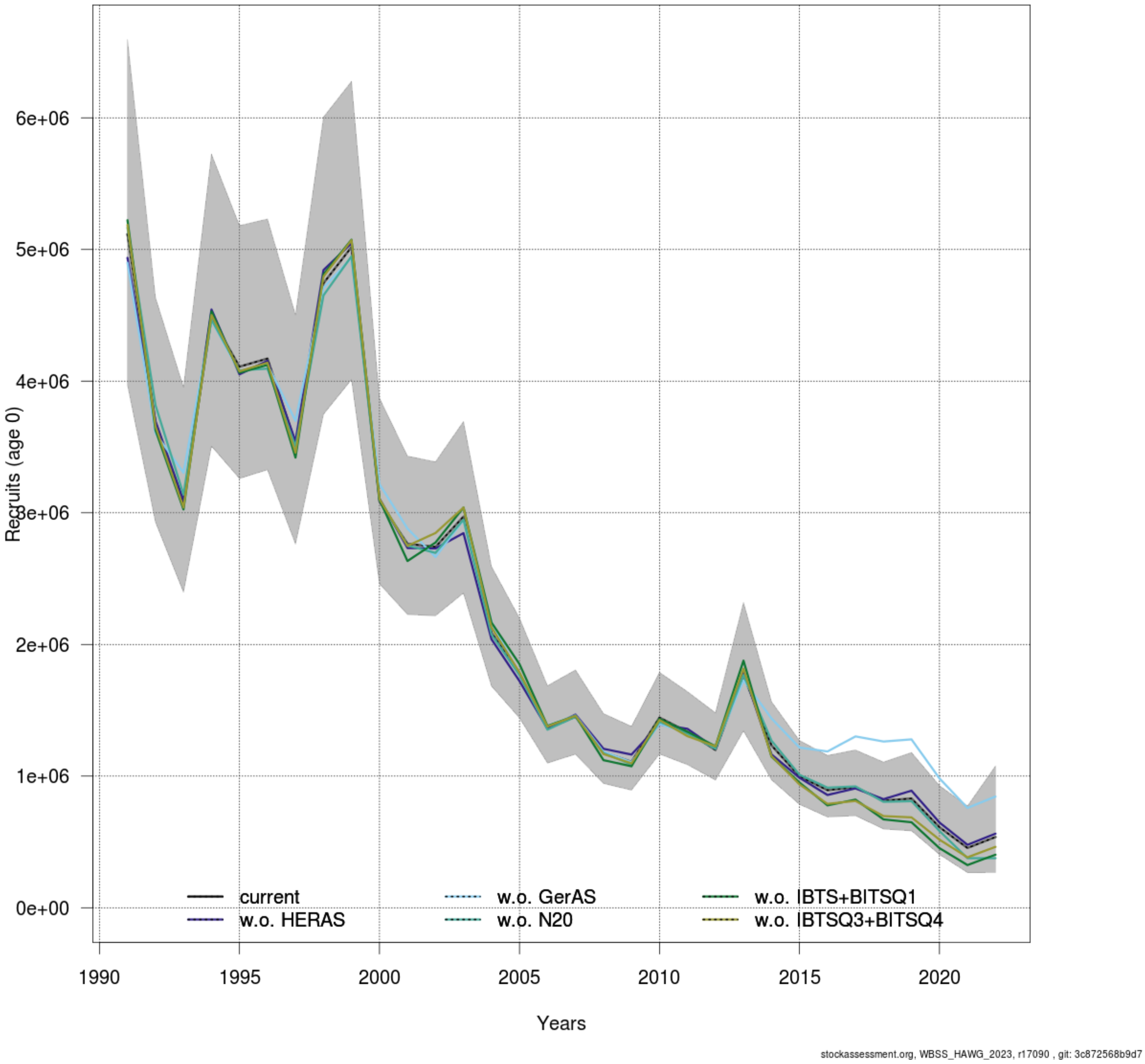


Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Recruitment.

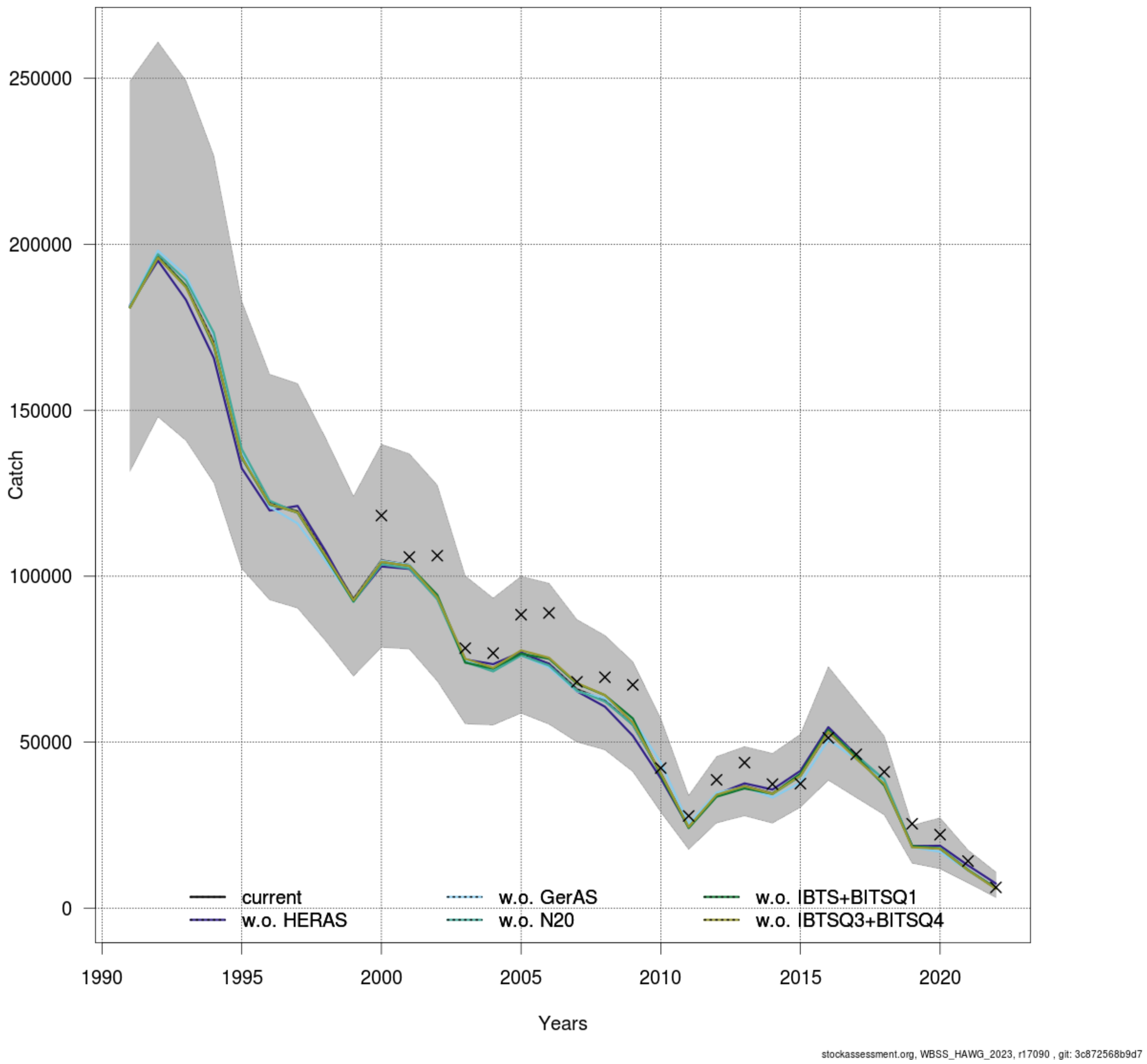


Figure 3.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Catch.

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.aS 7.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, 2021a) despite continuing to be considered by HAWG as discrete stocks. Following 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 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 “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 utilising age-based data for any of these herring stocks to consult the stock annex and if in doubt, consult a relevant member of the WG.

4.1 The Fishery

4.1.1 Advice and management applicable to 2016–2021

ICES gave separate advice for herring in 6.aN up to 2015, and advice for the combined stocks since 2016. After the benchmarking process in early 2015 (ICES 2015a), the stocks 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 approach. 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 0 t. In February 2016, the European Commission asked ICES to provide advice on a TAC of sufficiently small size to enable ongoing collection of fisheries-dependent data and 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.aS and 7.b–c (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.aS and 7.b–c; (EU, 2016), and the same for 2017, 2018 and 2019 (EU, 2017; 2018; 2019). This was reduced to 4840 t, split of 3480 t in 6.a.N and 1360 t in 6.a.S and 7.b-c for 2020 and 2021 (EU 2020; 2021).

Following the benchmark meeting in early 2022 (ICES 2023a), ICESreturned to providing separate advice for herring in 6.aN, although now this advice only covers the autumn spawning population in 6.aN. In 2022 the ICES herring assessment working group used a category 3 *chr* rule 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 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, and 3480 t in 2020 - 2022, a significant reduction on 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 bare minimum, the removal of herring was limited to sample hauls during the 6aSPAWN acoustic survey (see section 4.3.11) (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, industry reiterated their wish to minimise commercial catches in 6.aN in 2021 to a bare minimum, proposing 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 (section 4.3.11). Despite concerted searching, efforts to obtain a commercial catch of 6aN herring as compensation for the monitoring survey were unsuccessful, so no commercial samples from fisheries directed at herring in 6aN were available for use in assessment.

4.1.4 Stock recovery plan

In 2018, the Pelagic Advisory Council submitted a revised proposed rebuilding plan for both 6.aN and 6.aS 7.b–c stocks combined which was reviewed by HAWG 2018 (ICES 2018b, Annex 9). However, ICES ACOM considered that further quantitative evaluation would be required 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 bench- mark, anticipated for 2021'*. There is no specific stock recovery plan in place for herring in 6.aN.

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 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 in 6.aN.

4.1.5 Regulations and their affects

The 4° meridian divides 6.aN 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 boundary. The north–south boundary between 6.aN and 6.aS (56° parallel) is also 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.

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 has a bearing on the opportunities and extent of possible survey work and commercial catch sampling.

4.1.6 Catches in 2022

The Working Group's best estimate of removals from the stock is shown in Table 4.1.6.

4.1.7 Length Frequency information

Length frequency information are 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 2021 (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 one vessel (Chris Andra) only. During 2022 there were no commercial hauls from the fishery and therefore commercial length data are not available for the latest year.

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 commercial samples in 2022. Although the current assessment does not require data on numbers or weights at age in the catch, these data are detailed in tables 4.2.2 and 4.2.3 and displayed 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 HAWG 2017). The principles described in that document were followed in 2021 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 in June – July since 1991. It originally covered an area bounded by the 200 m depth contour in the north and west, to the 4°W in the east and extended south to 56°N; 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 recommendation from WESTHER, HAWG and SGHERWAY (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 2022 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 only go back to 2014.

The Malin Shelf herring estimate of SSB for autumn spawning herring in 6.aN in 2022 is 33 283 tonnes and 191 million individuals (Table 4.3.1), a slight decrease compared to 2021. Although estimates appear to be 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).

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 and 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 2022 is dominated by 3 and 4-winter ringers (22.7% and 30.2% of the abundance respectively, 2019 and 2018 year classes). Age disaggregated survey abundance indices for 6.aN autumn spawning herring since 2014 are given in Table 4.3.2 and displayed in Figure 4.3.1.1.

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.aS, 7.b–c stocks are offshore feeding (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 summer acoustic surveys. Genetic analyses outlined in Farrell *et al.*, 2021 split these indices into 6.aN autumn spawning herring and 6.aS, 7b-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 that may be used by ICES to assist in assessing the herring stocks and establishing a rebuilding plan.

Following the guidance arising from WKHASS (ICES 2020c), the survey area from 2020 onwards has focused on two principal spawning areas (Figure 4.1.3.1), with 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 consistent survey time-series (Mackinson and Berges 2022).

In 2022 the survey was limited to one vessel only, which reduced the period of observation compared to surveys from 2016 - 2021. Mechanical issues shortened the planned duration from 10 to 8 days. The survey detected and verified only one herring school, which was unprecedented since the survey began in 2016. One biological and genetic-baseline sample of spawning-ready fish was obtained. Full details of the survey can be found in ICES (2023b) and Mackinson *et al*. 2023, which conclude that (i) the 2022 survey was limited in the period of observation in relation to the extended duration that herring may potentially spawn, but the timing was consistent with previous observations of herring aggregating in this area and in condition for spawning. (ii) herring were nearly absent in the survey area during the period of the survey, and (iii) that despite the lack of herring, the data collected provides a reliable estimate of the minimum biomass of mature herring at age observed in survey areas during the survey period, noting that in effect the estimation is reduced to estimating the abundance of herring that were recorded on one transect alone.

4.4 Mean Weights-at-age, Maturity-at-age and natural mortality

4.4.1 Mean weight-at-age

Weights-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 been steadily declining since 2014 (Figure 4.4.1.1). Weights-at-age in the catches are presented in Table 4.2.3.

There have been fluctuations in catch weights over time. In several years no 1 winter ring fish have been taken in the 6.aN fishery. In 2022 there were no commercial samples from which to derive catch weights.

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 2022, but in some years no estimates are available at younger ages. The proportion mature of age 2 were the highest since 2014.

4.4.3 Natural mortality

The natural mortality used in previous assessments of several herring stocks to the West of Scotland, including 6.aN, were 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, the SMS model, used in WGSAM (Lewy and Vinther, 2004).

The benchmark of 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 it is 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 are averaged annual M values from the 2011 SMS key run (period 1974–2010) for each age. This approach is similar to the pre-benchmarked assessment in that it is time invariant and age variant. This time-series reflects the most recent period of stability in terms of M from the North Sea SMS as it excludes the gadoid outburst of the 1960 which is 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 benchmark (ICES 2023a) it was agreed that these values were the most suitable for herring in 6.aN. For the category three methods, the value of M was taken from ages 3-6.

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 appearance of a cohort appears at 2-wr in both the catch and the stock.

4.6 Assessment of 6.aN autumn spawning herring

The assessment presented here follows the procedure agreed by the most recent benchmark (ICES 2023a). The tool for the assessment of herring in 6.aN follows the category 3 WKLIFE guidelines (ICES 2021g; ICES 2021h).

Data Exploration

For category three 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 2021e).

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). Following the recommendations of WKLIFE, (ICES 2021e), the growth parameter *k* was calculated for this stock.

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 we don't have genetic samples available). Guidelines indicate that calculations of growth parameters should come from commercial data (ICES 2021e), 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 and estimated L_∞ value of 30.51cm and an associated k value of 0.335. Given that $0.32 \leq k \leq 0.45$, the Constant Harvest Rate should be used to provide advice.

Assessment

The *chr* applies a constant harvest rate ($F_{MSY\ proxy}$ calculated from catch length frequency data) that is considered a proxy for 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 does not change unless there are drastic changes to the fishery.

$F_{MSY\ proxy}$ 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 ($L_{F=M}$) is calculated from the length frequency data and is key to the $F_{MSY\ proxy}$ value calculation. Target reference length is usually calculated using the following equation:

$$L_{F=M} = (0.75*Lc_{(y)}) + (0.25*L_{inf})$$

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 2018b) 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), applying the following equation:

$$L_{F=\gamma M, K=\theta M} = \theta\ L_{inf} + L_c\ (\gamma + 1) / \theta + \gamma + 1$$

As per ICES, 2021e, advised catch is calculated as follows:

$$C_{y+1} = I_{y-1} \times F_{MSY\ proxy} \times b \times m$$

The components of this formula were estimated as follows.

- I_y is the biomass index for year y. In this case, using the 6.aN autumn spawning herring from the genetically-split Malin Shelf Herring Acoustic Survey , $\boldsymbol{I_y = 33\ 283}$.
- $F_{MSY\ proxy}$ is the average of the ratio of catch C to the biomass index I, calculated across all years for which $L_{mean}/L_{F=M} > 1$. The comparison between L_{mean} and $L_{F=M}$ is shown in Table 4.6.1, from which it can be seen that 2014 - 2018 should be used in the calculation of $F_{MSY\ proxy}$.The ratio C/I is shown in Figure 4.6.3, and the average is $\mathbf{0.335}$. After the initial implementation of the *chr* method (2022, ICES 2022a), this value does not change.
- $b = min\{1, I_y/I_{trigger}\}$. The value used for $I_{trigger}$, 14 711, is $1.4I_{loss}$, where $I_{loss} = 10\ 508$ is the lowest observed biomass index value. Doing so results in $\boldsymbol{b = 1.0}$.
- m is a multiplier intended to avoid biomass declining below B_{lim}. In this situation WKLIFE recommends that $\boldsymbol{m = 0.5}$.

Using these estimates the formula gives:

$$C_{y+1} = 33\ 283 \times 0.335 \times 1 \times 0.5 = 5\ 583 \text{ tonnes}$$

Under WKLIFE guidelines (ICES 2021e) 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 1 454 tonnes.

4.6.1 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 follows on from the benchmark in early 2022 (ICES 2023a).

4.6.2 State of the stock

Fishing mortality has been reduced since the introduction of zero catch advice and in line with the monitoring TAC in 2016. SSB remains at very low levels relative to the long term trend, despite improvements 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 7 years of a combined assessment with herring in 6.aS, 7.b-c. Unlike prior assessments for 6.aN herring, this assessment only includes the Cape Wrath autumn spawning component, as the Minch spring spawners cannot currently be split out from 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 since 2016 under the combined assessment. Despite increasing trend in recent biomass estimates, the survey biomass for this stock remains at low levels compared to historical values.

There have been indications that the autumn spawning herring population in 6.aN are genetically identical to the North Sea autumn spawning population. These unresolved stock identity issues should be investigated in the future.

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 have not yet been split out from the acoustic survey and are no longer assessed by HAWG.

Recruitment 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 4 170 t was implemented from 2016-2019, and reduced to 3480 t in 2020-2021. In 2022 the TAC level was reduced to 1212 t following the implementation of the *chr* rule.

4.9 Ecosystem Considerations

Herring constitute some of the highest biomass 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 that eat them, 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 act as predators on other fish species by their predation on fish eggs at certain times of year (ICES, 2014a). Work using length-based ecosystem modelling, suggests a link between herring biomass and North Sea cod (Speirs *et al.*, 2010), via the predation of cod eggs by herring.

As herring constitute an important part of the overall biomass of plankton feeding 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). It is considered that this may have implications for herring. 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). With environmental changes predicted to continue, the impacts on herring in 6.aN are uncertain.

4.11 Tables and Figures

Table 4.1.6. Herring in division 6.aN. ICES estimated catches by country. 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

Year	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Lithuania	Norway	UK	Unallocated	Discards*	Total	Area misreported	ICES estimate
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

***unraised discards**

Table 4.2.1. 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. 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

Year	1	2	3	4	5	6	7	8	9+
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
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

Year	1	2	3	4	5	6	7	8	9+
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	-	-	-	-	-	-	-	-	-

Table 4.2.3. 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

Year	1	2	3	4	5	6	7	8	9+
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
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

Year	1	2	3	4	5	6	7	8	9+
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	-	-	-	-	-	-	-	-	-

Table 4.3.1. Herring in division 6.aN. Total numbers (millions) and biomass (thousands of tonnes) of 6.aN autumn spawning herring from the Malin Shelf Survey June-July 2022. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	8.47	0.58	0.00	68.96	20.0
2	37.00	4.72	0.96	127.54	24.2
3	41.53	6.62	1.00	159.46	25.9

4	57.76	10.07	0.97	174.27	26.6
5	20.30	3.91	1.00	192.70	28.7
6	8.49	1.69	1.00	198.96	29.8
7	11.63	2.95	1.00	253.14	29.5
8	5.38	2.8	1.00	222.86	30.5
9+	0.88	0.22	1.00	252.00	20.6
Immature	10.2	0.8		76.0	20.6
Mature	190.9	33.3		174.4	26.5
Total	201.1	34.1	0.9	169.4	26.2

Table 4.3.2. 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 2022.

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

Table 4.4.1.1. 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 2022.

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

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
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

Table 4.4.2.1. 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 2022.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
2014		0.98	1	0.95	1	1	1	1	1
2015		0.88	0.99	0.99	1	1	1	1	1
2016		1	0.98	1	1	1	1	1	1
2017		1	1	1	1	1	1	1	1
2018	0	0.37	0.97	1	1	1	1	1	1
2019		0.51	0.48	1	1	1	1		1
2020	0	0.47	0.97	1	1	1	1		
2021	0	0.45	1	1	1	1	1	1	1
2022	0	0.99	1	0.97	1	1	1	1	1

Table 4.4.3.1. Natural mortality estimates for herring in 6.aN.

Age (Rings)	1	2	3	4	5	6	7	8	9	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. $F_{MSY\ proxy}$ calculation for herring in 6.aN under the constant harvest rate rule.

Year	Survey Index	ICES land-ings	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

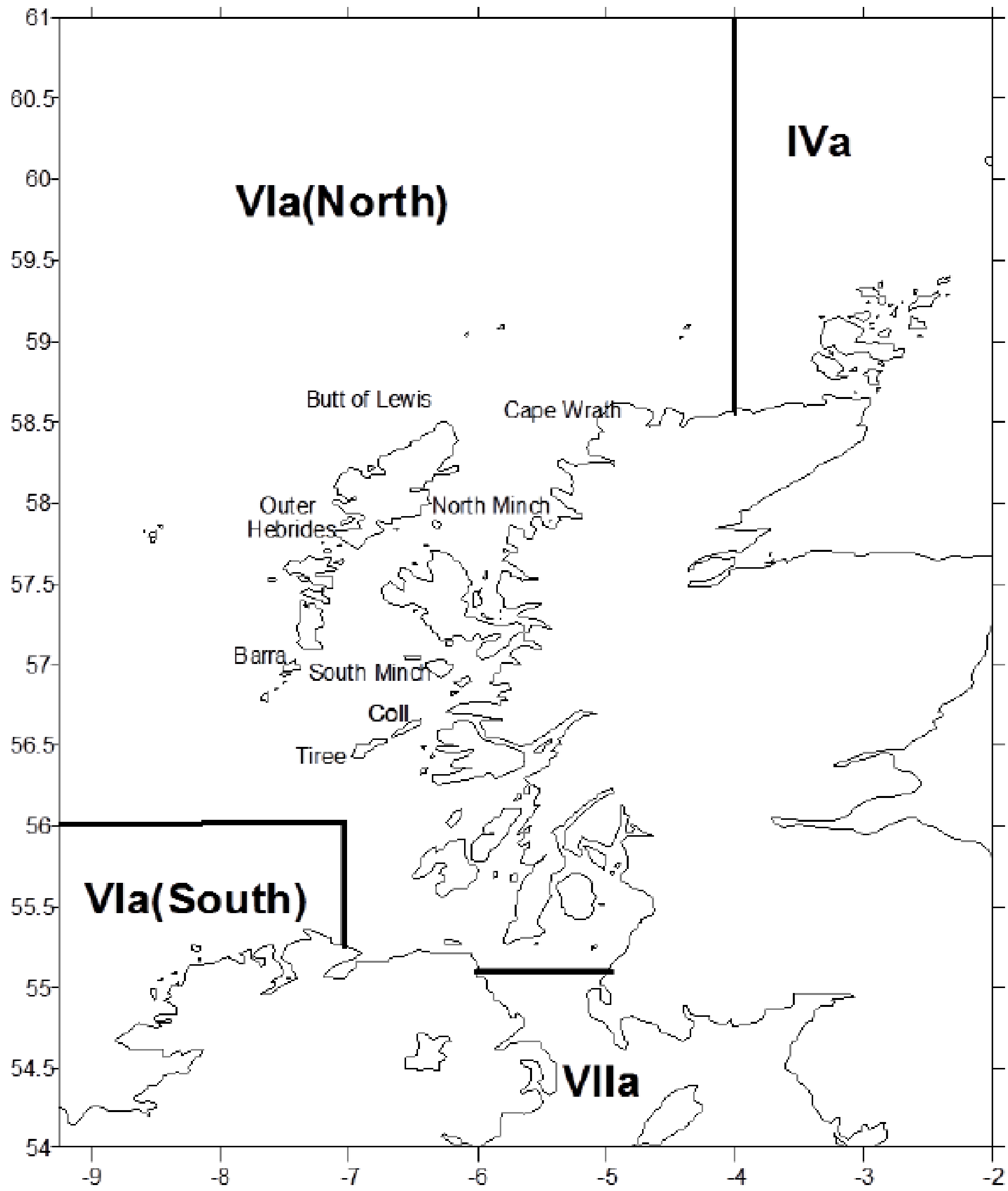


Figure 4.1. Location of ICES area 6.a (North) and adjacent areas with place names.

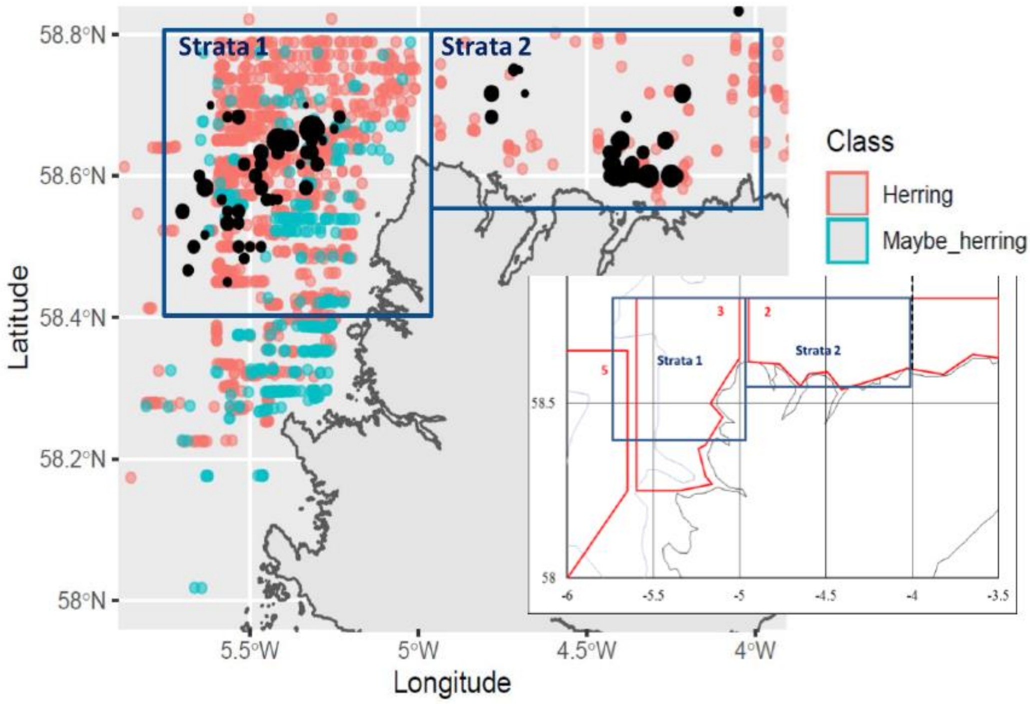


Figure 4.1.3.1. Acoustic survey recordings of herring and 'maybe herring' marks and locations of commercial catches 2016-2019 in defined Strata 1 and 2, showing overlap with previous survey Areas 2,3,5 (inset) and noting that the distribution of catches reflect spawning grounds. Catches (black dots) scaled proportionally. Acoustic marks are not scaled and denote location only.

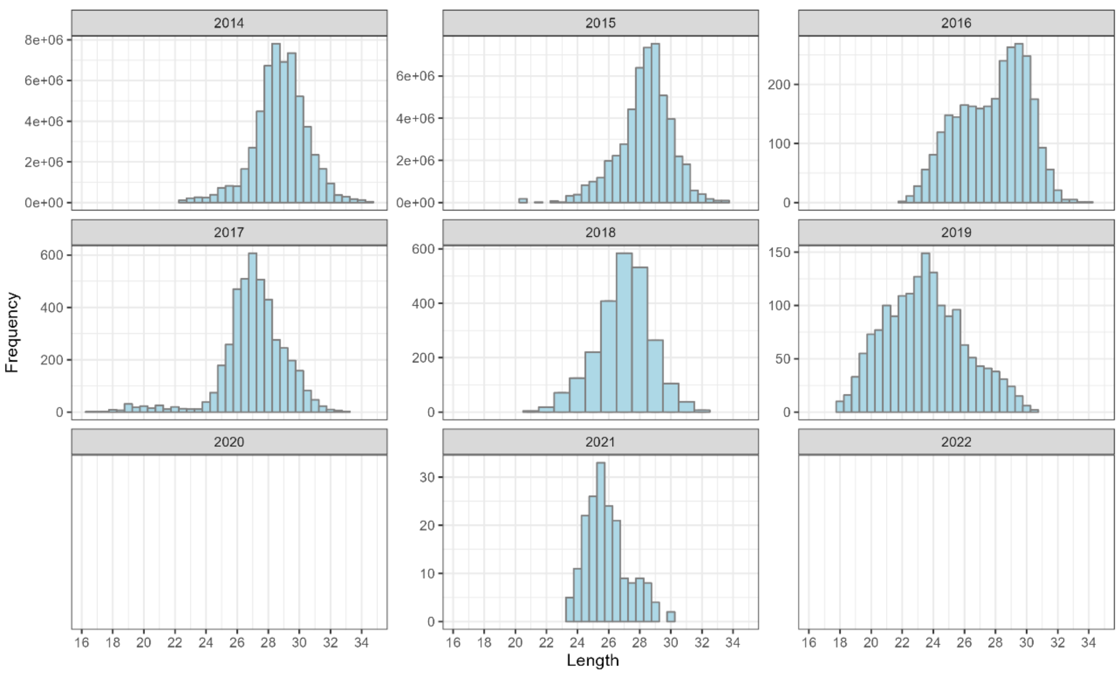


Figure 4.1.7.1. Length-frequency of commercial catches in division 6.aN. Since 2016 a monitoring TAC has been in place for this area. Some data in 2018 were reported to a 1cm resolution, and therefore all data in this year have been binned to this level in this year. No length data from commercial hauls are available for 2020 or 2022.

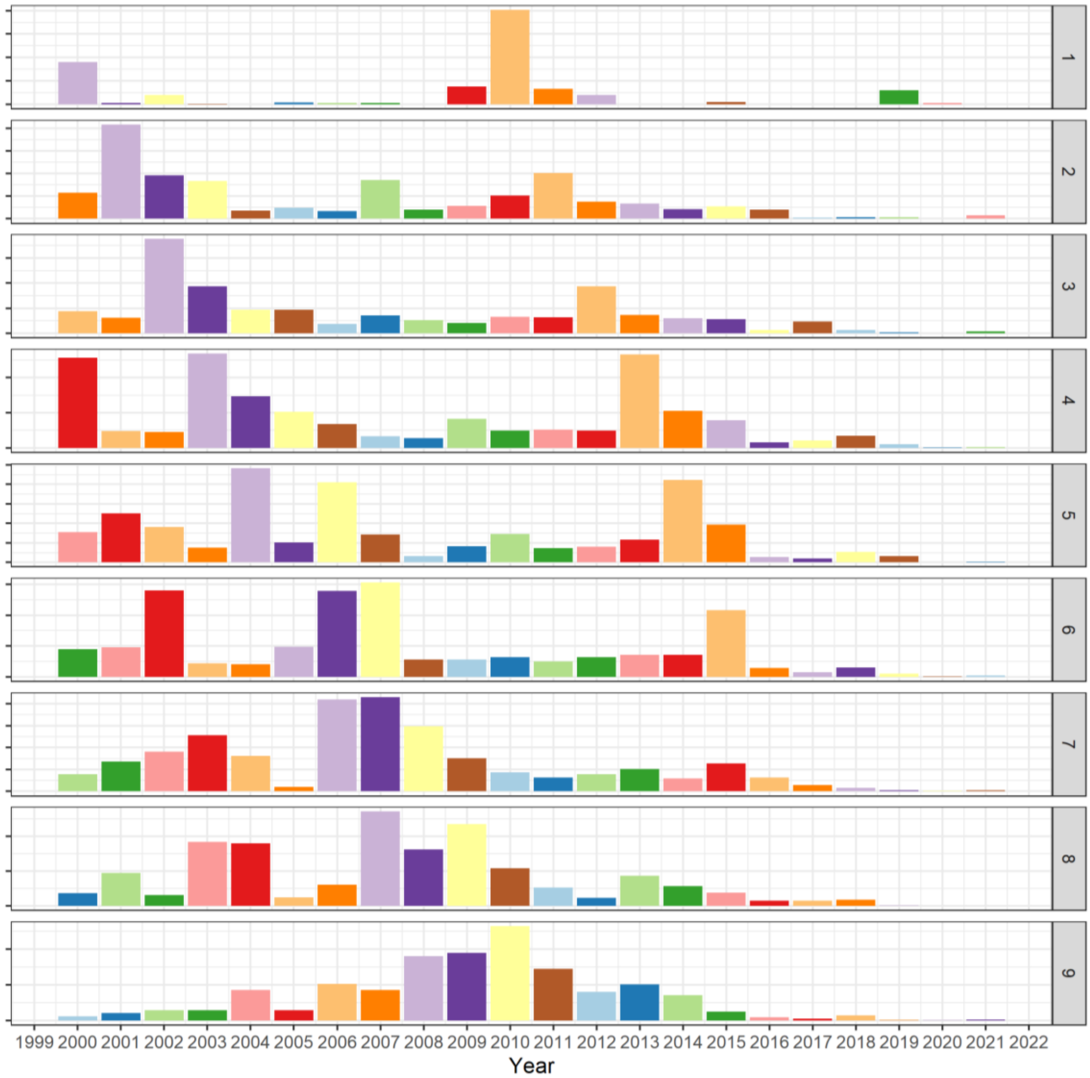


Figure 4.2.1. Catch numbers at age for herring in division 6.aN 2000-2022. Note no commercial samples available for 2022.

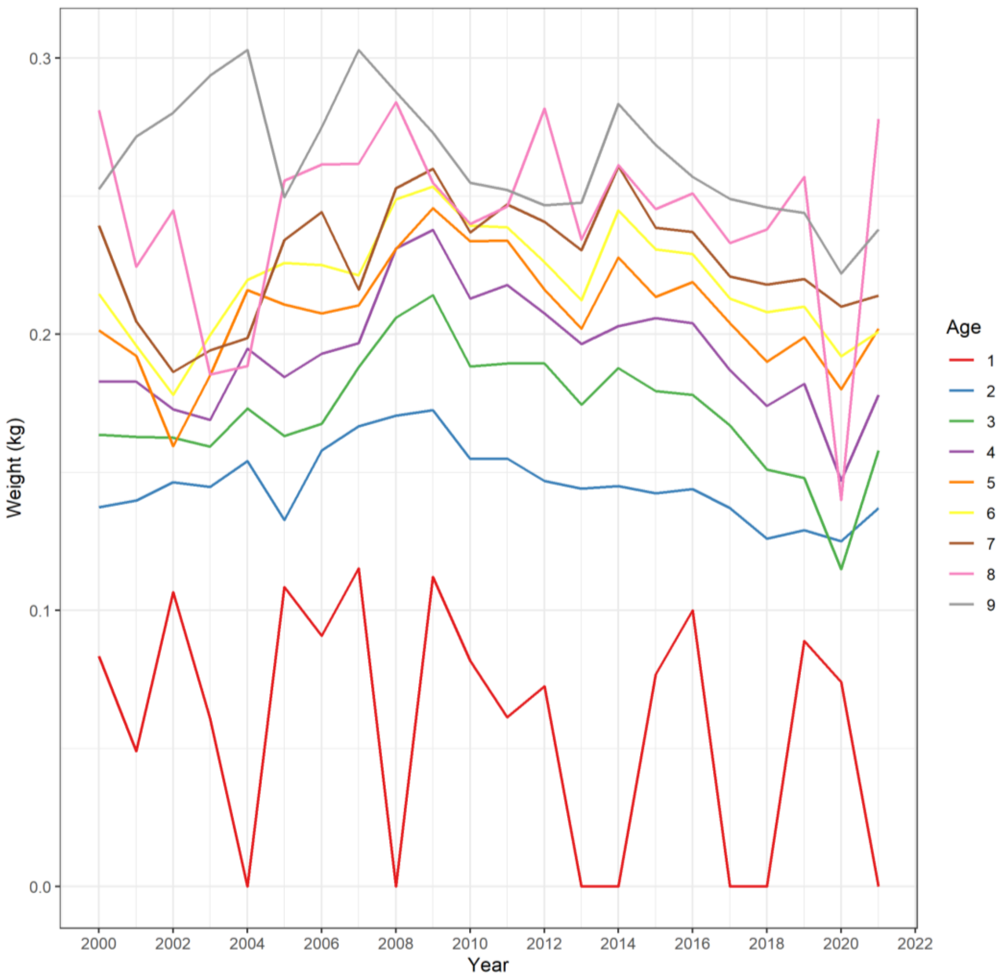


Figure 4.2.2. Weights at age in the catch for herring in 6.aN 2000 – 2022. Note no commercial samples available for 2022.

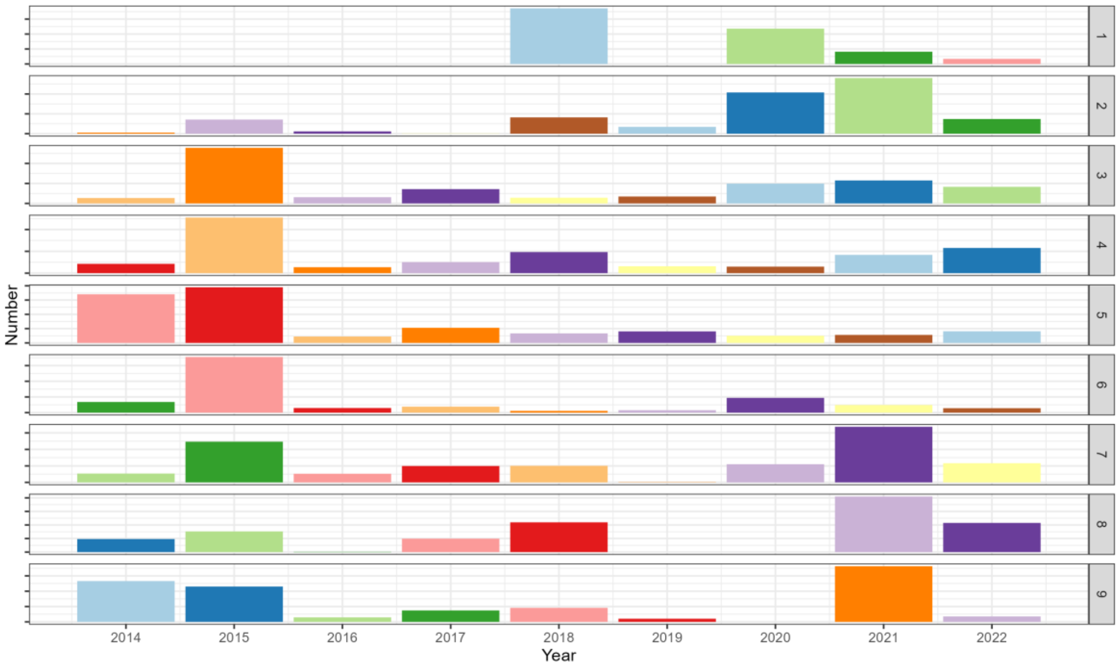


Figure 4.3.1.1. Catch numbers at age for 6.aN autumn spawning herring from the Malin Shelf herring acoustic survey 2014-2022.

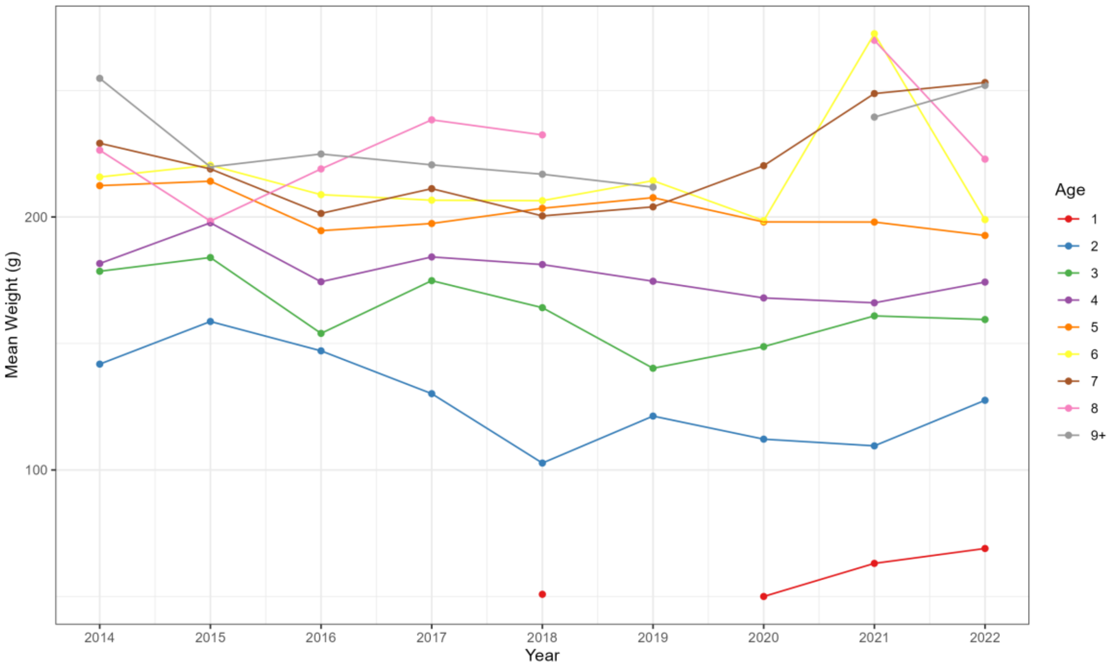


Figure 4.4.1.1. Weights-at-age for 6.aN autumn spawning herring from the genetically split Malin Shelf Herring acoustic survey 2014-2022.

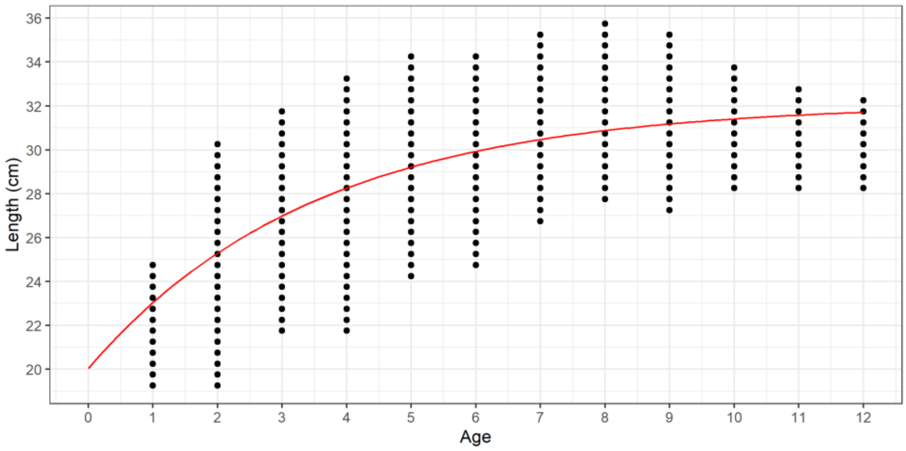


Figure 4.6.1. Growth curve calculated from commercial catches in division 6.aN, and gives an estimated L∞ value of 30.51cm with an associated *k* value of 0.335

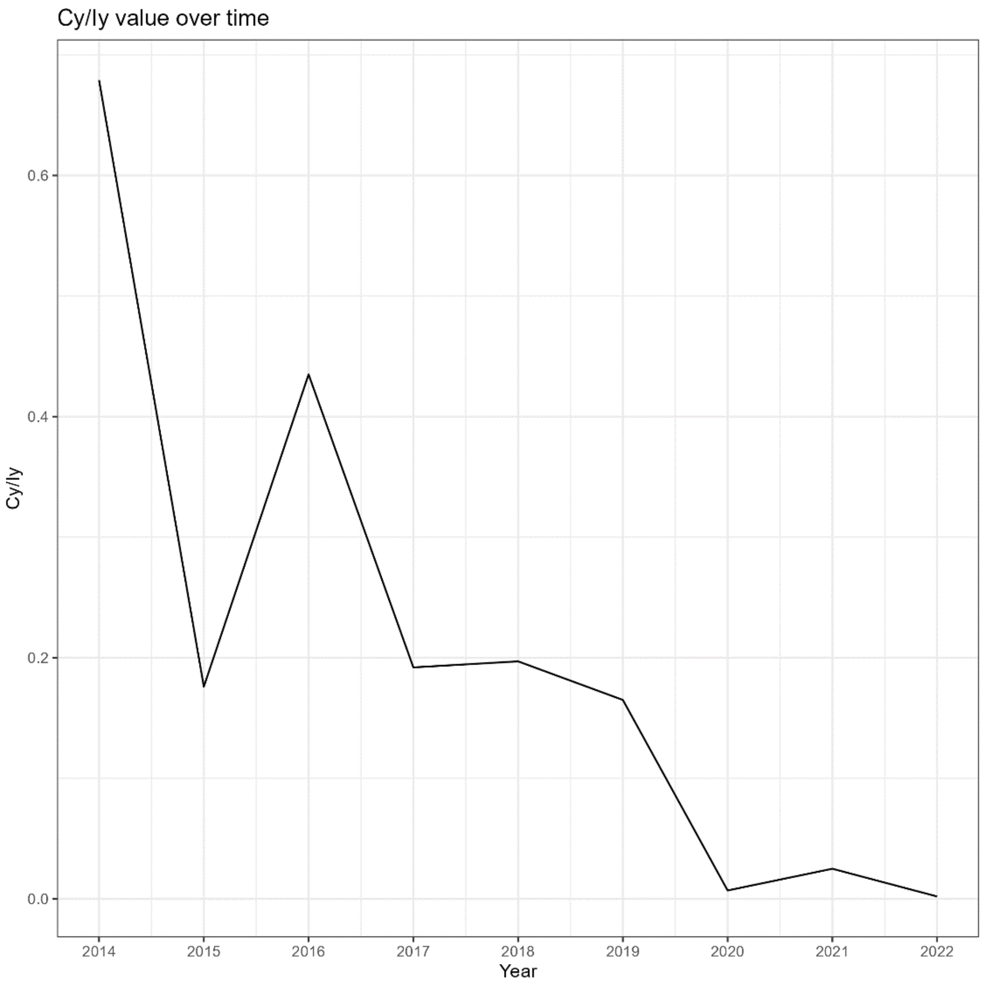


Figure 4.6.3. The ratio C/I for 6.aN herring 2014-2022, from which the $F_{MSY\ proxy}$ value is calculated in the first year of the CHR rule being implemented.

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 2022–2023

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 (ICES 2015a). The development of a genetic method to split the Malin Shelf Herring Acoustic Survey biomass index into the component stocks means that separate advice is now possible. After the benchmarking process in early 2022 (WKNSCS, 2023), the stocks were assessed separately again.

In February 2016, the European Commission asked ICES to provide advice on a TAC of sufficiently small size to enable ongoing collection of fisheries-dependent data and continue the long-term catch-at-age dataset. This monitoring TAC was 4840 t, split of 3480 t in 6.aN and 1360 t in 6.aS and 7.b-c for 2021 (EU 2021/92). The fishery was restricted to a monitoring fishery with a TAC of 1,630 t between 2016 – 2019, and 1,360 t between 2020 - 2022. 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 2023 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 2014-2022.

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 2022 opened on 1st November and was concentrated in 6.aS, primarily in two statistical rectangles (Figure 5.1.2). This was similar to the 2019-2021 fisheries. As in 2021, there was also a fishery in Spring 2022 to allow for additional data collection, in particular collection of baseline spawning genetic samples.

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.

5.1.4 Catches in 2022

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 1957-2022 is presented in Figure 5.1.4 and the Irish catch map is shown in Figure 5.1.2. In 2022 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 2022, the fishery was dominated by 3- 5-ringers, accounting for 87% of the catch (Table 5.2.1.2). Smaller proportions of 6-9 ringers are evident in the catch data and account for 10% of the total. 4 ringers are the dominant age class (44%) followed by 3 (33%), and 5 (10%) 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 4 ringers in 2022.

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 2020 the proportions of 1 ringers was higher in the acoustic survey than the catch while in 2019 a higher proportion of 1 ringers were found in the catch. In 2021 the catch picks up a high proportion of 3 ringers (2018 year-class) while the survey peaks at 2 ring (2019 year-class).

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 since 2016. 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.

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.

StoX survey analysis software: 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 from 2014-2022 is presented in Figure 5.3.1.1. Herring in 6aS, 7bc (her-irlw) shows a significant increase in biomass since the low SSB seen in all components in 2016. The latest year, 2022, shows a slight decrease in estimated biomass. 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 winter ring, 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 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.

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 2023 meeting, the 2022/23 industry/science acoustic survey was still underway so could not be reported. The following information relates to the 2021/22 survey. The 2021/22 survey again focused on 6 core areas and was carried out in December 2021 and January 2022. The 2021 survey was conducted using five vessels; MFVs Crystal Dawn WD201, Ros Ard SO745, Girl Kate SO427, K-Mar-K SO695 and Rachel D SO976. This survey is the sixth 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 2021. 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 =0.23). The stock was not overall contained in 2021, 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 by mid-December and the Foyle by mid-January. There was also a series of strong herring marks in Bruckless Bay, Fintra Bay (SE of Inishduff) and Inver Bay in discreet areas. 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 74% of the overall numbers in 2021. The total stock biomass (TSB) estimate of 35,944 tonnes is considered to be a minimum estimate of herring in the 6aS,7b survey area at the time of the survey. 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 2020 and 2021 surveys is 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), a herring index was developed from three groundfish surveys (IBTS), namely

- IE-IGFS – Irish Groundfish Survey (2003-2020) (G7212)
- SWC-IBTS – Scottish West Coast Groundfish Survey (1985-2009) (G1179, G4299)
- SCOWCGFS – Scottish West Coast Groundfish Survey (2011-2020) (G4748, G4815)

Using the same methodology as that used for the index calculations for many herring stocks, the model combines GAMs and continuation ratio logits (CRL) to model the probability of age given fish length and location. A geographic split was used, i.e. hauls were only included in the index calculation if they occurred within ICES divisions 6aS or 7b,c (Figure 5.3.3.1). The optimum model includes the effect of haul location, depth and time of day. The internal consistency of this time series is presented in Figure 5.3.3.2. The internal consistency of the index is poor outside of the range 2-7 and ages 1, 8 and 9 were excluded from exploratory assessment runs.

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).

5.6.1 Data Exploration

A comparison of the age structure in the catch data, acoustic survey and IBTS survey, is presented in Figure 5.6.1. In some years the surveys picks up a larger proportion of 1 winter ring fish but this is variable between years. Some years the 1 winter ring fish are not found in the catch or the survey but may be found in considerable quantities the following year as 2 winter ring fish.

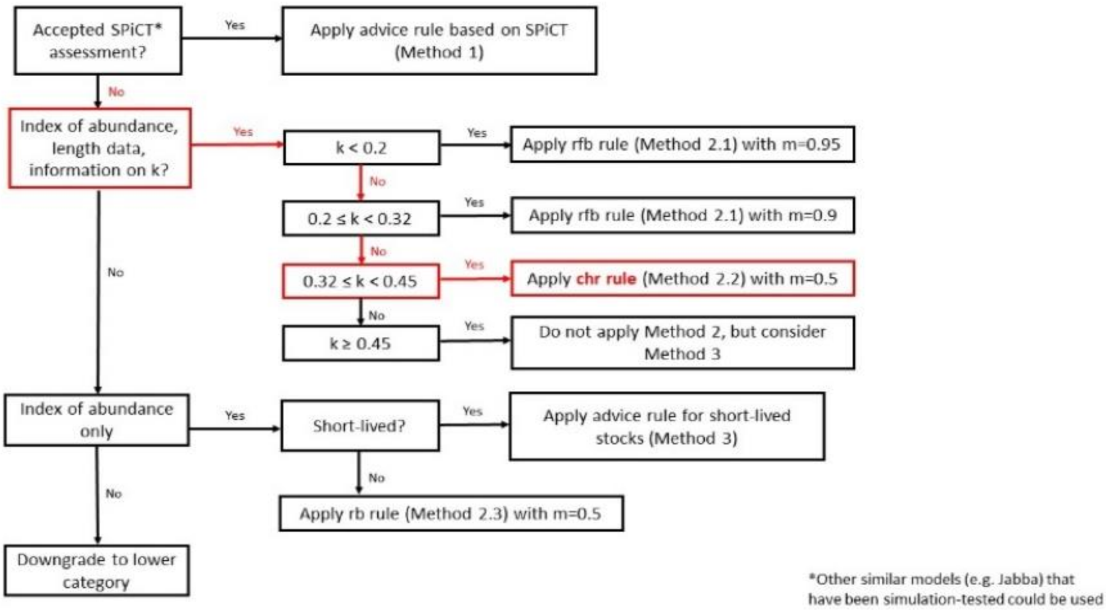
1 ringers in 2019 were not found in a high proportion in the acoustic survey but were found in the catch and contributed to a high proportion of the IBTS data. This 2018 year-class was found by the catch and the survey as 2 ringers in 2020 and 3 ringers in 2021.

The 2017 year-class was found in high quantities by the IBTS survey and was strong in the acoustic survey but not in the catch in 2018. In 2019 this 2017 year-class was strong in the catch data and this has followed through to 4 ringers in 2021. The 2019 year-class was strongest in the acoustic survey in 2020 and is seen in significant proportions in 2021 in both surveys but is not as strong in the catch data. The ability of each of the data sources to track cohorts is variable.

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.

5.6.2 Final Assessment for 6.aS and 7.b–c herring

The final 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 decision flow chart is included 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*)

Method 2.2 of WKLIFEX is the constant harvest rate (*chr*), also called the F_{proxy} rule or the "Icelandic" rule. It 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. This information is explained in further detail in the WKLIFEX report (see table 3.4.2.1 of that report for a full description of how $F_{MSY\ proxy}$ is calculated).

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. Most appropriate M/k ratio highlighted in bold.

Target Harvest Rate

The derivation of the target harvest rate, $F_{MSY\ proxy}$, from length frequency data requires calculating the target reference length, $L_{F=M}$. Target reference length is calculated 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.

All other calculations followed the WKLIFEX protocols.

5.6.2.3 Constant Harvest Rate Results

The split survey index has shown an increasing trend since 2016 with the exception of the latest SSB estimate (2022), which is lower than the previous year. However, the 2022 SSB estimate is still above the trigger, which is 1.4 times the lowest observed survey biomass (Figure 5.6.2.3.1).

$F_{MSY\ proxy}$ is estimated at 0.034 and the target reference length for the latest year is 27.11 cm. Length frequency distribution are presented in Figure 5.6.2.3.2. These length values will update for each year of data added to the time series but $F_{MSY\ proxy}$ is set unless there is a major change in the fishery or a new benchmark (WKLIFEX).

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.

Stability Clause

A stability clause constraining the change in advised catch to -30% or +20% is also included. ICES guidelines state the mean of the previous 3 years' catch should be used when calculating the stability clause for the first time, which in this case is appropriate given the uptake of the monitoring quota in those years. It was agreed at the most recent benchmark that the most appropriate starting value would be the average catch in the past three years (ICES, 2021h). Subsequent years use the previously advised catch as the basis of the stability clause.

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

Category 3 method 2.2 *chr* rule using a stock specific M/k value was recommended by the benchmark group. 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 – 2022 (inclusive). Note that $F_{MSY\ proxy}$ has been set at the benchmark value. All calculations are now uploaded on ICES TAF.

5.7 State of the Stock

The genetically-split Malin shelf acoustic survey abundance and biomass estimates for 2014-2022 (incl.) provide the most reliable index for this stock. The biomass has shown an increasing trend since 2016 (36,706 t) but there was a slight decrease in 2022 (Table 5.3.1.1. and Figure 5.3.1.1). Recent catches are among the lowest in the time series. A monitoring TAC has been 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 44% of the catch numbers at age in 2022.

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.

The length at first capture (L_c) and the target reference length were calculated independently for every year of data in order to have the option to be more responsive to changes in the stock and/or fishery selectivity as the stock rebuilds. However, the $F_{MSY\ proxy}$ reference point calculated during the benchmark is considered set and will not be changed in subsequent years unless major changes in the stock or fishery occur (ICES WKLIFEX).

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 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 of 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, 1992–2022. 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

***Unraised discards**

Table 5.2.1.1. Herring in divisions 6.aS, 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2022.

	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

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%

Table 5.2.2. Herring in divisions 6.aS, 7.b–c. Sampling intensity of catches in 2022.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.aS	1	584	12	653	3121	1118
6.aS	4	738	28	1048	6456	1420
6.aS	3	1				
7.b	1	1				
7.b	4	2				
Total	2021	1326	40	1701	9577	1283

Table 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the catches 1970–2022.

	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
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203

	1	2	3	4	5	6	7	8	9+
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
2018	0.085	0.101	0.127	0.144	0.155	0.166	0.172	0.170	0.174

	1	2	3	4	5	6	7	8	9+
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

Table 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2022.

	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
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

	1	2	3	4	5	6	7	8	9+
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
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

	1	2	3	4	5	6	7	8	9+
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

Table 5.3.1.1. Herring in divisions 6.aS, 7.b–c Total numbers (millions) and biomass (tonnes) of herring June–July 2014-2022. 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

Table 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Mean Weights at age of herring June–July 2014-2022. 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

Table 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Maturity at age of herring June–July 2014-2022. 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

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	Biomass	SSB
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
2006	Winter	27770	27200
2007	Winter	14222	13974
2016	Winter	35475	35475
2017	Winter	40646	40646

Year	Type	Biomass	SSB
2018	Winter	50145	49523
2019*	Winter	25289	22386
2020**	Winter	45046	44107
2021**	Winter	35944	35859
*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, see table 3.4.2.1 of that report for a full description of how $F_{MSY\ proxy}$ is calculated).

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	149,270	5,096	0.034	28.000	26.000	27.996	27.958	1.001	0.999
2015	226,293	1,078	0.005	27.000	26.500	27.680	28.241	0.980	1.020
2016	36707	2213	0.060	28.000	25.000	27.298	27.393	0.996	1.003
2017	66342	2227	0.034	26.000	25.000	27.006	27.393	0.986	1.014
2018	96138	1495	0.016	27.000	25.500	27.184	27.676	0.982	1.018
2019	92364	1690	0.018	25.500	23.000	26.170	26.264	0.996	1.004
2020	135335	1220	0.009	24.000	22.500	25.030	25.981	0.963	1.038
2021	189856	1821	0.010	25.500	24.500	25.993	27.111	0.959	1.043
2022	147199	1326	0.009	26.000	24.500	26.117	27.111	0.963	1.038

*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
$F_{MSY\ proxy}$	0.034
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 – 2022 (inclusive).

Previous Advice	1892 t
$Index_{y-1}$ (survey SSB)	147 199 t
$F_{MSY\ proxy}$	0.034
b (biomass safeguard)	1

m (multiplier)	0.5
chr ($C_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$)	2502 t
% Change (from previous advice)	32%
Stability Clause Applied (-30% or +20%)	2270 t
Advised Catch $_{y+1}$	2270 t

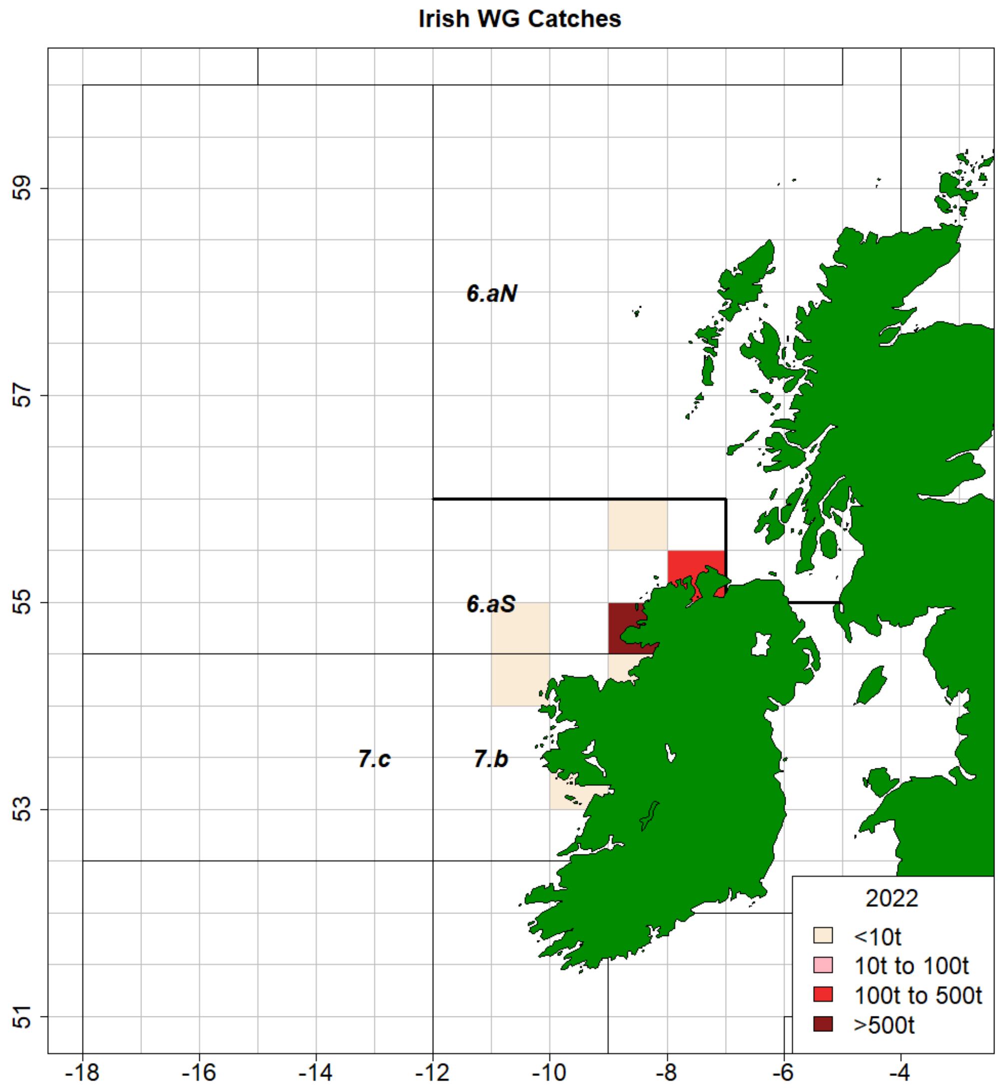


Figure 5.1.2 Herring in divisions 6.aS, 7.b–c. Irish catches in 2022.

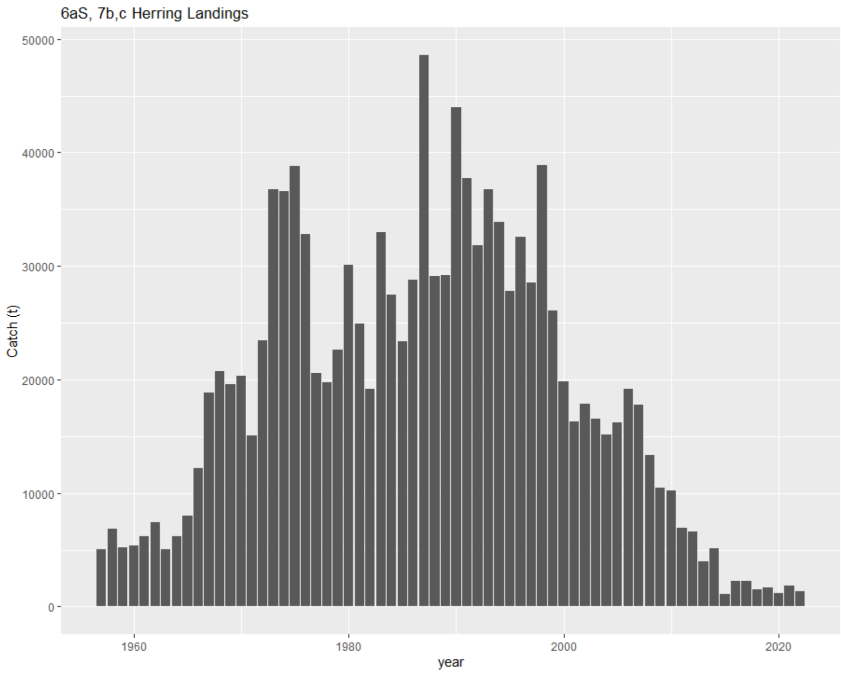


Figure 5.1.4 Herring in divisions 6.aS, 7.b–c. Working group estimate of catches from 1957–2022.

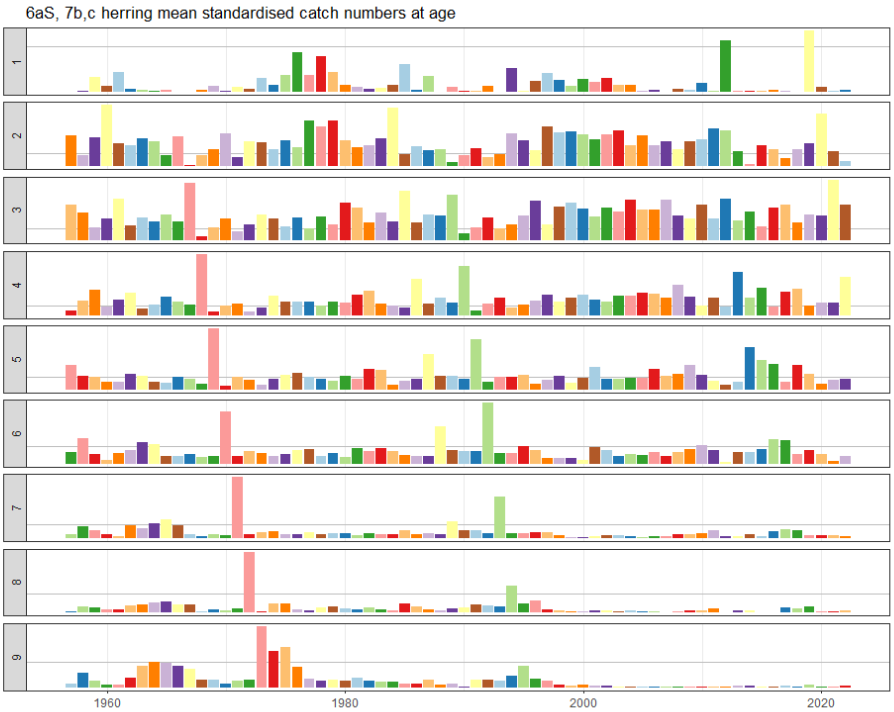
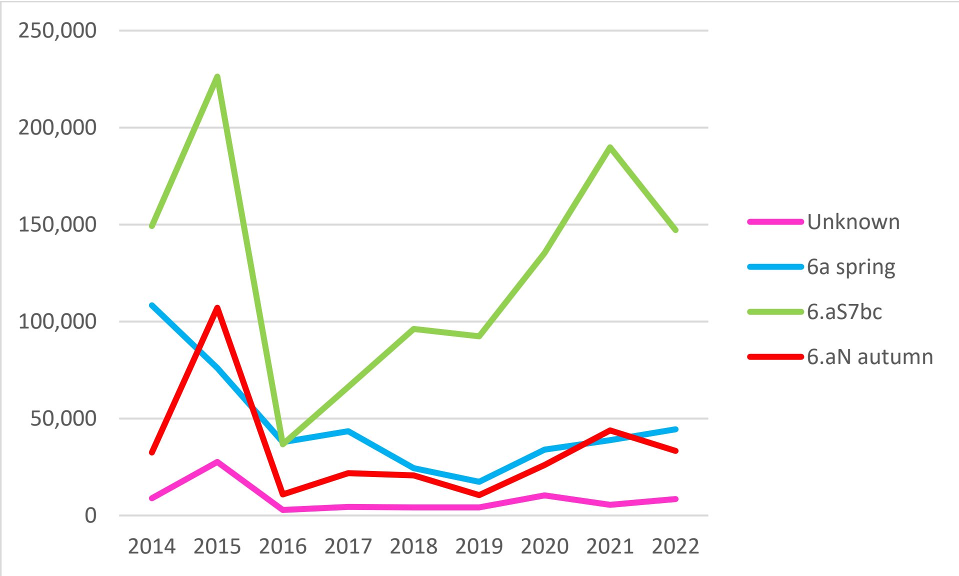


Figure 5.2.1. Herring in divisions 6.aS, 7.b–c. catch numbers-at-age standardized by year for the fishery 1957–2022.



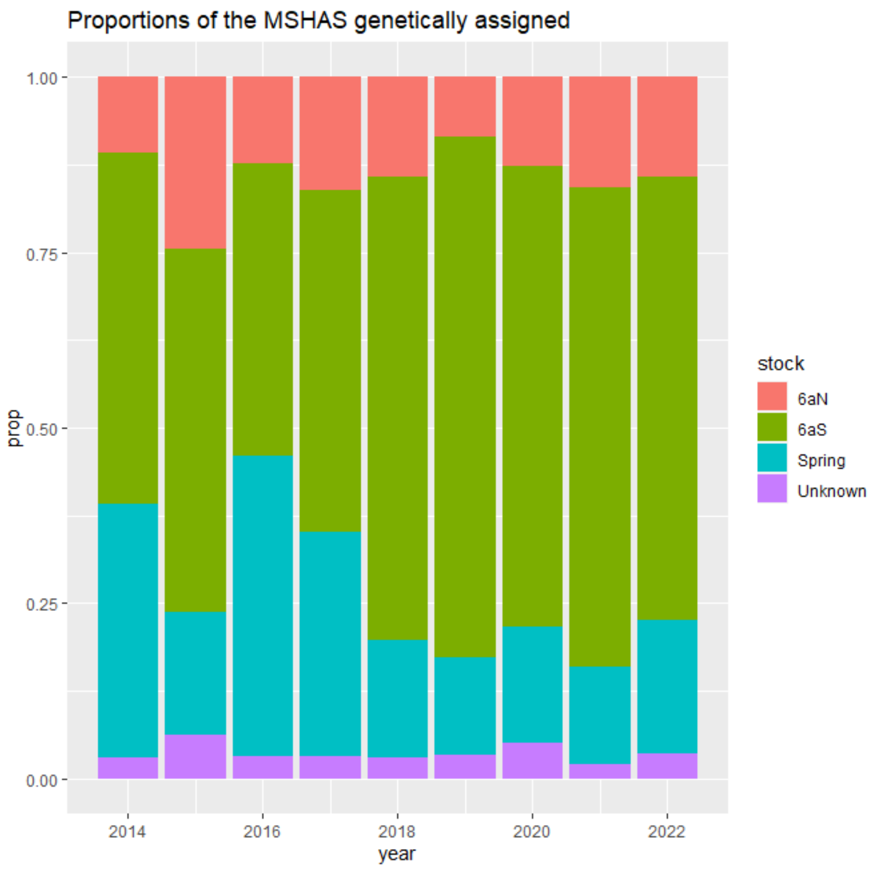


Figure 5.3.1.1. Herring in divisions 6.aS, 7.b–c . SSB (t) time-series for the individual MSHAS split indices (2014 – 2020). her-irlw refers to her.27.6aS,7b,c

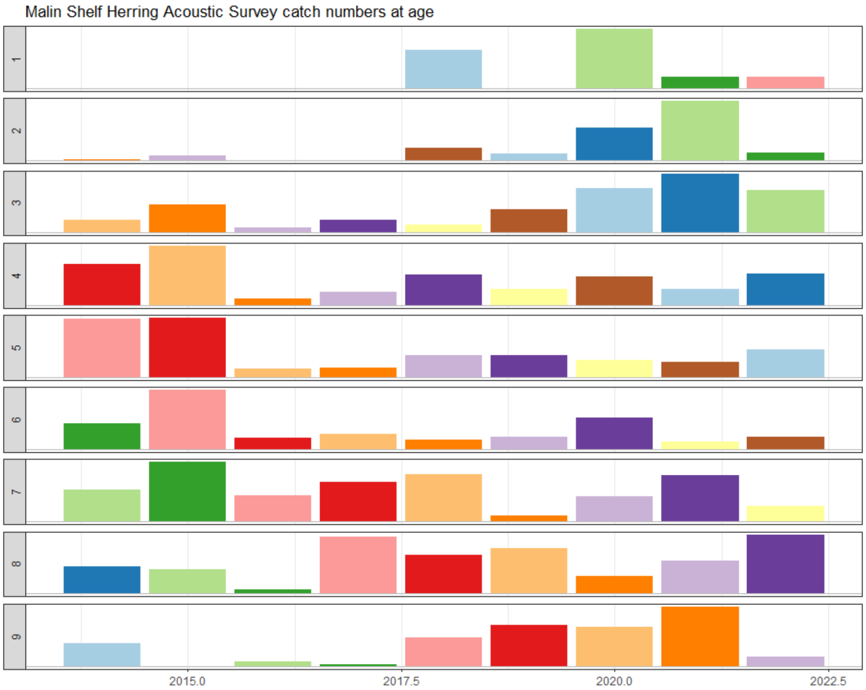


Figure 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Malin Shelf Acoustic Survey - split catch numbers at age.

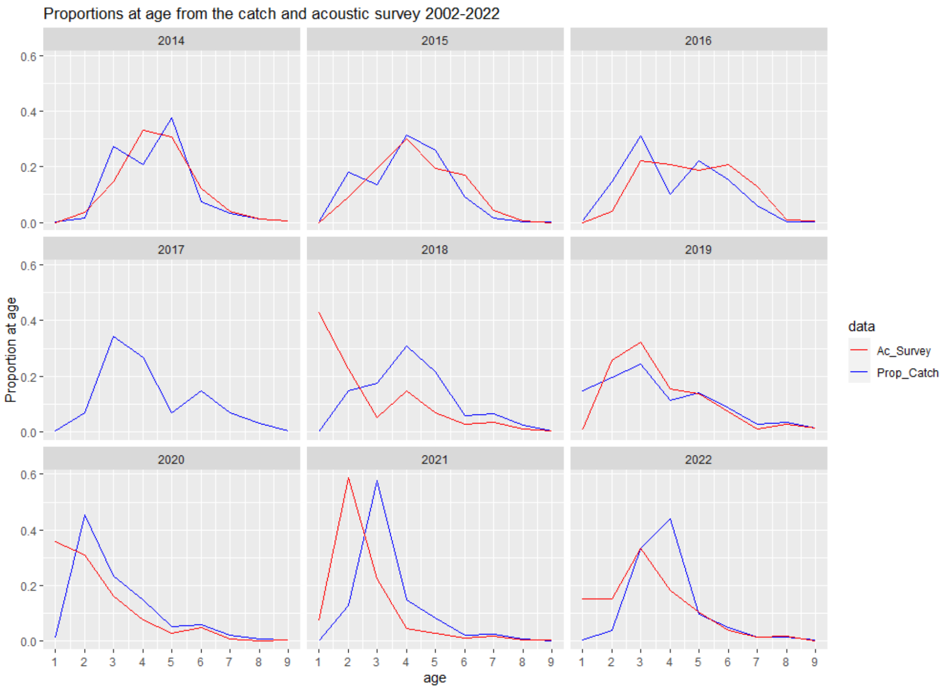


Figure 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Proportions-at-age in the 6aS, 7.b–c catch and 6aS, 7.b–c Split Malin Shelf acoustic survey (MSHAS) 2014–2022.

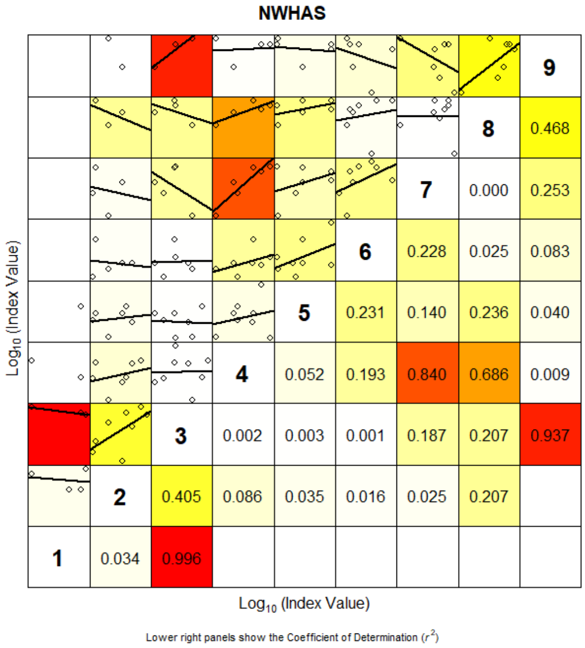
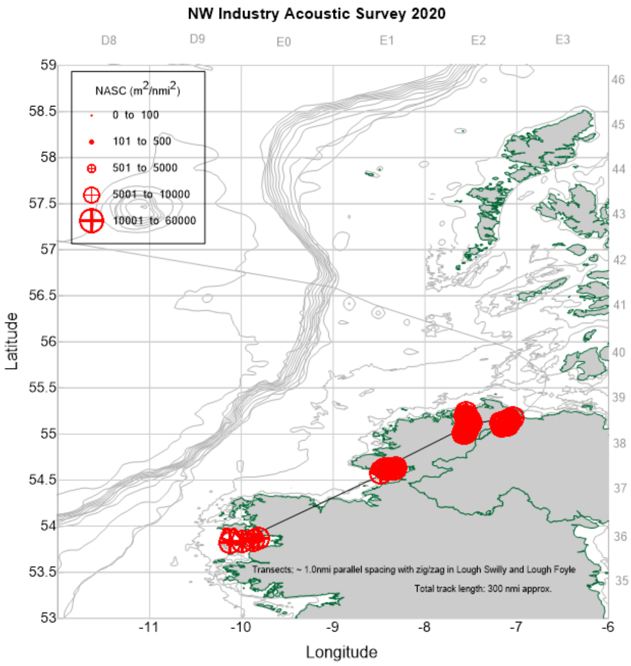


Figure 5.3.1.4 Herring in divisions 6.aS, 7.b–c. Internal consistency between ages (rings) in the Split MSHAS herring acoustic survey time-series (2014–2022).



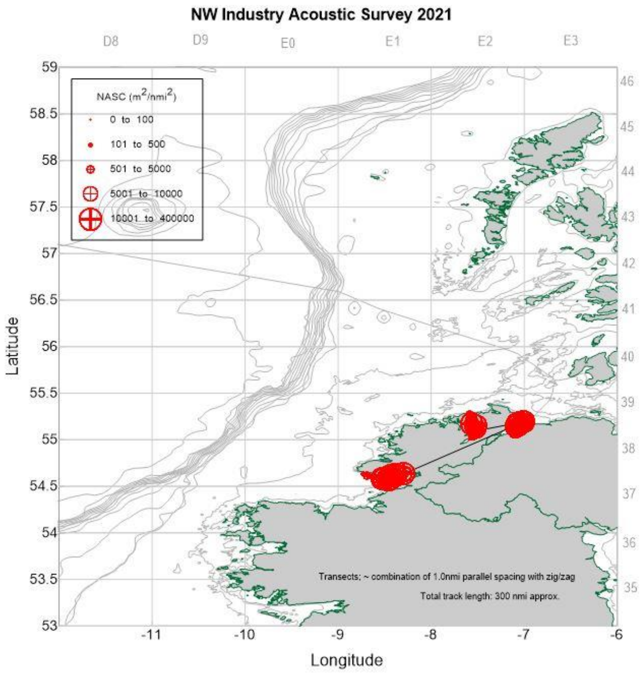
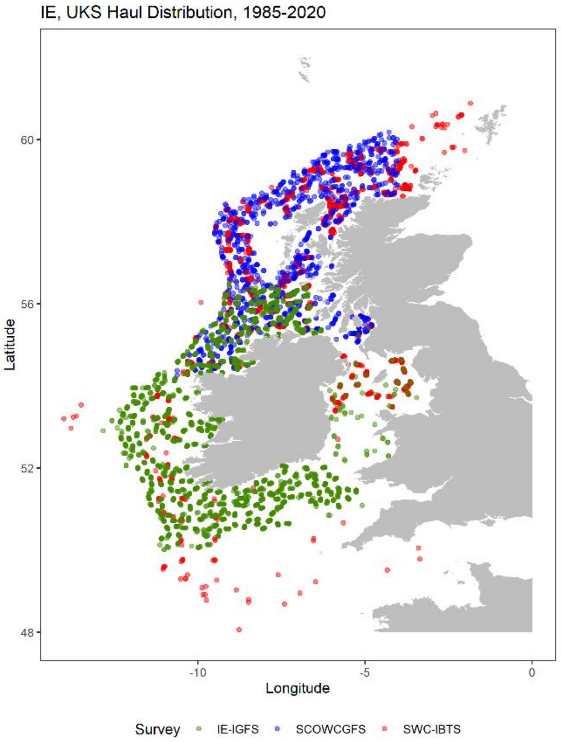


Figure 5.3.2.1. Herring in divisions 6.aS, 7.b–c. NASC distribution in the industry science surveys 2020 and 2021



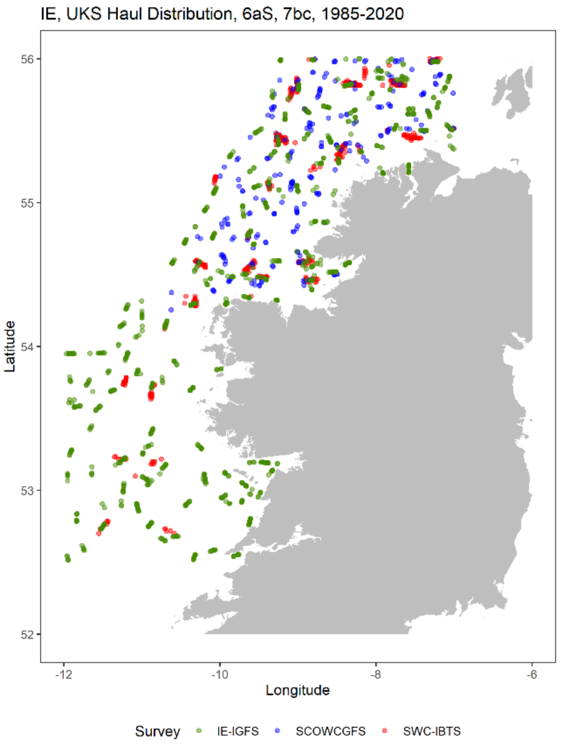


Figure 5.3.3.1 Herring in divisions 6.aS, 7.b–c . IBTS hauls positons from IE-IGFS (green), SWC-IBTS (red) and SCOWCGFS (blue) surveys, left – all hauls, right hauls in div 6a, south of 56˚N and divisions 7b and 7c

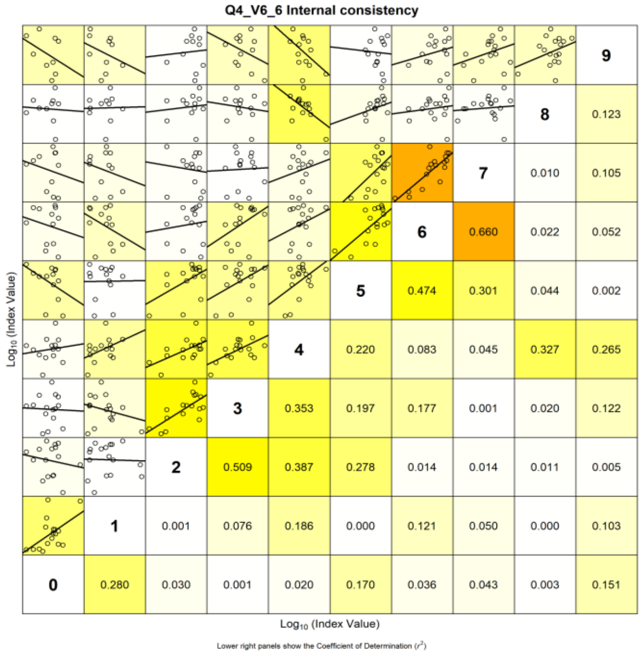


Figure 5.3.3.2. Herring in divisions 6.aS, 7.b–c. Internal consistency plot showing pairwise regressions and associated R² values from the IBTS Index.

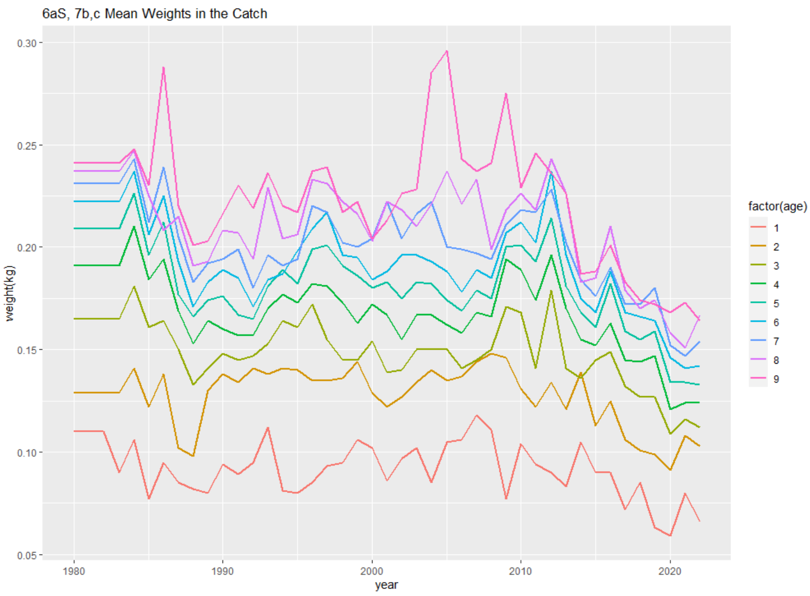


Figure 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2022). Prior to 1981 weights were fixed.

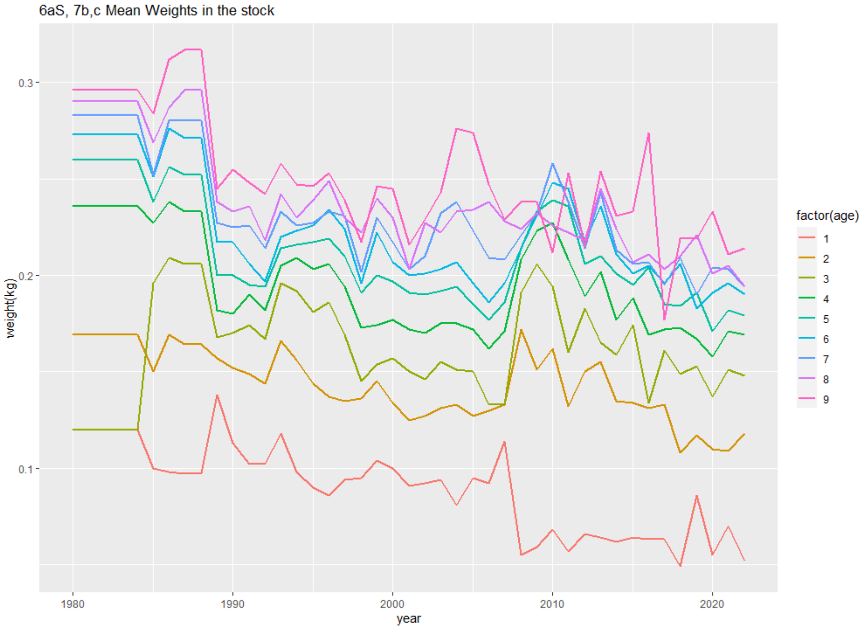


Figure 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2022). Prior to 1981 weights were fixed.

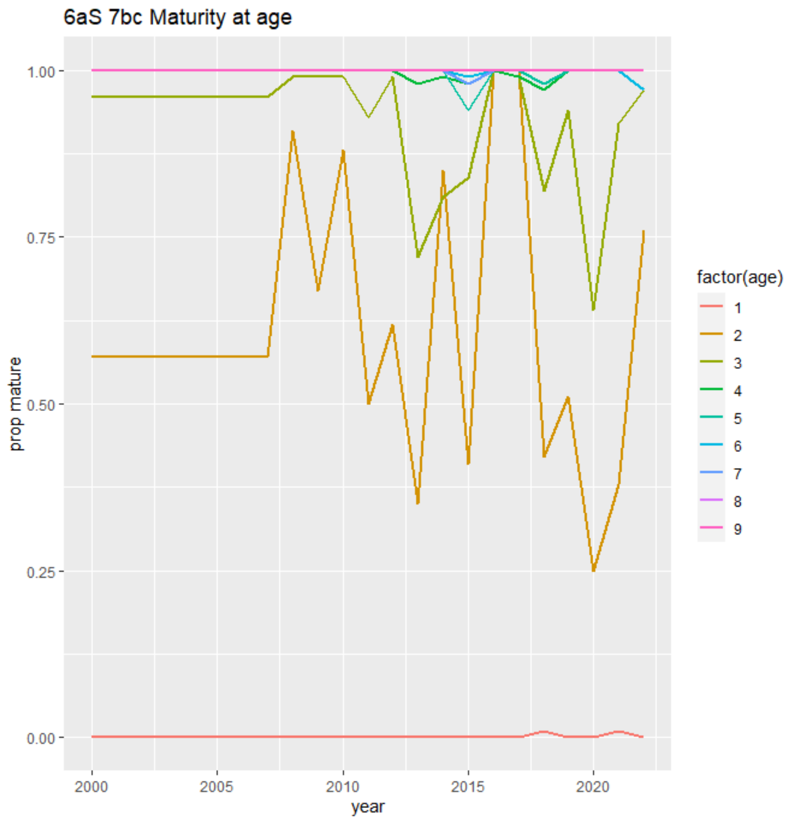


Figure 5.4.2. Herring in divisions 6.aS, 7.b–c. Maturity Ogive.

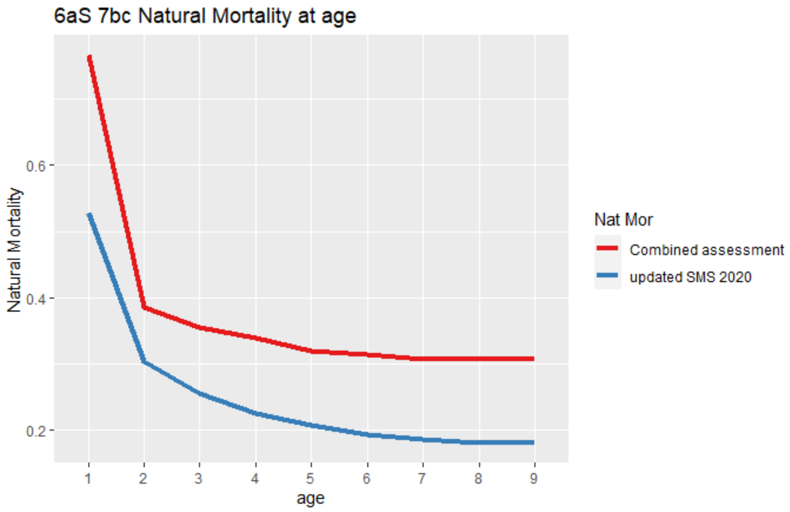


Figure 5.4.3. Herring in divisions 6.aS, 7.b–c. Natural Mortality at age updated at the benchmark in 2022 and the previously used value.

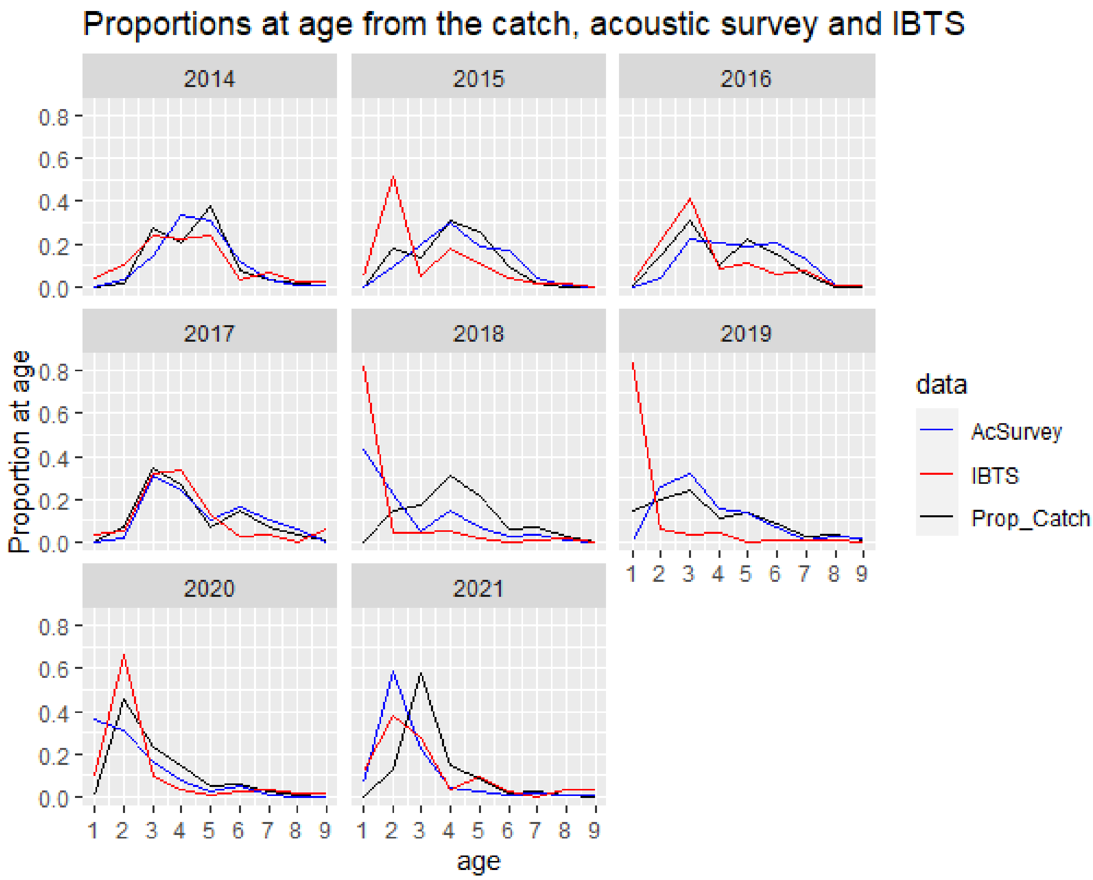


Figure 5.6.1. Herring in divisions 6.aS, 7.b–c. Proportions-at-age in the 6aS, 7.b–c catch and 6aS, 7.b–c Split Malin Shelf acoustic survey (MSHAS) and the IBTS survey 2014-2021.

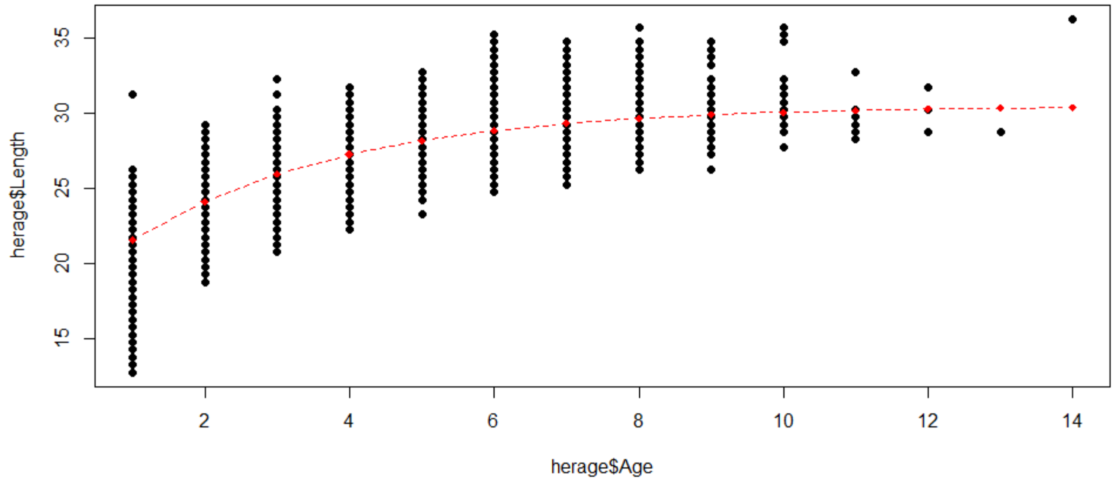


Figure 5.6.2.1. Herring in divisions 6.aS, 7.b–c. Fit of growth curve to length data from commercial catch of herring in 6aS and 7b. n = 594k.

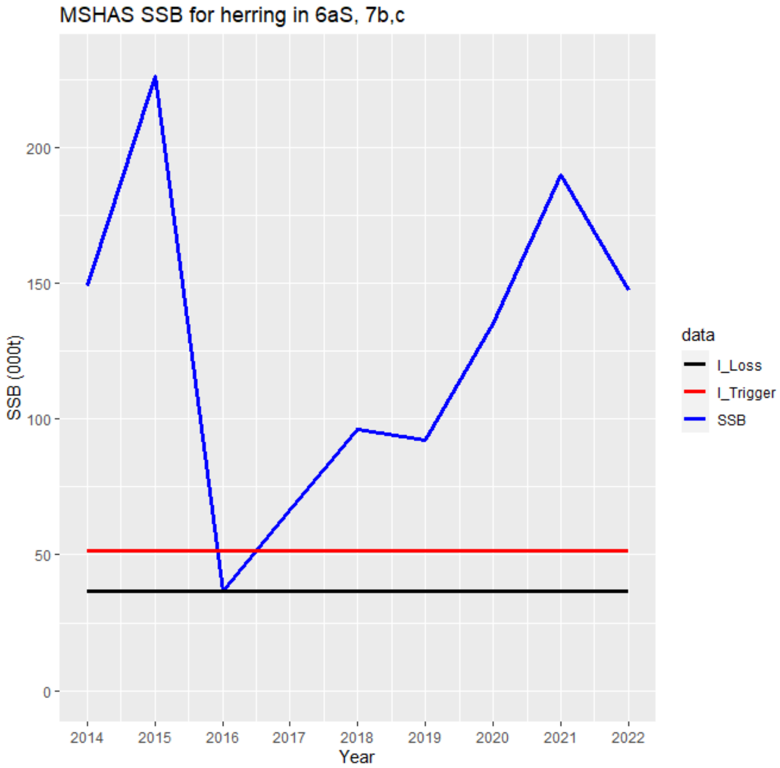


Figure 5.6.2.3.1 Herring in divisions 6.aS, 7.b–c. MSHAS 6aS Split Spawning Stock Biomass (tonnes) by year. Black line shows lowest observed value (I_{loss}); Red line shows 1.4 * I_{loss} ($I_{trigger}$).

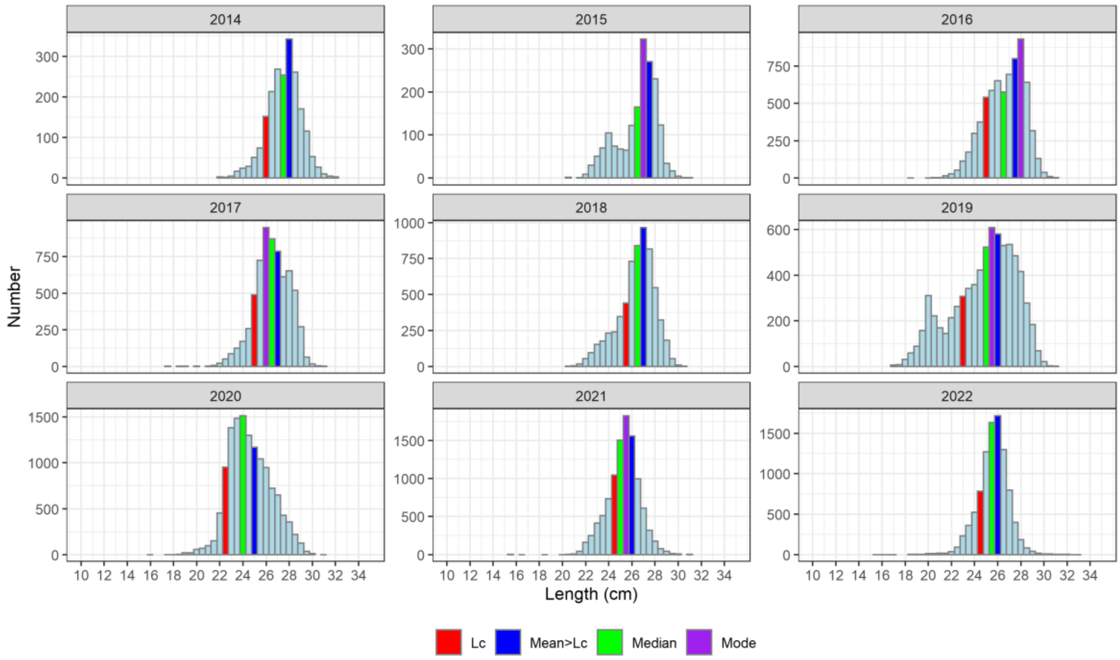


Figure 5.6.2.3.2 Herring in divisions 6.aS, 7.b–c. Length frequency distributions by year showing length at first capture (Lc), Mean length above Lc (Mean>Lc), the median and the mode from catch sampling data.

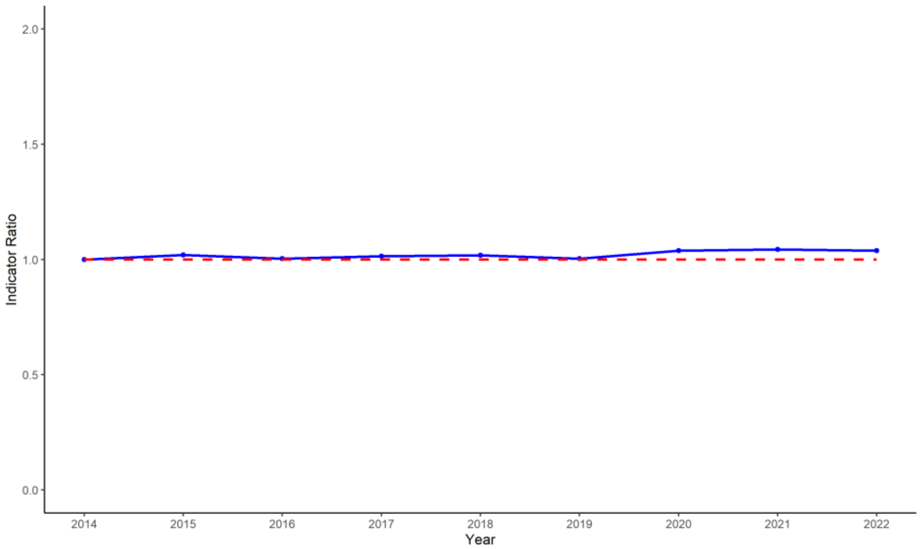


Figure 5.6.2.3.3 Herring in divisions 6.a South and 7.b–c. Indicator ratio $L_{F=\gamma M,K=\theta M}/L_{mean}$ (inverse of fishing proxy, *f*) from the length-based indicator (LBI) method is used for the evaluation of the exploitation status. The proxy fishing pressure is less than the pressure corresponding to the F_{MSY} proxy ($L_{F=M}$) when the indicator ratio value is lower than 1 (shown by a horizontal dotted red line

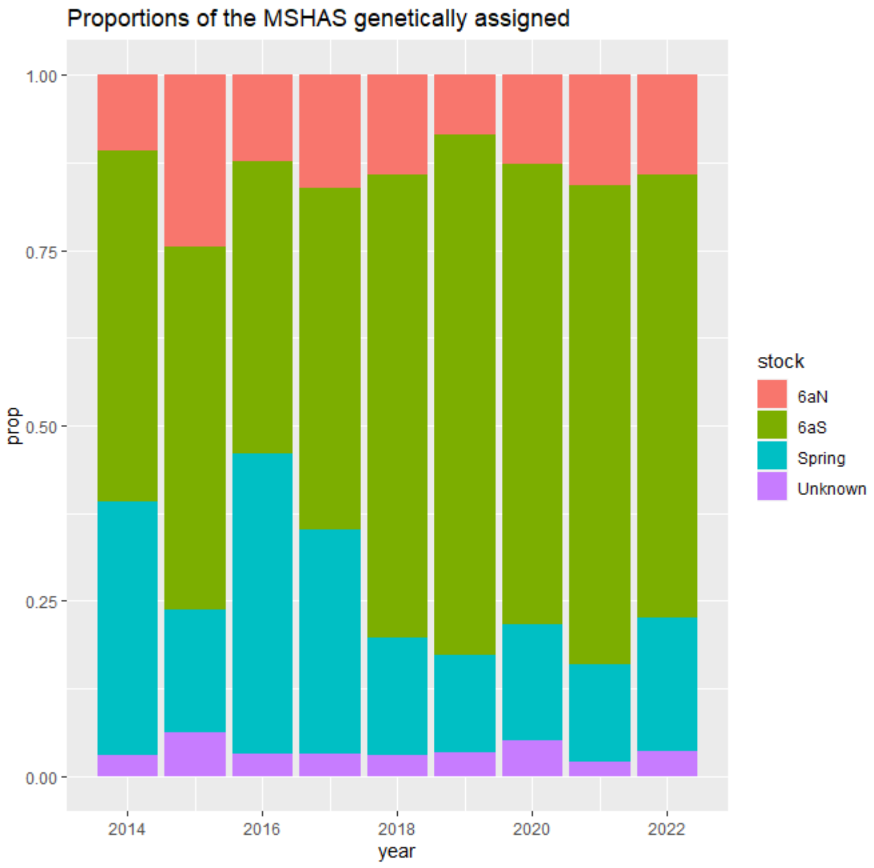


Figure 5.10.1. Herring in divisions 6.aS, 7.b–c. Proportions of the MSHAS genetically assigned.

6 Herring in the Celtic Sea (divisions 7.a South of 52°30’N and 7.g, 7.h and 7.j)

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. 2022 refers to the 2022–2023 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 2022–2023

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 2023 was 869 t.

6.1.2 The fishery in 2022–2023

In 2022, the Irish fishery took place in 7.j, 7.g and 7.a.S in Q4 as in previous years. There was also a small amount of catch (2t) taken from 7.aS in Q1 2023.

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 began in 7.g in late September and continued until early November, with over 143 t landed in total. The fishery in 7a.S started in late November and continued until mid-December. In Q1 2023 all of the catch was taken in 7.aS.

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 2022 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2022.

The estimated catches from 1988–2022 for the combined areas (7.a.S, 7.g, 7.h, 7.j) by quota year and by assessment year (1 April–31 March) are given in tables 6.1.2.1 and 6.1.2.2 respectively. The catch taken during the 2022–2023 season decreased to 350 t from 745 t in 2021-2022 (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.

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 2022 one observer trip was 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 landings 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 1958-2022. The dominant year class in recent years was the 2018 year class. These fish are currently 4 winter rings (34% in 2022). The 2019 year class, three winter ring fish, were the dominant in 2022 representing 61% of the total catch numbers at age (Table 6.2.1.1.).

The yearly mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Older ages 6, 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 and these have been caught as 2 ringers in 2020 and 3 ringers in 2021 and 4 ringers in 2022. 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 2022, the samples from 7aS Q4 cover a wider range of lengths from 16.5cm – 30cm than from 7g which cover lengths 22cm-28cm.

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 2022. There were 11 samples obtained from the monitoring TAC that was taken (350 t). Three samples were obtained from the main fleet and eight from the sentinel fleets in 2022.

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 2022, 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 6.3.1.4.

The acoustic survey of the 2022–2023 season was carried out from 9th to 29th October 2022, on the RV Tom Crean (O'Donnell *et al.*, 2022, http://hdl.handle.net/10793/1815). Geographical coverage was 28% lower than the 2021 survey. The acoustic survey track is shown in Figure 6.3.1.1.

NASC distribution plots from the 2022 survey are presented in Figure 6.3.1.2. Immature herring were widespread throughout the survey area, both offshore and in coastal waters in mixed species aggregations/layers dominated by sprat. Immature herring accounted for over 1.43% of TSB and over 10% of TSN. Mature herring were observed in a high density offshore aggregation.

The 2022 estimate represents an increase of 21% of TSB and a reduction of 174% of TSN compared to 2021. The reduction in abundance (number of fish) is driven by the smaller number of larger individuals contributing to the stock as compared to the more numerous but smaller individuals last year. Spawning stock biomass increased by 46% and SSN increased by 44% compared to 2021.

A total of 20 trawl hauls were carried out during the survey in 2022, with twelve 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 (3wr) and the 2018 year class (4wr) dominated the 2022 catch numbers. 3-wr fish contributed 52.2% to the TSB and 50.6% to TSN, followed by 4-wr fish 40.5% TSB & 34.5% TSN.

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 2022 decreases in mean weight can be seen for most age classes. 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 are the same as the catch weights with decreases seen across several ages in 2022.

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 surveys. 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 the exception of 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 0.85 in the 2023 assessment over a five-year peel. This is significantly higher than the threshold value of 0.2.but is a decrease from the 2022 assessment where the Mohns Rho was 1.34. These high Mohns Rho values are most likely due to the current low level of the stock and the low level of the survey index and associated high CV. Regarding SSB (top panel of Figure 6.6.1.8), 1 of the last 5 peels was outside the 95% CI bounds. Following the decision tree provided by WKFORBIAS, advice was given for this stock because SSB is less than B_{lim}.

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 2022. This may be related to the lack of a fisheries-independent estimate of recruitment.

State of the stock

The stock summary plots from the final assessment in 2022 and the update assessment in 2023 are presented in Figure 6.6.1.10 and the stock summary in Table 6.6.1.4. The assessment shows SSB is very low and is estimated to be 16 539 t in 2022, still well below B_{lim} (34 000 t). The 2023 assessment shows a similar SSB trajectory to the 2022 assessment. The assessment indicates that the stock has been below B_{lim} since 2016.

The update assessment estimated mean F (2–5 ring) in 2022 to be 0.028, decreasing from the high of 1.1 for 2018 and from 0.058 in 2021. 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 0.2 and 0.58, 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 of the 2020 year class. This can be seen in the catch data which shows very low numbers of 1 wr fish in 2021 and 2 wr fish in 2022.

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 (2021). As this SSB value (8 741 t) is below the change-point (16 887 t), the following adjustment is applied.

$$Recruitment_{forecast\ year} = plateau\ recruitment \times \frac{SSB_{forecast\ year-2}}{SSB_{changepoint}}$$

$$Recruitment_{2023} = 398427 \times \frac{14215}{32944.5} = 171915$$

Interim year catch was taken to be the monitoring TAC (869 t), which has been agreed for 2023. 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 in previous years.

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 2024.

6.7.2 Multiannual short-term forecasts

No multiannual simulations were conducted in 2023.

6.7.3 Yield-per-recruit

No yield-per-recruit analyses were conducted in 2023.

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 the management plan could not ensure that the stock is fished and maintained at levels that can produce maximum sustainable yield as soon as or by 2020. The long-term management plan is no longer used to give advice for this stock.

In the framework of the development of a monitoring TAC for the CSH, long-term simulations were carried out to study the recovery of the stock under 2 scenarios, no catch and monitoring TAC (869 t). A shortcut approach implemented in SimpSim was used (ICES, 2016). The operating model was the update assessment agreed by the HAWG in 2019 (ICES, 2019). The simulations showed that in the no catch scenario, the stock would recover in 2023 (risk to B_{lim} < 5%). The recovery would be delayed by one year if the monitoring TAC would be taken. (ICES, 2019, special request monitoring TAC).

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 σB = 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 0.1 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 2022 are compared with the assessment outputs in 2023 and are shown in the table below. The assessment in 2023 shows SSB revised upward in 2020 but downwards in 2021 and 2022. In the 2023 assessment F is revised downwards in 2020, 2021 and 2022. 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.

2022 Assessment				2023 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2020	8741	132	0.023	2020	10563	132	0.020	21%	15%
2021	15084	745	0.069	2021	14215	745	0.058	-6%	15%
2022*	19349	869	0.058	2022	16539	350	0.028	-15%	52%

*** from intermediate year in STF.**

The 2022 acoustic survey estimate is an increase on the 2021 estimate but is still at a very low level with an SSB estimate of 12,354 t. The survey time-series used in the assessment includes data from 2002 to 2022 (no survey in 2004 and the 2017 survey excluded). The 2019 year class (3wr fish) was the strongest encountered in the survey and the catch in 2022. 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 reliably. 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 and 2022 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 need 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 forecast to be below B_{lim} in 2024 and 2025. F is well below F_{MSY} (0.26) and F_{lim} (0.45). The advice provided for this stock for 2024 is based on the ICES MSY approach, as in recent years. The Council of the European Union set the 2022-2023 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 bases as with a commercial fishery.

The change in fish behaviour that was 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.

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 7aS.

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 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 6.4.4.1 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), 1988–2022. (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

*** Added in 2014 after report of 1% discarding.**

Table 6.1.2.2. Herring in the Celtic Sea. Landings (t) by assessment year (1 April–31 March) 1988/1989–2022/2023. (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
1988/1989	-	-	-	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
2014/2015	-	244	578	17 287	821	-	-	644	19 574

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
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

*** Added in 2014 after report of 1% discarding.**

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 1970–2022/2023. 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%
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%

Year	1	2	3	4	5	6	7	8	9
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%
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%

Year	1	2	3	4	5	6	7	8	9
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%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2022/2023 season.

	7gQ4	7aSQ4
16.5		2
17		0
17.5		5
18		11
18.5		17
19		13
19.5		21
20		8
20.5		2
21		3
21.5		2
22	1	11
22.5	15	27
23	42	93
23.5	76	169
24	133	277
24.5	142	338
25	113	326
25.5	71	174
26	26	86
26.5	8	48
27	4	20
27.5	2	7
28	1	0
28.5		0
29		0
29.5		0
30		1

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2022–2023). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
7.g	2022	4	137	3	150	634	1095
7.J	2022	4	6	0			
7.aS	2022	4	205	8	400	1661	1953
7.aS	2023	1	2	0			
Total			350	11	550	2295	1573

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
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
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
3	112	48	43	3	27	0.5	5	35.3	57.3

	2014 2015	2015 2016	2016 2017	2017 2018	2018 2019	2019 2020	2020 2021	2021 2022	2022 2023
4	69	41	40	7	6	0.3	1	3.3	39.1
5	20	38	36	5	0	0.1	0	1.2	3.36
6	24	7	25	4	0	0	0	0	0.9
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
SSB	48	25	30	4	8	0.3	3.1	6.6	12.3
CV	0.59	0.18	0.33	-	0.49	0.55	0.51	0.44	1.24

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

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
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293

	1	2	3	4	5	6	7	8	9
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
2005	0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233

	1	2	3	4	5	6	7	8	9
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

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
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
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

Year	1	2	3	4	5	6	7	8	9	Total catch
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
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

Year	1	2	3	4	5	6	7	8	9	Total catch
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

Table 6.6.1.1. Continued. Herring in the Celtic Sea: 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
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

year	value	CV	2	3	4	5	6	7	Sample Size
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
2021	102062	0.5	793	57320	39146	3366	909	529	7

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	2002–2021 (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 herring samples 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 2015-2021
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	208079	282385	0.130	407026
1959	15086	199297	325536	0.111	1575120
1960	18283	190175	256899	0.125	361935
1961	15372	160525	222166	0.119	392846
1962	21552	156984	253398	0.193	842972
1963	17349	145418	207686	0.154	402358
1964	10599	165209	288372	0.096	1380460
1965	19126	169938	239676	0.140	415829
1966	27030	165132	265612	0.199	734437
1967	27658	158940	259871	0.226	767627
1968	30236	162169	274435	0.243	898891
1969	44389	141818	229096	0.363	461580
1970	31727	107013	165571	0.331	248305
1971	31396	97901.6	192658	0.454	821055
1972	38203	85839.8	148444	0.560	279093
1973	26936	64538.8	117991	0.518	325107

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
1974	19940	50035.5	85999	0.495	160135
1975	15588	39602.4	73666	0.517	201789
1976	9771	36762.6	68416	0.389	225842
1977	7833	37359.1	64290	0.291	184486
1978	7559	36104.3	58922	0.269	145377
1979	10321	35958.1	70481	0.426	278252
1980	13130	32944.5	59841	0.545	166205
1981	17103	36455.2	86575	0.838	464491
1982	13000	57364.9	126312	0.459	723789
1983	24981	76305.5	158753	0.557	784109
1984	26779	78917.3	148444	0.473	665672
1985	20426	84996.7	153781	0.320	641875
1986	25024	92973.5	170404	0.366	653472
1987	26200	105361	211067	0.390	1199270
1988	20447	108867	170468	0.232	475158
1989	23254	95607.1	164188	0.285	575256
1990	18404	89136.5	147020	0.248	503026
1991	25562	70979	111548	0.381	207218
1992	21127	70890.5	152662	0.485	961732
1993	18618	73574.2	119352	0.326	359515
1994	19300	80333.5	151640	0.322	768209
1995	23305	81841.3	149808	0.388	721691
1996	18816	72376.7	116482	0.309	352152
1997	20496	59849.4	104755	0.408	372720
1998	18041	47968	83113	0.446	248764
1999	18485	42000.6	87826	0.623	486727
2000	17191	42115.1	87492	0.633	478254
2001	15269	41853.3	83740	0.533	496519
2002	7465	54178.9	100496	0.209	545855

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
2003	11536	43176.8	65549	0.306	142195
2004	12743	39450.3	71631	0.392	365937
2005	9494	55138	118398	0.305	1071370
2006	6944	68041.4	104127	0.132	361670
2007	7636	70939.6	118807	0.130	735976
2008	5872	84178.2	118811	0.078	299693
2009	5745	95874.6	163665	0.075	1027200
2010	8370	103921	163318	0.099	762359
2011	11470	112227	179248	0.128	967730
2012	21820	101864	158127	0.250	638149
2013	16247	89798.9	130422	0.210	368570
2014	19574	69469.1	106827	0.318	305090
2015	18355	44895.9	71757	0.454	177058
2016	16318	26533.4	49906	0.755	202804
2017	10767	12127.1	24629	1.156	62180.2
2018	4418	6473.58	13593	1.107	55466.9
2019	1841	7023.9	16319	0.636	206623
2020	132	10563.1	17035	0.020	152616
2021	745	14215.1	19825	0.058	72139.2
2022	350	16539.1	28047	0.028	297226

Table 6.7.1.1. Herring in the Celtic Sea. Input data for short-term forecast.

2023								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	171915	0.77	0.5	0.5	0.5	0.05	0.00	0.06
2	137752	0.38	1	0.5	0.5	0.09	0.03	0.09
3	22216	0.36	1	0.5	0.5	0.11	0.04	0.11
4	31297	0.34	1	0.5	0.5	0.12	0.04	0.12
5	27984	0.32	1	0.5	0.5	0.13	0.04	0.13
6	3203	0.31	1	0.5	0.5	0.14	0.04	0.14
7	917	0.31	1	0.5	0.5	0.15	0.04	0.15
8	664	0.31	1	0.5	0.5	0.16	0.04	0.16
9	1854	0.31	1	0.5	0.5	0.16	0.01	0.18

2024								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	171915	0.77	0.5	0.5	0.5	0.05	0.00	0.06
2	-	0.38	1	0.5	0.5	0.09	0.03	0.09
3	-	0.36	1	0.5	0.5	0.11	0.04	0.11
4	-	0.34	1	0.5	0.5	0.12	0.04	0.12
5	-	0.32	1	0.5	0.5	0.13	0.04	0.13
6	-	0.31	1	0.5	0.5	0.14	0.04	0.14
7	-	0.31	1	0.5	0.5	0.15	0.04	0.15
8	-	0.31	1	0.5	0.5	0.16	0.04	0.16
9	-	0.31	1	0.5	0.5	0.16	0.01	0.18

2025								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	171915	0.77	0.5	0.5	0.5	0.05	0.00	0.06
2	-	0.38	1	0.5	0.5	0.09	0.03	0.09
3	-	0.36	1	0.5	0.5	0.11	0.04	0.11
4	-	0.34	1	0.5	0.5	0.12	0.04	0.12
5	-	0.32	1	0.5	0.5	0.13	0.04	0.13
6	-	0.31	1	0.5	0.5	0.14	0.04	0.14
7	-	0.31	1	0.5	0.5	0.15	0.04	0.15
8	-	0.31	1	0.5	0.5	0.16	0.04	0.16
9	-	0.31	1	0.5	0.5	0.16	0.01	0.18

Table 6.7.1.2. Herring in the Celtic Sea. Results of short-term deterministic forecast.

Rationale	F_{bar} 2023	Catch (2023)	SSB -2023	Fbar (2024)	Catch (2024)	SSB -2024	SSB -2025
Catch(2024) = Zero	0.048	869	22149	0	0	23998	25850
Catch(2024) = 2023 TAC	**0.048**	**869**	**22149**	**0.042**	**869**	**23569**	**24728**
Fbar(2024) = Fmsy	0.048	869	22149	0.260	4927	21454	19677
Fbar(2024) = Fpa	0.048	869	22149	0.260	4927	21454	19677
Fbar(2024) = Flim	0.048	869	22149	0.450	7858	19791	16382
Fbar(2024) = F2023	0.048	869	22149	0.048	1000	23504	24535
Fbar(2024) = Fmsy * SSB2023 /MSY Btrigger	0.048	869	22149	0.107	2171	22911	23035

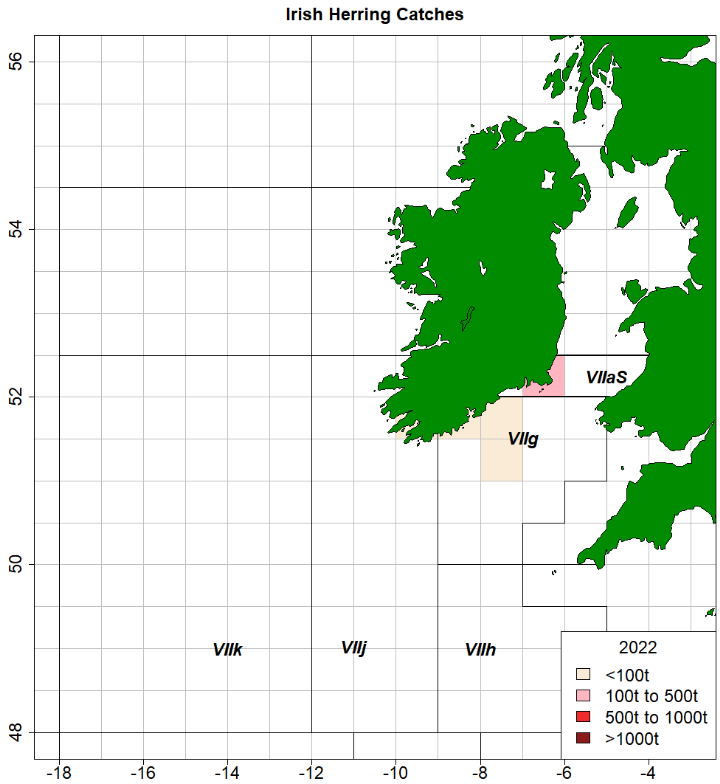


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2022/2023.

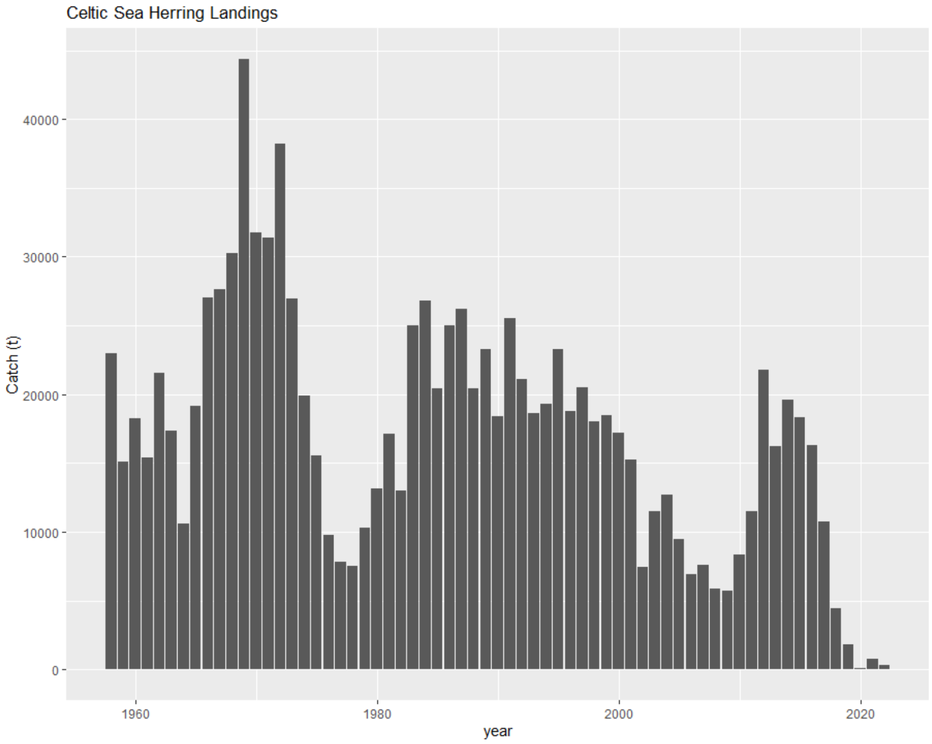


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

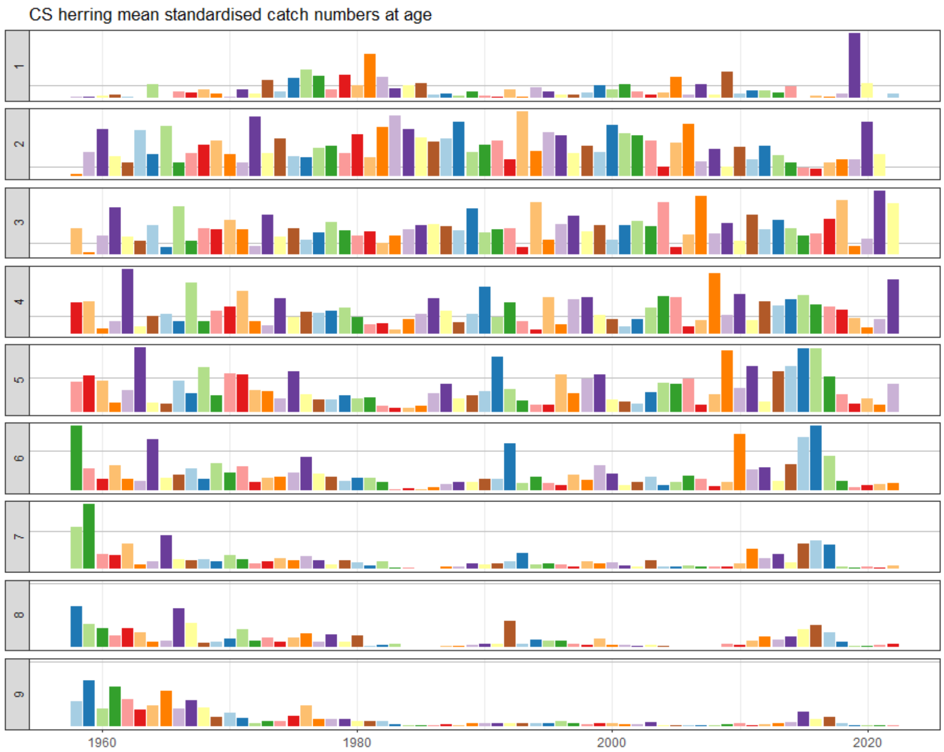


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardized by yearly mean. 9-wr is the plus group. Age in winter rings.

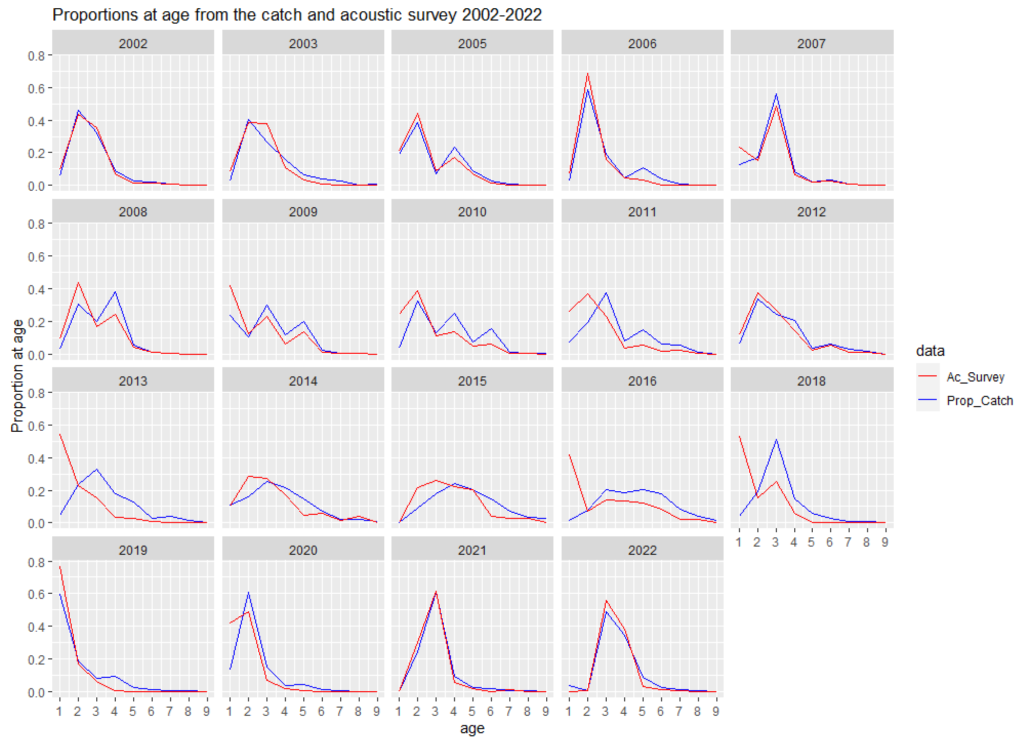


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9 wr) and the commercial fishery (1–9 wr) by year. Age in winter rings.

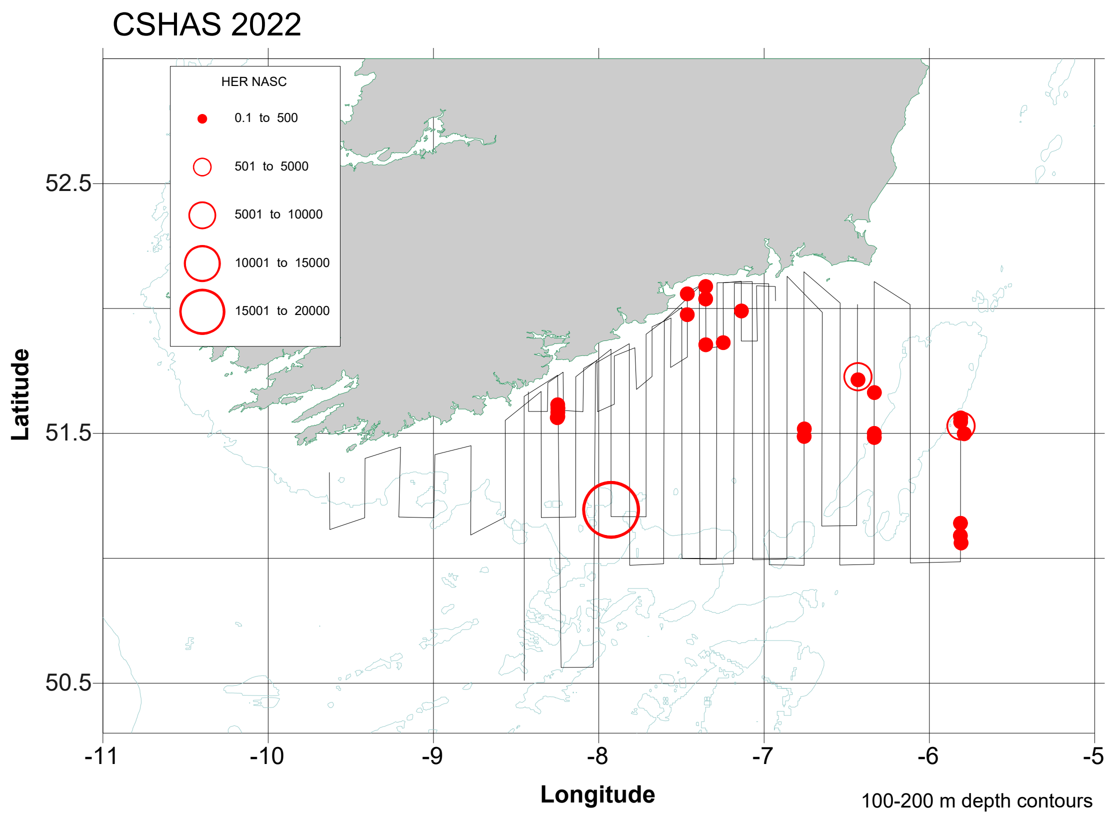


Figure 6.3.1.1. Herring in the Celtic Sea. Herring NASC (Nautical area scattering coefficient) plot of herring distribution 2022 from combined survey effort.

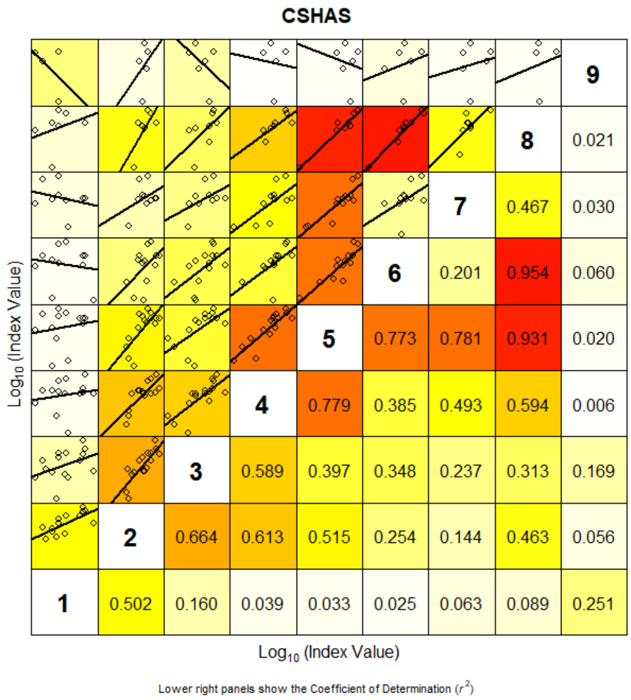


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

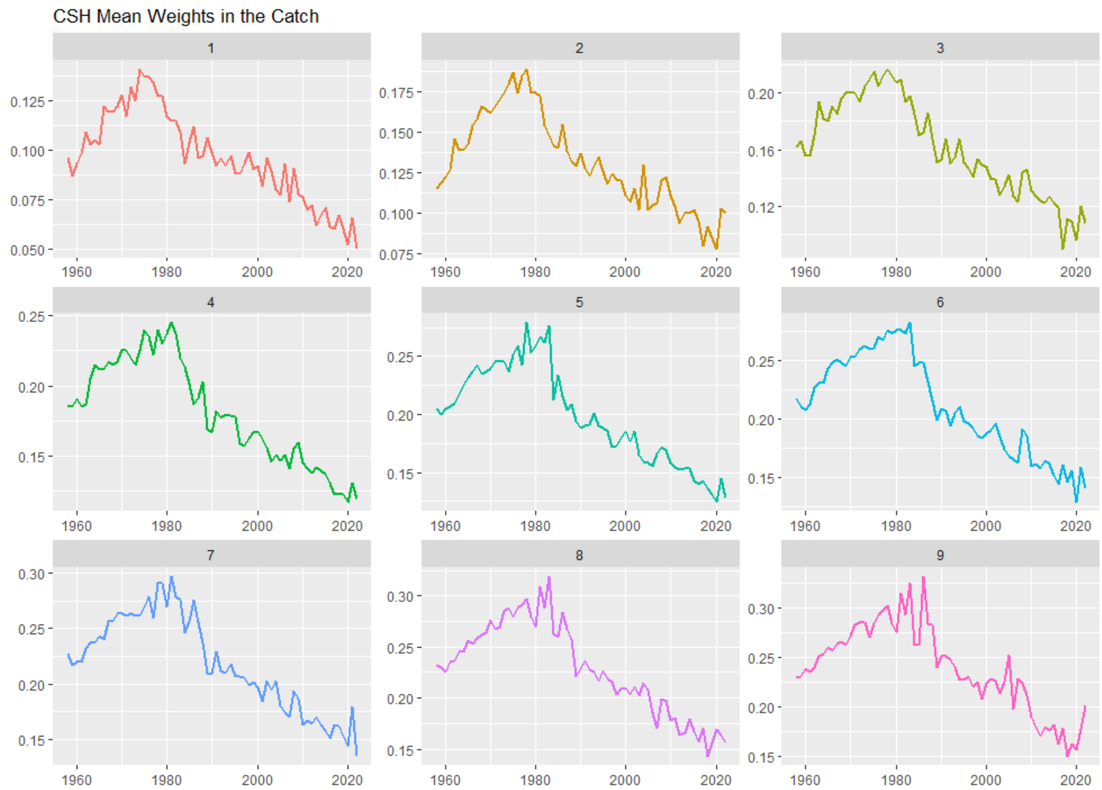


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2022 for 1–9+.

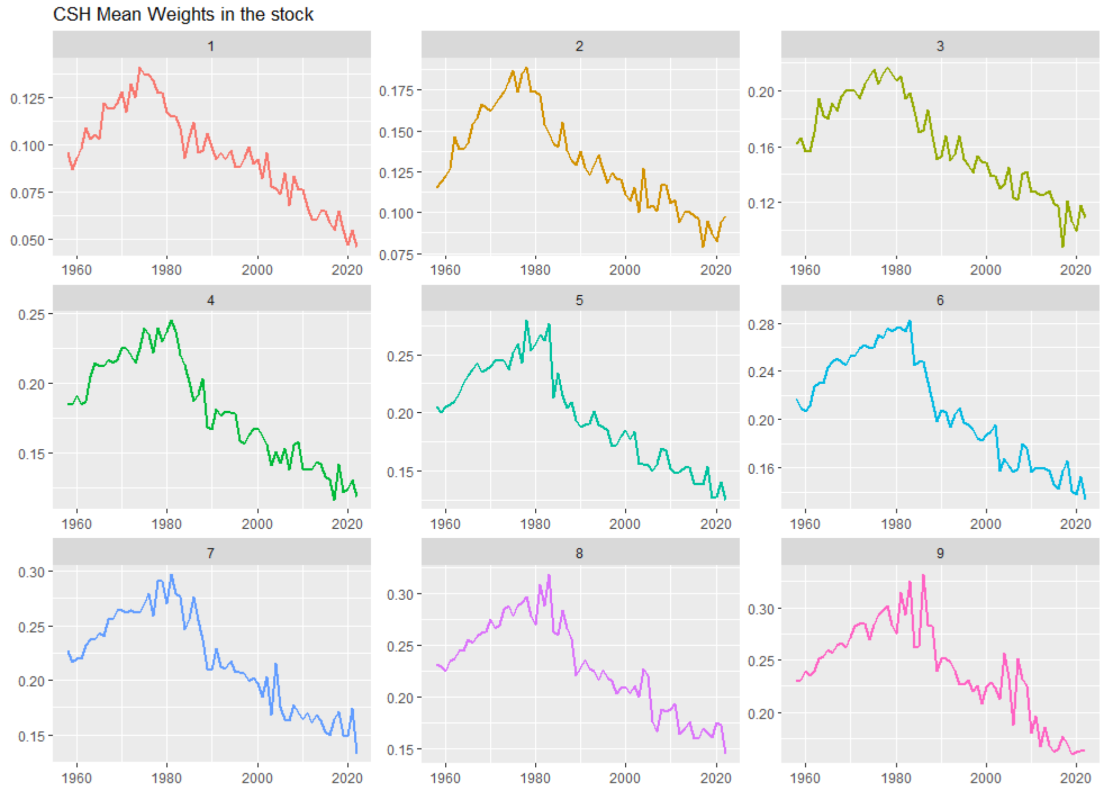


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2022 for 1–9+. Age in winter rings.

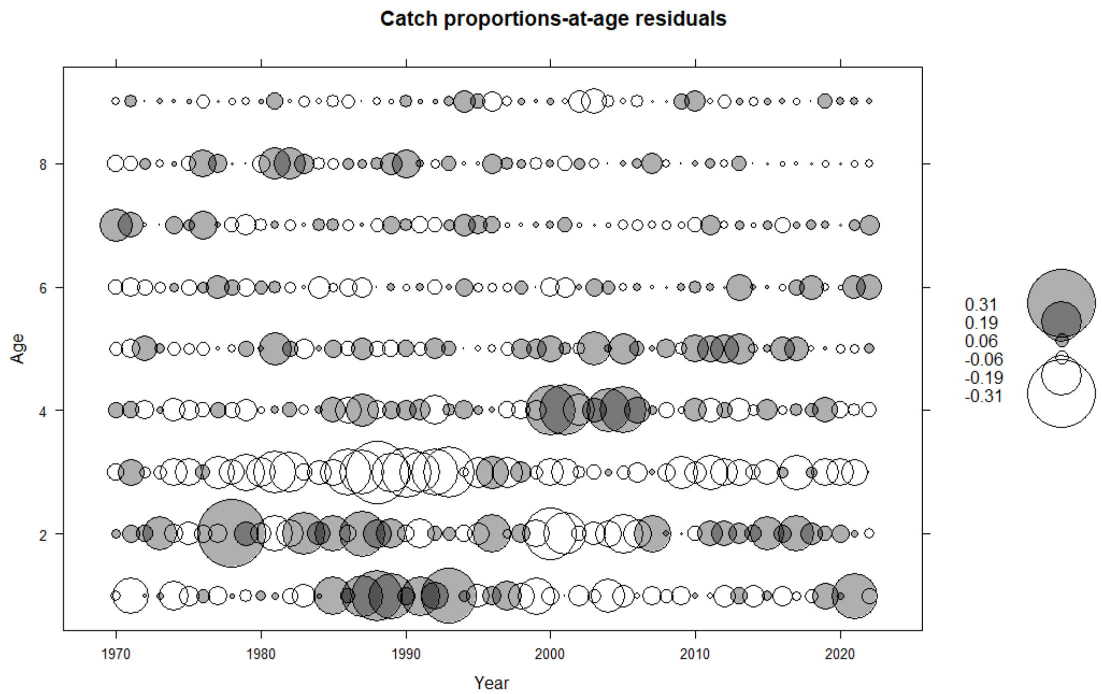


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

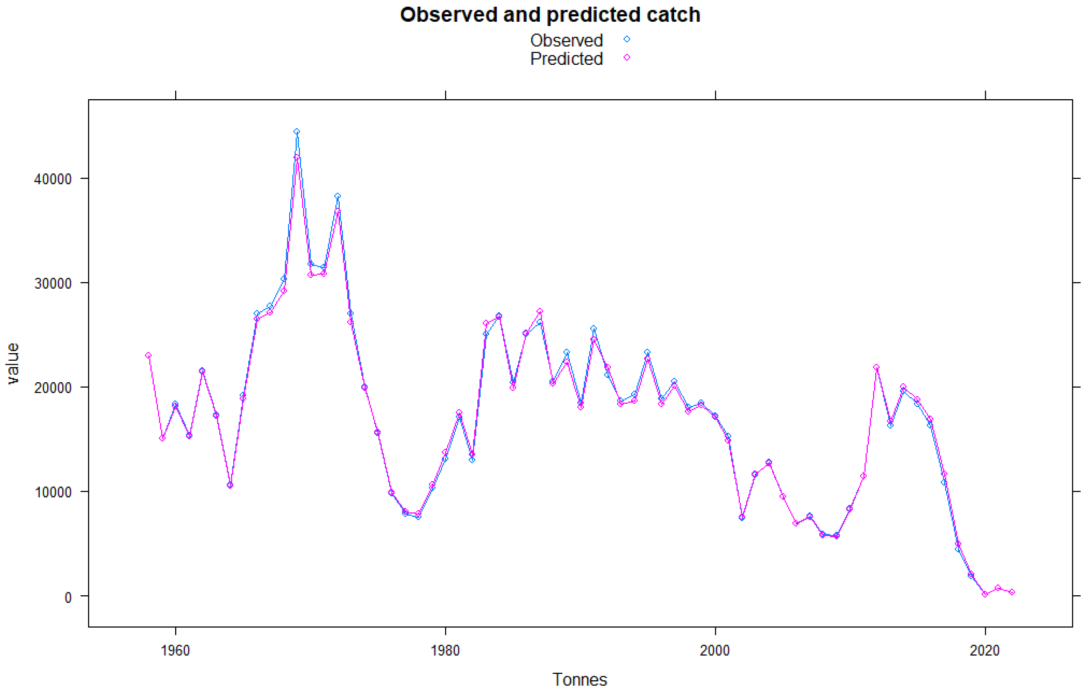


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

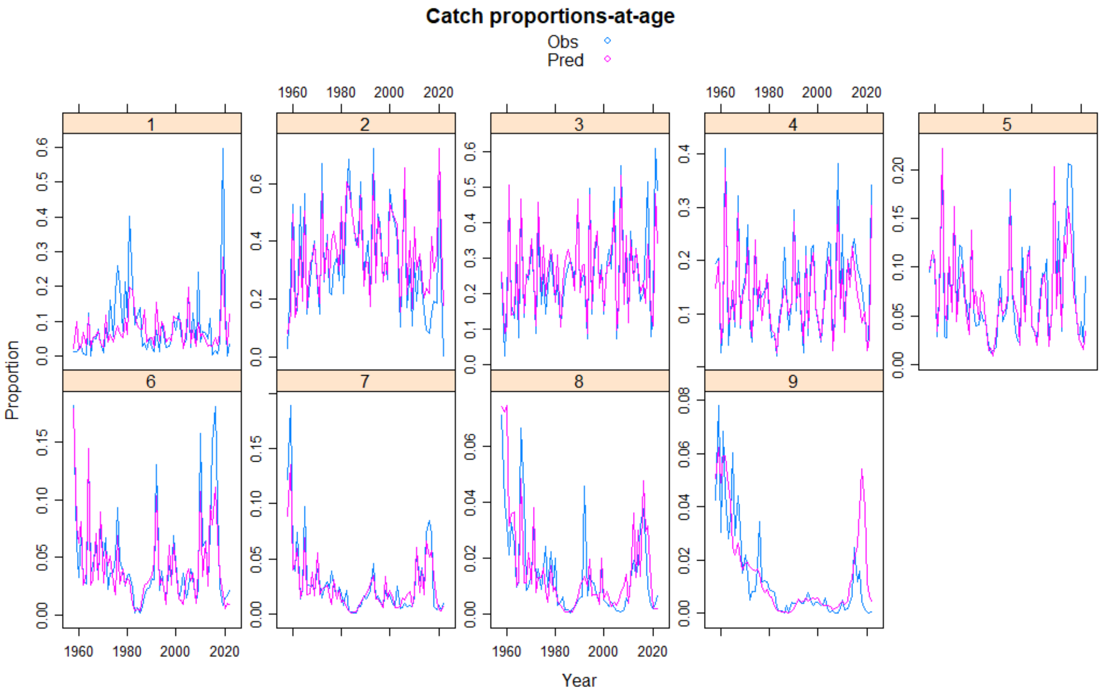


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

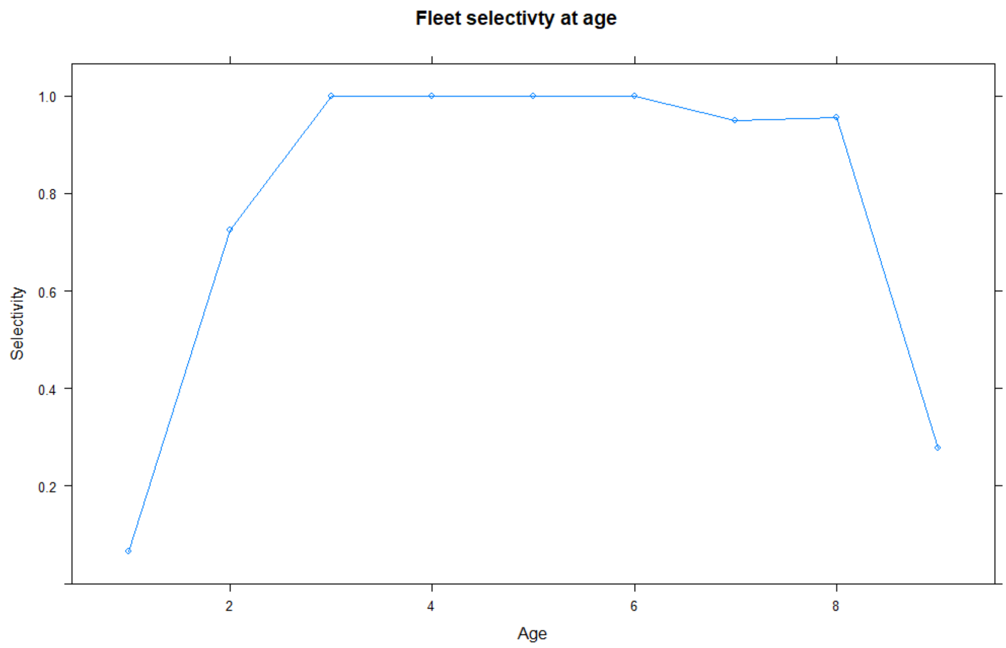


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

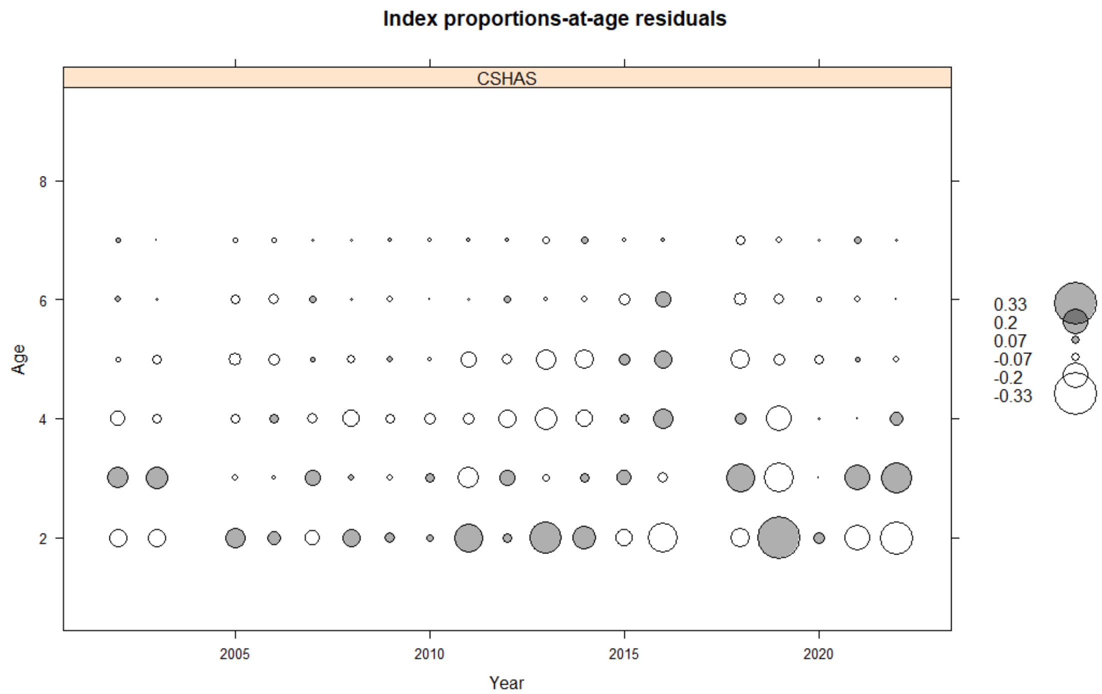


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

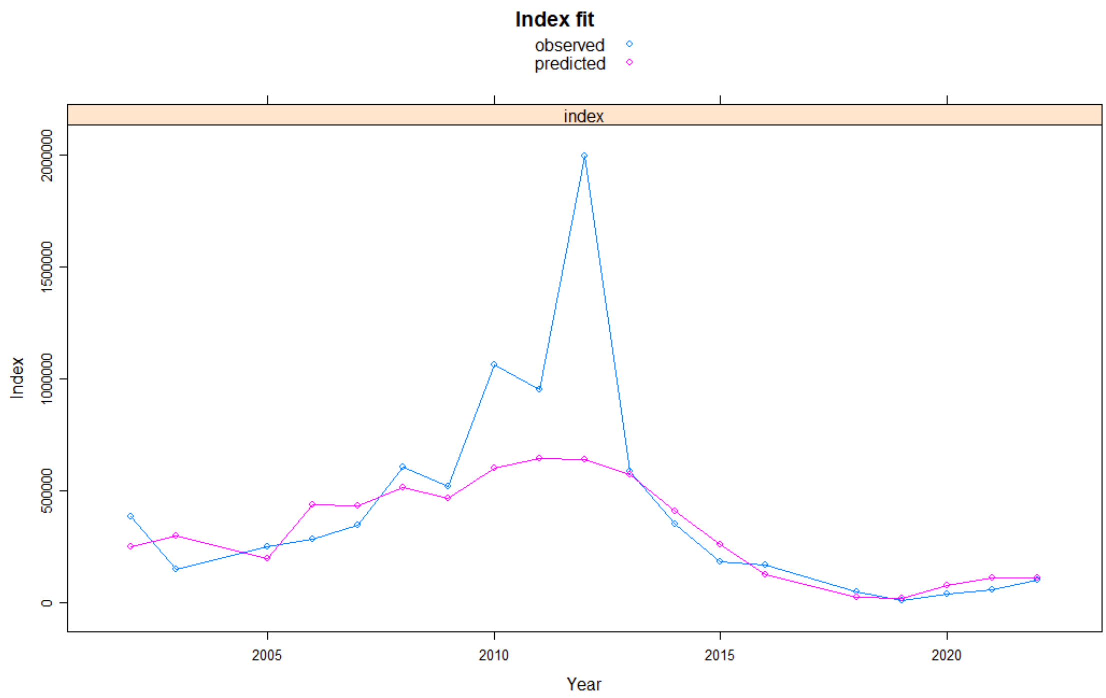


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

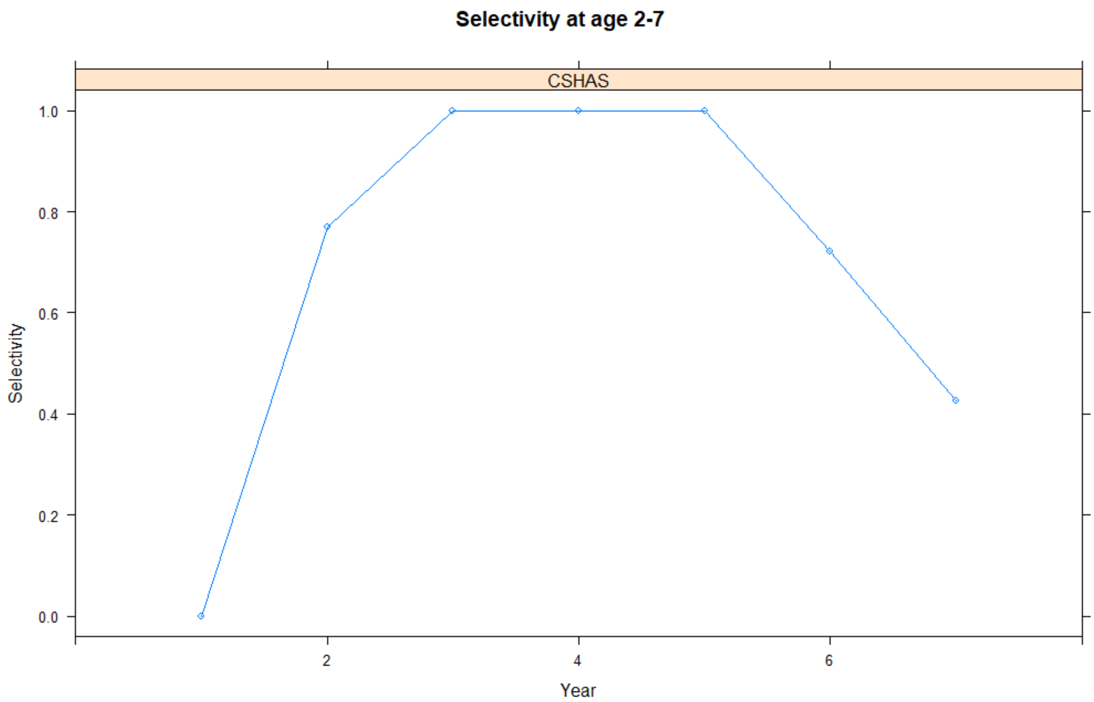


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

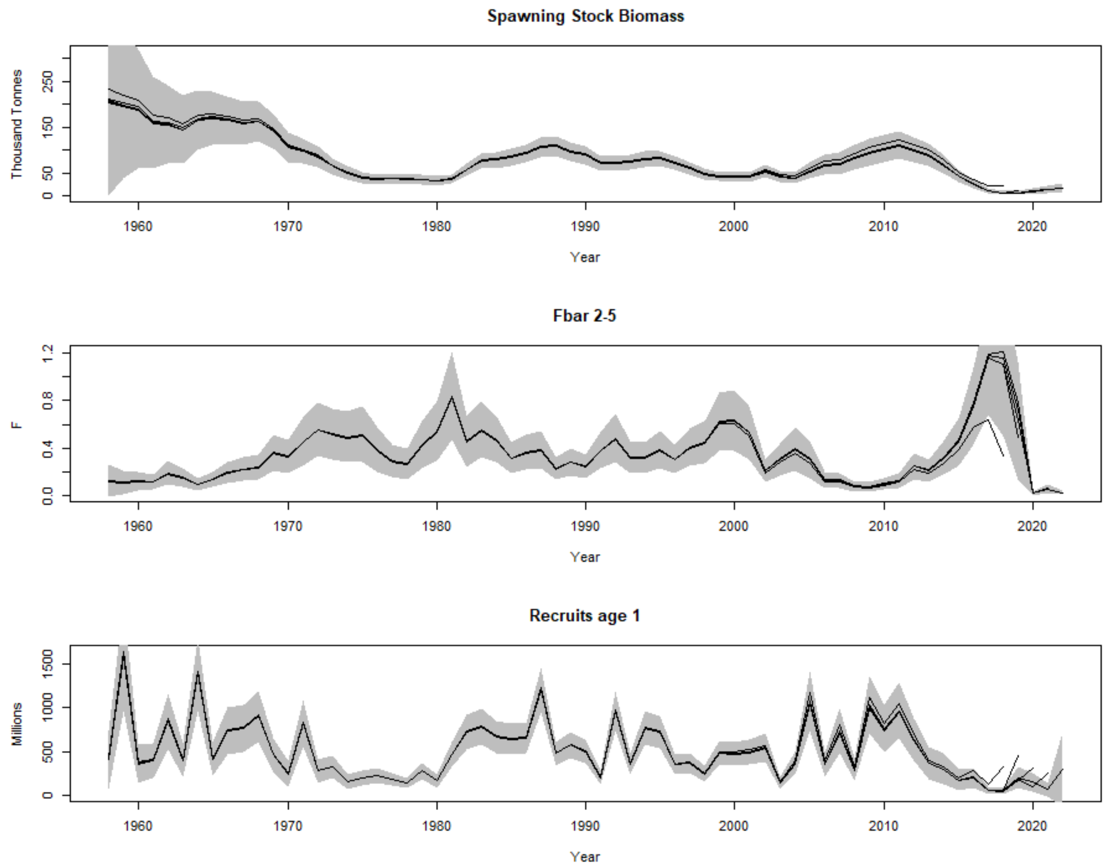


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), and Recruitment (bottom). The shaded area is the 95% confidence interval.

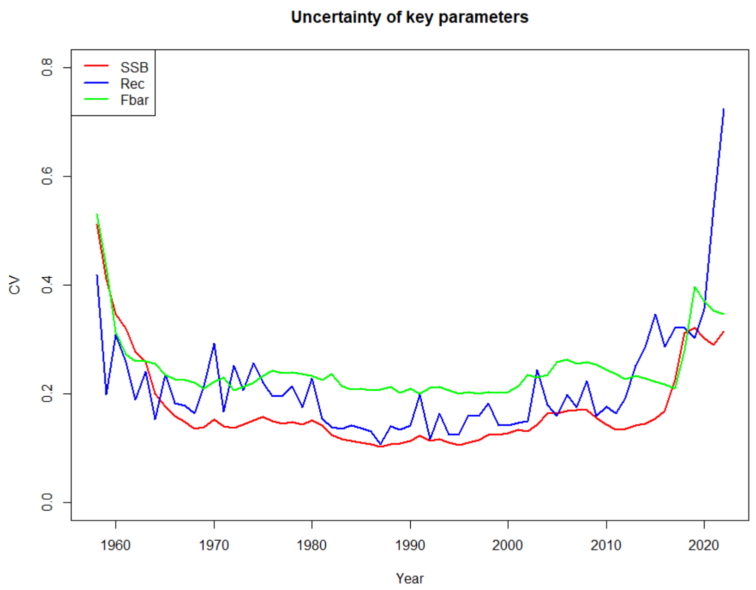


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

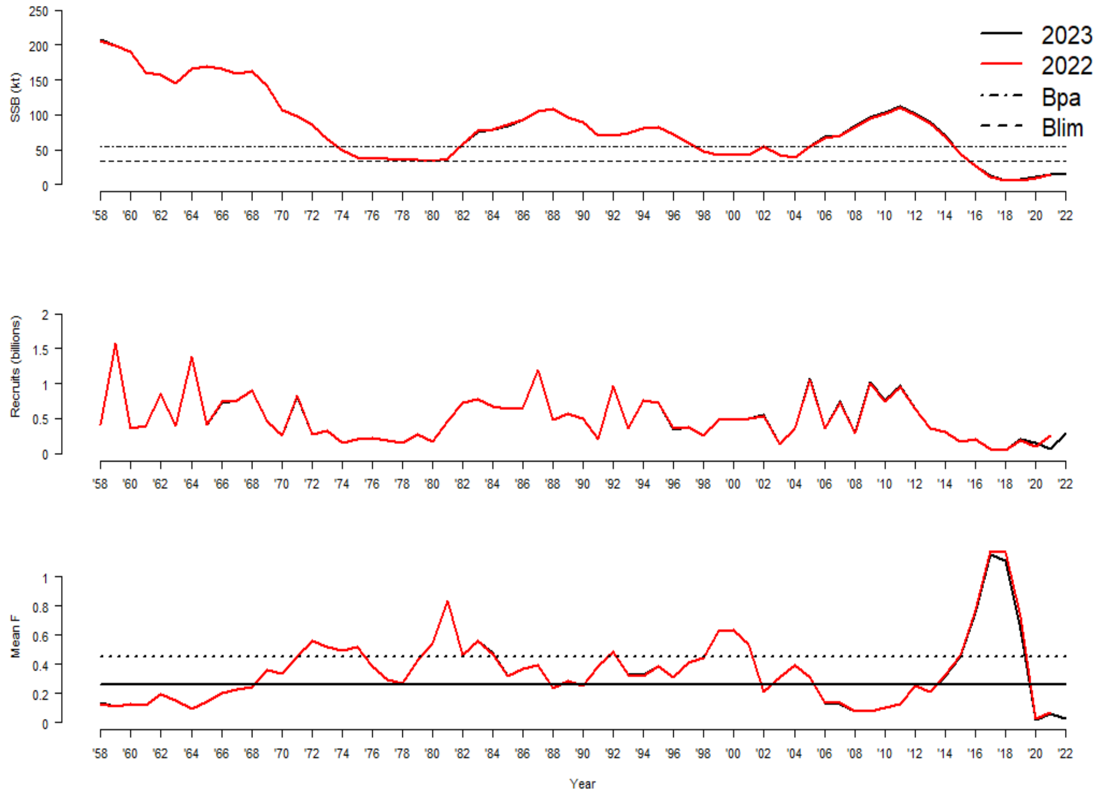


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run in 2022 and 2023 showing SSB (top), Recruitment (middle) and Mean F2–5 (bottom)

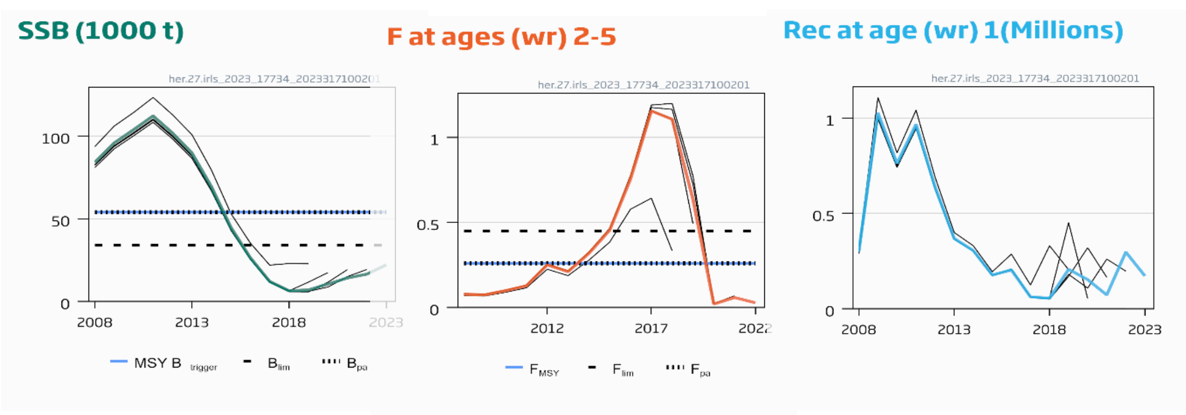


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospectives from the final assessments 2019–2023

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).

The WG notes that the use of "age", "winter rings", "rings" and "ringers" can causes 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 2022 should be no more than 8455 tonnes. ICES advised that when the MSY approach is applied, catches in 2023 should be no more than 7309 tonnes.

7.1.1 The fishery in 2022

The catches reported from each country for the period 1987 to 2022 are given in Table 7.1.1, and total catches from 1987 to 2022 in Figure 7.1.1. Reported international landings in 2022 for the Irish Sea amounted to 7888 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2022 were taken during the 3rd quarter, with landings also made in quarter 4, this is typical of the annual fishery pattern.

As in previous years, the 2021 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 43t in 2022.

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 fisherycontinues 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, there was less than 10 t landings attributed to this fishery in 2018, no catches in 2019, 33 t in 2020, 55 t in 2021 and 43 t in 2022. 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 6% in 2022, 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 2022. 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 2022 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 2022, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 28 in 2022, which are similar sampling levels than has been achieved in the past. The number of measurements also 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 2022 was carried out over the period 27th August– 12th 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 2022 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 2022 survey with 32 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 prespawning 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 2022 the survey was conducted from the 3rd to 6th of October. The spawning stock biomass was estimated to be 47.3kt, this is similar to the estimate of 2020 (47.9kt) but a decline from 2021 (57.1 kt) and is within the previously observed range (28.4 – 114.0kt).

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 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2022 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).

7.5 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.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

The stock was benchmarked in 2017. The assessment model did not change and was applied without change in 2022. At the benchmark the following changes were made to the input data and model setting:

- The input data series was shortened to include data only from 1980 onwards, to remove poor quality historic data. Mohn's rho on SSB was reduced from 13.3 to 9% under shortened time-series, which will improve the basis for advice (9% in the current assessment);
- Minor changes have been made to the variance and parameter bindings, to improve the model fit (see Table 7.6.3.10);
- The random walk assumption on recruitment was removed. Recruitment patterns are now estimated from cohort back-tracking from older ages;
- Includes a new SSB survey index (derived from acoustic methods; see Section 7.3.2). The primary aim is to generate an SSB index constituting mainly herring on or around spawning ground to eliminate some of the age and mixing issues. The larval survey (also an indicator of SSB) was removed as it contributes little to the assessment model. In addition, the modelling framework did not allow from a technical perspective to include two SSB surveys;
- The SSB survey index was included in the assessment without estimating catchability, which effectively implies an assumed catchability of 1, with variance fixed at 0.4 (this corresponded to the observation variance value when catchability was freely estimated in a trial run).

The benchmark accepted the assessment and model settings, but requested further exploration of the sensitivity to catchability assumption for the SSB survey. This was completed post benchmark, however, the reviewers could not reach consensus and proposed that HAWG is best place to propose a final assessment model.

HAWG in 2017 had discussions on the final assessment model that could form the basis for the advice. This process is described in detail in Section 1.9 in the HAWG 2017 report. Despite ongoing concerns over the catchability assumption and the mixing issues from some members, the decision was made to use the SAM assessment settings agreed at the benchmark, together with the catchability assumptions discussed at HAWG, as the final model.

The primary issue with the current perception of stock status of Irish Sea herring is trying to reconcile the SAM model estimates of stock size (primarily driven by catch data) and the much higher estimate of stock size estimates from surveys that specifically focused on the spawning population within the Irish Sea. By design, acoustic surveys are aimed to produce an absolute estimate of stock biomass (with some uncertainty). This would result in a catchability of ~1. The previous assessment estimates catchability to be around ~ 2.5 for the acoustic survey. The benchmark also revealed very significant issues with the catch data, on which the previous assessment and advice is based on.

The concerns from the benchmark were satisfactorily addressed and did not highlight any major issues that could not be explained. In general, the assessment model fit improved in the proposed model where the SSB survey is included at the catchability set to 1. Given that the primary aim is to provide credible scientific advice, the best proposal on this trade-off scenario (neither of which are ideal), is to base the assessment and advice on a more balanced assessment model.

HAWG did recognize that this is not an ideal scenario and further work needs to be done in the short term to improve the assessment (see Section 1.9, HAWG 2017)

Acoustic (AC(7.a.N)) 1–8+ winter rings) and the SSB indices are available for the assessment of Irish Sea herring. 2021catch-at-age data are derived from the international landings. The SAM model fits the catch well, with the model being weighted towards the catch information. The residuals are relatively small (figures 7.6.1–17). The residuals in the numbers-at-age in the catch and acoustic survey generally appear to be independent of time, but there are still some patterns in later years. These patterns are somewhat expected and could be explained by annual changes in migration patterns, magnitude and extent of the mixed component and converging trends in the surveys in recent years. The year effect in the 2011 survey is also evident from these plots with consistent negative residuals at older (3+) ages (winter rings).

The acoustic survey fits reasonably well at all ages except for 1 winter rings, with a model overestimate of fish 5 years +. The model fit is poor for SSB survey index (Figure 7.6.17). This is expected considering the catchability assumption, but it also highlights the fact that the model can deviate from the q=1 fit and the realized catchability for the survey deviated from one.

Model fit is poor for 1 ringers in the catch and survey, which is the age with the highest occurrence of fish mixing from different hatching seasons. The modelled acoustic survey catchability parameter and the selectivity of the fishery by pentad are illustrated in figures 7.6.18–19. The variability of fishery selection is thought to reflect variable migration patterns and the effect of the spawning closure.

A feature of the assessment model is the estimation of an observation variance parameter for each dataset (Figure 7.6.20). Overall, the catch data (2+ winter ring) are associated with low observation variances, where 1 ringers (from catch and survey) are perceived to be the noisiest data series. Figure 7.6.21 shows observation variance vs. uncertainty of the data sources used in the model. Although the majority of the data sources are associated with relatively high observation variances, none of the uncertainty estimates are particularly high. The CVs do not indicate a lack of convergence of the assessment model.

7.6.2 Final assessment

The final assessment was carried out by fitting the state-space model (SAM, in the FLR environment) using the settings and data inputs in accordance to the stock annex (as decided at the 2017 benchmark and HAWG 2017). The input data and model settings are shown in Tables 7.6.3.1–11, the SAM output is presented in Tables 7.6.3.13–21, the stock summary in Table 7.6.3.12 and Figure 7.6.22, model fit and parameter estimates in Table 7.6.3.22, and negative log-likelihood for the model fit in Table 7.6.3.23.

Diagnostics and selectivity parameters for this run are presented in Figure 7.6.1–19. The stock parameters are estimated well by the model, as indicated by the relatively low uncertainty associated with the stock parameter (Figure 7.6.23), except for the most recent estimates.

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2017–22 (Figure 7.6.24). The retrospective bias from the model is low.

A comparison of the estimates of this year's assessment with last year's is given in Figure 7.6.25. The stock was benchmarked in 2017, with updates made to the model configurations and input data sources (including a new SSB survey). The new perception of the stock provides biomass estimates more in between the acoustic survey and catch estimates. Recruitment assumptions in the assessment were changed, which resulted in higher interannual variability. While the trend in fishing mortality is estimated to be stable, a historical comparison of the current assessment with previous assessments shows annual upward revision of fishing mortality and wide confidence intervals.

7.6.3 State of the stock

Trends from the final assessment indicate an increase in SSB and recruitment since the mid-2000s, with a stabilizing trend in the most recent years (although uncertain). The associated F has decreased significantly over the last 10 years to below F_{MSY}. Based on the most recent estimates the stock is being harvested sustainably at, or below, F_{MSY}.

7.7 Short-term projections

7.7.1 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, 1980–2021 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2011–2020) replaced recruitment for 1-ringers in 2022 and is used as the intermediate year assumption. The forecast was based on catches (2021 advice = 8455 t) assuming full uptake of the ICES fishing opportunity advice. 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 short-term catch option table is given in Table 7.7.2. SSB is expected to be well above MSY $B_{trigger}$ in 2023–2025, but is predicted to decrease slightly if fishing at F_{MSY}. SSB with zero catch is forecast to increase (+16%). This is largely comprised of the 2022, 2023 and 2024 year classes, which would contribute more than 53% of the SSB in 2025.

7.7.2 Yield per recruit

Not available, previous explorations are detailed in the stock annex.

7.8 Medium term projections

No medium term stock projections of stock size were conducted by the Working Group.

7.9 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2017 assessment (WKIRISH3 and HAWG 2017). B_{lim} was set to the lowest SSB that generate above average recruitment, 8500 t. B_{pa}, 11 800 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 to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.266). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35(0.345) and the lower bound at 0.20(0.198). F_{lim} is estimated to be 0.40 (0.397) as F with 50% probability of SSB <B_{lim} with F_{pa} was modified to F_{p05} as 0.309 calculated as the F that leads to SSB ≥ B_{lim} with 95% probability.

7.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were scrutinized during the 2017 benchmark (WKIRISH3 2017). The benchmark group performed sensitivity tests to test model configurations and optimized the model fit to the data with the least amount of parameters estimated. The Working Group checked for convergence and judged that a good model fit was found. FLSAM will not run if convergence criteria are not achieved.

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 at the 2017 benchmark given that there was no new information presented. Genetic analysis and biological data collection is ongoing. The noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across the younger ages in the survey, or most likely a combination of these. Although mixing of mature herring has been observed, most of the mixing is thought to occur at younger ages, and this is objectively, but only partially, corrected for in the model through a high catchability estimated for the acoustic survey. Currently, the model doesn't have the structure to specifically deal with the contribution of small herring from other stocks.

The F_{bar} range 4–6 is considered representative of the mortality (Figure 7.6.26) on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components and represent the age range with highest fish mortality.

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.

No major violations of the assumptions underpinning the assessment model were found. 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. The model does fit the catch data significantly better despite the significant quality issues with the catch data reported at the 2017 benchmark. This is not desirable. The new survey information adds more weight to the previously observed increase abundance trend observed from the main age-disaggregated acoustic survey. The 2017 assessment model attempted to provide a more balanced model, giving more weight to the SSB survey.

SAM down weights the 1 ring data and survey information in general. The uncertainty estimates of the model parameters, suggest the model is both appropriate for the available data and that the model describes these data reasonably well. Whilst, the trend in fishing mortality is estimated to be stable the historic comparison of the current assessment with previous assessments shows an annual upward revision of fishing mortality. The confidence range of Fishing mortality estimates are large and inter-annual signal difficult to observe. This should be further explored.

7.11 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).

The current assessment indicates SSB in 2022 to remain at a relatively high level relative to the time-series and fishing mortalities below F_{MSY}. The forecast predicts a reduction in SSB in 2022. 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.

7.12 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.

7.13 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, 1987–2021. 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
Ireland	119	0	82	200	1299	1317	1957	753	492
UK	5089	4868	4245	3696	5504	5061	5969	6455	5395
Unallocated		22							
Total	5208	4891	4327	3896	6804	6378	7927	7208	7888

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).Catch at length data 1995–2021. 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	2002
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	2002
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	2002
30	40	32	8	84		6	9		43						-			17		0	8							
30.5																												
31																											1	

Table 7.2.3 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 2022.

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	263	4	1129	200
	UK (N. Ireland)	5864	20	3233	939
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	229	1	157	50
	UK (N. Ireland)	1545	3	503	150
	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 1989–2021. 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

[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
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

AGE (RINGS)	1	2	3	4	5	6	7	8+
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

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
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

age/year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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
1	7991	12176	15260	5708	13155
2	22903	23112	29059	35337	23817
3	15657	11083	20869	13744	23740
4	12364	6776	4099	3033	14134
5	3240	6661	3355	1163	5616
6	538	1360	3200	976	377
7	391	182	777	140	152
8+	50	194	209	26	160

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
1	0.054	0.072	0.060	0.057	0.057	0.069	0.051
2	0.102	0.093	0.096	0.096	0.095	0.101	0.086
3	0.126	0.121	0.120	0.119	0.119	0.119	0.108
4	0.143	0.140	0.132	0.137	0.138	0.133	0.123
5	0.159	0.147	0.147	0.143	0.143	0.148	0.137
6	0.161	0.154	0.159	0.156	0.152	0.148	0.156
7	0.167	0.154	0.164	0.159	0.160	0.160	0.165
8+	0.177	0.162	0.204	0.181	0.174	0.167	0.168

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
1	0.054	0.072	0.060	0.057	0.057	0.069	0.051
2	0.102	0.093	0.096	0.096	0.095	0.101	0.086
3	0.126	0.121	0.120	0.119	0.119	0.119	0.108
4	0.143	0.140	0.132	0.137	0.138	0.133	0.123
5	0.159	0.147	0.147	0.143	0.143	0.148	0.137
6	0.161	0.154	0.159	0.156	0.152	0.148	0.156
7	0.167	0.154	0.164	0.159	0.160	0.160	0.165
8+	0.177	0.162	0.204	0.181	0.174	0.167	0.168

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
1	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
3	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
5	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
7	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

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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

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
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
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
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
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
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
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
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
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

TABLE 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

```
   min     max plusgroup   minyear   maxyear   minfbar   maxfbar
    1       8       8     1980     2022       4       6
```

TABLE 7.6.3.10 Irish Sea Herring. sam CONFIGURATION SETTINGS

```
name         :
desc         :
range        :      min      max plusgroup   minyear   maxyear   minfbar   maxfbar
range        :       1       8       8     1980     2021       4       6
fleets       :     catch  AC(VIIaN) VIIaNSpawn
fleets       :        0        2        3
plus.group    : TRUE
states       :           age
states       : fleet       1  2  3  4  5  6  7  8
states       :   catch      1  2  3  4  5  6  7  7
states       :   AC(VIIaN)  NA NA NA NA NA NA NA NA
states       :   VIIaNSpawn NA NA NA NA NA NA NA NA
logN.vars     : 1 1 1 1 1 1 1 1
catchabilities :           age
catchabilities : fleet       1  2  3  4  5  6  7  8
catchabilities :   catch      NA NA NA NA NA NA NA NA
catchabilities :   AC(VIIaN)   1  2  3  4  4  4  4  4
catchabilities :   VIIaNSpawn NA NA NA NA NA NA NA NA
power.law.exps :           age
power.law.exps : fleet       1  2  3  4  5  6  7  8
power.law.exps :   catch      NA NA NA NA NA NA NA NA
power.law.exps :   AC(VIIaN)  NA NA NA NA NA NA NA NA
power.law.exps :   VIIaNSpawn NA NA NA NA NA NA NA NA
f.vars       :           age
f.vars       : fleet       1  2  3  4  5  6  7  8
f.vars       :   catch      1  1  2  2  2  3  4  4
f.vars       :   AC(VIIaN)  NA NA NA NA NA NA NA NA
f.vars       :   VIIaNSpawn NA NA NA NA NA NA NA NA
obs.vars      :           age
obs.vars      : fleet       1  2  3  4  5  6  7  8
obs.vars      :   catch      1  2  2  2  3  3  3  3
```

obs.vars : AC(VIIaN) 4 5 5 5 5 6 6 6

obs.vars : VIIaNSpawn NA NA NA NA NA NA NA NA

srr : 0

cor.F : FALSE

nohess : FALSE

timeout : 3600

sam.binary :

TABLE 7.6.3.11 Irish Sea Herring. FLR, R SOFTWARE VERSIONS

FLSAM.version	1.02
FLCore.version	2.6.6
R.version	R version 3.2.0 (2015-04-16)
platform	i386-w64-mingw32
run.date	2023-03-17 19:44:30

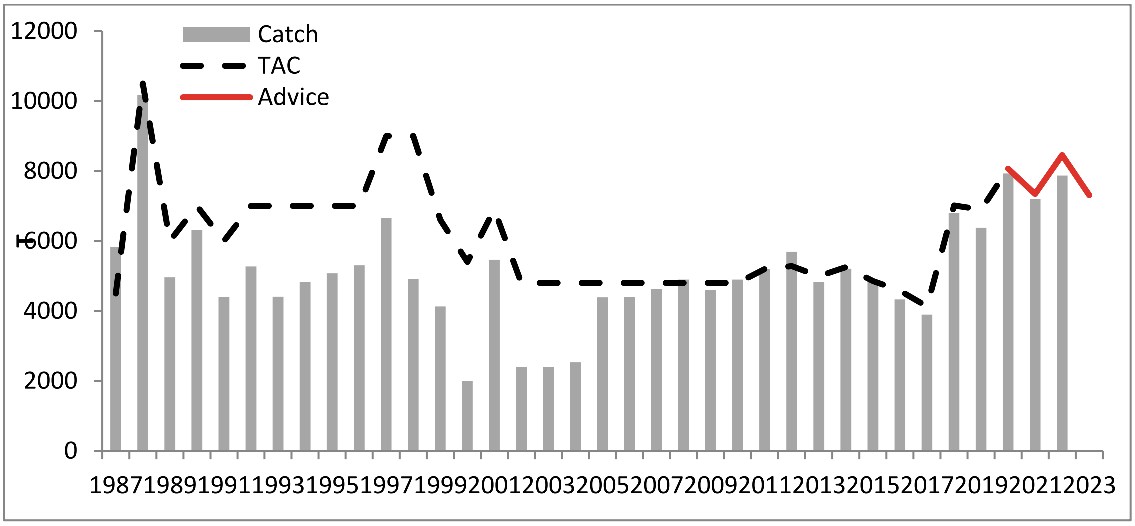


Figure 7.1.1 Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1961 to 2022.

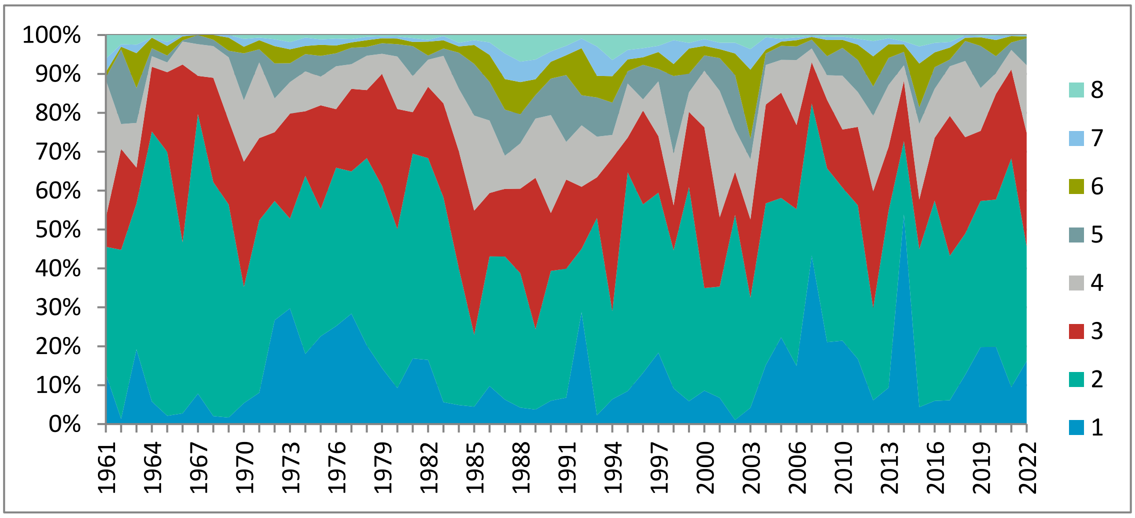


Figure 7.2.1 Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1980 to 2022. No 2009 commercial samples.

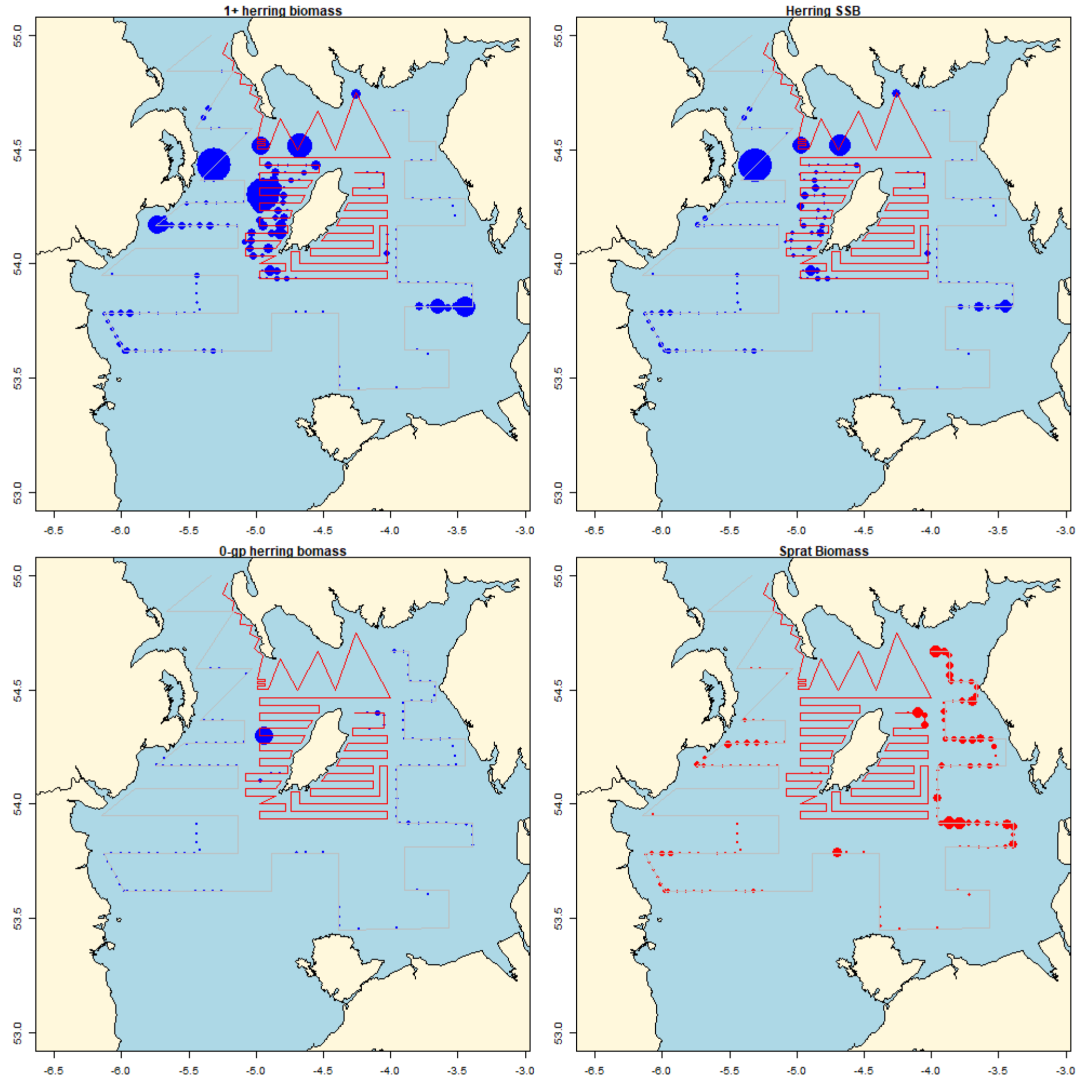
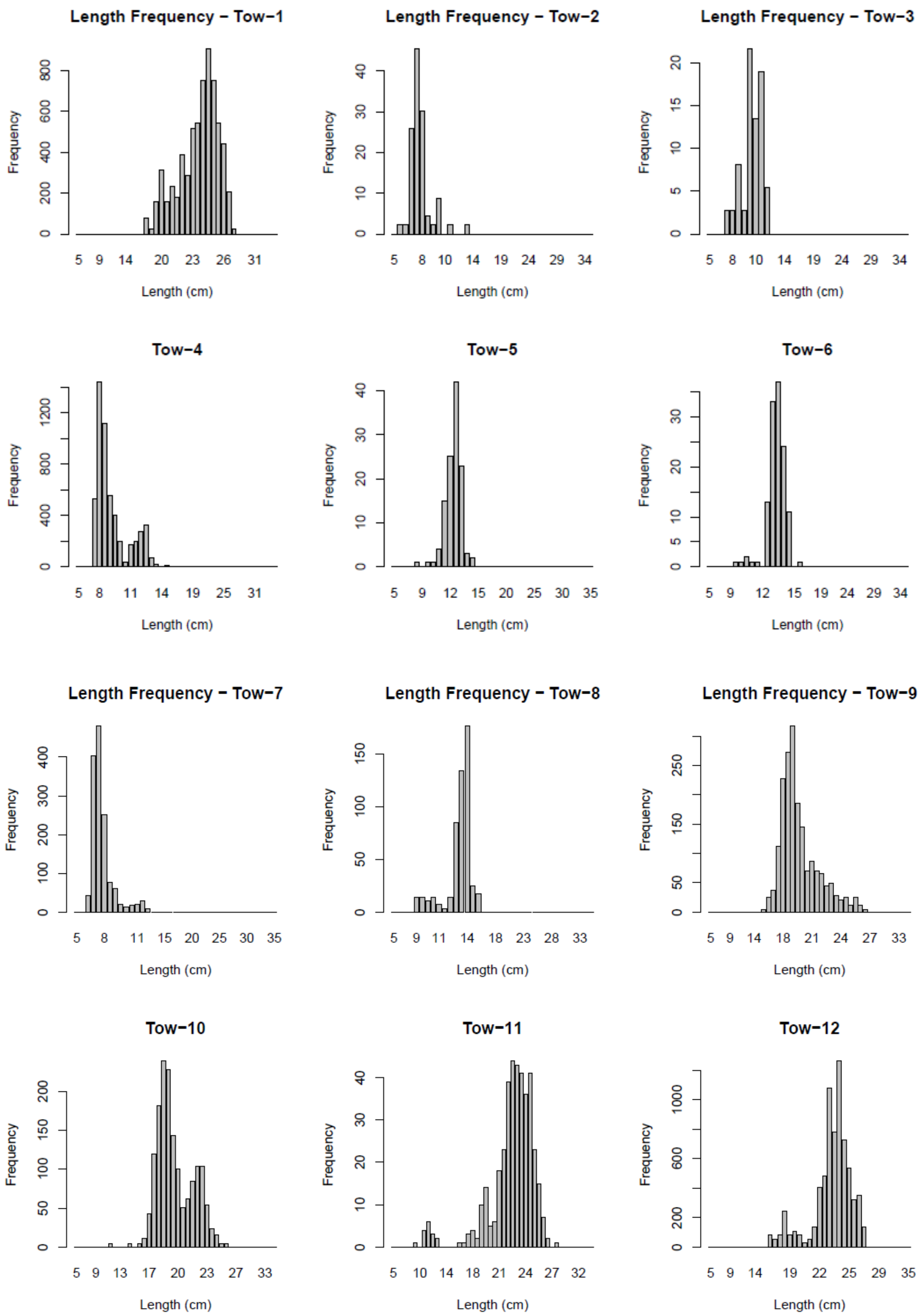
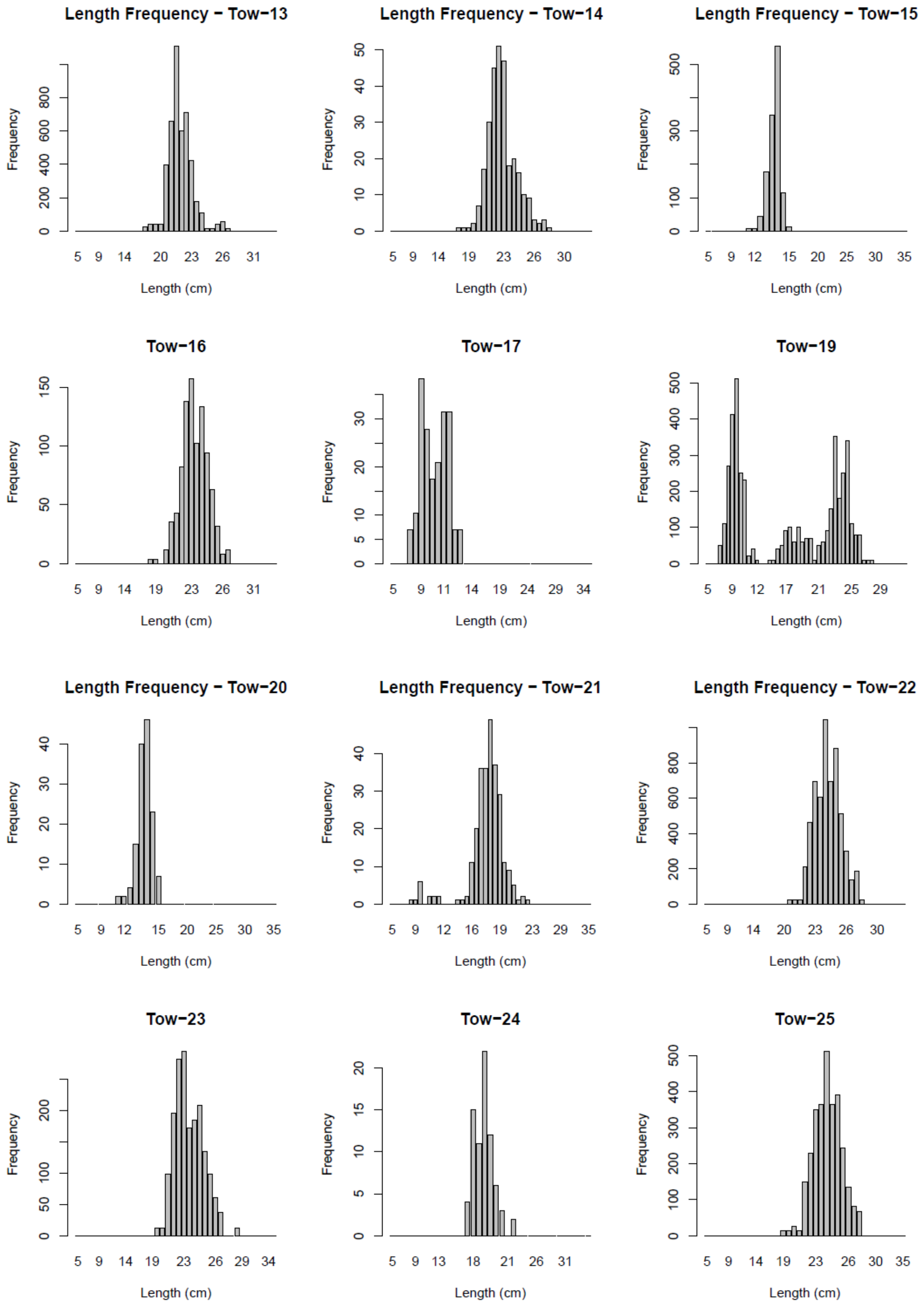


Figure 7.3.1 Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2022 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root 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
Frequency
0 200 400 600 800
5 9 14 20 23 26 31
Length (cm)
Length Frequency – Tow-14
Frequency
0 10 20 30 40 50
5 9 14 19 23 26 30
Length (cm)
Length Frequency – Tow-15
Frequency
0 100 300 500
5 9 12 15 20 25 30 35
Length (cm)
Tow-16
Frequency
0 50 100 150
5 9 14 19 23 26 31
Length (cm)
Tow-17
Frequency
0 5 10 20 30
5 9 11 14 19 24 29 34
Length (cm)
Tow-19
Frequency
0 100 200 300 400 500
5 9 12 17 21 25 29
Length (cm)
Length Frequency – Tow-20
Frequency
0 10 20 30 40
5 9 12 15 20 25 30 35
Length (cm)
Length Frequency – Tow-21
Frequency
0 10 20 30 40
5 9 12 16 19 23 29 35
Length (cm)
Length Frequency – Tow-22
Frequency
0 200 400 600 800
5 9 14 20 23 26 30
Length (cm)
Tow-23
Frequency
0 50 100 200
5 9 14 19 23 26 29 34
Length (cm)
Tow-24
Frequency
0 5 10 15 20
5 9 13 18 21 26 31
Length (cm)
Tow-25
Frequency
0 100 200 300 400 500
5 9 14 19 23 26 30 35
Length (cm)

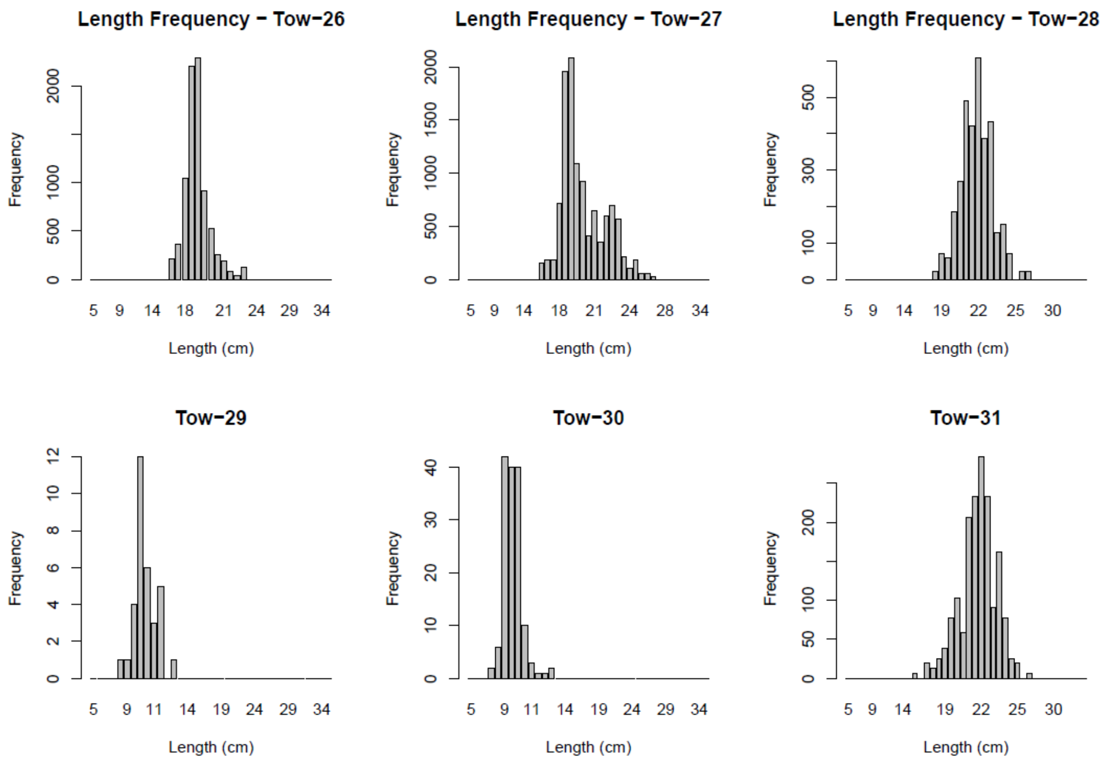


Figure 7.3.2 Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2019 acoustic survey.

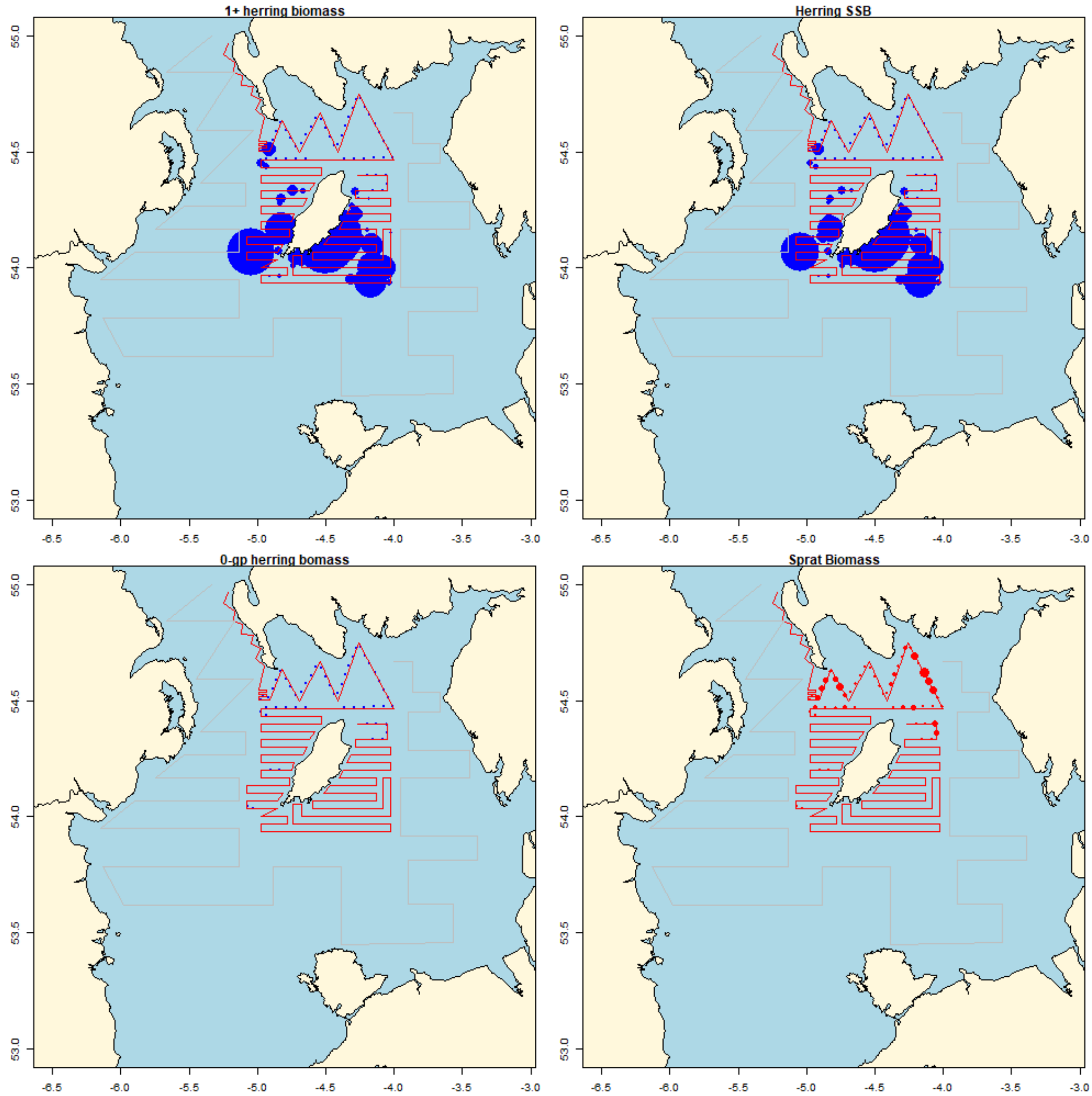


Figure 7.3.3 Herring in Division 7.a North (Irish Sea). Distribution plots for the 7.aNSpawn survey (2022) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).

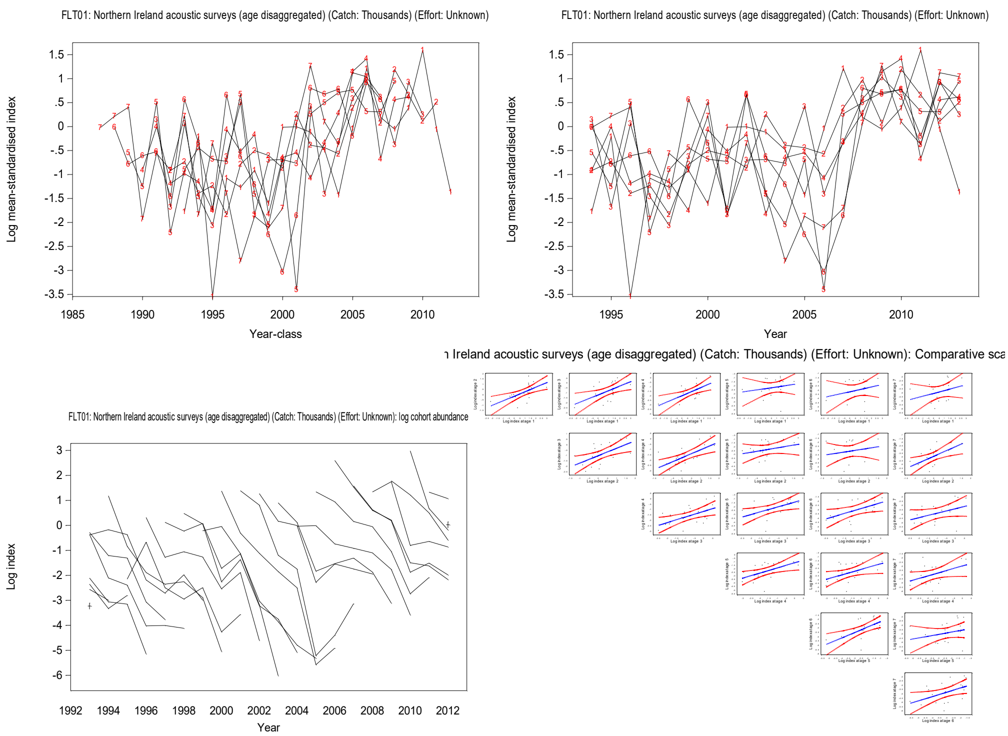
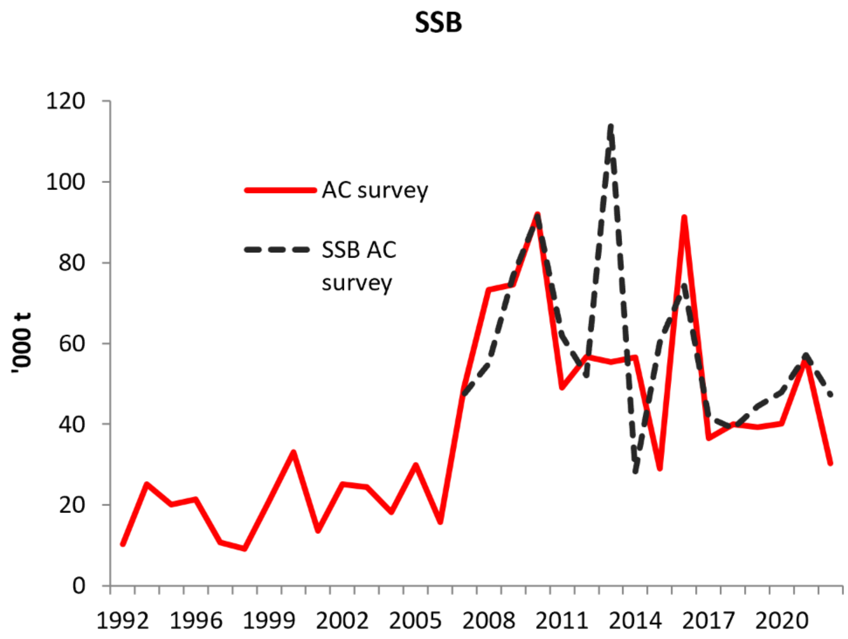


Figure 7.3.4 Herring in Division 7.a North (Irish Sea). Acoustic survey (AC(7.aN)) log mean-standardised indices by year and age class, scatter plots and catch curves.



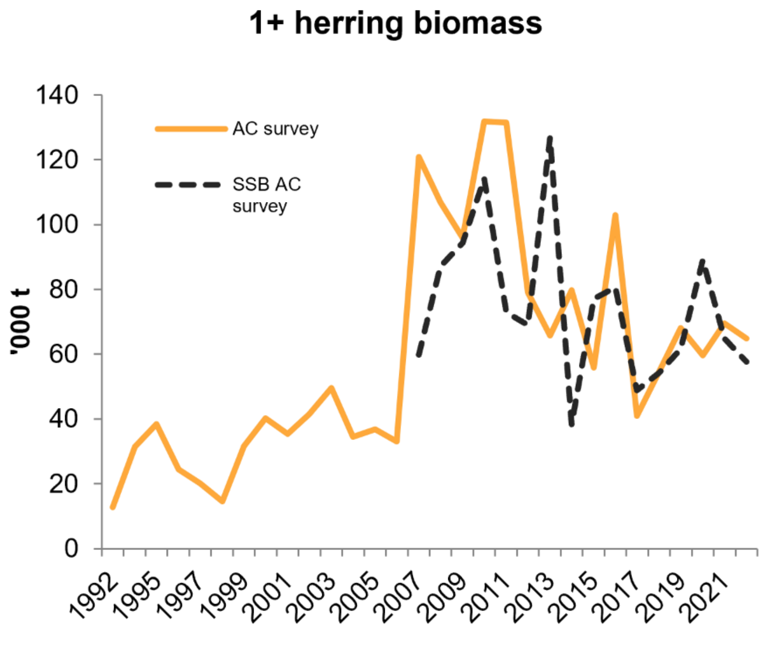


Figure 7.3.5 Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

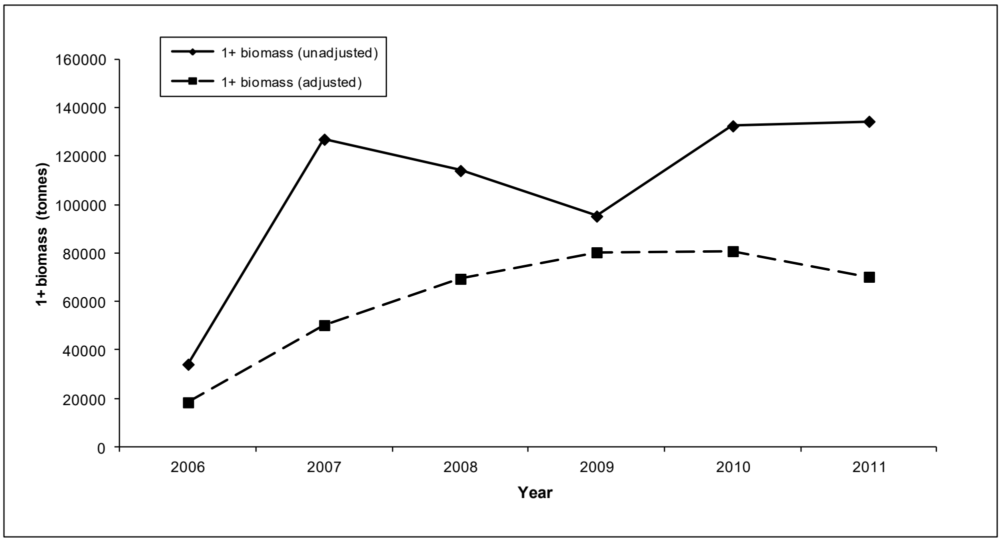


Figure 7.3.6 Herring in Division 7.a North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

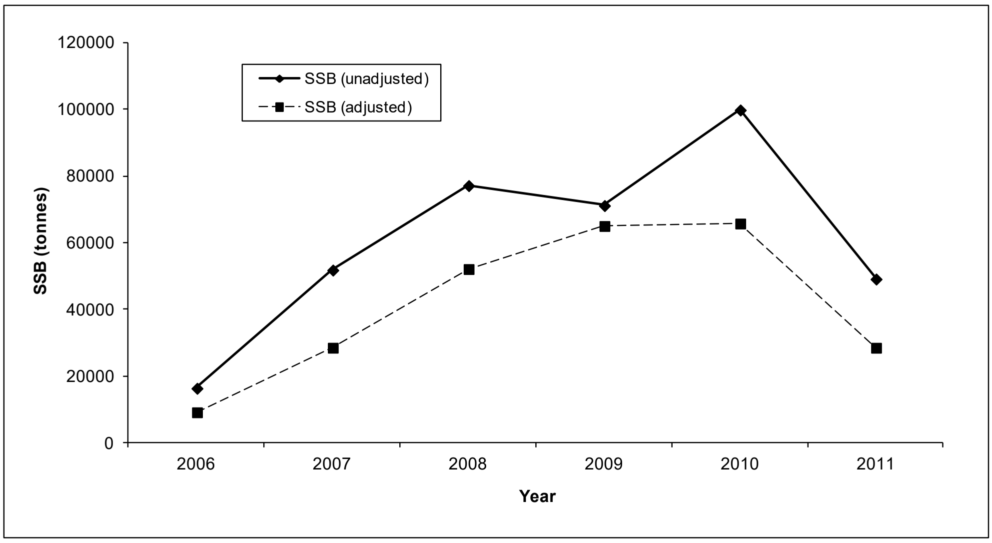


Figure 7.3.7 Herring in Division 7.a North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

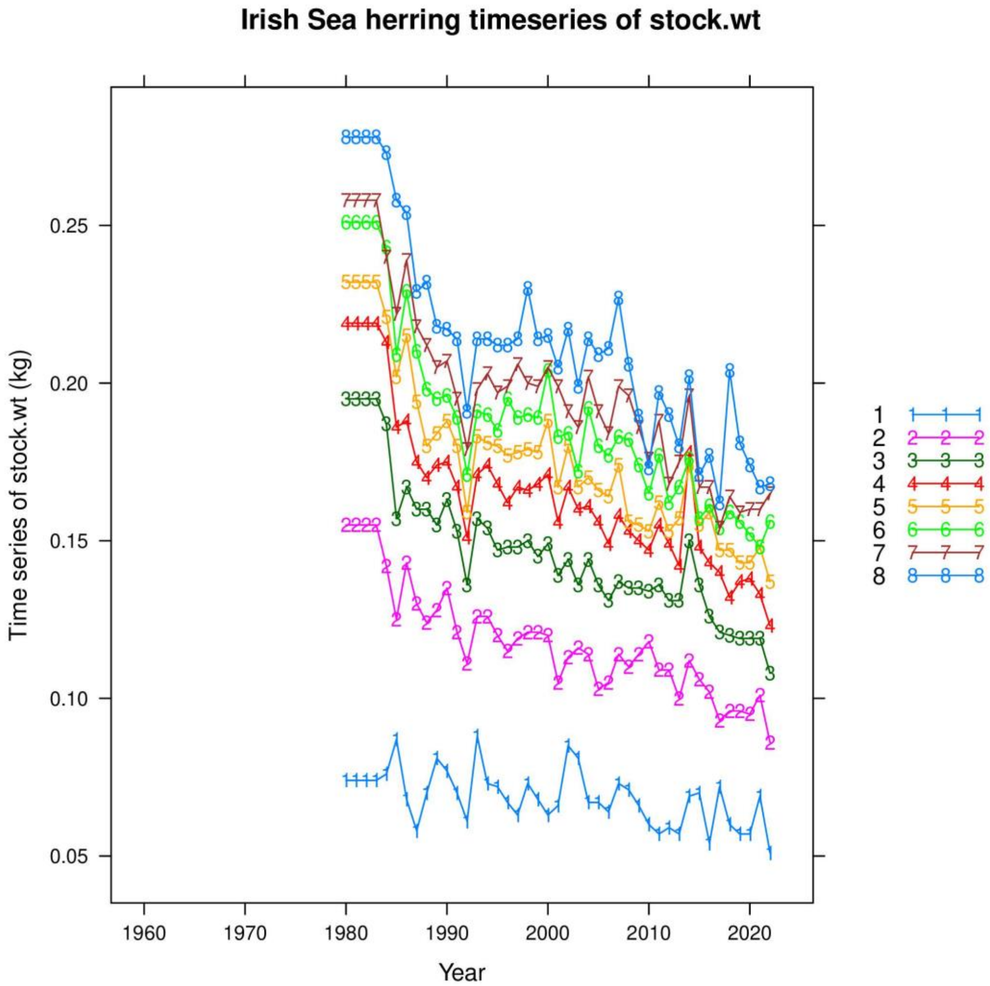


Figure 7.4.1 Herring in Division 7.a North (Irish Sea). Time series of catch weights at age.

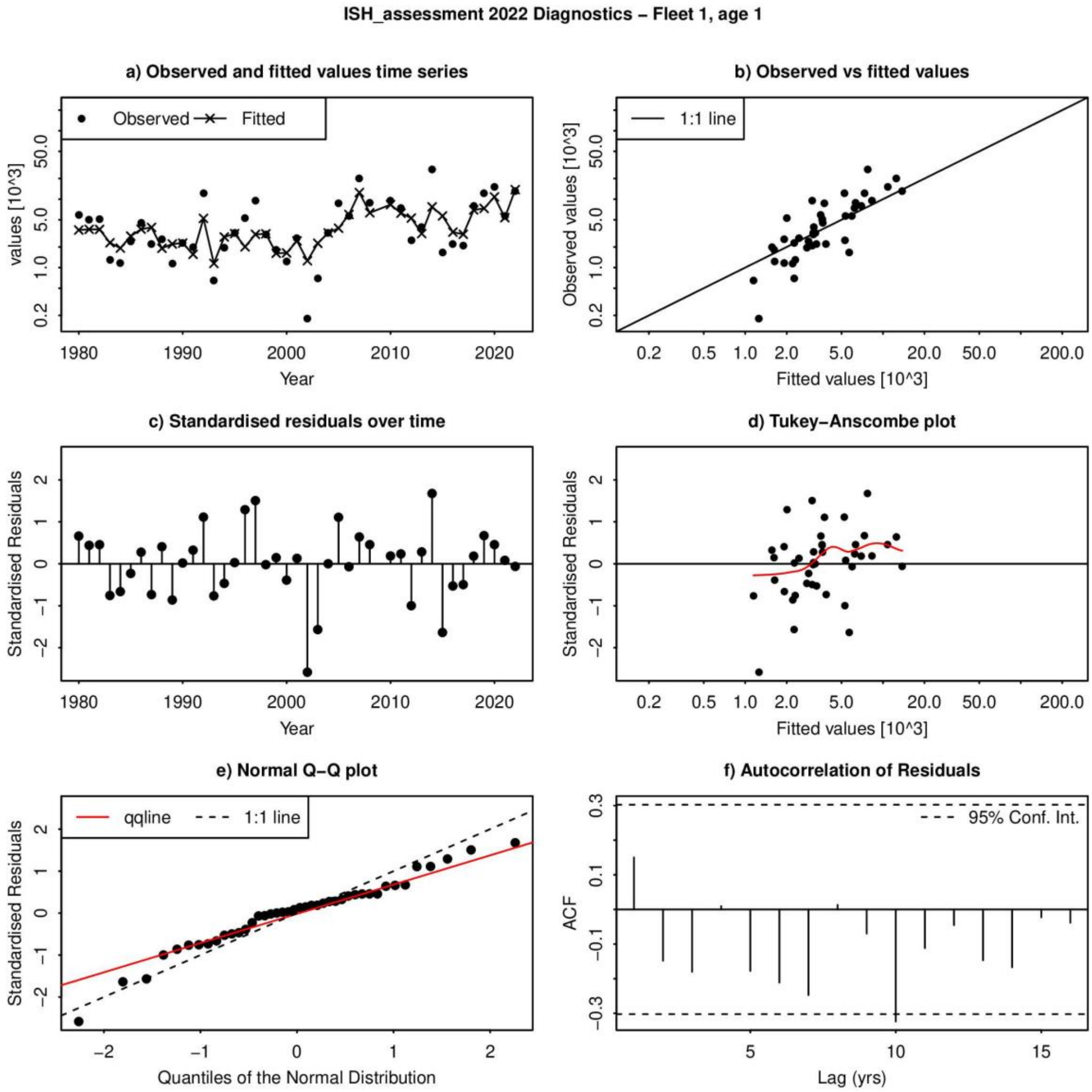


Figure 7.6.1 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

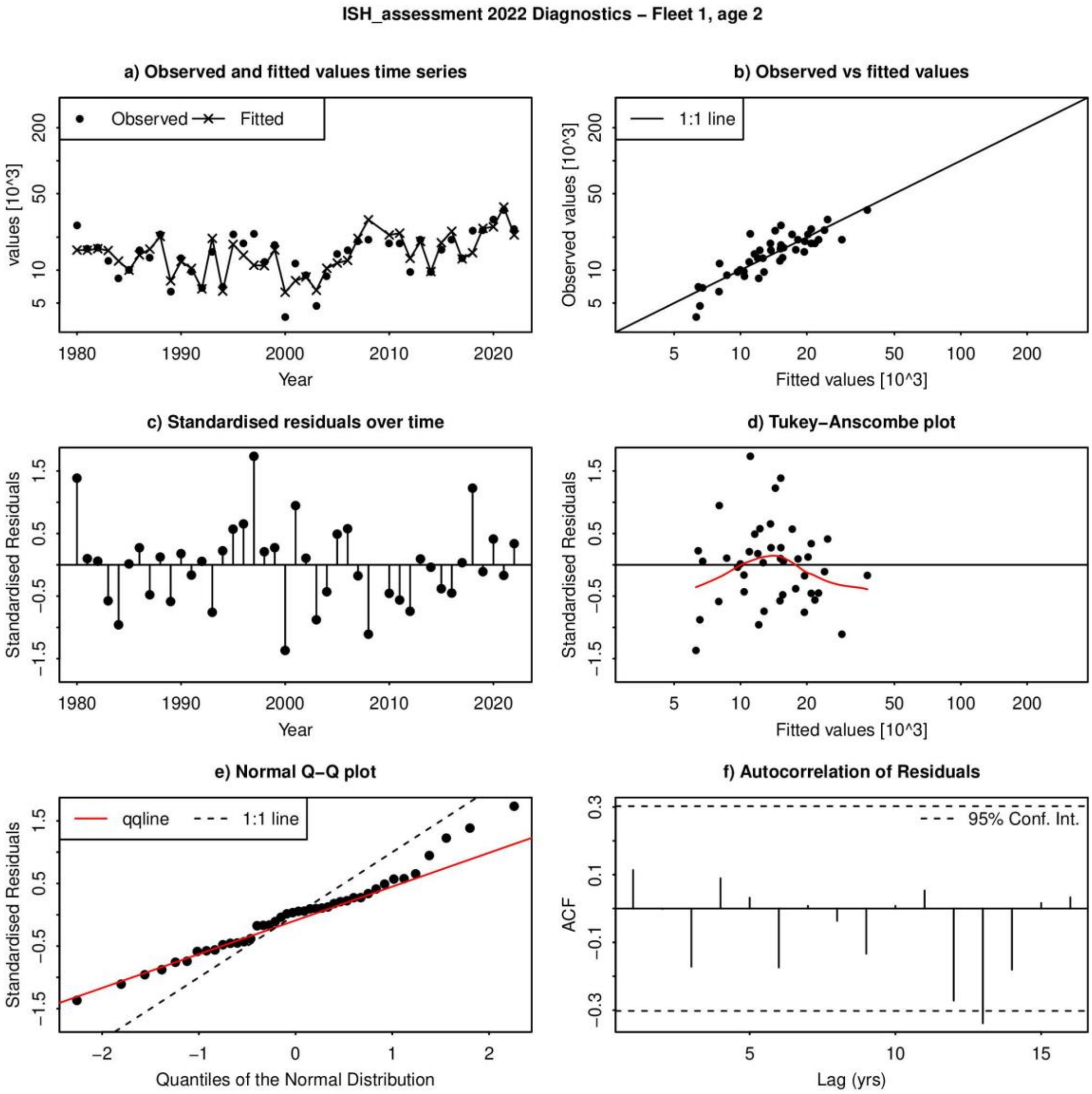


Figure 7.6.2 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.

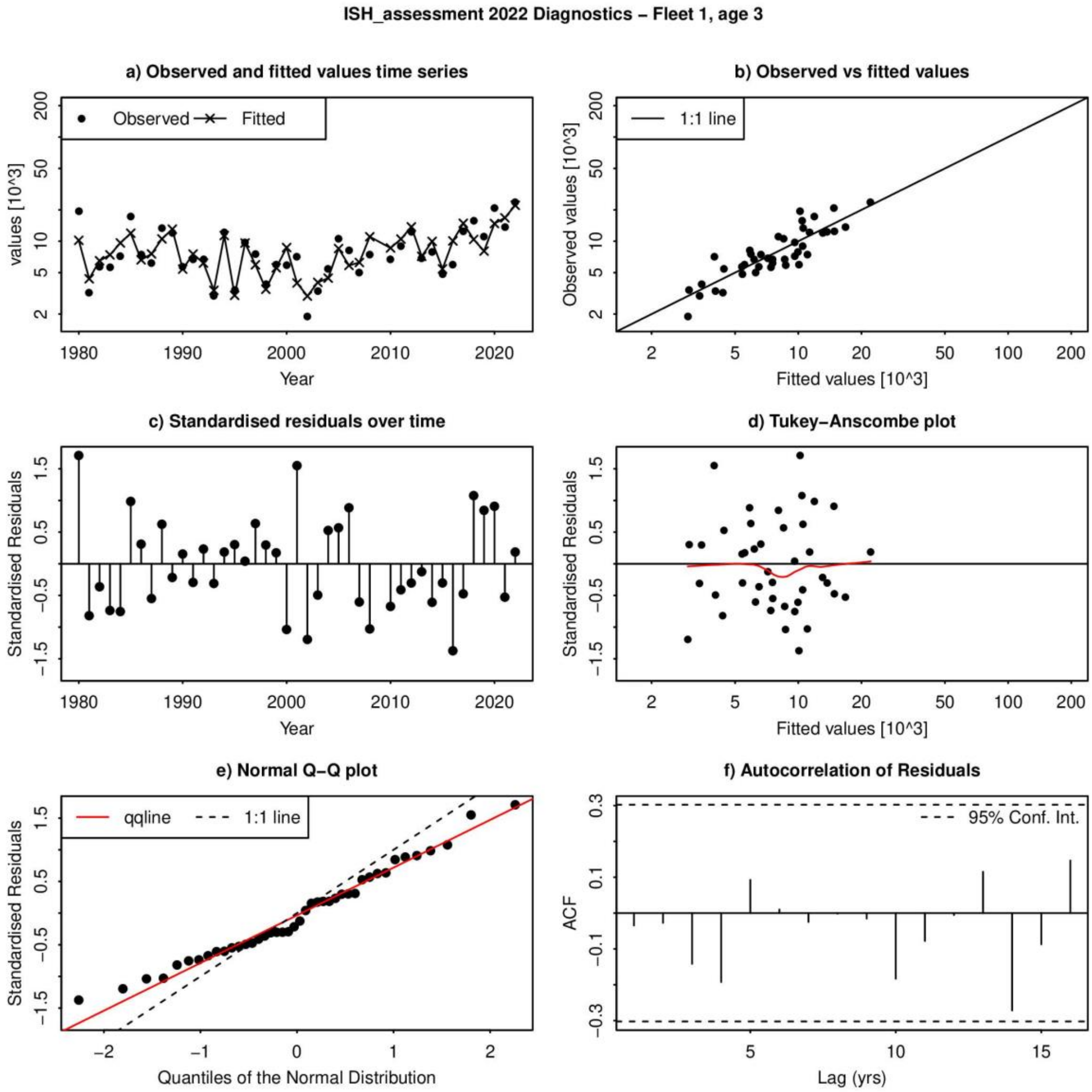


Figure 7.6.3 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

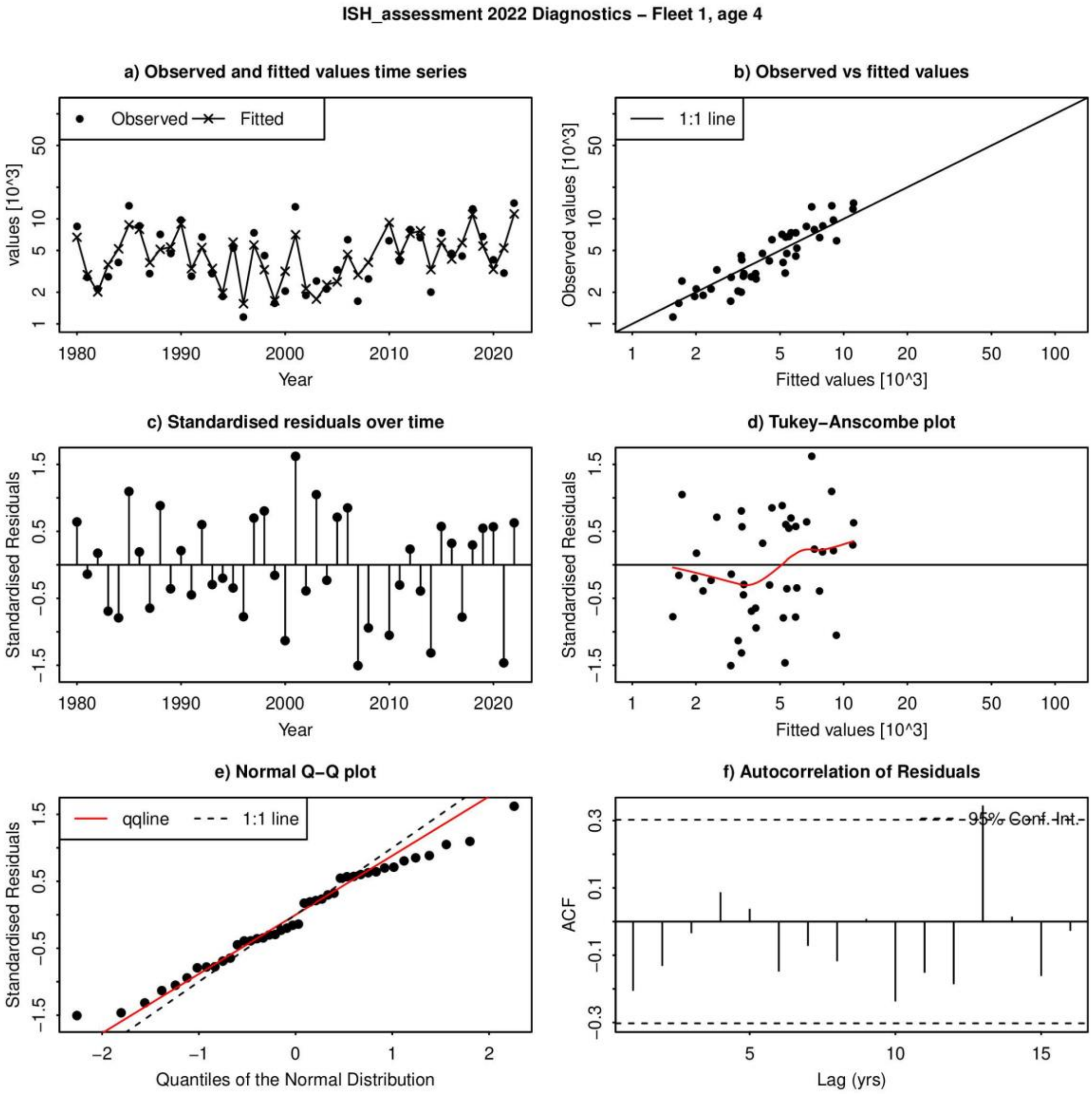


Figure 7.6.4 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.

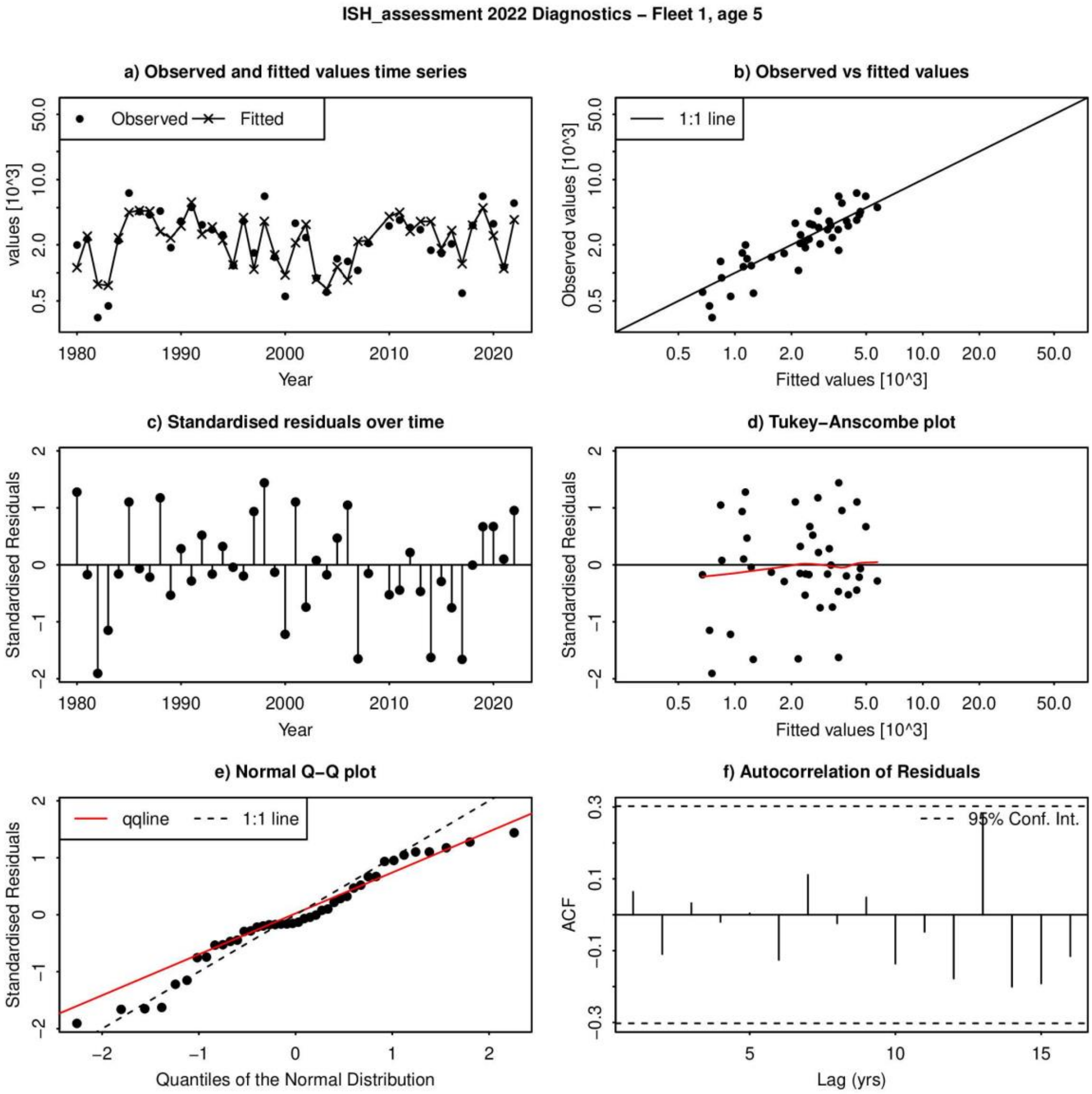


Figure 7.6.5 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.

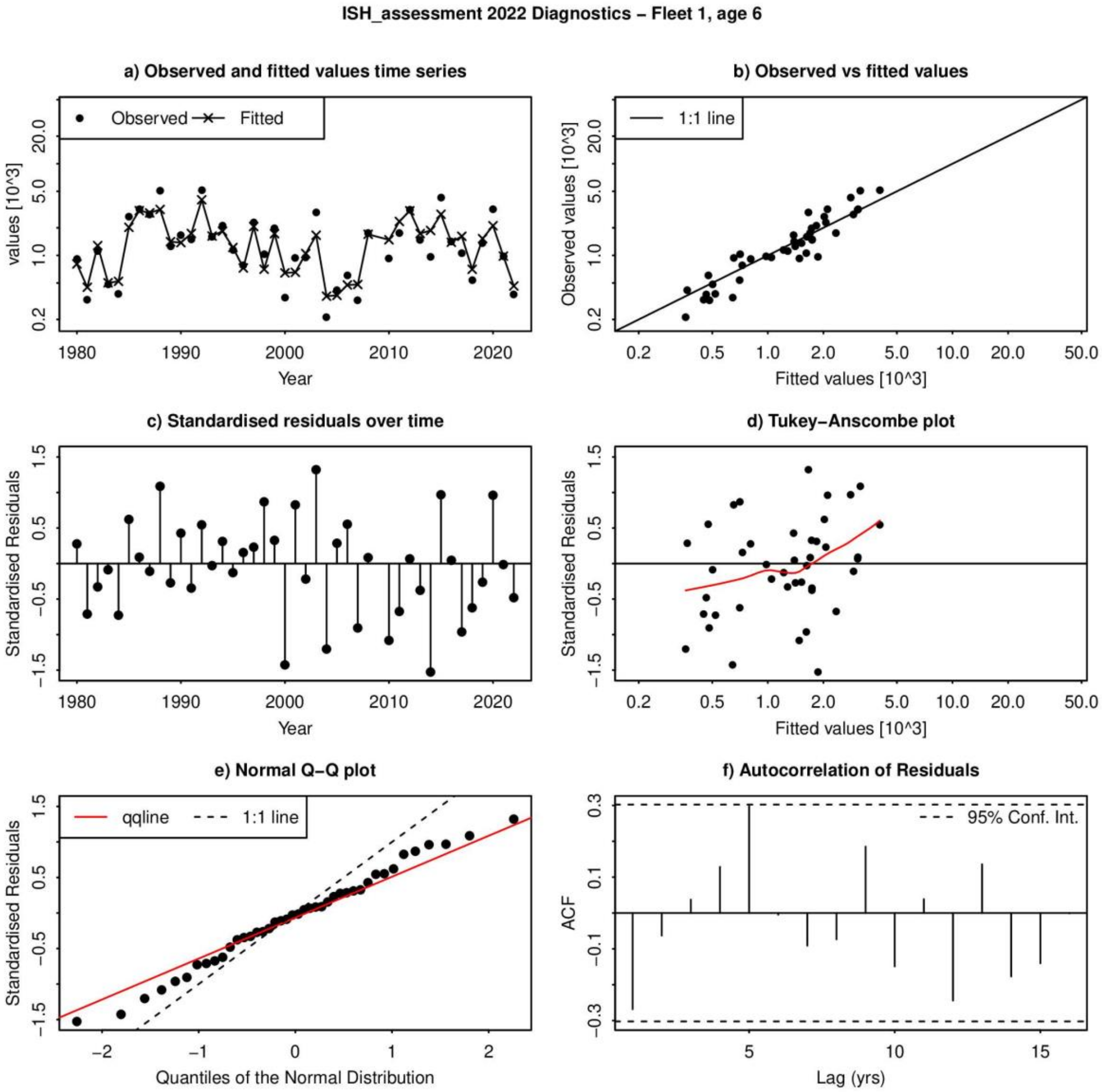


Figure 7.6.6 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

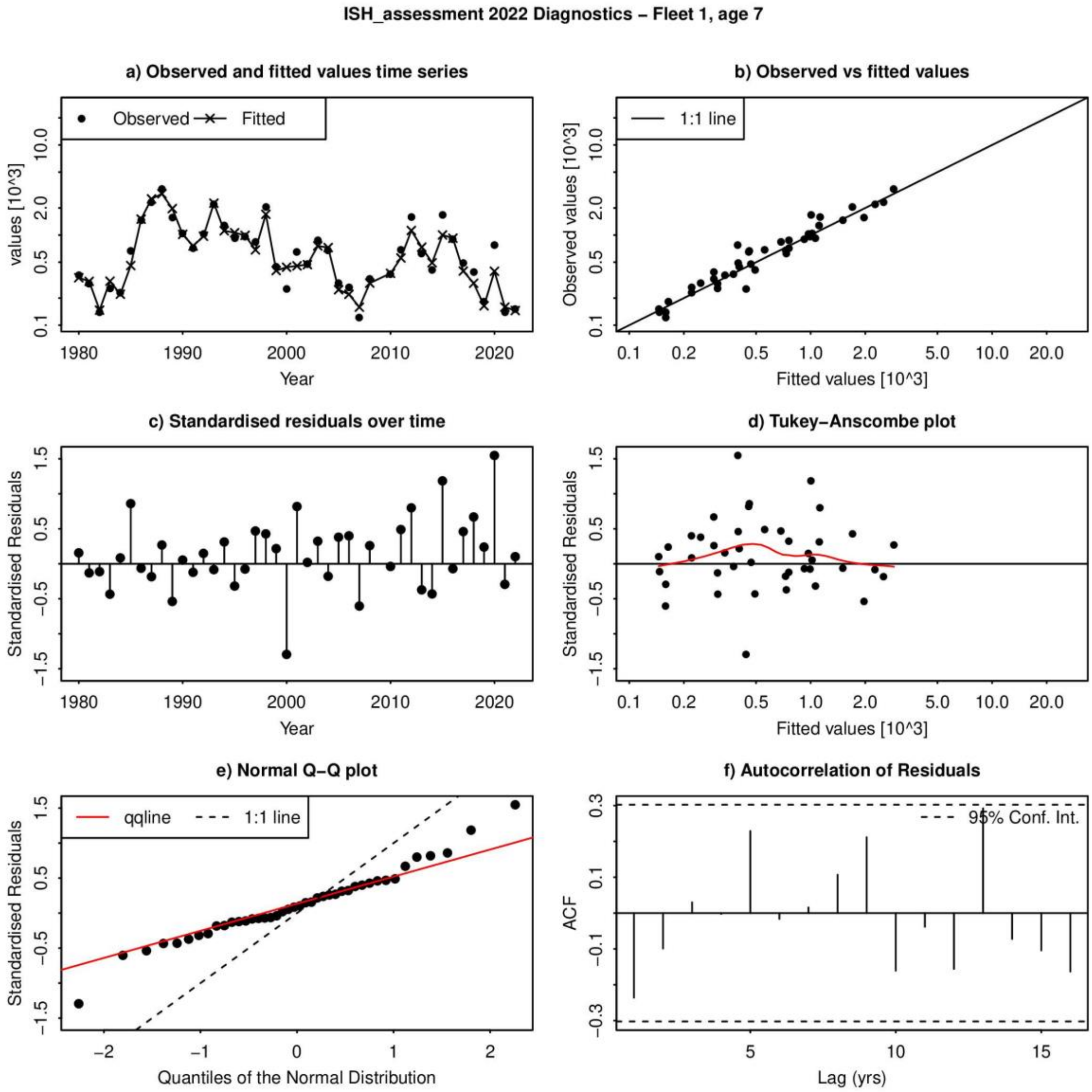


Figure 7.6.7 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

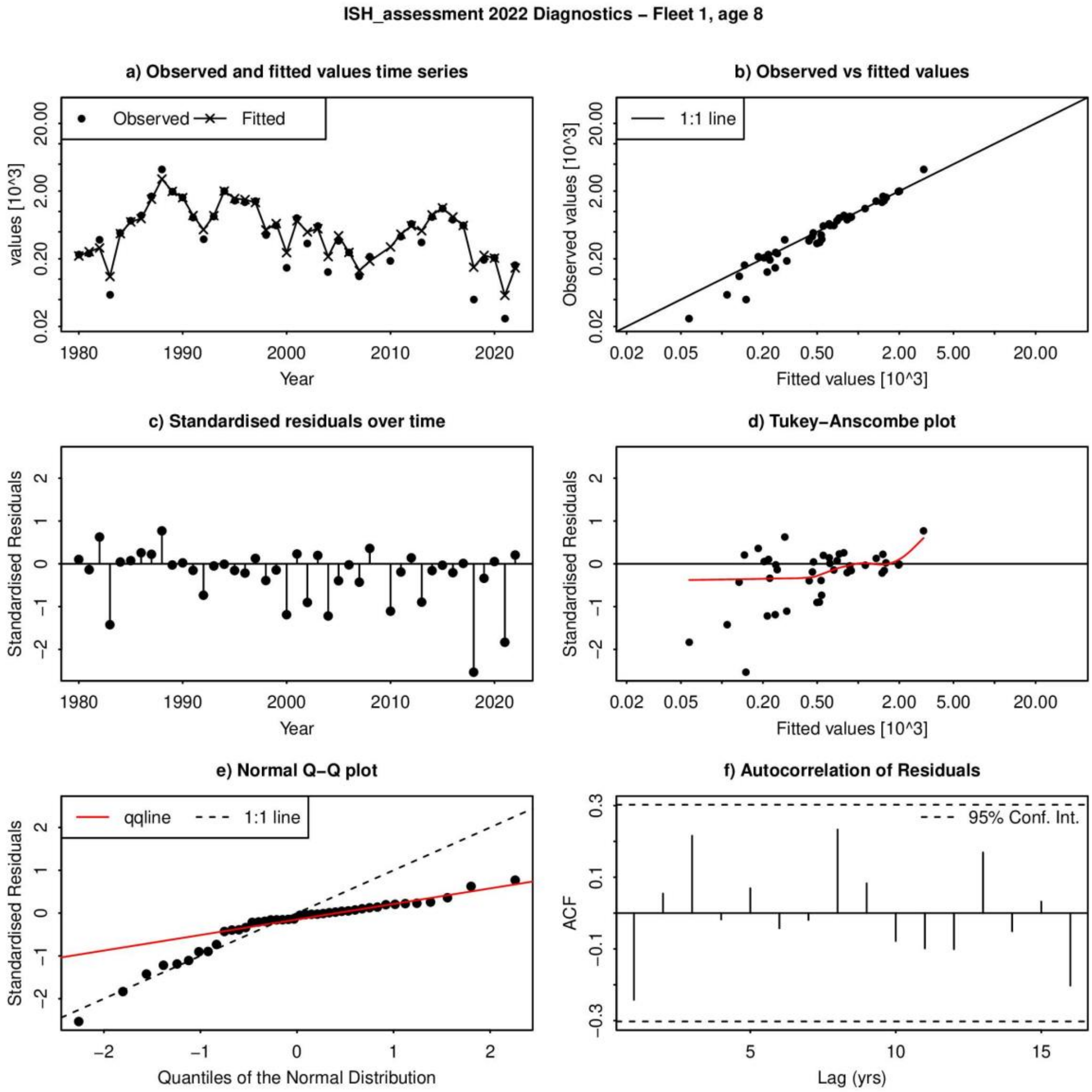
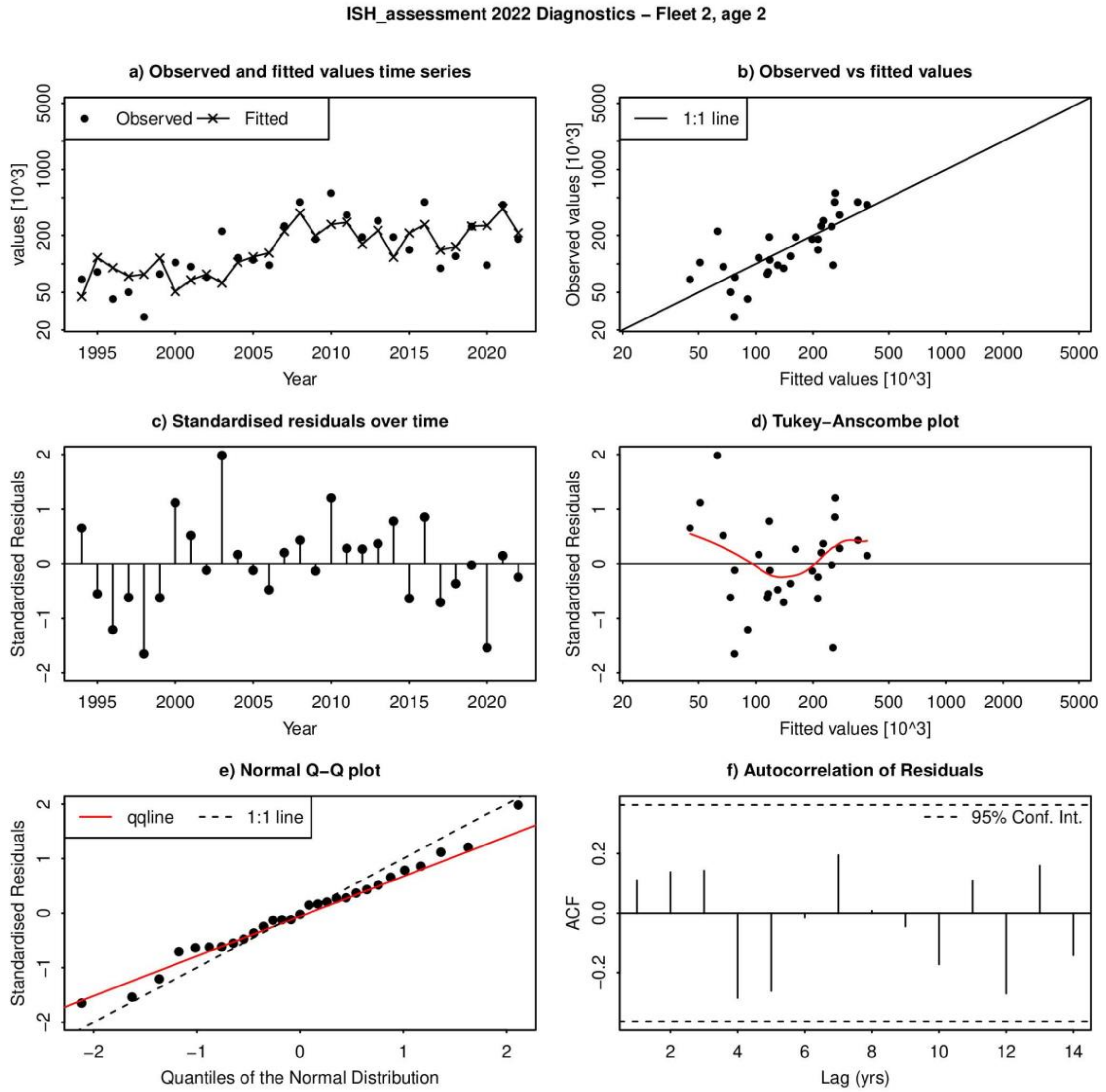


Figure 7.6.8 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.


ISH_assessment 2022 Diagnostics – Fleet 2, age 2
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey–Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q–Q plot
qqline
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

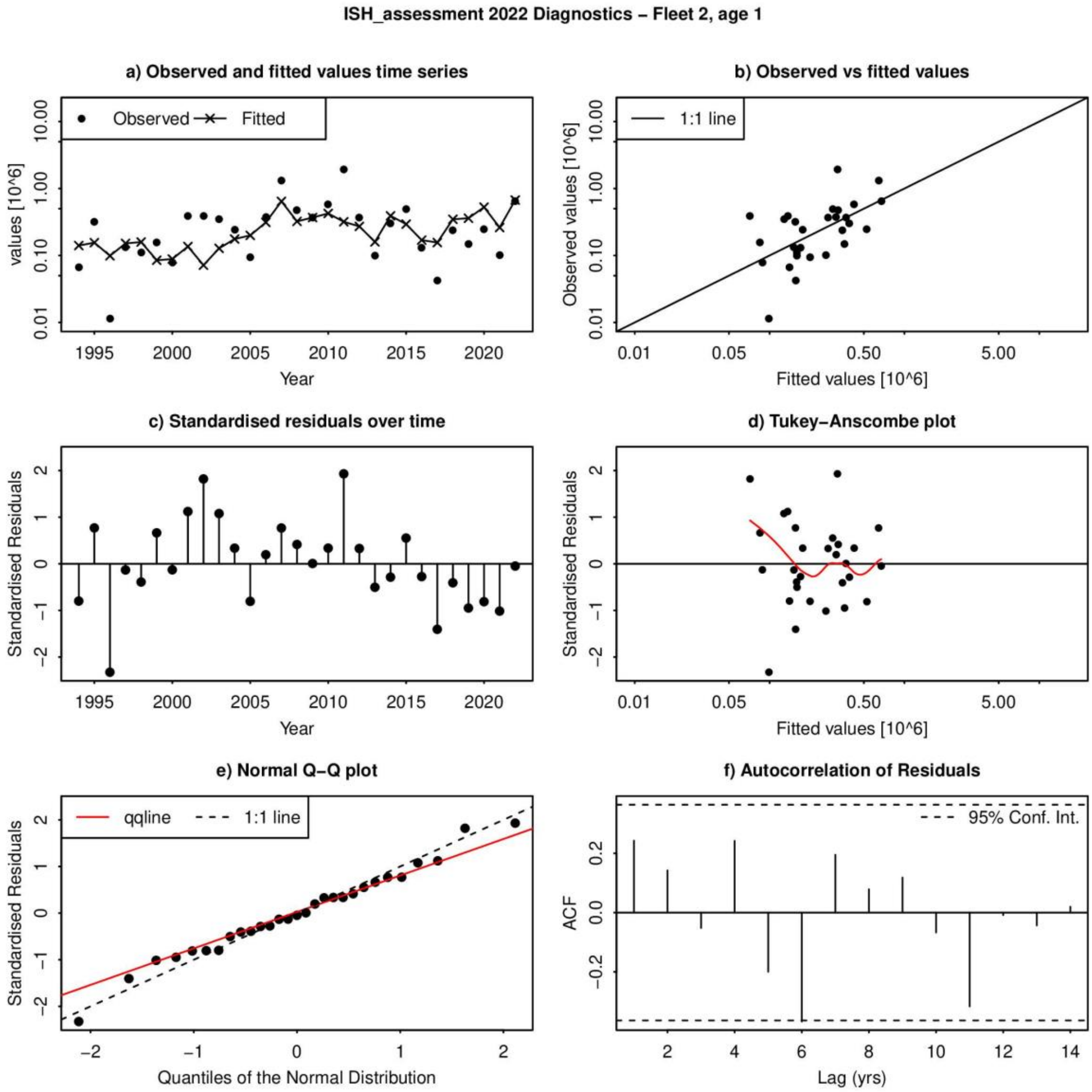
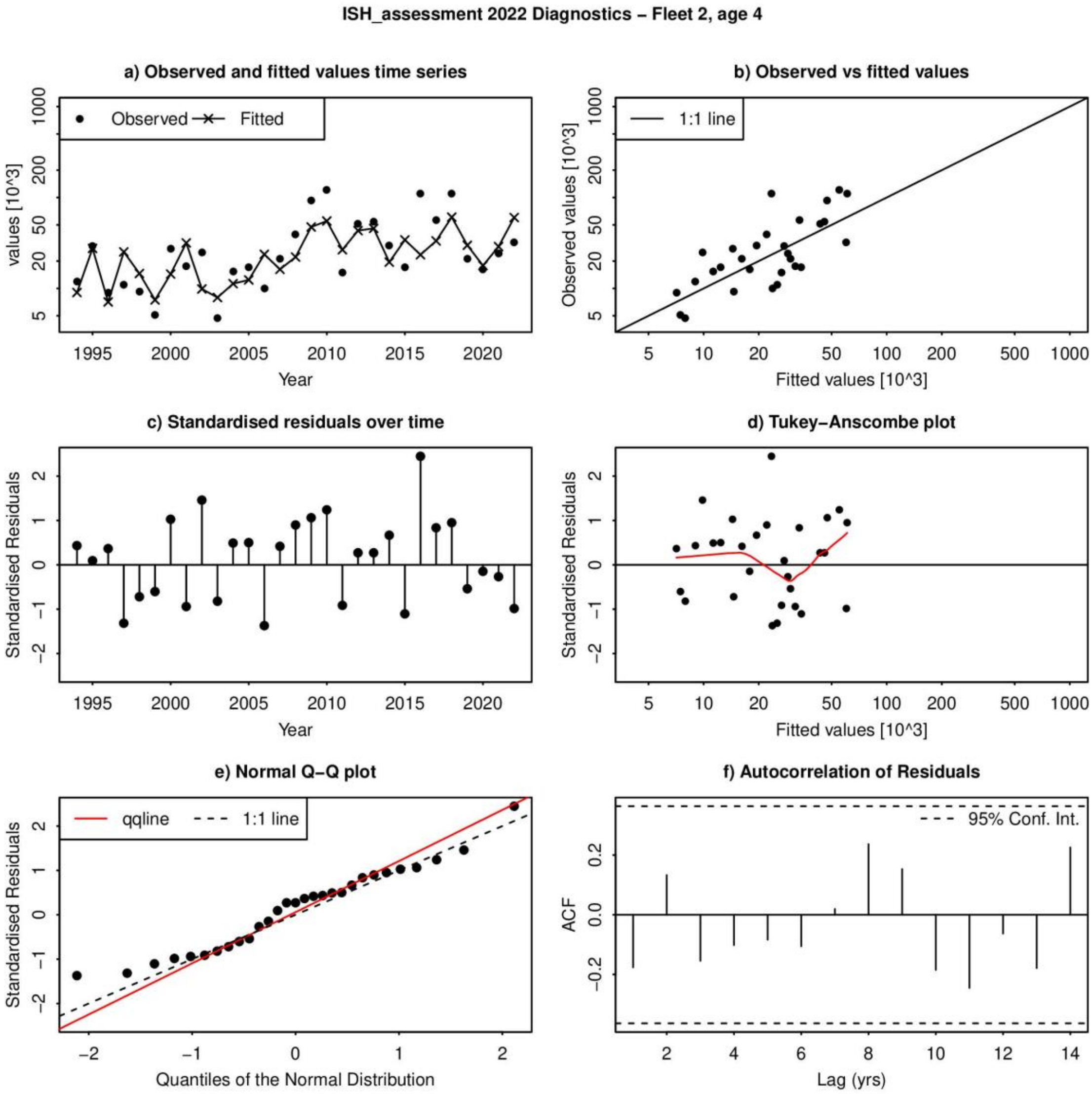


Figure 7.6.9 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age1.


ISH_assessment 2022 Diagnostics – Fleet 2, age 4
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey–Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q–Q plot
qqline
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

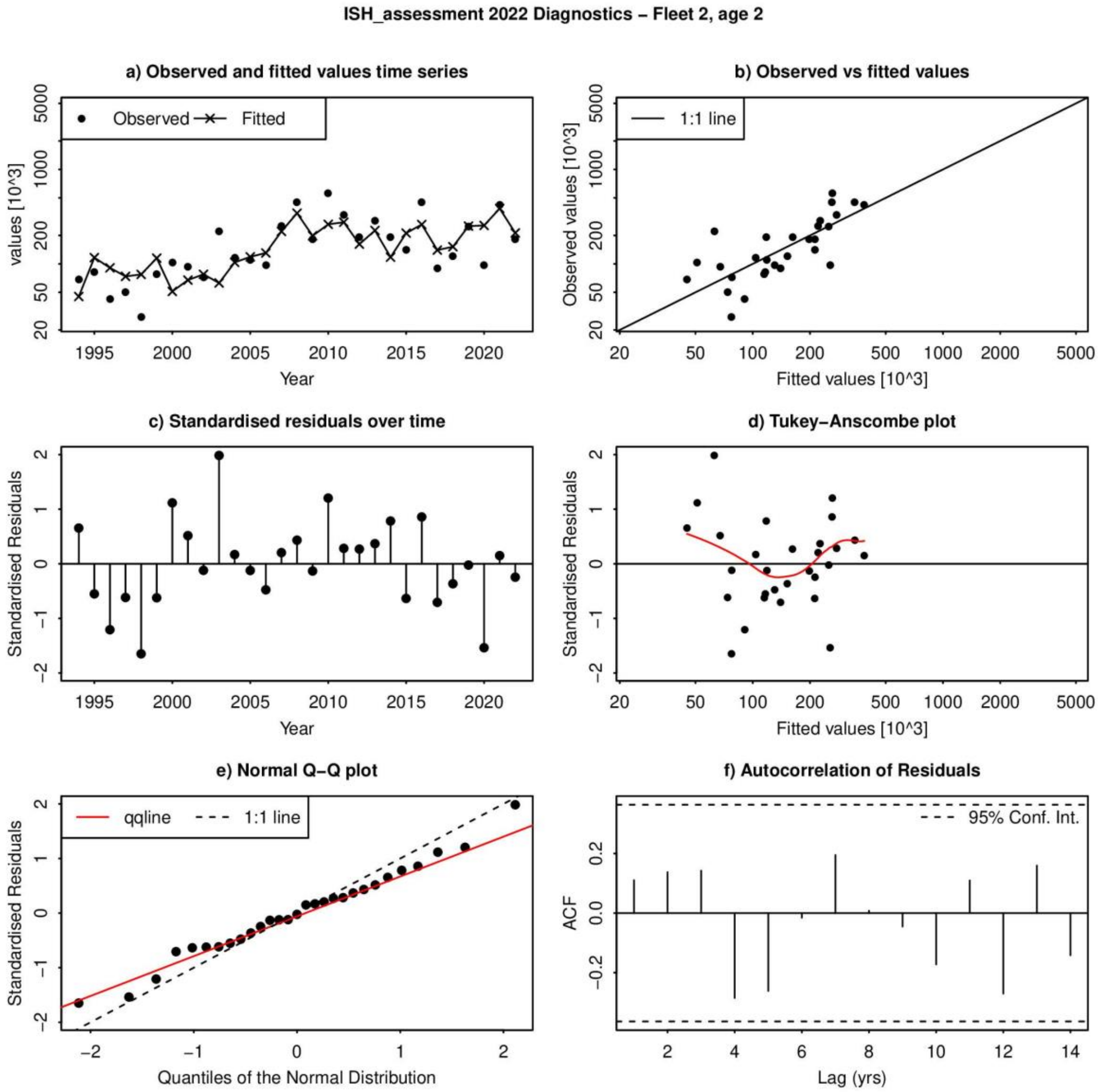


Figure 7.6.10 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age2.

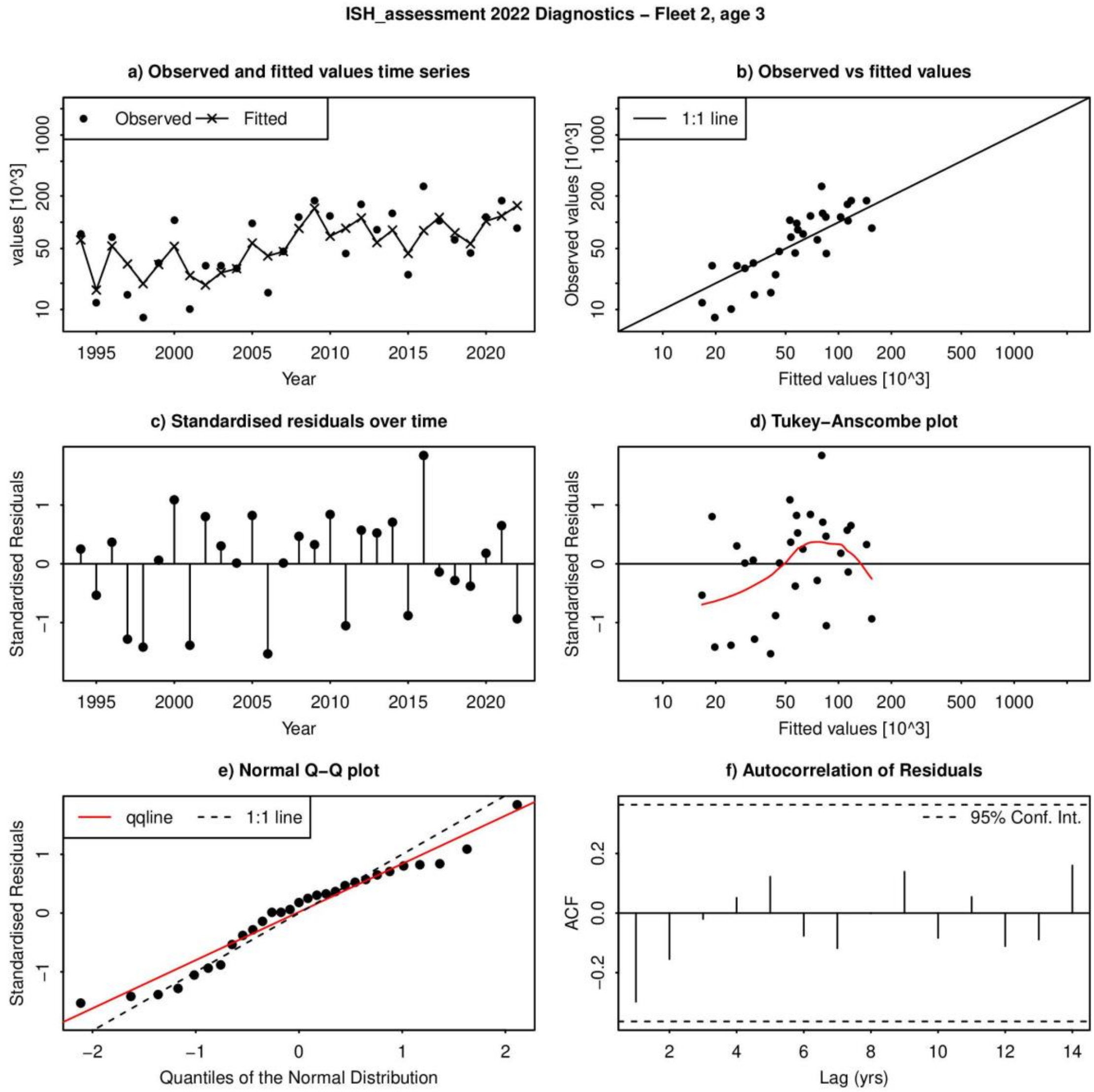


Figure 7.6.11 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age3.

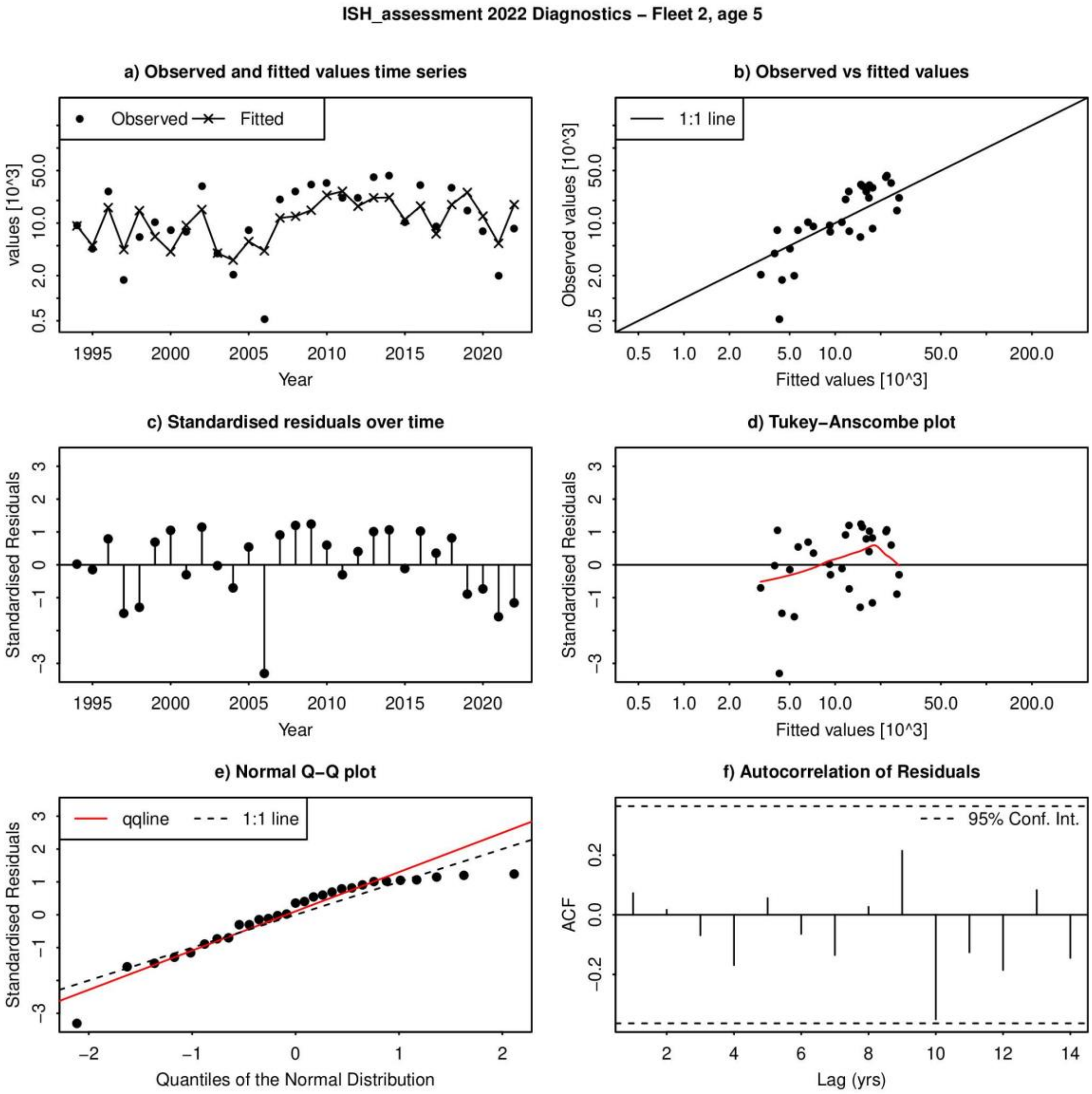


Figure 7.6.12 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age4.

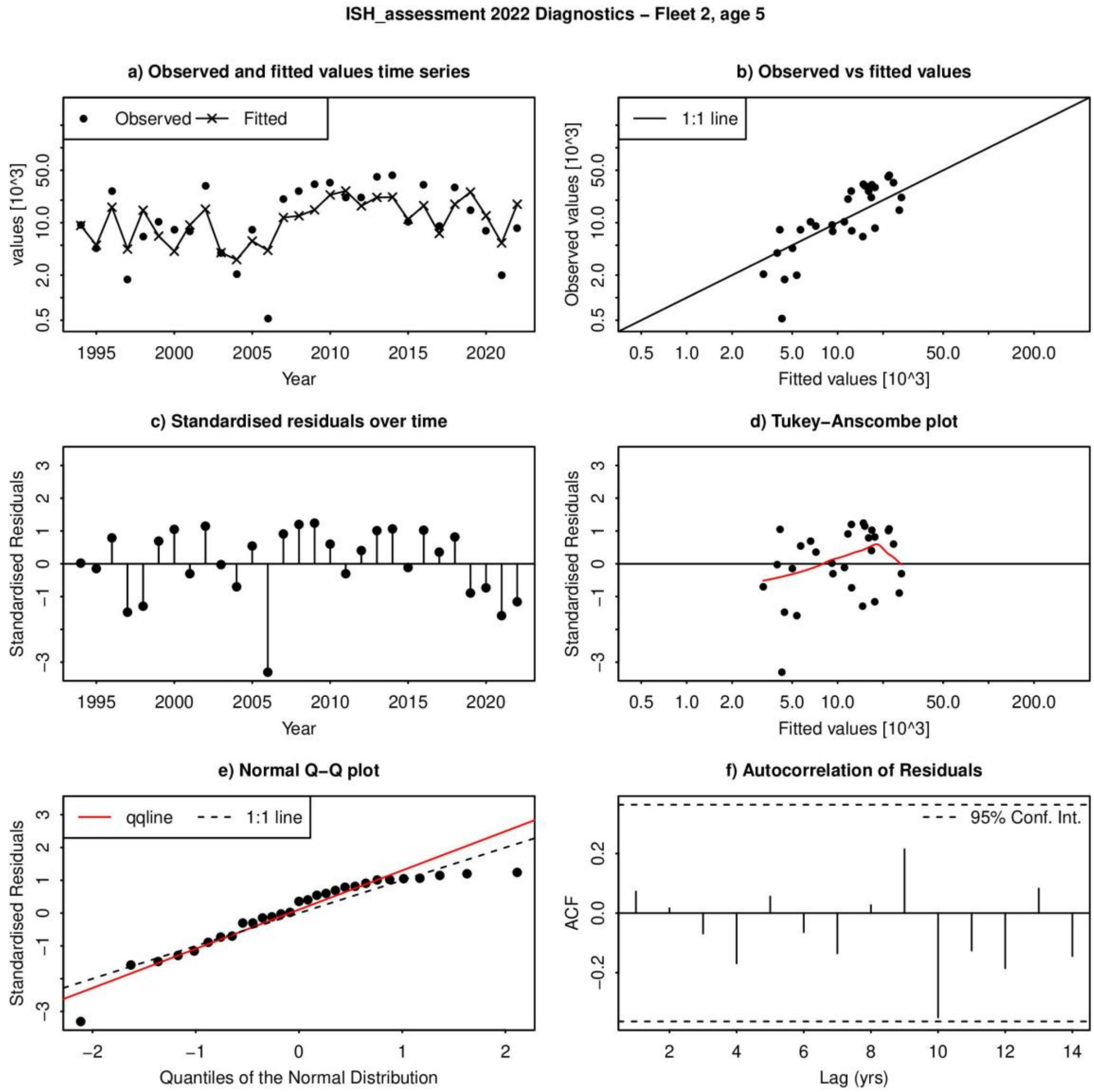


Figure 7.6.13 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age5.

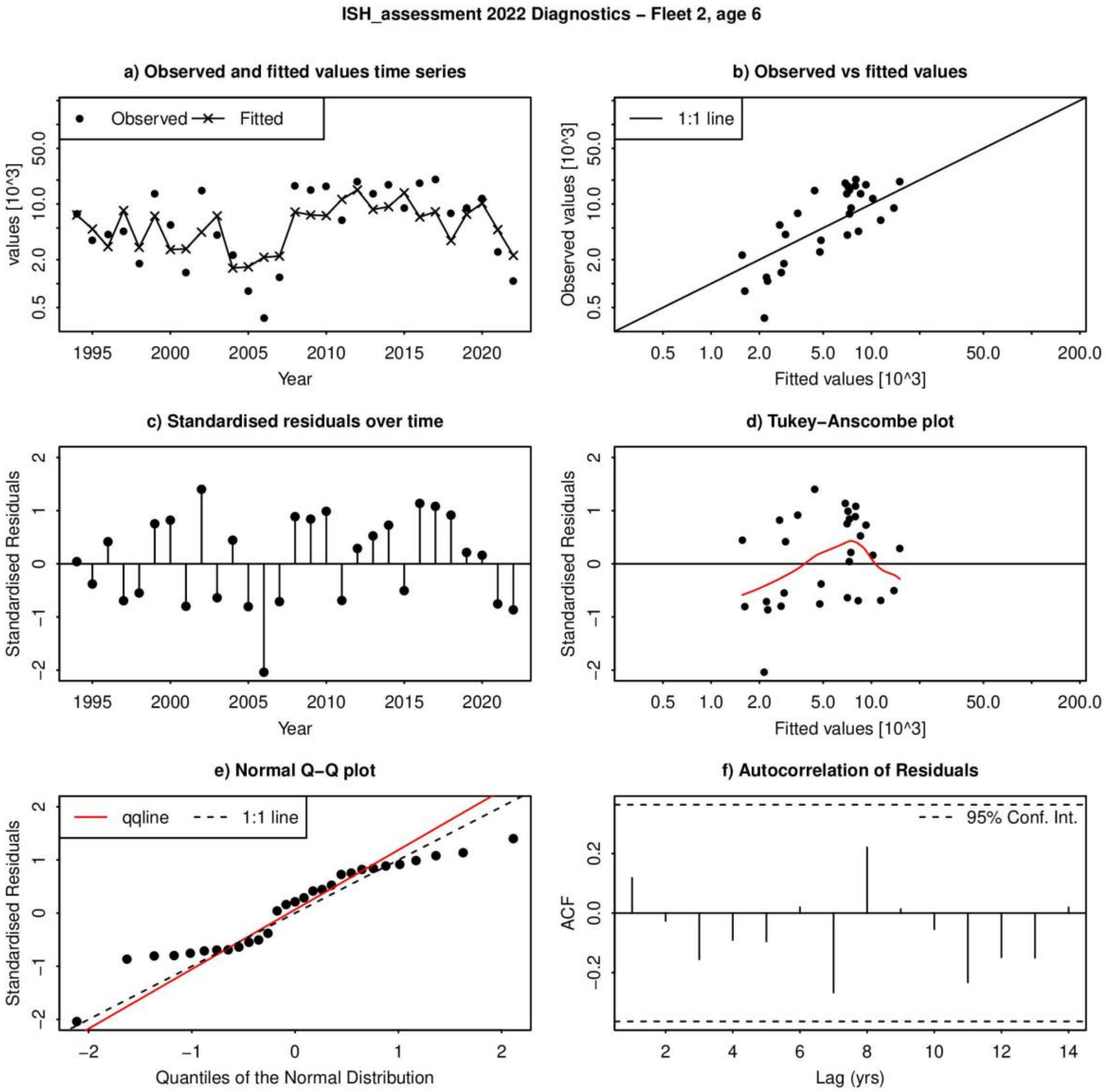
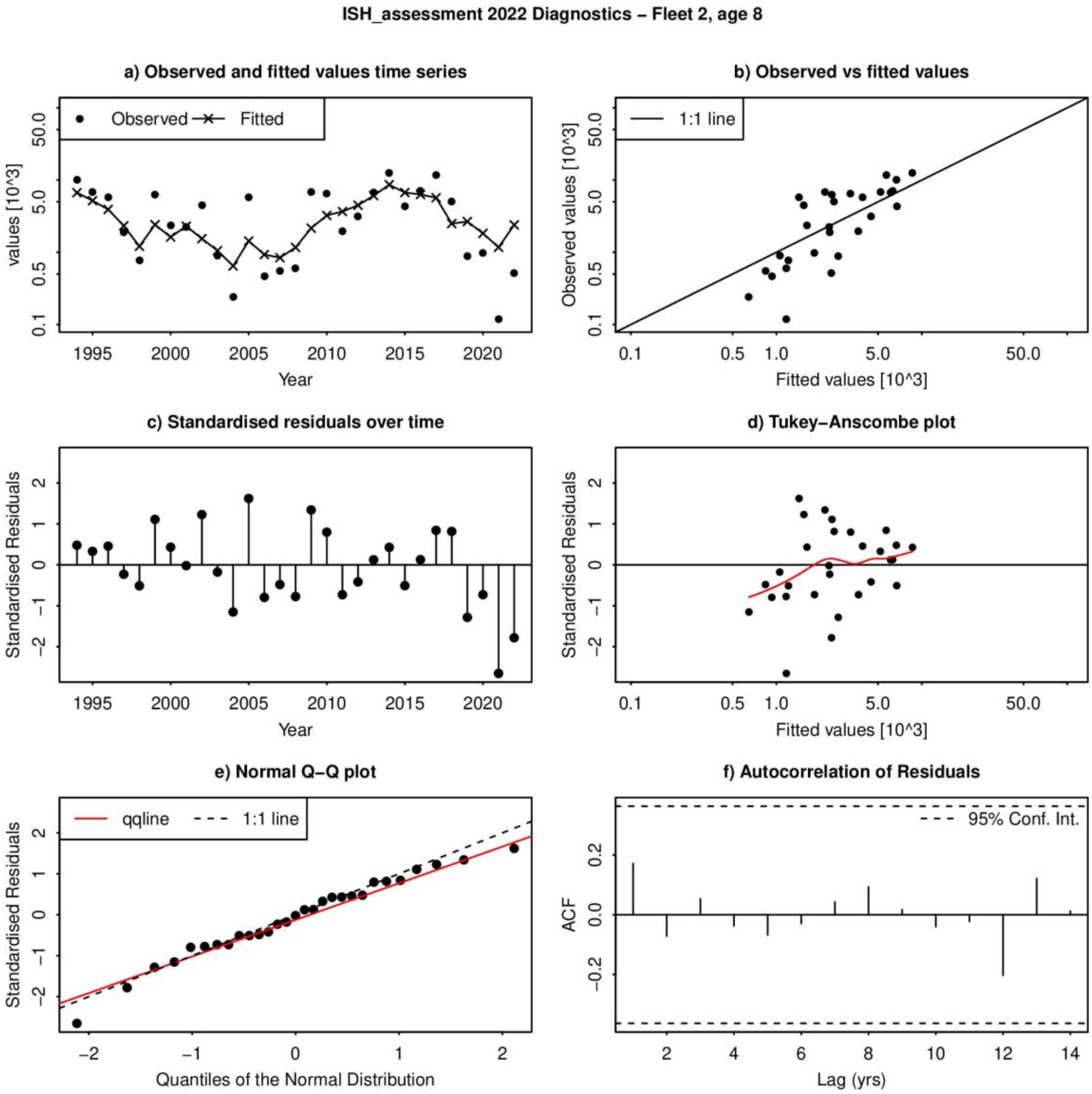


Figure 7.6.14 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age6.


ISH_assessment 2022 Diagnostics – Fleet 2, age 8
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey–Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q–Q plot
qqline
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

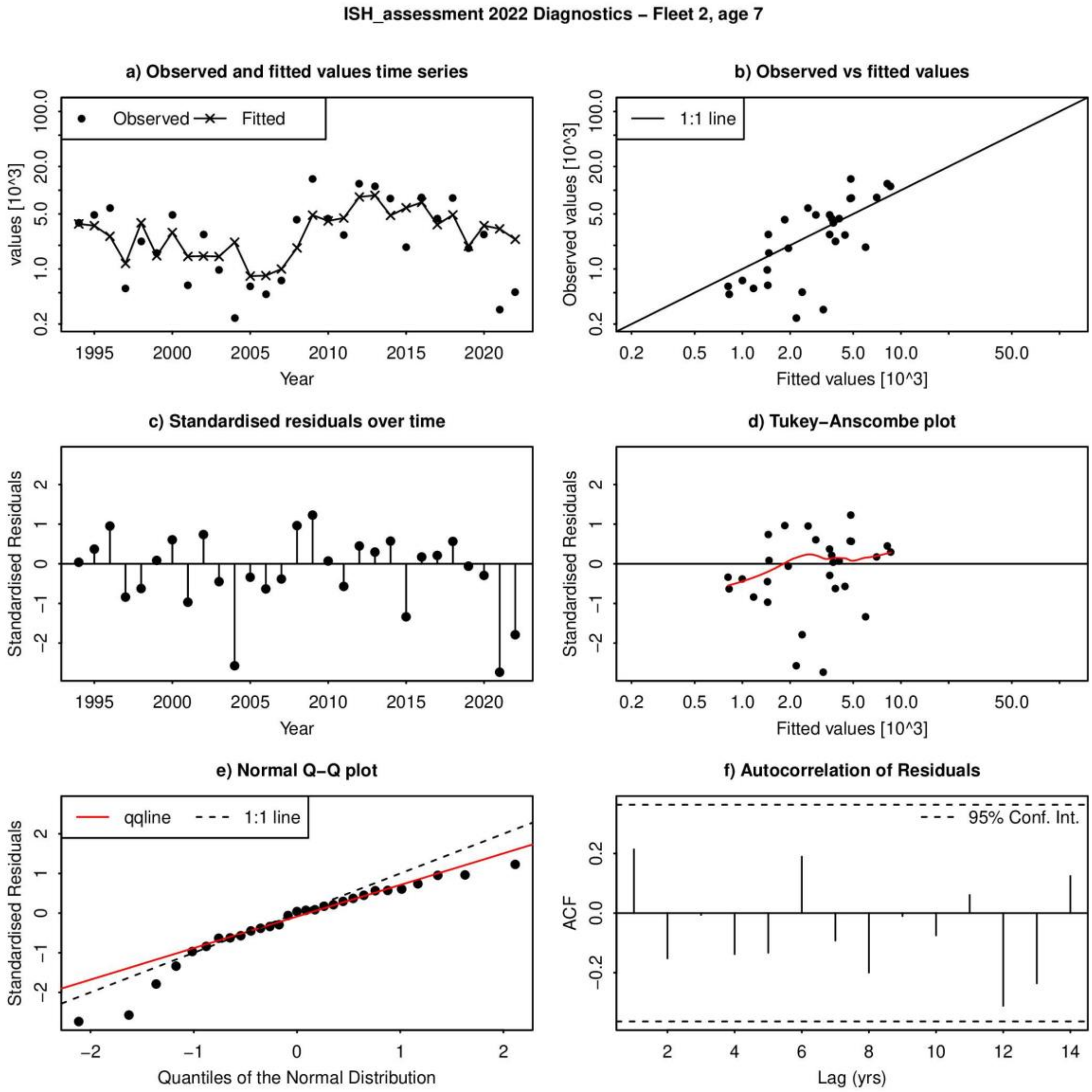


Figure 7.6.15 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age7.

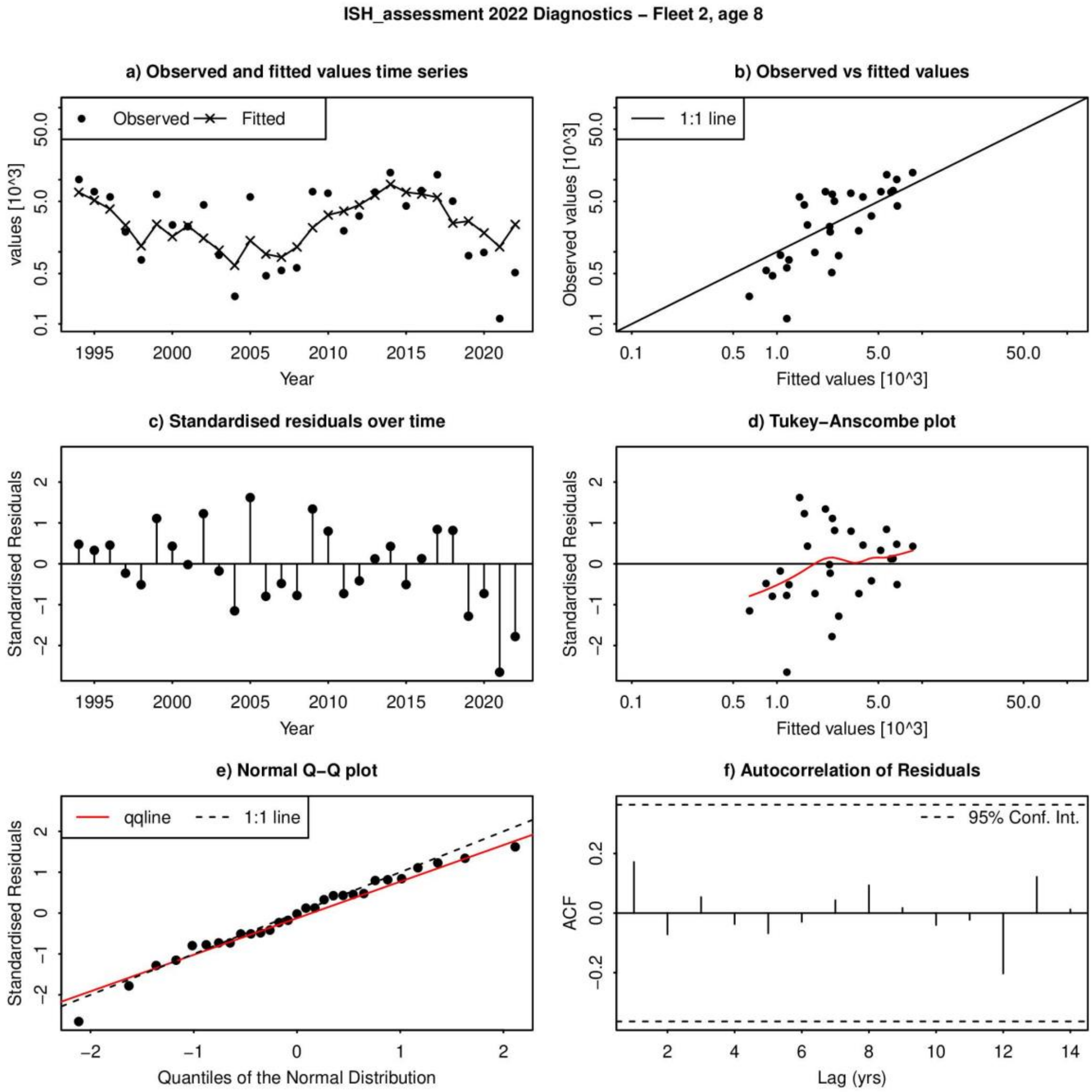


Figure 7.6.16 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age8.

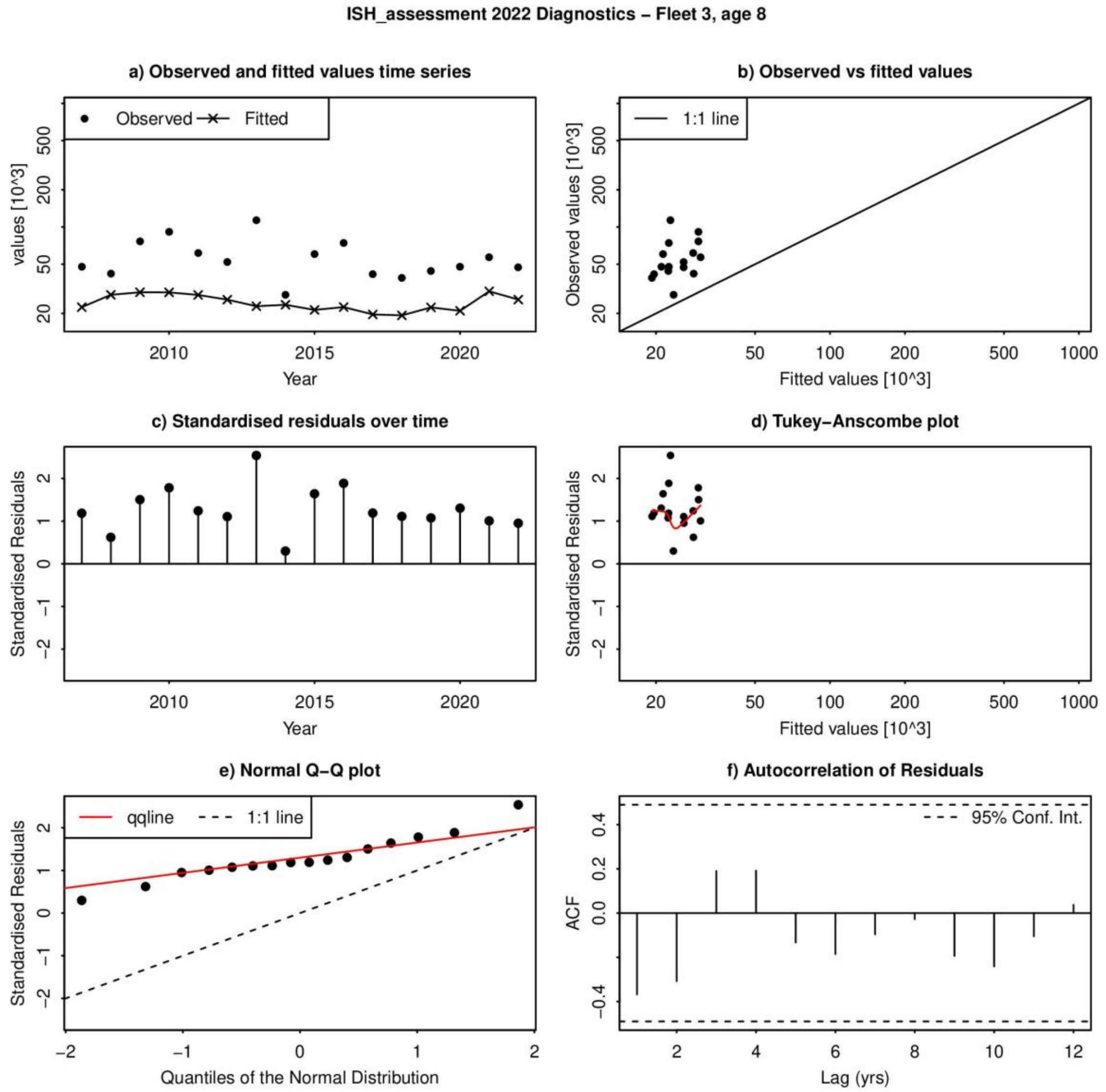


Figure 7.6.17 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the SSB acoustic survey (SSB 7.aN)).

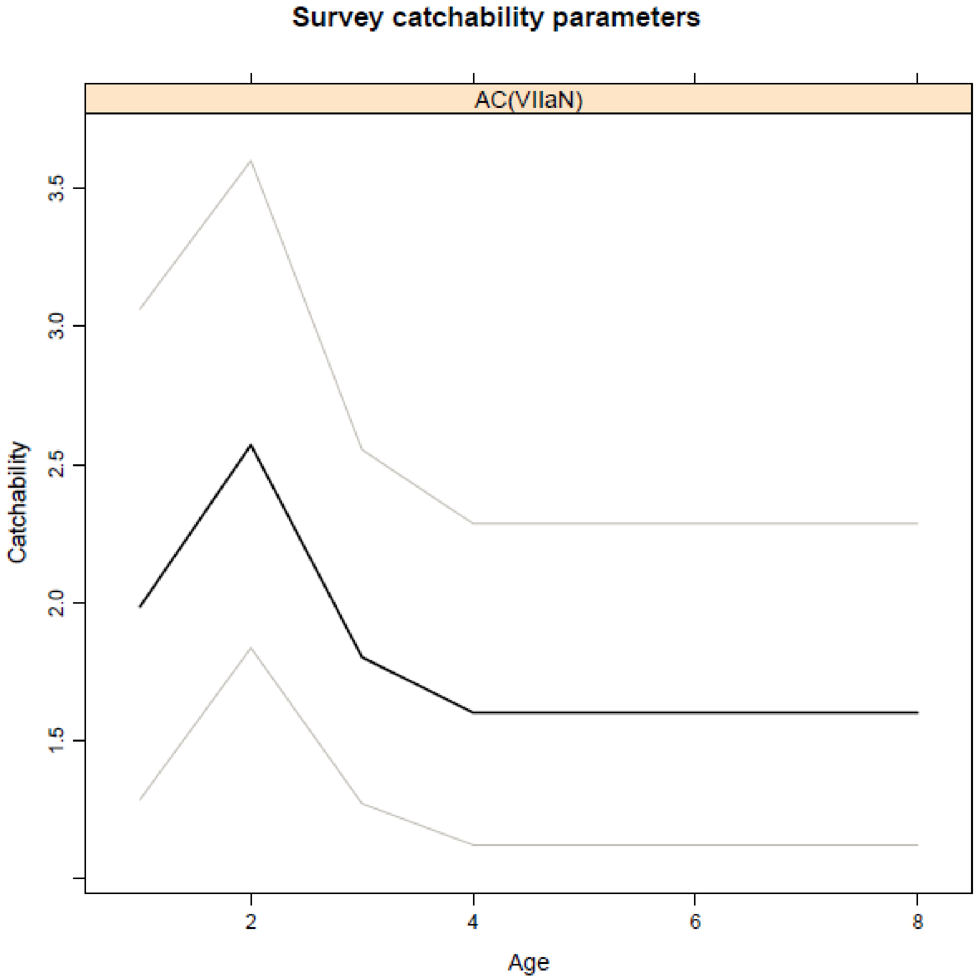


Figure 7.6.18 Herring in Division 7.a North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(7.aN).

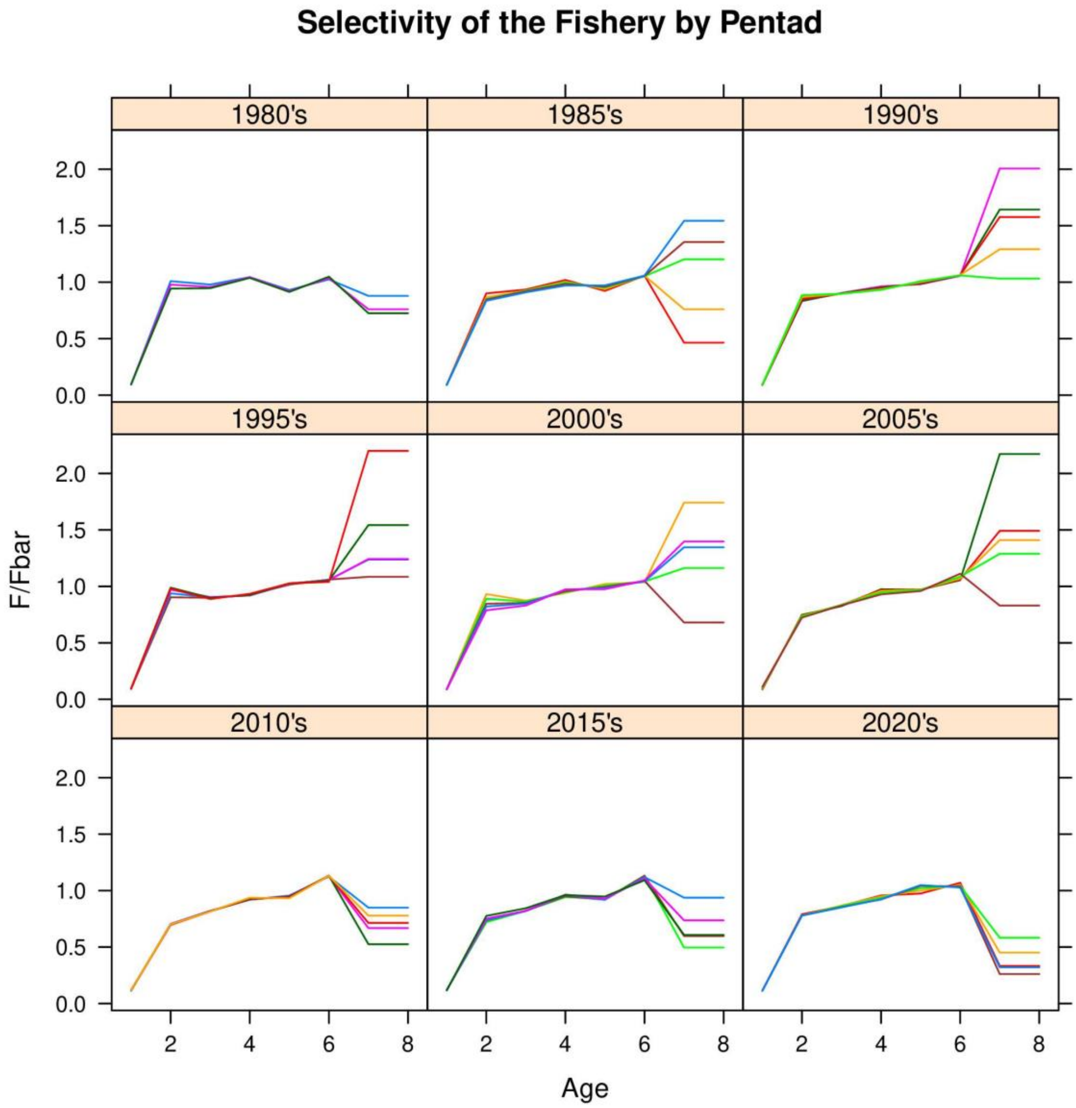


Figure 7.6.19 Herring in Division 7.a North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

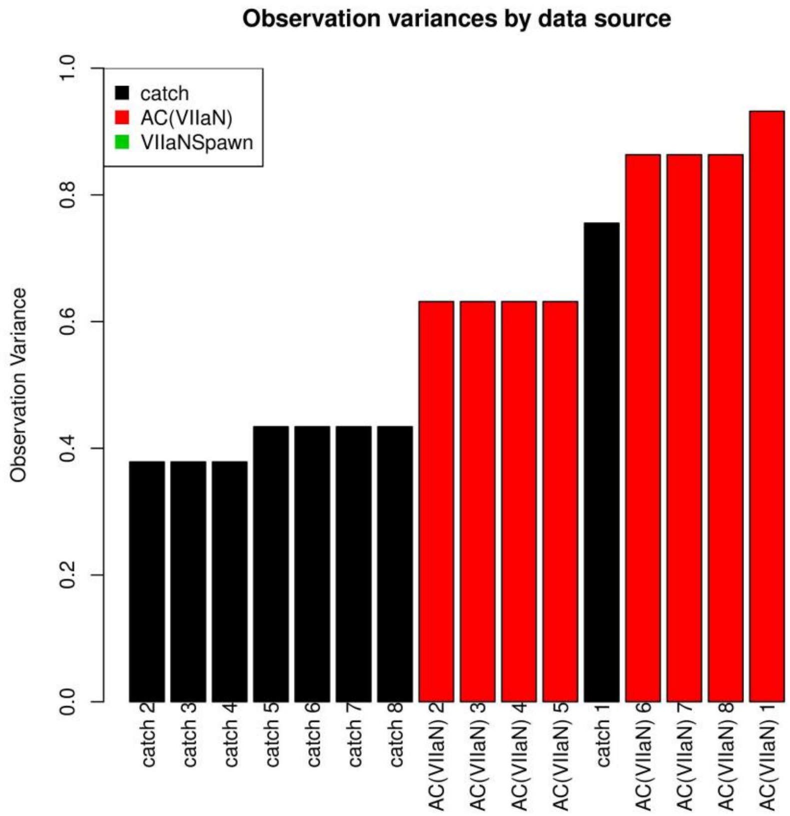


Figure 7.6.20 Herring in Division 7.a North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model. The observation variance of 7.aNSpawn is fixed at 0.4

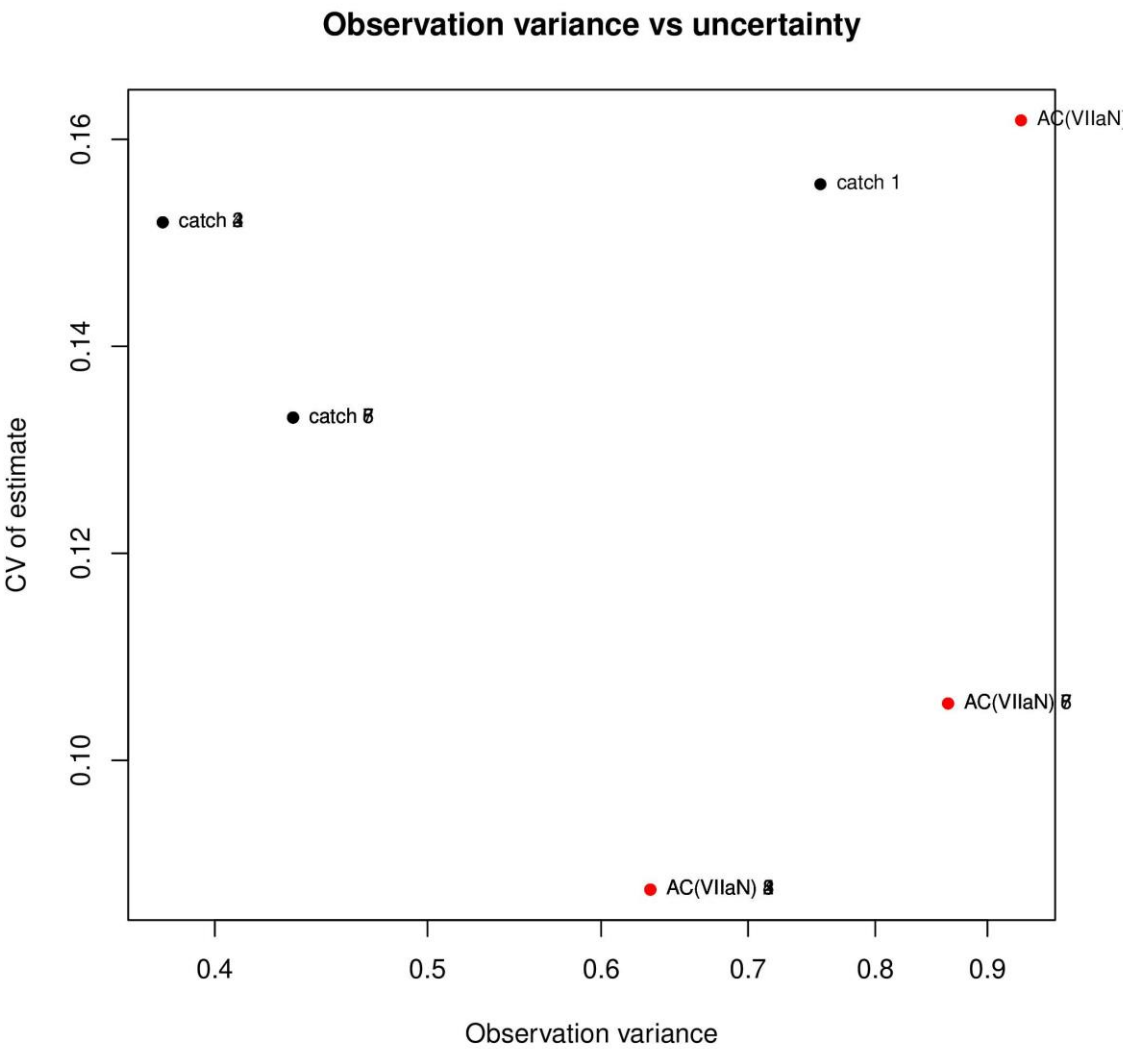


Figure 7.6.21 Herring in Division 7.a North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

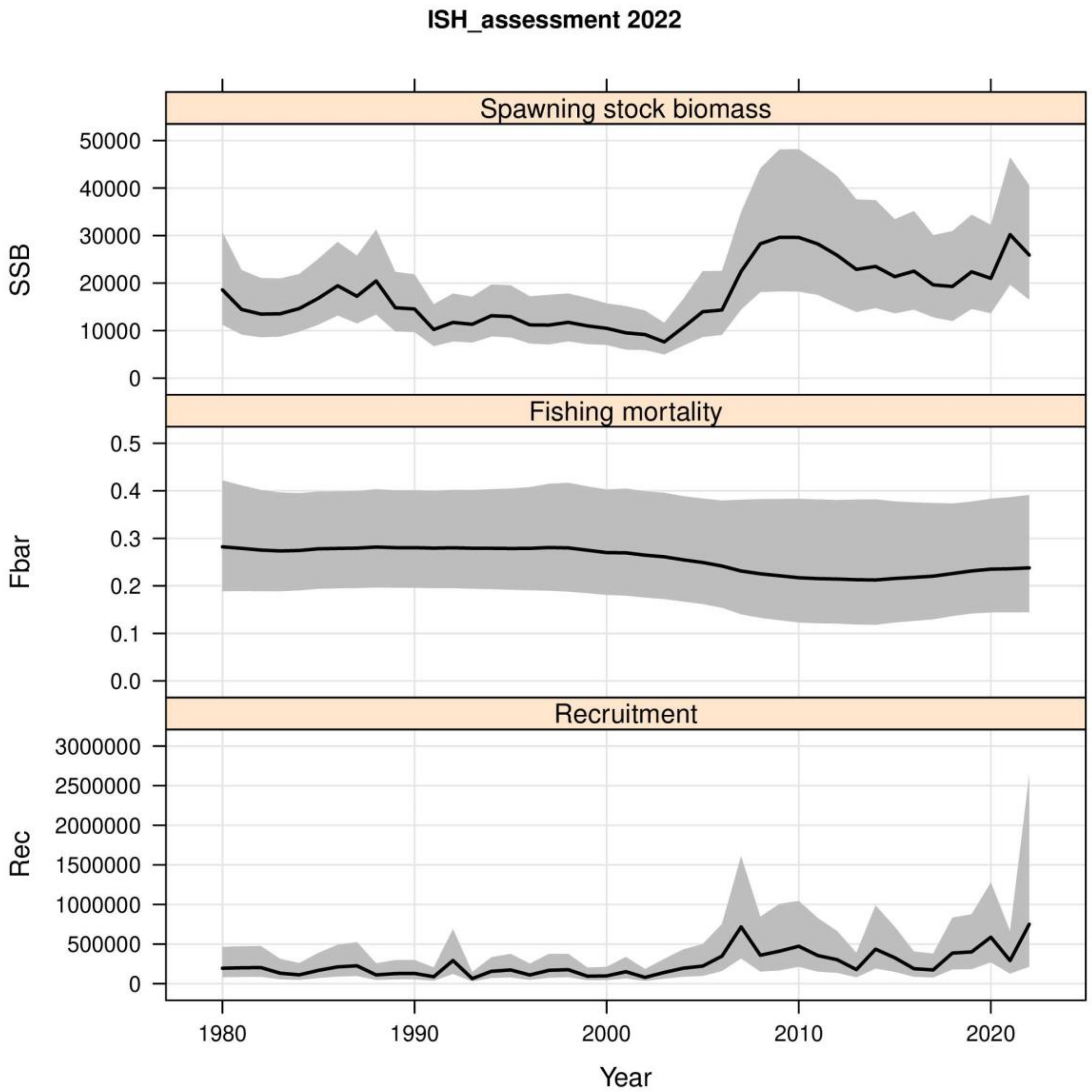


Figure 7.6.22 Herring in Division 7.a North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean $F_{4\text{-}6}$.

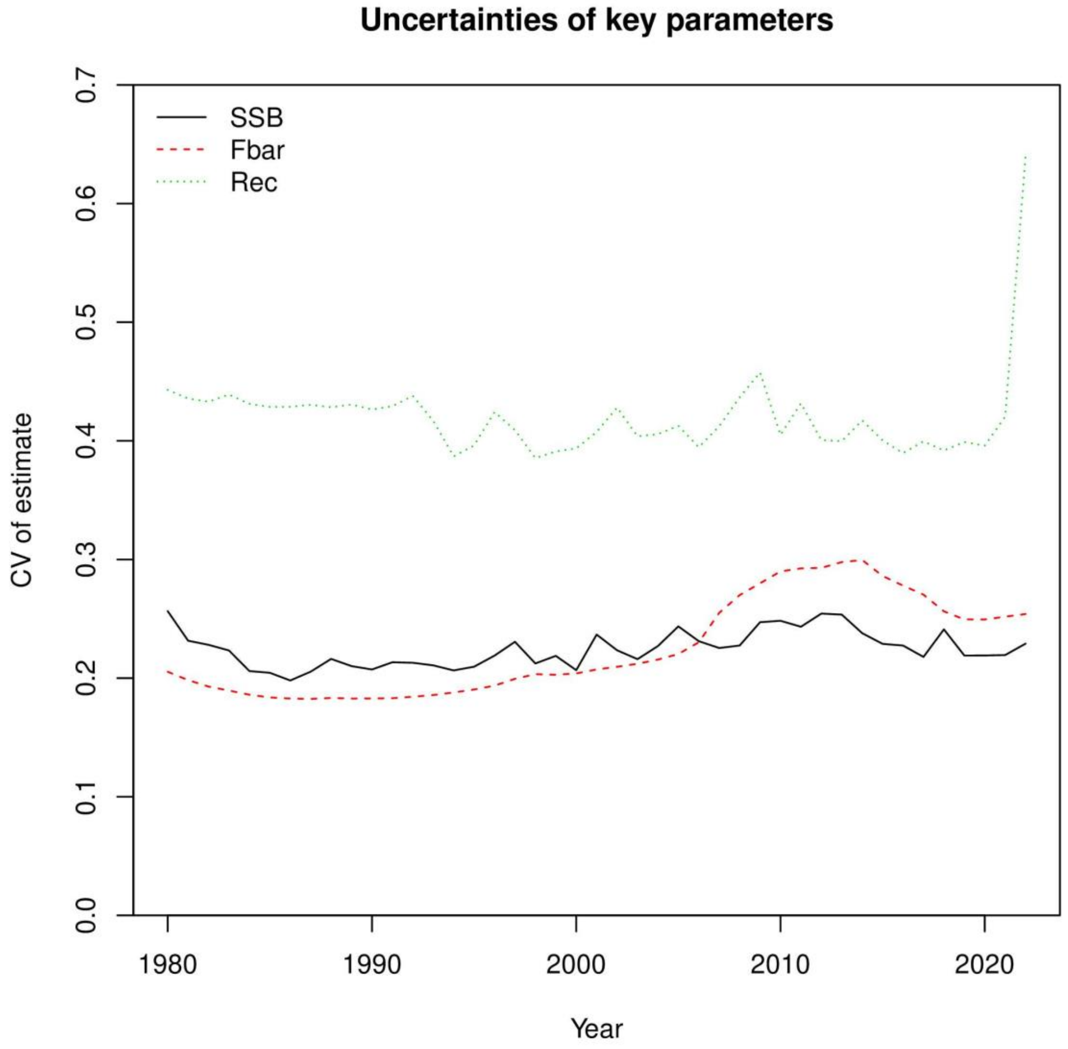


Figure 7.6.23 Herring in Division 7.a North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment 1 winter ring.

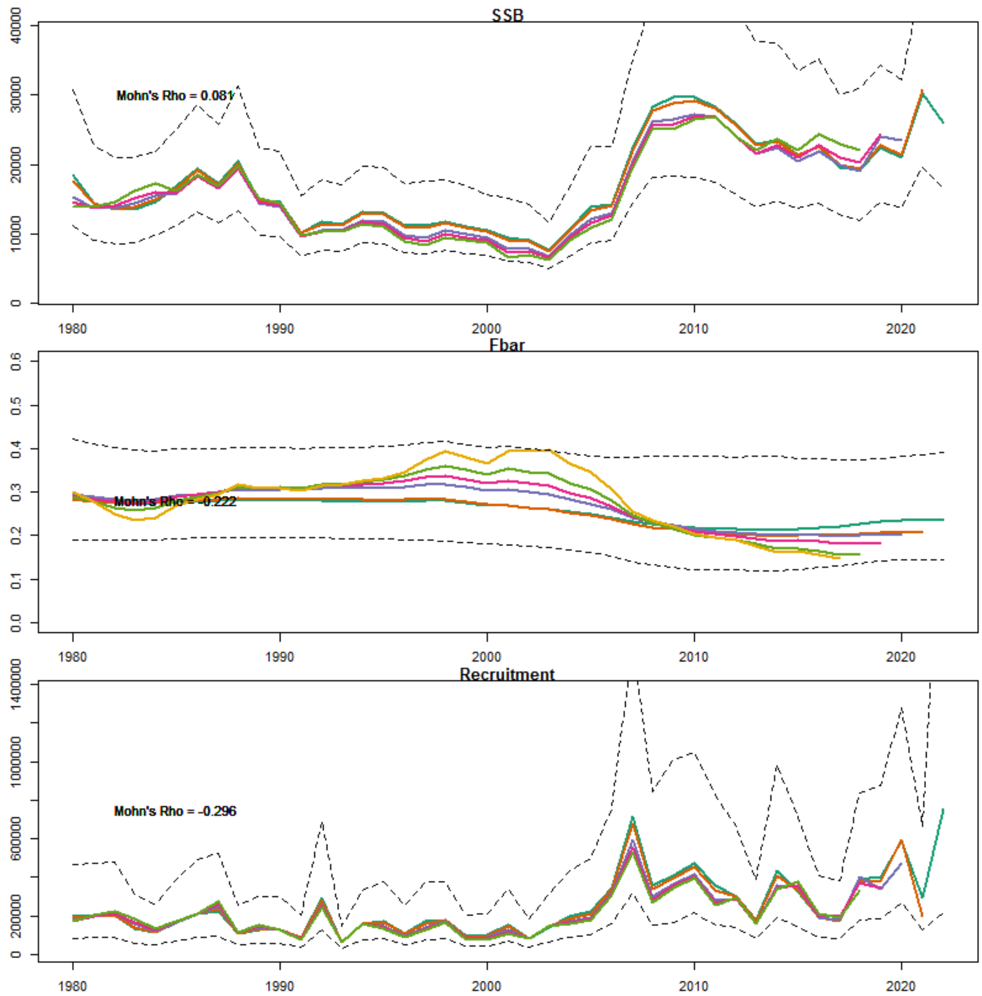


Figure 7.6.24 Herring in Division 7.a North (Irish Sea). Analytical retrospective patterns (2018 to 2013) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment. Confidence limits for the current year assessment are shown with dashed lines.

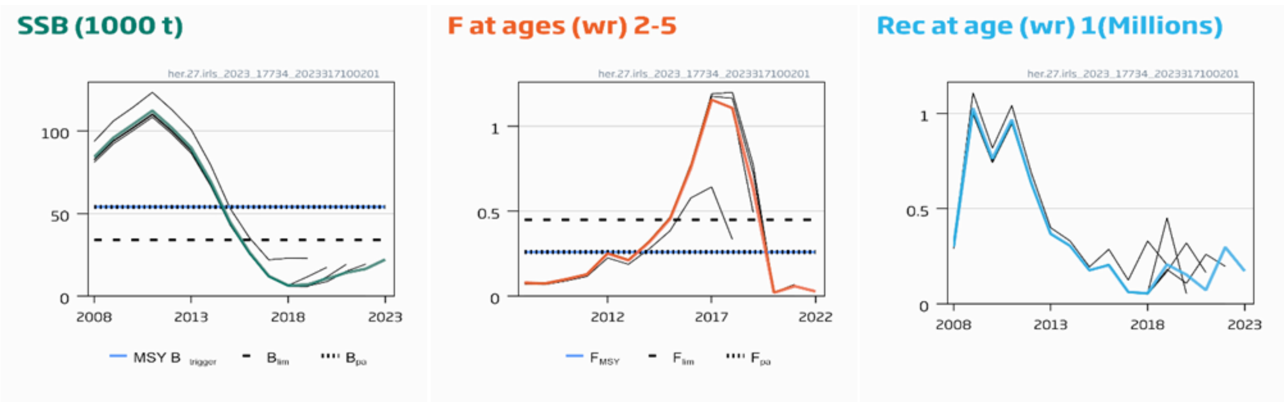


Figure 7.6.25 Herring in Division 7.a North (Irish Sea). Comparison of stock parameters between the 2019 (red line) and previous assessments.

8 Stocks with limited data

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). In 2022, 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.

Figure 12.1 shows the time-series of landings over the period 1974–2021 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 27.7.e are stable and have fluctuated between 5 and 800 t except in 2008 where they reached more than 1000 t (Figure 12.1). In 2022, landings amount to 6 tonnes (Figure 12.1).

In Division 27.7.f, it can be seen that 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 12.2).

8.3 Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1660 t in 1976, declining gradually to very low levels by the late 1980s. Landings by the Netherlands had peaked in 1985 (8619 t), and more recently there was a sudden pulse of Dutch landings of 7575 t in 2002, declining to low levels since (Figure 12.2, 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, 1959–2021. Spring and autumn-spawners combined.

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
All Catches																
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	4 061
Year	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
All Catches																
Total	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	2 343	2 259
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Scotland	713	929	852	608	392	598	371	779	16	1	78	46	88	-	-	-
Other UK	-	-	1	-	194	127	475	310	240	0	392	335	240	-	318	512
Unallo-cated*	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	1 000	1 000	1 000
Total	731	929	853	608	586	725	846	1089	256	1	480	381	328	0	318	512
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Scotland	163	54	266	48	90	118	21	0	0	0	0	0	0	0	180	0
Other UK	458	622	488	301	-	184	-	-	-	-	-	-	-	-	-	-
Unallo-cated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	800	800	800	720	720	720	648	648	583	583	583	583	583	583	583	466
Total	621	676	754	349	90	302	25	0	0	0	0	0	0	0	180	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 12.2. Stocks with limited data. Landings of herring in Divisions 7.e. Source: ICES official landings database 2009 – 2019, national databases and ICES preliminary catch statistics 2020 and 2021.

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
UK	0	89	57	231	32	14	3	148	69	199	162	83	151	161	69	221	206	399	294	855	430	446	471	482
Denmark	0	0	0	0	0	0	0	0	0	0	194	0	0	0	0	0	0	0	19	10	9	0	0	0
France	193	21	8	12	50	27	21	56	176	195	0	2	18	0	1	0	0	86	42	3	12	503	22	551
Germany	0	0	0	0	19	1	0	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0
Netherlands	0	8	147	292	17	234	133	566	470	2110	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0
total	193	118	474	535	118	276	157	770	715	2504	356	85	169	161	70	221	296	485	355	868	451	949	493	1033

Country	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*
UK	377	165	159	193	163	315	199	66	189	106	78	130	185	218	162	274	435	268	204	22	11	8	11	6	5
Denmark	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
France	26	0	335	526	500	497	496	516	516	502	499	489	493	486	278	7	314	3	1	0	380	193	0	0	1
Germany	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
Netherlands	0	0	0	0	0	0	0	0	0	0	433	0	2	6	0	0	4	1	0	0	0	0	0	0	0
Poland	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
Total 7.e	403	165	494	719	663	812	695	582	705	608	1010	619	680	710	440	281	753	272	205	23	391	201	12	6	6

***Preliminary data**

Table 12.3. Stocks with limited data. Landings of herring in Divisions 7.f. Source: ICES official landings database 2009 – 2019, national databases and ICES preliminary catch statistics 2020 and 2021.

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
France	469	83	226	99	69	27	19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Netherlands	101	1233	692	611	173	137	22	24	0	0	0	0	0	0	0	0	0	154	0	0	0	0	0	0
UK	21	1	27	1	0	1	1	1	3	1	2	1	18	1	5	2	1	1	1	3	2	3	3	8
USSR	0	2062	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 7.f	591	3379	1006	711	242	165	42	25	3	1	2	2	18	1	5	2	2	155	1	3	2	3	3	8

Country	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*
Belgium	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
France	0	0	150	1	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
UK	14	12	81	0	5	21	47	198	76	115	29	8	23	78	113	136	20	111	227	28	3	4	1	65	200
USSR	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
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
Total 7.f	14	12	231	1	5	21	47	198	76	115	29	8	23	104	113	136	20	111	227	28	3	9	1	84	200

***Preliminary data**

Table 12.4. Stocks with limited data. Landings of herring in Subarea 8. Source: ICES Official Landings database (2006–2020), Historical Catches database (1974–2005), and ICES preliminary catch statistics (2021–2022).

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	0	0	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	974	1115	1660	613	285	386	531	0	0	0	292	227	272	595	255	0	0	0	141	181	68	193	98	86
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	30	0	0	0	0	0	0	8619	0	0	977	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USSR	0	35	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 8	974	1150	1677	613	525	386	531	0	0	0	292	8846	272	595	1232	0	0	3	141	181	69	193	98	86

Country	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*
Denmark	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
France	64	0	80	48	81	43	15	14	6	22	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	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Netherlands	0	0	0	0	7575	1425	1396	0	0	0	0	0	402	222	0	0	0	0	0	0	0	0	0	0	0
Portugal	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
Spain	0	0	232	232	266	197	0	50	214	120	131	55	38	54	0	0	0	0	0	0	0	0	0	0	0

Country	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*
UK	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
USSR	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
Total 8	64	0	312	280	7922	1665	1411	64	220	142	153	89	490	357	22	7	5	5	4	2	3	1	1	2	1

***Preliminary data**

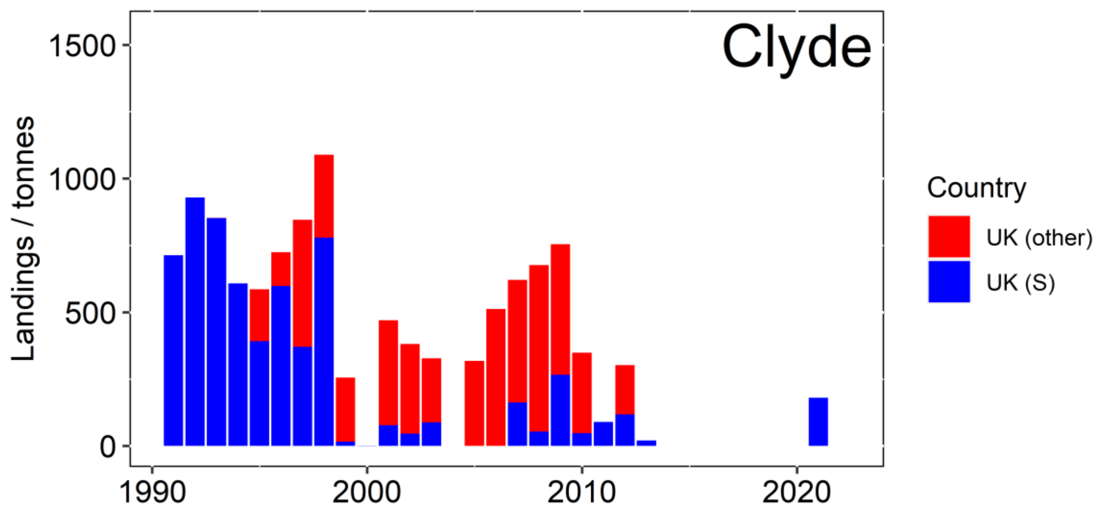


Figure 12.1. Stocks with limited data. Landings over time of herring in the Firth of Clyde.

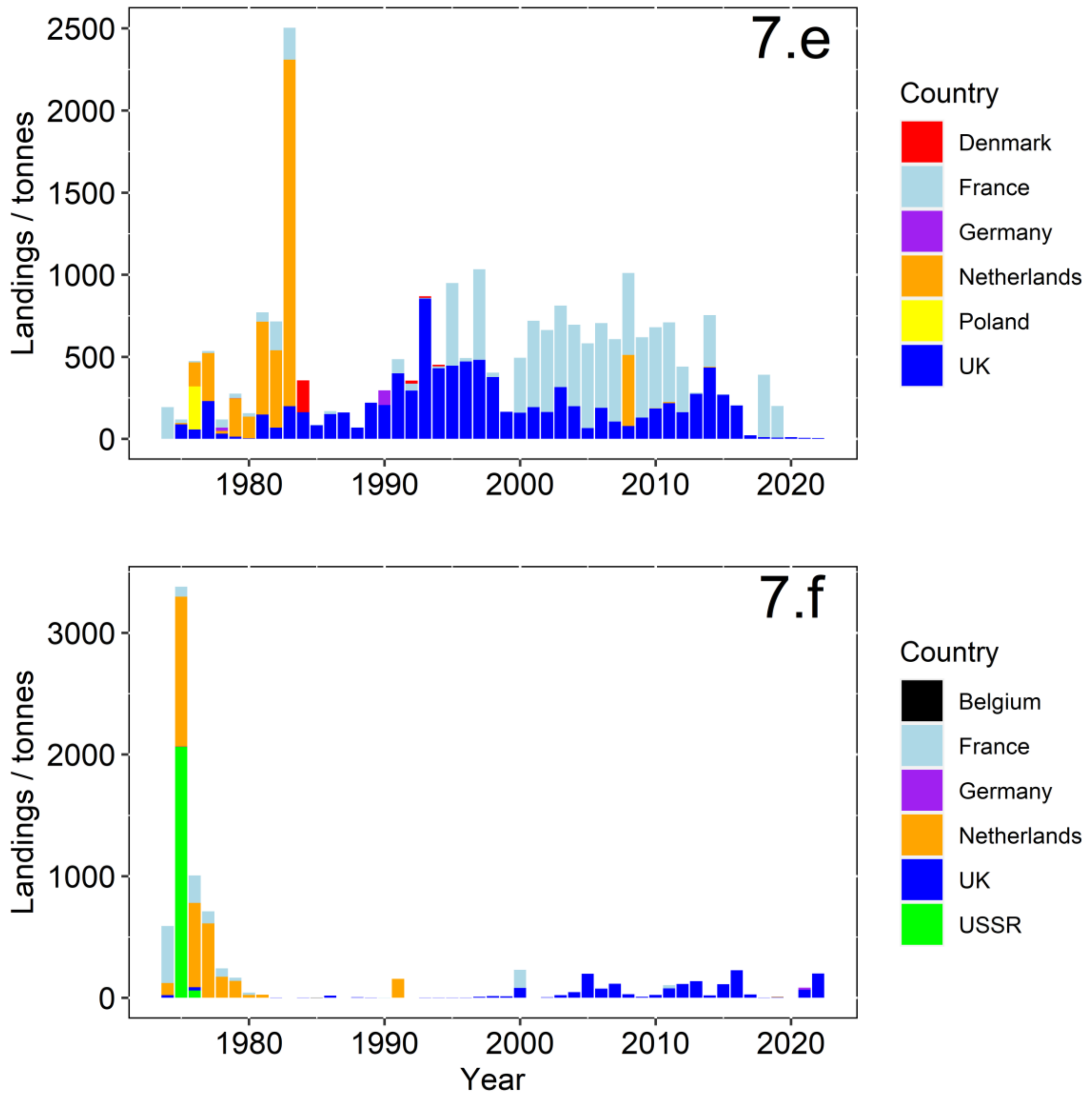


Figure 12.2. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

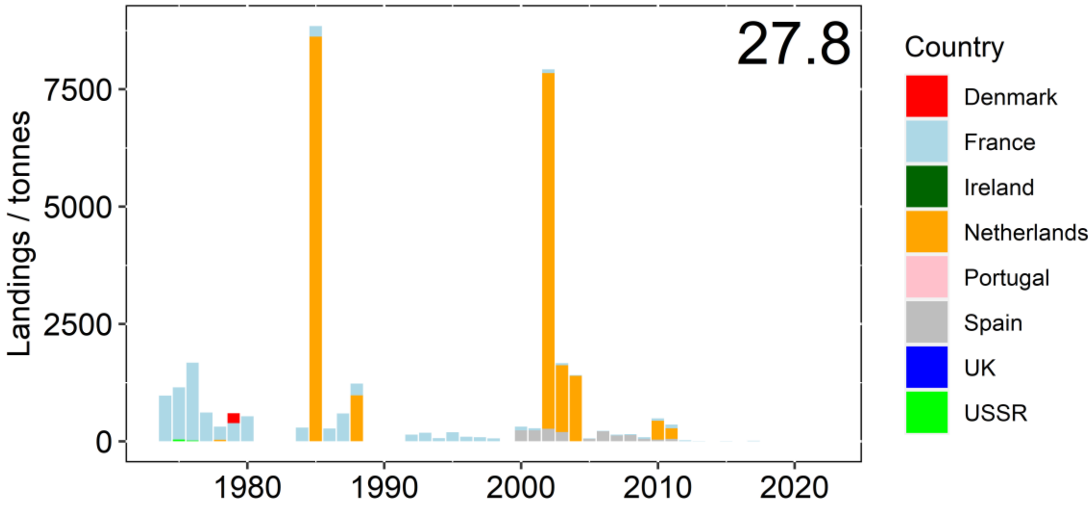


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

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, 2016a, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these seven areas (sandeel area (SA) 1r, 2r, 3r, 4, and 6). Analytical stock assessments are currently carried out in SA 1r–3r and 4, whereas SA 6 is managed under the ICES approach for data limited stocks (Category 5).

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, 2016a).

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 in several areas in recent years concurrent with a marked change in distribution has 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 2022, 26 vessels participated in the fishery. From 2011 to 2020, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1636 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 2022 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 2022 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2023 (Escapement strategy). This approach resulted in an advised catch / TAC for 2022 in SA 1r, SA 2r, SA 3r, and 4 of 0 t / 5000 t, 71 859 t, 85 559 t / 101 845 t and 0 t / 5000 t, respectively. Advised catches for SA 5, SA 6, and SA 7 for 2021 and 2022 were based on data limited approaches and set at 0 t, 140 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 2022 was given. As the acoustic survey abundance estimate of age 1 and the total biomass estimate (256 000 000 tonnes, RSE=25%) the final TAC increased to 95 000 tonnes. Fishery was allowed in the subareas 1a, 1c, 2b, 2c, 3b, 3c, 4a (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

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.

Since 2005, Danish vessels have not been allowed to fish sandeel before 31 March and after 1 August.

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

Previously, there has been 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 working 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 2000–2022 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 76% 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 16% 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, but for 2022 zero catch was advised.

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, 2016a).

The dredge survey in 2022 was carried out as planned in areas 1r, 2r and 3r 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 2022, the majority of catches were comprised of 1-group. The catches contained very few older age-groups (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 2022 and is above the long term mean for all age-groups. For all age-groups the mean weights-at-age are either the highest or in top-3 of all mean weights-at-age in the last two decades.

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 2020 provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, ICES, 2021b). 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 equal to or slightly higher than the values in the old time-series, except for 2018 and onward where the new values are slightly lower in the 1st half of the year. The values used in the 2018 and 2019 assessments were simply replicates of the 3-year average value from 2015. 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 2018–2022.

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 2022 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 ($R^2 = 0.17$).

9.2.6 Data analysis

Following the two latest Benchmark assessments (ICES, 2010, 2016a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2022. 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 (0.51) for age 0 and high (0.76) 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, 2, and 3 (0.56, 0.44, and 0.46) 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 (0.40) for age 1 and age 2 in the first half of the year and moderate to high (> 0.68) 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 showed the opposite tendency.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.84), 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 (-0.07). 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 0.56 and 1.09, 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 stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{lim} in periods from 2004–2007, 2013–2015 and 2019–2020, whereas in last two years SSB has been above B_{lim}. F_{1-2} is estimated to have been just below the long-time average since 2010 but have been historically low the last two years 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. In 2018, 2020 and 2021 the recruitment was below average, whereas 2019 and 2022 shows around average recruitment.

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 1983–2021 (101 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 since 2010, 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 2018–2022. Natural mortality 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 120 428 t should be set for 2023. The predicted F that follows from this TAC is 0.424. The TAC according to the escapement strategy ($B_{escapement} = B_{pa}$) is therefore 120 428 t in 2022.

9.2.10 Biological reference points

B_{lim} is set at 110 000 t and B_{pa} at 145 000 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 biases. 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. There are indications of a retrospective pattern in recent years as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g., overwintering mortality increasing when fish condition is low.

9.2.12 Status of the stock

The SSB was below B_{lim} in 2019 and 2020, but above in 2021 and 2022. As noted in a previous HAWG report (ICES, 2019), the introduction of a very low recruitment in 2018 combined with a continued decrease in mean weight-at-age and catches exceeding TAC advice (due to "borrowing and banking") led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 2020. The SSB in 2023 is within the level expected from the forecast in 2022. There can be several reasons for that, such as increased weight-at-age to some of the highest levels observed the last two decades and low catches following TAC advice in preceding years.

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 ICES WKMSYREF2 and WKMSYREF5 meetings (ICES, 2014, 2017b) 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 0.49 (ICES, 2017b).

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, and the effects should be investigated further to provide more firm conclusions on such management.

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 proportion of ages comprised 1-group in the catch in the period 2020–2022, although not as high as in 2017 (98%), following the high recruitment in 2016. The 2016 year-class was even seen in the 2019 catch as a high proportion of 3-group fish. Older fish constitutes smaller proportions compared to the 2010s (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 2022, weights had increased across all age-groups compared to 2021 being among the record highs for age-2 and above. A drastic increase to highest in the time-series for age-4 were noted but judging from the number of samples from the commercial fleet there were no reason to believe that the mean weight was biased.

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 WGAM 2015 (ICES, 2016c) 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 not updated in response to the WGSAM 2020 key run (ICES, 2021b) as the update is not likely to 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 was on the level of years of 2018–2020 and 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 were moderate in 2022, and in particularly higher in the Northern parts, resulting in the fourth highest age-0 index in the time-series. In 2021 a few explorative hauls were taken close to some of the existing stations. However, catch rates in these hauls were not much different from the adjacent fixed station hauls. In 2022, two of the explorative stations were visited again. The explorative hauls were uploaded to the database as valid hauls and were therefore included in the survey index. SA 2r have the highest internal consistency ($R^2 = 0.57$ on log-scale) across management areas, i.e., the ability of the dredge survey to follow cohorts.

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. In 2020, during an inter-benchmark (ICES, 2020b), the working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run and considered that the retrospective pattern could be caused by ignoring density dependence in catchability (increased catchability at high abundance). The relationship seemed to be well fitted using a power relationship between dredge index and abundance, with no indication of this given errors in estimated abundance in high or low abundance years. The use of a power model for survey catchability of the youngest age groups is routinely used for North Sea sprat (ICES, 2018). It is an adjustment of the model where one additional parameter is estimated. HAWG evaluated the retrospective bias in recruitment in 2020 without density dependent catchability (Mohn's rho = 0.63) and with density dependent catchability (Mohn's rho = 0.52). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 (ICES, 2020a) decided to include density dependent catchability in the final run. HAWG 2023 re-examined the density dependent parameter and found that it is still well above 1 (1.4).

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 hitting the bound (model restrictions that has a bound of 0.30) for the 0-group. This indicates that the model has high confidence in the survey after the introduction of the density dependent catchability for age 0, indicating a high consistency between the results from the dredge survey and the overall model results. The CV for age-1 is moderately high, indicating that the model has difficulty in following this age-group. 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 (0.45) 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 (0.99) 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 (0.10 in "objective function weight" in Table 9.3.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit. Although, this weight has been set lower for SA 1r, and similarly a lower weight may solve these issues.

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 and estimated F (Figure 9.3.12) shows a good relationship between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the five periods 1983–1988, 1989–1998, 1999–2004, 2005–2009, and 2010–2022, the relation between effort and F varies between these periods. 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 2016a).

The retrospective analysis (Figure 9.3.9) shows consistent assessment estimates of F from one year to the next. There has been a systematic overestimation of SSB in most years since around 2011 (with few exceptions), sometimes, but not always, as a result of an overestimation of recruitment (and therefore lower than expected abundance of these cohorts in the subsequent catches). This pattern was improved by the introduction of density dependent catchability in the model. The 5-year Mohn´s rho values are, however, still fairly high (0.45 and 0.45 for SSB and recruitment, respectively). Reasons for the previous pattern can be connected to either overestimation of recruitment in the dredge survey, lower than expected survival of the two cohorts, or lower than expected catchability of these cohorts in the fishery. Also, possible overestimation of mean weight-at-age in some years can be part of the explanation. Both the selectivity pattern and the dredge survey are based on a relatively short time-series, and hence variation between years is to be expected.

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 stock summary (Figure 9.3.13 and Table 9.3.10) show that recruitment has been highly variable and with a weak decreasing trend over the full time-series until the 2016 year-class, which is estimated to be the fourth strongest on record, followed by a 2017 year-class which is estimated to be the lowest observed and a 2018 year-class which was the fifth lowest on record. In recent times, the recruitment was above average in 2019. 2021 and 2022 but being below average in 2020. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2012 to 2017 and 2019 to 2021. Since 2022, SSB has been above B_{lim}. Since 2004, SSB has been below B_{pa} in all years. $F_{1\text{–}2}$ 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 2023 is the geometric mean of the recruitment in 2012–2021. The exploitation pattern and F_{sq} (2022-value) is taken from the 2023-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 2018–2022. Natural mortality and proportion mature are the fixed values applied in the terminal year in the assessment.

Output

The short-term forecast (Table 9.3.12) shows that a fishing mortality of 0.29 will bring SSB down to B_{pa} in 2024. Accordingly, a TAC of 40 997 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 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.44 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex and Benchmark report from 2016 (ICES, 2016a).

9.3.11 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessments where the ICES statistical rectangles included in SA 2r changed. The assessment now includes fisheries independent information from a dredge survey representative for the area. The assessment is considered to be of medium to good quality but with some indications of a retrospective pattern in recent time periods as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g., overwintering mortality increasing when fish condition is low (van Deurs *et al.,* 2011.). HAWG also highlighted that the pattern might also have a link to the possible multispecies fishery within this area (i.e., suspected to catch *Ammodytes tobianus*). The dredge survey time-series in SA 2r is still short (2010–2022) and the quality of the assessment will likely improve once a longer time-series becomes available. Next benchmark will take place in 2022 and is still ongoing due to an extension.

9.3.12 Status of the Stock

A moderate F in most of the years from 2010 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004 to 2010. SSB in the period for 2019-2021 were estimated below B_{lim}. In 2022 the stock was estimated to be above and remain above B_{lim} in 2023. The stock has been below B_{lim} in 16 out of the last 20 years never reaching above B_{pa}. Recruitment in 2016 is estimated to be the fourth highest on record. The 2019–recruitment was estimated to be the fifth highest since 1997. Recruitment in 2017 and 2018 were extremely low. Recruitment in 2019 was average and recruitment in 2020 was low. The recruitment in 2021 were high and appears to remain high in 2022. However, based on the retrospective patterns of this stock, we anticipate some down-scaling in the coming years.

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, 2016a) 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 0.44. 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 2022, the catches consisted of all age groups, where the proportion in numbers of 1-, 2-, 3- and 4-group, respectively, were 38%, 25%, 20% and 17%.

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 has increased for four consecutive years in all age-groups and is now the highest ever observed for age-1 and the second highest for age-2.

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 2020, WGSAM (ICES, 2021b) 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 resulted in a substantial change in the historic perception of the stock, including possible changes to reference points. For this reason, it was decided not to use the new natural mortalities but to refer to HAWG for consideration of whether new reference points should be estimated.

3-year averages of natural mortality-at-age from the WGSAM 2015 (ICES, 2016c) multispecies modelling of southern and 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.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2022 show 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., $r^2 = 0.37$ 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, 2016a).

The Norwegian acoustic survey (2009–2022) 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 0 vs. age 1 ($r^2 = 0.84$ on log scales), age 1 vs. age 2 ($r^2 = 0.89$ on log scales), and age 2 vs. age 3 ($r^2 = 0.6$ on log scales).

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. In 2020 an inter-benchmark (ICES, 2020b) decided to include density dependent catchability in the final run to reduce the recruitment overestimation problem. This approach was continued in 2021–2023.

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 medium for age 0 (0.61) and high for age 1 (0.73), 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 both age 1 and age 2 (0.54) and high for age 3 (1.08), showing an overall medium consistency between the results from the acoustic survey and the overall model results. The residual plot shows high positive residuals in recent years, indicating that high acoustic indices were not confirmed by the model.

The model CV of catch-at-age is high (0.72) 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 (> 1.00). 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.

The recruitment CV (Table 9.4.5) is very high (1.49), 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 (0.01 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 the recruitment that consistently overestimated large recruiting year-classes. However, after implementing density dependence on the relationship between recruitment and the dredge survey in 2020 (i.e., increasing catchability with increasing densities), the retrospective bias was reduced (Mohn´s rho).

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. As the model assumes a different catchability-at-age for the three periods 1986–1998, 1999–present, the relation between effort and F varies between these periods. There is a shift in the ratio between effort and F over the full time-series. In the year range 1986–1998, F is in generally lower than effort on the plot, while the opposite is the case for the remaining periods, corresponding to a technical creep over time (ICES, 2016a).

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

SSB has been at or below B_{lim} from 1999 to 2006 after which SSB increased to above B_{pa} in 2008. This was followed by SSB below B_{lim} in 2013 (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} in 2015 onwards. However, a steep drop in SSB from 2022 to 2023 is estimated.

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 2023 is the geometric mean of the recruitment 1986–2021 (118 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2021. As the SMS-model assumes a fixed exploitation pattern since 1999, 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 2018–2022. 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 a fishing mortality of 0.13 will bring SSB down to B_{pa}. Accordingly, the advised catch of maximum 30 570 t for 2023 is forecasted to keep SSB at or above MSY $B_{trigger}$ (=B_{pa}).

9.4.10 Biological reference points

B_{lim} is set at 80 000 t and B_{pa} is estimated to 129 000 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 from 2016 (ICES, 2016a).

9.4.11 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessment. The new sandeel area 3r is slightly different from the previous sandeel area 3, and mainly consists of fishing grounds in Norwegian EEZ. There is a large retrospective pattern in the recruitment that overestimates high recruitments. 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 and the change in the spatial coverage of the dredge survey. 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 from below B_{lim} in 2013 to above B_{pa} since 2015, due to above average recruitment in 2013, 2014, 2016, 2018 to 2020 combined with a low fishing mortality. However, fishing mortality has increased since 2016, peaking in 2020, but decreased in 2021 and 2022 SSB decreased considerably between 2021 and 2022, due to high fishing mortality and decreasing recruitment (but SSB is still well above B_{pa}). Recruitment estimates for 2018–2020 were all above average but declining since 2019. Recruitment in 2021 and 2022 were estimated to be below average.

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).

9.5.2 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 9.5.2 and Figure 9.5.2 by half year. Mean weight-at-age in the first half year seems to have recovered to above average and currently stable for all ages after the very low levels in 2001 to 2005. The second half year the mean weights are affected by the very limited sampling at this time of year.

9.5.3 Maturity

Maturity estimates are obtained from the averages observed in the dredge survey (1983–2016) in December as described in the Stock Annex. Maturities are listed in Table 9.5.3.

9.5.4 Natural mortality

Long-term averages of natural mortality-at-age from the WGSAM 2015 (ICES, 2016c) 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 not updated in response to the new WGSAM 2020 key run (ICES, 2021b) as the update is not likely to affect long-term averages greatly.

9.5.5 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. Effort in 2021 was the third highest in the time-series reflecting the high TAC given that year. The effort in 2022 was low, but slightly above the effort in the period 2004–2016 which reflects either a closed or very limited fishery. This low level of effort reflects the 5000 tonnes monitoring TAC for 2022.

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 2022 recruitment is slightly above average. Recruitment was below average in 2021 but preceded by two strong year-classes (2019 and 2020).

An error discovered in the code used to calculate the 2020 indices was discovered and resulted in overestimated abundance indices for age 0-, 1- and 2-groups in 2020. The corrected indices (for 2020) were used in 2022.

The ability of the area 4 dredge survey to provide accurate estimates of abundance by age was discussed in detail in 2021. All the values are estimated as stratified mean values (mean within position followed by mean within square followed by mean across squares), an approach which is known to be sensitive to skewed data at low sampling levels. Up to 2018, indices of cohorts at age 1 averaged at 1.22 times the catch of the index of the cohort at age 0 (range 0.6–2.35). The corresponding number from age 1 to 2 was 0.43 (range 0.09–1.58). In 2019, the index of 1-year olds (2018 cohort) was 5.75 times the index of the cohort at age 0. This pattern persisted in 2020 where the index of 1-year olds (2019 cohort) was 3.49 times the index of the cohort at age 0, corresponding to the 2nd all-time highest appearances relative to earlier estimates of the cohort. The 2020 index of the 2018 cohort was 1.22 times the 2019 index of the cohort, corresponding to the second highest appearance relative to earlier estimates of the cohort. In all cases, these values represent all time high appearance relative to earlier estimates of the cohort. In the 2021 survey index, the 2019 and the 2020 cohorts were registered as 0.24 and 0.03 times the values observed in 2020. Both values are the lowest relative changes observed in the time series. In the 2022 survey index, the 2020 and the 2021 cohorts were registered as 0.9 and 2.81 times the values observed in 2021. While still high, these values are respectively within and closer to the ranges observed before 2018. It was suggested that some of these issues might be related to the stratified mean approach in years with reduced sampling at the most productive stations and that adopting the approach in place for the other management areas (as explored at the benchmark) might alleviate some of these issues.

The internal consistency, i.e., the ability of the survey to follow cohorts, (Figure 9.5.4) shows a high correlation between the 0-group and 1-group explaining 56% of the variation.

9.5.6 Data analysis

Following the Benchmark assessment (ICES, 2016a) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2022. 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 2008–2022) ("sqrt (Survey variance) ~CV" in the table) is low to moderate (<0.52) for all ages. The CV remained similar for age 0 between the 2022 and 2023 assessments (0.55 to 0.52). The CV for age 1 is on the pre-determined boundary of 0.3. 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 in 2020 are large and positive for both ages (Figure 9.5.6), indicating that the large observed indices in 2020 are not supported by other information about the abundance of these cohorts. Survey residuals in 2022 are also positive for both age groups but are small to moderate.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.73) for age 1 and 2. The catch-at-age residuals (Figure 9.5.7) show no alarming patterns, except for a negative tendency in the residuals (observed catch is lower than model catch) for age 1 in season 1 in the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.49), 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 except for the 2020 peel. The high recruitment in the 2019 and 2020 cohort expected from the 2020 survey was downscaled after adding the 2021 survey, leading to a high retrospective bias in both recruitment and SSB in 2019 and 2020. While 2021 recruitment has been upscaled with the inclusion of the 2022 survey, little to no change was observed in SSB.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.5.10) are moderate to high.

9.5.7 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).

9.5.8 Historic Stock Trends

The stock summary (Figure 9.5.13 and Table 9.5.10) shows that SSB have been at or below B_{lim} from 2007 to 2010. Since 2010, SSB has been above B_{lim} in 2011, 2016 and 2021, but below B_{pa} in 2015 only. SSB is estimated at 97 538 in 2023. F_{1-2} is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004 with a decrease in 2019 and 2020, to a record-high (second) F in 2021 and was low again in 2022. Recruitment has been high in 2014, 2016, 2017, 2019, 2021 and 2022. The high F in 2021 was the result of the lack of confirmation in the 2021 survey of the high survey indices in 2020. The biomass did however not decline below B_{lim}.

9.5.9 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) a fishing mortality of 0.15 (F_{cap}) will bring SSB above B_{pa} in 2024. The catch advice is 35 020 t for 2023.

9.5.10 Biological reference points

B_{lim} is set at 48 000 t and B_{pa} at 102 000 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.

9.5.11 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 2022 is high (0.30, see Figure 9.5.10).

9.5.12 Status of the Stock

Recruitment in 2014, 2016, 2017, 2019, 2021 and 2022 are above the long-term geometric average, while the remaining years after 2010 are below. A very restrictive F since 2005, with the exception of 2018 and 2021, together with the return of recruitment to historic levels in 2009, 2014, 2019 and 2022 has resulted in SSB above B_{pa} in 2016 to 2019 and in 2021. It is between B_{lim} and B_{pa} in 2020, 2022 and 2023.

9.5.13 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 presented at the ICES WKMSYREF2 and WKMSYREF5 meeting (ICES, 2014, 2017b) 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 (in accordance with the concepts of a conventional management strategy evaluation and a selection criterion of 0.05 probability of SSB < B_{lim}) is set at 0.15 (ICES, 2017b).

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. Therefore, such a high TAC may not be sustainable and future work should consider how to incorporate the spatial management in place in future advice.

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 (2009–2022) (see Johnsen, 2022) 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.

9.10 References

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Stock annexes

San.sa.1r – stock annex

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San.sa.2r – stock annex

ICES. 2020. Stock Annex: Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, and Subdivision 20, Sandeel Area 2r (Skagerrak, central and southern North Sea). ICES Stock Annexes. 40 pp. https://doi.org/10.17895/ices.pub.18623168.v1

San.sa.3r – stock annex

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San.sa.4 – stock annex

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San.sa.5r – stock annex

ICES. 2016. Stock Annex: Sandeel (*ammodytes marinus*) in Division 4.a, the North Sea area 5 (SA5). ICES Stock Annexes. 17 pp. https://doi.org/10.17895/ices.pub.18623153

San.sa.6 – stock annex

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San.sa.7r – stock annex

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9.11 Tables and Figures

Table 9.1.1 Sandeel. Official catches ('000 t), 1952–2022 for area 27.4 and 27.3.a. Note that catches from 27.3.a are only available from 1973–2022.

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	0.179	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	0.067	18.7	-	-	509.1
1977	27.3.a + 27.4	680.4	-	11.4	-	-	78.7	6.132	25.5	-	-	802.1
1978	27.3.a + 27.4	669.2	-	12.102	-	-	93.5	2.321	32.5	-	-	809.7
1979	27.3.a + 27.4	483.1	-	13.2	-	-	101.4	0.003	13.4	-	-	611.1
1980	27.3.a + 27.4	581.6	-	7.2	-	-	144.8	0.009	34.3	-	-	767.9
1981	27.3.a + 27.4	523.8	-	4.9	-	-	52.6	0.044	46.7	-	-	628.1
1982	27.3.a + 27.4	528.4	-	4.9	-	-	46.5	0.405	52.2	-	-	632.4
1983	27.3.a + 27.4	515.2	-	2	-	-	12.378	0.23	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	0.002	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	-	-	185.265	-	5.8	-	-	915.3
1989	27.3.a + 27.4	841.6	-	16.6	-	-	186.84	-	11.5	-	-	1056.3
1990	27.3.a + 27.4	512.1	-	2.2	-	0.3	88.999	-	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	-	-	89.349	0.588	4.9	-	-	907.6
1993	27.3.a + 27.4	533.4	-	0.344	-	-	95.5	-	1.5	-	-	630.8
1994	27.3.a + 27.4	688.6	-	10.3	-	-	165.8	0.02	5.9	-	-	870.7
1995	27.3.a + 27.4	672.6	-	-	-	-	263.4	0.04	6.7	-	-	942.8
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	-	-	350.209	0.001	24.6	-	-	1217.8
1998	27.3.a + 27.4	628.2	-	11	-	-	343.3	8.565	23.8	-	-	1014.8
1999	27.3.a + 27.4	511.3	-	13.2	0.4	-	187.6	23.21	11.5	-	-	747.1
2000	27.3.a + 27.4	557.3	-	-	-	-	119	28.643	10.8	-	-	715.7

Year	Area	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	France	Total
2001	27.3.a + 27.4	650.0	-	-	-	-	183	49.979	1.3	-	-	884.3
2002	27.3.a + 27.4	659.5	-	0.025	-	-	176	19.211	4.9	-	-	859.6
2003	27.3.a + 27.4	282.8	-	-	-	-	29.6	21.822	0.5	-	-	334.7
2004	27.3.a + 27.4	288.8	2.7	-	-	-	48.5	33.331	-	-	-	373.3
2005	27.3.a + 27.4	158.9	-	-	-	-	17.3	0.472	-	-	-	176.6
2006	27.3.a + 27.4	255.4	3.2	-	-	-	5.6	27.858	-	-	-	292.8
2007	27.3.a + 27.4	166.9	1	2	-	-	51.1	7.875	1	-	-	229.9
2008	27.3.a + 27.4	246.9	4.4	2.4	-	-	81.6	12.51	-	-	-	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	32.72	4	0.6	-	414.2
2011	27.3.a + 27.4	278.5	9.8	-	-	-	109	32.717	6.1	1.65	-	437.8
2012	27.3.a + 27.4	51.8	1.70844	-	-	0.317	42.4804	5.652	-	-	0.00328	101.9
2013	27.3.a + 27.4	208.7	7.89833	-	-	0.387	30.44615	26.811	2.436	1.32035	0.00387	278.0
2014	27.3.a + 27.4	156.5	5.05196	-	-	-	82.49885	18.815	0.03	0.82463	0.00262	263.8
2015	27.3.a + 27.4	166.5	9.09745	-	-	-	100.85862	33.43879	2.00003	-	4e-05	311.9
2016	27.3.a + 27.4	28.4	-	-	-	-	40.86736	4.2595	-	-	-	73.5
2017	27.3.a + 27.4	353.9	5.7985	-	-	-	120.20534	42.33624	3.32389	-	-	525.5
2018	27.3.a + 27.4	175.6	5.937	-	-	-	69.53076	16.655512	1.848779	-	-	269.6
2019	27.3.a + 27.4	93.7	3.95	-	-	1.2e-05	124.7855	11.54334	1.05792	-	-	235.1
2020	27.3.a + 27.4	169.2	3.81522	-	-	-	244.37908	25.5189974	3.89595	-	2e-05	446.8
2021	27.3.a + 27.4	69.5	1.81976	-	-	-	146.4421	14.837449	-	-	4.7e-05	232.6
2022	27.3.a + 27.4	72.7	-	-	-	-	81.675654	11.828	0.003066	-	-	166.2

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

Year	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
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	99059	64707	95426	4505	0	65	0	263762
2015	162861	39492	104607	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	131898	20240	75143	42298	0	0	0	269579

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2019	86723	5151	136901	6666	0	96	0	235537
2020	108944	70198	247411	20116	0	97	0	446765
2021	17082	4146	157524	53765	0	93	0	232610
2022	5156	71569	83964	5507	0	42	0	166238

Table 9.1.3 Sandeel. Total catch (tonnes) by area, first half year as estimated by ICES.

Year	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
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	94278	62110	95426	4505	0	65	0	256383
2015	162860	38723	104607	4736	0	197	0	311123

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	125303	19957	74567	42298	0	0	0	262126
2019	71590	5148	136896	6666	0	96	0	220396
2020	107762	69894	247411	19896	0	97	0	445060
2021	16615	4142	157397	51448	0	93	0	229695
2022	5154	71569	83964	5507	0	42	0	166236

Table 9.1.4 Sandeel. Total catch (tonnes) by area, second half year as estimated by ICES.

Year	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
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

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2013	6902	4354	0	0	0	0	0	11256
2014	4781	2598	0	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	6595	283	576	0	0	0	0	7453
2019	15133	3	5	0	0	0	0	15141
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

Table 9.1.5 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	8992	4719	864	63	0	9	0	14649
1984	10166	4009	1378	48	212	50	37	15901
1985	10876	3570	619	655	139	65	0	15923
1986	7372	5038	4641	284	12	469	145	17962
1987	5680	1153	5094	177	64	45	0	12213
1988	7980	3876	7472	42	0	90	0	19460
1989	8553	6552	7677	57	31	44	0	22914
1990	8529	4209	5143	55	0	24	0	17960
1991	5991	5117	5864	338	19	1	0	17330
1992	8805	4944	2383	571	0	197	0	16900
1993	3893	4396	5124	1387	29	265	0	15093
1994	3149	4230	4854	1588	0	114	0	13934
1995	5899	2497	3791	437	1915	50	0	14589
1996	5497	4608	4352	1464	605	48	0	16573
1997	5366	5308	7749	622	0	60	6	19111
1998	6580	2743	11062	611	96	26	0	21118
1999	8900	1975	6179	850	0	0	0	17904
2000	7141	2597	4117	421	5	0	149	14429
2001	11021	2505	4726	669	0	1	0	18921
2002	8162	3162	2491	140	1	13	0	13968
2003	6805	2351	1634	1098	19	6	0	11913
2004	7057	4208	1264	203	0	27	0	12758
2005	3412	1131	468	88	0	10	0	5109
2006	4160	1235	205	1	0	5	0	5606
2007	1560	874	1214	1	0	0	0	3650
2008	2878	906	1344	7	0	0	0	5136
2009	3551	802	111	0	0	0	0	4464

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2010	2859	1136	1446	4	0	0	0	5444
2011	3195	677	924	7	0	18	0	4821
2012	585	472	561	68	0	13	0	1699
2013	3876		273	37	0	8	0	5992
2014	2270	1416	1072	51	0	4	0	4812
2015	2073	1233	1412	43	0	5	0	4767
2016	146	429	561	79	0	6	0	1220
2017	2711	2082	1198	166	0	0	0	6157
2018	3126	563	1437	524	0	0	0	5651
2019	2823	136	1957	203	0	3	0	5121
2020	2696	1384	3392	165	0	5	0	7642
2021	434	259	1799	1297	0	3	0	3792
2022	128	1656	2104	114	0	1	0	4002

Table 9.1.6 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, first half year as estimated by ICES.

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	6926	3032	739	63	0	9	0	10770
1984	7910	2471	1172	48	212	46	37	11896
1985	8449	2564	508	652	139	29	0	12341
1986	6568	3884	2508	281	4	437	81	13763
1987	4287	779	5063	161	64	42	0	10395
1988	7172	2660	6030	40	0	69	0	15970
1989	8240	4852	7586	56	31	42	0	20808
1990	8008	3380	3738	49	0	24	0	15201
1991	4588	3538	4750	111	19	1	0	13008
1992	7926	3793	2290	309	0	197	0	14514
1993	3496	2597	3950	1200	29	256	0	11527
1994	2852	3097	4411	1410	0	98	0	11867
1995	5298	1527	3589	436	1915	50	0	12815
1996	4805	1627	3147	519	441	48	0	10587
1997	3997	3440	5895	490	0	52	0	13874
1998	6011	1707	7059	576	93	26	0	15473
1999	7875	772	3204	850	0	0	0	12702
2000	6181	1991	4040	421	5	0	149	12786
2001	8041	1362	1681	656	0	1	0	11741
2002	7942	2489	2491	140	1	13	0	13076
2003	5907	1034	1246	1027	19	6	0	9239
2004	6601	3179	862	201	0	27	0	10870
2005	3288	816	468	88	0	10	0	4670
2006	3982	858	200	1	0	5	0	5046

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2007	1560	874	1214	1	0	0	0	3650
2008	2793	797	1344	7	0	0	0	4942
2009	3377	608	110	0	0	0	0	4094
2010	2725	948	1436	4	0	0	0	5113
2011	3070	665	924	7	0	18	0	4684
2012	585	447	561	68	0	13	0	1674
2013	3704	1618	273	37	0	8	0	5639
2014	2174	1344	1072	51	0	4	0	4645
2015	2073	1214	1412	43	0	5	0	4748
2016	146	413	561	79	0	6	0	1205
2017	2661	1827	1198	166	0	0	0	5852
2018	2817	558	1425	524	0	0	0	5324
2019	2489	136	1957	203	0	3	0	4788
2020	2656	1304	3392	165	0	5	0	7522
2021	405	242	1791	1197	0	3	0	3636
2022	128	1656	2104	114	0	1	0	4002

Table 9.1.7 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	2066	1687	126	0	0	0	0	3879
1984	2256	1538	207	0	0	4	0	4005
1985	2427	1005	110	3	0	35	0	3582
1986	804	1154	2133	3	8	32	64	4199
1987	1393	374	31	16	0	3	0	1817
1988	809	1215	1442	2	0	22	0	3490
1989	313	1700	92	0	0	1	0	2106
1990	520	828	1405	5	0	0	0	2759
1991	1403	1579	1113	227	0	0	0	4322
1992	879	1151	93	262	0	0	0	2385
1993	398	1799	1174	187	0	10	0	3567
1994	297	1133	443	178	0	16	0	2067
1995	601	970	201	1	0	0	0	1774
1996	691	2981	1205	945	163	0	0	5986
1997	1369	1868	1854	132	0	7	6	5237
1998	568	1036	4003	35	3	0	0	5645
1999	1024	1203	2975	0	0	0	0	5202
2000	960	606	78	0	0	0	0	1643
2001	2979	1143	3044	13	0	0	0	7180
2002	220	672	0	0	0	0	0	892
2003	898	1316	388	71	0	0	0	2673

Year	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2004	456	1028	402	2	0	0	0	1888
2005	124	316	0	0	0	0	0	439
2006	178	377	5	0	0	0	0	560
2007	0	0	0	0	0	0	0	0
2008	85	109	0	0	0	0	0	194
2009	174	194	2	0	0	0	0	370
2010	134	187	10	0	0	0	0	331
2011	126	11	0	0	0	0	0	137
2012	0	25	0	0	0	0	0	25
2013	172	181	0	0	0	0	0	353
2014	96	71	0	0	0	0	0	167
2015	0	19	0	0	0	0	0	19
2016	0	15	0	0	0	0	0	15
2017	50	255	0	0	0	0	0	305
2018	309	6	12	0	0	0	0	327
2019	334	0	0	0	0	0	0	334
2020	40	80	0	0	0	0	0	120
2021	30	18	8	100	0	0	0	156
2022	0	0	0	0	0	0	0	0

Table 9.1.8 Sandeel. Number of samples from commercial catches by year and area.

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	79	49	0	0	0	0	0	128
1984	116	46	13	0	2	3	0	180
1985	101	32	1	19	2	3	0	158
1986	26	17	27	1	0	1	0	72
1987	62	12	60	1	0	1	0	136
1988	42	15	67	0	0	1	0	125
1989	40	9	43	0	0	1	0	93
1990	1	4	37	0	0	2	0	44
1991	25	32	30	1	0	0	0	88
1992	56	42	24	4	0	7	0	133
1993	23	63	64	15	0	7	0	172
1994	20	38	50	15	0	4	0	127
1995	41	32	58	7	7	2	0	147
1996	43	62	113	27	19	1	0	265
1997	41	84	116	25	8	3	0	277
1998	53	30	145	7	0	2	0	237
1999	263	42	40	44	0	0	0	389
2000	102	34	47	59	0	0	0	242

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
2001	213	39	32	90	1	0	0	375
2002	288	97	50	62	0	0	0	497
2003	281	75	30	160	0	1	0	547
2004	451	217	26	47	0	1	0	742
2005	320	42	34	30	0	1	0	427
2006	550	56	72	2	0	2	0	682
2007	295	79	95	0	0	0	0	469
2008	290	100	45	1	0	0	0	436
2009	302	102	3	0	0	0	0	407
2010	169	194	30	1	0	0	0	394
2011	167	54	17	4	0	4	0	246
2012	220	112	31	21	0	12	0	396
2013	292	220	41	5	0	3	0	561
2014	143	133	29	18	0	5	0	328
2015	308	117	48	38	0	4	0	515
2016	154	159	42	35	0	0	0	390
2017	279	204	50	40	0	0	0	573
2018	350	136	162	71	0	0	0	719
2019	282	81	140	32	0	0	0	535
2020	241	182	184	36	0	1	0	644
2021	69	51	169	121	0	2	0	412
2022	25	159	125	24	0	1	0	334

Table 9.2.1 Sandeel Area-1r. Catch at age numbers (million) by half year.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	10223	1846	264	28971	3085	772	564	320	2
1984	0	47117	9241	1701	90	10002	566	333	43
1985	8524	6217	1354	31364	2305	1987	1595	211	213
1986	87	44940	4163	7553	228	1652	188	31	14
1987	187	4504	1938	23572	4173	1199	123	171	32
1988	0	1997	0	8564	162	15229	1439	2354	47
1989	0	62503	757	6364	77	1346	16	4736	58
1990	522	16846	1257	13917	417	2060	62	622	18
1991	7344	14939	6917	6870	209	983	67	338	0
1992	104	50883	3041	8451	298	845	122	524	26
1993	1624	2181	362	5882	271	1638	156	491	43
1994	0	22172	1533	2669	126	1195	55	882	78
1995	76	36677	3440	6236	940	737	109	289	28
1996	6470	10402	1064	12301	1027	4527	211	860	65

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1997	19	38667	8899	2332	177	3522	164	713	56
1998	211	9387	438	28364	1384	2164	136	1505	90
1999	440	44621	2498	5433	205	10158	717	699	149
2000	7887	32625	2760	3355	170	630	84	1076	122
2001	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	208	0	1193	0	97	0	17	0
2017	3	33038	253	3015	40	4604	38	103	7
2018	91	1699	158	14468	792	971	44	331	10
2019	5947	4703	96	830	18	1885	19	101	0
2020	54	11911	80	1098	12	270	2	457	5
2021	2	1141	49	991	28	53	2	33	1
2022	0	549	0	35	0	31	0	5	0
arith. mean	2549	21836	1571	8434	564	2182	179	647	36

Table 9.2.2 Sandeel Area-1r. Individual mean weight (gram) at age in the catch and in the sea.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	4.9	4.0	9.7	8.3	17.2	13.2	20.5	11.6
1984	3.7	5.5	7.3	10.1	12.8	14.1	16.8	13.4	15.8
1985	3.0	5.1	5.8	9.2	10.7	16.4	12.9	17.9	16.6
1986	3.0	5.3	7.5	11.7	12.7	11.7	12.8	13.6	14.7
1987	4.0	7.2	7.8	10.6	11.2	18.5	20.2	14.7	16.1
1988	3.9	6.1	6.8	10.4	12.0	16.0	17.0	17.8	24.4
1989	6.2	5.0	9.6	8.6	15.5	9.1	17.2	12.0	28.3
1990	5.0	6.6	9.0	9.6	13.1	14.2	19.3	17.0	23.1

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1991	3.8	7.8	6.1	14.2	11.8	37.8	32.0	19.6	17.2
1992	4.9	7.8	9.5	11.9	15.3	17.7	19.7	19.0	21.2
1993	4.0	7.3	7.5	11.5	10.5	14.4	13.6	20.2	18.2
1994	4.4	5.5	7.6	8.7	12.3	12.7	16.3	19.8	18.8
1995	3.8	7.6	6.8	11.3	9.9	14.1	14.1	19.0	19.0
1996	2.9	5.6	4.6	8.4	7.6	12.2	9.5	17.7	14.2
1997	3.7	7.3	8.5	8.3	14.2	9.9	15.5	14.4	16.1
1998	3.2	6.3	6.7	8.9	10.0	11.5	11.9	13.5	14.5
1999	3.4	5.3	5.9	7.5	9.6	10.3	12.8	13.1	14.7
2000	3.1	6.3	4.8	8.7	7.9	11.9	10.6	14.5	12.2
2001	3.1	4.5	5.0	8.7	12.1	11.5	16.5	16.6	23.6
2002	3.8	6.0	6.7	7.4	10.8	9.8	14.4	13.8	16.5
2003	2.2	3.6	2.7	7.2	3.6	9.5	8.4	12.8	9.1
2004	3.5	5.1	4.5	8.3	6.6	9.0	6.7	10.4	8.8
2005	3.0	6.5	5.3	8.7	8.5	10.3	11.3	12.1	13.0
2006	3.2	5.9	5.5	9.7	8.9	11.6	11.9	13.0	13.7
2007	4.1	5.6	7.0	9.4	11.3	13.5	15.1	14.7	17.3
2008	4.5	6.3	7.8	10.9	12.6	13.3	16.8	15.8	19.3
2009	2.8	6.2	4.9	9.4	7.9	12.1	10.5	13.2	12.1
2010	3.4	6.3	5.9	12.4	9.5	13.9	12.6	17.2	14.5
2011	2.8	5.3	4.9	8.7	7.8	12.7	10.4	14.8	12.0
2012	3.8	6.4	6.6	9.5	10.6	11.3	14.1	14.5	16.2
2013	3.8	4.7	6.5	6.5	10.5	10.1	14.0	11.3	16.1
2014	3.0	4.7	5.2	7.1	8.5	9.5	11.3	11.7	13.0
2015	4.0	5.5	6.9	8.3	11.1	10.6	14.8	14.0	17.0
2016	3.2	5.2	5.4	10.1	8.7	12.5	11.6	14.7	13.3
2017	2.9	5.3	6.0	7.1	8.2	9.2	10.5	10.7	12.4
2018	3.3	4.7	8.2	7.0	10.6	9.5	13.9	11.5	15.5
2019	3.3	4.7	8.2	7.7	10.6	8.4	13.9	10.7	15.5
2020	3.3	7.1	8.2	9.6	10.6	12.3	13.9	13.8	15.5
2021	3.0	5.3	6.5	9.6	11.0	11.5	15.6	13.1	18.8
2022	3.0	7.3	6.5	12.0	11.0	16.2	15.6	17.0	18.8
arith. mean	3.6	5.9	6.5	9.4	10.4	12.9	14.2	14.9	16.2

Table 9.2.3 Sandeel Area-1r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0.02	0.8	0.99	1

Table 9.2.4. Sandeel Area-1r. Dredge survey indices.

Year	Age 0	Age 1
2004	140061.87	7077.655
2005	277241.20	3288.987
2006	117233.03	12244.596
2007	402355.16	5326.731
2008	35633.70	13619.791
2009	474590.87	9040.642
2010	49722.00	125308.581
2011	77113.07	27178.527
2012	136586.42	3922.222
2013	80356.85	13156.382
2014	235943.73	3413.488
2015	23030.02	13597.662
2016	304655.46	7277.881
2017	32663.00	38561.000
2018	165064.00	11168.000
2019	199148.10	18720.400
2020	71890.40	7497.200
2021	65614.29	8315.977
2022	136688.00	21760.000

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

```
Date: 01/19/23  Start time:11:57:31 run time:6 seconds

 objective function (negative log likelihood):  32.5703
 Number of parameters: 81
 Maximum gradient: 2.23032e-006
 Akaike information criterion (AIC):   227.141
 Number of observations used in the likelihood:
                             Catch    CPUE     S/R Stomach     Sum
                              360      77      40       0     954

 objective function weight:
                           Catch  CPUE   S/R
                           1.00  1.00  0.05

 unweighted objective function contributions (total):
                Catch    CPUE     S/R   Stom.  Stom N.  Penalty     Sum
               39.8    -7.8    13.0     0.0     0.0      0.00      45


 unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.11   -0.10    0.33    0.00


 contribution by fleet:
 ----------------------
 RTM 2007-2021              total:  -8.679   mean:  -0.223
 Dredge survey 2004-2022     total:   0.847   mean:   0.022

 F, season effect:
 -----------------
```

```
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2004:   0.000 1.000
    2005-2009:   0.000 1.000
    2010-2022:   0.000 1.000
age: 1 - 4
    1983-1988:   0.457 0.500
    1989-1998:   0.467 0.500
    1999-2004:   0.371 0.500
    2005-2009:   0.249 0.500
    2010-2022:   0.532 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.266  0.942  1.406  1.406
1989-1998:  0.011  0.552  0.708  0.726  0.726
1999-2004:  0.067  1.022  1.137  1.146  1.146
2005-2009:  0.007  1.503  2.246  2.254  2.254
2010-2022:  0.015  0.299  0.593  0.922  0.922


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.332  1.176  1.755  1.755
          season 2:  0.021  0.108  0.383  0.572  0.572

1989-1998 season 1:      0  0.842  1.080  1.108  1.108
          season 2:  0.001  0.034  0.044  0.045  0.045

1999-2004 season 1:      0  0.806  0.896  0.903  0.903
          season 2:  0.018  0.141  0.157  0.158  0.158

2005-2009 season 1:      0  0.745  1.114  1.118  1.118
          season 2:  0.001  0.056  0.084  0.085  0.085

2010-2022 season 1:      0  0.641  1.270  1.974  1.974
          season 2:  0.003  0.030  0.059  0.091  0.091


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.720
 1       0.402   0.575
 2       0.402   0.575
 3       0.682   1.013
 4       0.682   1.013


Survey catchability:
--------------------
                          age 0    age 1    age 2    age 3
 RTM 2007-2021                     0.954    2.011    3.016
 Dredge survey 2004-2022       2.806    1.239

sqrt(Survey variance) ~ CV:
---------------------------
                          age 0    age 1    age 2    age 3
 RTM 2007-2021                      0.56     0.44     0.46
 Dredge survey 2004-2022        0.51     0.76

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-1r             994.572   1.100e+005   0.705          0.840
```

Table 9.2.6 Sandeel Area-1r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.012	0.295	1.011	1.494	1.502	0.653
1984	0.014	0.334	1.143	1.687	1.696	0.738
1985	0.015	0.358	1.223	1.813	1.808	0.790
1986	0.005	0.252	0.860	1.263	1.258	0.556
1987	0.008	0.188	0.649	0.960	0.958	0.418
1988	0.005	0.274	0.933	1.360	1.355	0.603
1989	0.001	0.840	1.046	1.062	1.054	0.943
1990	0.002	0.836	1.041	1.056	1.052	0.939
1991	0.005	0.562	0.708	0.725	0.726	0.635
1992	0.003	0.844	1.060	1.077	1.078	0.952
1993	0.001	0.372	0.465	0.478	0.477	0.419
1994	0.001	0.308	0.383	0.390	0.388	0.345
1995	0.002	0.577	0.714	0.727	0.725	0.646
1996	0.003	0.541	0.668	0.679	0.678	0.604
1997	0.005	0.510	0.633	0.645	0.648	0.571
1998	0.002	0.669	0.812	0.823	0.823	0.741
1999	0.017	1.011	1.070	1.065	1.067	1.041
2000	0.016	0.808	0.851	0.853	0.852	0.830
2001	0.049	1.225	1.310	1.318	1.322	1.267
2002	0.004	0.937	1.001	0.976	0.969	0.969
2003	0.015	0.780	0.836	0.820	0.823	0.808
2004	0.007	0.822	0.870	0.849	0.849	0.846
2005	0.000	0.919	1.297	1.293	1.290	1.108
2006	0.001	1.123	1.585	1.572	1.568	1.354
2007	0.000	0.424	0.601	0.597	0.593	0.513
2008	0.000	0.792	1.118	1.101	1.098	0.955
2009	0.001	0.978	1.387	1.376	1.368	1.182
2010	0.002	0.480	0.900	1.338	1.330	0.690
2011	0.001	0.546	1.001	1.497	1.482	0.774
2012	0.000	0.103	0.192	0.288	0.286	0.148
2013	0.000	0.623	1.124	1.709	1.700	0.873
2014	0.001	0.363	0.659	1.012	1.010	0.511
2015	0.000	0.349	0.629	0.968	0.960	0.489
2016	0.000	0.025	0.045	0.070	0.069	0.035
2017	0.001	0.465	0.864	1.304	1.291	0.665
2018	0.004	0.461	0.877	1.315	1.311	0.669

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2019	0.004	0.450	0.858	1.289	1.285	0.654
2020	0.000	0.438	0.830	1.237	1.231	0.634
2021	0.000	0.070	0.134	0.201	0.200	0.102
2022	0.000	0.021	0.041	0.061	0.060	0.031
arith. mean	0.005	0.549	0.836	1.009	1.006	0.692

Table 9.2.7 Sandeel Area-1r. Fishing mortality (F) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.012	0.198	0.065	0.701	0.229	1.047	0.341	1.047	0.341
1984	0.014	0.226	0.071	0.801	0.250	1.195	0.373	1.195	0.373
1985	0.015	0.242	0.076	0.855	0.268	1.276	0.400	1.276	0.400
1986	0.005	0.188	0.025	0.665	0.089	0.993	0.133	0.993	0.133
1987	0.008	0.123	0.044	0.434	0.154	0.648	0.230	0.648	0.230
1988	0.005	0.205	0.025	0.726	0.090	1.084	0.134	1.084	0.134
1989	0.001	0.682	0.028	0.874	0.036	0.897	0.036	0.897	0.036
1990	0.002	0.662	0.046	0.849	0.059	0.871	0.061	0.871	0.061
1991	0.005	0.380	0.124	0.486	0.159	0.499	0.164	0.499	0.164
1992	0.003	0.656	0.078	0.840	0.100	0.862	0.102	0.862	0.102
1993	0.001	0.289	0.035	0.371	0.045	0.380	0.046	0.380	0.046
1994	0.001	0.236	0.026	0.302	0.034	0.310	0.035	0.310	0.035
1995	0.002	0.438	0.053	0.562	0.068	0.576	0.070	0.576	0.070
1996	0.003	0.397	0.061	0.509	0.078	0.523	0.081	0.523	0.081
1997	0.005	0.331	0.121	0.424	0.155	0.435	0.159	0.435	0.159
1998	0.002	0.504	0.050	0.646	0.064	0.663	0.066	0.663	0.066
1999	0.017	0.730	0.128	0.812	0.142	0.819	0.144	0.819	0.144
2000	0.016	0.573	0.120	0.638	0.133	0.643	0.134	0.643	0.134
2001	0.049	0.746	0.372	0.829	0.414	0.836	0.418	0.836	0.418
2002	0.004	0.737	0.027	0.819	0.031	0.826	0.031	0.826	0.031
2003	0.015	0.548	0.112	0.609	0.125	0.614	0.126	0.614	0.126
2004	0.007	0.612	0.057	0.680	0.063	0.686	0.064	0.686	0.064
2005	0.000	0.712	0.054	1.063	0.081	1.067	0.081	1.067	0.081
2006	0.001	0.861	0.077	1.286	0.116	1.291	0.116	1.291	0.116
2007	0.000	0.337	0.000	0.504	0.000	0.506	0.000	0.506	0.000
2008	0.000	0.604	0.037	0.902	0.055	0.906	0.055	0.906	0.055
2009	0.001	0.730	0.076	1.090	0.113	1.095	0.113	1.095	0.113
2010	0.002	0.356	0.016	0.706	0.033	1.097	0.051	1.097	0.051
2011	0.001	0.402	0.012	0.796	0.023	1.237	0.036	1.237	0.036
2012	0.000	0.077	0.000	0.152	0.000	0.237	0.000	0.237	0.000
2013	0.000	0.483	0.000	0.958	0.000	1.488	0.000	1.488	0.000

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0.001	0.278	0.010	0.550	0.020	0.854	0.031	0.854	0.031
2015	0.000	0.271	0.000	0.537	0.000	0.834	0.000	0.834	0.000
2016	0.000	0.019	0.000	0.038	0.000	0.058	0.000	0.058	0.000
2017	0.001	0.361	0.006	0.716	0.012	1.112	0.019	1.112	0.019
2018	0.004	0.346	0.036	0.685	0.071	1.065	0.110	1.065	0.110
2019	0.004	0.334	0.042	0.661	0.082	1.027	0.128	1.027	0.128
2020	0.000	0.347	0.005	0.688	0.010	1.069	0.015	1.069	0.015
2021	0.000	0.053	0.004	0.105	0.007	0.163	0.011	0.163	0.011
2022	0.000	0.017	0.000	0.033	0.000	0.052	0.000	0.052	0.000
arith. mean	0.005	0.407	0.053	0.648	0.085	0.796	0.103	0.796	0.103

Table 9.2.8 Sandeel Area-1r. Natural mortality (M) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.499	0.400	0.462	0.357	0.378	0.261	0.326	0.243	0.337
1984	0.499	0.400	0.462	0.357	0.378	0.261	0.326	0.243	0.337
1985	0.519	0.385	0.468	0.345	0.382	0.281	0.358	0.253	0.337
1986	0.534	0.376	0.475	0.342	0.409	0.270	0.368	0.249	0.353
1987	0.550	0.387	0.490	0.344	0.422	0.269	0.371	0.252	0.358
1988	0.553	0.396	0.484	0.357	0.418	0.282	0.358	0.270	0.344
1989	0.532	0.415	0.460	0.377	0.392	0.303	0.356	0.271	0.333
1990	0.544	0.403	0.471	0.341	0.395	0.282	0.355	0.267	0.343
1991	0.560	0.394	0.457	0.326	0.384	0.230	0.344	0.227	0.344
1992	0.549	0.397	0.434	0.311	0.371	0.218	0.328	0.221	0.331
1993	0.530	0.407	0.404	0.343	0.331	0.240	0.318	0.221	0.309
1994	0.530	0.386	0.447	0.327	0.362	0.243	0.329	0.217	0.315
1995	0.521	0.380	0.470	0.337	0.376	0.247	0.339	0.217	0.324
1996	0.552	0.340	0.492	0.304	0.391	0.244	0.351	0.211	0.341
1997	0.567	0.372	0.508	0.323	0.389	0.271	0.349	0.224	0.341
1998	0.615	0.416	0.546	0.350	0.392	0.305	0.352	0.237	0.343
1999	0.620	0.456	0.566	0.379	0.401	0.315	0.350	0.249	0.340
2000	0.608	0.469	0.551	0.391	0.369	0.322	0.334	0.243	0.309
2001	0.614	0.410	0.528	0.366	0.366	0.297	0.326	0.227	0.297
2002	0.671	0.454	0.566	0.424	0.456	0.354	0.357	0.272	0.329
2003	0.690	0.475	0.585	0.442	0.472	0.388	0.377	0.320	0.368
2004	0.709	0.544	0.629	0.473	0.476	0.417	0.375	0.356	0.368
2005	0.695	0.542	0.554	0.426	0.396	0.395	0.371	0.318	0.354
2006	0.729	0.571	0.580	0.441	0.417	0.346	0.365	0.288	0.348
2007	0.769	0.549	0.566	0.405	0.433	0.312	0.396	0.270	0.376

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2008	0.725	0.541	0.610	0.414	0.456	0.300	0.385	0.268	0.375
2009	0.704	0.460	0.597	0.346	0.452	0.282	0.406	0.250	0.383
2010	0.715	0.475	0.667	0.366	0.540	0.299	0.443	0.256	0.419
2011	0.787	0.528	0.731	0.367	0.544	0.321	0.472	0.273	0.437
2012	0.787	0.593	0.710	0.454	0.541	0.368	0.455	0.321	0.433
2013	0.732	0.591	0.655	0.495	0.435	0.369	0.407	0.324	0.388
2014	0.723	0.522	0.605	0.481	0.390	0.324	0.364	0.302	0.357
2015	0.718	0.578	0.622	0.442	0.391	0.299	0.380	0.276	0.356
2016	0.725	0.526	0.617	0.394	0.396	0.288	0.384	0.268	0.354
2017	0.673	0.534	0.600	0.425	0.454	0.307	0.394	0.286	0.363
2018	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2019	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2020	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2021	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
2022	0.619	0.440	0.538	0.427	0.454	0.328	0.360	0.293	0.345
arith. mean	0.628	0.457	0.544	0.388	0.421	0.304	0.367	0.266	0.352

Table 9.2.9 Sandeel Area-1r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1983	285026	13418	50882	2905	229
1984	75507	170943	4358	9620	435
1985	518333	45234	53651	730	1166
1986	75342	304118	14022	8438	193
1987	49079	43975	104960	3115	1481
1988	201059	28085	15490	27081	1017
1989	90935	115096	9252	3157	4390
1990	136383	53383	23596	1728	1586
1991	160226	79030	10966	4557	699
1992	37824	91022	20400	2827	1528
1993	159213	21780	19030	4025	959
1994	225498	93537	6997	6398	1873
1995	56290	132577	31276	2509	3337
1996	410037	33370	34668	8163	1749
1997	62133	235544	9178	9614	3014
1998	116846	35070	62189	2522	3801
1999	154573	63019	7697	14548	1658
2000	244381	81766	9619	1358	3208
2001	422468	131038	14751	2082	1173
2002	28060	217798	16759	2046	517

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	163711	14297	36570	2969	547
2004	68572	80944	2560	7039	791
2005	157839	33487	12833	471	1687
2006	76729	78731	5205	1797	343
2007	182569	36969	9740	543	261
2008	74861	84604	8652	2545	244
2009	549178	36254	14106	1392	540
2010	34856	271487	5630	1905	295
2011	38661	17030	59671	1087	336
2012	98194	17577	3198	10575	184
2013	56200	44691	4426	1015	3733
2014	192702	27042	7923	670	519
2015	34426	93456	6575	1874	250
2016	254748	16788	21476	1671	471
2017	19225	123434	5250	9390	1043
2018	28676	9800	27496	1053	1678
2019	81354	15392	2516	5352	437
2020	29518	43644	3978	496	921
2021	58360	15893	11541	821	249
2022	84015	31426	5649	4279	457
2023		45257	11623	2266	2273

Table 9.2.10 Sandeel Area-1r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (modelled yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	285000075	615279	452254	378795	0.596
1984	75526942	1118720	194269	498626	0.674
1985	518266424	753676	431059	437114	0.720
1986	75376039	1875330	265402	382844	0.484
1987	49081856	1508460	977741	373021	0.377
1988	201037095	783049	577810	413646	0.523
1989	90966330	734865	157157	446028	0.809
1990	136386047	631692	240626	306240	0.808
1991	160210639	957620	321258	332204	0.575
1992	37806817	1030230	287219	558599	0.837
1993	159252253	455531	254995	132024	0.370
1994	225538177	693410	176840	193241	0.299
1995	56288454	1461400	402721	400588	0.561
1996	410136258	607428	366224	265869	0.523
1997	62146186	1922600	234216	426089	0.515

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1998	116803080	854793	527551	377073	0.632
1999	154545638	566146	223463	422718	0.906
2000	244322590	660654	140505	299167	0.732
2001	422626767	764051	158419	531265	1.181
2002	28064051	1449670	154045	606466	0.807
2003	163774330	350978	247212	148039	0.697
2004	68544930	502053	96086	203646	0.706
2005	157825413	355213	119731	123422	0.955
2006	76745092	539216	75207	240646	1.170
2007	182634966	308354	88965	109624	0.421
2008	74850249	662345	123624	234447	0.799
2009	549214701	380377	134726	290995	1.004
2010	34865209	1811450	122884	300508	0.556
2011	38647784	629904	437574	318840	0.616
2012	98149266	264658	147119	46117	0.115
2013	56175990	290482	79858	214359	0.721
2014	192768395	196284	59814	78830	0.429
2015	34414894	590547	77653	163381	0.404
2016	254802680	332204	203414	14613	0.028
2017	19230344	787376	140225	241916	0.548
2018	28688302	269049	185350	133659	0.569
2019	81327925	141771	66304	66444	0.559
2020	29532444	367906	55770	106100	0.525
2021	58351755	207309	102744	17245	0.084
2022	84056521	373410	135266	5011	0.025
2023			146825		
arith. mean	144840168	720137	229035	270986	0.597
geo. mean	101340835				

arith. mean for the period 1983–2022

geo. mean for the period 1983–2021

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	101314.11	45257.3	11622.8	2265.98	2273.16
Exploitation pattern 1st half		0.017	0.033	0.052	0.052
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.824	9.164	11.589	13.220
Weight in the catch 1st half		5.824	9.164	11.589	13.220
Weight in the catch 2nd half	3.191	7.501	10.761	14.595	16.825
Proportion mature (2023)	0.000	0.021	0.801	0.988	1.000
Proportion mature (2024)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.440	0.427	0.328	0.293
Natural mortality 2nd half	0.619	0.538	0.454	0.360	0.345

Table 9.2.12 Sandeel Area-1r. Short term forecast (000 tonnes).

Basis: Fsq = F(2022) = 0.025; Yield(2022) = 5.011; Recruitment(2022) = 84.056521; Recruitment(2023) = geometric mean (GM 1983–2021) = 101.314110 billions; SSB(2023) = 146.825

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
SSB(2024) =MSY $B_{escapement}$ = B_{pa}	120 428	0.424	145 000	-1	2309
F = 0	0	0	217 821	48	-100
B_{lim}	180 743	0.741	110 000	-25	3515
F = F_{2022}	8 827	0.025	212 382	45	77

* SSB2024 relative to SSB2023.
** Catch scenario for 2023 relative to TAC in 2022 (5000 t).

Table 9.3.1 Sandeel Area-2r. Catch at age numbers (million) by half year.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	12882	4162	476	6190	877	203	104	67	0
1984	0	10284	3846	912	186	1154	193	38	10
1985	1827	1411	392	5501	768	473	387	109	50
1986	1443	24479	3495	3144	208	436	95	6	7
1987	45	831	512	2621	591	131	17	20	4
1988	5602	1030	545	3379	226	3163	775	478	31
1989	2819	23364	3809	1666	273	938	10	909	34
1990	5046	7332	854	3967	196	587	29	177	9
1991	10053	14203	3628	2099	110	451	35	156	1
1992	6830	12016	886	4066	85	475	34	298	7
1993	14083	4814	873	1294	660	642	226	475	56
1994	0	25596	4477	3619	919	341	275	199	118
1995	1798	4897	1316	1598	1777	209	211	88	159
1996	26463	2472	7161	1573	475	905	278	260	186
1997	284	29071	8330	1640	193	628	83	207	47

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1998	1070	645	106	4749	1424	437	136	348	144
1999	4130	841	1113	177	102	855	501	186	149
2000	519	8160	1066	566	164	217	98	518	134
2001	5767	2625	2414	1010	563	129	73	367	228
2002	4	15855	1379	891	185	393	35	85	28
2003	3711	267	79	1723	453	136	43	67	17
2004	755	10761	2034	711	212	537	297	174	55
2005	15	2171	490	513	336	48	32	116	91
2006	8	2441	1030	276	125	100	64	27	39
2007	0	6431	0	240	0	32	0	5	0
2008	1	4621	187	434	64	90	36	15	5
2009	103	2817	1867	671	145	42	25	4	1
2010	2	6490	1308	193	35	374	27	60	4
2011	0	404	19	1474	91	236	17	59	3
2012	0	168	6	194	51	293	6	60	10
2013	0	4824	431	1158	47	296	16	99	5
2014	301	2987	141	2371	28	340	3	119	5
2015	0	2275	42	772	9	561	2	197	2
2016	4	272	1	136	3	108	0	66	0
2017	0	23040	1325	243	5	51	25	20	2
2018	0	50	0	1949	22	63	2	11	0
2019	0	226	0	52	0	172	0	4	0
2020	4	8068	16	433	1	173	1	356	3
2021	0	606	0	96	0	3	0	3	0
2022	0	5950	0	1000	0	450	0	271	0
arith. mean	2639	6974	1391	1633	290	422	105	168	41

Table 9.3.2 Sandeel Area-2r. Individual mean weight (gram) at age in the catch and in the sea.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	5.2	9.9	10.8	16.5	12.8	22.9	15.0	27.3
1984	5.9	5.6	10.2	11.1	14.1	15.6	25.8	18.8	30.1
1985	4.5	6.7	10.7	9.9	16.8	17.5	23.3	24.1	27.5
1986	3.2	5.9	9.8	10.3	15.8	12.7	15.0	15.0	17.0
1987	2.8	5.8	8.7	11.1	12.9	16.4	21.1	14.6	19.4
1988	3.5	5.5	7.2	11.1	15.3	16.1	21.0	23.1	30.6
1989	4.8	5.7	9.4	9.1	13.4	10.1	14.4	12.1	18.0
1990	4.4	7.1	8.1	9.7	11.8	14.4	17.4	17.3	20.8
1991	3.8	7.7	5.7	12.1	11.0	35.8	32.6	21.2	20.1
1992	4.7	6.9	15.0	9.9	20.6	13.5	29.3	17.9	29.2
1993	2.8	7.7	9.3	15.1	14.8	16.9	17.5	22.3	22.0
1994	3.6	5.4	7.6	10.5	18.8	15.3	23.0	19.5	20.7
1995	5.2	7.6	8.9	12.4	13.2	16.0	17.6	19.2	21.1
1996	2.7	7.0	4.9	12.4	13.2	17.0	15.8	27.9	24.5
1997	3.2	5.3	7.1	8.0	11.2	13.1	13.8	15.9	14.9
1998	3.4	6.2	6.7	11.4	14.0	14.7	16.5	17.4	18.3
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
2001	4.0	6.0	5.0	12.9	16.1	16.6	21.7	20.4	26.2
2002	3.2	5.7	8.3	8.4	13.2	9.6	15.3	17.3	17.7
2003	5.4	6.0	8.1	11.3	16.0	15.1	21.4	18.2	27.2
2004	4.8	6.5	7.4	9.4	10.9	12.4	12.2	13.1	13.7
2005	3.4	7.5	7.4	11.8	11.9	14.4	15.4	14.8	17.5
2006	4.6	7.6	9.9	11.5	15.9	13.9	20.6	14.8	23.4
2007	5.8	6.2	6.2	12.4	12.4	15.4	15.4	17.8	17.8
2008	3.4	5.5	7.5	12.5	12.0	16.1	15.6	18.0	17.7
2009	6.0	6.1	5.0	8.7	10.9	16.5	18.6	12.2	11.0
2010	2.5	5.7	5.3	10.3	8.4	11.5	11.0	13.2	12.5
2011	3.6	6.9	7.6	11.1	12.2	13.8	15.8	14.6	18.0
2012	4.4	8.2	9.4	12.4	15.1	14.8	19.6	21.8	22.3
2013	3.9	5.9	8.8	7.9	11.5	14.2	14.4	14.1	16.5
2014	3.3	5.3	7.0	9.9	11.2	12.0	14.6	18.6	16.6
2015	5.3	6.8	11.4	12.4	18.4	15.3	23.9	17.3	27.1
2016	2.6	3.3	5.5	12.2	8.9	14.6	11.5	16.0	13.1
2017	2.9	5.5	7.8	7.8	10.7	13.1	10.8	14.8	15.5
2018	3.8	4.6	8.2	9.6	13.9	12.4	18.6	14.0	20.7

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2019	3.8	7.7	8.2	12.4	13.9	15.4	18.6	18.7	20.7
2020	3.8	6.6	8.2	12.8	13.9	16.2	18.6	20.4	20.7
2021	3.6	4.8	9.1	11.8	15.5	16.6	19.0	18.8	25.2
2022	3.6	6.6	9.1	13.7	15.5	18.5	19.0	35.1	25.2
arith. mean	3.9	6.3	8.2	11.0	13.7	15.2	18.3	18.1	20.7

Table 9.3.3 Sandeel Area-2r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0.02	0.83	1	1

Table 9.3.4. Sandeel Area-2r. Dredge survey indices.

Year	Age 0	Age 1
2010	938.752	1482.382
2011	2290.448	259.021
2012	11342.580	94.156
2013	7546.966	2103.482
2014	5760.235	810.806
2015	706.350	106.920
2016	53839.804	113.297
2017	899.000	2976.000
2018	2326.000	372.000
2019	26129.000	522.000
2020	7662.000	665.000
2021	45488.020	499.877
2022	21982.000	2124.000

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

```
Date: 01/18/23  Start time:09:52:51 run time:12 seconds

 objective function (negative log likelihood):  86.2127
 Number of parameters: 76
 Maximum gradient: 7.0277e-005
 Akaike information criterion (AIC):   324.425
 Number of observations used in the likelihood:
                            Catch    CPUE      S/R Stomach      Sum
                             360      26      40       0     426

 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
               92.0    -7.7    19.6     0.0     0.0      0.00     104
```

```
unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.26   -0.30    0.49    0.00


contribution by fleet:
----------------------
Dredge survey 2010-2022     total:  -7.716   mean:  -0.297

F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2004:   0.000 1.000
    2005-2009:   0.000 1.000
    2010-2022:   0.000 1.000
age: 1 - 4
    1983-1988:   0.474 0.500
    1989-1998:   0.686 0.500
    1999-2004:   0.421 0.500
    2005-2009:   0.190 0.500
    2010-2022:   0.563 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.041  0.281  0.903  1.489  1.489
1989-1998:  0.099  0.336  0.401  0.474  0.474
1999-2004:  0.041  0.598  0.714  0.720  0.720
2005-2009:  0.001  1.955  1.656  1.730  1.730
2010-2022:  0.001  0.289  0.467  0.599  0.599


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.299  0.962  1.587  1.587
          season 2:  0.051  0.175  0.564  0.930  0.930

1989-1998 season 1:      0  0.726  0.867  1.024  1.024
          season 2:  0.109  0.185  0.221  0.261  0.261

1999-2004 season 1:      0  0.310  0.370  0.373  0.373
          season 2:  0.082  0.602  0.718  0.724  0.724

2005-2009 season 1:      0  0.537  0.455  0.475  0.475
          season 2:  0.001  0.546  0.462  0.483  0.483

2010-2022 season 1:      0  0.638  1.033  1.324  1.324
          season 2:  0.001  0.125  0.203  0.260  0.260


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.651
 1       0.415   0.829
 2       0.415   0.829
 3       0.874   1.076
 4       0.874   1.076


Survey catchability:
--------------------
                           age 0    age 1
 Dredge survey 2010-2022       0.105   24.492

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1
```

```
Dredge survey 2010-2022        1.40     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Dredge survey 2010-2022        0.30     0.72

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-2r            1070.765   5.600e+004   0.982          0.991
```

Table 9.3.6 Sandeel Area-2r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.037	0.370	1.176	1.934	1.932	0.773
1984	0.034	0.310	0.992	1.636	1.635	0.651
1985	0.022	0.291	0.917	1.497	1.495	0.604
1986	0.025	0.417	1.303	2.112	2.108	0.860
1987	0.008	0.092	0.293	0.481	0.481	0.192
1988	0.027	0.310	0.981	1.607	1.605	0.646
1989	0.075	0.729	0.852	0.994	0.992	0.790
1990	0.037	0.490	0.570	0.663	0.661	0.530
1991	0.070	0.552	0.648	0.759	0.757	0.600
1992	0.051	0.561	0.655	0.763	0.762	0.608
1993	0.080	0.442	0.523	0.617	0.616	0.482
1994	0.050	0.470	0.550	0.642	0.641	0.510
1995	0.043	0.255	0.302	0.355	0.355	0.279
1996	0.132	0.379	0.459	0.553	0.553	0.419
1997	0.083	0.556	0.654	0.768	0.767	0.605
1998	0.046	0.286	0.338	0.397	0.397	0.312
1999	0.036	0.370	0.454	0.470	0.471	0.412
2000	0.017	0.549	0.646	0.647	0.646	0.598
2001	0.036	0.479	0.579	0.593	0.594	0.529
2002	0.020	0.664	0.780	0.780	0.779	0.722
2003	0.037	0.441	0.535	0.551	0.551	0.488
2004	0.030	0.896	1.055	1.058	1.056	0.975
2005	0.001	1.170	0.998	1.056	1.056	1.084
2006	0.001	1.222	1.049	1.115	1.116	1.136
2007	0.000	0.746	0.615	0.627	0.625	0.681
2008	0.000	0.803	0.672	0.697	0.696	0.737
2009	0.000	0.768	0.655	0.692	0.692	0.712
2010	0.000	0.377	0.594	0.749	0.747	0.486
2011	0.000	0.243	0.381	0.479	0.477	0.312
2012	0.000	0.139	0.218	0.273	0.272	0.178
2013	0.000	0.602	0.943	1.183	1.179	0.773
2014	0.000	0.457	0.712	0.891	0.888	0.585

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2015	0.000	0.402	0.625	0.780	0.778	0.514
2016	0.000	0.173	0.271	0.339	0.337	0.222
2017	0.001	0.782	1.222	1.532	1.528	1.002
2018	0.000	0.234	0.365	0.456	0.454	0.300
2019	0.000	0.055	0.085	0.106	0.106	0.070
2020	0.000	0.537	0.837	1.046	1.043	0.687
2021	0.000	0.098	0.153	0.190	0.190	0.125
2022	0.000	0.657	1.017	1.266	1.262	0.837
arith. mean	0.025	0.484	0.667	0.834	0.832	0.576

Table 9.3.7 Sandeel Area-2r. Fishing mortality (F) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.037	0.217	0.127	0.696	0.408	1.149	0.674	1.149	0.674
1984	0.034	0.176	0.116	0.567	0.372	0.936	0.614	0.936	0.614
1985	0.022	0.184	0.076	0.591	0.245	0.974	0.404	0.974	0.404
1986	0.025	0.277	0.087	0.892	0.279	1.472	0.461	1.472	0.461
1987	0.008	0.056	0.028	0.179	0.091	0.295	0.150	0.295	0.150
1988	0.027	0.190	0.092	0.611	0.294	1.008	0.486	1.008	0.486
1989	0.075	0.502	0.128	0.599	0.153	0.708	0.181	0.708	0.181
1990	0.037	0.350	0.062	0.417	0.074	0.493	0.088	0.493	0.088
1991	0.070	0.366	0.119	0.437	0.142	0.516	0.168	0.516	0.168
1992	0.051	0.392	0.087	0.468	0.103	0.553	0.122	0.553	0.122
1993	0.080	0.269	0.135	0.321	0.162	0.379	0.191	0.379	0.191
1994	0.050	0.320	0.085	0.382	0.102	0.452	0.120	0.452	0.120
1995	0.043	0.158	0.073	0.189	0.087	0.223	0.103	0.223	0.103
1996	0.132	0.168	0.224	0.201	0.268	0.237	0.317	0.237	0.317
1997	0.083	0.356	0.141	0.425	0.168	0.502	0.198	0.502	0.198
1998	0.046	0.179	0.078	0.214	0.093	0.253	0.110	0.253	0.110
1999	0.036	0.138	0.267	0.164	0.319	0.166	0.322	0.166	0.322
2000	0.017	0.359	0.127	0.428	0.152	0.432	0.153	0.432	0.153
2001	0.036	0.222	0.267	0.265	0.319	0.267	0.322	0.267	0.322
2002	0.020	0.440	0.144	0.526	0.171	0.530	0.173	0.530	0.173
2003	0.037	0.191	0.269	0.229	0.321	0.231	0.323	0.231	0.323
2004	0.030	0.579	0.222	0.692	0.266	0.698	0.268	0.698	0.268
2005	0.001	0.579	0.588	0.490	0.498	0.512	0.520	0.512	0.520
2006	0.001	0.554	0.702	0.469	0.595	0.490	0.622	0.490	0.622
2007	0.000	0.596	0.000	0.505	0.000	0.527	0.000	0.527	0.000
2008	0.000	0.525	0.188	0.445	0.159	0.464	0.167	0.464	0.167
2009	0.000	0.387	0.374	0.328	0.317	0.342	0.331	0.342	0.331

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2010	0.000	0.266	0.052	0.430	0.085	0.551	0.108	0.551	0.108
2011	0.000	0.179	0.019	0.290	0.031	0.372	0.040	0.372	0.040
2012	0.000	0.105	0.007	0.169	0.011	0.217	0.015	0.217	0.015
2013	0.000	0.445	0.054	0.720	0.087	0.923	0.112	0.923	0.112
2014	0.000	0.349	0.020	0.564	0.033	0.723	0.042	0.723	0.042
2015	0.000	0.314	0.005	0.507	0.009	0.650	0.011	0.650	0.011
2016	0.000	0.133	0.004	0.215	0.007	0.276	0.009	0.276	0.009
2017	0.001	0.580	0.071	0.939	0.116	1.203	0.148	1.203	0.148
2018	0.000	0.183	0.002	0.296	0.003	0.379	0.003	0.379	0.003
2019	0.000	0.043	0.000	0.069	0.000	0.088	0.000	0.088	0.000
2020	0.000	0.412	0.023	0.666	0.036	0.854	0.047	0.854	0.047
2021	0.000	0.076	0.000	0.123	0.000	0.158	0.000	0.158	0.000
2022	0.000	0.523	0.000	0.846	0.000	1.084	0.000	1.084	0.000
arith. mean	0.025	0.308	0.127	0.439	0.164	0.557	0.203	0.557	0.203

Table 9.3.8 Sandeel Area-2r. Natural mortality (M) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1984	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1985	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1986	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1987	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1988	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1989	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1990	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1991	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1992	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1993	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1994	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1995	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1996	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1997	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1998	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1999	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2000	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2001	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2002	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2003	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2004	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2005	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2006	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2014	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2015	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2016	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2017	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2018	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2019	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2020	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2021	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2022	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
arith. mean	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41

Table 9.3.9 Sandeel Area-2r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1983	157383	16389	14516	728	27
1984	47378	60438	3644	1898	58
1985	280436	18254	14146	562	198
1986	60233	109302	4413	2421	92
1987	35679	23403	23803	540	174
1988	173459	14102	6747	7173	219
1989	87334	67305	3336	1077	793
1990	158618	32283	11240	621	370
1991	113517	60939	6703	2712	266
1992	117645	42188	11766	1483	719
1993	231388	44557	8193	2621	538
1994	108060	85161	9325	1995	855
1995	78575	40960	17798	2267	772
1996	418249	29999	10193	5330	1053
1997	16194	146099	6351	2517	1756
1998	27125	5942	27884	1386	1021

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1999	74989	10326	1440	8093	806
2000	44207	28818	2160	351	2613
2001	132798	17315	5558	477	802
2002	10297	51032	3329	1223	343
2003	47428	4024	8921	654	371
2004	19076	18223	796	2032	283
2005	19254	7376	2562	121	422
2006	26874	7667	720	376	94
2007	40617	10700	684	98	74
2008	26112	16187	1849	163	49
2009	78766	10404	2487	399	54
2010	8395	31375	1524	515	110
2011	11261	3344	7155	359	155
2012	43005	4487	860	2048	163
2013	25006	17137	1258	283	838
2014	17712	9960	3261	221	193
2015	5075	7057	2160	709	93
2016	114737	2022	1608	508	198
2017	4026	45723	553	508	255
2018	9869	1603	7472	76	95
2019	42395	3933	418	2188	56
2020	23501	16895	1182	154	981
2021	79240	9364	3431	231	224
2022	52864	31579	2720	1197	187
2023		21067	5871	461	224

Table 9.3.10 Sandeel Area-2r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (modelled yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean $F_{1\text{-}2}$
1983	157352646	251236	141634	155664	0.724
1984	47393706	407379	71182	133343	0.616
1985	280476360	276568	133252	110546	0.548
1986	60249209	718400	82951	225470	0.768
1987	35676401	412520	233515	49070	0.177
1988	173380646	273508	184425	149466	0.593
1989	87312134	437127	53370	223507	0.691
1990	158616516	353043	110525	133874	0.452
1991	113464435	651357	179512	215508	0.532
1992	117623570	442708	135944	184033	0.525
1993	231479066	522587	165877	139826	0.443

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1994	108038694	603217	137585	244939	0.445
1995	78609255	584603	240386	113899	0.253
1996	418421560	456214	228891	182562	0.431
1997	16191549	883035	118421	242094	0.544
1998	27125912	392585	302549	99814	0.282
1999	75000100	241040	156061	69427	0.444
2000	44189599	270505	74236	92908	0.533
2001	132752892	199277	85905	90200	0.536
2002	10293261	334383	46583	117388	0.641
2003	47441124	141416	100710	53710	0.505
2004	19077115	154107	37459	110546	0.879
2005	19249584	93284	34235	34396	1.078
2006	26882874	72786	14647	37860	1.160
2007	40629298	77095	11167	43090	0.550
2008	26114467	116388	24441	35604	0.658
2009	78766631	91810	26370	35687	0.703
2010	8393767	202252	24005	51670	0.416
2011	11262622	110039	73718	24896	0.260
2012	43012443	81362	43478	10594	0.146
2013	25015345	126753	26134	47814	0.653
2014	17716377	91240	34201	48033	0.483
2015	5075827	87466	35668	37902	0.418
2016	114719434	36772	26984	5230	0.180
2017	4024857	268282	19051	141314	0.853
2018	9869897	81683	62193	20307	0.241
2019	42414464	70085	39656	5091	0.056
2020	23511495	148811	37235	68932	0.568
2021	79240651	93714	42574	4147	0.100
2022	52851677	275877	63831	71128	0.684
2023			73350		
arith. mean*	76719418	278313	91075	96537	0.519
geo. mean**	45037228				

*** arith. mean for the period 1983-2022**

**** geo. mean for the period 1983-2021**

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	22601.859	21067.2	5870.66	460.717	224.027
Exploitation pattern 1st half		0.523	0.846	1.084	1.084
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.065	12.057	15.806	21.403
Weight in the catch 1st half		6.065	12.057	15.806	21.403
Weight in the catch 2nd half	3.724	8.573	14.565	18.802	22.521
Proportion mature (2023)	0.000	0.020	0.830	1.000	1.000
Proportion mature (2024)	0.000	0.020	0.830	1.000	1.000
Natural mortality 1st half		0.570	0.440	0.320	0.310
Natural mortality 2nd half	0.920	0.590	0.490	0.420	0.410

Table 9.3.12 Sandeel Area-2r. Short term forecast (000 tonnes).

Basis: Fsq = F(2022)=0.684; Yield(2022) = 71.128; Recruitment(2022) = 52.851677; Recruitment(2023) = geometric mean (GM 2012-2021) = 22.601859 billions; SSB(2023) = 73.35

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
SSB2024 =MSY $B_{escapement}$ = B_{pa}^	40 997	0.291	84 000	15	-43
F = 0	0	0	110 821	51	-100
B_{lim}	85 165	0.73	56 000	-24	19
F2023 = Fsq	81 334	0.684	58 379	-20	13

* SSB2024 relative to SSB2023

** Catch scenario for 2023 relative to TAC in 2022 (71 859 t)

Table 9.4.1 Sandeel Area-3r. Catch at age numbers (million) by half year.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	7965	18939	7987	2063	533	161	2	0	0
1987	5	33760	65	14020	4	453	0	200	0
1988	8769	6584	853	17321	233	893	144	19	13
1989	159	47004	190	1844	13	2806	0	4	0
1990	9793	9302	1377	2791	286	413	43	125	13
1991	14442	24009	942	1391	30	526	9	184	3
1992	525	7100	87	2862	8	342	3	215	1
1993	9663	15164	851	558	155	211	71	1336	12
1994	0	23742	615	4818	684	938	78	386	10
1995	1020	25037	484	1894	78	238	13	156	17
1996	6263	4319	3111	3394	97	465	33	399	248
1997	2975	66856	10388	2912	134	607	13	194	9
1998	30136	3954	992	28137	740	2553	192	290	32

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1999	6444	5182	1835	1554	118	1979	401	421	169
2000	0	18793	344	3286	4	541	1	533	9
2001	18263	5327	3968	992	9	163	2	160	6
2002	0	9075	21	2680	3	387	1	135	0
2003	2755	939	61	808	53	130	2	78	1
2004	1091	1976	737	256	16	74	6	92	1
2005	0	1404	1	146	0	21	0	12	0
2006	0	769	3	47	1	27	0	4	0
2007	0	8600	0	571	0	86	0	19	0
2008	0	4077	0	2012	0	460	0	73	0
2009	1	827	12	69	2	8	0	0	0
2010	0	3042	51	740	1	1006	1	173	0
2011	0	1304	0	5224	0	825	0	24	0
2012	0	32	0	186	0	1157	0	356	0
2013	0	648	0	211	0	55	0	42	0
2014	0	5384	0	2373	0	643	0	319	0
2015	0	6451	0	2340	0	956	0	99	0
2016	0	156	0	2006	0	415	0	284	0
2017	0	11734	0	671	0	434	0	409	0
2018	0	413	6	6631	48	40	1	305	1
2019	0	7105	0	716	0	4241	0	131	0
2020	0	21133	0	1981	0	391	0	1249	0
2021	10	2273	7	4215	1	995	0	2357	0
2022	0	1683	0	1115	0	864	0	747	0
arith. mean	3251	10922	946	3374	88	716	27	312	15

Table 9.4.2 Sandeel Area-3r. Individual mean weight (gram) at age in the catch and in the sea.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	4.0	6.1	12.7	9.7	21.0	12.4	18.9	15.9	20.4
1987	6.9	6.4	12.8	11.7	20.4	20.5	31.6	22.5	29.6
1988	4.1	5.1	6.4	13.1	16.1	23.0	22.5	36.2	31.5
1989	4.8	6.1	9.3	10.5	12.7	14.3	14.0	18.8	17.5
1990	4.4	7.5	7.7	9.8	11.2	15.2	16.5	20.2	19.8
1991	3.7	7.3	5.7	11.4	13.8	36.4	27.5	26.3	16.3
1992	4.6	6.1	13.4	10.3	26.7	14.7	28.7	23.0	30.9
1993	3.5	5.8	7.3	16.4	16.7	17.9	20.8	23.3	22.4
1994	3.6	6.1	13.0	14.6	20.8	20.6	35.2	21.1	27.1
1995	4.7	5.6	8.2	9.7	10.2	13.8	13.7	16.5	16.1

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1996	2.5	8.8	8.0	13.3	14.0	26.1	15.7	38.5	24.0
1997	2.9	5.2	6.7	10.1	10.2	13.7	14.2	18.3	14.4
1998	3.2	5.0	7.0	10.1	15.2	13.7	17.3	20.3	20.7
1999	8.7	7.4	14.5	10.1	19.4	14.1	21.1	26.3	30.7
2000	5.2	6.9	10.8	10.5	17.4	15.3	23.7	20.5	25.6
2001	5.6	6.8	8.9	13.7	16.0	17.8	15.9	23.2	25.5
2002	9.4	8.1	19.7	12.7	31.6	14.6	43.2	19.2	46.7
2003	4.3	5.3	5.4	14.6	15.3	20.3	24.1	26.9	26.7
2004	5.8	7.3	7.3	9.5	14.1	14.5	18.4	15.1	12.7
2005	3.4	7.8	7.0	16.5	11.2	19.9	15.3	22.6	16.6
2006	11.0	7.5	23.1	13.5	36.9	17.1	50.5	26.9	54.5
2007	4.1	7.5	8.6	15.1	13.9	21.7	18.9	14.6	20.5
2008	4.1	8.0	8.6	15.0	13.9	22.0	18.9	25.8	20.5
2009	4.2	6.3	8.8	10.4	14.1	19.9	19.2	12.1	20.8
2010	2.5	7.5	5.2	17.7	8.3	20.7	11.4	24.3	12.3
2011	4.1	7.7	8.6	12.6	13.9	19.4	18.9	36.2	20.5
2012	4.1	9.9	8.6	15.2	13.9	22.7	18.9	30.0	20.5
2013	4.1	9.1	8.6	11.6	13.9	14.3	18.9	16.2	20.5
2014	4.1	8.6	8.6	12.7	13.9	13.9	18.9	18.3	20.5
2015	3.8	8.3	8.4	12.7	15.4	19.3	20.2	30.1	21.9
2016	3.8	4.0	8.4	12.4	15.4	19.8	20.2	32.1	21.9
2017	3.8	7.7	8.4	11.9	15.4	17.7	20.2	24.2	21.9
2018	3.8	5.8	8.4	9.9	15.4	13.5	20.2	20.6	21.9
2019	3.8	8.5	8.4	11.6	15.4	15.2	20.2	20.2	21.9
2020	3.8	8.8	8.4	14.6	15.4	17.2	20.2	19.3	21.9
2021	3.6	7.7	9.3	14.1	20.3	19.4	26.5	26.0	32.6
2022	3.6	11.3	9.3	16.6	20.3	21.4	26.5	36.6	32.6
arith. mean	4.5	7.2	9.5	12.6	16.5	18.2	21.8	23.5	23.8

Table 9.4.3 Sandeel Area-3r. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983-2016	0.04	0.77	1	1

Table 9.4.4. Sandeel Area-3r. Dredge survey indices.

Year	Age 0	Age 1
2005	68667.988	
2006	55709.239	1225.934
2007	10611.085	3717.149
2008	16658.095	1521.160
2009	37088.951	16328.039
2010	1844.740	5076.749
2011	973.111	1961.856
2012	47713.266	767.514
2013	174467.733	790.887
2014	92703.238	5349.152
2015	2667.397	11100.794
2016	194644.941	322.967
2017	6359.000	15640.000
2018	82359.000	5980.000
2019	112538.400	10448.300
2020	69976.000	20816.000
2021	23486.023	6259.908
2022	12369.000	1818.000

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

```
Date: 01/19/23  Start time:11:53:59 run time:2 seconds

 objective function (negative log likelihood):  125.393
 Number of parameters: 62
 Maximum gradient: 2.55801e-005
 Akaike information criterion (AIC):   374.785
 Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             333      91      37       0     461

 objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.01

 unweighted objective function contributions (total):
                Catch    CPUE    S/R   Stom.  Stom N.  Penalty     Sum
              108.7    16.5    19.2     0.0     0.0      0.00     144


 unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.33    0.18    0.52    0.00


 contribution by fleet:
 ----------------------
 Acoustic survey            total:  13.094   mean:   0.234
 Dredge survey 2004-2022    total:   3.453   mean:   0.099

 F, season effect:
 -----------------
 age: 0
```

```
    1986-1998:   0.000 1.000
    1999-2022:   0.000 1.000
age: 1 - 4
    1986-1998:   0.879 0.500
    1999-2022:   1.014 0.500

F, age effect:
--------------
               0      1      2      3      4
1986-1998:  0.102  0.377  0.414  0.333  0.333
1999-2022:  0.052  0.150  0.216  0.209  0.209


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                       0      1      2      3      4
1986-1998 season 1:      0  0.642  0.706  0.567  0.567
          season 2:  0.168  0.310  0.342  0.274  0.274

1999-2022 season 1:      0  0.564  0.810  0.785  0.785
          season 2:  0.177  0.257  0.369  0.357  0.357


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.126
 1       0.716   1.039
 2       0.716   1.039
 3       1.018   1.248
 4       1.018   1.248


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                         2.732    5.015    4.165    4.165
 Dredge survey 2004-2022       0.446    0.446

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1    age 2    age 3    age 4
Acoustic survey                           1.00     1.00     1.00     1.00
Dredge survey 2004-2022        1.03     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                          0.54     0.54     1.08     1.08
 Dredge survey 2004-2022        0.61     0.73

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-3r            1495.466   8.000e+004   1.040          1.020
```

Table 9.4.6 Sandeel Area-3r. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1986	0.075	0.457	0.496	0.397	0.398	0.476
1987	0.001	0.719	0.758	0.593	0.592	0.738
1988	0.051	0.923	0.975	0.773	0.773	0.949
1989	0.003	1.041	1.097	0.879	0.876	1.069
1990	0.050	0.585	0.624	0.499	0.499	0.604
1991	0.039	0.707	0.753	0.599	0.598	0.730
1992	0.003	0.328	0.346	0.268	0.268	0.337
1993	0.041	0.609	0.651	0.516	0.514	0.630
1994	0.016	0.651	0.692	0.537	0.533	0.671
1995	0.007	0.518	0.553	0.431	0.430	0.536
1996	0.043	0.508	0.547	0.429	0.429	0.527
1997	0.065	0.914	0.982	0.785	0.781	0.948
1998	0.139	1.158	1.256	1.007	1.001	1.207
1999	0.127	0.637	0.909	0.867	0.863	0.773
2000	0.003	0.657	0.910	0.839	0.833	0.783
2001	0.132	0.411	0.595	0.575	0.578	0.503
2002	0.000	0.431	0.591	0.569	0.566	0.511
2003	0.017	0.230	0.318	0.310	0.309	0.274
2004	0.017	0.160	0.223	0.218	0.218	0.191
2005	0.000	0.077	0.106	0.101	0.101	0.092
2006	0.000	0.033	0.045	0.043	0.043	0.039
2007	0.000	0.195	0.269	0.255	0.254	0.232
2008	0.000	0.210	0.290	0.280	0.279	0.250
2009	0.000	0.018	0.025	0.023	0.023	0.021
2010	0.000	0.228	0.317	0.302	0.300	0.273
2011	0.000	0.147	0.205	0.196	0.194	0.176
2012	0.000	0.089	0.124	0.120	0.119	0.107
2013	0.000	0.043	0.060	0.059	0.058	0.052
2014	0.000	0.173	0.241	0.234	0.232	0.207
2015	0.000	0.228	0.317	0.307	0.305	0.272
2016	0.000	0.089	0.124	0.120	0.119	0.107
2017	0.000	0.197	0.274	0.266	0.264	0.236
2018	0.000	0.211	0.293	0.284	0.282	0.252
2019	0.000	0.317	0.440	0.426	0.423	0.378
2020	0.000	0.531	0.737	0.714	0.710	0.634
2021	0.000	0.283	0.393	0.381	0.378	0.338
2022	0.000	0.332	0.460	0.446	0.443	0.396
arith. mean	0.022	0.407	0.486	0.423	0.421	0.446

Table 9.4.7 Sandeel Area-3r. Fishing mortality (F) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	0.075	0.288	0.139	0.317	0.153	0.254	0.123	0.254	0.123
1987	0.001	0.581	0.002	0.639	0.002	0.513	0.002	0.513	0.002
1988	0.051	0.691	0.094	0.761	0.103	0.611	0.083	0.611	0.083
1989	0.003	0.870	0.006	0.957	0.007	0.768	0.005	0.768	0.005
1990	0.050	0.429	0.092	0.472	0.101	0.379	0.081	0.379	0.081
1991	0.039	0.545	0.073	0.599	0.080	0.481	0.064	0.481	0.064
1992	0.003	0.263	0.006	0.289	0.007	0.232	0.005	0.232	0.005
1993	0.041	0.453	0.077	0.498	0.084	0.400	0.068	0.400	0.068
1994	0.016	0.506	0.029	0.556	0.032	0.447	0.026	0.447	0.026
1995	0.007	0.411	0.013	0.453	0.014	0.364	0.012	0.364	0.012
1996	0.043	0.361	0.079	0.397	0.086	0.319	0.069	0.319	0.069
1997	0.065	0.676	0.121	0.744	0.133	0.597	0.107	0.597	0.107
1998	0.139	0.800	0.257	0.881	0.283	0.707	0.227	0.707	0.227
1999	0.127	0.407	0.185	0.585	0.266	0.567	0.258	0.567	0.258
2000	0.003	0.514	0.005	0.738	0.007	0.715	0.007	0.715	0.007
2001	0.132	0.214	0.192	0.308	0.276	0.298	0.267	0.298	0.267
2002	0.000	0.320	0.000	0.459	0.000	0.444	0.000	0.444	0.000
2003	0.017	0.159	0.025	0.228	0.037	0.220	0.035	0.220	0.035
2004	0.017	0.110	0.025	0.157	0.036	0.152	0.035	0.152	0.035
2005	0.000	0.059	0.000	0.085	0.000	0.083	0.000	0.083	0.000
2006	0.000	0.025	0.000	0.036	0.000	0.035	0.000	0.035	0.000
2007	0.000	0.154	0.000	0.221	0.000	0.214	0.000	0.214	0.000
2008	0.000	0.171	0.000	0.245	0.000	0.238	0.000	0.238	0.000
2009	0.000	0.014	0.000	0.021	0.000	0.020	0.000	0.020	0.000
2010	0.000	0.185	0.001	0.265	0.001	0.257	0.001	0.257	0.001
2011	0.000	0.117	0.000	0.169	0.000	0.163	0.000	0.163	0.000
2012	0.000	0.071	0.000	0.102	0.000	0.099	0.000	0.099	0.000
2013	0.000	0.035	0.000	0.050	0.000	0.048	0.000	0.048	0.000
2014	0.000	0.139	0.000	0.199	0.000	0.193	0.000	0.193	0.000
2015	0.000	0.183	0.000	0.263	0.000	0.255	0.000	0.255	0.000
2016	0.000	0.071	0.000	0.102	0.000	0.099	0.000	0.099	0.000
2017	0.000	0.158	0.000	0.227	0.000	0.220	0.000	0.220	0.000
2018	0.000	0.169	0.000	0.243	0.000	0.235	0.000	0.235	0.000
2019	0.000	0.255	0.000	0.366	0.000	0.355	0.000	0.355	0.000
2020	0.000	0.431	0.000	0.619	0.000	0.599	0.000	0.599	0.000
2021	0.000	0.227	0.000	0.327	0.000	0.316	0.000	0.316	0.000
2022	0.000	0.267	0.000	0.384	0.000	0.372	0.000	0.372	0.000
arith. mean	0.022	0.306	0.038	0.377	0.046	0.332	0.040	0.332	0.040

Table 9.4.8 Sandeel Area-3r. Natural mortality (M) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	1.340	0.760	0.600	0.600	0.470	0.420	0.370	0.360	0.35
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.34
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.34
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.32
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.29
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.28
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.29
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.31
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.32
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.34
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.35
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.36
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.33
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.30
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.37
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.49
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.61
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.60
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.53
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.45
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.41
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.39
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.37
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.33
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.35
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.39
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2019	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2020	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2021	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
2022	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.42
arith. mean	1.166	0.712	0.569	0.565	0.462	0.419	0.407	0.386	0.39

Table 9.4.9 Sandeel Area-3r. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1986	503091	77959	5442	285	678
1987	117504	122181	13058	1167	317
1988	361037	28089	18226	2431	417
1989	108557	73560	3525	2825	684
1990	193477	28618	9511	541	794
1991	128746	51194	5606	2316	456
1992	259479	36546	9193	1227	870
1993	192127	78680	8671	2837	901
1994	176753	58952	14098	1949	1207
1995	161467	57347	9701	2909	993
1996	726851	58394	10639	2214	1267
1997	66017	258837	11000	2413	1132
1998	93171	25140	36217	1770	815
1999	122192	30735	2793	4600	494
2000	140654	38020	4583	434	1127
2001	135298	45739	5309	682	350
2002	35570	36067	6150	783	220
2003	83569	10501	5082	968	194
2004	53715	24245	1764	1002	274
2005	88232	15743	4497	404	354
2006	122917	27938	3343	1219	271
2007	67307	40097	6516	1020	590
2008	103013	23553	8909	1773	564
2009	156425	38277	6101	2696	828
2010	15888	58119	13071	2503	1714
2011	12398	5234	16237	4197	1604
2012	81284	3697	1388	5201	2236
2013	218978	24728	996	461	2894
2014	236936	66618	6912	349	1413
2015	7251	72072	16776	2083	640
2016	770851	2206	17368	4745	904
2017	34617	234509	594	5768	2183
2018	286415	10531	57924	174	2737
2019	561044	87134	2573	16714	1021
2020	172419	170682	19539	656	5279
2021	69807	52454	32103	3872	1442
2022	46069	21237	12092	8520	1662
2023		14015	4705	3031	2996

Table 9.4.10 Sandeel Area-3r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (modelled yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1986	502949336	544524	72042	282315	0.448
1987	117506005	968835	175958	395296	0.612
1988	360859773	453212	258849	330358	0.825
1989	108580240	541124	97831	350409	0.920
1990	193541013	331037	103570	163224	0.546
1991	128700686	535431	158895	274839	0.648
1992	259430655	355996	118658	86788	0.282
1993	192190956	668299	197008	175786	0.556
1994	176706372	629452	235861	267281	0.561
1995	161497464	470081	140365	173607	0.446
1996	726682345	761475	233281	159024	0.461
1997	65989091	1517900	187775	470670	0.837
1998	93175931	530096	324487	462081	1.110
1999	122179276	332069	107689	191253	0.722
2000	140680230	338972	76039	186837	0.632
2001	135299311	404532	87029	193684	0.495
2002	35569532	385592	86077	116298	0.389
2003	83553692	154806	83700	34673	0.224
2004	53704105	211796	37835	31285	0.164
2005	88189635	212375	77265	13991	0.072
2006	122914555	282686	70193	7094	0.031
2007	67322159	428400	116774	74972	0.188
2008	102975330	376269	163081	74933	0.208
2009	156411357	369593	120813	6261	0.018
2010	15886814	760964	286932	61241	0.226
2011	12397433	383412	297152	92452	0.143
2012	81246638	242788	202602	40116	0.087
2013	218872516	290720	70404	9844	0.042
2014	236864783	688106	118302	90876	0.169
2015	7253539	870137	243775	104631	0.223
2016	770846639	347260	288370	42845	0.087
2017	34622004	1962260	225032	115642	0.193
2018	286428643	690940	498321	75388	0.206
2019	560870164	1044490	324811	135899	0.311
2020	172343477	1904080	386157	246139	0.525

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2021	69789910	967283	473544	157480	0.277
2022	46085089	684731	405550	83420	0.325
2023			178439		
arith. mean*	181381734	611938	192919	156187	0.384
geo. mean**	118805707				

* arith. mean for the period 1986–2022

** geo. mean for the period 1986–2021

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	118831.84	14015	4704.64	3030.81	2996.03
Exploitation pattern 1st half		0.267	0.384	0.372	0.372
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		8.428	13.371	17.334	24.526
Weight in the catch 1st half		8.428	13.371	17.334	24.526
Weight in the catch 2nd half	3.708	8.780	17.355	22.714	26.159
Proportion mature (2023)	0.000	0.036	0.766	1.000	1.000
Proportion mature (2024)	0.000	0.036	0.766	1.000	1.000
Natural mortality 1st half		0.700	0.550	0.420	0.390
Natural mortality 2nd half	1.190	0.540	0.450	0.440	0.420

Table 9.4.12 Sandeel Area-3r. Short term forecast (000 tonnes).

Basis: Fsq = F(2022)=0.3254; Yield(2022) = 83.42; Recruitment(2022) = 46.085089; Recruitment(2023) = geometric mean (GM 1986-2021) = 118.831839 billions; SSB(2023) = 178.439

Basis	Total catch (2023)	F_{total} (2023)	SSB (2024)	% SSB change *	% TAC change **
ICES advice basis					
$SSB_{2024} \geq$ MSY $B_{escapement} = B_{pa}$	30 570	0.133	129 000	-28	-70
Other scenarios					
F = 0	0	0	146 667	-18	-100
$SSB_{2024} = B_{lim}$	118 388	0.65	80 000	-55	16
$F = F_{2022}$	68 521	0.33	107 456	-40	-33

* SSB in 2024 relative to SSB in 2023

** Catch in 2023 relative to TAC in 2022

Table 9.4.13. Sandeel Area-3r. Acoustic survey indices (millions of individuals).

Year	Age 1	Age 2	Age 3	Age 4
2009	8436.31 (CV=0.27)	4617.72 (CV=0.321)	1134.76 (CV=0.342)	96.78 (CV=0.47)
2010	16231.98 (CV=0.181)	6460.47 (CV=0.209)	1529.58 (CV=0.335)	953.6 (CV=0.328)
2011	953.91 (CV=0.713)	8677.02 (CV=0.179)	884.78 (CV=0.366)	232.4 (CV=0.414)
2012	168.03 (CV=1.12)	328.98 (CV=0.474)	3676.77 (CV=0.197)	540.15 (CV=0.226)
2013	2153.53 (CV=0.233)	285.18 (CV=0.392)	76.16 (CV=0.408)	650.27 (CV=0.431)
2014	21957.69 (CV=0.211)	1892.03 (CV=0.353)	189.03 (CV=0.559)	2910.96 (CV=0.449)
2015	9514.13 (CV=0.132)	2230.46 (CV=0.226)	703.44 (CV=0.342)	807.63 (CV=0.259)
2016	74.11 (CV=0.831)	4887 (CV=0.222)	603.88 (CV=0.268)	931.07 (CV=0.416)
2017	35207.5 (CV=0.154)	121.62 (CV=0.655)	3614.4 (CV=0.252)	1187.82 (CV=0.24)
2018	1657.81 (CV=0.245)	17448.76 (CV=0.086)	86.21 (CV=0.36)	429.69 (CV=0.185)
2019	11257.12 (CV=0.165)	725.63 (CV=0.222)	15438.34 (CV=0.125)	1055.27 (CV=0.542)
2020	41473.35 (CV=0.23)	10152.87 (CV=0.256)	546.56 (CV=0.362)	10270.09 (CV=0.192)
2021	14837.61 (CV=0.19)	12843.12 (CV=0.165)	2791.19 (CV=0.172)	4357.89 (CV=0.232)
2022	4810.19 (CV=0.312)	5035.2 (CV=0.24)	5601.63 (CV=0.339)	2143.56 (CV=0.28)

Table 9.5.1 Sandeel Area-4. Catch at age numbers (million) by half year.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	674	1235	149	6337	381	1861	122	534	39
1994	0	1070	256	1522	62	5144	257	2092	159
1995	4	2690	4	1229	1	529	0	30	0
1996	2666	754	2584	2536	3461	476	227	130	1110
1997	0	2879	1369	291	35	1683	43	413	10
1998	0	2159	61	3766	97	235	6	130	3
1999	0	1472	86	1137	46	1543	47	252	11
2000	0	6537	0	376	0	323	0	297	0
2001	0	2048	64	4961	20	601	1	377	0
2002	0	337	0	807	0	511	0	101	0
2003	145	4322	148	1002	10	2721	5	1253	1
2004	0	920	4	220	1	45	0	82	0
2005	0	49	0	145	0	32	0	17	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0
2012	0	83	0	40	0	196	0	3	0
2013	0	182	0	100	0	71	0	133	0

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0	346	0	54	0	15	0	47	0
2015	0	866	0	29	0	9	0	14	0
2016	0	181	0	406	0	20	0	36	0
2017	0	719	0	468	0	578	0	30	0
2018	0	874	0	1259	0	355	0	1133	0
2019	0	314	0	159	0	143	0	60	0
2020	33	2363	17	256	0	72	0	82	0
2021	1	3310	20	2155	78	347	12	372	40
2022	0	331	0	72	0	124	0	40	0
arith. mean	117	1201	159	978	140	588	24	255	46

Table 9.5.2 Sandeel Area-4. Individual mean weight (gram) at age in the catch and in the sea.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	3.0	7.4	6.7	11.9	12.0	14.9	14.0	20.1	18.9
1994	3.8	10.9	8.6	11.1	15.5	14.7	18.0	20.5	24.4
1995	4.4	8.4	10.1	15.7	18.0	19.1	21.0	15.5	28.5
1996	6.3	5.3	7.3	12.9	13.1	18.6	18.0	23.0	22.3
1997	3.1	6.7	7.0	7.5	12.4	11.2	14.5	18.1	19.6
1998	2.6	6.1	6.0	10.4	10.7	13.6	12.5	14.6	16.9
1999	3.2	6.1	7.2	10.8	12.9	16.1	15.1	20.2	20.4
2000	4.0	3.9	9.0	8.0	16.2	13.2	18.8	17.3	25.5
2001	1.8	3.4	4.2	6.0	7.5	9.0	8.7	14.2	11.8
2002	4.0	3.8	9.0	5.9	16.2	9.5	18.8	17.9	25.5
2003	3.6	4.6	5.6	6.6	6.2	8.1	7.8	10.9	10.1
2004	1.4	4.0	3.3	7.4	5.8	9.3	6.8	13.8	9.2
2005	4.0	4.2	9.0	6.1	16.2	8.6	18.8	11.0	25.5
2006	4.0	5.5	9.0	10.0	16.2	14.3	18.8	18.1	25.5
2007	4.0	4.8	9.0	8.8	16.2	12.6	18.8	16.0	25.5
2008	4.0	4.8	9.0	8.7	16.2	12.4	18.8	15.7	25.5
2009	4.0	5.8	9.0	10.7	16.2	15.2	18.8	19.3	25.5
2010	4.0	5.1	9.0	9.4	16.2	13.4	18.8	17.0	25.5
2011	4.0	4.9	9.0	8.9	16.2	12.7	18.8	16.1	25.5
2012	4.0	4.0	9.0	8.2	16.2	9.6	18.8	12.2	25.5
2013	4.0	5.3	9.0	9.3	16.2	14.7	18.8	17.1	25.5
2014	4.0	7.1	9.0	12.4	16.2	17.2	18.8	20.0	25.5
2015	4.4	4.4	7.7	9.5	10.7	11.4	14.6	16.2	17.6
2016	4.4	5.0	7.7	9.9	10.7	18.1	14.6	24.7	17.6
2017	4.4	7.5	7.7	10.2	10.7	13.4	14.6	18.5	17.6

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	4.4	5.7	7.7	9.4	10.7	13.1	14.6	18.3	17.6
2019	4.4	5.9	7.7	10.2	10.7	13.7	14.6	20.2	17.6
2020	4.4	6.7	7.7	8.6	10.7	11.9	14.6	12.4	17.6
2021	7.5	5.5	9.8	9.8	13.3	13.0	19.6	18.6	21.0
2022	3.8	6.1	8.6	9.6	15.7	15.3	18.8	22.1	27.7
arith. mean	4.0	5.6	8.0	9.5	13.4	13.3	16.3	17.3	21.4

Table 9.5.3 Sandeel Area-4. Proportion mature.

Time period	Age 1	Age 2	Age 3	Age 4
1983–2016	0	0.79	0.98	1

Table 9.5.4. Sandeel Area-4. Dredge survey indices.

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	
2004		
2005		
2006		
2007		
2008	52	24
2009	832	87
2010	147	1032
2011	89	165
2012	95	135
2013	62	85
2014	445	43
2015	136	1044
2016	300	81
2017	346	223
2018	16	461
2019	371	92
2020	441	1296
2021	160	194
2022	356	451

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

```
Date: 01/20/23  Start time:16:12:43 run time:2 seconds

 objective function (negative log likelihood):  12.4168
 Number of parameters: 49
 Maximum gradient: 7.46213e-005
 Akaike information criterion (AIC):   122.834
 Number of observations used in the likelihood:
                             Catch    CPUE     S/R Stomach     Sum
                              270      39      30       0     339

 objective function weight:
                           Catch  CPUE   S/R
                           1.00  1.00  0.05

 unweighted objective function contributions (total):
                 Catch    CPUE    S/R   Stom.  Stom N.  Penalty     Sum
                35.2   -23.8    21.0     0.0     0.0      0.00      32


 unweighted objective function contributions (per observation):
                 Catch   CPUE     S/R   Stomachs
                0.13   -0.61    0.70    0.00


 contribution by fleet:
 ----------------------
 Old Dredge survey 1999-2003     total:  -9.527   mean:  -1.059
 New Dredge survey 2008-2022     total: -14.315   mean:  -0.477

 F, season effect:
 -----------------
 age: 0
     1993-2022:   0.000 1.000
 age: 1 - 4
     1993-2022:   0.704 0.500

 F, age effect:
 --------------
                 0      1      2      3      4
 1993-2022:  0.002  0.097  0.188  0.268  0.268


 Exploitation pattern (scaled to mean F=1)
 -----------------------------------------
                         0      1      2      3      4
 1993-2022 season 1:      0  0.612  1.189  1.697  1.697
           season 2:  0.002  0.068  0.131  0.187  0.187


 sqrt(catch variance) ~ CV:
 --------------------------

              season
 ----------------------
 age        1       2

  0               2.272
  1       0.732   0.521
  2       0.732   0.521
  3       0.672   1.251
  4       0.672   1.251


 Survey catchability:
 --------------------
                            age 0    age 1
  Old Dredge survey 1999-2003       0.772   17.707
  New Dredge survey 2008-2022       0.742    4.405
```

```
sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Old Dredge survey 1999-2003        0.30     0.30
 New Dredge survey 2008-2022        0.52     0.30

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-4             1318.189   4.800e+004   1.490          1.221
```

Table 9.5.6 Sandeel Area-4. Annual fishing mortality (F) at age.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0.001	0.346	0.650	0.902	0.900	0.498
1994	0.001	0.401	0.753	1.042	1.039	0.577
1995	0.000	0.120	0.224	0.308	0.307	0.172
1996	0.005	0.236	0.469	0.687	0.691	0.352
1997	0.001	0.147	0.280	0.391	0.390	0.214
1998	0.000	0.161	0.302	0.417	0.415	0.231
1999	0.000	0.233	0.434	0.598	0.595	0.334
2000	0.000	0.116	0.216	0.298	0.297	0.166
2001	0.000	0.181	0.339	0.467	0.465	0.260
2002	0.000	0.039	0.072	0.100	0.099	0.056
2003	0.000	0.288	0.539	0.745	0.742	0.414
2004	0.000	0.056	0.104	0.144	0.143	0.080
2005	0.000	0.024	0.046	0.063	0.063	0.035
2006	0.000	0.000	0.001	0.001	0.001	0.001
2007	0.000	0.000	0.001	0.001	0.001	0.000
2008	0.000	0.002	0.004	0.005	0.005	0.003
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.002	0.003	0.003	0.002
2011	0.000	0.002	0.003	0.005	0.005	0.003
2012	0.000	0.019	0.035	0.048	0.048	0.027
2013	0.000	0.010	0.019	0.027	0.027	0.015
2014	0.000	0.014	0.026	0.035	0.035	0.020
2015	0.000	0.011	0.021	0.028	0.028	0.016
2016	0.000	0.022	0.040	0.056	0.055	0.031
2017	0.000	0.047	0.089	0.122	0.121	0.068
2018	0.000	0.135	0.252	0.347	0.346	0.193
2019	0.000	0.057	0.107	0.148	0.147	0.082
2020	0.000	0.045	0.085	0.117	0.117	0.065
2021	0.001	0.336	0.629	0.870	0.867	0.483
2022	0.000	0.031	0.059	0.081	0.081	0.045
arith. mean	0.000	0.103	0.193	0.269	0.268	0.148

Table 9.5.7 Sandeel Area-4. Fishing mortality (F) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	0.001	0.259	0.029	0.503	0.055	0.718	0.079	0.718	0.079
1994	0.001	0.304	0.027	0.591	0.053	0.843	0.076	0.843	0.076
1995	0.000	0.094	0.000	0.182	0.000	0.260	0.001	0.260	0.001
1996	0.005	0.112	0.145	0.217	0.281	0.310	0.401	0.310	0.401
1997	0.001	0.106	0.020	0.205	0.039	0.293	0.056	0.293	0.056
1998	0.000	0.124	0.005	0.241	0.010	0.344	0.015	0.344	0.015
1999	0.000	0.184	0.000	0.357	0.000	0.510	0.000	0.510	0.000
2000	0.000	0.091	0.000	0.177	0.000	0.252	0.000	0.252	0.000
2001	0.000	0.142	0.002	0.275	0.004	0.393	0.006	0.393	0.006
2002	0.000	0.030	0.000	0.059	0.000	0.084	0.000	0.084	0.000
2003	0.000	0.222	0.011	0.431	0.021	0.616	0.030	0.616	0.030
2004	0.000	0.043	0.000	0.084	0.001	0.120	0.001	0.120	0.001
2005	0.000	0.019	0.000	0.037	0.000	0.053	0.000	0.053	0.000
2006	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
2008	0.000	0.002	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.000	0.002	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2012	0.000	0.015	0.000	0.028	0.000	0.040	0.000	0.040	0.000
2013	0.000	0.008	0.000	0.016	0.000	0.022	0.000	0.022	0.000
2014	0.000	0.011	0.000	0.021	0.000	0.030	0.000	0.030	0.000
2015	0.000	0.009	0.000	0.017	0.000	0.024	0.000	0.024	0.000
2016	0.000	0.017	0.000	0.033	0.000	0.047	0.000	0.047	0.000
2017	0.000	0.037	0.000	0.072	0.000	0.103	0.000	0.103	0.000
2018	0.000	0.106	0.000	0.206	0.000	0.294	0.000	0.294	0.000
2019	0.000	0.045	0.000	0.087	0.000	0.125	0.000	0.125	0.000
2020	0.000	0.036	0.000	0.069	0.000	0.099	0.000	0.099	0.000
2021	0.001	0.258	0.015	0.501	0.030	0.716	0.043	0.716	0.043
2022	0.000	0.025	0.000	0.048	0.000	0.068	0.000	0.068	0.000
arith. mean	0.000	0.077	0.009	0.149	0.017	0.212	0.024	0.212	0.024

Table 9.5.8 Sandeel Area-4. Natural mortality (M) at age.

Year	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1994	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1995	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1996	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1997	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1998	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1999	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2000	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2001	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2002	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2003	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2004	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2005	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2006	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2007	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2008	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2009	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2010	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2011	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2012	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2013	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2014	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2015	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2016	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2017	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2018	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2019	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2020	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2021	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2022	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
arith. mean	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378

Table 9.5.9 Sandeel Area-4. Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of the year.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
1993	120289	25195	23838	7704	1488
1994	240283	38432	4856	4586	1834
1995	64443	76772	7088	858	1140
1996	342465	20610	17951	1985	694
1997	94866	108963	4096	3667	585
1998	43209	30318	24684	1079	1326
1999	228380	13816	6845	6457	757
2000	187255	73040	2953	1610	1913
2001	23562	59888	17133	832	1233
2002	81975	7535	13324	4356	626
2003	154821	26217	1878	4224	2024
2004	11616	49496	5335	402	1460
2005	7042	3715	12172	1648	752
2006	4309	2252	936	3943	1014
2007	6051	1378	578	315	2197
2008	18725	1935	354	194	1148
2009	276364	5988	496	119	611
2010	47497	88387	1539	167	333
2011	34775	15190	22690	516	226
2012	27966	11122	3897	7607	330
2013	18210	8944	2816	1274	3354
2014	252959	5824	2279	932	2056
2015	34198	80901	1480	751	1316
2016	73781	10937	20606	489	913
2017	93158	23597	2763	6705	606
2018	22866	29794	5842	864	2909
2019	212587	7313	6884	1598	1281
2020	56007	67990	1796	2121	1140
2021	90615	17912	16856	563	1319
2022	128823	28964	3500	3331	400
2023		41200	7261	1122	1539

Table 9.5.10 Sandeel Area-4. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (modelled yield) and average fishing mortality.

Year	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1993	120239964	612310	365492	132599	0.423
1994	240204211	576474	146239	158690	0.488
1995	64424207	791616	121662	52591	0.139
1996	342574599	393194	234685	158490	0.378
1997	94868284	811425	74757	58446	0.185
1998	43228044	473578	235861	58746	0.190
1999	228489314	277262	175782	53334	0.270
2000	187258393	360816	72620	37714	0.134
2001	23558565	331134	105979	47902	0.212
2002	81981158	160077	114348	12736	0.045
2003	154855038	189367	65513	63731	0.343
2004	11617231	261881	54940	6882	0.064
2005	7039164	112414	80741	1557	0.028
2006	4308068	96413	80983	0	0.000
2007	6052609	50904	43088	0	0.000
2008	18718071	32768	22880	0	0.002
2009	276300611	53755	17732	0	0.000
2010	47488589	475105	19235	0	0.001
2011	34760770	285750	169397	0	0.002
2012	27979985	153782	101013	2585	0.021
2013	18201235	149706	96568	5225	0.012
2014	253025289	126783	79142	4314	0.016
2015	34209023	396783	40864	4392	0.013
2016	73809647	290463	192914	6188	0.025
2017	93175931	306416	121540	18474	0.055
2018	22862304	290383	107796	42296	0.156
2019	212616366	161211	102642	6651	0.066
2020	56007715	507996	51021	20101	0.052
2021	90603192	295548	161943	53081	0.403
2022	128829451	270418	85477	5490	0.036
2023			97538		
arith. mean	99969892	309858	110973	33740	0.125
geo. mean	55839943				

arith. mean for the period 1993–2022

geo. mean for the period 1993–2021

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2023)	61281.945	41199.9	7261.05	1122.02	1538.65
Exploitation pattern 1st half		0.025	0.048	0.068	0.068
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.993	9.508	13.413	18.335
Weight in the catch 1st half		5.993	9.508	13.413	18.335
weight in the catch 2nd half	4.917	8.289	12.248	16.417	20.292
Proportion mature (2023)	0.000	0.000	0.790	0.980	1.000
Proportion mature (2024)	0.000	0.000	0.790	0.980	1.000
Natural mortality 1st half		0.767	0.602	0.431	0.398
Natural mortality 2nd half	1.140	0.592	0.488	0.392	0.378

Table 9.5.12 Sandeel Area-4. Short term forecast (000 tonnes).

Basis: Fsq = F(2022)=0.0361; Yield(2022) = 5.49; Recruitment(2022) = 128.829451; Recruitment(2023) = geometric mean (GM 2012-2021) = 61.281945 billions; SSB(2023) = 97.538

Basis	Total catch (2023)	Ftotal (2023)	SSB (2024)	% SSB change *	% TAC change **
ICES advice basis					
SSB(2024) ≥ MSY $B_{escapement}$ with F_{cap}	35 020	0.15	114 743	18	538
Other scenarios					
F = 0	0	0	133 616	37	-100
SSB(2024) = MSY $B_{escapement}$ = B_{pa}	59 252	0.27	102 000	5	979
SSB(2024) = B_{lim}	170 570	1.10	48 000	-51	3 007
F = F_{2022}	8 947	0.036	128 747	32	32

* SSB in 2024 relative to SSB in 2023

** Catch in 2023 relative to catches in 2022

Table 9.6.1. Area-5r. Acoustic survey sandeel biomass estimates (tonnes).

Year	Biomass (tonnes)	CV
2009	255	0.57
2010	5724	0.92
2011	3280	0.38
2012	739	0.60
2013	3910	0.24
2014	1283	0.40
2015	12751	0.57
2016	667	0.53
2017	465	0.34
2018	938	0.35
2019	3903	0.31

Year	Biomass (tonnes)	CV
2020	3221	0.37
2021	121	0.48
2022	71	0.97

Table 9.9.1 Sandeel in Division 6.a. History of the total catch (in tonnes) as estimated by ICES.

Year	Denmark	Faroe Islands	Norway	UK – Scotland	Total
1970	-	.	-	-	0
1971	-	.	-	-	0
1972	-	.	-	-	0
1973	-	.	-	-	0
1974	-	.	-	< 0.5	0
1975	-	.	-	< 0.5	0
1976	-	.	17	< 0.5	17
1977	-	.	54	13	67
1978	-	.	-	5	0
1979	-	.	-	-	0
1980	-	.	-	211	211
1981	-	.	-	5972	5972
1982	-	.	-	10873	10873
1983	-	.	-	13051	13051
1984	-	.	-	14166	14166
1985	-	.	-	18586	18586
1986	-	.	-	24469	24469
1987	-	.	-	14479	14479
1988	-	.	-	24465	24465
1989	-	.	-	18785	18785
1990	-	.	-	16515	16515
1991	-	.	-	8532	8532
1992	-	.	-	4985	4985
1993	80	.	-	6156	6236
1994	-	.	-	10627	10627
1995	-	.	-	7111	7111
1996	-	.	-	13257	13257
1997	-	.	-	12679	12679
1998	-	.	-	5320	5320
1999	-	.	-	2627	2627
2000	-	.	-	5771	5771
2001	-	.	-	295	295
2002	-	.	-	706	706
2003	-	.	-	-	0

Year	Denmark	Faroe Islands	Norway	UK – Scotland	Total
2004	-	.	-	566	566
2005	-	.	-	-	0
2006	-	-	-	.	0
2007	.	57	-	.	57
2008	.	-	.	.	0
2009	.	.	.	.	0
2010	.	.	.	.	0
2011	-	-	-	-	0
2012	-	-	-	-	0
2013	-	-	-	-	0
2014	-	-	-	-	0
2015	-	-	-	-	0
2016	-	-	-	-	0
2017	-	-	-	-	0
2018	-	-	-	-	0
2019	-	-	-	-	0
2020	2.7	-	-	-	2.7
2021	-	-	-	-	0
2022*	-	-	-	-	0

* Preliminary

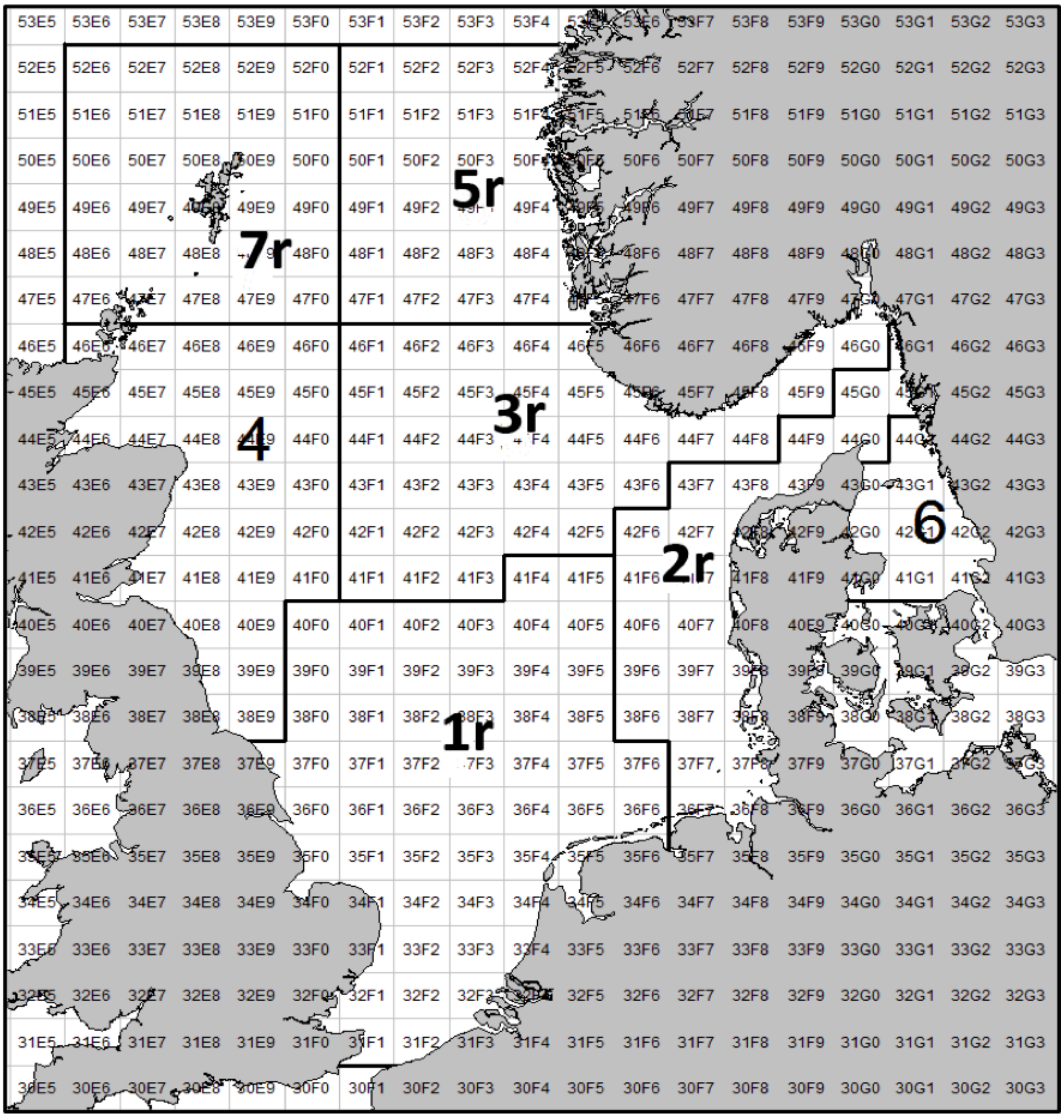


Figure 9.1.1 Sandeel in ICES Subarea 4 and Div. 3.a. Sandeel management areas.


2022
2021
2020
2019
2018
2017
2016
2015
2014
2013
2012
2011
2010
2009
2008
2007

Figure 9.1.2 Sandeel in ICES Subarea 4 and Div. 3.a. Catch by ICES rectangles 2006–2022 (upper, red circles). Number of samples per ICES square in commercial catches (lower, blue circles). Area of the circles is proportional to catch by rectangle.

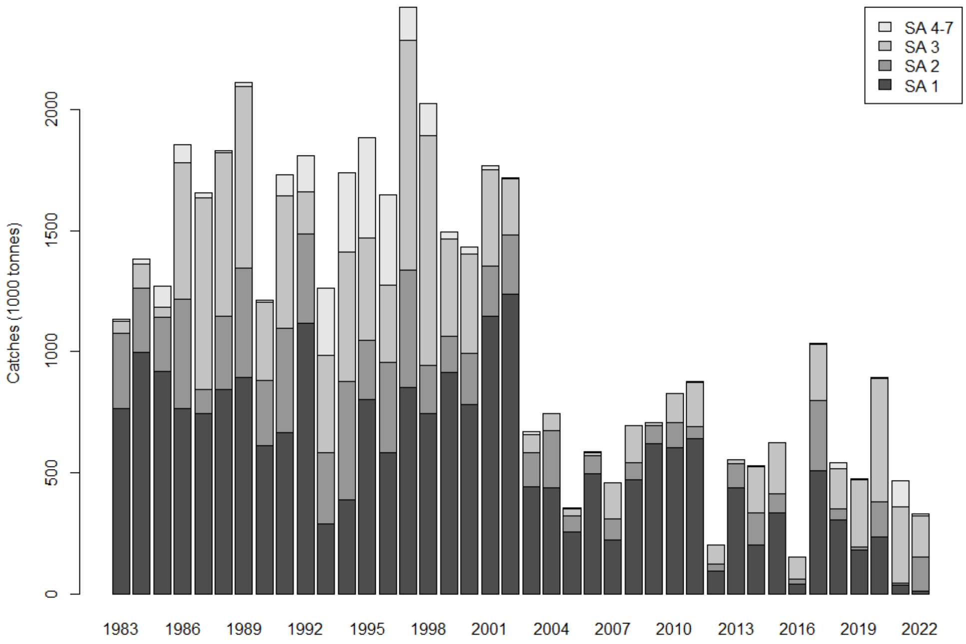


Figure 9.1.3 Sandeel in ICES Subarea 4 and Div. 3.a. Total catches by year and area.

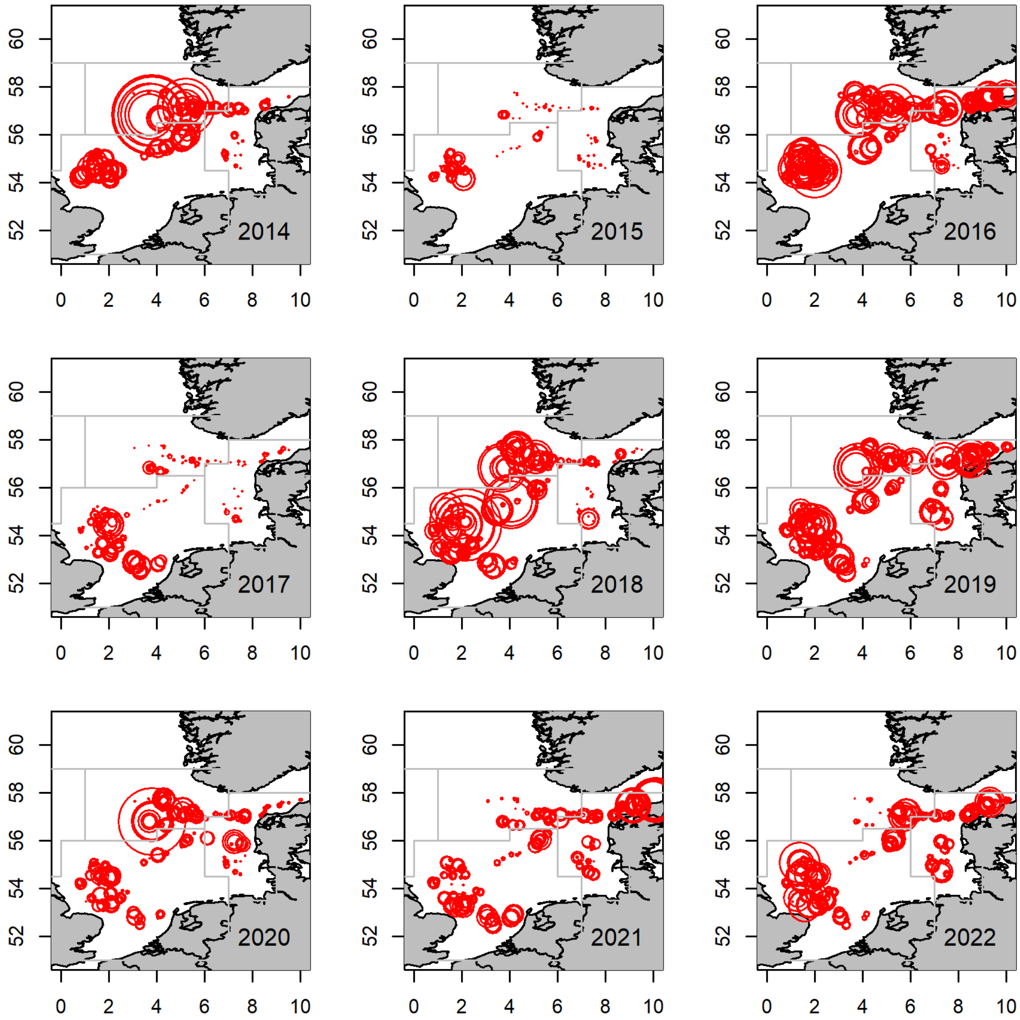


Figure 9.1.4 Sandeel in ICES Subarea 4 and Div. 3.a. Danish dredge survey catches by haul for 0-group. Area of the circles is proportional to catch number.

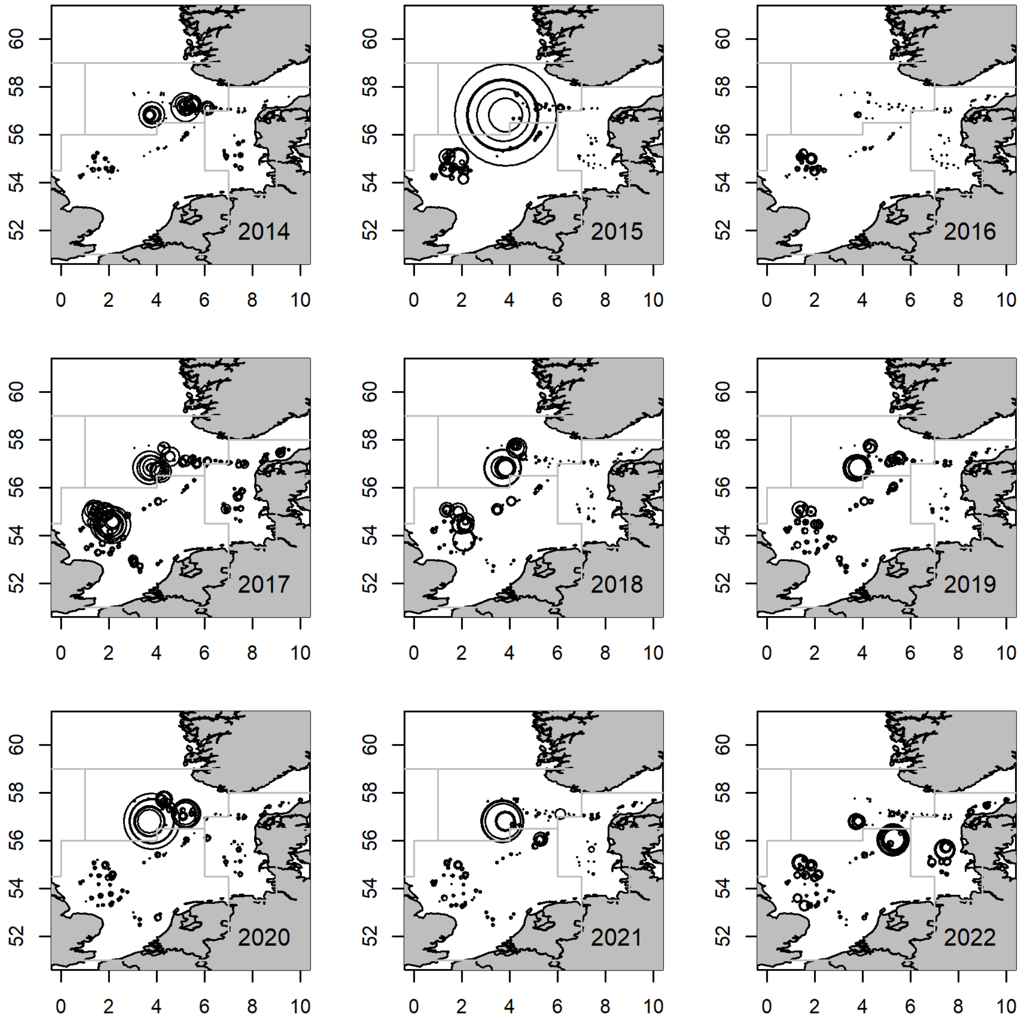


Figure 9.1.5 Sandeel in ICES Subarea 4 and Div. 3.a. Danish dredge survey catches by haul for 1-group. Area of the circles is proportional to catch number.

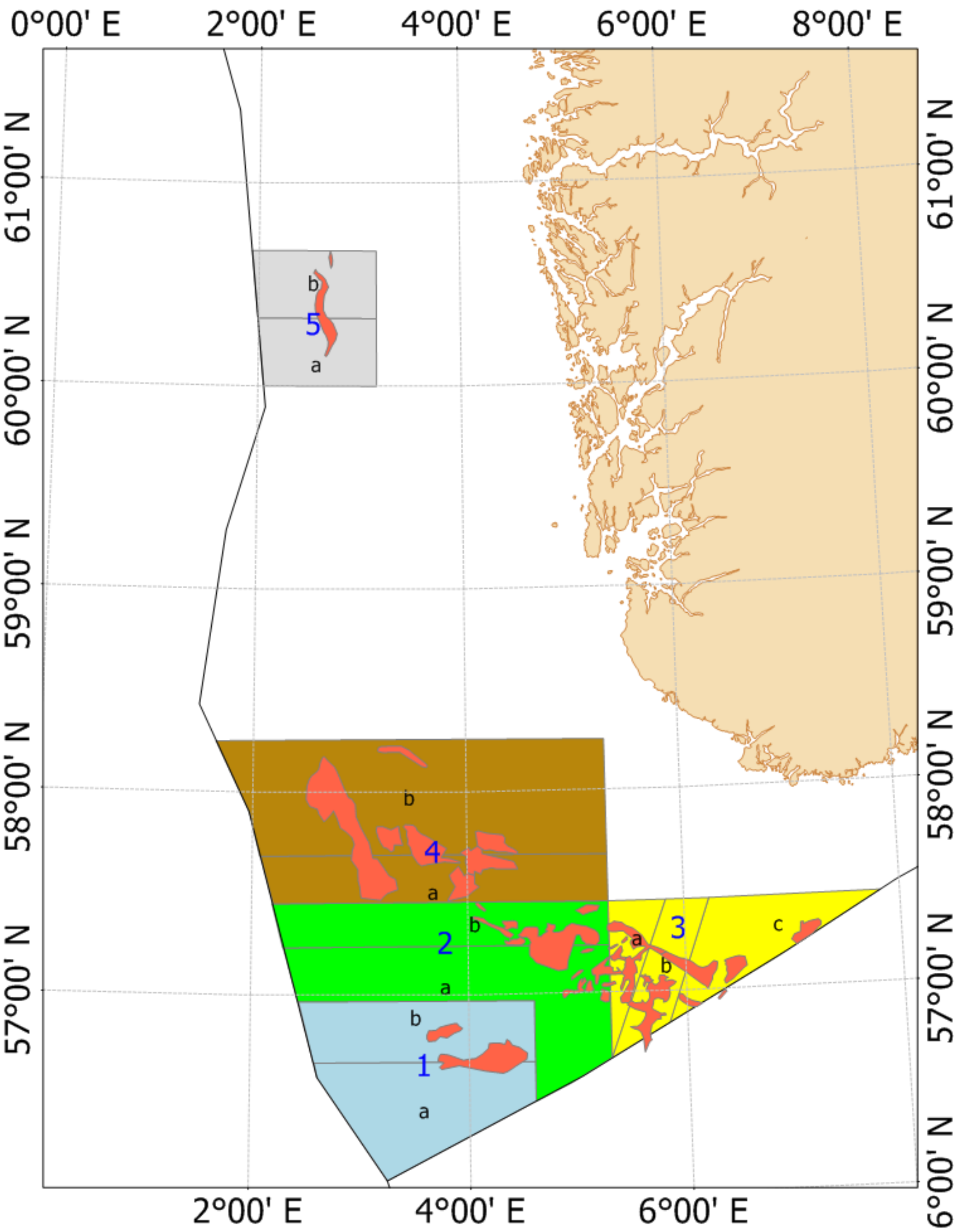


Figure 9.1.6 Sandeel in ICES Subarea 4 and Div. 3.a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.

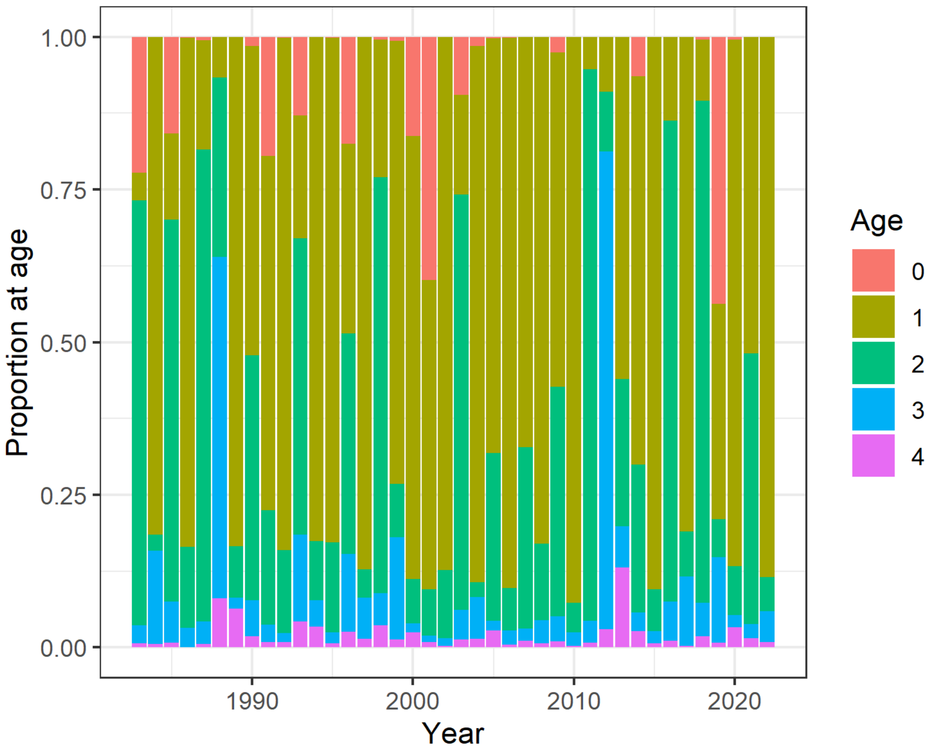


Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

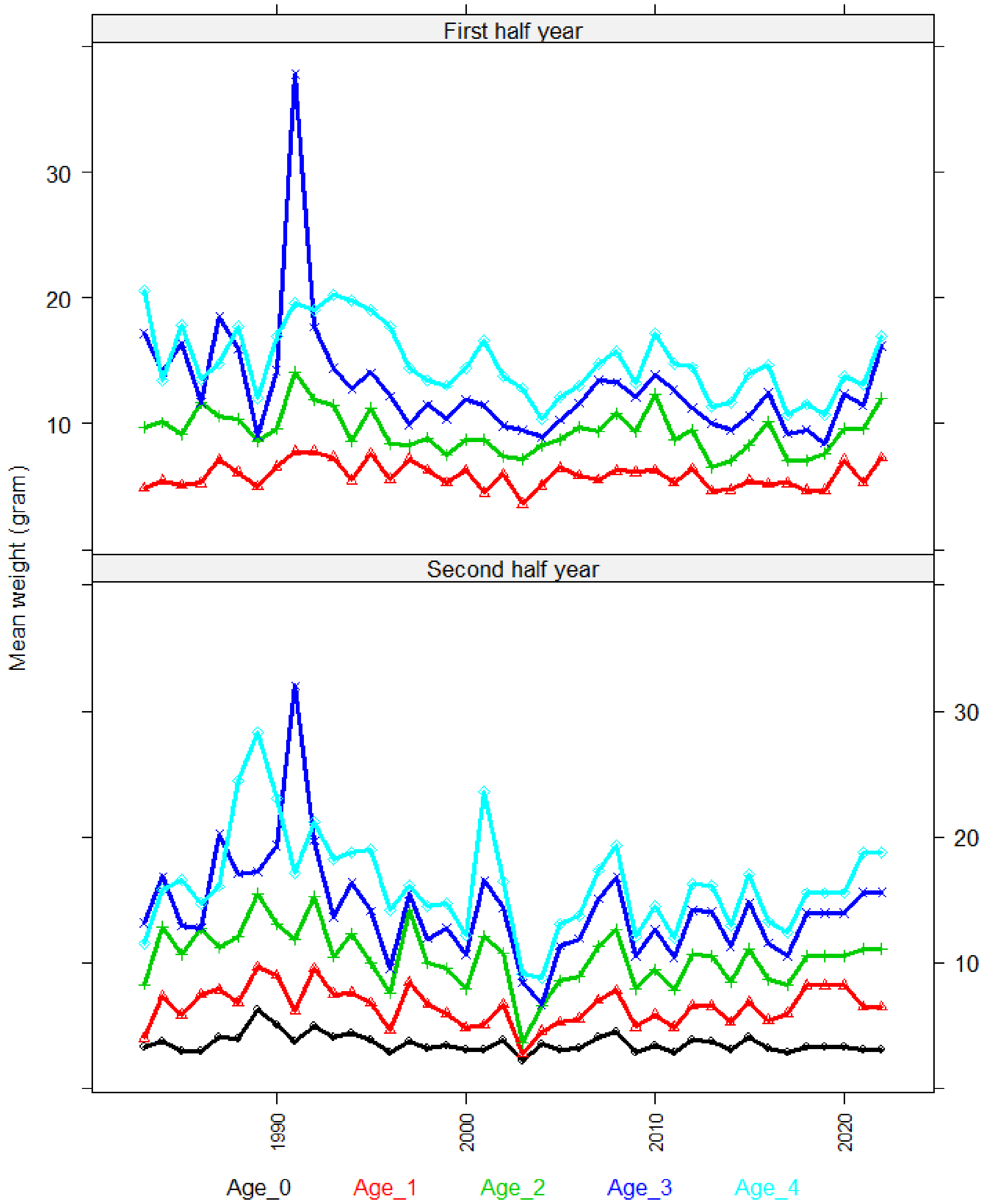


Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

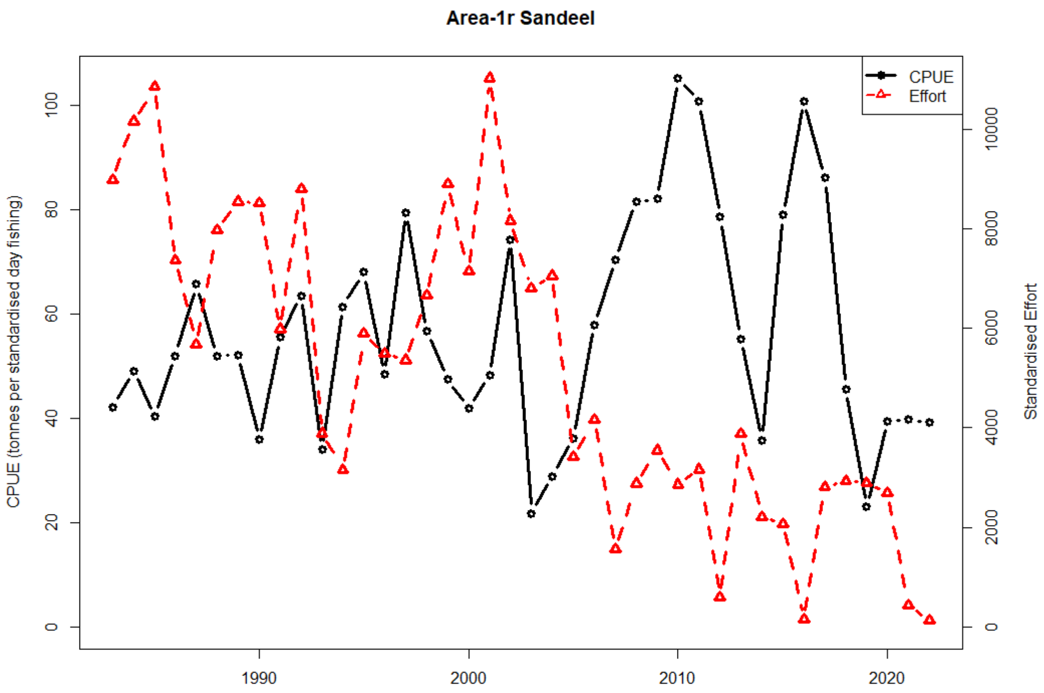


Figure 9.2.3 Sandeel Area-1r. Commercial CPUE and effort.

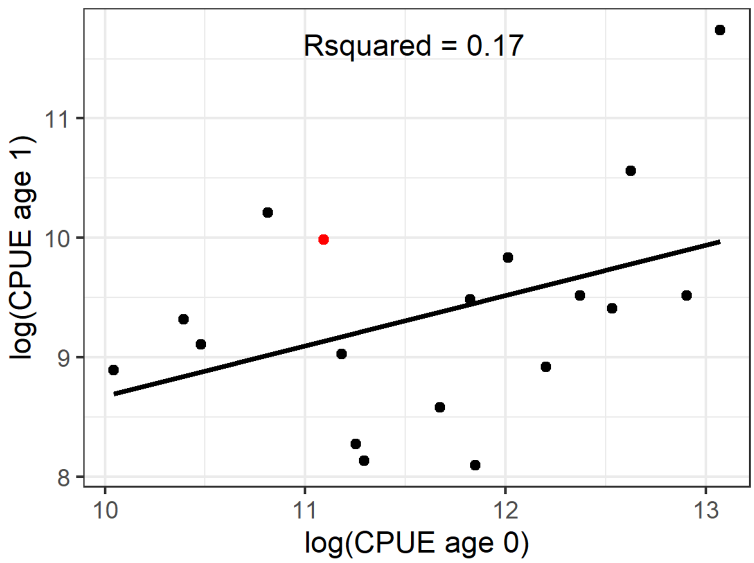


Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

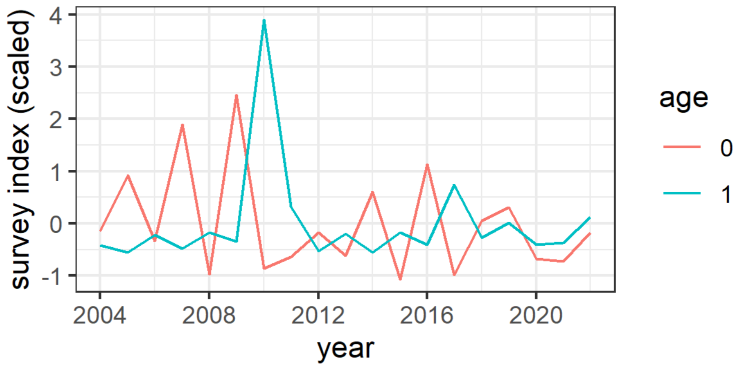


Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.

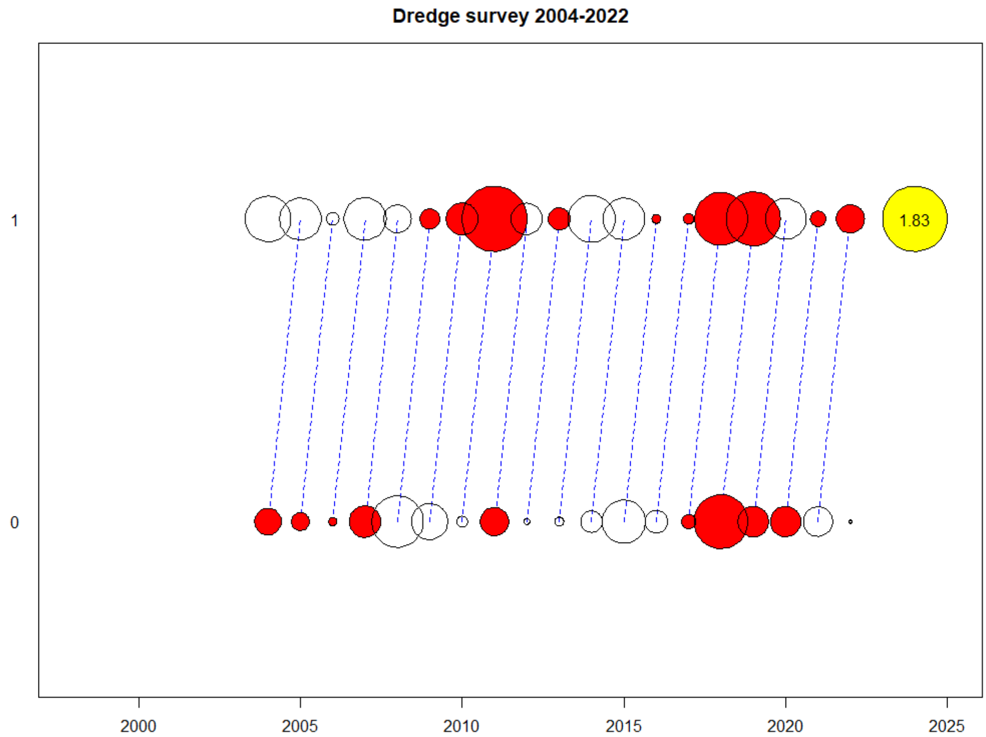


Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

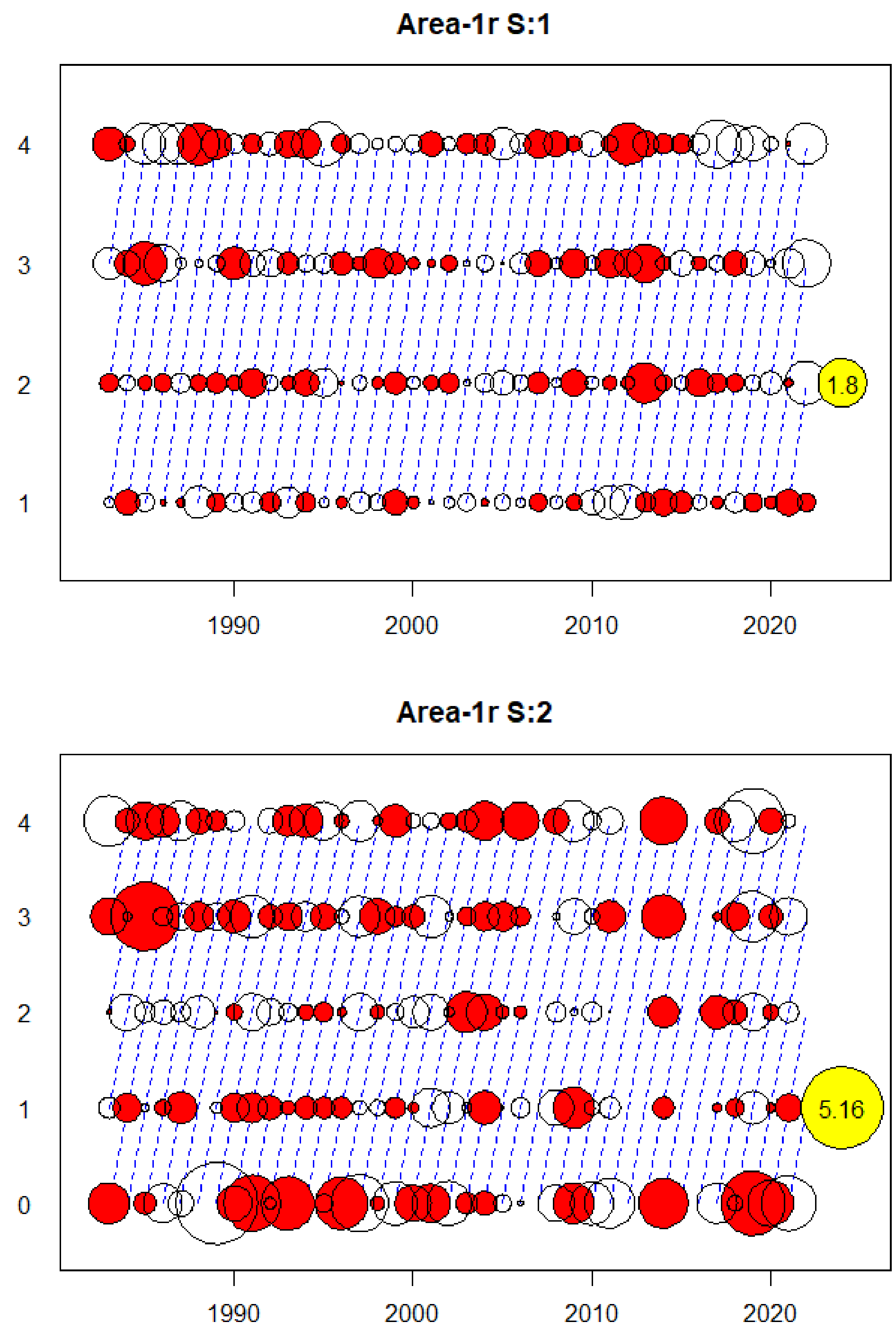


Figure 9.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

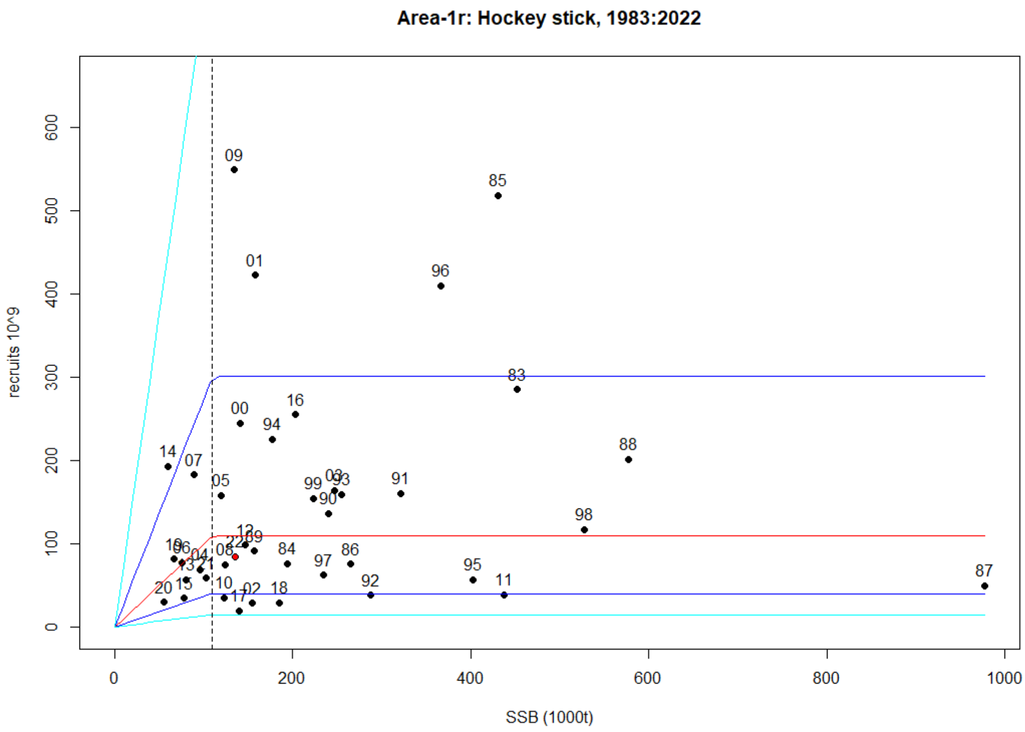


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

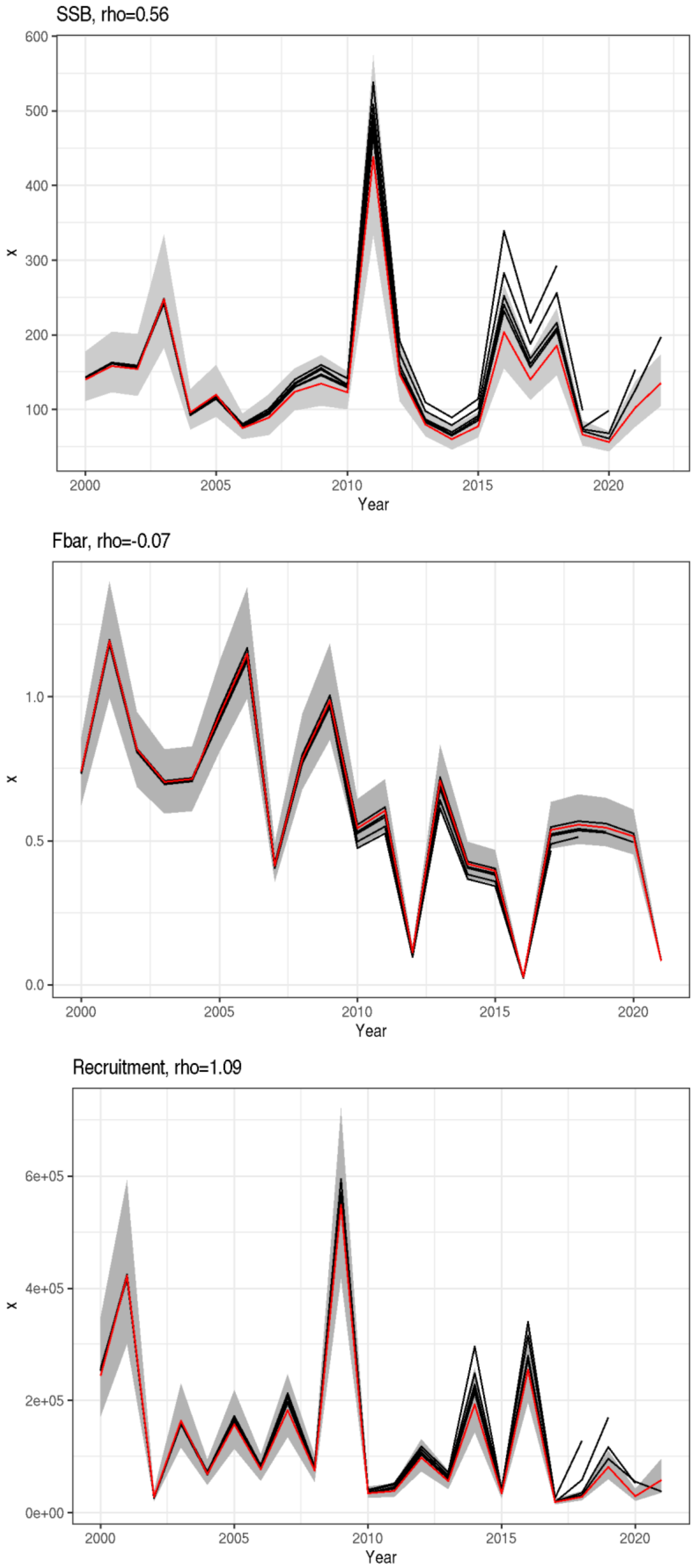


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

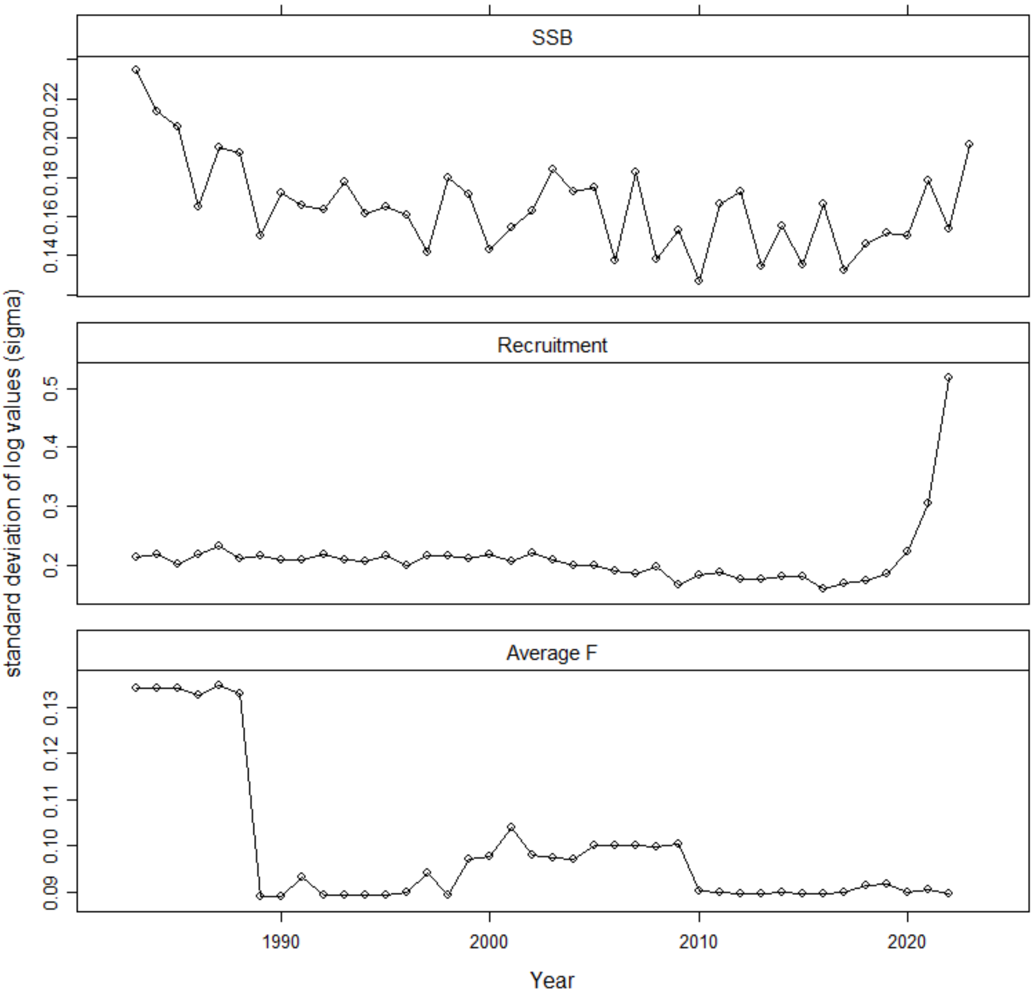


Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

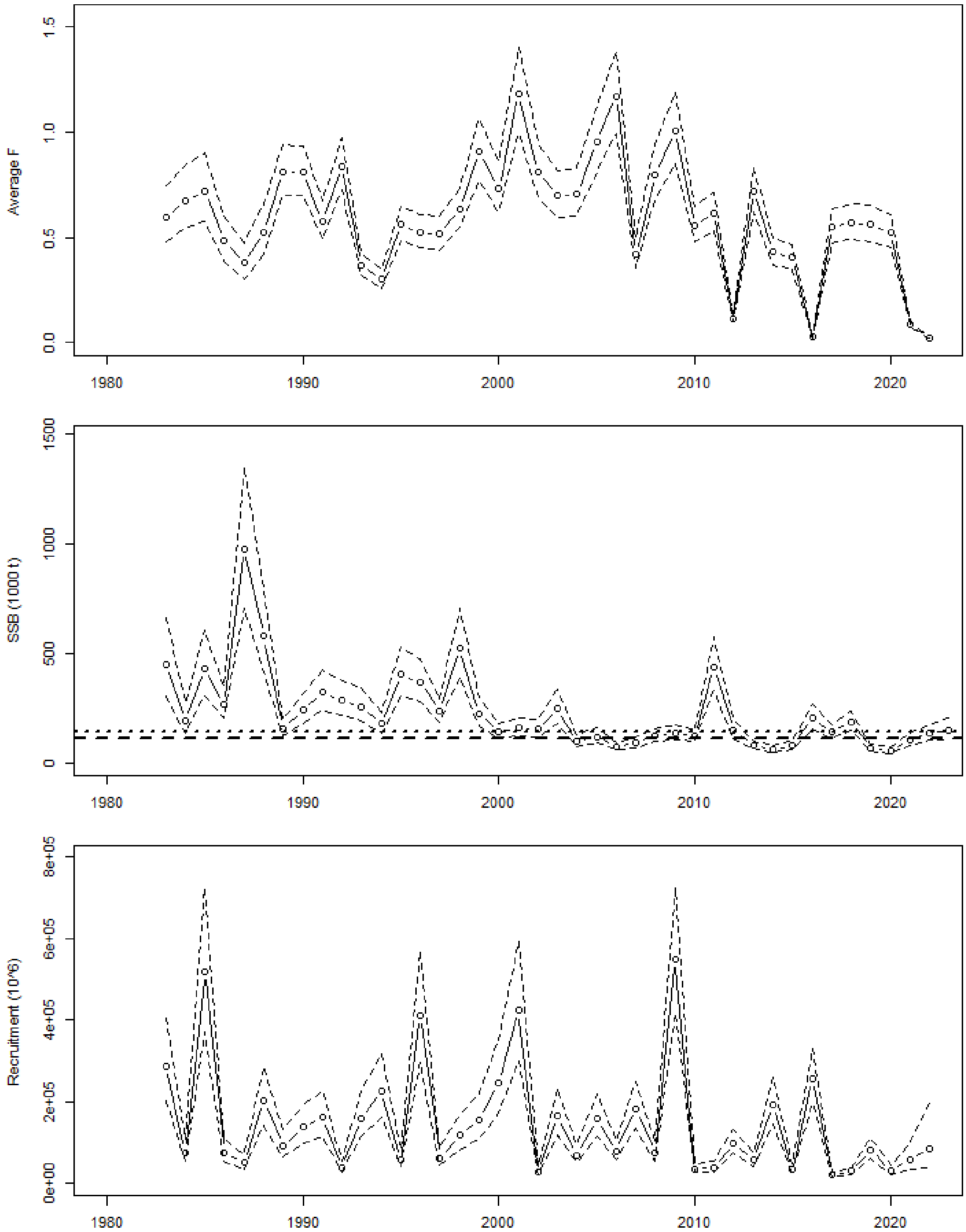


Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

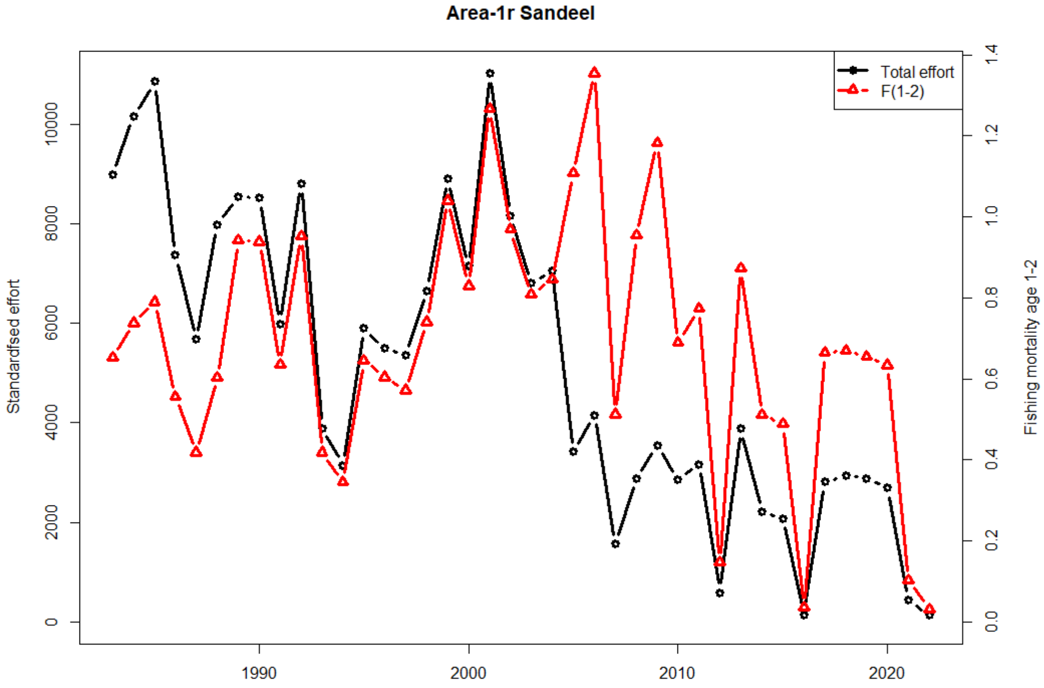


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

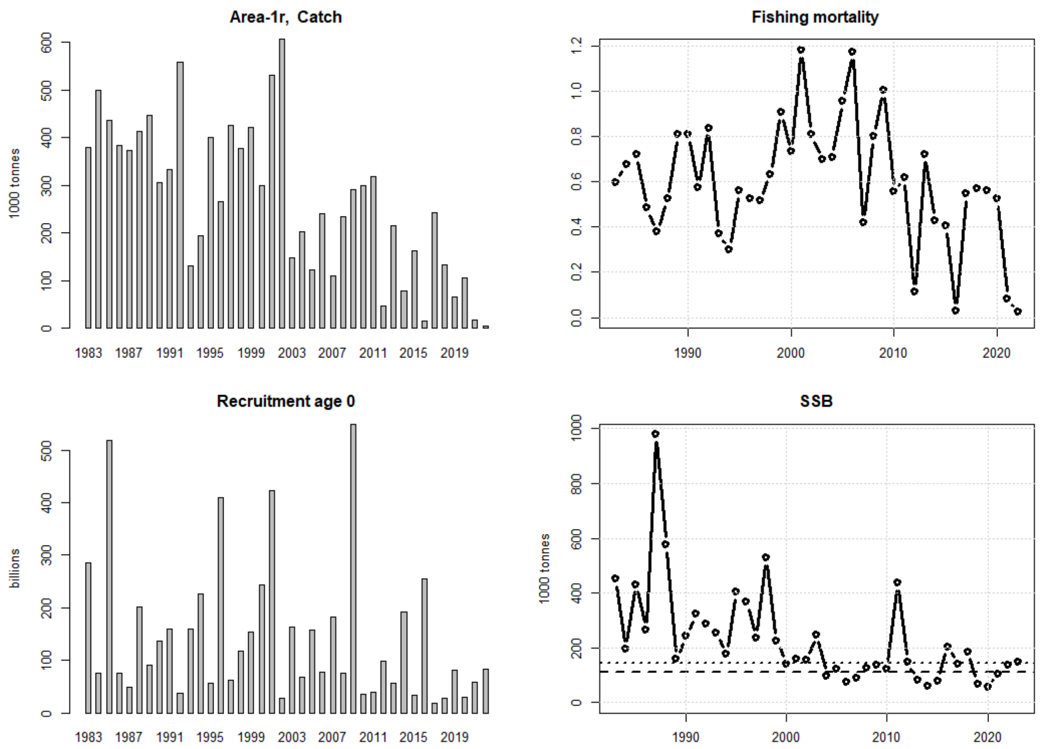


Figure 9.2.13 Sandeel Area-1r. Stock summary.

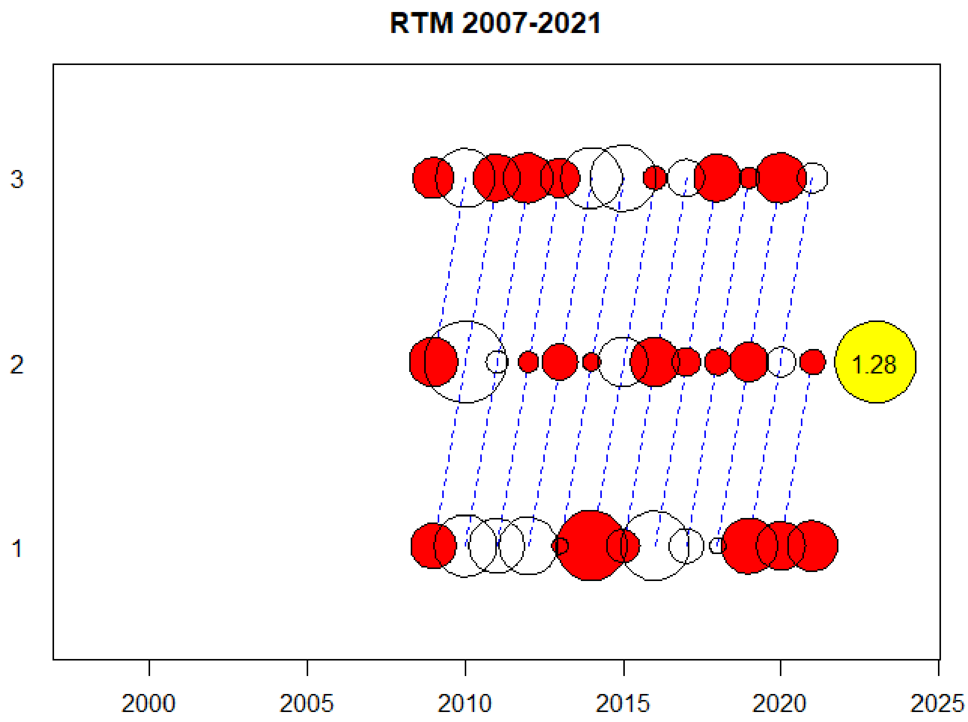


Figure 9.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

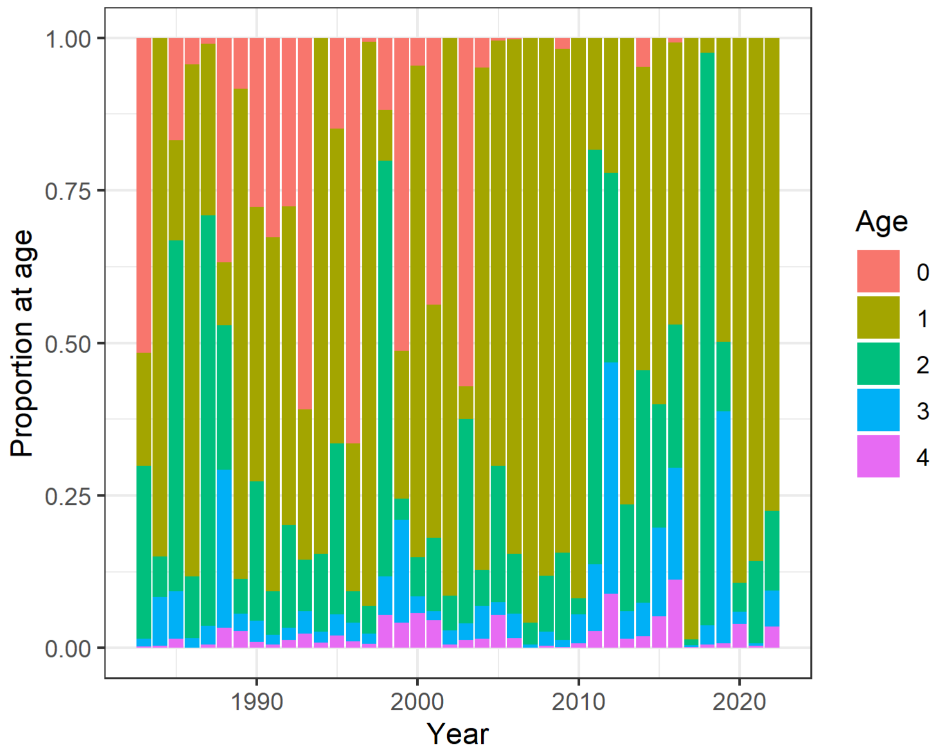


Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

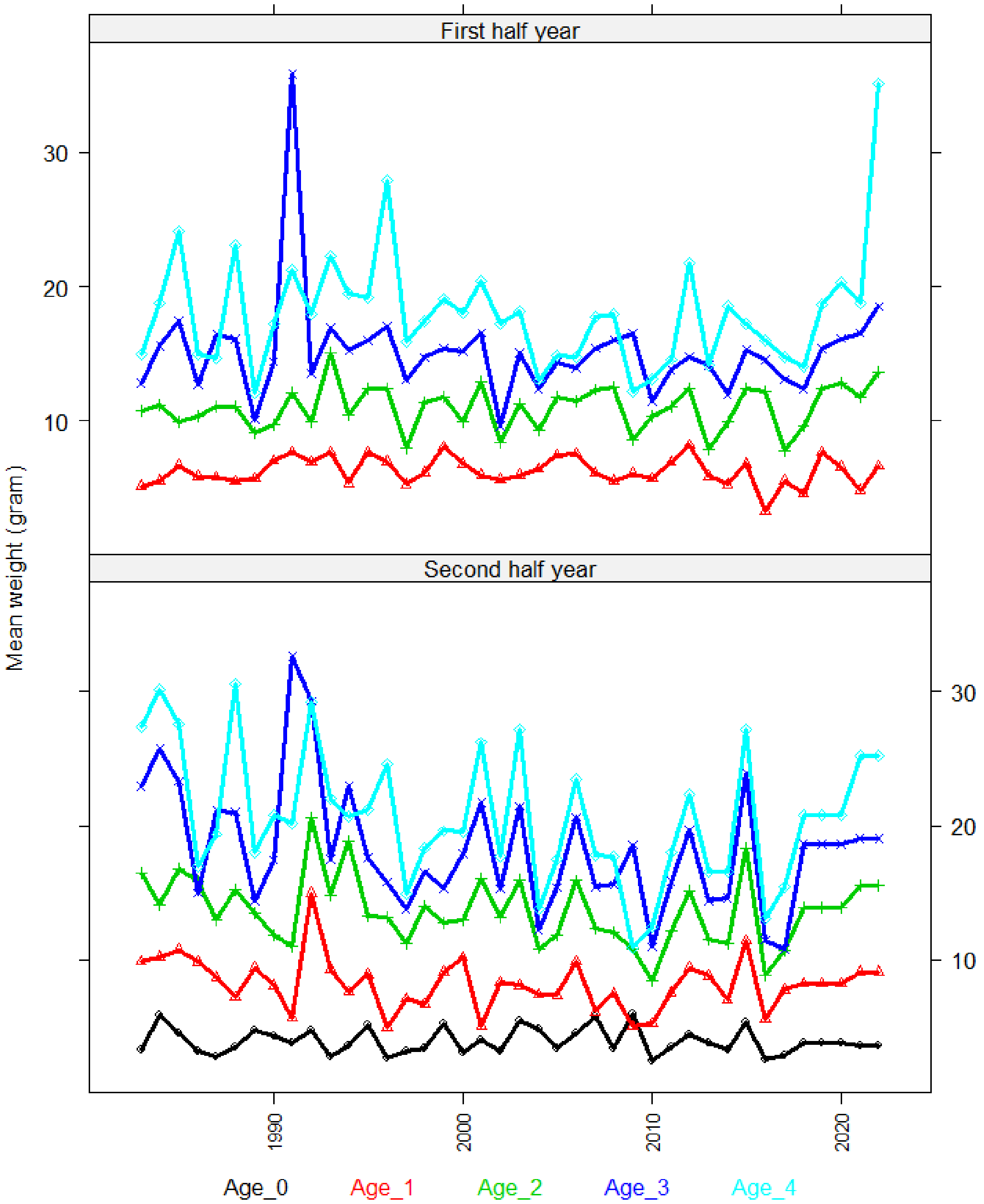


Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

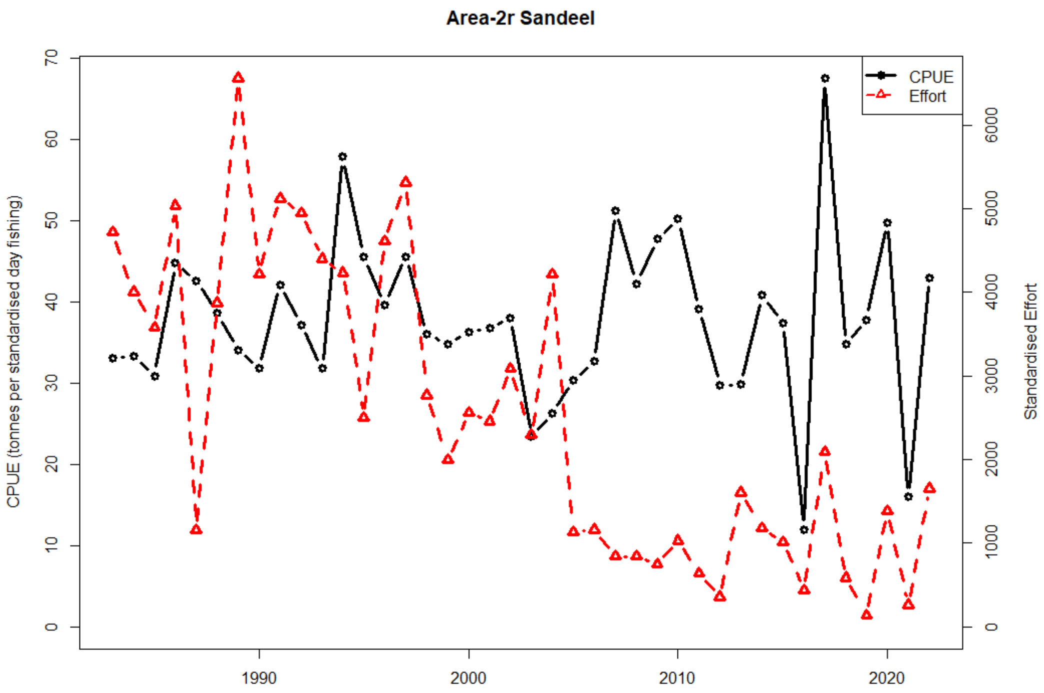


Figure 9.3.3 Sandeel Area-2r. Commercial CPUE and effort.

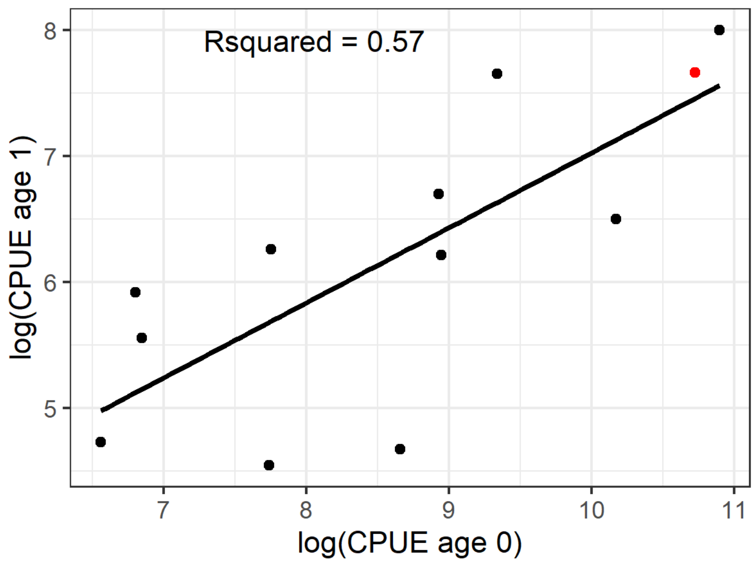


Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

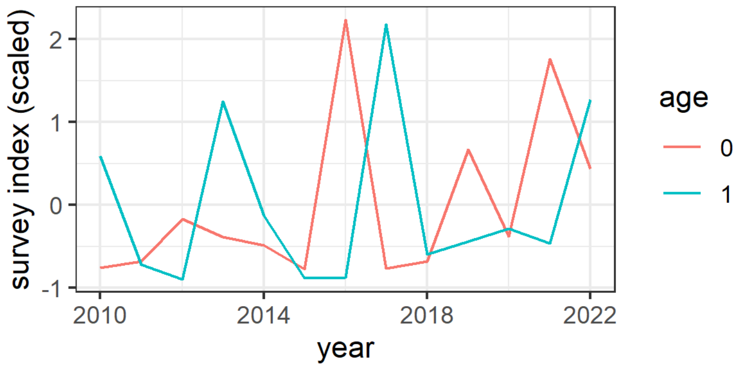


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

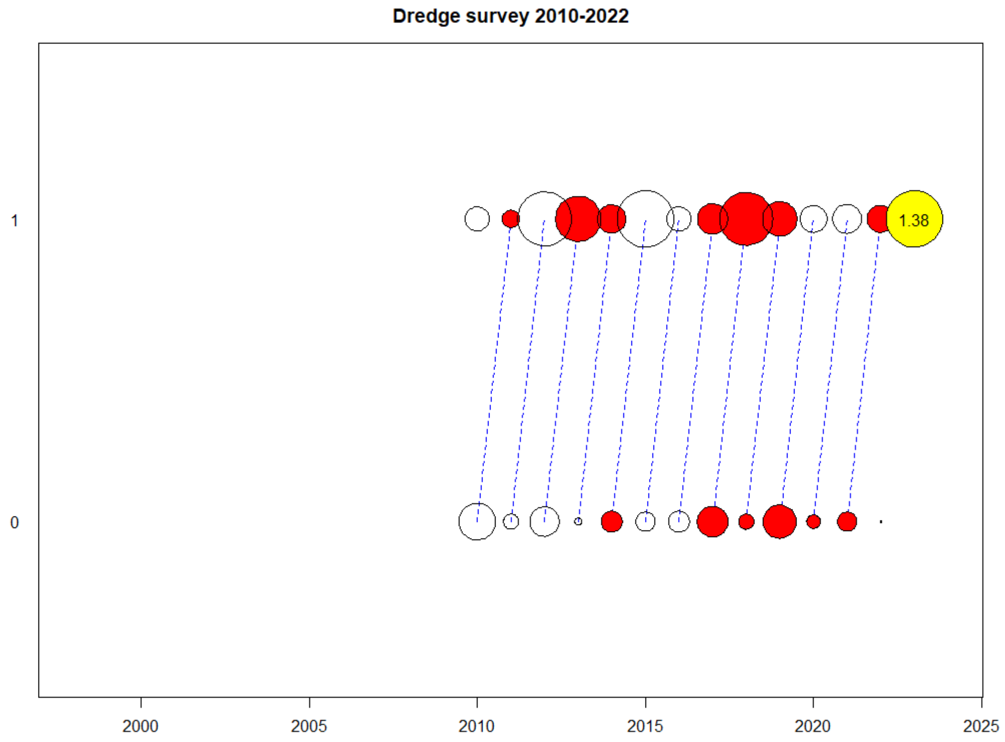


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

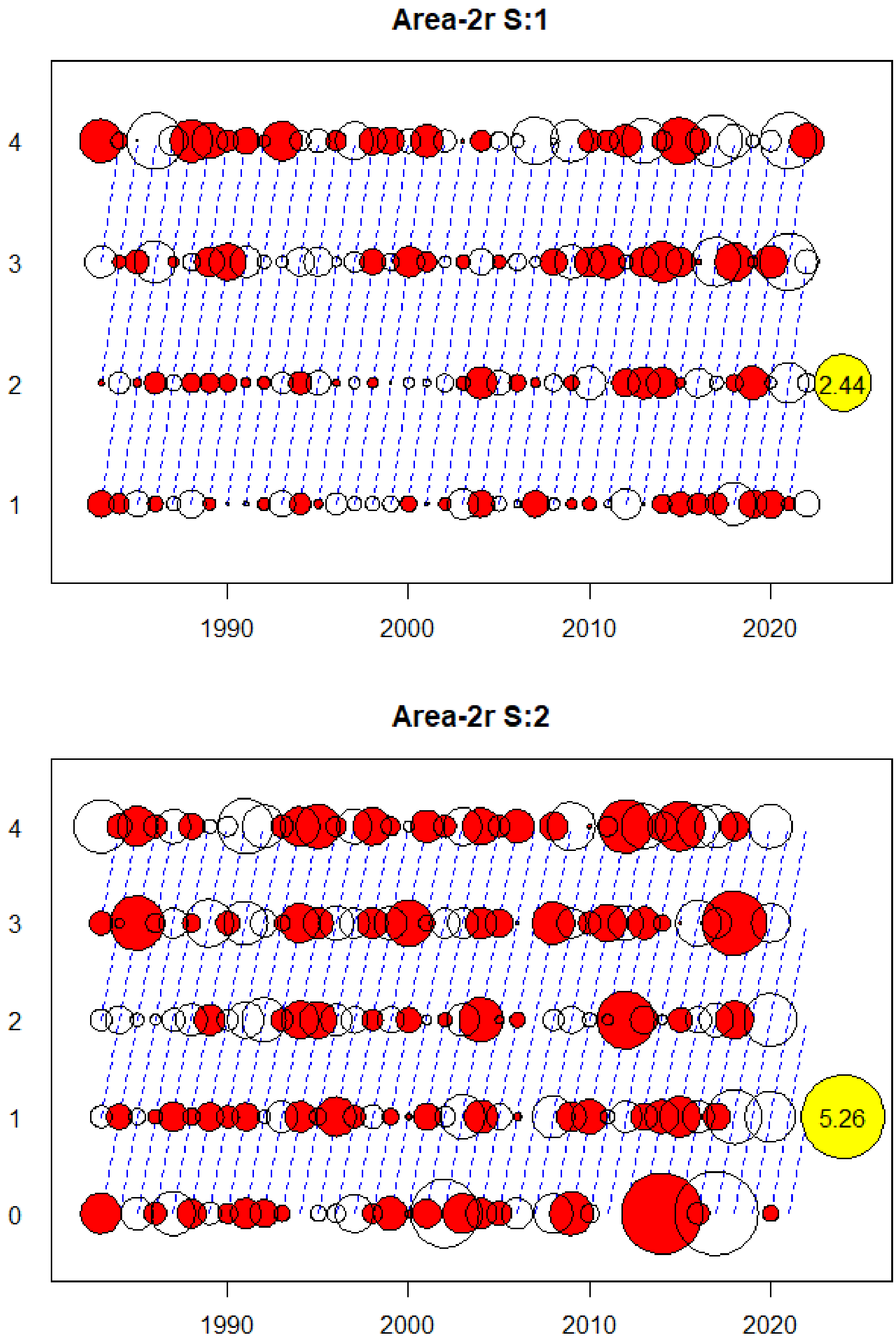


Figure 9.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). “Red” dots show a positive residual.

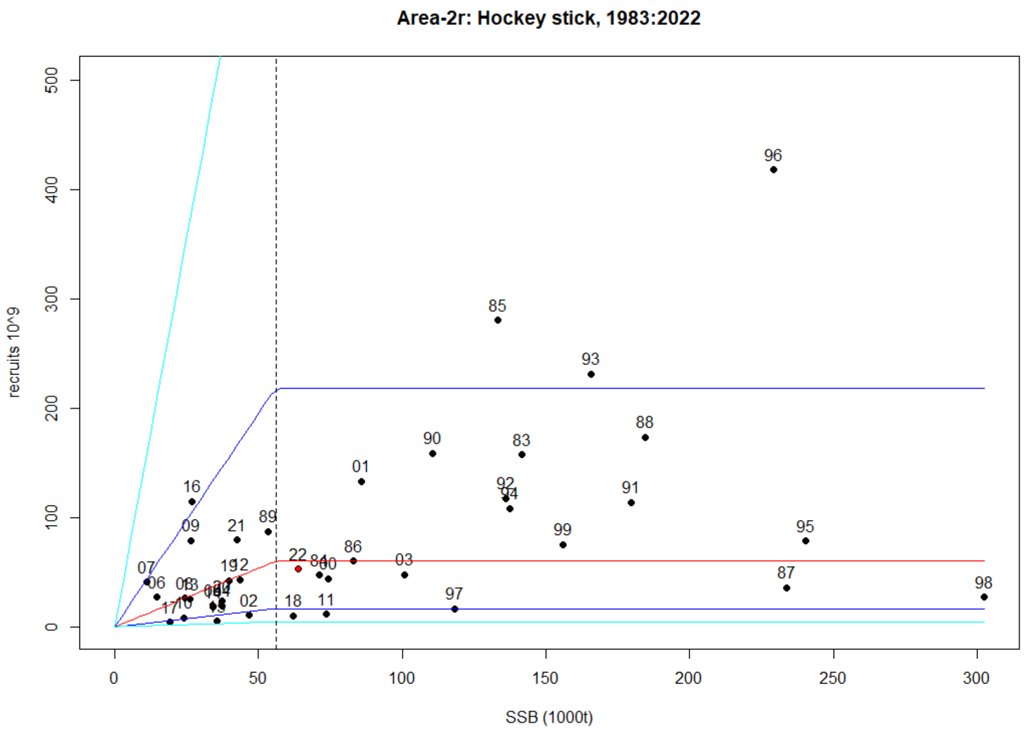


Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

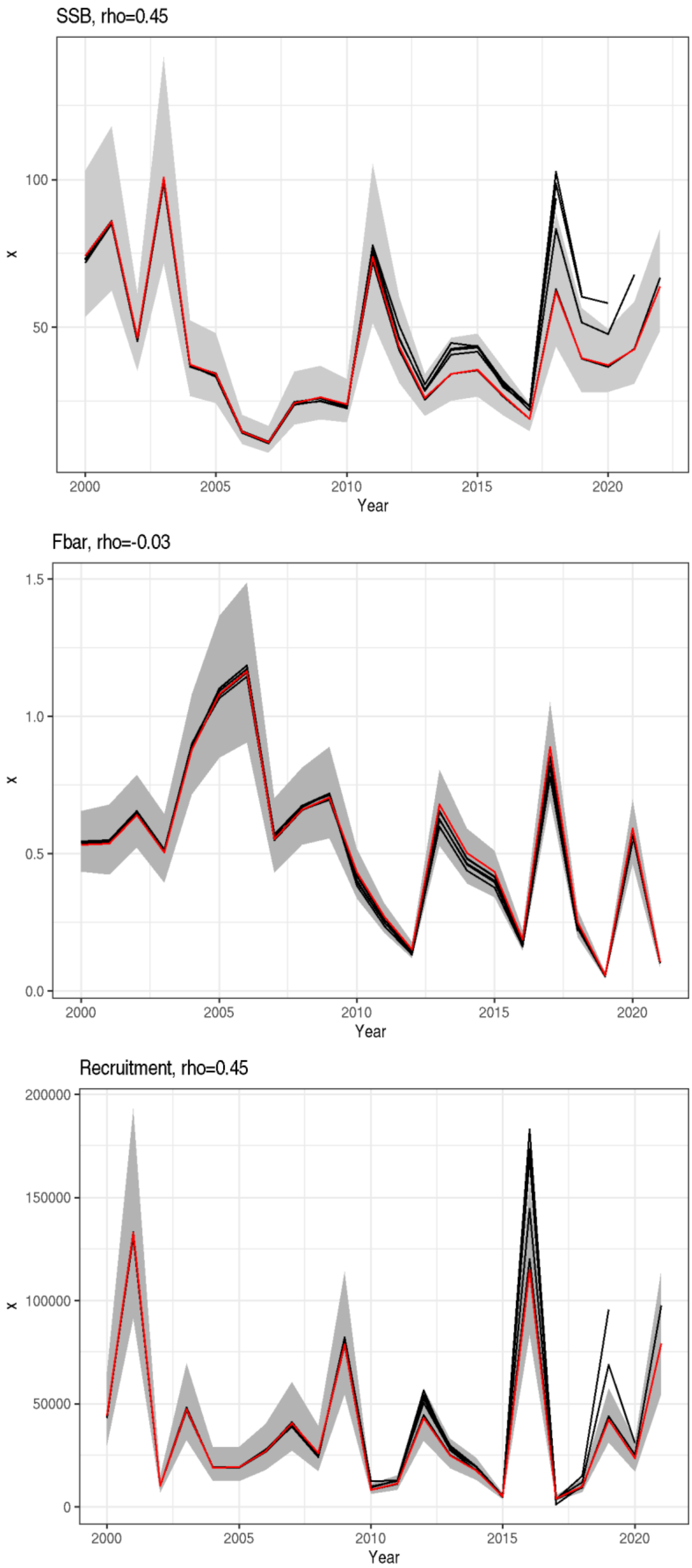


Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.

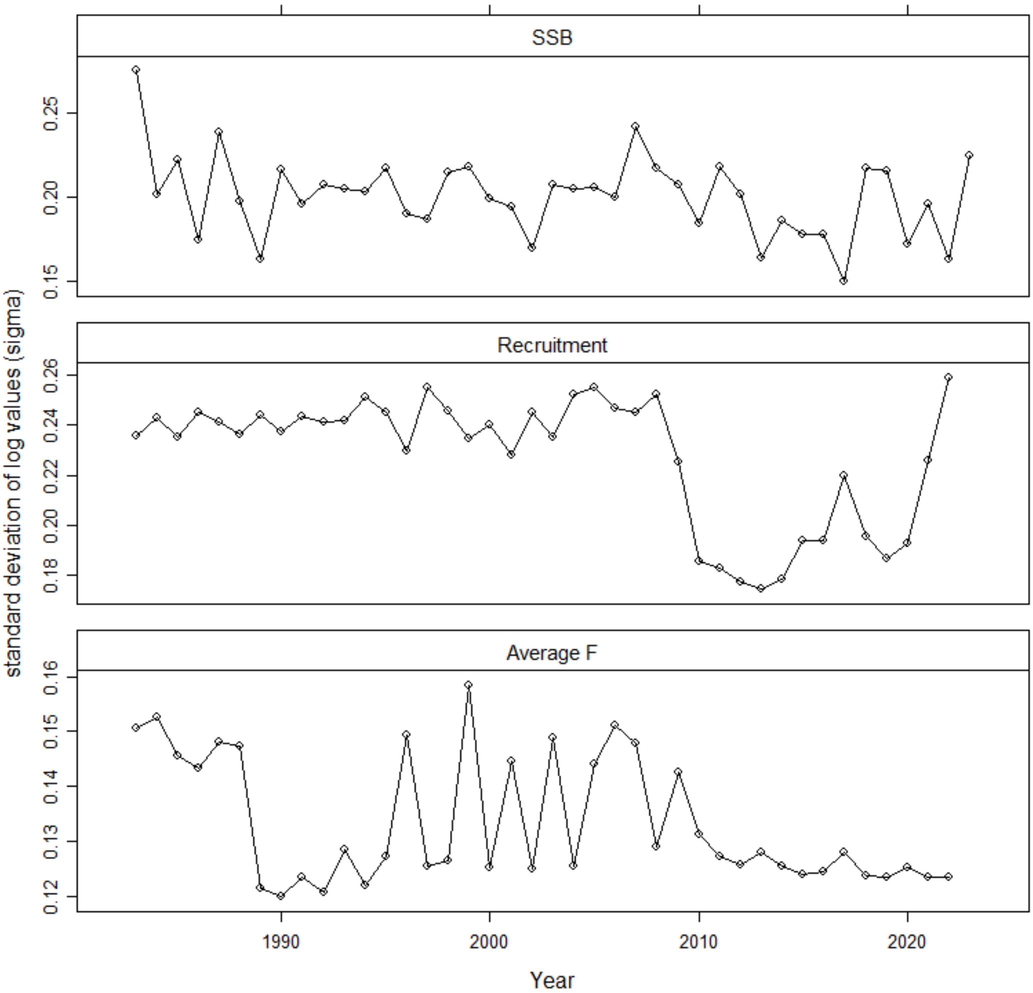


Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

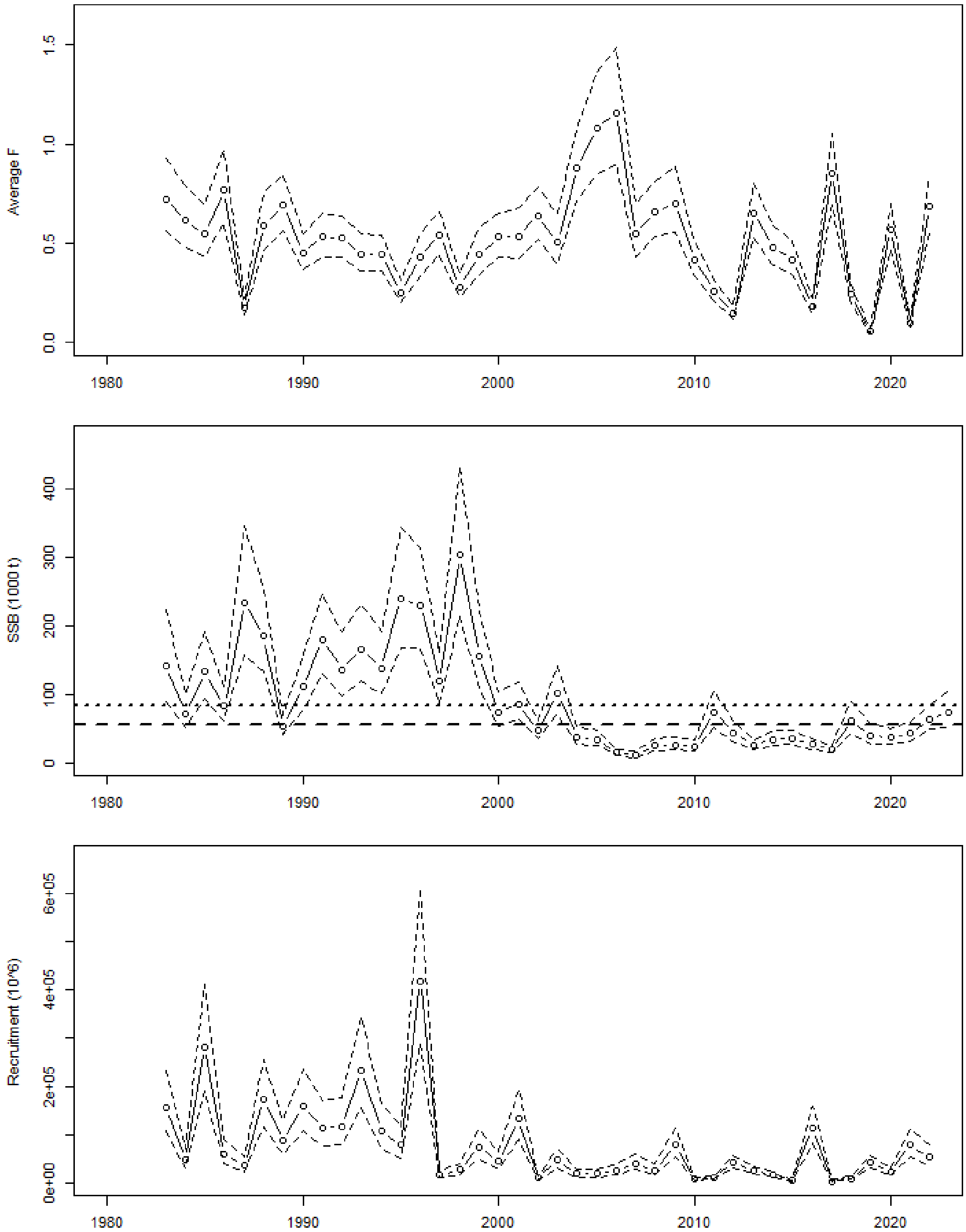


Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

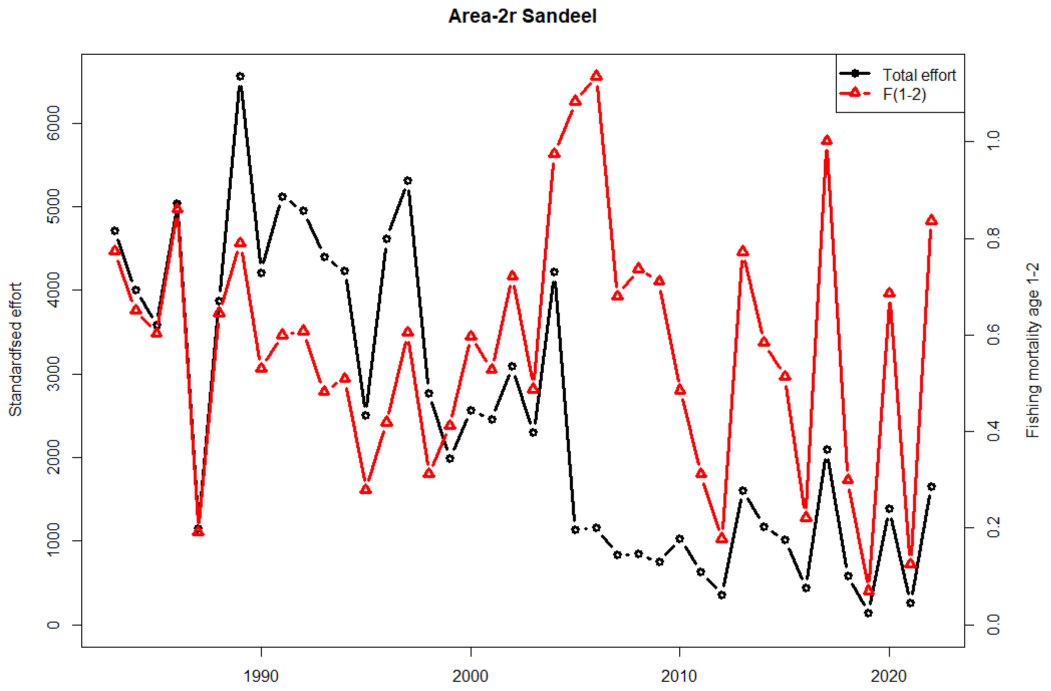


Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

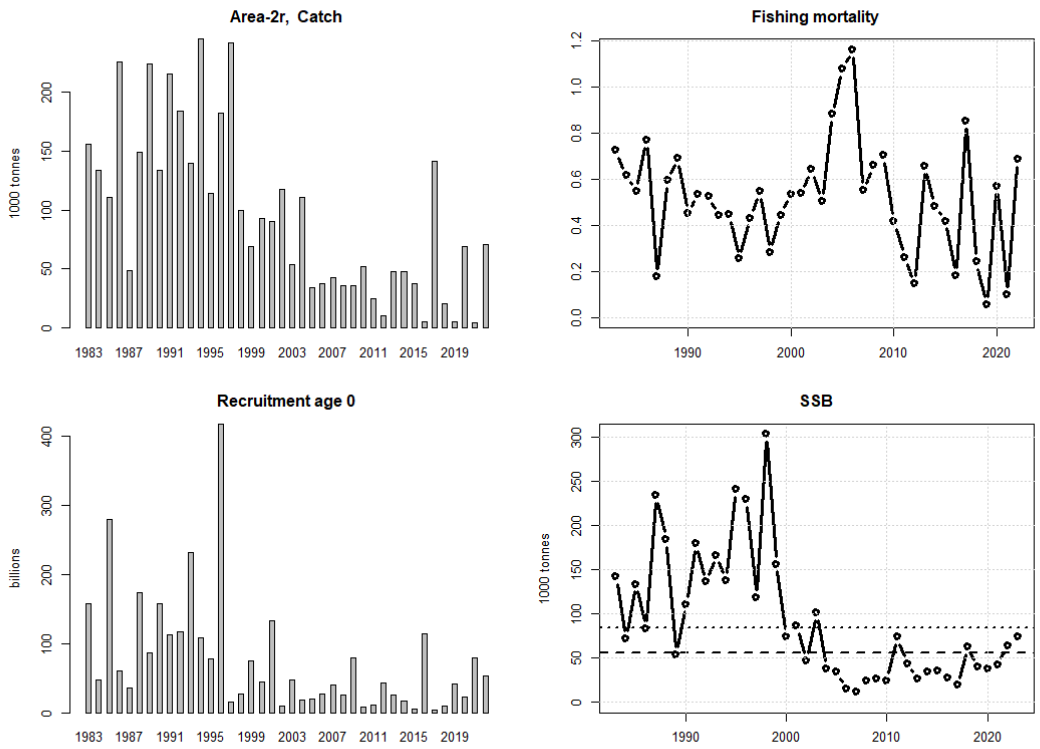


Figure 9.3.13 Sandeel Area-2r. Stock summary.

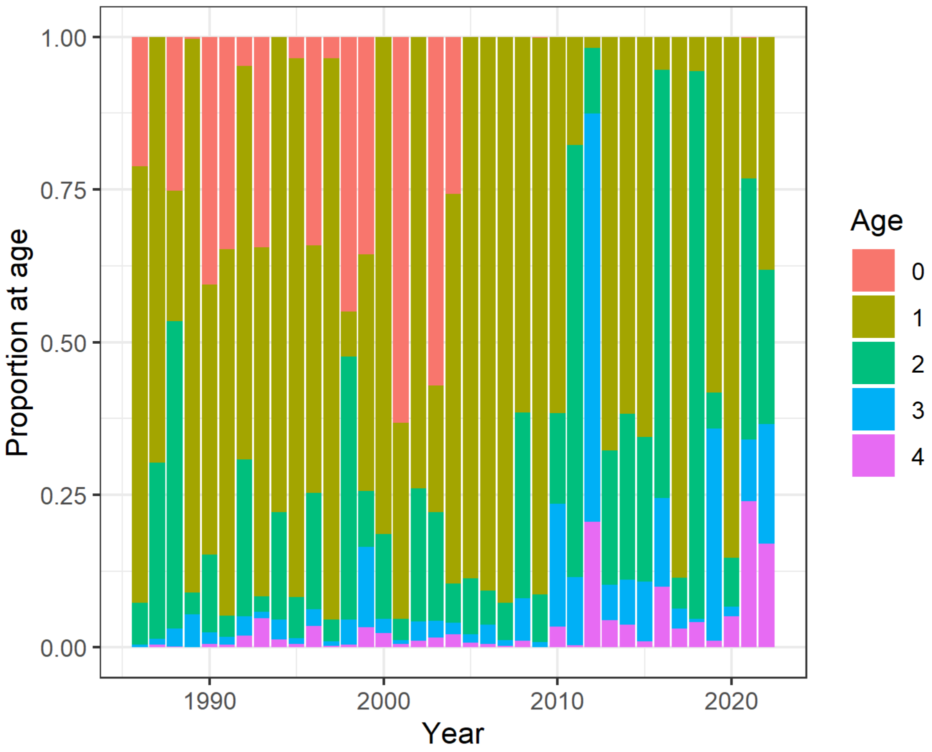


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

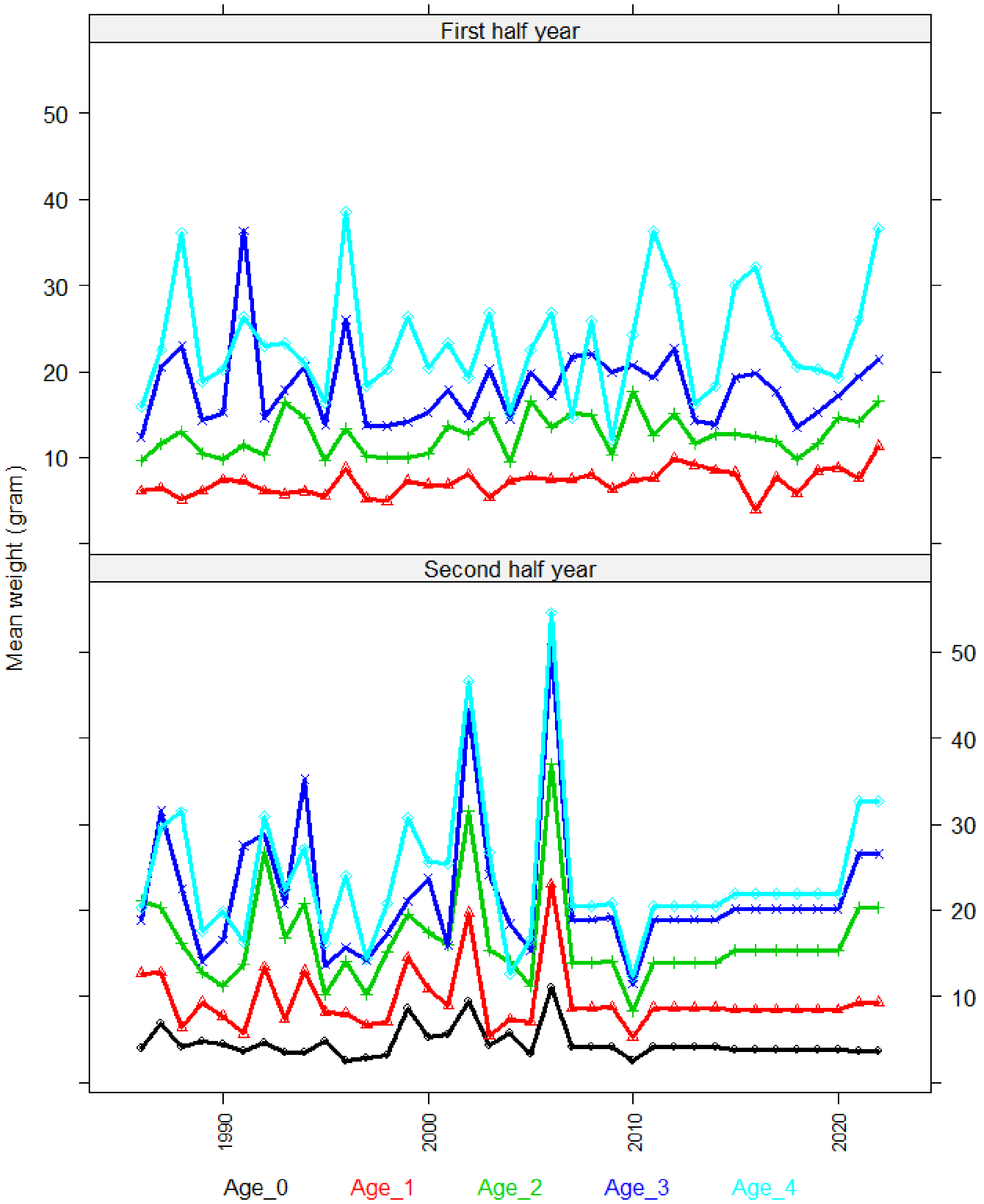


Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

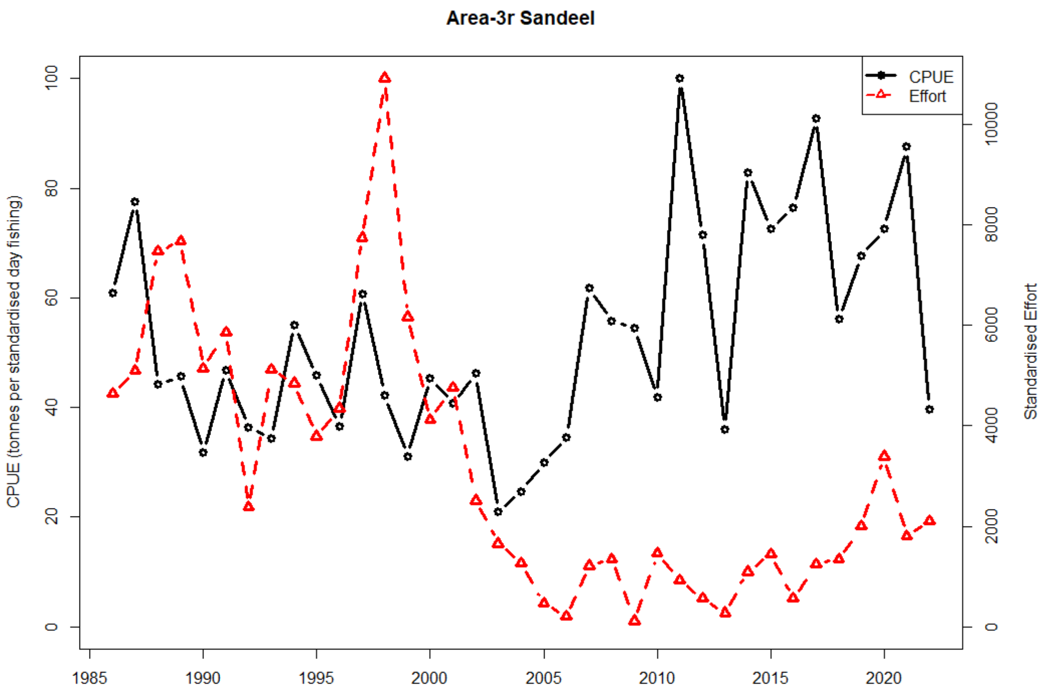


Figure 9.4.3 Sandeel Area-3r. Commercial CPUE and effort.

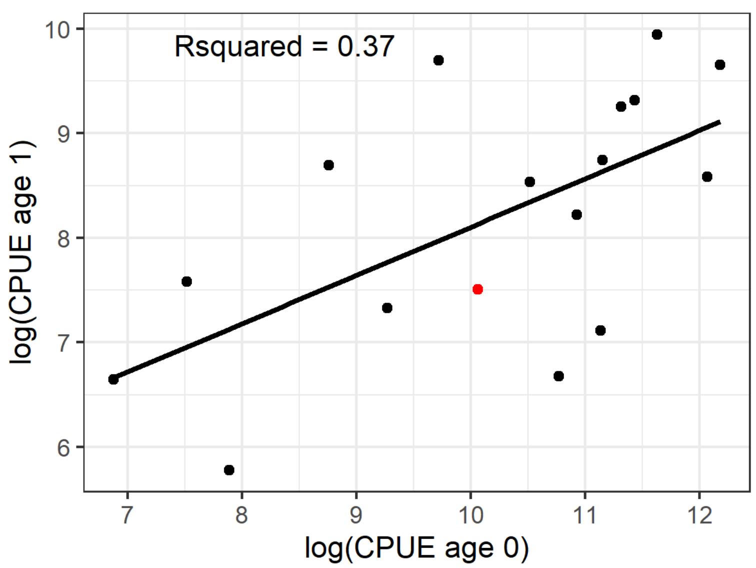


Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

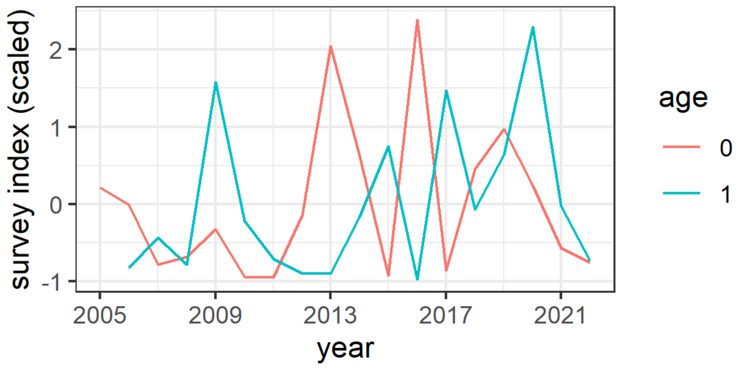


Figure 9.4.5 Sandeel Area-3r. Dredge survey index timeline.

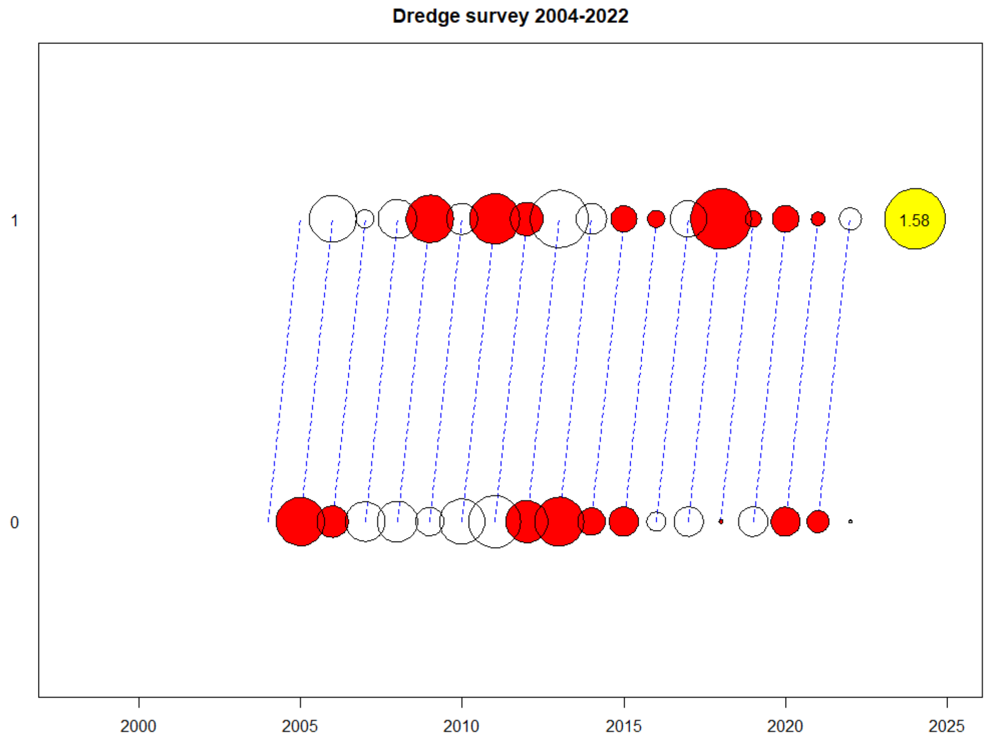


Figure 9.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

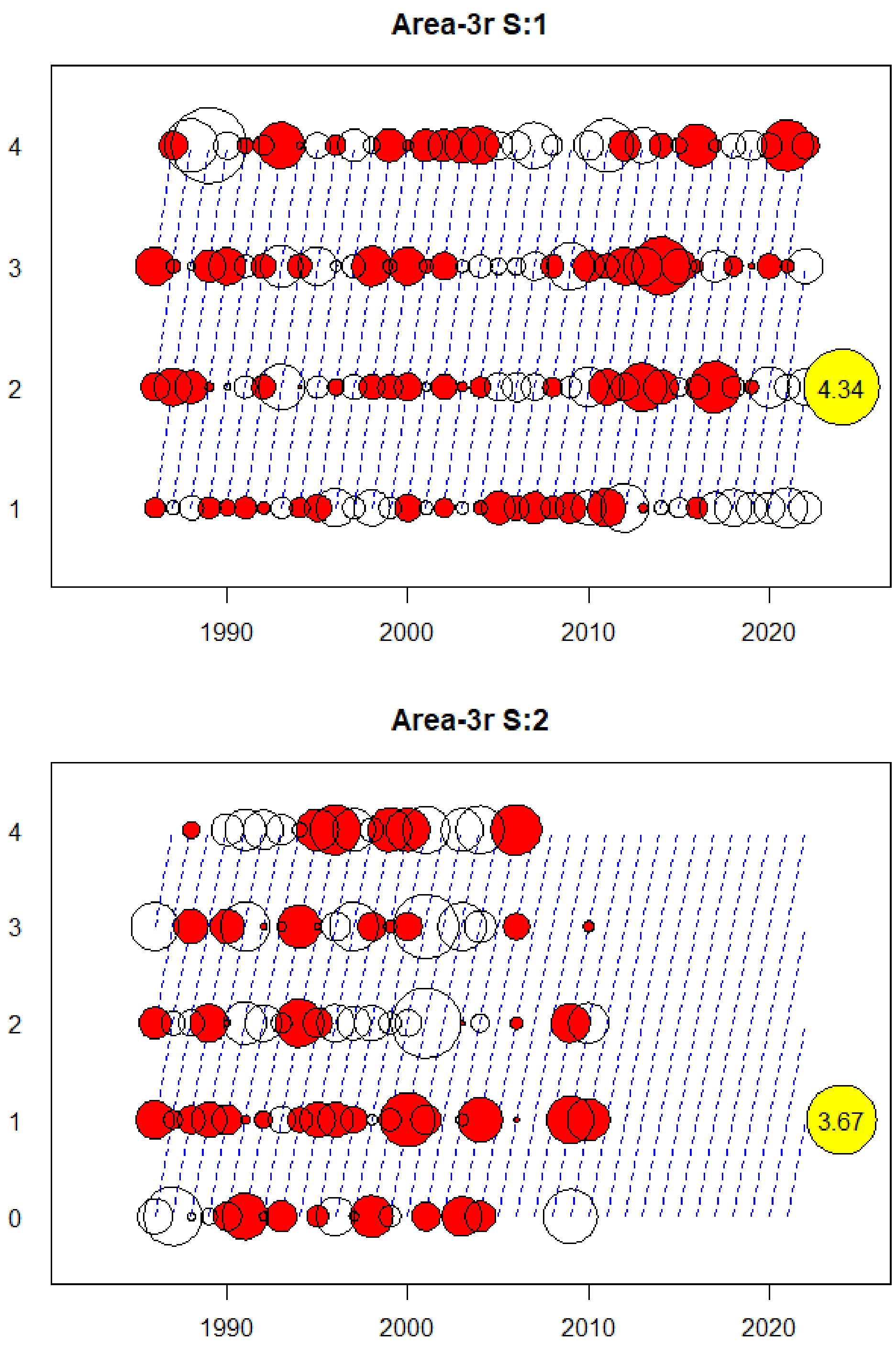


Figure 9.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

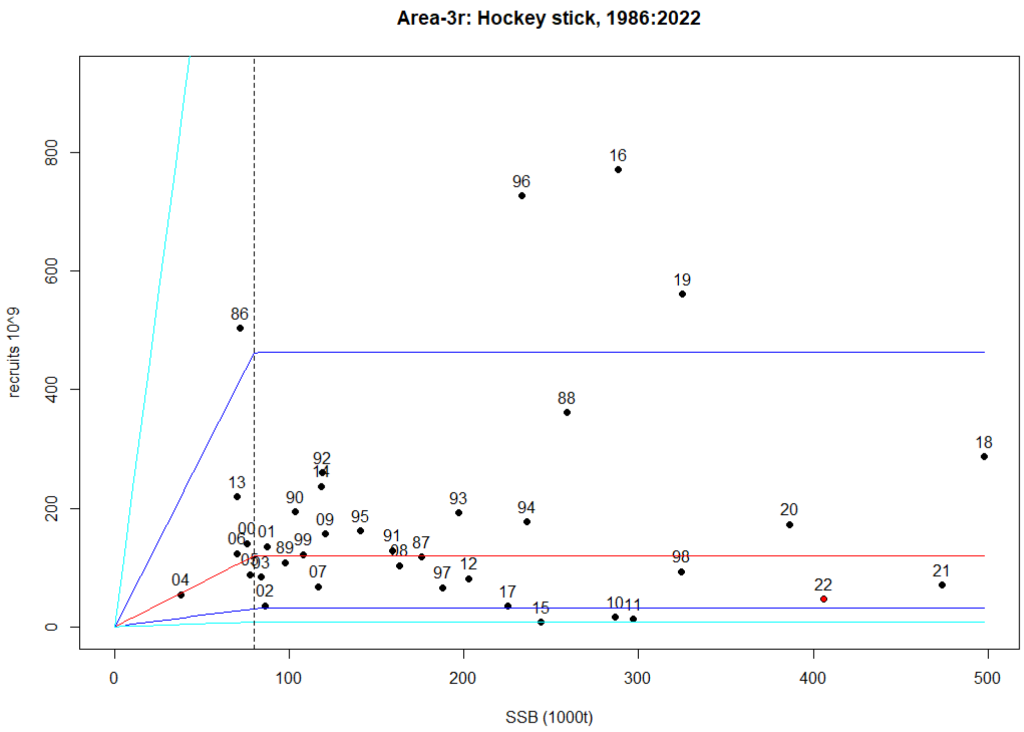


Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

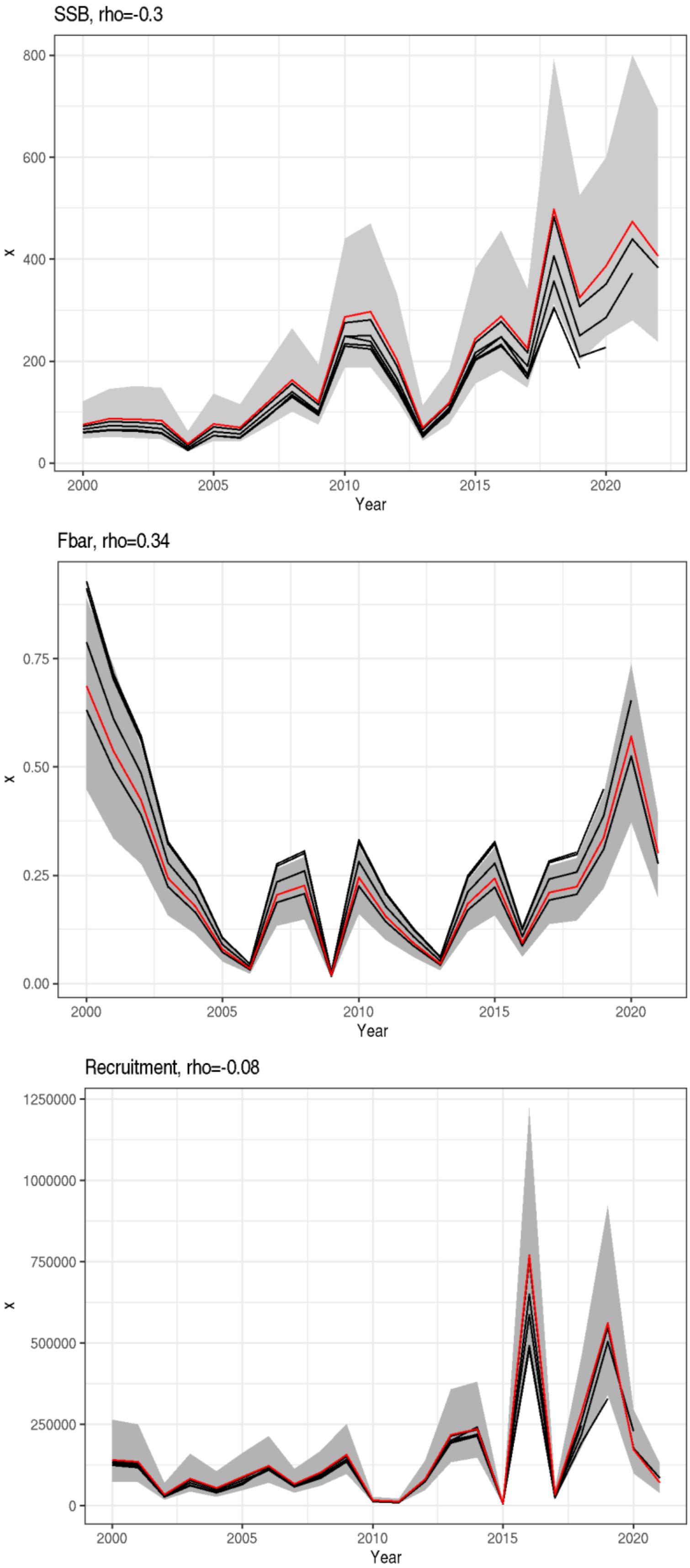


Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.

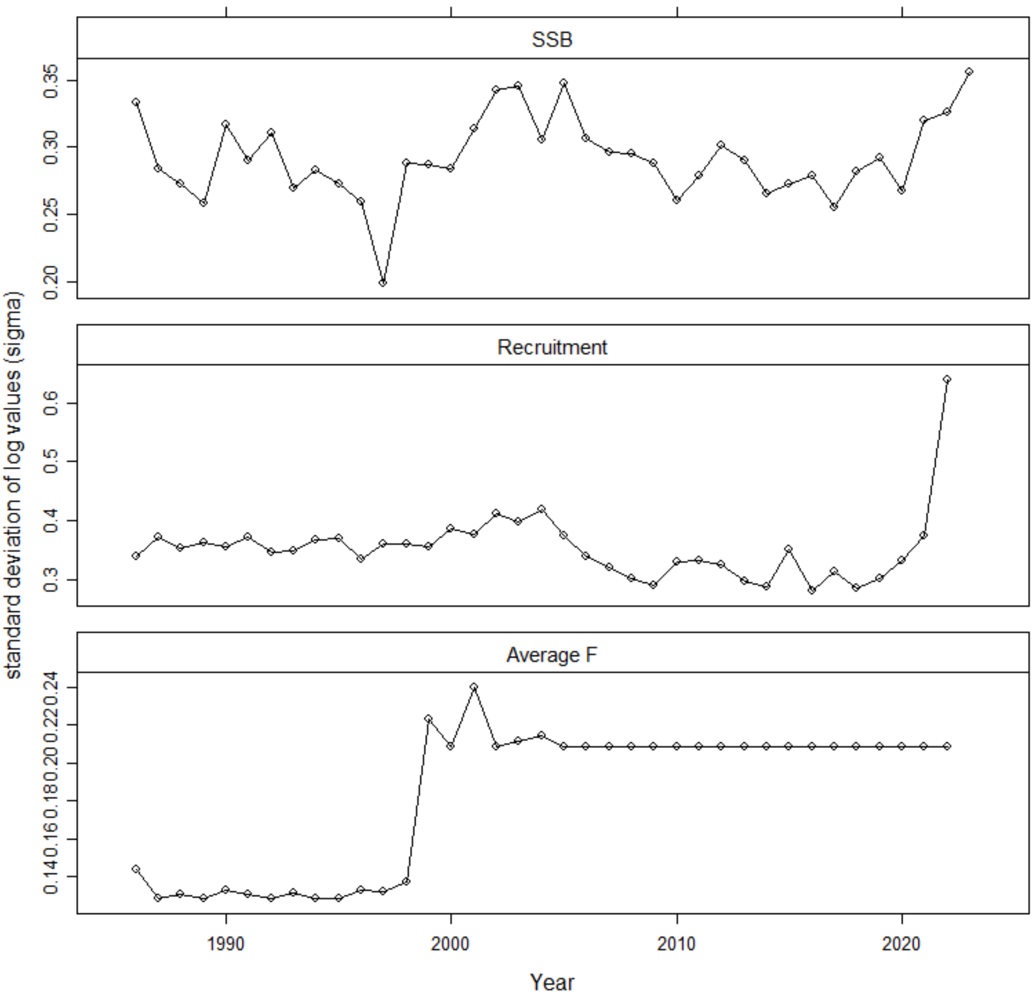


Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

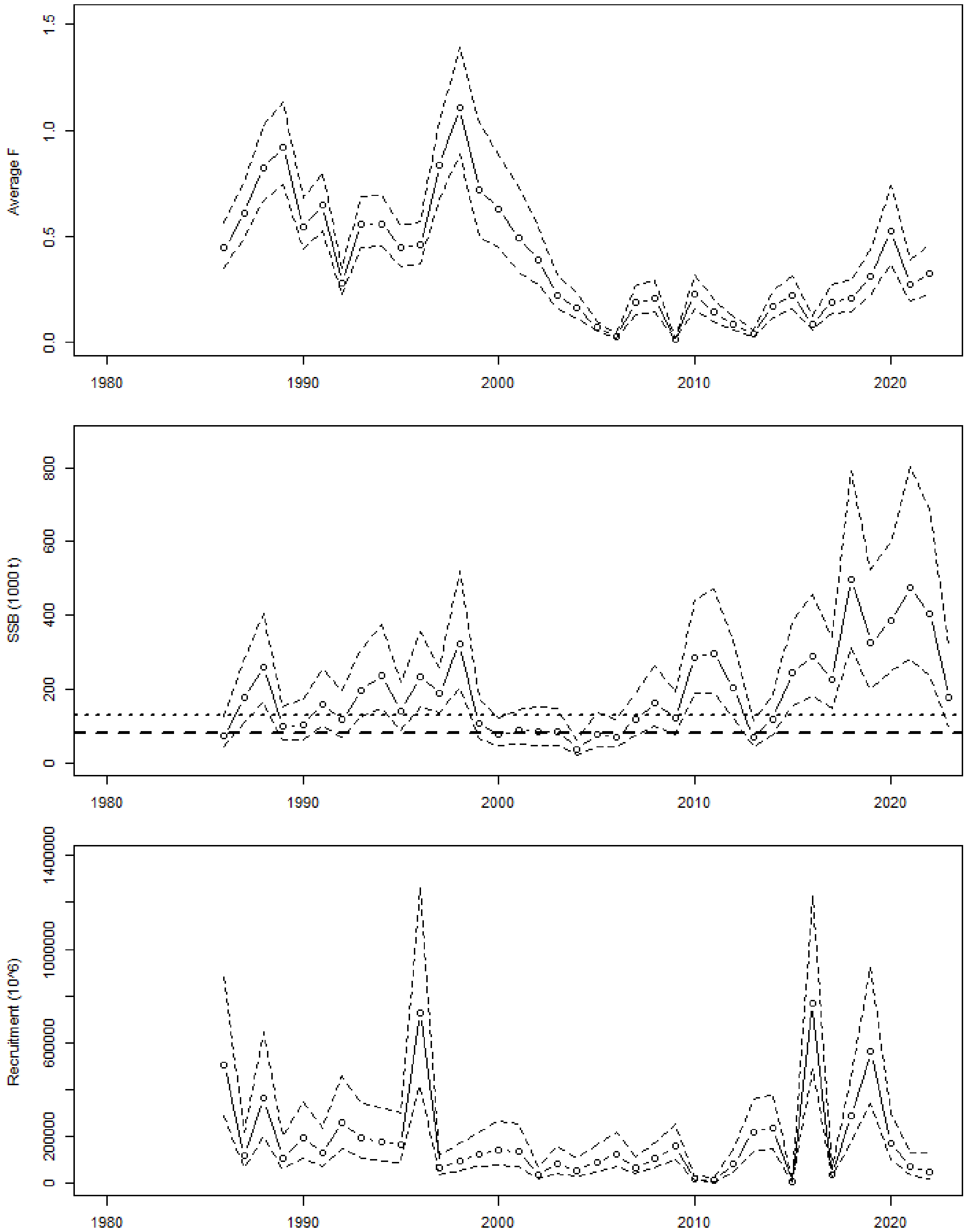


Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

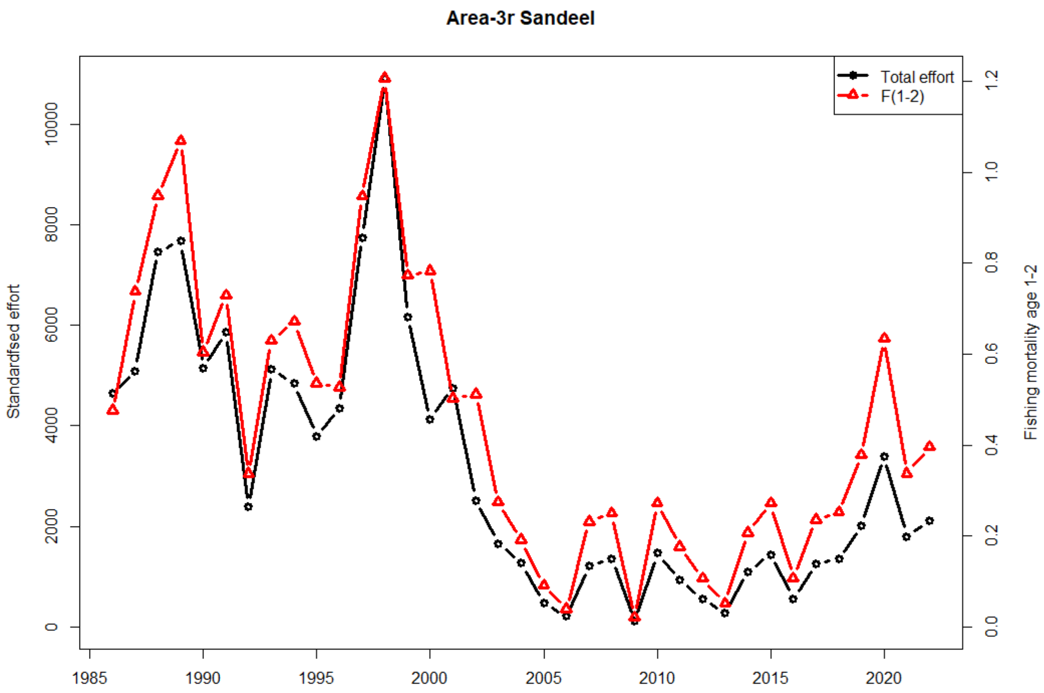


Figure 9.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

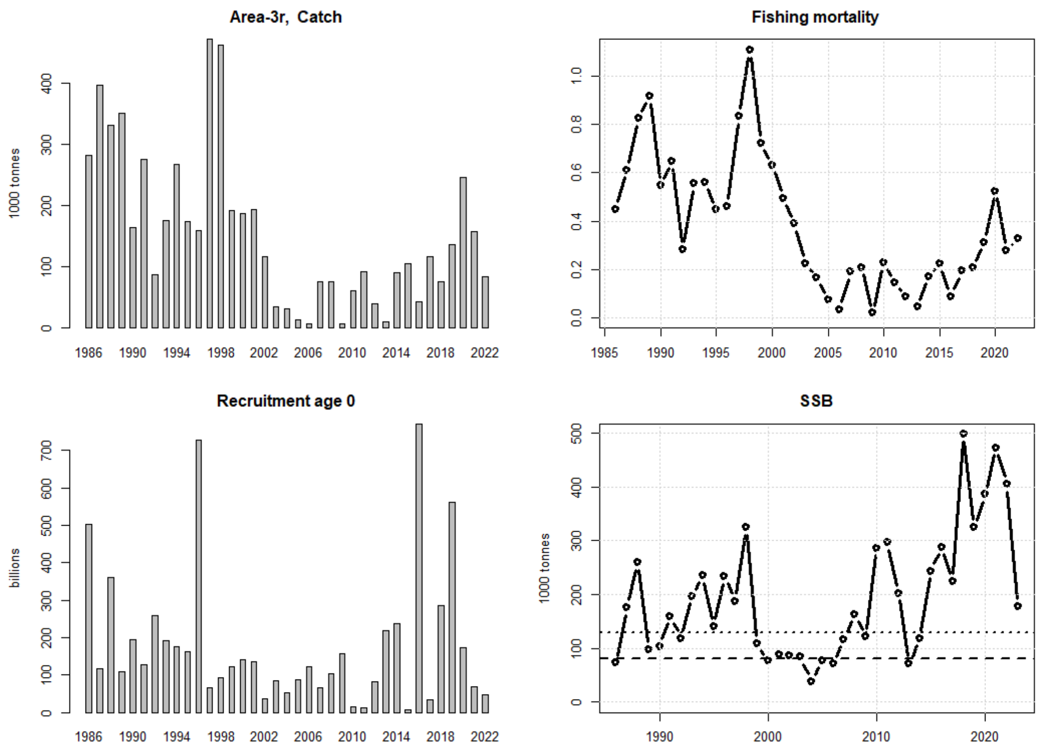


Figure 9.4.13 Sandeel Area-3r. Stock summary.

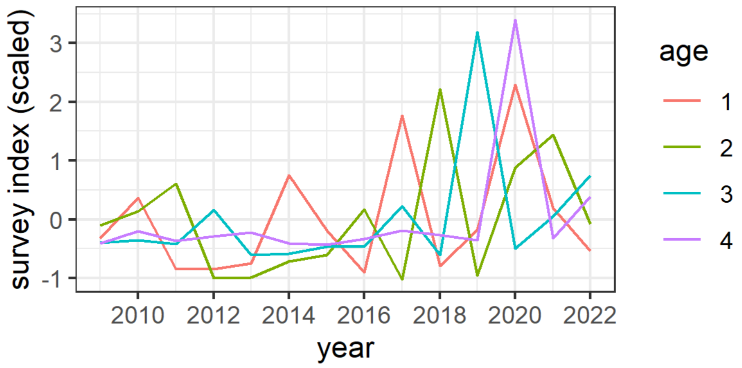


Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.

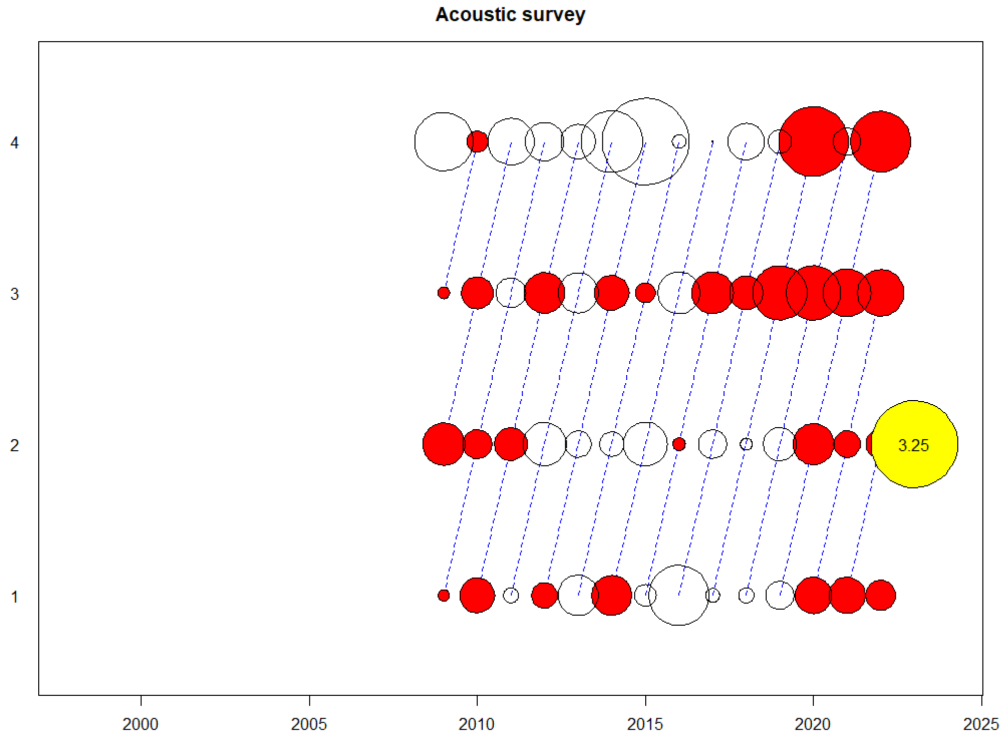


Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

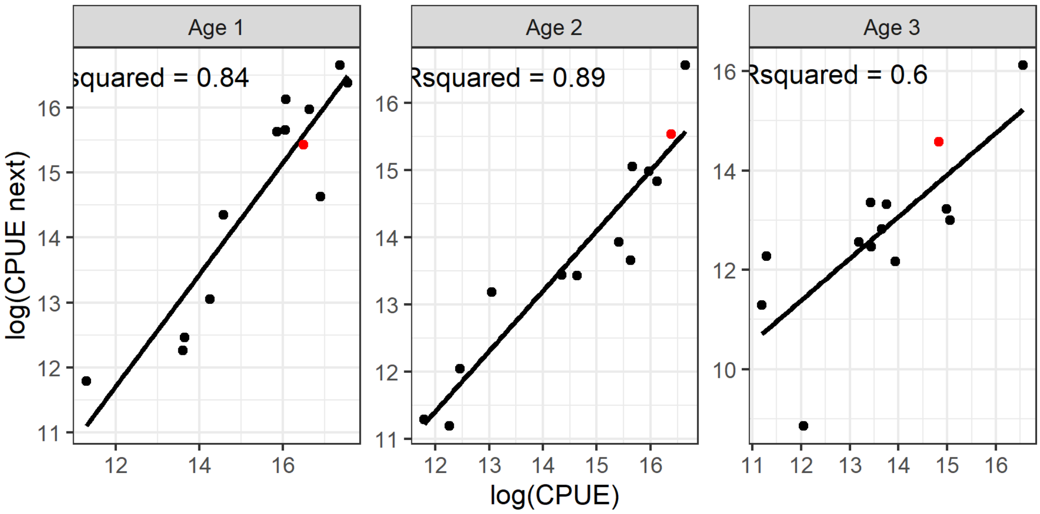


Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

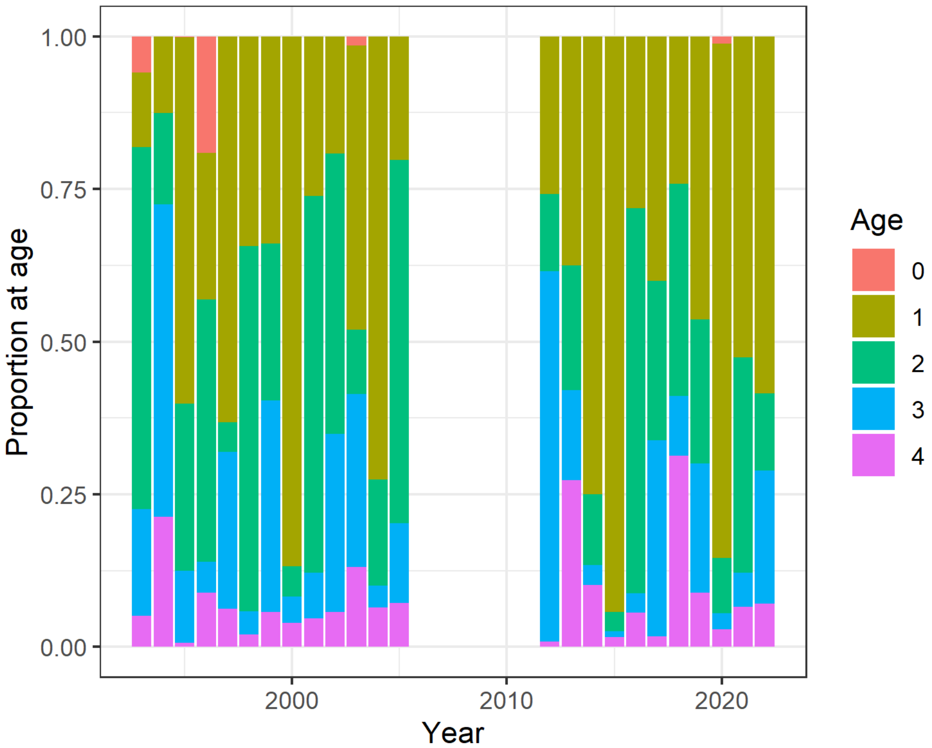


Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.

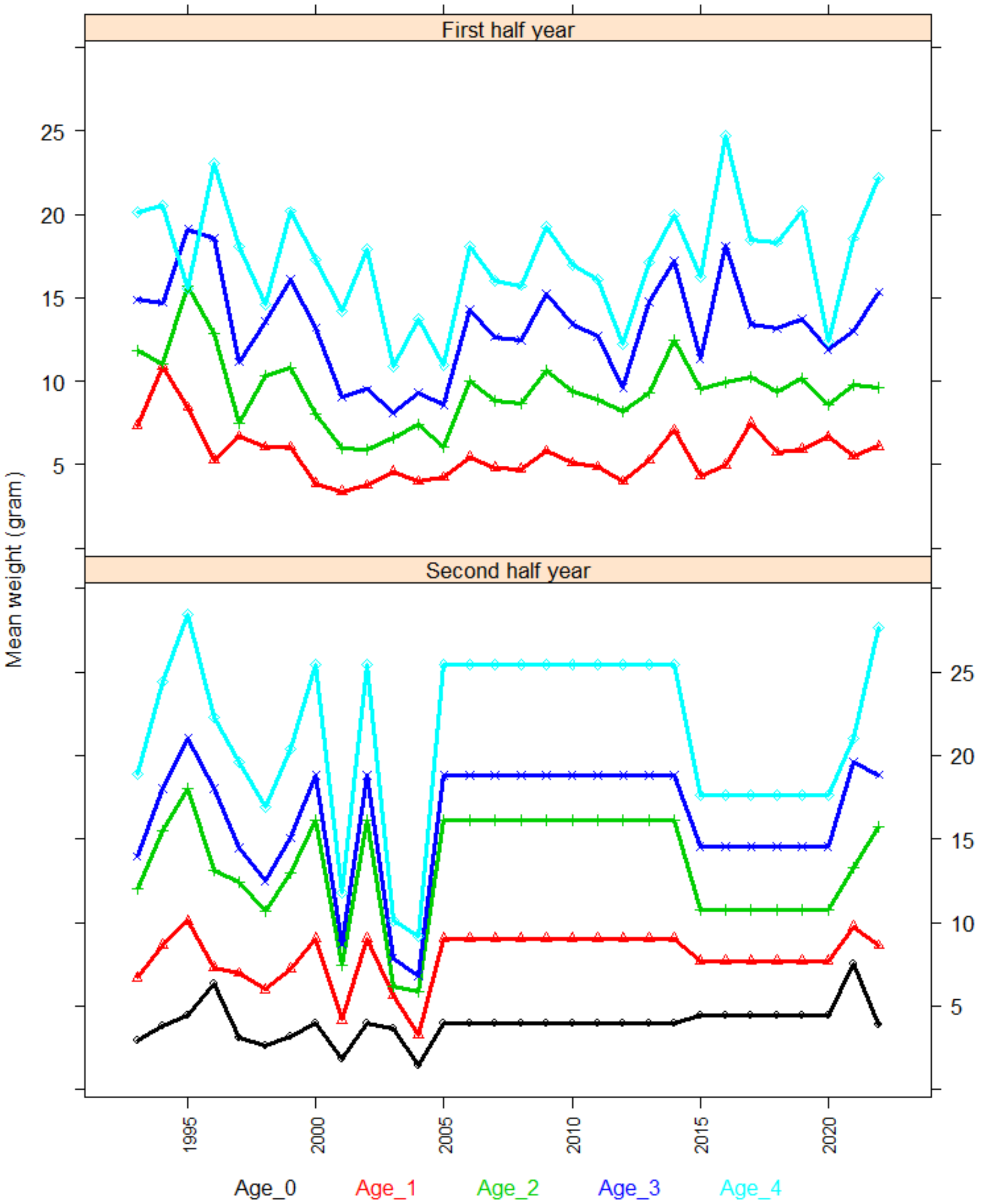


Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

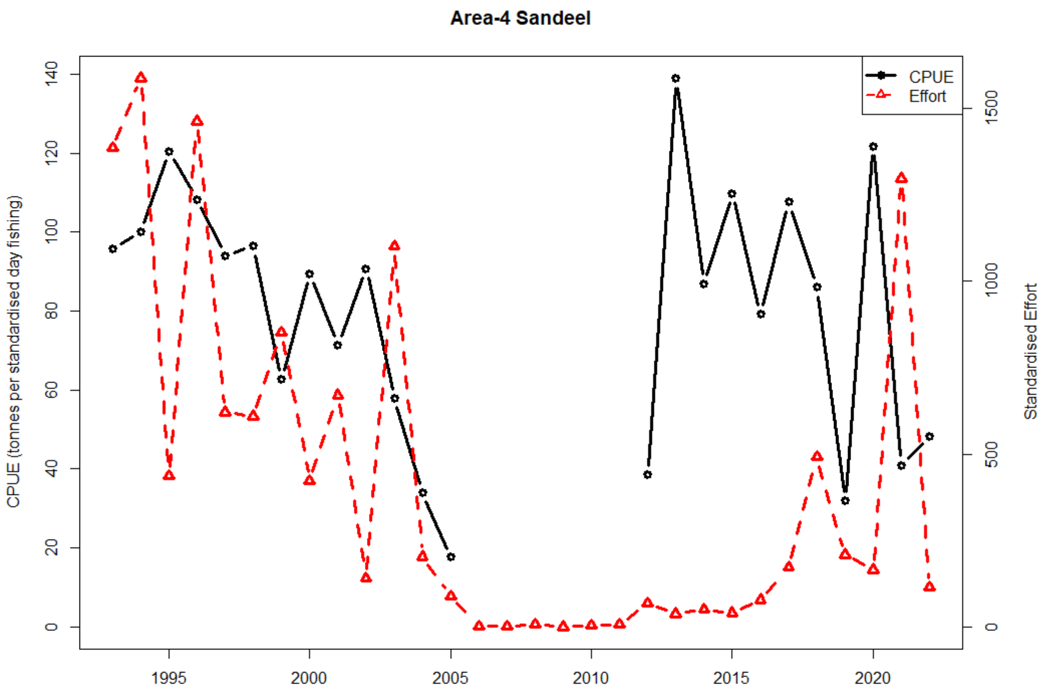


Figure 9.5.3 Sandeel Area-4. Commercial CPUE and effort.

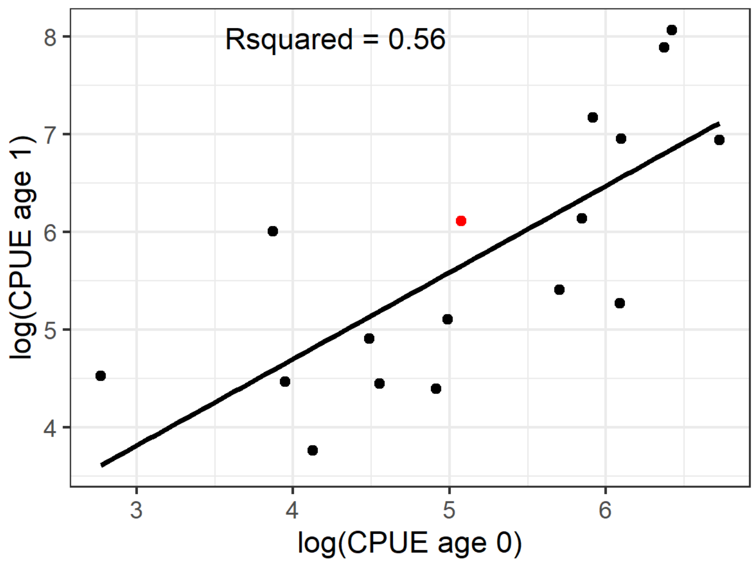


Figure 9.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

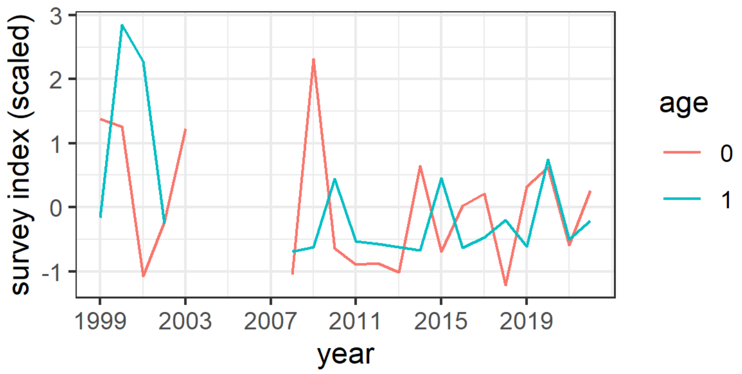


Figure 9.5.5 Sandeel Area-4. Dredge survey index timeline.

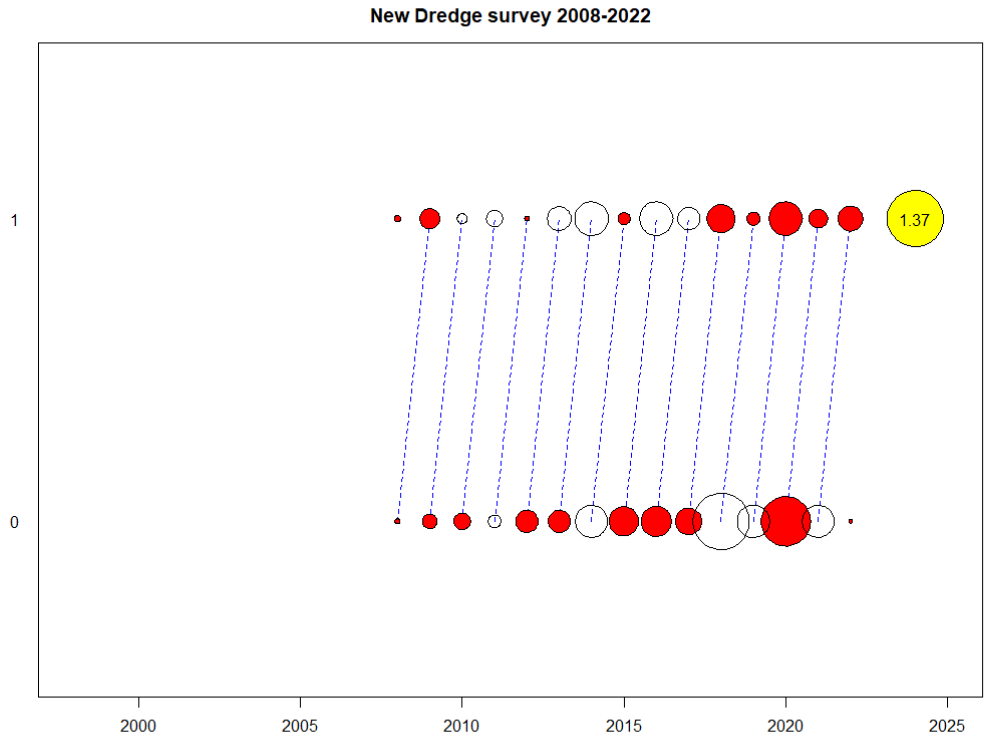


Figure 9.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

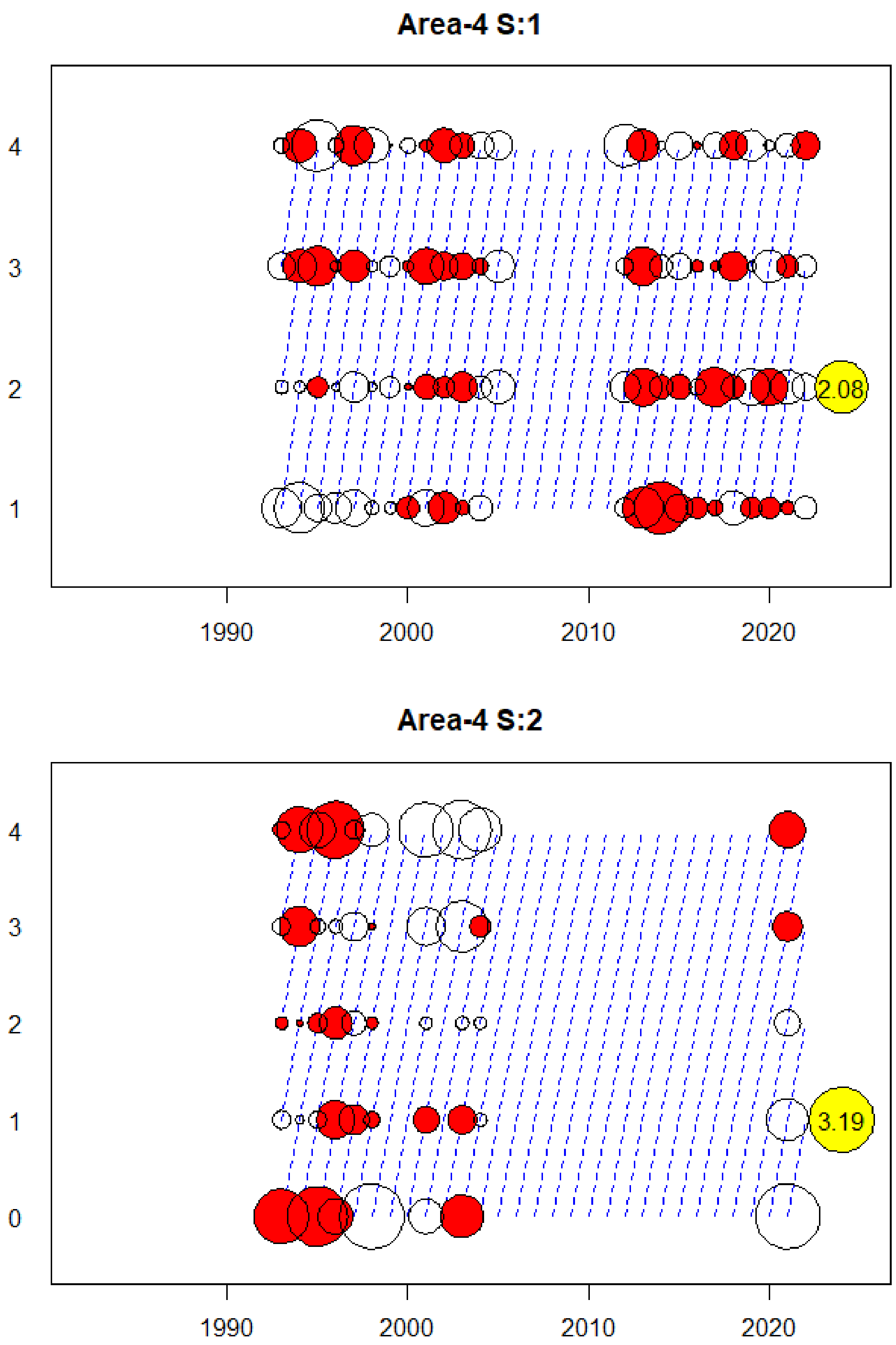


Figure 9.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). “Red” dots show a positive residual.

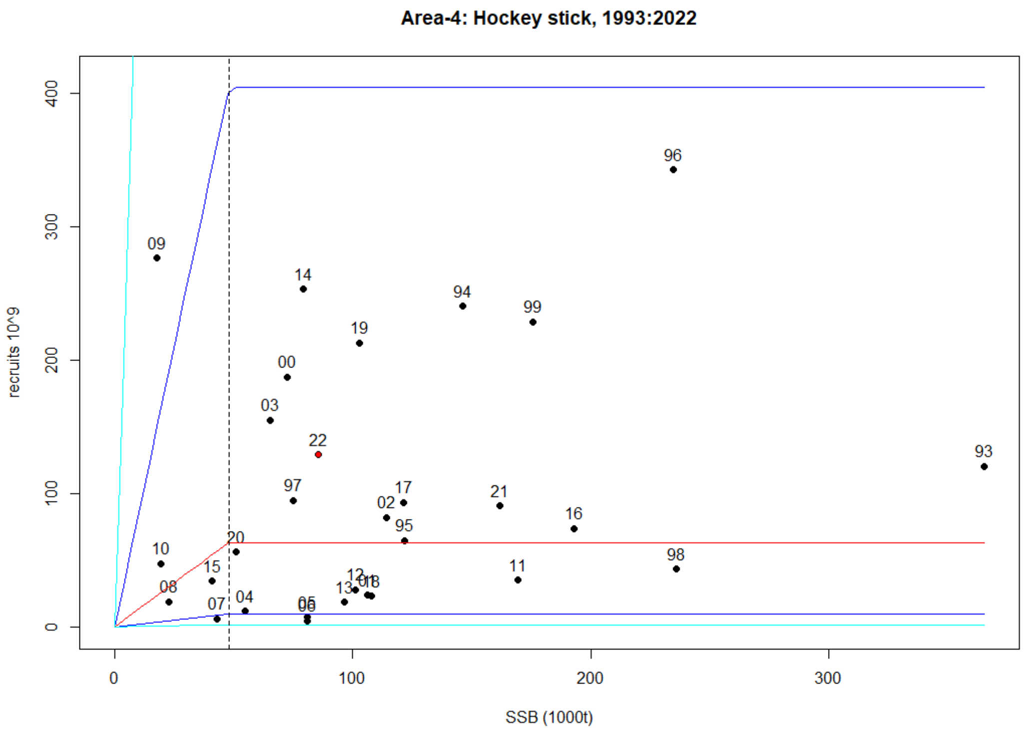


Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

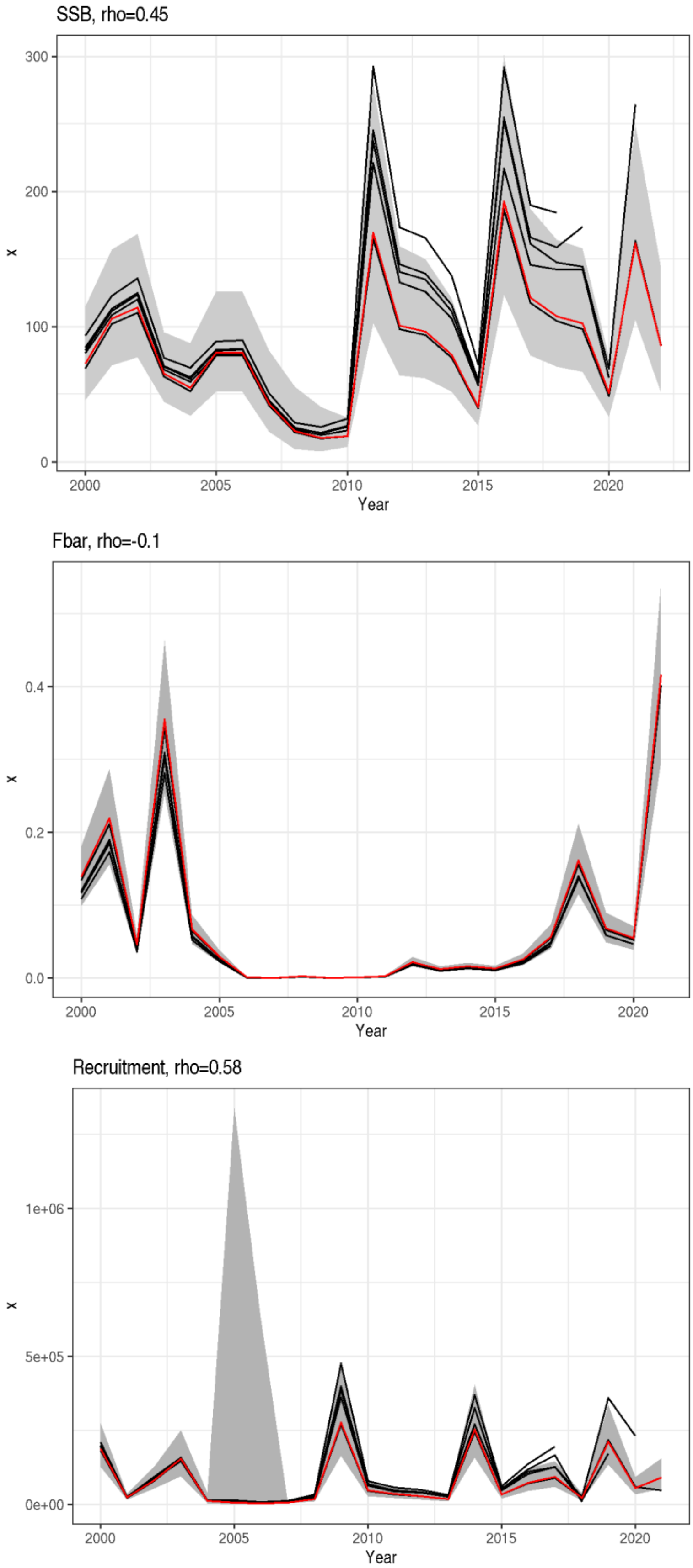


Figure 9.5.9 Sandeel Area-4. Retrospective analysis.

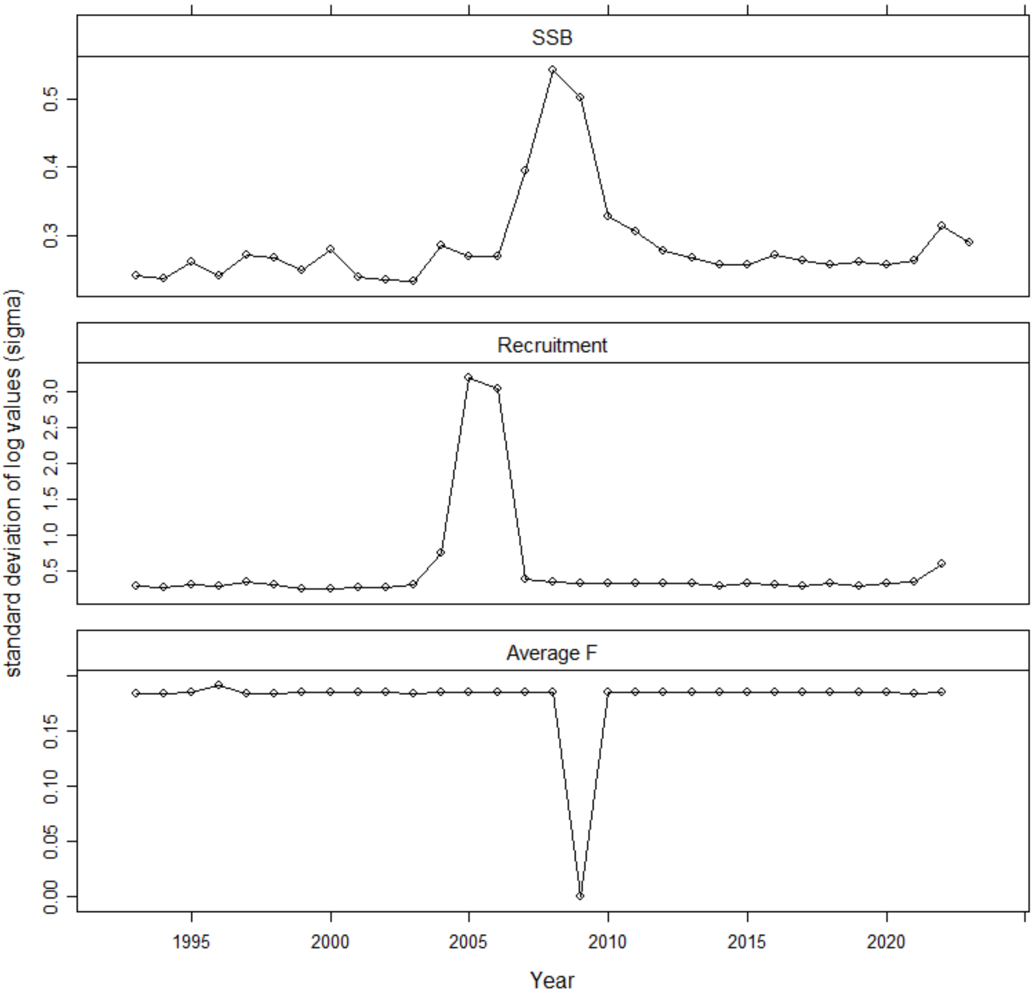


Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

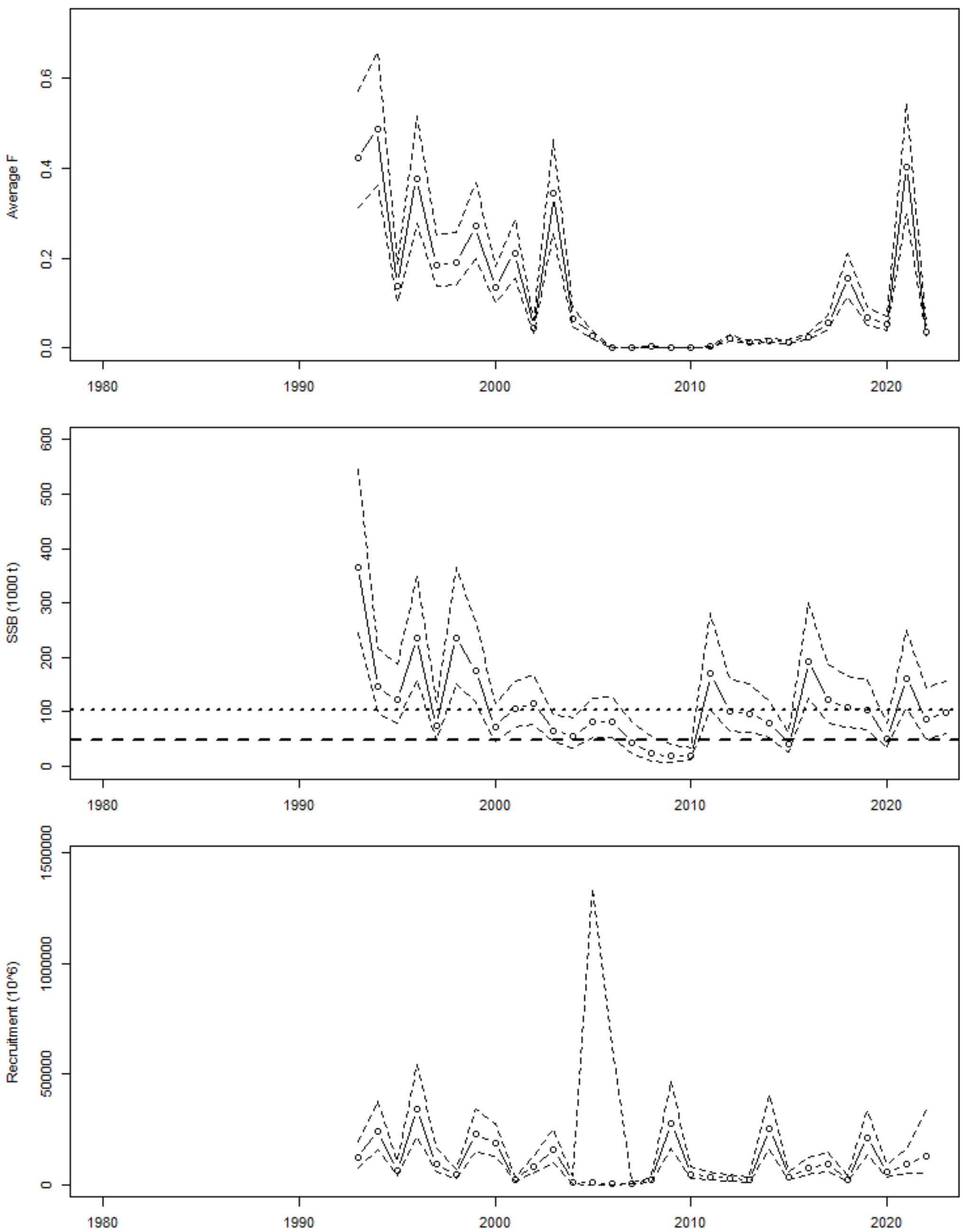


Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

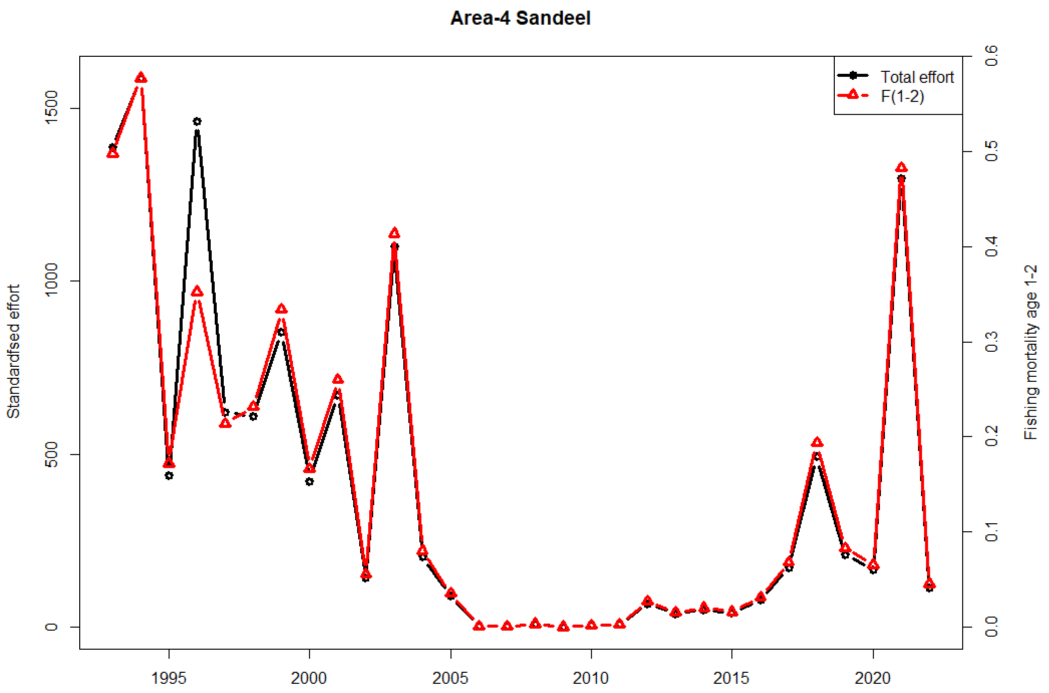


Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

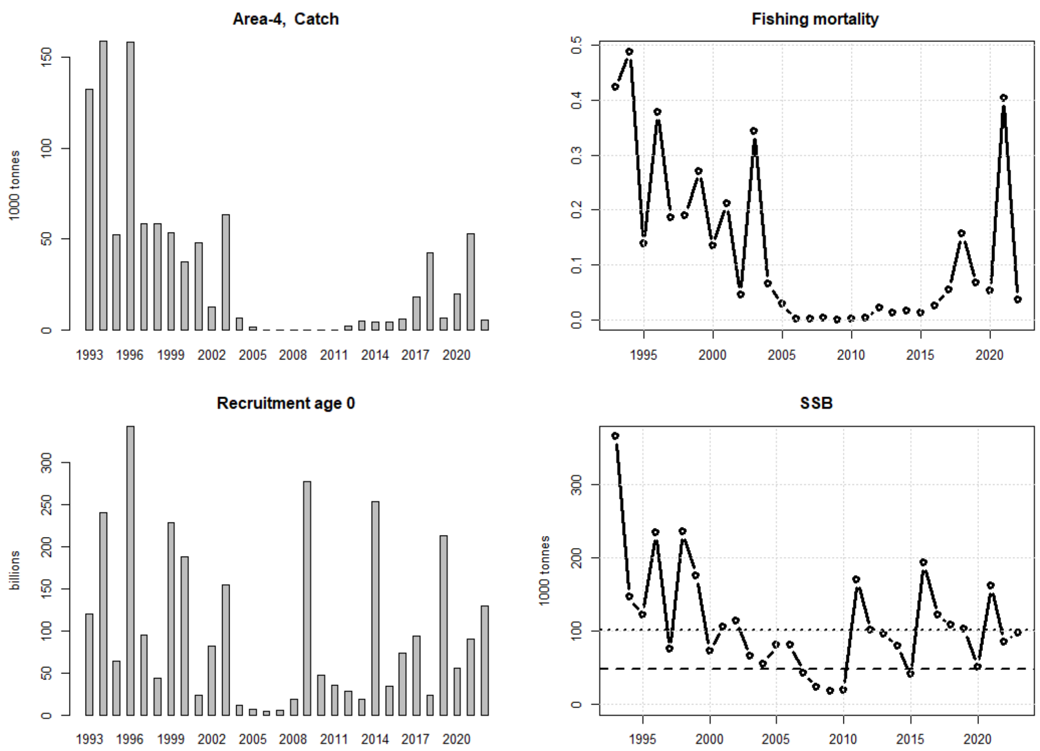


Figure 9.5.13 Sandeel Area-4. Stock summary.

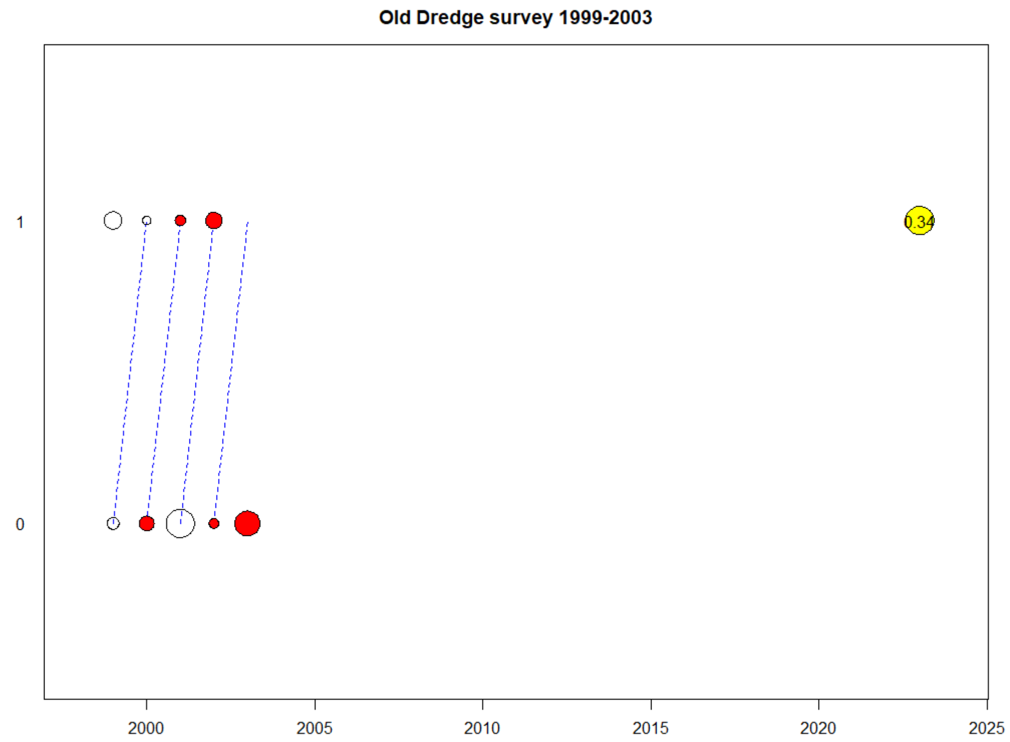


Figure 9.5.1 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

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 2022 and 2023

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2022 to June 2023) was set to 68 690 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 2022 herring bycatch quotas were 8 174 t for the North Sea and 6 659 t for Division 3.a. For 2022 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).

10.1.2 Catches in 2022

Catch statistics for 2000–2022 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 2022 was 90 105t (total official catches amounted to 90 038t). This is a 12% increase compared to 2021. The Danish catches represent 89% of the total catches.

The spatial distribution of landings was overall like recent years, although smaller catches were seen close to the coast (Figure 10.1.1). Compared to last year, 22% of the catches were landed in the first and second quarter of 2022 (Table 10.1.2).

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 (2020: 92% 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 4.6% and 5.6% bycatch of herring in 2022 in the North Sea and Division 3.a, respectively. 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 by-catch 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 1974–2022 and the mean weights-at-age are presented in Table 10.2.2-3. In the model year 2022, 1-year-old sprat so far has contributed 74% of the total landings, which is more than the 1990–2020 average (66%). 2-year-olds contributed 11%, which is below the 1990–2020 average (15%). 0-year-olds contributed 12% of the total landings, which is close to the 1990–2020 average (16%).

Denmark and Sweden provided age data of commercial landings in 2022 (Table 10.2.4). Quarters 1, 3 and 4 were covered. Quarter 1 in 2022 had very low catches and no sampling. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by Germany (2 360 t), the Netherlands (374 t), UK-Scotland (379 t), UK-England and Wales (304 t) and Belgium (<1 t) were unsampled and Norway didn't catch the stock in 2022. The sampling level 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 level in 2020 (model year) was substantially reduced with only 0.6 samples taken per 2000 t. The low level of sampling in 2020 was caused by a not fully implemented change in the Danish sampling program. Since the introduction of the new by-catch estimation method in 2020, mentioned above, the Danish institute has been able to get samples from most of the buyers / 3rd party companies. Therefore, the Danish institute introduced a new sampling strategy in 2020, where vessels above 24 meters 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. The new sampling strategy has secured a high level of sampling in 2022.

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 10.3.1-2a give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report (ICES, 2018a) for further details). The data source is the IBTS Q1 data from 1983–2023. The index for IBTS Q1 1-year-old in 2022 (age-0 in the model and the table, serving as a recruitment index) was the fourth highest in the time-series, being 205% above the long-term average and 366% higher than last year's index. There has been a tendency for an increase in the IBTS Q1 age-0 in the time-series since 1990. Furthermore, older age-groups of age-1 and age-2 increased by 122% and 62% 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 2022 values were 36% above and below the indices for 2021 for age-1 and age-2, respectively.

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2022) (see Section 1.4.2). The abundance indices for Subarea 4 and Division 3.a were summed (Table 10.3.2 and Figure 10.3.2b). The 2022 values were 28%, 130%, and 91% higher (age-1, age-2, and age-3, respectively) compared to 2021. In 2022, one of the 12 strata relevant for sprat (131 in central North Sea) was not covered. This stratum has on average contributed 7% to the total HERAS sprat abundance in the period 2016-2021 (Lusseau et al. 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. 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 was arrested. In 2021-2022 mean weights increased in both S1 and S2, where the largest increase happened in S2 (Figure 10.4.1).

Proportion of mature fish was derived from IBTSQ1, 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

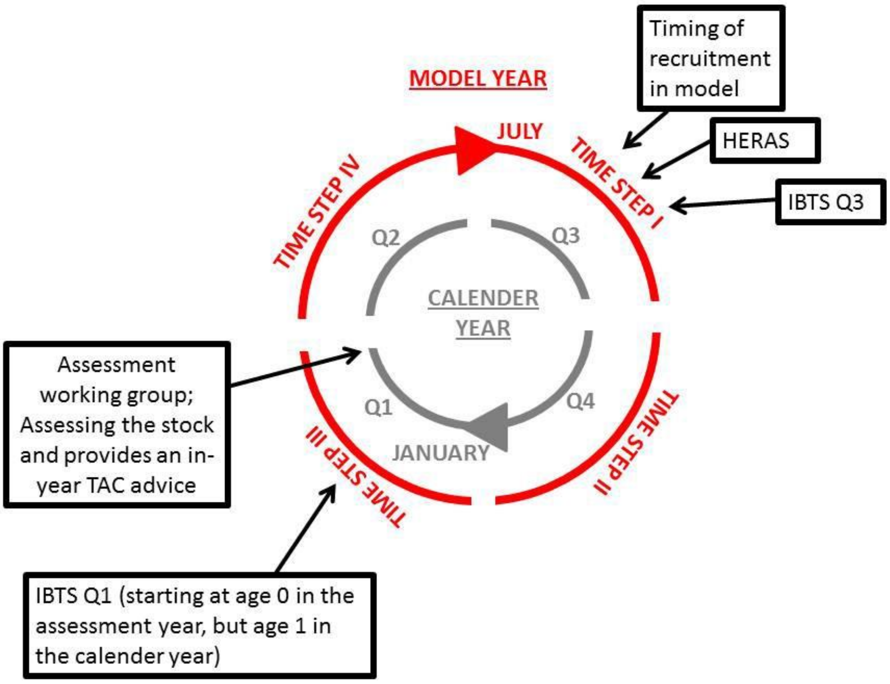
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1a) is used as a recruitment index for this stock. At the most recent benchmark, it was decided to implement a power model (directly within the assessment model) to the age-0 IBTS Q1 index to dampen the effect of very high index values. This was done to reduce the retrospective bias on recruitment (see WKSPRAT (ICES, 2018) for further details). In 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 2023 IBTS Q1 Rec value, indicative of the 2022 recruitment, was the fourth highest in the time-series, being 205% above the long-term average and 366% higher than the 2022 index. The 2022 recruitment estimated by the model is 98% higher than the 2021 recruitment and 35% above the 2012-2021 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
MODEL YEAR
JULY
HERAS
TIME STEP I
IBTS Q3
TIME STEP IV
Q2
Q3
CALENDER YEAR
Assessment working group; Assessing the stock and provides an in-year TAC advice
Q1
Q4
JANUARY
TIME STEP III
TIME STEP II
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 are 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.

Since catches in quarter 2 (season 4 in the model) 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. In the model year 2022, only 586 kg were taken in S3, i.e., quarter 1 2023, and no age samples taken. To avoid the resulting high uncertainty in the age distribution of these catches, they were transferred to 2022 S2, i.e., quarter 4 2022, leading to a total catch of 17 290 t in this quarter in the model.

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

New natural mortalities were available from the 2020 North Sea key run from WGSAM (ICES, 2021b). The major changes were changes to mean weight of whiting leading to lower mortalities particularly in the early part of the time series. HAWG 2021 (ICES, 2021a) reviewed stock assessments based on the old and new M's. The new mortalities reduced AIC of the model from 865 to 859, indicating a substantially improved fit. CVs for the catches decreased by up to 3% while survey CVs changed by -4 to +5% (average +0.2%). The CV on the terminal SSB increased by 9%. For comparison, the change from the 2019 to the 2020 assessment, both using old mortalities, was an increase in CVs for the catches of up to 4% while survey CVs changed by -5 to +20% (average +6%). The CV on the terminal SSB decreased by 20%). In summary, the AIC of the assessment using new mortalities was substantially improved and changes to estimated parameters were within the range observed in annual updates. The change in average recruitment, SSB and F over the past 20 years were 2%, -4% and +1% (new compared to old). The change to selection pattern was between -2 and 5% for age groups 1 and 2 (the F-bar ages). The group inspected the stock-recruitment plot and found no substantial changes. According to benchmark guidelines, no substantial changes in stock parameters or stock-recruitment plot would lead to the adoption of new mortalities in the assessment. However, the recent guidance from ACOM LS requires that reference points are re-estimated, and an inter-benchmark process conducted when new Ms are introduced. Given the strict time schedule for advice on this stock and the fact that the reference points according to the benchmark are estimated in a full (time consuming) MSE model, the group did not consider it feasible to conduct an inter-benchmark in time for the 2021 advice. Further, the group felt that they could not guarantee that using new mortalities would not lead to changes in reference points if these were re-estimated. Therefore, the use of the old mortalities from the 2017 North Sea key run (ICES, 2018b) was continued in the assessments onwards. Variable mortality is applied as three-year averages up till 2015, and after this the average mortality for 2013–2015 is used. 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 IBTSQ1, 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+, 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.

The model converged and fitted the catches of the main ages caught in the main seasons reasonably (ages 1–2, seasons 1 and 2, Table 10.6.2). The CVs for the catches were high, possibly hitting 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 (<0.55), 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 (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 large retrospective pattern in SSB (5-year Mohn´s rho = 0.25). The assessment model was improved with this respect during the last benchmark and Mohn´s rho was reduced by roughly a factor of 3 due to the improvement. In 2023, the retrospective patterns were further improved for both the recruitment and SSB, where 5-years Mohn´s rhos were 0.12 and 0.14 respectively, compared to >0.24 in 2022.

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

A B_{lim} of 94 000 t (Figure 10.7.1) and B_{pa} of 125 000 t were agreed at the most recent benchmark. 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 1991, with the exception of 2022 when it is estimated to be below B_{pa}. The stock is now estimated to be above B_{pa} again. The current SSB is estimated to be 65% above B_{pa}. Fishing mortality has fluctuated without a trend, but the F of 2.169 in 2021 was the third highest in the time-series. The advised TAC was based on the predicted catch at F equal to F_{cap} (0.69). 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}). 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 is a revision of the previous value of 0.7. This means, that the fishing mortality (F_{bar}(1–2)) derived from the $B_{escapement}$ strategy, should not exceed 0.69.

The forecast input is given in Table 10.9.1.

SSB in 2024 is expected to be higher than in 2023, above the long-term average and well above B_{pa} (+101%). Using the input and assumptions detailed above, the F = 0 catch option projects an SSB in July 2024 of 332 077 t (Table 10.9.2). The F_{MSY} approach prescribes the use of an F value of 0.69 (F_{cap}, see explanation above) and results in a catch advice of 143 598 t (July 2023–June 2024), which is expected to result in an SSB of 250 950 t in July 2024, i.e., well 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 (ICES, 2018a). A complete overview of the choices made during the benchmark can be found in the report (ICES, 2018a) and 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 0.12 and 0.14, respectively) is below the advised limit of 0.3 discussed 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 2023 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 units

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) 2000–2022. 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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Division 27.4.a																							
Denmark		0.1	1.1		*		*	0.8	*	*					*	*	0.1	0.1		*	0.5	*	*
Norway										*		*								0.1	*		
Sweden		0.1																					
UK (Scotland)												0.5						*	*				
Germany																*	*						*
Netherlands																*							
France																							*
Total		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1	0.5	*	*
Division 27.4.b																							
Denmark	162.9	143.9	126.1	152.9	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
Norway	0.9	5.9	*		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		
Sweden		1.4				*				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
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	163.8	151.2	126.1	152.9	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
Division 27.4.c																							
Denmark	28.2	13.1	14.8	22.3	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	
Norway	1.8	3.6					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	
UK (Scotland)									0.2			0.4					*				0.7	0.1	
UK (Engl. & Wales)	2	2	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	0.1	0.2	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	32	18.7	16.4	23.6	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

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Division 27.3.a																							
Denmark	12.8	20.2	13.4	10.2	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	6.4	7.6	4.3	5.5	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
Germany															*				*				
Faroe Islands																	*						
Total	19.2	27.7	17.7	15.7	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
Total North Sea and Skagerrak-Kattegat																							
Denmark	203.9	177.3	155.4	185.4	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
Norway	2.7	9.5	*		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		
Sweden	6.4	9.1	4.3	5.5	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
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)	2	2	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	*	0.2	0.2	*	0.3
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	215.1	197.9	161.3	192.2	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

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	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
2000	1		18 126	28 063		46 189
	2		1722	45		1767
	3		131 306	1216		132 522
	4		12 680	2718		15 398
	Total		163 834	32 042		195 876
2001	1	115	40 903	9716		50 734
	2		1071			1071

Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
2012	1		81	1649	4668	6399
	2		2924	0	909	3832
	3		26 779	307	1631	28 717
	4		47 765	6060	2728	56 553
	Total		77 549	8016	9936	95 501
2013	1		1281	3158	1296	5734
	2		32	0	443	474

Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
	3		44 174	481		44 655
	4	79	65 102	8538		73 719
	Total	194	151 249	18 735		170 177
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

Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
	3		25 577	720	211	26 509
	4		18 892	16 276	943	36 110
	Total		45 781	20 154	2893	68 827
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

Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total	Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
	3		40 051	8	1440	41 499		3		112 361	1	1328	113 690
	4	2	26 579	77	2335	28 993		4		46 411	5922	2249	54 582
	Total	49	80 533	33 627	12 204	126 413		Total	*	179 664	7551	3969	191 184
2007	1		582	247	2646	3475	2019	1		389	9 592	627	10 609
	2		241	3	1291	1535		2	2	3 606	11	379	3 999
	3		16 603		5357	21 960		3	2	95 829	7	2 249	98 087
	4	769	41 850	23 531	4761	70 911		4	49	32 750	3	2 296	35 098
	Total	769	59 276	23 781	14 055	97 881		Total	53	132 574	9 614	5 551	147 793
2008	1		2872	43	2890	5805	2020	1	3	298	1 076	378	1 746
	2		52	*	1017	1069		2		19 430	*	173	19 603
	3		21 787		636	22 423		3	2	120 890	*	4 268	125 160
	4		27 994	8334	3672	40 001		4	520	24 049	4 489	7 087	36 145
	Total		52 706	8377	8215	69 298		Total	526	164 667	5 566	11 896	182 654
2009	1		36	1268	2600	3904	2021	1	0	137	236	445	818
	2		2526	1	300	2827		2	*	326	1	11	338
	3	22	41 513		3300	44 835		3	1	63 401	902	57	64 361
	4		78 373	9336	2400	90 109		4	1	11 601	2 850	791	15 244
	Total	22	122 448	10 604	8600	141 675		Total	2	75 464	3 989	1 305	80 761
2010	1		10 976	17 072	1462	29 510	2022	1		82	85	331	499
	2		3235	3	648	3886		2		19 449		16	19 465
	3		14 220		3405	17 625		3	*	52 852			52 852
	4		62 006	35 973	4278	102 257		4	8	17 237	8	36	17 289
	Total		90 437	53 048	9793	153 278		Total	8	89 620	94	383	90 105
2011	1		3747	21 039	3216	28 002	2023	1**		*		1	1
	2		2067	3	617	2687							

Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total	Year	Quarter	Div. 27.4.a	27.4.b	27.4.c	27.3.a	Total
	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							

* < 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.

North Sea:

	Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
t	1998	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
t	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
t	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
t	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
t	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
t	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
t	2004	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
t	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
t	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
t	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
t	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
t	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
t	2010	112 395	4 410	11	119	2	18	0	1 236	577	118 769
t	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026
t	2012	67 263	8 573	2	354	0	246	0	93	411	76 943
t	2013	55 792	5 176	47	445	0	277	2	1	369	62 109
t	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280
t	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
t	2016	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
t	2017	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394
t	2018	161 536	7 528	174	716	0	366	0	24	344	170 687
t	2019	118 302	2 757	1	897	1	176	0	3	503	122 639
t	2020	140 954	6 227	19	898	93	1 188	0	11	724	150 114
t	2021	68 492	5 518	39	1 064	345	747	0	3	602	76 809
t	2022	78 825	3 854	2	439	106	400		4	192	83 823
%	1998	88.6	8.1	0.4	0.5	0	0.2	0	1.5	0.8	100
%	1999	91.4	4.2	0.2	0.6	0	0.2	0	2.9	0.4	100
%	2000	90.3	5.6	1.6	1	0	0.4	0	0.2	0.9	100
%	2001	79.9	8.2	0	1	0.1	0.2	0	10	0.7	100
%	2002	83.9	9.9	1.2	1.5	0	0.4	0	2.4	0.5	100
%	2003	88.8	5.3	0.4	0.6	0	0.4	0	2.8	1.8	100
%	2004	89.6	5	0.2	0.2	0	2.2	0	1.9	0.9	100
%	2005	85.9	9	1.1	0.2	0	0.4	0	2.9	0.4	100
%	2006	86	7.5	0.5	0.3	0	0.8	0	4.5	0.5	100
%	2007	90.3	8	0.2	1.1	0	0.2	0	0	0.3	100
%	2008	85.4	11.1	0	0.5	0	0.5	0	0	2.4	100
%	2009	92.1	5.9	0	0.3	0	0.1	0	1.2	0.3	100
%	2010	94.6	3.7	0	0.1	0	0	0	1	0.5	100
%	2011	91.1	6.7	0	0.2	0	0.1	0	1.6	0.3	100
%	2012	87.4	11.1	0	0.5	0	0.3	0	0.1	0.5	100
%	2013	89.8	8.3	0.1	0.7	0	0.4	0	0	0.6	100
%	2014	89.7	8.3	0	0.7	0	0.1	0	0	1.2	100
%	2015	96.2	1.7	0	0.7	0	0.2	0	0.1	1.2	100
%	2016	91.5	5.3	0	2	0	0.2	0	0	1	100

Division 3.a:

	Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
t	1998	9 143	3 385	230	467	54	0	49	7	2 866	16 202
t	1999	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
t	2000	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
t	2001	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
t	2002	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
t	2003	8 182	4 928	340	252	4	4	4	1	567	14 282
t	2004	13 374	4 620	97	976	18	24	27	116	2 155	21 408
t	2005	30 157	6 171	244	871	63	18	20	746	1 758	40 047
t	2006	6 814	2 852	215	276	13	3	45	1	232	10 451
t	2007	7 116	2 043	34	190	31	8	4	1	469	9 896
t	2008	4 805	1 948	14	285	0	0	11	462	39	7 563
t	2009	4 839	3 016	37	169	15	0	1	53	47	8 177
t	2010	2 851	2 134	25	142	6	1	2	135	171	5 466
t	2011	4 754	2 461	0	43	0	7	1	141	40	7 447
t	2012	5 707	5 495	9	149	7	10	5	0	228	11 610
t	2013	1 143	1 751	2	46	0	0	1	1	27	2 971
t	2014	16 751	3 777	5	343	1	20	5	12	888	21 801
t	2015	11 448	5 831	0	565	0	29	8	1	154	18 036
t	2016	7 001	2 140	0	335	1	19	3	0	78	9 579
t	2017	963	328	0	172	0	19	1	0	32	1 515
t	2018	2 872	257	2	150	1	11	0	0	12	3 304
t	2019	3 429	351	0	59	0	2	0	0	8	3 850
t	2020	9 494	551	4	249	5	41	1	0	27	10 372
t	2021	638	82	0	13	1	1	0	0	32	767
t	2022	302	20	0	1	0	1	0	0	32	356
%	1998	56.4	20.9	1.4	2.9	0.3	0	0.3	0	17.7	100
%	1999	50.7	25.9	0.4	3.1	0.6	0	0.2	10.2	8.8	100
%	2000	49.1	31.4	0	4.1	1.2	0	0.2	0.1	13.9	100
%	2001	54.6	24.5	0.2	3.8	0.2	0	0.1	12.8	3.8	100
%	2002	40.1	45.5	0.1	4.1	0	0	0.1	2.1	8	100
%	2003	57.3	34.5	2.4	1.8	0	0	0	0	4	100
%	2004	62.5	21.6	0.5	4.6	0.1	0.1	0.1	0.5	10.1	100
%	2005	75.3	15.4	0.6	2.2	0.2	0	0	1.9	4.4	100
%	2006	65.2	27.3	2.1	2.6	0.1	0	0.4	0	2.2	100
%	2007	71.9	20.6	0.3	1.9	0.3	0.1	0	0	4.7	100
%	2008	63.5	25.8	0.2	3.8	0	0	0.1	6.1	0.5	100
%	2009	59.2	36.9	0.5	2.1	0.2	0	0	0.6	0.6	100
%	2010	52.2	39	0.5	2.6	0.1	0	0	2.5	3.1	100
%	2011	63.8	33	0	0.6	0	0.1	0	1.9	0.5	100
%	2012	49.2	47.3	0.1	1.3	0.1	0.1	0	0	2	100
%	2013	38.5	58.9	0.1	1.6	0	0	0	0	0.9	100
%	2014	76.8	17.3	0	1.6	0	0.1	0	0.1	4.1	100
%	2015	63.5	32.3	0	3.1	0	0.2	0	0	0.9	100
%	2016	73.1	22.3	0	3.5	0	0.2	0	0	0.8	100

	Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total		Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
%	2017	83.8	4.3	0	1.1	0	0.2	0	0.4	10.3	100	%	2017	63.6	21.6	0	11.4	0	1.2	0.1	0	2.1	100
%	2018	94.6	4.4	0.1	0.4	0	0.2	0	0	0.2	100	%	2018	86.9	7.8	0.1	4.5	0	0.3	0	0	0.4	100
%	2019	96.5	2.2	0	0.7	0	0.1	0	0	0.4	100	%	2019	89.1	9.1	0	1.5	0	0.1	0	0	0.2	100
%	2020	93.9	4.1	0	0.6	0.1	0.8	0	0	0.5	100	%	2020	91.5	5.3	0	2.4	0	0.4	0	0	0.3	100
%	2021	90.0	6.3	0.1	1.4	0.5	1.0	0.0	0.0	0.8	100	%	2021	83.1	10.7	0.0	1.6	0.2	0.1	0.0	0.0	4.2	100
%	2022	94.0	4.6	0.0	0.5	0.1	0.5	0.0	0.0	0.2	100	%	2022	84.8	5.6	0.0	0.3	0.0	0.4	0.0	0.0	8.9	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					
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
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

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					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
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

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					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
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

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					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
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

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					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
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	799272	2399200	1041391	139590
2019	3	211007	34475	3918	413
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 have 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	233794.6	803967.8	392200.2	138805.2
2021	3	50586.52	9703.778	711.0113	7.420633
2021	4	0	0	0	0
2022	1	362861.6	7104276	814121.1	99399.03
2022	2	791194.7	269013.3	338847.8	106443
2022	3	0	0	0	0
2022	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

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**
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
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

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**
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
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

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**
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
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

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**
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
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

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**
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	0.0063	0.0088	0.0116
2019	2	0.0041	0.0076	0.0098	0.0141
2019	3	0.0058	0.0010	0.0130	0.0165
2019	4	0.0064	0.0078	0.0105	0.0157
2020	1	0.0049	0.0093	0.0122	0.0162
2020	2	0.0071	0.0108	0.0144	0.0172
2020	3	0.0057	0.0100	0.0143	0.0165
2020	4	0.0065	0.0103	0.0134	0.0161
2021	1	0.0061	0.0071	0.0110	0.0131
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	0.0078	0.0127	0.0171	0.0188
2022	3	0.0058	0.0100	0.0143	0.0165
2022	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 2022. 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	0.4	0	0	0
	2	18.0	9	891	370
	3	47.1	41	4065	1933
	4	14.5	19	1905	951
	Total	80.1	69	6831	3254
Norway	1	0.0	0	0	0
	2	0.0	0	0	0
	3	0.0	0	0	0
	4	0.0	0	0	0
	Total	0.0	0	0	0
Sweden	1	0.0	0	0	0
	2	0.0	0	0	0
	3	4.3	0	0	0
	4	2.3	8	599	596
	Total	6.6	8	599	596
All countries	1	0.5	0	0	0
	2	19.5	9	891	370
	3	52.9	41	4065	1933
	4	17.3	27	2504	1547
Total		90.1	77	7460	3850

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
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

Year	S1	S2	S3	S4
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	26	0	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
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

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**
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

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
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

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**
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

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
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

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, 2018b) 2017 key run.

Year	Season	age 0	age 1	age 2	age 3
1974	1	0.483	0.456	0.402	0.280
1974	2	0.327	0.235	0.217	0.188
1974	3	0.297	0.275	0.175	0.175
1974	4	0.445	0.409	0.318	0.318
1975	1	0.518	0.492	0.422	0.237
1975	2	0.289	0.220	0.200	0.169
1975	3	0.329	0.299	0.218	0.218
1975	4	0.474	0.442	0.423	0.423
1976	1	0.490	0.466	0.415	0.290
1976	2	0.318	0.242	0.225	0.195
1976	3	0.364	0.332	0.240	0.240
1976	4	0.485	0.443	0.421	0.421
1977	1	0.441	0.411	0.368	0.312
1977	2	0.373	0.245	0.227	0.199
1977	3	0.380	0.351	0.248	0.248
1977	4	0.490	0.440	0.432	0.432
1978	1	0.411	0.398	0.385	0.330
1978	2	0.347	0.230	0.218	0.192
1978	3	0.382	0.356	0.208	0.208
1978	4	0.445	0.396	0.374	0.374
1979	1	0.436	0.424	0.419	0.405
1979	2	0.416	0.252	0.245	0.227
1979	3	0.393	0.366	0.232	0.232
1979	4	0.444	0.389	0.377	0.377
1980	1	0.470	0.464	0.444	0.415
1980	2	0.447	0.261	0.257	0.230
1980	3	0.388	0.355	0.232	0.232
1980	4	0.419	0.372	0.336	0.336
1981	1	0.501	0.486	0.448	0.360
1981	2	0.409	0.271	0.267	0.232
1981	3	0.361	0.314	0.222	0.222
1981	4	0.376	0.330	0.267	0.267
1982	1	0.511	0.431	0.377	0.245
1982	2	0.331	0.231	0.217	0.177
1982	3	0.305	0.231	0.182	0.182
1982	4	0.318	0.277	0.205	0.205
1983	1	0.532	0.429	0.349	0.224
1983	2	0.336	0.235	0.217	0.194
1983	3	0.296	0.207	0.173	0.173

Year	Season	age 0	age 1	age 2	age 3
1983	4	0.312	0.259	0.168	0.168
1984	1	0.539	0.425	0.287	0.182
1984	2	0.397	0.236	0.209	0.189
1984	3	0.309	0.239	0.177	0.177
1984	4	0.321	0.274	0.197	0.197
1985	1	0.549	0.502	0.373	0.198
1985	2	0.482	0.277	0.251	0.210
1985	3	0.323	0.249	0.178	0.178
1985	4	0.318	0.269	0.165	0.165
1986	1	0.590	0.534	0.422	0.254
1986	2	0.452	0.313	0.288	0.227
1986	3	0.346	0.258	0.188	0.188
1986	4	0.335	0.284	0.169	0.169
1987	1	0.596	0.484	0.443	0.256
1987	2	0.470	0.315	0.299	0.232
1987	3	0.356	0.217	0.190	0.190
1987	4	0.338	0.281	0.185	0.185
1988	1	0.622	0.502	0.455	0.258
1988	2	0.493	0.342	0.316	0.270
1988	3	0.371	0.238	0.220	0.220
1988	4	0.361	0.301	0.233	0.233
1989	1	0.603	0.509	0.433	0.214
1989	2	0.525	0.332	0.294	0.261
1989	3	0.356	0.228	0.221	0.221
1989	4	0.374	0.312	0.281	0.281
1990	1	0.518	0.489	0.402	0.244
1990	2	0.496	0.331	0.283	0.261
1990	3	0.337	0.260	0.249	0.249
1990	4	0.387	0.319	0.287	0.287
1991	1	0.462	0.423	0.320	0.263
1991	2	0.396	0.269	0.232	0.211
1991	3	0.310	0.264	0.223	0.223
1991	4	0.389	0.320	0.287	0.287
1992	1	0.410	0.360	0.281	0.255
1992	2	0.312	0.227	0.204	0.180
1992	3	0.294	0.275	0.212	0.212
1992	4	0.371	0.299	0.270	0.270
1993	1	0.456	0.414	0.340	0.303
1993	2	0.238	0.209	0.190	0.173
1993	3	0.272	0.253	0.192	0.192

Year	Season	age 0	age 1	age 2	age 3
1993	4	0.347	0.274	0.244	0.244
1994	1	0.502	0.446	0.348	0.337
1994	2	0.292	0.223	0.197	0.182
1994	3	0.258	0.219	0.190	0.190
1994	4	0.318	0.248	0.223	0.223
1995	1	0.512	0.460	0.338	0.308
1995	2	0.290	0.223	0.195	0.182
1995	3	0.222	0.191	0.178	0.178
1995	4	0.265	0.211	0.190	0.190
1996	1	0.504	0.395	0.263	0.214
1996	2	0.363	0.227	0.202	0.177
1996	3	0.215	0.171	0.151	0.151
1996	4	0.238	0.195	0.156	0.156
1997	1	0.451	0.293	0.210	0.155
1997	2	0.298	0.204	0.187	0.154
1997	3	0.227	0.193	0.171	0.171
1997	4	0.269	0.214	0.171	0.171
1998	1	0.430	0.283	0.226	0.190
1998	2	0.362	0.197	0.176	0.145
1998	3	0.252	0.209	0.173	0.173
1998	4	0.318	0.245	0.197	0.197
1999	1	0.421	0.287	0.232	0.214
1999	2	0.291	0.191	0.169	0.152
1999	3	0.275	0.241	0.191	0.191
1999	4	0.335	0.267	0.242	0.242
2000	1	0.406	0.342	0.253	0.219
2000	2	0.355	0.199	0.180	0.170
2000	3	0.254	0.213	0.157	0.157
2000	4	0.279	0.236	0.192	0.192
2001	1	0.409	0.328	0.233	0.190
2001	2	0.299	0.213	0.202	0.195
2001	3	0.266	0.225	0.191	0.191
2001	4	0.306	0.258	0.213	0.213
2002	1	0.434	0.321	0.240	0.171
2002	2	0.315	0.223	0.214	0.206
2002	3	0.252	0.206	0.194	0.194
2002	4	0.323	0.262	0.218	0.218
2003	1	0.419	0.269	0.215	0.168
2003	2	0.295	0.229	0.208	0.204
2003	3	0.259	0.229	0.226	0.226

Year	Season	age 0	age 1	age 2	age 3
2003	4	0.383	0.308	0.286	0.286
2004	1	0.436	0.276	0.231	0.192
2004	2	0.278	0.216	0.193	0.185
2004	3	0.231	0.212	0.208	0.208
2004	4	0.376	0.302	0.278	0.278
2005	1	0.442	0.321	0.227	0.216
2005	2	0.309	0.219	0.181	0.174
2005	3	0.220	0.201	0.179	0.179
2005	4	0.367	0.291	0.225	0.225
2006	1	0.504	0.315	0.226	0.215
2006	2	0.265	0.212	0.172	0.166
2006	3	0.217	0.197	0.172	0.172
2006	4	0.364	0.277	0.202	0.202
2007	1	0.480	0.312	0.204	0.184
2007	2	0.287	0.222	0.170	0.166
2007	3	0.210	0.175	0.152	0.152
2007	4	0.312	0.237	0.175	0.175
2008	1	0.478	0.307	0.187	0.166
2008	2	0.269	0.203	0.157	0.151
2008	3	0.200	0.173	0.167	0.167
2008	4	0.304	0.225	0.197	0.197
2009	1	0.444	0.362	0.233	0.162
2009	2	0.327	0.200	0.158	0.150
2009	3	0.190	0.170	0.163	0.163
2009	4	0.293	0.215	0.190	0.190
2010	1	0.527	0.412	0.312	0.170
2010	2	0.395	0.217	0.179	0.164
2010	3	0.207	0.182	0.159	0.159
2010	4	0.309	0.226	0.197	0.197
2011	1	0.511	0.437	0.386	0.182
2011	2	0.381	0.239	0.193	0.179
2011	3	0.229	0.202	0.179	0.179
2011	4	0.338	0.254	0.224	0.224
2012	1	0.509	0.432	0.344	0.176
2012	2	0.368	0.238	0.191	0.178
2012	3	0.219	0.176	0.145	0.145
2012	4	0.292	0.225	0.180	0.180
2013	1	0.399	0.367	0.285	0.150
2013	2	0.271	0.209	0.164	0.158
2013	3	0.206	0.175	0.148	0.148

Year	Season	age 0	age 1	age 2	age 3
2013	4	0.270	0.221	0.178	0.178
2014	1	0.367	0.335	0.245	0.140
2014	2	0.257	0.198	0.167	0.154
2014	3	0.211	0.181	0.153	0.153
2014	4	0.272	0.227	0.184	0.184
2015	1	0.365	0.339	0.249	0.139
2015	2	0.237	0.194	0.164	0.149
2015	3	0.212	0.177	0.149	0.149
2015	4	0.278	0.224	0.181	0.181
2016	1	0.377	0.347	0.260	0.143
2016	2	0.255	0.200	0.165	0.153
2016	3	0.212	0.177	0.149	0.149
2016	4	0.278	0.224	0.181	0.181
2017	1	0.377	0.347	0.260	0.143
2017	2	0.255	0.200	0.165	0.153
2017	3	0.212	0.177	0.149	0.149
2017	4	0.278	0.224	0.181	0.181
2018	1	0.377	0.347	0.260	0.143
2018	2	0.255	0.200	0.165	0.153
2018	3	0.212	0.177	0.149	0.149
2018	4	0.278	0.224	0.181	0.181
2019	1	0.377	0.347	0.260	0.143
2019	2	0.255	0.200	0.165	0.153
2019	3	0.212	0.177	0.149	0.149
2019	4	0.278	0.224	0.181	0.181
2020	1	0.377	0.347	0.260	0.143
2020	2	0.255	0.200	0.165	0.153
2020	3	0.212	0.177	0.149	0.149
2020	4	0.278	0.224	0.181	0.181
2021	1	0.377	0.347	0.260	0.143
2021	2	0.255	0.200	0.165	0.153
2021	3	0.212	0.177	0.149	0.149
2021	4	0.278	0.224	0.181	0.181
2022	1	0.377	0.347	0.260	0.143
2022	2	0.255	0.200	0.165	0.153
2022	3	0.212	0.177	0.149	0.149
2022	4	0.278	0.224	0.181	0.181

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 03/15/23 Start time:14:56:48 run time:2 seconds

objective function (negative log likelihood): 334.326

Number of parameters: 145

Maximum gradient: 0.000235226

Akaike information criterion (AIC): 958.652

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
784	308	49	0	1141

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
448.7	-115.5	10.8	0.0	0.0	0.00	344

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.57	-0.37	0.22	0.00

contribution by fleet:

IBTS Q1 Rec total: -32.068 mean: -0.782

IBTS Q1 total: -50.983 mean: -0.414

IBTS Q3 total: -23.901 mean: -0.257

Acoustic total: -8.541 mean: -0.167

F, Year effect:

1974: 1.000

1975: 1.787

1976: 1.854

1977: 1.619

1978: 1.038

1979: 0.648

1980: 2.531

1981: 1.296

1982: 1.095

1983: 1.780

1984: 0.981

1985: 1.420

1986: 1.385

1987: 0.409

1988: 1.382

1989: 0.441

1990: 1.684

1991: 0.922

1992: 0.997

1993: 1.682

1994: 0.846

1995: 1.339

1996: 1.525

1997: 1.128

1998: 1.869

1999: 1.007

2000: 1.661

2001: 1.731

2002: 1.780

2003: 1.407

2004: 2.203

2005: 1.445

2006: 1.769

2007: 1.812

2008: 1.692

2009: 0.989

2010: 1.169

2011: 1.014

2012: 1.469

2013: 1.569

2014: 0.708

2015: 1.342

2016: 2.437

2017: 1.555

2018: 1.620

2019: 1.326

2020: 2.081

2021: 2.104

2022: 1.719

```
F, season effect:
-----------------
age: 0
   1974-2022:   0.038 0.203 0.345 0.250
age: 1
   1974-2022:   0.568 0.525 0.186 0.250
age: 2
   1974-2022:   0.243 0.477 0.105 0.250
age: 3
   1974-2022:   0.228 0.600 0.326 0.250


F, age effect:
--------------
            0     1     2     3
1974-2022:  0.037  0.403  1.494  1.494


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                  0     1     2     3
1974-2022 season 1:  0.001  0.206  0.327  0.307
       season 2:  0.007  0.190  0.641  0.806
       season 3:  0.012  0.068  0.142  0.438
       season 4:  0.008  0.091  0.336  0.336
```

sqrt(catch variance) ~ CV:

----

	season			
age	1	2	3	4
0	1.414	1.414	1.314	0.100
1	0.880	0.856	1.414	0.100
2	0.983	1.070	1.414	0.100
3	0.983	1.070	1.414	0.100

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1 Rec	0.845			
IBTS Q1		1.690	3.196	7.059
IBTS Q3		0.941	1.202	1.205
Acoustic		1.309	2.662	7.091

Stock size dependent catchability (power model)

---	age 0	age 1	age 2	age 3
IBTS Q1 Rec	1.91			
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		0.40	0.40	0.40
IBTS Q3		0.53	0.44	0.44
Acoustic		0.47	0.54	0.54

Average F:

----

	sp. 1
1974:	1.106
1975:	1.689
1976:	1.773
1977:	1.596
1978:	1.015
1979:	0.640
1980:	2.328
1981:	1.195
1982:	0.998
1983:	1.593
1984:	0.916
1985:	1.274
1986:	1.236
1987:	0.372
1988:	1.253
1989:	0.415
1990:	1.566
1991:	0.891

1992: 0.966

1993: 1.545

1994: 0.780

1995: 1.203

1996: 1.379

1997: 1.062

1998: 1.745

1999: 0.975

2000: 1.531

2001: 1.631

2002: 1.676

2003: 1.389

2004: 2.104

2005: 1.373

2006: 1.657

2007: 1.680

2008: 1.585

2009: 0.920

2010: 1.062

2011: 0.920

2012: 1.307

2013: 1.418

2014: 0.662

2015: 1.233

2016: 2.197

2017: 1.419

2018: 1.477

2019: 1.215

2020: 1.884

2021: 1.904

2022: 1.396

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1287.509	9.000e+04	0.572	0.75

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	536673000	330665000	236695000	173689000	140026000	70559500	45126000	31803600	10118000	4705470	1855070	1330460	586582	315322	106576	54978
1975	707297000	420125000	310293000	218183000	110281000	44776100	24617000	15965900	19098700	6537050	1495880	907761	693924	297743	50604	17043
1976	330657000	202091000	145008000	98380200	135880000	55759200	29586300	18458000	10266000	3454320	735280	431867	605887	240887	37600	11990
1977	627792000	403187000	274303000	183785000	60549400	27718300	15409700	9601550	11851500	4550370	1141780	690270	291411	122767	23543	8348
1978	1087750000	720014000	504789000	340017000	112641000	59660900	38042600	24635000	6185790	2885690	1105900	763118	453607	228906	74430	36479
1979	562257000	363173000	238386000	159531000	217941000	122967000	83330600	55038300	16573100	8614050	4246140	3041760	550050	294245	131184	75906
1980	331334000	206338000	129404000	84993600	102295000	36049900	16252000	9420180	37288300	9531500	1211840	644871	2138550	595484	48890	11300
1981	79910900	48346300	31791200	21800000	55901700	25561800	14815800	9821200	6492560	2589740	786246	513331	468731	210082	52088	22184
1982	38772500	23233800	16545700	12022900	14962100	7565040	4765050	3482460	7058800	3249950	1197950	840454	410060	220858	69241	33861
1983	56639000	33172800	23382400	16994600	8748080	3790340	2055790	1462570	2640250	974982	220298	139994	711999	310035	51726	18282
1984	36687000	21379600	14273800	10348900	12436600	6492360	4168370	3050280	1128350	592640	238821	171367	133755	79767	27384	14222
1985	25241800	14544800	8884510	6317940	7504210	3283370	1843270	1291710	2318740	952523	269078	180168	152363	77005	17468	7325
1986	63356800	35058100	22071000	15340400	4595550	1962770	1070600	745062	986708	391118	109184	72760	158969	76854	17675	7462
1987	40589000	22352600	13921900	9697370	10971600	6157940	4120030	3217050	560618	310220	171793	133200	67728	45588	25055	16977
1988	64355300	34499300	20856400	14132100	6916950	3052190	1618880	1149550	2428930	932095	253620	163734	124858	60183	13298	5445
1989	51642500	28226000	16636100	11586400	9846330	5349790	3496420	2691800	850408	469711	255690	191198	134072	93131	48325	31253
1990	74941200	44545400	26792700	18718200	7969890	3324210	1672540	1136150	1970700	714366	161903	96823	167894	74048	12602	4327
1991	96272600	60561800	40492700	29337700	12711900	6741760	4237300	3036970	826176	428938	176194	121867	75931	42617	15090	7702
1992	86768000	57496900	41767700	30733600	19885300	11043100	7129380	5023650	2205050	1158250	464116	320879	97227	53641	18327	9124
1993	93452600	59119000	45991600	34281000	21213800	9542280	5425960	3712330	3725200	1437650	358137	226766	251856	104759	19478	7084
1994	99795400	60309700	44735200	34199900	24218700	12768300	8539130	6433780	2821590	1464530	657912	476136	183231	98068	38295	20972
1995	38858100	23241800	17211500	13550000	24890000	11569400	6971910	5209130	5021860	2199610	695896	471708	397783	185219	46472	20262
1996	55155400	33241600	22853300	18077200	10399400	4940000	2850720	2141570	4218440	1861680	512465	346568	406982	195286	41666	17046

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
1997	50673700	32221700	23726200	18630000	14249400	8210400	5273360	3994130	1762470	947446	351272	247927	311053	181304	56511	27502
1998	114831000	74530500	51175800	38847500	14235000	6995820	3868500	2727990	3223720	1302630	287845	180451	232134	101440	16410	5557
1999	75668400	49576700	36793300	27600500	28270400	16843100	11248500	8196990	2134640	1172820	482518	340137	152790	87459	30424	15388
2000	74044000	49218400	34074000	25880700	19751400	9597250	5536270	3948500	6275410	2663050	680096	447575	279010	127260	24219	9222
2001	58811500	38981100	28526900	21372600	19587400	9495420	5320440	3728330	3119500	1316780	313041	196885	376970	172721	30104	10705
2002	80273300	51853400	37318200	28352700	15733700	7589360	4168540	2966990	2879250	1185040	268688	167156	167731	77046	12705	4396
2003	102228000	67076400	49419300	37459300	20533500	11367600	6714790	4803400	2283990	1103630	328238	209873	137977	72136	16645	6693
2004	161300000	103938000	77411900	59724700	25550400	11708000	5918670	4057690	3529570	1257670	215455	123754	162707	63340	7298	2028
2005	61186300	39261200	28504900	22443200	41016700	21382500	12656200	9287630	2998960	1412960	420496	279949	95219	46863	10775	4456
2006	78291800	47181200	35726300	28107700	15552300	7573210	4215380	3030890	6940420	2910400	693262	441579	227103	100211	17360	6173
2007	60113700	37098500	27449300	21731500	19526200	9437020	5152470	3775260	2297070	968800	224295	144823	365736	163959	27326	9711
2008	115587000	71505100	53956200	43207300	15901600	7944380	4532260	3356590	2977260	1334130	341095	221224	129722	61685	11630	4319
2009	98347200	62987100	45077900	36789400	31881500	17701500	11755100	9209670	2679100	1481100	624916	454197	185232	112397	39852	20912
2010	89665300	52838000	35271300	28256400	27458500	13909800	8742300	6673370	7425620	3552620	1289520	914784	393015	222426	66149	31924
2011	93113000	55793500	37830000	29706400	20746100	10625600	6754500	5113380	5321390	2502240	1000270	712738	777600	458749	154390	78759
2012	66617700	39952000	27335700	21549200	21185500	9830710	5677140	4264190	3967950	1648810	477715	327828	632455	321314	72009	30456
2013	125612000	84086800	63362900	50511800	16095700	7785080	4534570	3382990	3404630	1446530	400909	269995	299378	150952	31560	12674
2014	147542000	102116000	78518600	62975000	38561000	23456200	16560000	13103700	2712600	1641090	838037	643021	236510	161516	73403	44601
2015	82155700	56917600	44448900	35331000	47980900	25135000	15592200	11806600	10441700	4995930	1628050	1135510	572233	314900	81391	36478
2016	138704000	94802700	72105400	56511300	26758900	10823700	5290780	3689570	9433850	2998420	446850	262301	978404	369293	35588	9357
2017	160923000	110128000	84323700	66842800	42800400	21188600	12483400	9302620	2948100	1291630	361279	243683	226788	115667	24599	9940
2018	137708000	94231900	72116800	57118600	50625200	24691200	14347700	10639600	7433110	3180320	849144	566901	211731	105614	21186	8294
2019	131797000	90224400	69203800	55019000	43260300	22565900	13953000	10577900	8501430	4047270	1332390	931605	480188	264750	69106	31211
2020	82959600	56730800	43265200	34064200	41670200	18286700	9638160	6903620	8452080	3057780	587484	364738	803783	342562	45433	14208

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
2021	74991900	51280500	39101800	30777200	25799500	11262900	5907610	4224250	5516230	1979150	374106	231429	316354	133780	17383	5376
2022	148669000	101718000	77787800	62909400	23309900	11114900	6325240	5298050	3375320	1393240	346705	298714	197691	95346	17506	15082
2023	0				47646100				4233320				261965			

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	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
1974	536673000	975214801	295337918	606751	995848	369682	463344	1.106	1.734	0.706
1975	707297000	1259146982	397307902	615149	999320	378666	732312	1.689	2.517	1.134
1976	330657000	580527309	188335760	498822	817360	304423	628598	1.773	2.572	1.222
1977	627792000	1077142496	365896617	339628	527433	218695	385257	1.596	2.331	1.092
1978	1087750000	2068720591	571947738	388524	616186	244976	458804	1.015	1.731	0.596
1979	562257000	1014386372	311649429	650101	1125002	375672	463638	0.64	1.248	0.328
1980	331334000	526496916	208514459	456364	782266	266237	387434	2.328	3.21	1.689
1981	79910900	119083654	53624084	305247	457447	203686	280582	1.195	1.816	0.787
1982	38772500	49131157	30597829	165424	248814	109982	162357	0.998	1.434	0.694
1983	56639000	71825291	44663603	72603	92743	56836	115440	1.593	1.956	1.298
1984	36687000	47758155	28182328	55173	67631	45010	113444	0.916	1.272	0.66
1985	25241800	33230366	19173682	58741	73147	47171	62514	1.274	1.628	0.997
1986	63356800	80266356	50009547	24647	31238	19447	27520	1.236	1.587	0.963
1987	40589000	52376425	31454360	45388	56283	36603	53942	0.372	0.57	0.242
1988	64355300	82780081	50031416	50938	62239	41689	103652	1.253	1.566	1.003
1989	51642500	66385031	40173933	44220	54920	35604	58420	0.415	0.767	0.225
1990	74941200	94059587	59708783	40318	50564	32148	78180	1.566	1.93	1.27
1991	96272600	120346871	77014163	86753	106909	70397	125815	0.891	1.23	0.645
1992	86768000	108201767	69580064	105823	128769	86966	156471	0.966	1.28	0.729
1993	93452600	118040615	73986301	137855	166959	113825	208848	1.545	1.85	1.291
1994	99795400	125097892	79610629	91894	112198	75263	424206	0.78	1.035	0.588
1995	38858100	49134440	30731030	139212	168755	114841	446555	1.203	1.485	0.974
1996	55155400	69001085	44087976	105229	127623	86764	95496	1.379	1.692	1.125
1997	50673700	63548870	40407074	102068	124036	83991	125174	1.062	1.378	0.818
1998	114831000	143361985	91978069	132016	160048	108894	188907	1.745	2.055	1.483
1999	75668400	94638560	60500781	135732	165977	110998	243158	0.975	1.296	0.733
2000	74044000	92469917	59289703	184584	224264	151925	222027	1.531	1.869	1.254
2001	58811500	73312807	47178558	124865	151563	102870	153321	1.631	1.975	1.346
2002	80273300	100293920	64249186	107840	130753	88942	174713	1.676	2.002	1.403
2003	102228000	127751565	81803804	136758	166493	112333	174988	1.389	1.726	1.118
2004	161300000	203130063	128083897	166168	201959	136720	231352	2.104	2.437	1.816
2005	61186300	75855248	49354045	197987	244683	160203	280275	1.373	1.687	1.118
2006	78291800	97039310	63166215	152849	186454	125301	78028	1.657	1.984	1.384
2007	60113700	74382202	48582279	126320	152647	104534	99902	1.68	1.996	1.414
2008	115587000	143555273	93067669	98402	118582	81656	69892	1.585	1.91	1.316
2009	98347200	122135968	79191838	156305	189722	128774	170934	0.92	1.222	0.692

Year	Recruitment (thousands)	High	Low	SSB (tonnes)	High	Low	Catches (tonnes)	F ages 1-2 (per year)	High	Low
2010	89665300	111842363	71885695	157604	190313	130517	145415	1.062	1.362	0.828
2011	93113000	115498812	75065973	129007	155055	107335	122472	0.92	1.23	0.689
2012	66617700	82291789	53929050	120790	145076	100570	96030	1.307	1.607	1.062
2013	125612000	157830966	99970081	103055	124269	85462	60207	1.418	1.778	1.131
2014	147542000	187486718	116107647	163494	199985	133662	190268	0.662	0.913	0.48
2015	82155700	102938333	65568956	263242	323604	214139	298227	1.233	1.536	0.99
2016	138704000	172975735	111222534	190090	232612	155341	227169	2.197	2.5	1.93
2017	160923000	202551977	127849712	174785	214447	142458	135824	1.419	1.726	1.166
2018	137708000	174613624	108602598	195150	238926	159395	190779	1.477	1.781	1.224
2019	131797000	166208265	104510141	183614	225959	149205	137489	1.215	1.559	0.947
2020	82959600	103413467	66551247	260337	320587	211410	181990	1.884	2.209	1.607
2021	74991900	95911286	58635280	131539	160395	107874	80266	1.904	2.254	1.609
2022	148669000	201874078	109486427	114861	141104	93499	89605	1.396	1.83	1.064
2023	109840549*			206581	268259	159084				

* 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)	109841	47646	4233	262
Exploitation pattern S1	0.00	0.48	0.77	0.72
Exploitation pattern S2	0.02	0.45	1.50	1.89
Exploitation pattern S3	0.03	0.16	0.33	1.02
Exploitation pattern S4	0.00	0.00	0.00	0.00
Weight in the stock S1 (gram)	5.71	8.27	11.34	14.27
Weight in the catch S1 (gram)	5.71	8.27	11.34	14.27
Weight in the catch S2 (gram)	7.00	10.70	14.30	17.12
Weight in the catch S3 (gram)	6.39	10.36	13.73	16.88
Weight in the catch S4 (gram)	6.64	9.73	12.27	15.93
Proportion mature(2021)	0.00	0.41	0.87	0.95
Proportion mature(2022)	0.00	0.41	0.87	0.95
Natural mortality S1	0.38	0.35	0.26	0.14
Natural mortality S2	0.26	0.20	0.16	0.15
Natural mortality S3	0.21	0.18	0.15	0.15
Natural mortality S4	0.28	0.22	0.18	0.18

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}	143598	0.69	250950	21%	109%
F=0.0	0	0.0	332077	61%	-100%
F=0.1	25441	0.1	317464	54%	-63%
F=0.2	49069	0.2	303974	47%	-29%
F=0.3	71051	0.3	291502	41%	3%
F=0.4	91533	0.4	279954	36%	33%
F=0.5	110645	0.5	269245	30%	61%
F=0.6	128506	0.6	259301	26%	87%
F=0.7	145220	0.7	250055	21%	111%
F=0.8	160881	0.8	241448	17%	134%
F=0.9	175575	0.9	233425	13%	156%
F=1.0	189376	1.0	225938	9%	176%
$B_{escapement}$ without F_{cap}	394098	4.14	125000	-39%	474%

* 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.

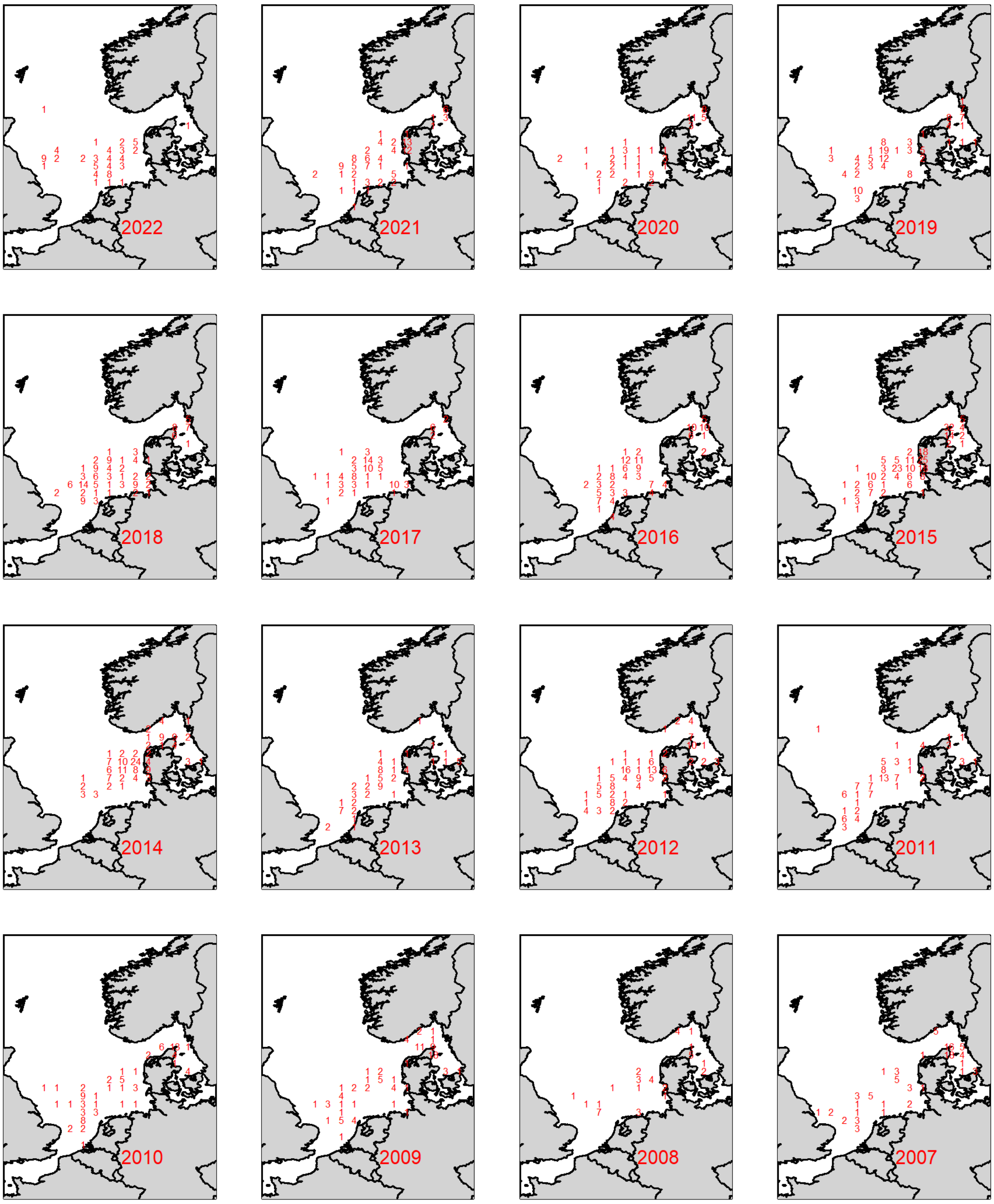


Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

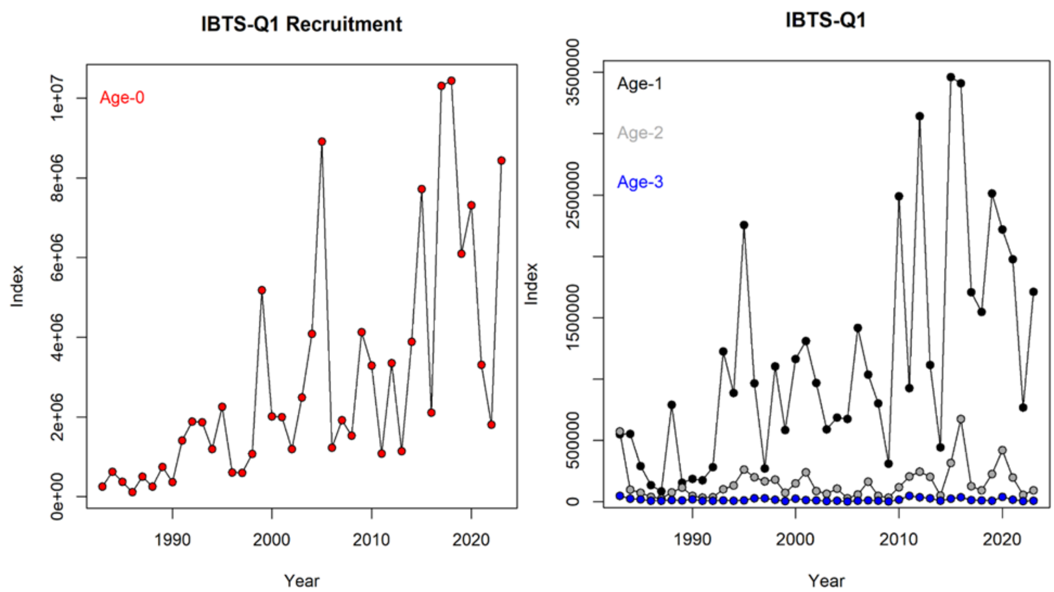


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

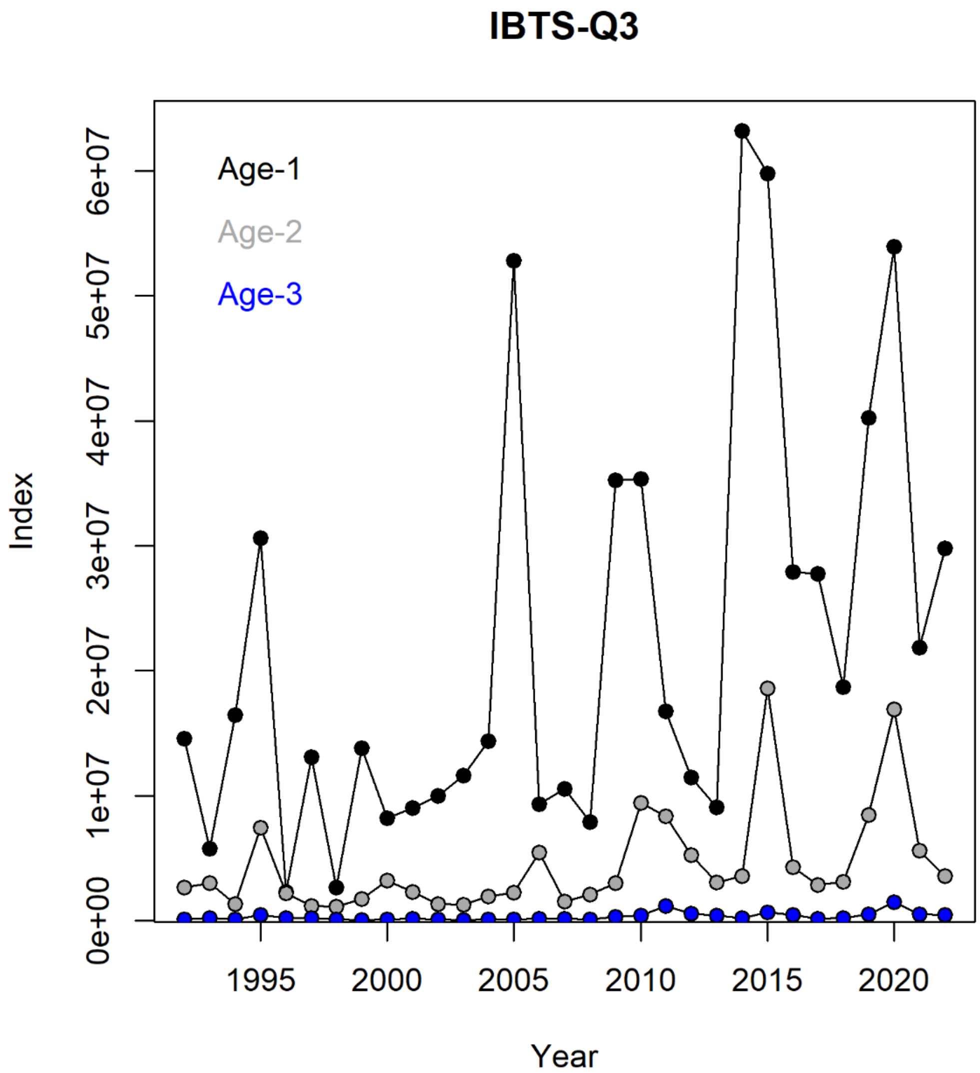


Figure 10.3.2a. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018a) for details). Years refer to the calendar year.

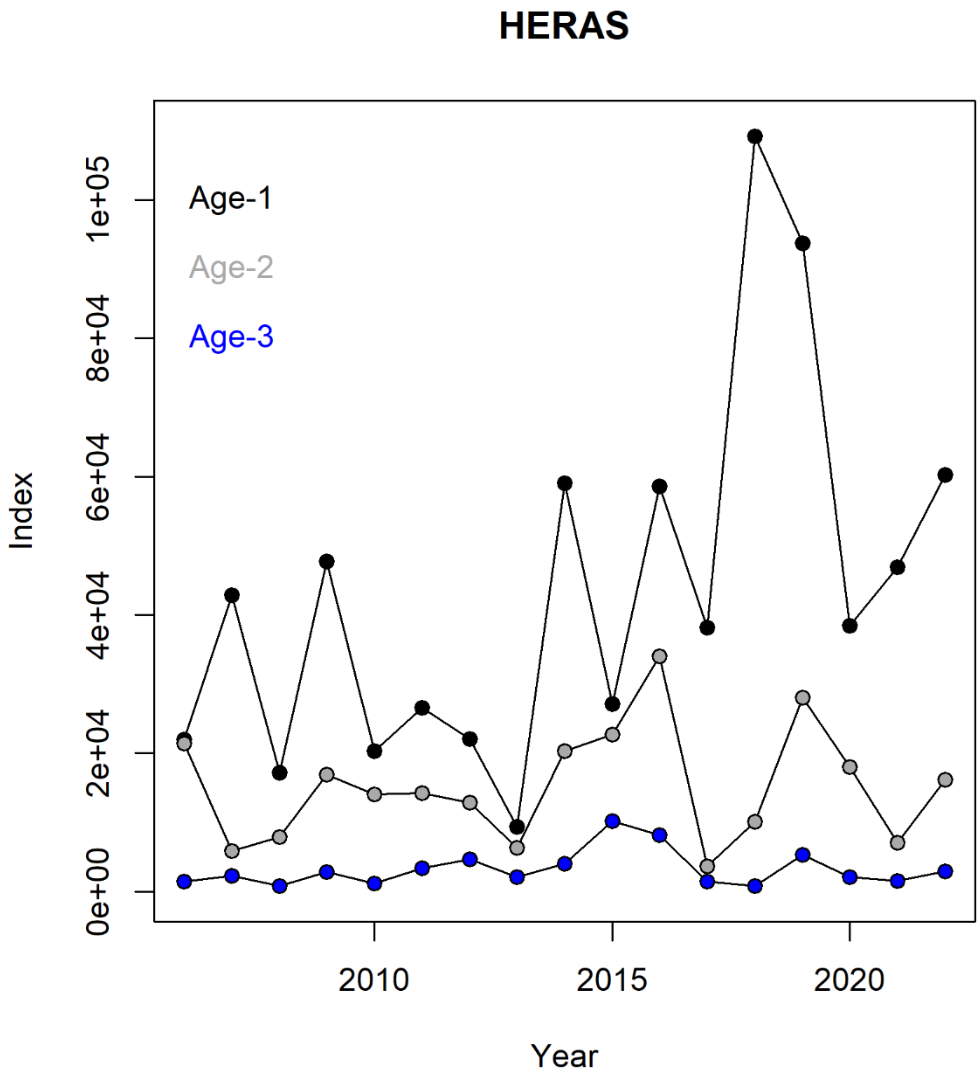
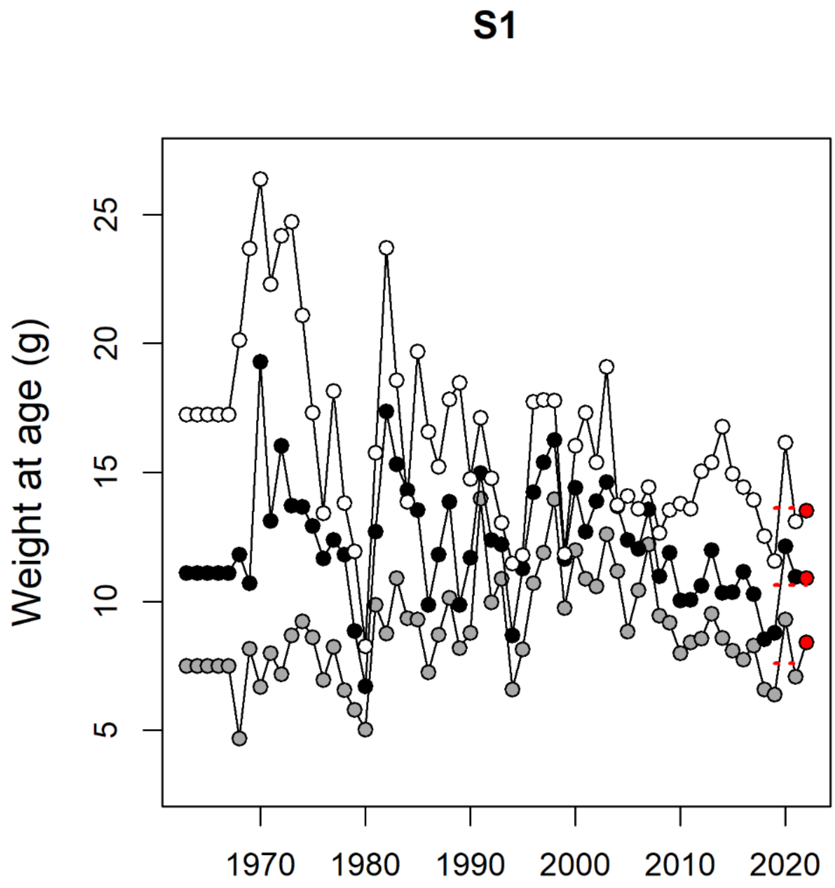
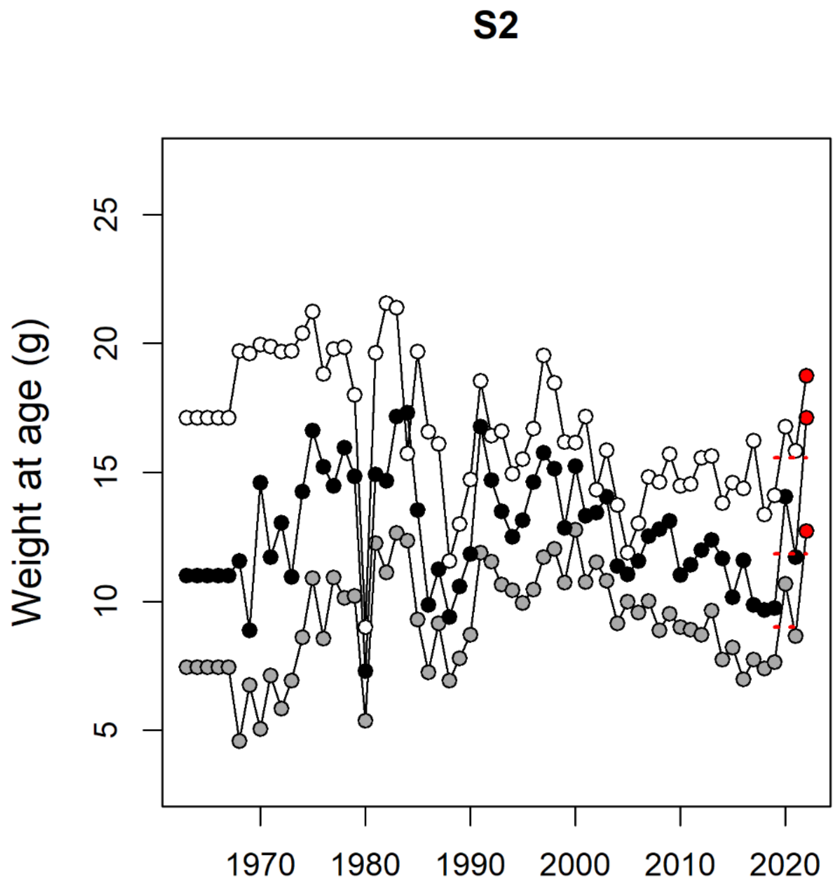
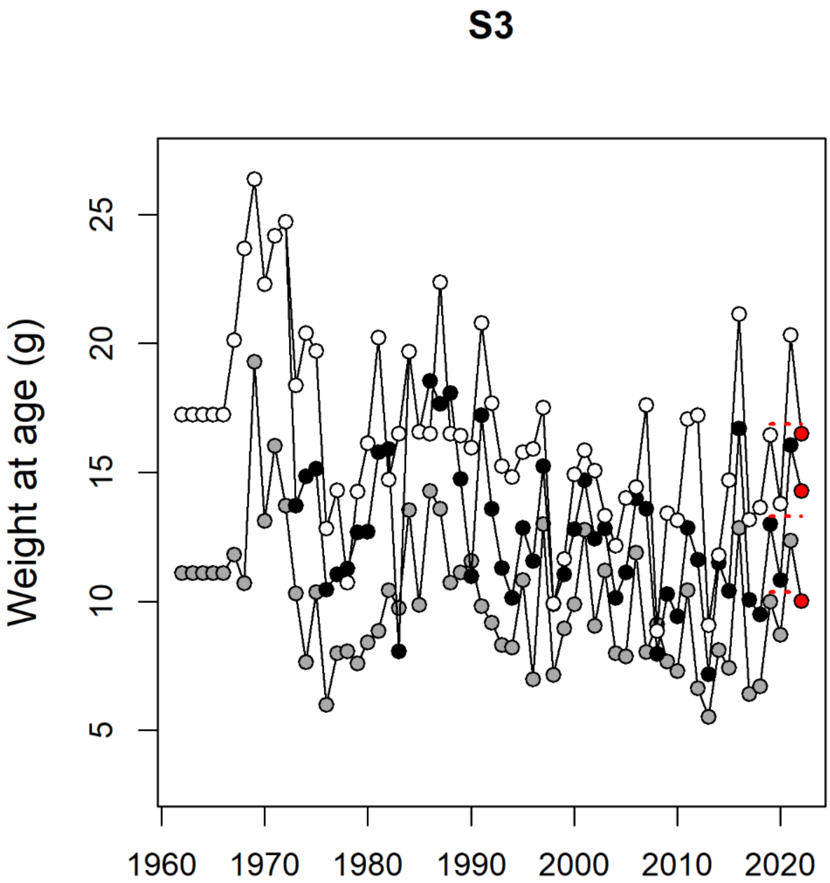


Figure 10.3.2b. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS [ICES *in press*]). Years refer to the calendar year.


S1
Weight at age (g)
5
10
15
20
25
1970
1980
1990
2000
2010
2020


S2
Weight at age (g)
5
10
15
20
25
1970
1980
1990
2000
2010
2020


S3
Weight at age (g)
5
10
15
20
25
1960
1970
1980
1990
2000
2010
2020

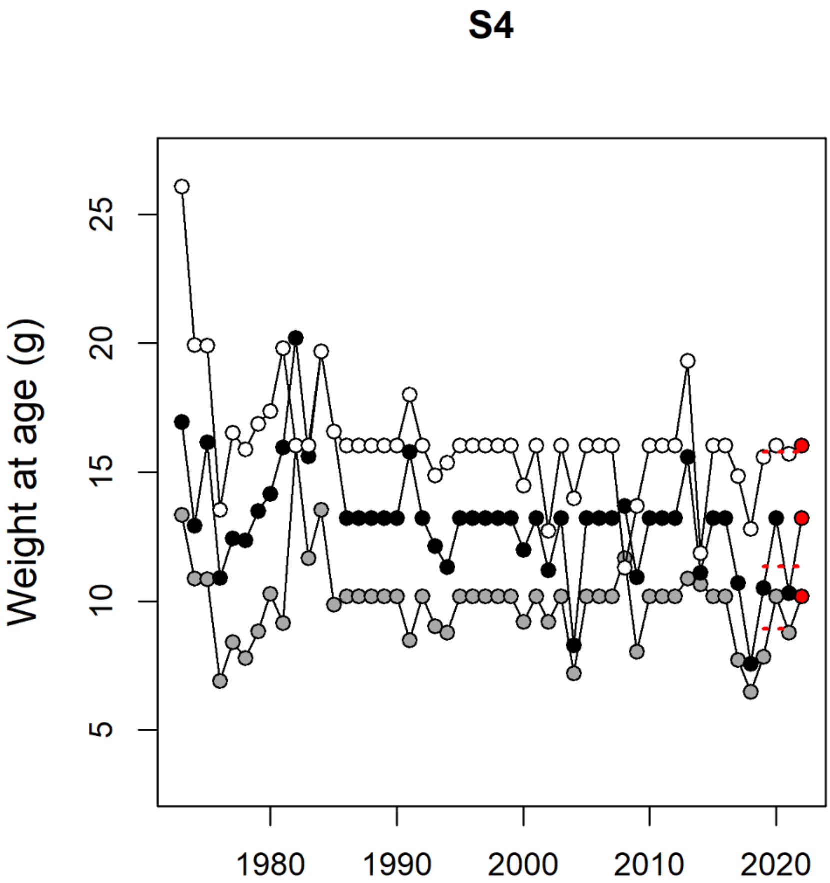


Figure 10.4.1. North Sea & 3.a sprat. Mean weight at age in season 1–4 (S1–S4) (years refer to the model year, e.g., 2021 = July 2021–June 2022). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year.

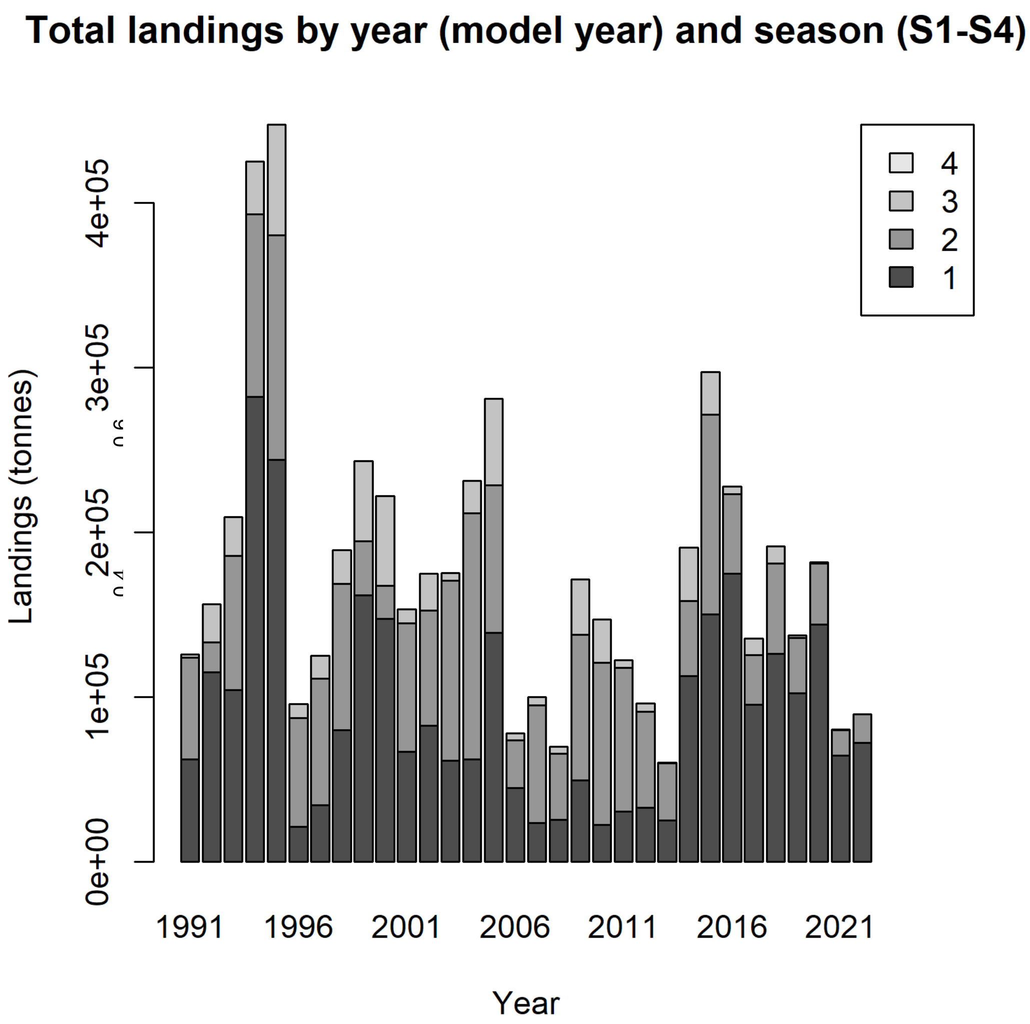


Figure 10.6.1a. North Sea & 3.a sprat. Seasonal distribution of catches. Year and season 1-4 refer to the time-steps of the model (e.g., 2021 = July 2021–June 2022). Note that since the model year of 2022 is not yet finished, the 2022 column will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT 2018 report (ICES, 2018a) for details).

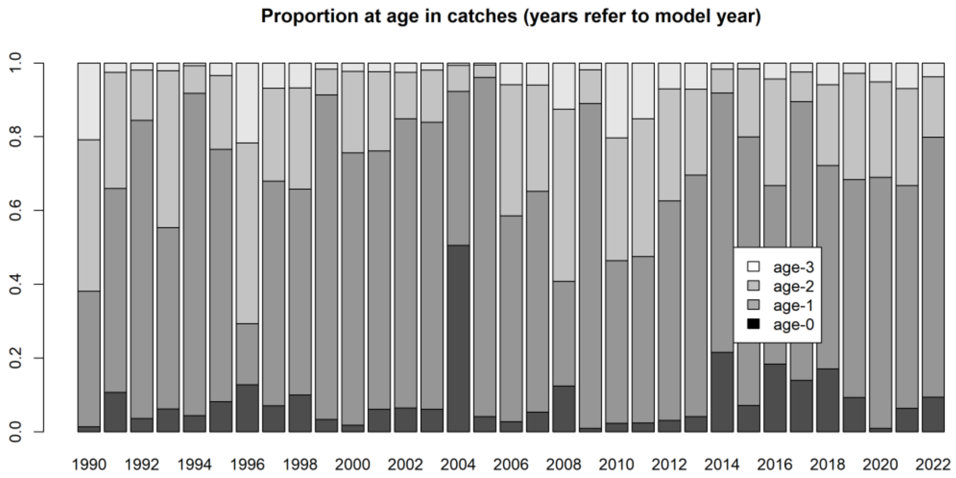


Figure 10.6.1b. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year (e.g., 2021 = July 2021–June 2022).

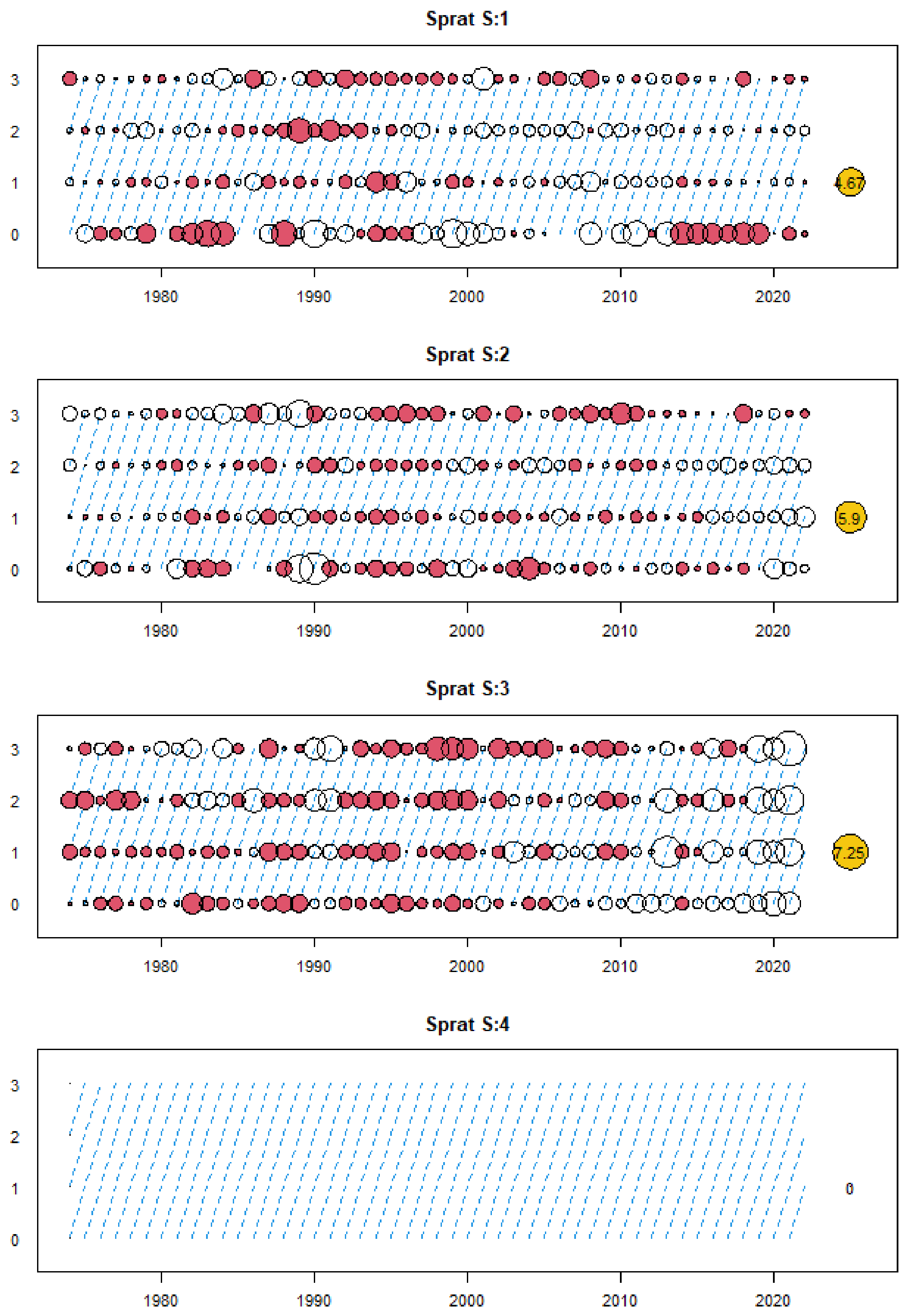


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

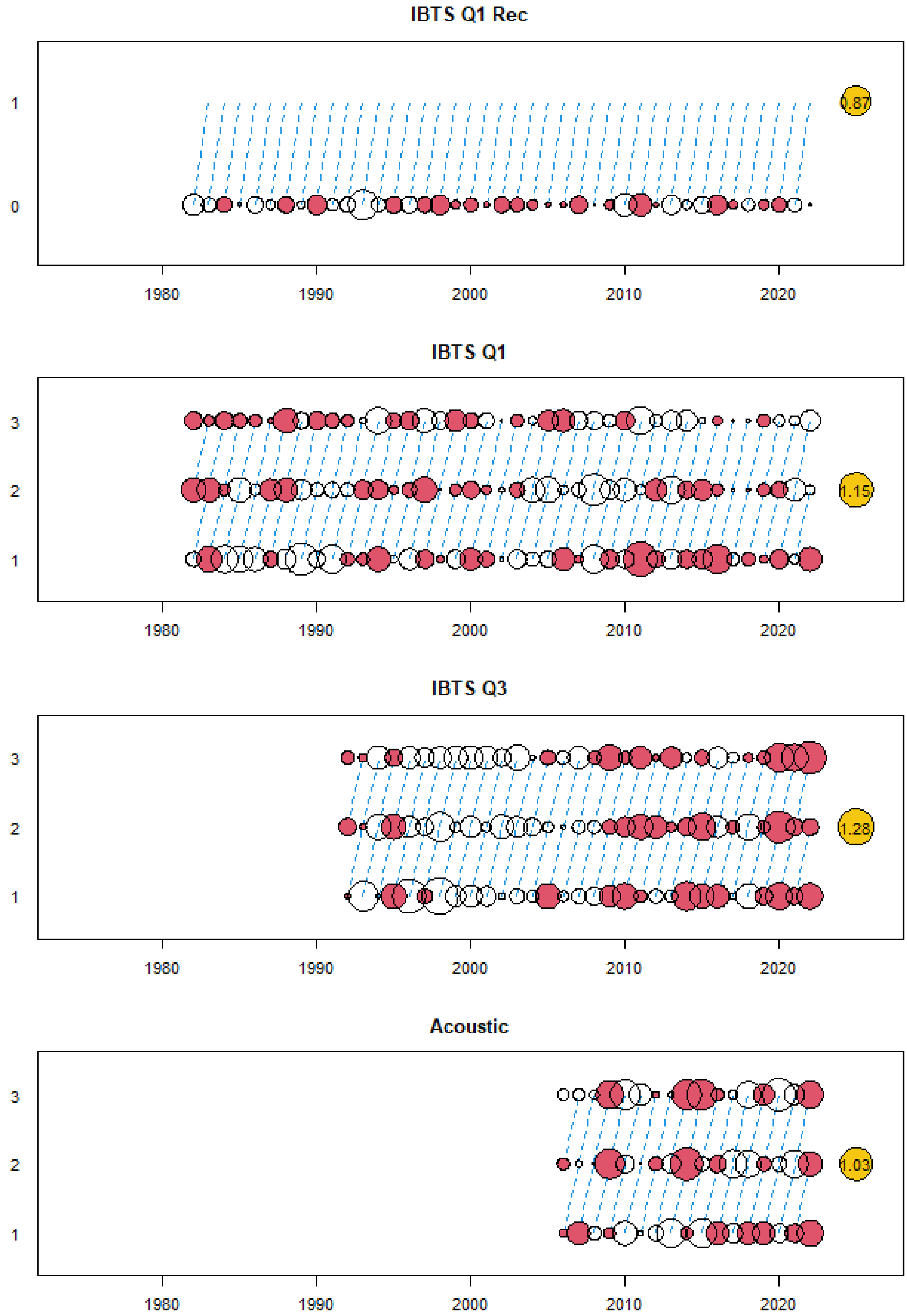


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

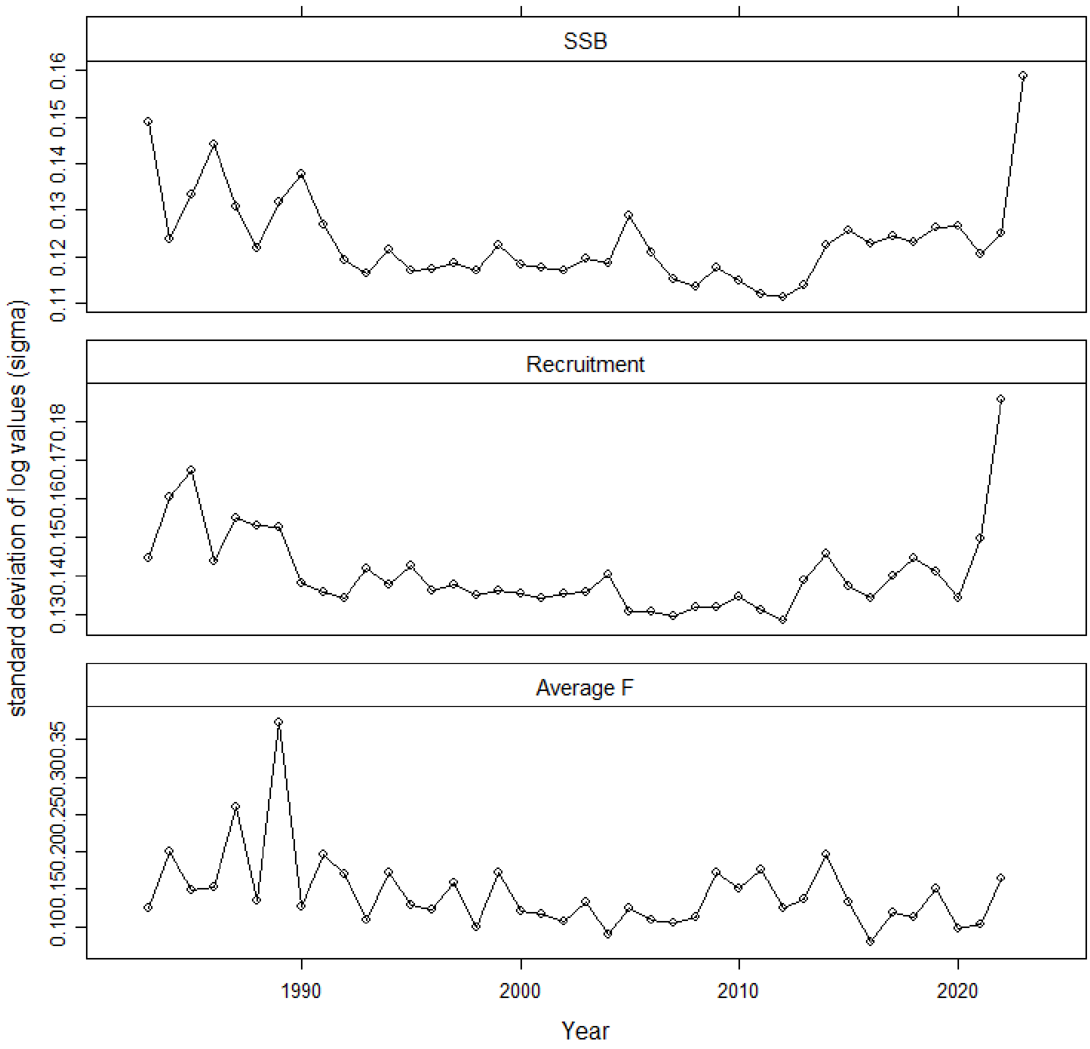


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year, e.g., 2021 = July 2021–June 2022).

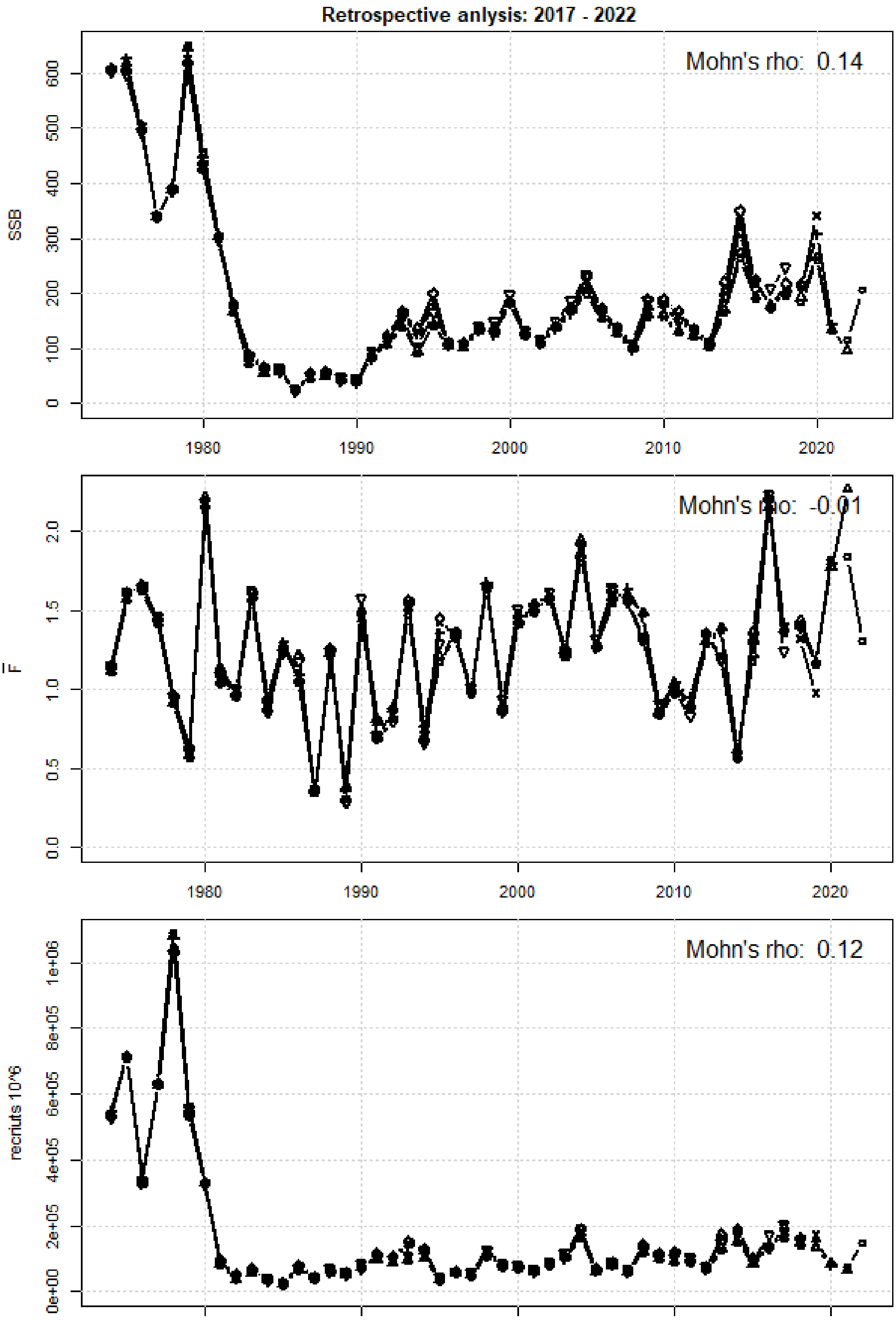


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year, e.g., 2021 = July 2021–June 2022)

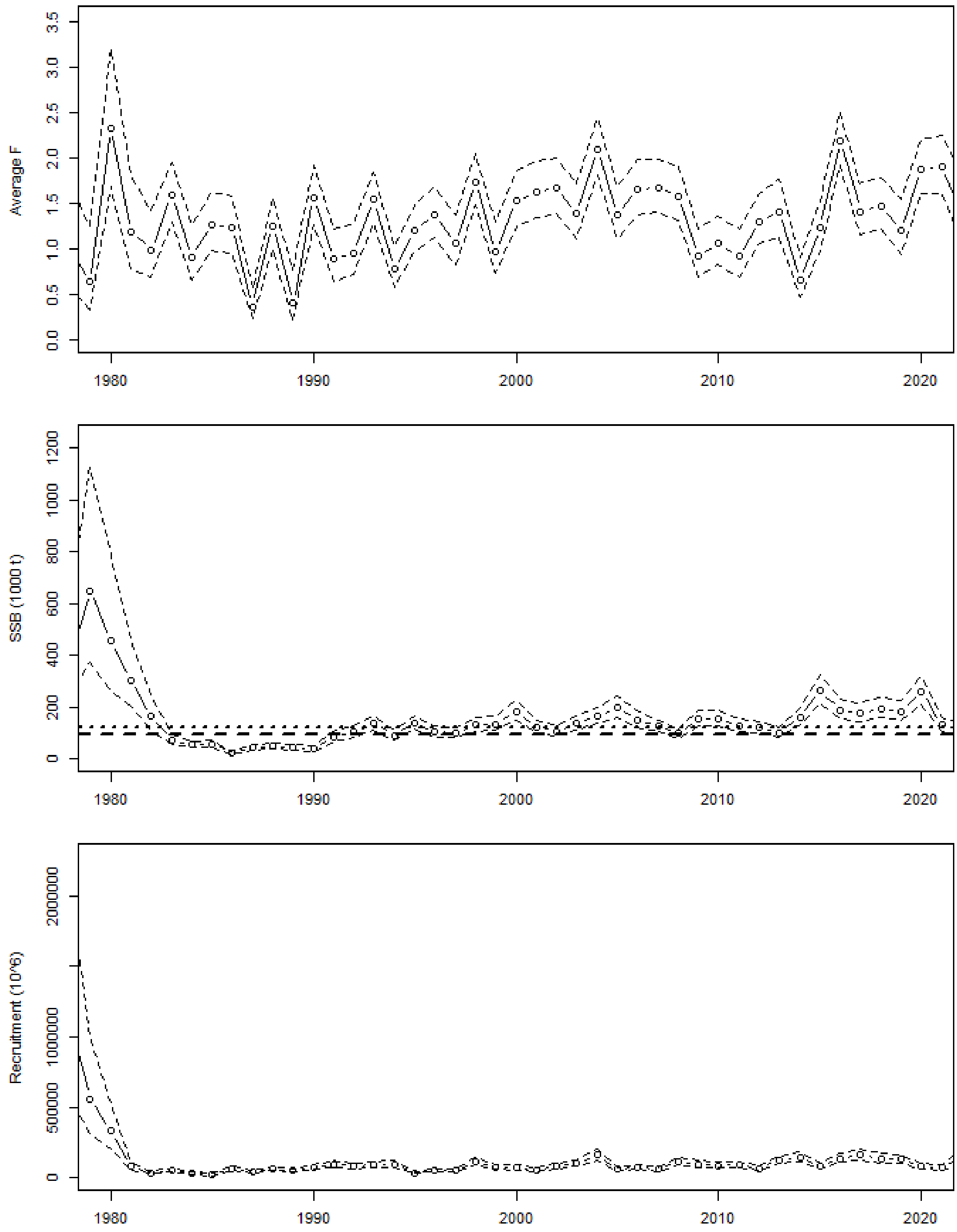


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year, e.g., 2021 = July 2021–June 2022).

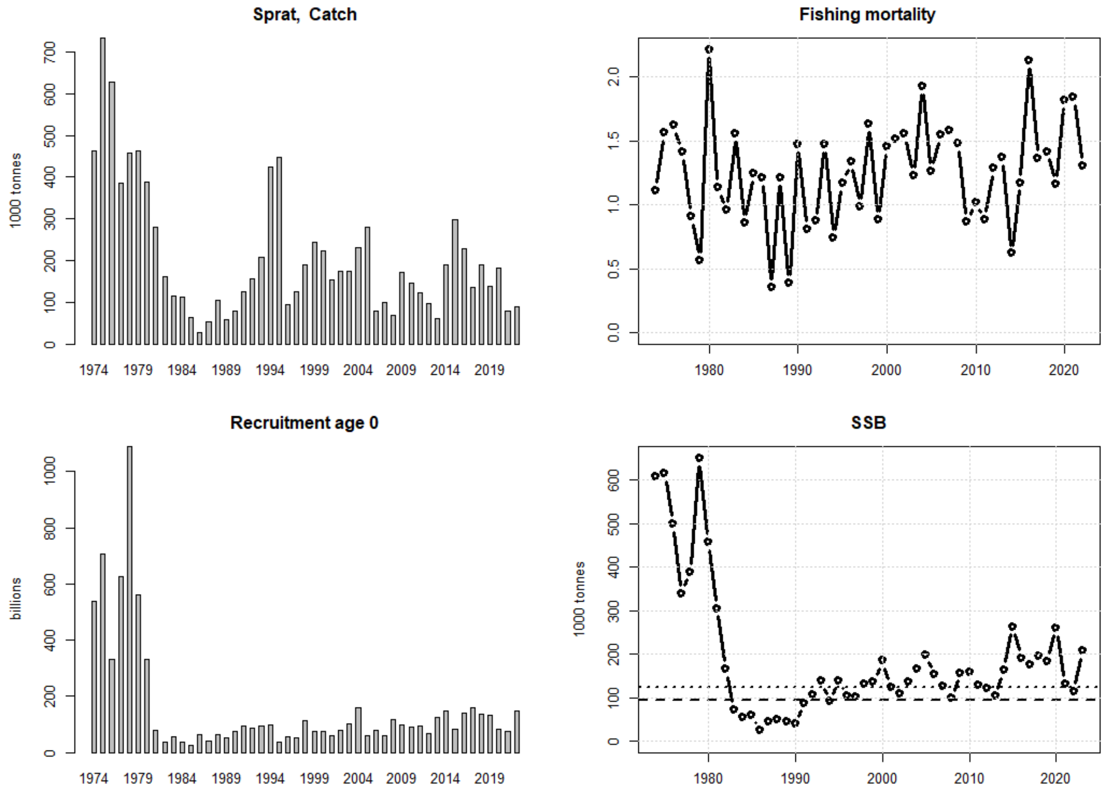


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year, e.g., 2021 = July 2021–June 2022).

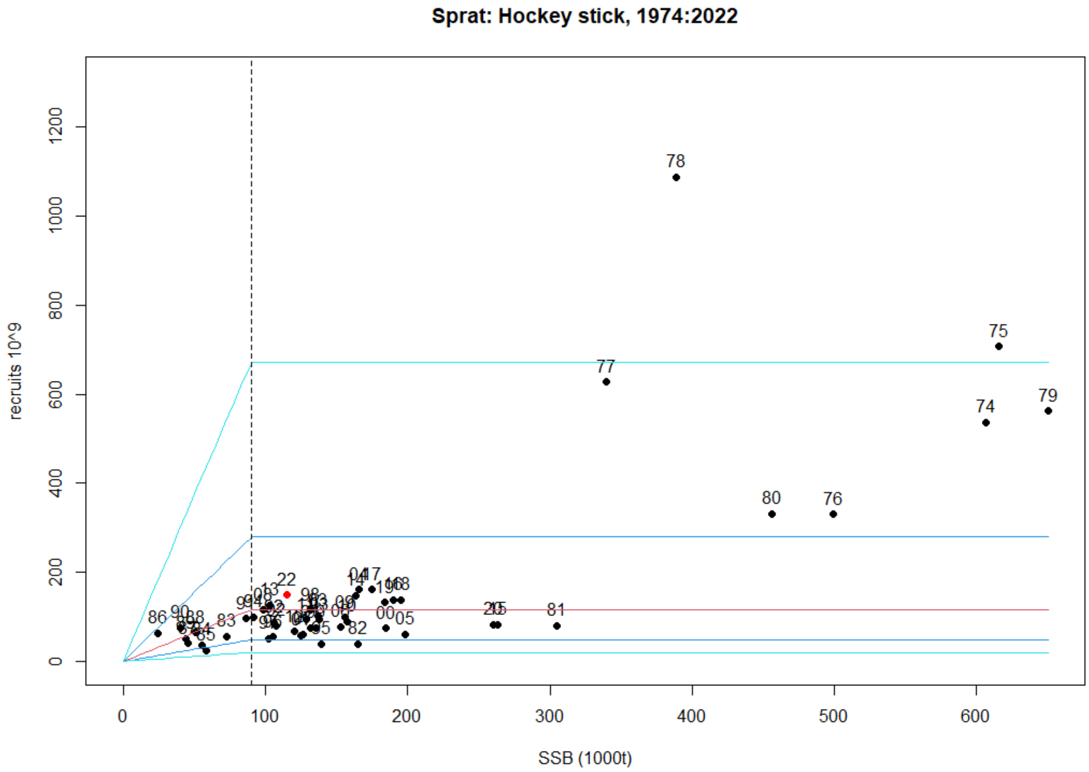


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year, e.g., 2021 = July 2021–June 2022).

10.15 References

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Lusseau et al. 2022.

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 2473 tonnes.

11.1.2 Landings

The total sprat landings by country from 1986-2022 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 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 Netherlands, Denmark appearing, and 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. In 2022, Landings were very low, with 8 tonnes caught by UK vessels and 4 tonnes caught by French vessels. Landings were also very low in 2021, 49 tonnes in total. Low landings in both years were 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

In 2017/2018 fishing season a pilot self-sampling program started in the Southwest of UK, involving sprat fishers from Lyme bay. This program has continued through to 2022 however no sprat data were received in 2022 as fish were not of a marketable size. The graphs have therefore not been updated this year as the previous year's data 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.

Biomass estimates for 2021 showed a huge increase in Sprat biomass. The PELTIC survey reports that there was a 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) program and fishers also support the survey findings, with the Pelagic fisheries noting difficulties in being able to fish because of too much "whitebait" everywhere, below marketable size. The demand in the fishery tied more to size and marketability than stock biomass, with the processors reluctant to take catches with small fish.

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 biomass of age 0 fish identified in 2021. This may indicate either high mortality or migration of sprat.

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), and sprat is one of the target species. This 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. This supports anecdotal information from the fishery and is linked to the reduced catch in 2021, citing a high volume of small fish. Biological information from trawl catches for the 2022 survey were not made available in time for HAWG in 2023.

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 9-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 survey also covered the area around the Channel Islands (Figure 11.6.1) and found a large quantity of sprat present off the coast of France. This biomass does not feed into the assessment, which looks only at the "core area" of Lyme Bay. The 2022 survey did not identify large amounts of age 1 or 2 sprat, 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 greatest sprat biomass was found in the Lyme Bay region, however due to vessel issues the 2022 PELTIC survey extent was greatly reduced to an area of approximately 1/3 of the typical extent, covering only the Western Channel stratum.

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 proved: 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 751t) 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 (70680 t, 85184 t and 65219 t respectively), Table 11.6.1. The PELTIC biomass increased substantially from 36 798 tonnes in 2020 to 107355 tonnes in 2021, and reduced to 28439 tonnes in 2022. The harvest rate has been low for the past 2 years at 0.05% and 0.04% for 2021 and 2022 respectively. The low catch in 2021 which has been attributed to a large number small sprat mixed in with the catch and the low catch in 2022 has been attributed to a continued absence of large marketable sprat.

11.8 Catch Advice

Applying the constant harvest rate of 8.57% to the current estimate of PELTIC biomass gives an advised catch of 2437 tonnes.

11.9 Short-term projections

No projections are presented for this stock.

Reasons for change in advice

The decrease in advised catch this year is caused by the decreased PELTIC biomass index in 2022, 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)
2021	2022	107355	9200
2022	2023	28439	2437

11.10 Reference Points

The IBP suggested the use of the Istat value developed as part of WKDSLLS2 (ICES, 2021b) could be used 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 island 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 IBTS channel groundfish survey indicated that the amount of sprat in 7d 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 once the RV change issue is addressed. The survey gear are not targeted to sprat, however they 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 IBTS data are a decreasing mean length of sprat over the last decade Seine (Figure 11.1.3; Figure 11.1.4). 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 2408 tonnes on average. The average harvest rate for the 10-year time-series is 7.4% however it has been close to 0.05% for two years.

The strong biomass fluctuations observed in the acoustic index and the relatively strong 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 March 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 for 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, 1988–2022.

Coun-try	Denmark	France	Germany	Nether-lands	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

Coun-try	Denmark	France	Germany	Nether-lands	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

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

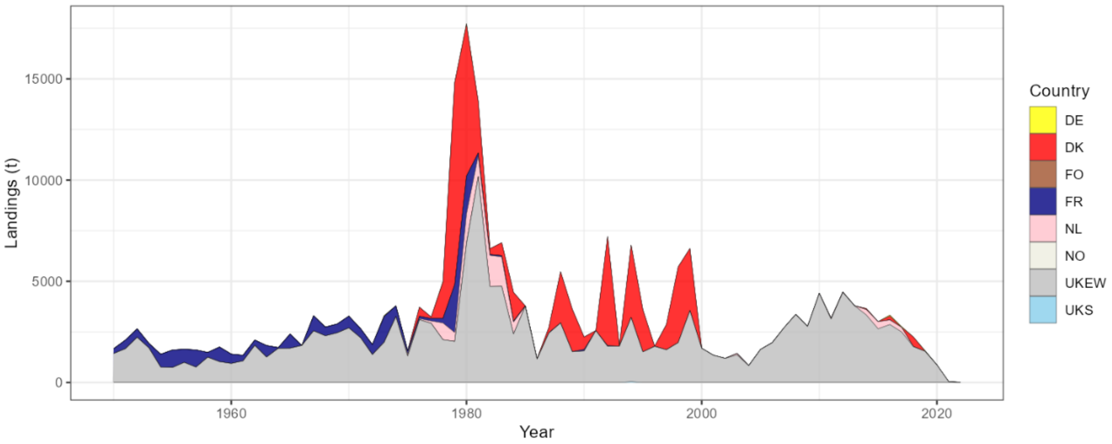

Figure 11.1.1. Sprat in 7.d-e. Landings of sprat 1950–2022.

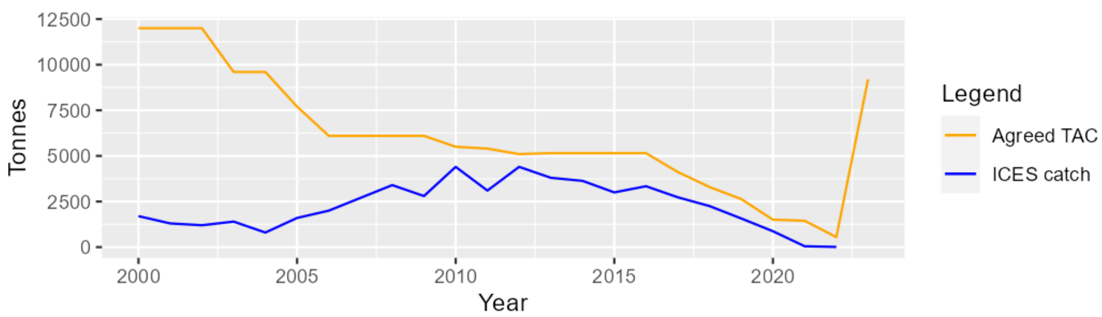

Figure 11.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2022.

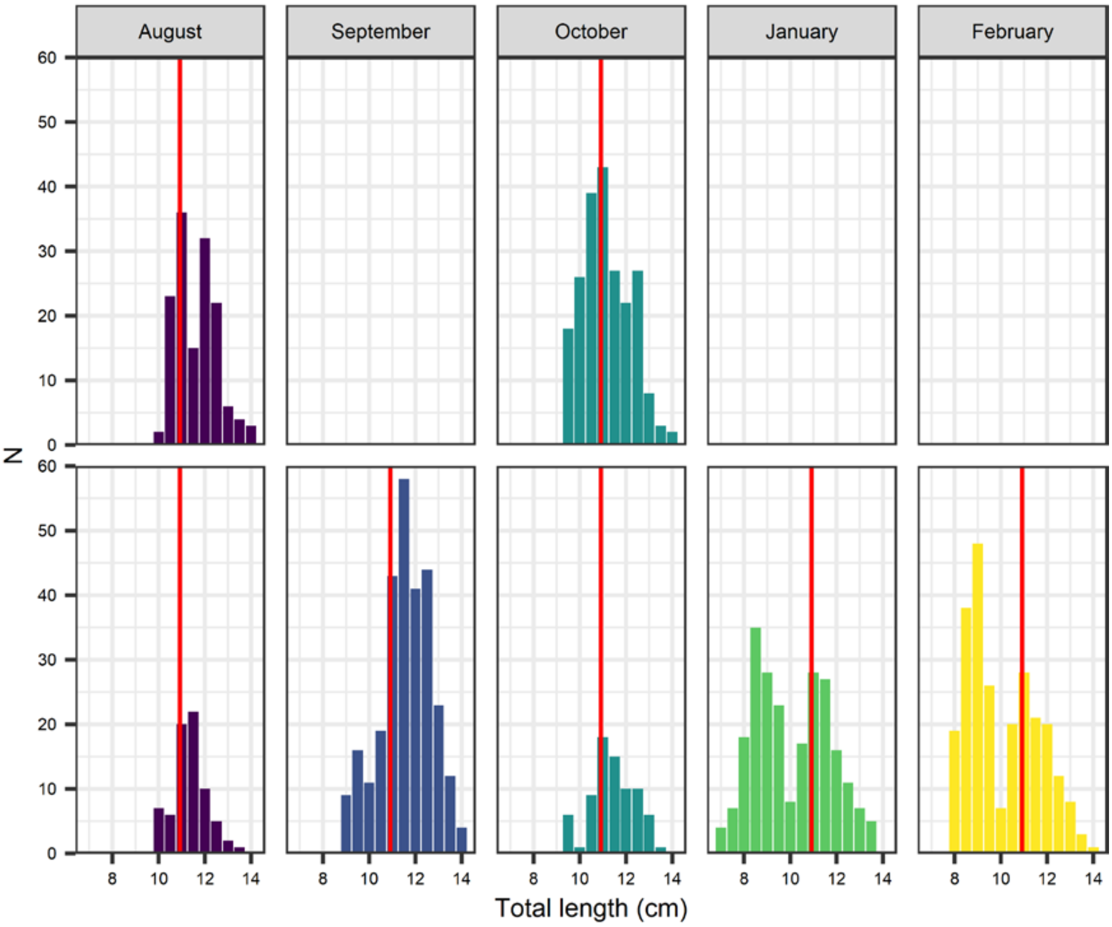

Figure 11.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month 2019, for the two boats supplying the FSP program.

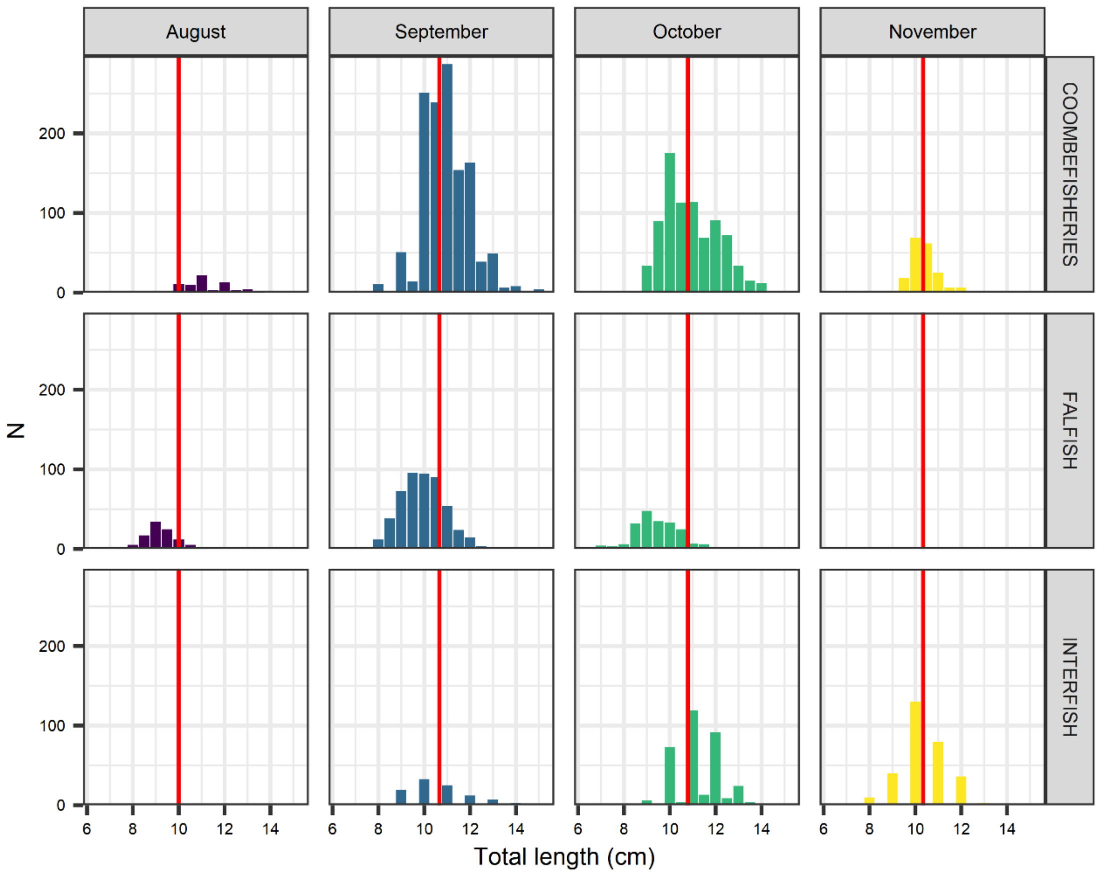

Figure 11.2.2. Monthly sprat total length distribution collected by the three processors in the 2020 season. Red line indicates weighted mean length at each month.

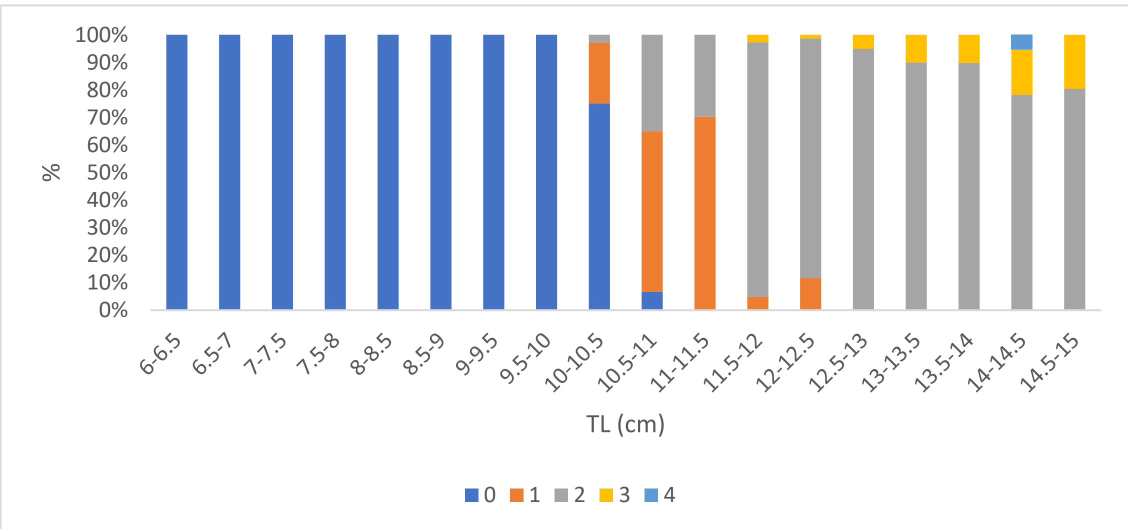

Figure 11.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2021 PELTIC acoustic survey.

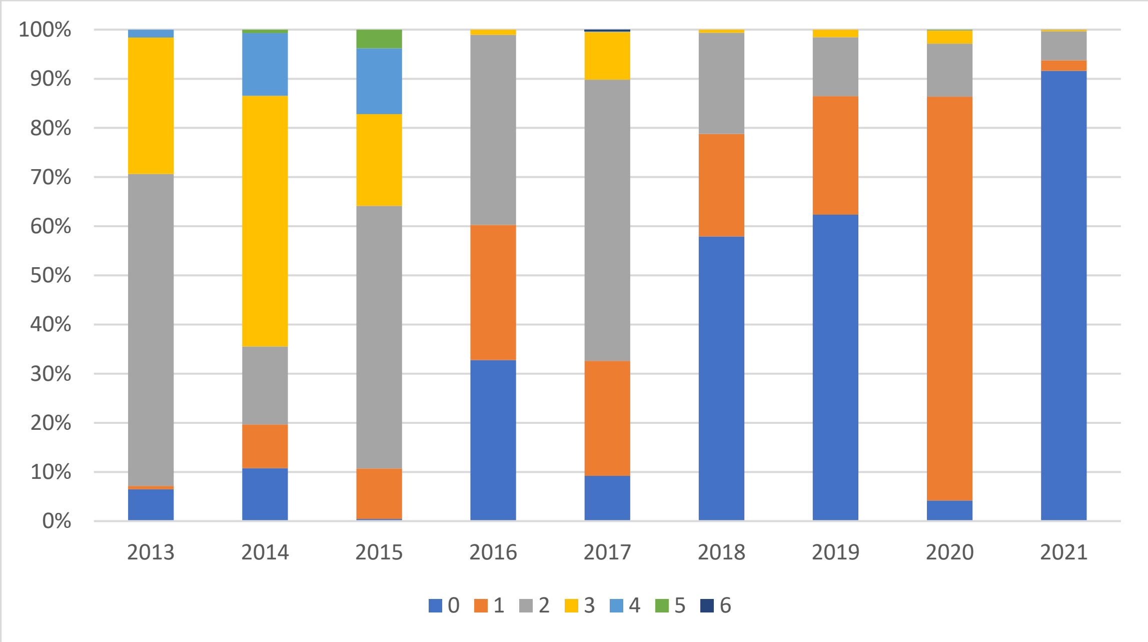

Figure 11.3.3. Sprat in 7.d-e. Proportion of numbers-at-age in the biological samples collected during the 2013–2021 PELTIC acoustic surveys.

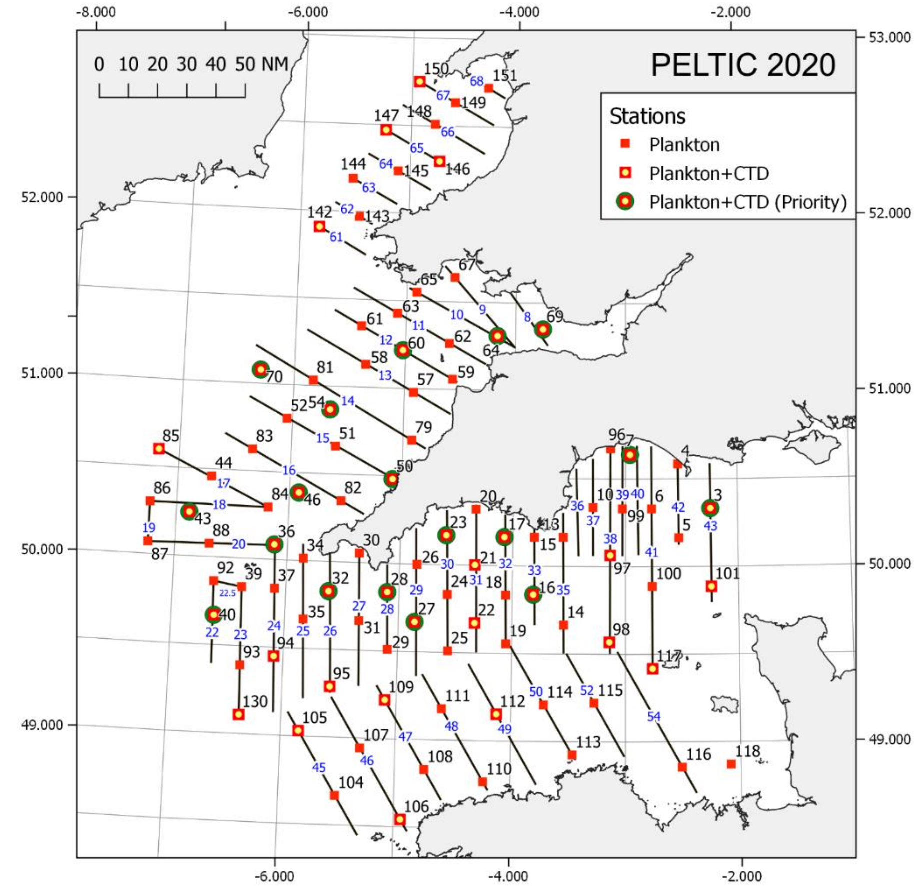

Figure 11.3.1. Sprat in 7.d–e. Survey design (2021) with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

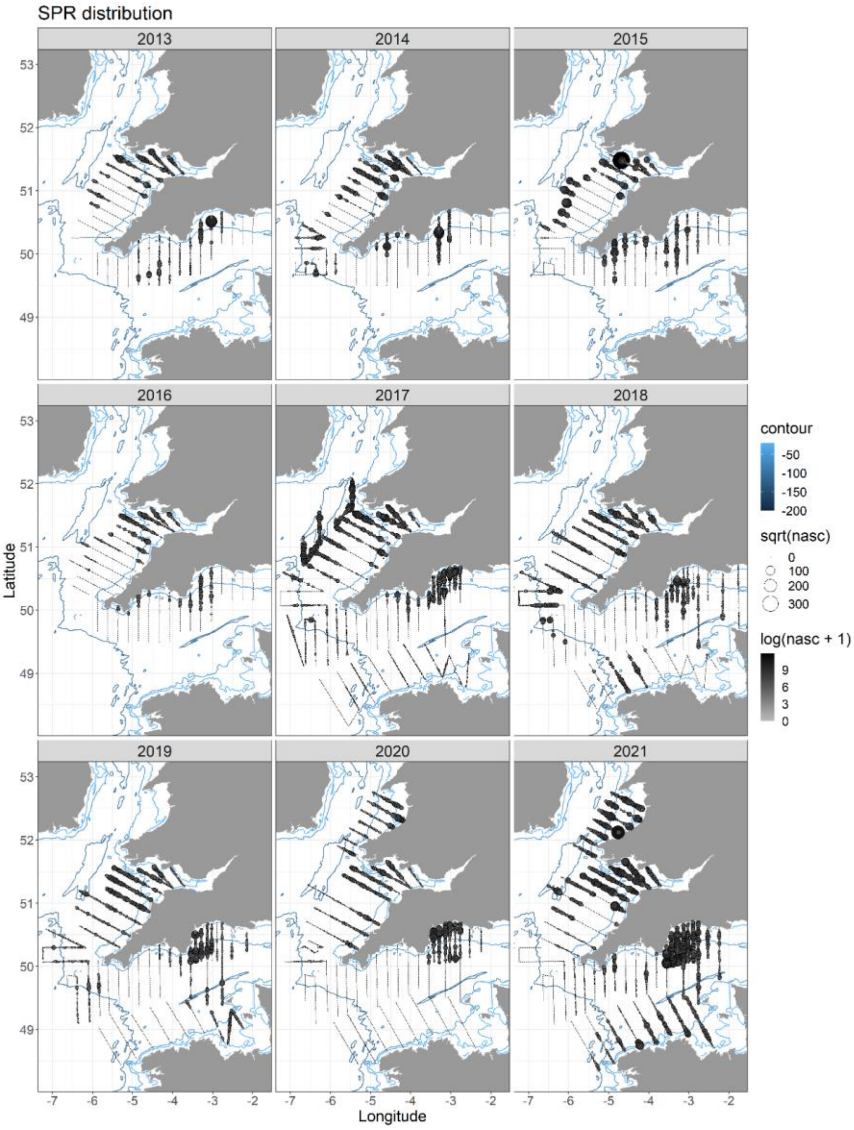

Figure 11.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2013–2021 PELTIC surveys.

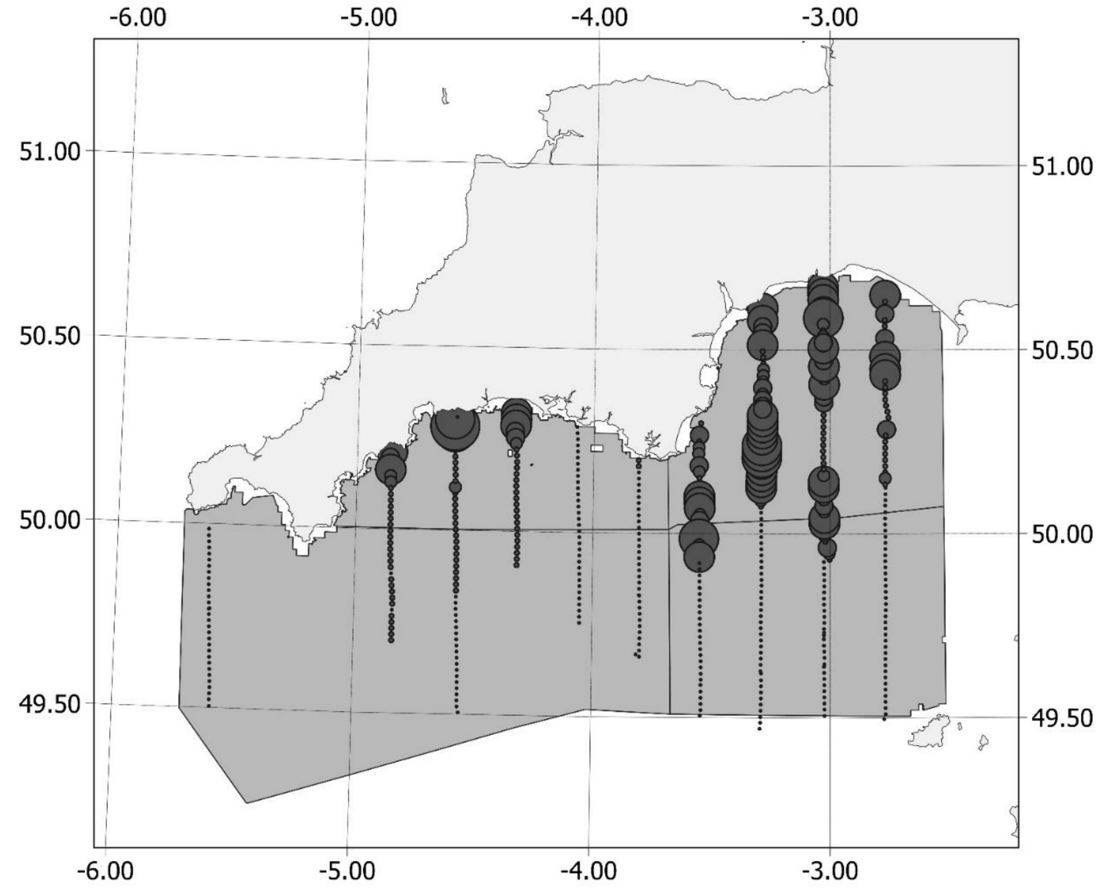

Figure 11.6.2. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2022 PELTIC survey, which reduced spatial coverage.

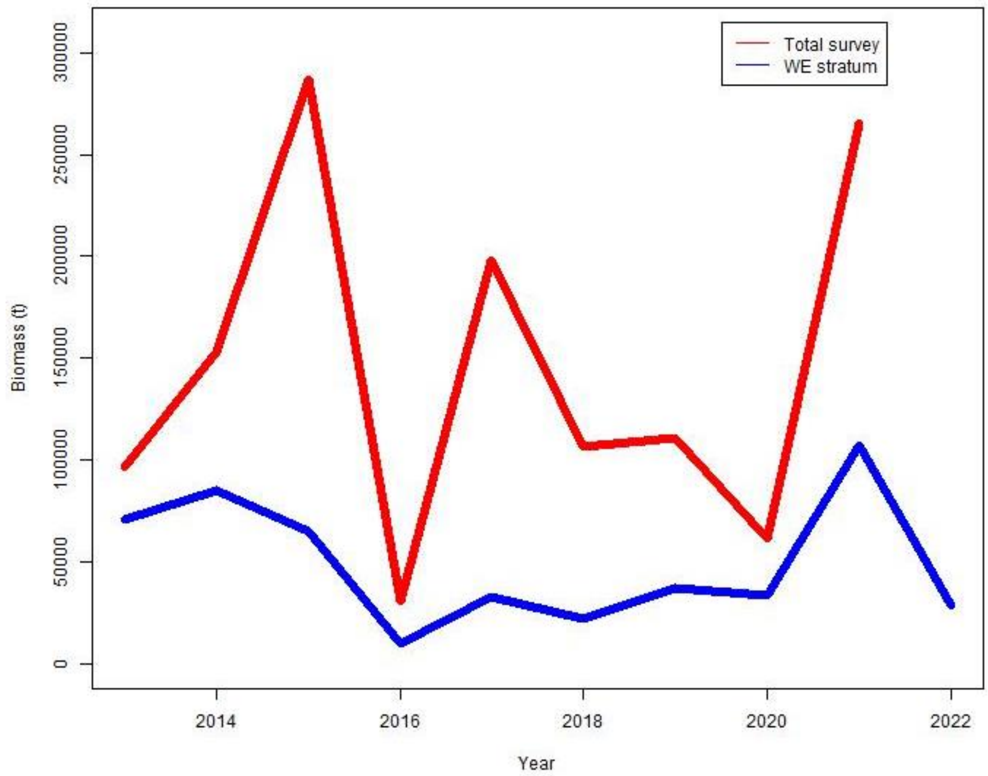

Figure 11.6.3. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2022 for Division 7.e (red line) and the Lyme Bay area (blue line). The Partial survey has not been run since 2019.

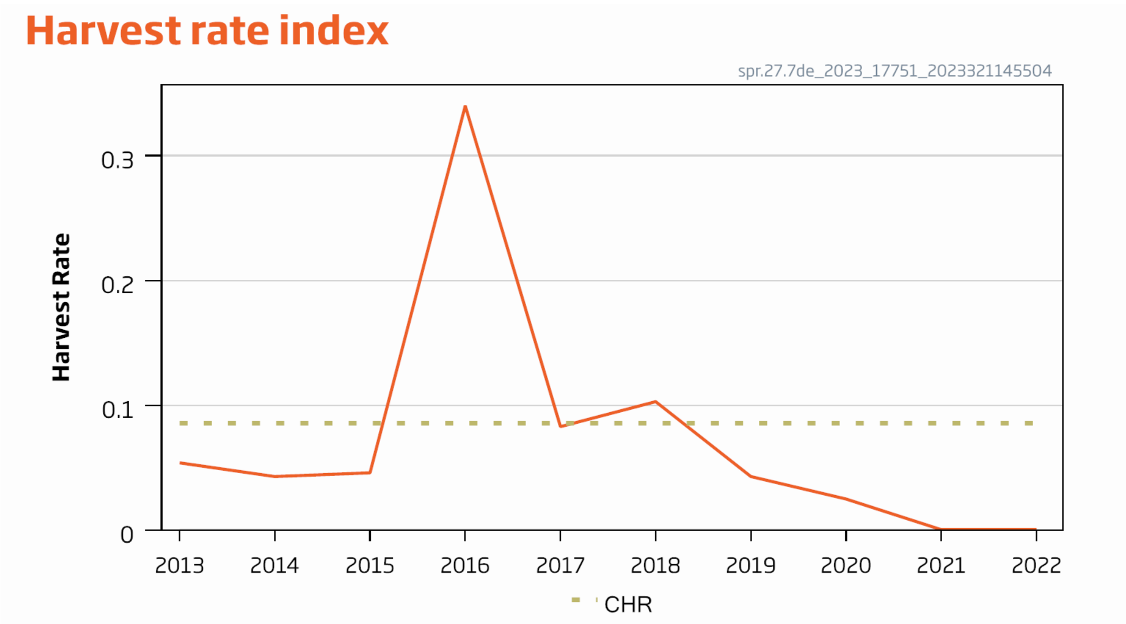

Figure 11.7.1. Sprat in 7.d-e. Constant Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

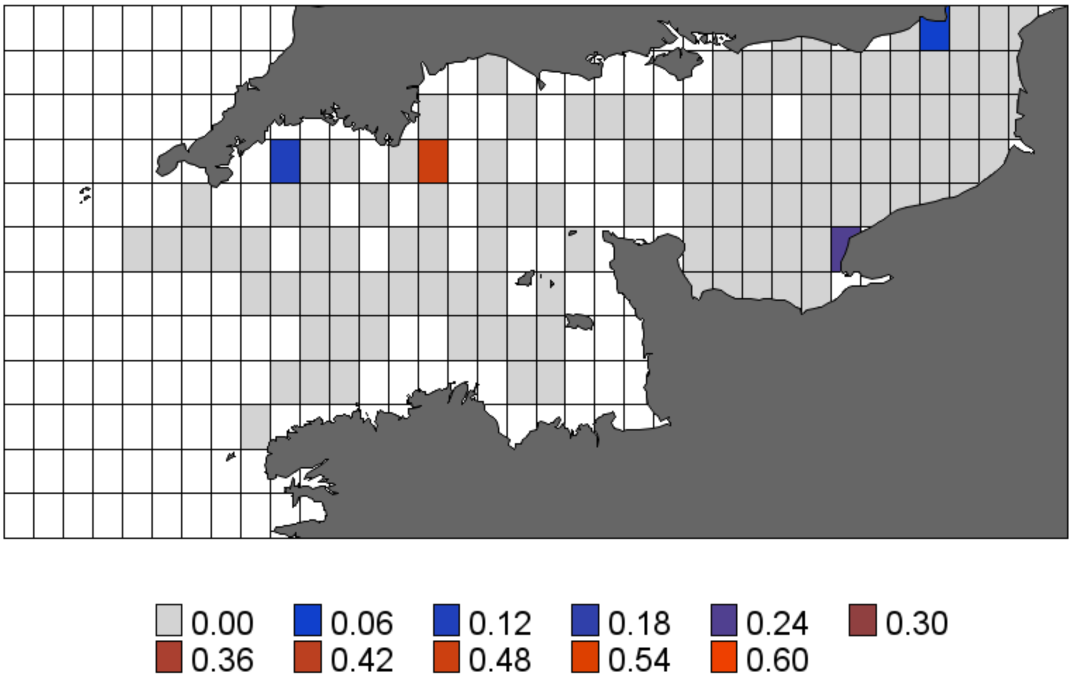

Figure 11.11.1. Proportions of summed sprat distribution in 7.d-e from the 2015-2022 from the IBTS groundfish survey. All rectangles add to 1. Grey rectangles indicate a proportion of between 0 and 0.06. All grey rectangles add to approximately 20%, and the remaining 80% is within 4 coloured rectangles. White cells have not been sampled.

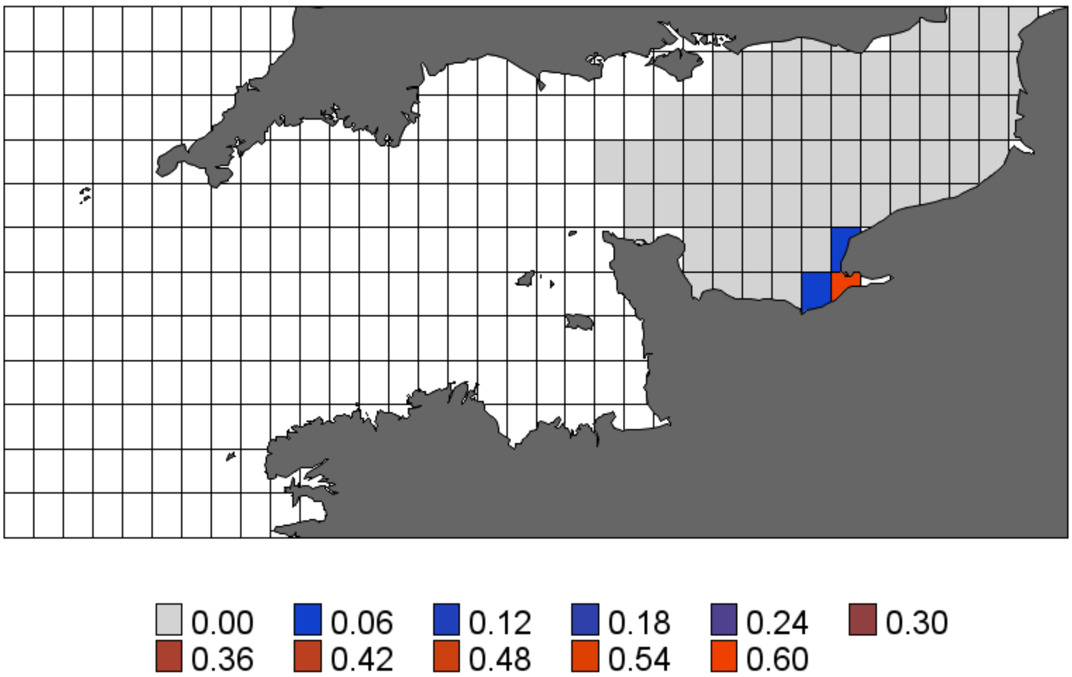

Figure 11.11.2. Proportions of summed sprat distribution from the 1988-2014 from the IBTS groundfish survey, a period when only 7.d was sampled by the survey. All rectangles add to 1. Grey rectangles indicate a proportion of between 0 and 0.06. All grey rectangles add to approximately 10%, and the remaining 90% is within 4 coloured rectangles.

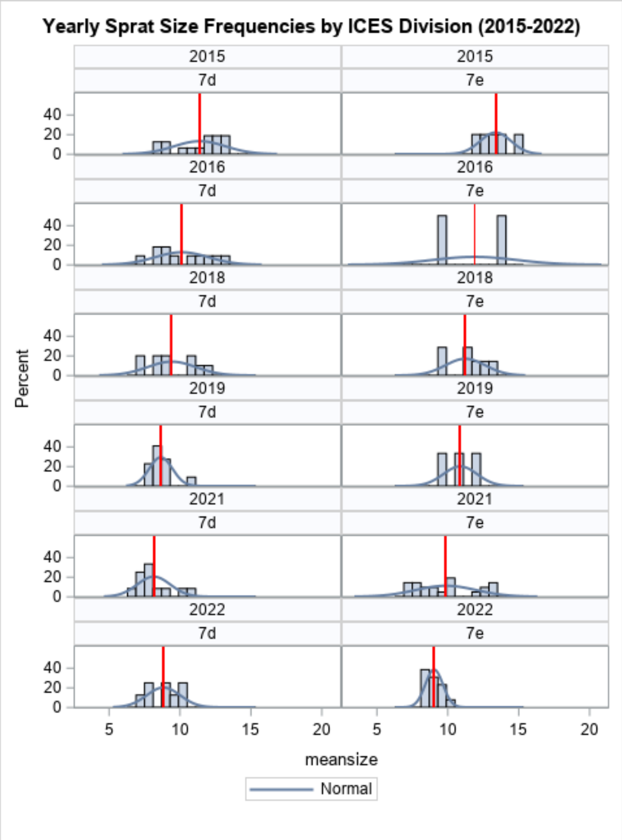

Figure 11.11.3. Length frequency (%) plots for 7d and 7e from the IBTS groundfish survey between 2015-2022. Red vertical line indicates mean length.

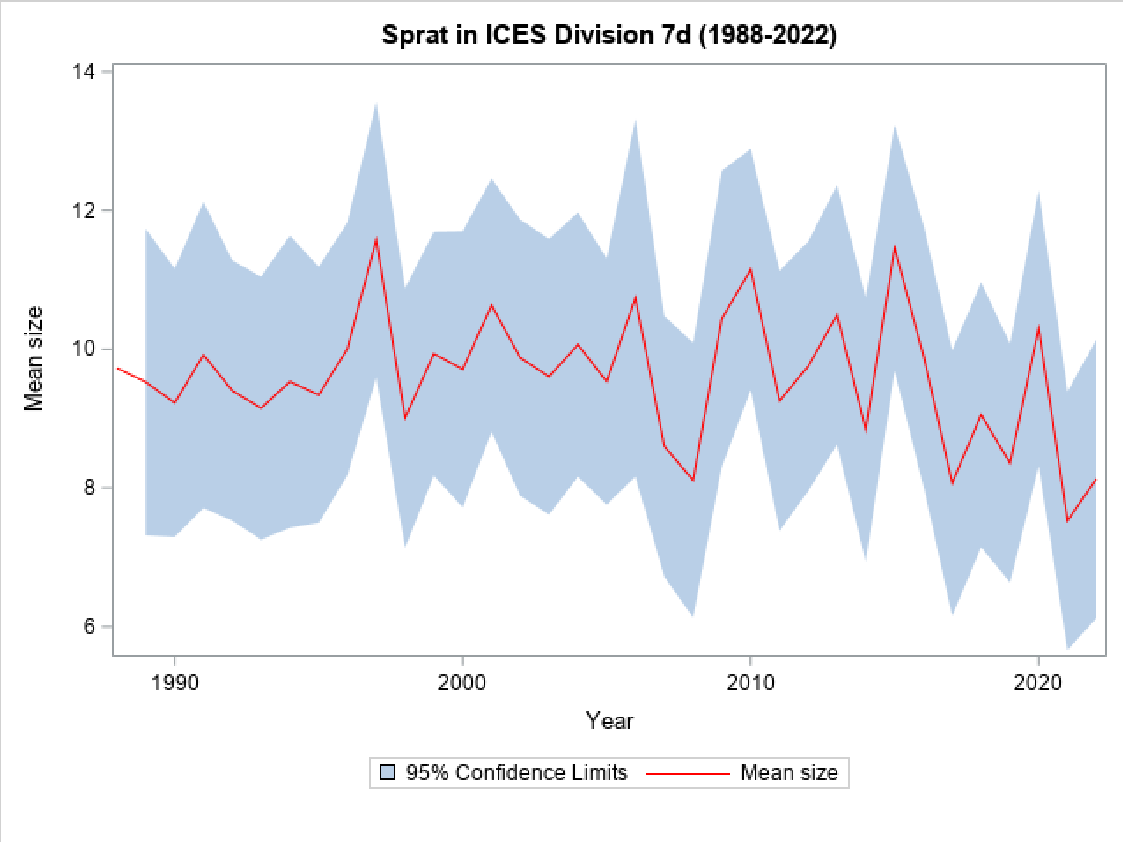

Figure 11.11.4. Mean length (cm) in 7d from the IBTS groundfish survey between 1988-2022. Note the survey vessel changed in 2015.

11.15 References

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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 (England and Wales) recorded catches from the stock in 2022, 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 1697 tonnes was taken in 2022, all by Ireland, with no Scottish catches in 2021 or 2022.

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. 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.

12.1.4 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 re- ported for 2016, increasing to above 500 tonnes in the two subsequent years. Irish catches were 1308 tonnes in 2020, 295 tonnes in 2021 and 197 tonnes in 2022. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.5 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. Irish data may be underestimated, due to difficulties in quantifying the catches from vessels of less than 10 m length.

12.1.6 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.

12.1.7 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.

12.1.8 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.

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 1998–2022 is shown in Figure 12.3.5 and from 1994-2022 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 2023. 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 12 - 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 theinformation available for sprat in the Celtic Seas began with the Workshop on a Research Roadmap for Channel and Celtic Seas sprat (WKRRCCSS) and a second iteration of this workshop was scheduled to meet after HAWG in March 2023.

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, 1985–2022, 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

Table 12.1.2 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2022 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
1999	0	0	146	0	146

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
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

Table 12.1.3 Sprat in the Celtic Seas Ecoregion. Irish catches of sprat, 1985–2022 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

Table 12.1.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2022, 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
2000	698

Country	Ireland
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

Table 12.1.6 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2022, 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

Table 12.1.7 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2022, 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
1999	0	0	3263	0	0	0	3263

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
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

Table 12.1.8 Sprat in the Celtic Seas Ecoregion. Catches of sprat, 1985–2022 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

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
2009	16229

Year	Biomass (t)
2011	31593
2012	35114
2013	44685
2014	54826
2015	83779
2016	42694
2017	70745
2018	47806
2019	60608
2020	4523
2021	12376
2022	34508

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
2005	141 900	0.1	96	136 100
2006	143 200	0.09	87	125 000

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
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

Figure 12.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

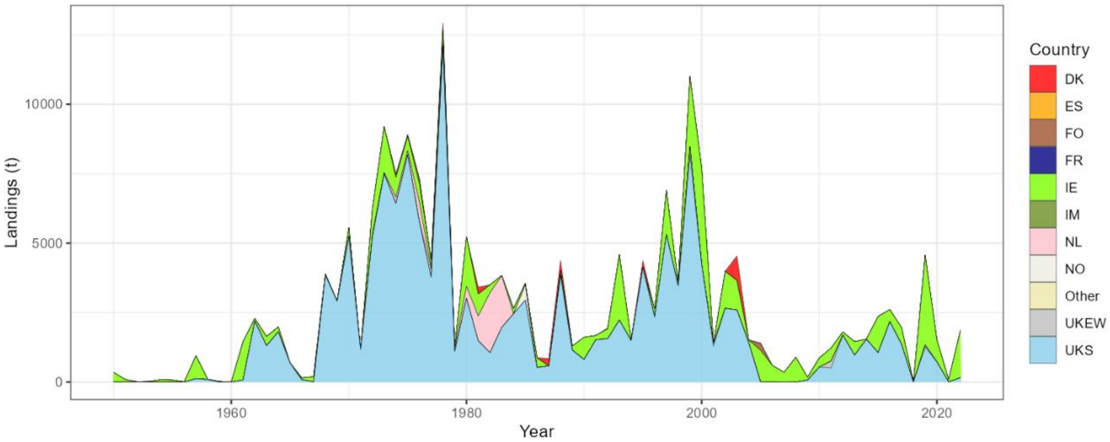

Figure 12.2.1. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES Division 6.a.

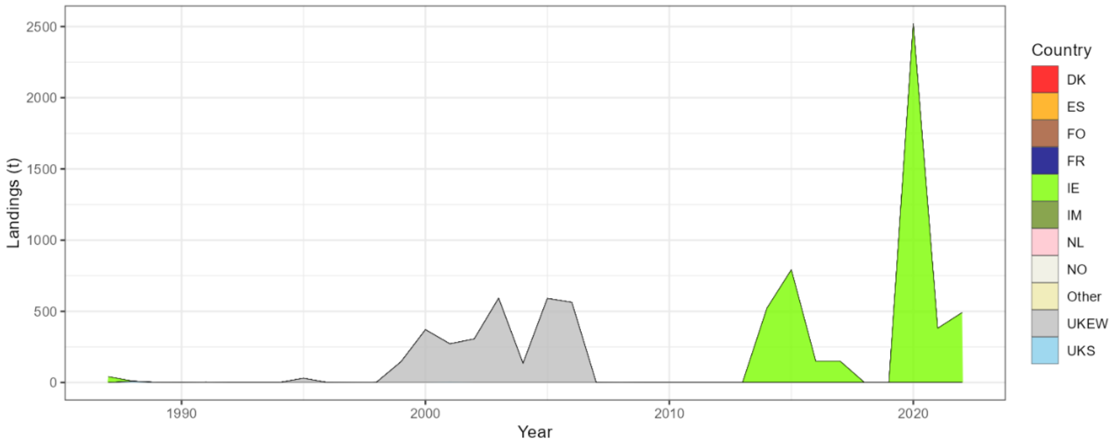

Figure 12.2.2. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES Division 7.aN. Note: Irish catches from 1973–1995 may be from 7.aN or 7.aS.

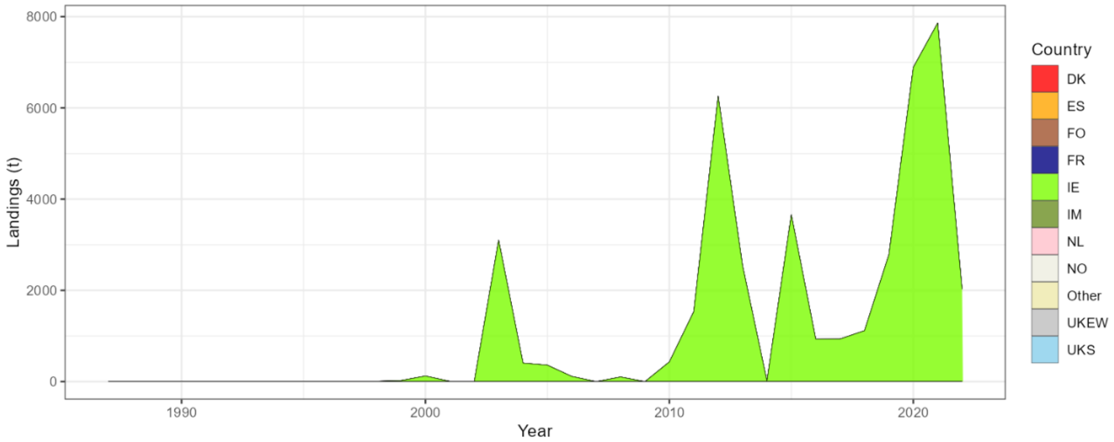

Figure 12.2.3. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES Division 7.aS.

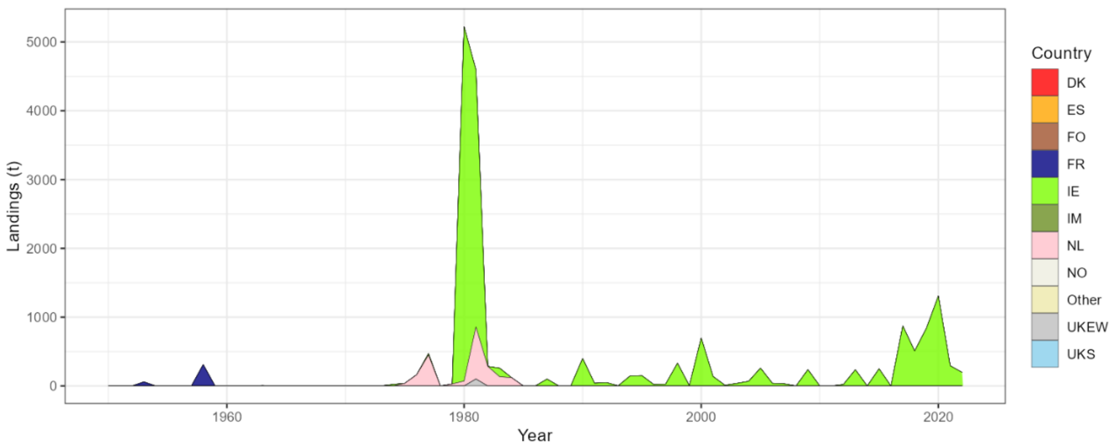

Figure 12.2.4. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES divisions 7.b–c.

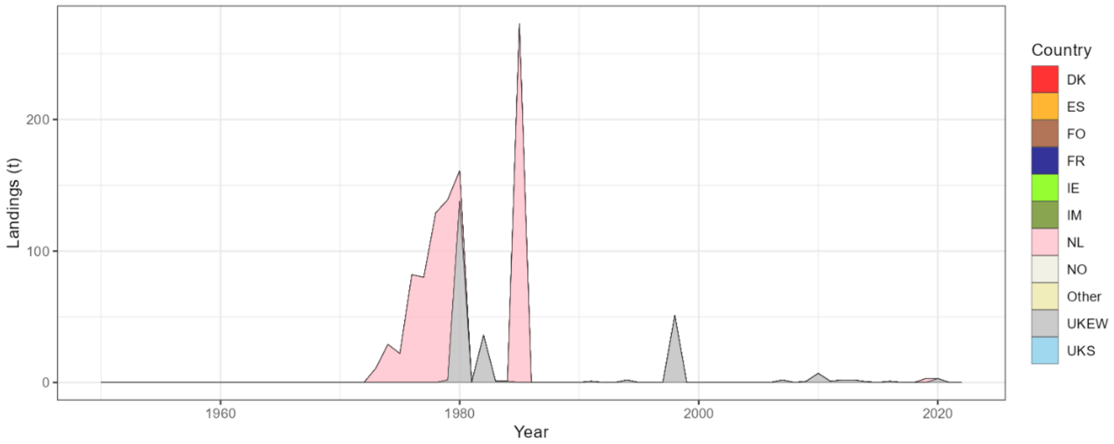

Figure 12.2.6. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES Division 7.f.

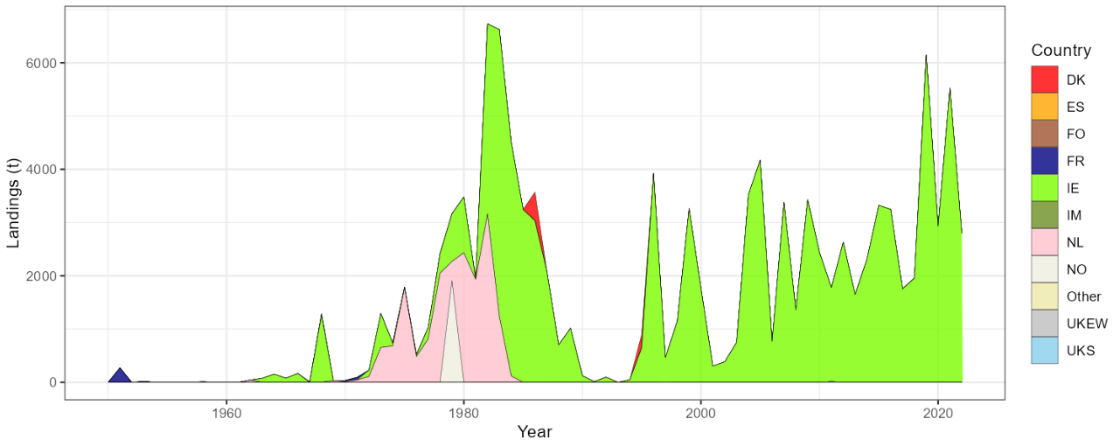

Figure 12.2.7. Sprat in the Celtic Seas Ecoregion. Catches of sprat 1987–2022 ICES divisions 7.g–k.

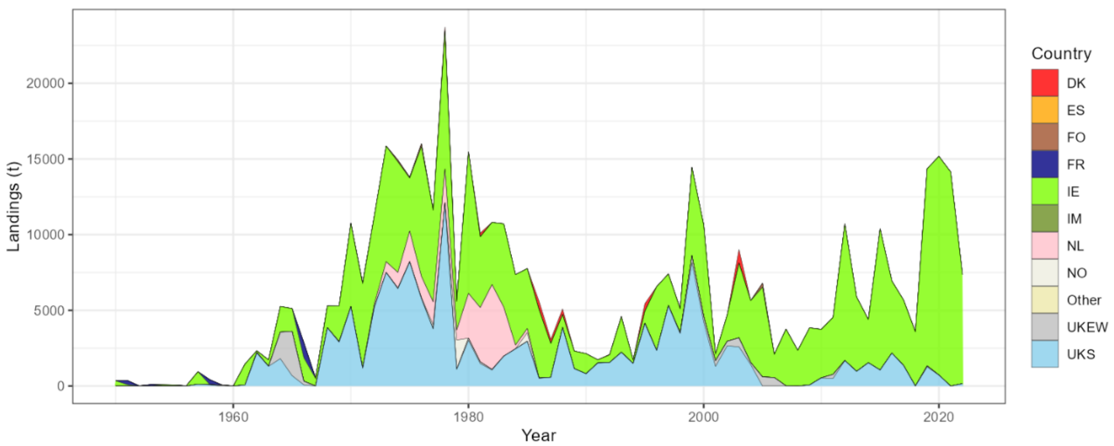

Figure 12.2.8. Catches of sprat 1987–2022 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by country.

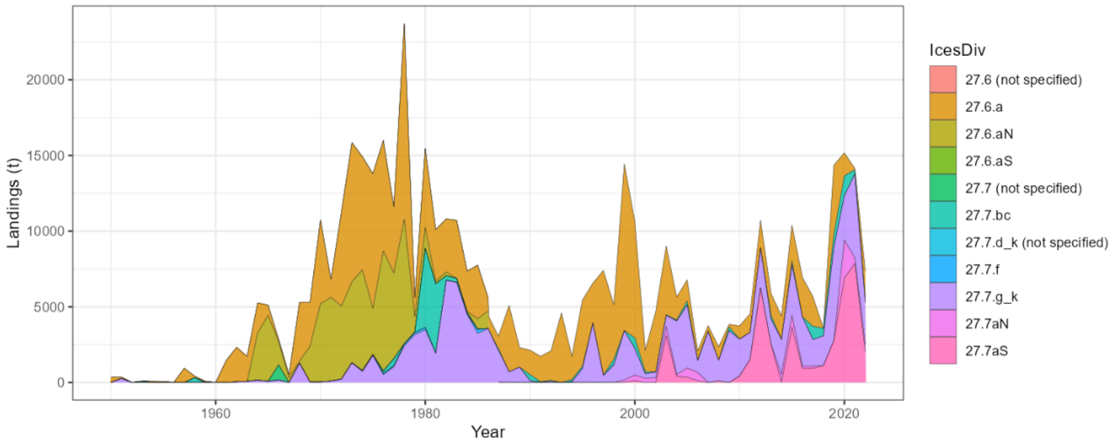

Figure 12.2.9.Catches of sprat 1987–2022 ICES subareas 6 and 7 excluding 7.d and 7.e (Celtic Seas Ecoregion) by Ices Division.

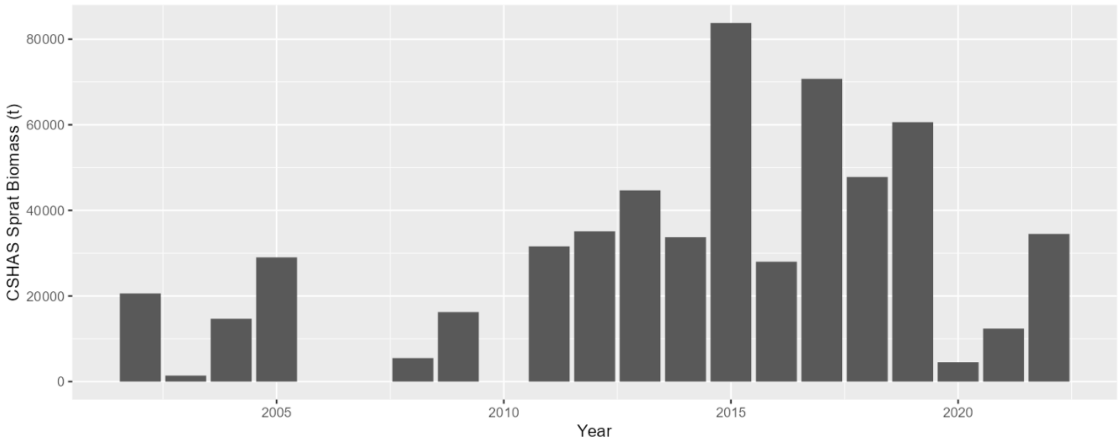

Figure 12.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass from the MI Celtic Sea Herring Acoustic Survey 2004–2022 (A4705).

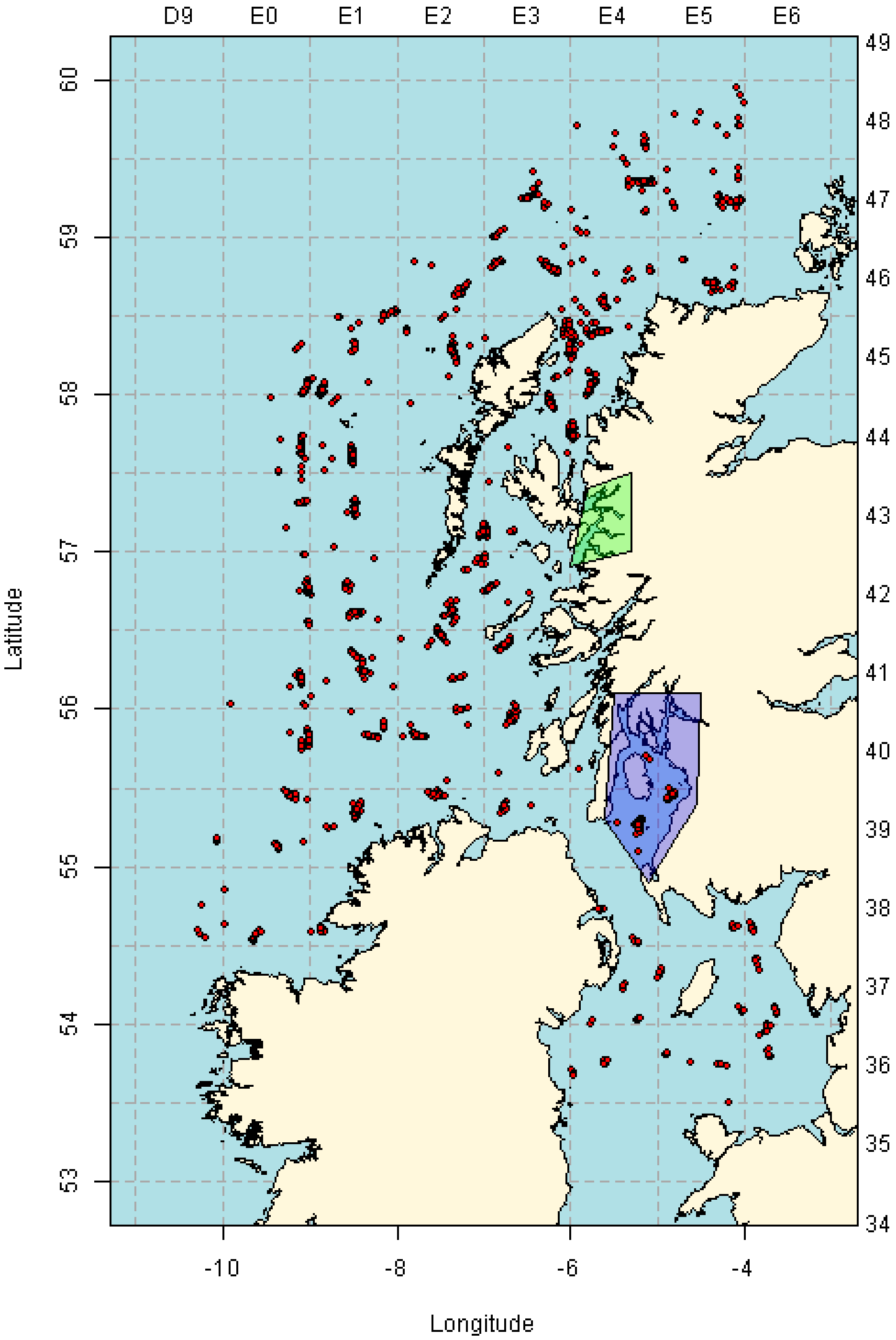

Figure 12.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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).

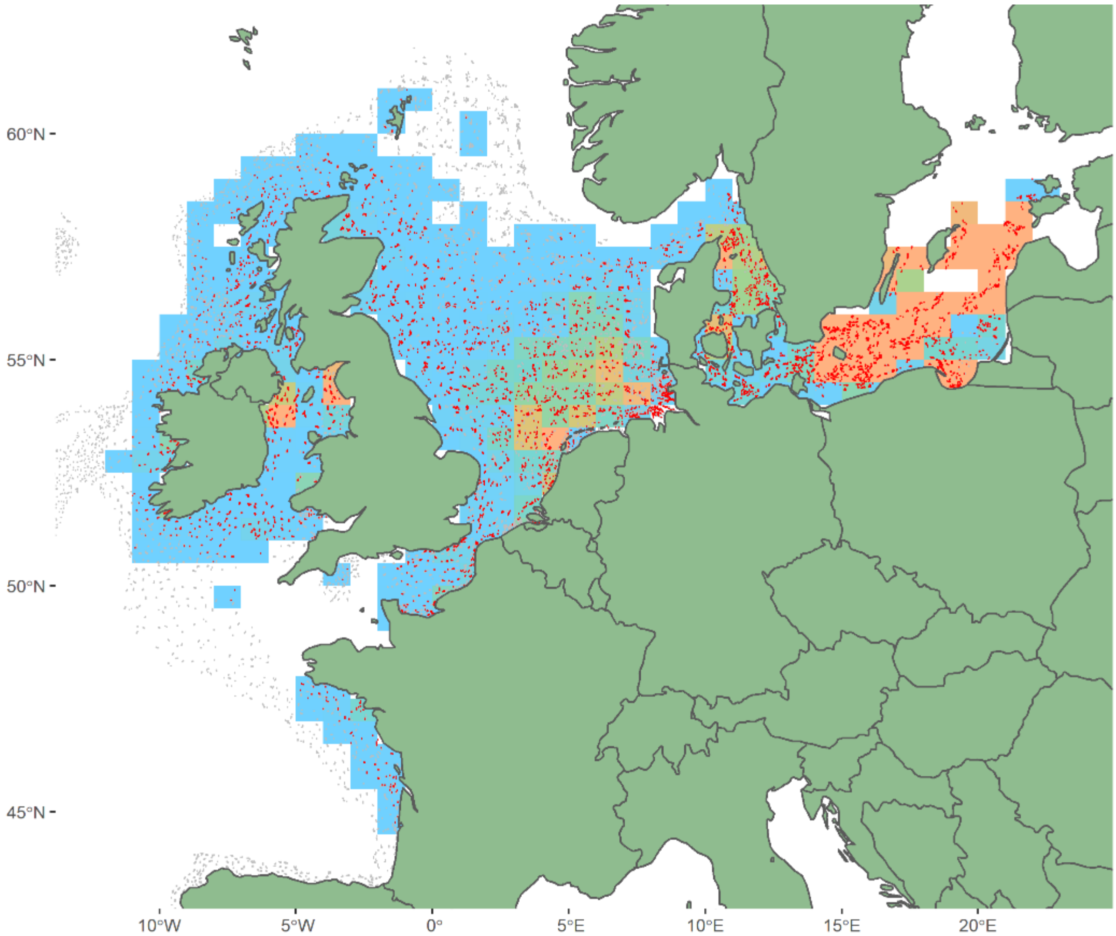

Figure 12.3.3. Total numbers of sprat caught by DATRAS surveys by ICES rectangle, adjusted for tow duration but not adjusted for number of hauls. Since this is a sum, no compensation is made for the varying number of hauls per rectangle. Generated using DATRAS records downloaded 29 Oct 2022, Figure applies 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.

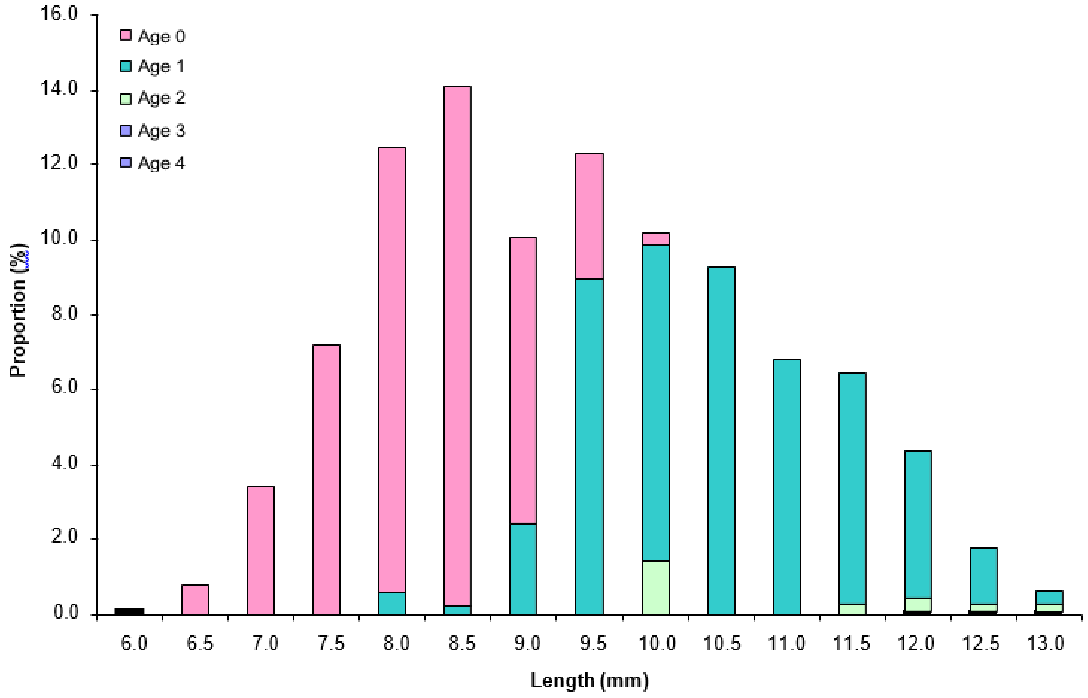

Figure 12.3.4. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged (G7144).

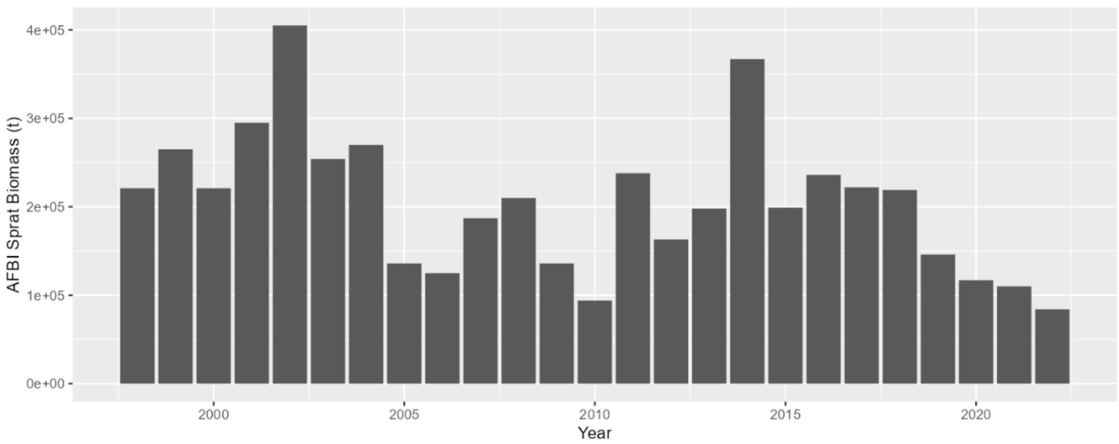

Figure 12.3.5. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN from the AFBI Acoustic Survey (A4075)

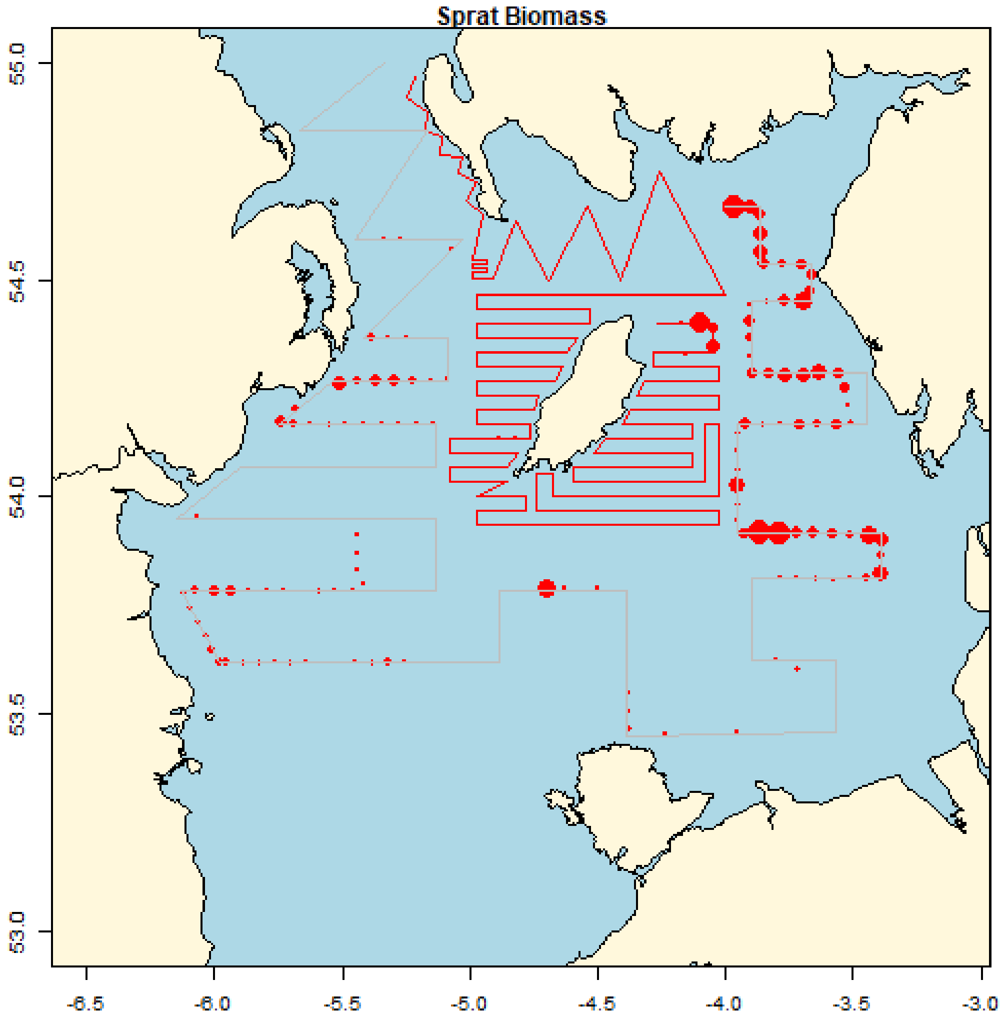

Figure 12.3.6. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) which include juvenile herring and sprat. Obtained during the 2021 AFBI acoustic survey (A4705).

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Annex 2: Resolutions

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:

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

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

   v) descriptions of ecosystem impacts on fisheries

   vi) descriptions of developments and recent changes to the fisheries

   vii) mixed fisheries considerations, and

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

l) Conduct an assessment on the stock(s) to be addressed in 2023 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:

   ix) 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.

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

   xi) 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.

   xii) For category 3 and 4 stocks requiring new advice in 2022, 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

   xiii) 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 interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

xiv) 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.

xv) 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;

xvi) 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.

m) 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.

n) 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)

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

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

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

r) 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.

HAWG – Herring Assessment Working Group for the Area South of 62ºN

2021/2/FRSG03 The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Aaron Brazier, UK, and Cecilie Kvamme, Norway will meet:

In Copenhagen, Denmark or as a hybrid meeting 24–26 January 2023 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 Copenhagen, Denmark or as a hybrid meeting 14–22 March to:

b) compile the catch data of North Sea and Western Baltic herring on (14–15 March);

c) address generic ToRs for Regional and Species Working Groups on (16–22 March) for all other 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 2022 ICES data call.

HAWG will report by 6 February (sandeel), 28 March (sprat), 31 May (North Sea, Western Baltic herring), and 30 June (remaining herring stocks) 2023 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Annex 3: List of stock annexes

The table below provides an overview of the HAWG Stock Annexes. Stock Annexes for other stocks are available on the ICES website library under the content type Stock Annexes. Enter the stock code, year, ecoregion, species, and/or acronym of the relevant ICES expert group into the search box, and sort by Publication date to see the results. Follow the need help? link for searching tips.

Stock ID	Stock name	Last updated	Link
her.27.20-24	Herring (*Clupea harengus*) in subdivisions 20-24, spring spawners (Skagerrak, Kattegat, and western Baltic)	March 2023	her.27.20-24_SA
her.27.3a47d	Herring (*Clupea harengus*) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, eastern English Channel)	August 2021	her.27.3a47d_SA
her.27.6aN	Herring (*Clupea harengus*) in Division 6.a North (North of 56°00'N and East of 07°00'W), autumn spawners (West of Scotland)	February 2022	her.27.6aN_SA
her.27.6aS7bc	Herring (Clupea harengus) in Division 6.a South (South of 56°00'N and West of 07°00'W) and 7.b-c (northwest and west of Ireland)	May 2022	her.27.6aS7bc_SA
her.27.irls	Herring (*Clupea harengus*) in divisions 7.a South of 52°30'N, 7.g-h, and 7.j-k (Irish Sea, Celtic Sea, and southwest of Ireland)	April 2021	her.27.irls_SA
her.27.nirs	Herring (*Clupea harengus*) in Division 7.a North of 52°30'N (Irish Sea)	June 2017	her.27.nirs_SA
san.sa.1r	Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank)	Jan 2018	san.sa.1r_SA
san.sa.2r	Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, and Subdivision 20, Sandeel Area 2r (Skagerrak, central and southern North Sea)	Jan 2020	san.sa.2r_SA
san.sa.3r	Sandeel (*Ammodytes* spp.) in Divisions 4.a and 4.b, and Subdivision 20, Sandeel Area 3r (Skagerrak, northern and central North Sea)	Jan 2020	san.sa.3r_SA
san.sa.4	Sandeel (*Ammodytes* spp.) in divisions 4.a and 4.b, Sandeel Area 4 (northern and central North Sea)	Nov 2016	san.sa.4_SA
san.sa.5r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 5r (northern North Sea, Viking and Bergen banks)	Nov 2016	san.sa.5r_SA
san.sa.6	Sandeel (*Ammodytes* spp.) in subdivisions 20-22, Sandeel Area 6 (Kattegat)	Nov 2016	san.sa.6r_SA
san.sa.7r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 7r (northern North Sea, Shetland)	Nov 2016	san.sa.7r_SA
spr.27.3a4	Sprat (*Sprattus sprattus*) in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)	March 2019	spr.27.3a4_SA

Stock ID	Stock name	Last updated	Link
spr.27.67a–cf–k	Sprat (*Sprattus sprattus*) in Subarea 6 and Divisions 7.a-c and 7.f-k (West of Scotland, southern Celtic Seas)	March 2023	spr.27.67a–cf–k_SA
spr.27.7de	Sprat (*Sprattus sprattus*) in divisions 7.d and 7.e (English Channel)	March 2021	spr.27.7de_SA

Annex 4: Working documents

- **WD01 – Stock splitting of North Sea autumn spawners (NSAS) and western Baltic spring spawners (WBSS) for their 2023 assessments**
- **WD02 – 2022 Western Baltic spring-spawning herring recruitment monitored by the Rügen Herring Larvae Survey**

Stock splitting of North Sea autumn spawners (NSAS) and western Baltic spring spawners (WBSS) for their 2023 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. With effect from the assessment in 2022, Denmark and Norway discontinued their previous sampling and data collection method in favor of stock classification with genetic markers. Similarly, Sweden collected genetic samples with effect from the 2023 assessment. 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 2023. To ensure minimal disruption to the update assessments, genetic information was transformed from the eight biological populations to the two previously assessed stocks based on spawning time and mean vertebral counts. Further, the mixed-stock analysis was updated to be completely model based. Through a re-analysis of 2020 data, the new mixed-stock model was found to give similar estimates as the previous method. This working document describes the necessary, but minimally disruptive, changes made to the stock splitting procedure in order to complete the 2023 update assessments of North Sea autumn spawning and western Baltic spring spawning herring. The experiences gained lay out several possibilities for improving the assessment in a future benchmark.

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Introduction

Several Atlantic herring (*Clupea harengus*) stocks co-occur in the Baltic Sea, North Sea, and connecting areas Skagerrak and Kattegat. In the North Sea, Skagerrak, Kattegat and western Baltic Sea. In terms of productivity, 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.

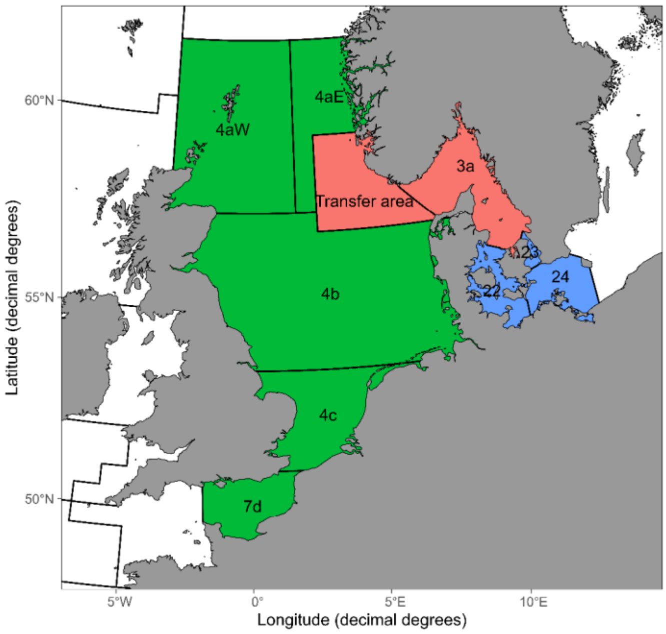

Figure 1: ICES Divisions for the her.27.3a47d (green area) and her.27.20-24 blue area) assessments. The stocks are split in the 'Transfer area' and Division 3.a (red area).

Historically, the approach for 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 to increase sample sizes. In 2021, Denmark and Norway discontinued the previous sampling methods in favor of genetic marker-based stock classification (hereafter 'genetics'). In this working document, we will report in detail how genetic assignments have been implemented in the splitting of these two stocks for their 2023 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 2023

From 2021, genetic methods have been applied by Denmark and Norway replacing the two previously used methods, thereby allowing for a more detailed and precise stock assignment of herring. Likewise, Sweden has discontinued the use of otolith microstructure from 2022 in favor of genetic methods.

A detailed description of the applied genetic stock identification method is presented in Bekkevold et al. (2023). 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 clearly comparable. In contrast to the previous splitting methods, the genetics allow for a much more detailed small-scale population identification resulting in eight 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 2023 update assessments of her.27.3a47d and her.27.20-24. The new genetic information revealed that more herring stocks are present in the assessment areas than previously accounted for. Further, all stocks 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 stocks. In the short term, however, that 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 stock identification was converted to the assignments that would be expected from the previous methods (Table 1). For microstructure, predominantly spring spawning genetic stocks were converted to WBSS while predominantly autumn and winter spawning stocks were converted to NSAS. For vertebral counts, genetic stocks with VS lower than 56.15 (midpoint between mean VS of NSAS and WBSS) were converted to WBSS while stocks 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 stock 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 stock 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: 57.1). However, roughly 10% of NSS herring have a VS of 56 or below (Eggers et al. 2014; Berg et al. 2017a; Berg et al. 2017b). 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 in Norwegian catches in 2021, 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 data was split by otolith microstructure into different hatching season. Mismatch between assigned stocks based on Norwegian and Danish data is presented in *italic*.

Genetic population	VS	Hatching season	Stock assigned	
			Norwegian data	Danish/Swedish data
North Sea autumn spawners	56.5 (n = 530)	Autumn	NSAS	NSAS
Downs	56.5 (n = 782)	Winter	NSAS	NSAS
Western Baltic spring spawners	55.7 (n = 206)	Spring	WBSS	WBSS
WBSS-Skagerrak	56.8 (n = 172)	Spring	*NSAS*	*WBSS*
Norwegian spring spawners	57.1 (n = 194)	Spring	*NSAS*	*WBSS*
Northeast Atlantic (Faroes, Iceland)	56.3 (n = 6)	Autumn	NSAS	NSAS
Central Baltic herring	55.6 (n = 54)	Spring	WBSS	WBSS
Baltic autumn spawning herring	55.6 (n = 23)	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. For the 2023 update assessment, '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 catches in 2022 in the 'Transfer area', 25 Norwegian commercial samples with length-at-age and genetic assignments were available, but 23 samples were collected in quarter 2, whereas only one sample was collected in quarter 3 and 4. Further, one Swedish and three Danish commercial samples were available in quarters 2 and 3. Thus, the resolution was not optimal, but improved compared to previous years when only two or less samples were available. As most samples were collected in quarter 2 but close to the month change to quarter 3, consequently, these samples were used to estimate the splitting proportion for quarter 2 and 3 combined. To increase the sample size of older fish to estimate more precise proportions of stocks, we, in line with earlier stock assessments, 'borrowed' data from the Danish and

Norwegian HERAS samples as well as the Swedish IBTS samples which have been collected in the 'Transfer area' at similar locations and time as commercial catches. Proportions for quarter 1 and 4 were identical to what has been used in the last years since the new data was not reliable. 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 2022, it was necessary to reduce the number of spline knots to 3 to ensure the model was identifiable and converged properly. The estimated proportions of North Sea autumn spawners in the 'Transfer are' are shown in Table 2.

Table 2: Estimated proportion of North Sea autumn spawners (NSAS) per age and each quarter in the 'Transfer area' in commercial catches 2022.

Age	Q1	Q2	Q3	Q4
0	100.00			100.00
1	97.92	99.37	99.37	100.00
2	87.50	99.29	99.29	100.00
3	76.19	92.79	92.79	100.00
4	72.53	50.52	50.52	95.80
5	28.57	28.54	28.54	100.00
6	60.32	22.99	22.99	82.14
7	100.00	26.96	26.96	100.00
8	28.57	39.49	39.49	41.56
9+	100.00	58.81	58.81	80.00

The total catch in 2022 in the 'Transfer area' and Division 3.a resulting from the split between NSAS and WBSS is given in Table 3.

Table 3: 2022 catches (tonnes) in the 'Transfer area' and Division 3.a split by stocks.

	NSAS		WBSS	
Transfer area (A-fleet)	85 521		5402	
Division 3.a	C-fleet	D-fleet	C-fleet	D-fleet
	296	219	180	32

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 2022. Therefore, like in previous years, samples from 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	26	0	38	121	**185**
	2	0	0	184	0	0	**184**
	3	0	8	608	47	142	**805**
	4	0	0	0	0	0	**0**
	Total	0	34	792	85	263	**1174**
3.a.21	1	0	0	0	0	100	**100**
	2	0	0	0	0	0	**0**
	3	0	0	480	0	189	**669**
	4	0	0	0	0	0	**0**
	Total	0	0	480	0	289	**769**
Total		**0**	**34**	**1272**	**85**	**552**	**1943**

Stock compositions of commercial catches was 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 of 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+. There were no observations of age 0 in quarters 1 and 2) was included to allow additional flexibility. 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. Due to the properties of the available samples in 2022, it was necessary to combine commercial and IBTS samples in the trip type factor as well as Age0Quarter3 and Age0Quarter4 in the factor for age/quarter. The estimated proportions of NSAS are shown in Table 5.

The total catch in Division 3.a in 2022 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		0.97	0.87		1.00			0.94
1		0.99	0.92	0.92	0.88	0.98	0.81	0.81
2	0.90	0.96	0.71	0.71	0.65	0.84	0.33	0.33
3			0.50	0.50	0.21	0.62	0.21	0.21
4			0.40	0.40	0.04	0.53	0.28	0.28
5			0.38	0.38	0.01	0.60	0.45	0.45
6			0.42	0.42			0.56	0.56
7			0.47	0.47			0.46	0.46
8+			0.49	0.49			0.11	0.11

Comparing stock composition methods

To quantify the effect of updating the stock splitting methods, the updated method for Division 3.a was compared to the results from 2020 stock split. Two comparisons were made for 2020 data. In the first comparison, the exact procedure used for 2021 data was applied. However, due to limited sampling, the model used for 2021 was not identifiable when using 2020 samples meaning that some parameters could not be estimated from the available data. Therefore, a second comparison was made where Danish surveys were combined and quarters 1 and 2 were combined to make the model identifiable. Genetic samples were not available for 2020. Therefore, the comparison only concerned the composition estimation.

Using the exact same model, most estimated proportions (by area, quarter, and age) were close to the proportions obtained with the previous method (Pearson correlation between the previous and new estimates: 0.345, R^2 using the new estimates as a prediction of the old estimates: -1.23; Fig 3). However, there were clear outliers, in particular for quarter 2 where the sampling was very limited (without quarter 2 - Pearson correlation: 0.897, $R^{2:}$ 0.781). In general, the largest differences in composition estimates were obtained for groups with limited sampling and limited catches. When comparing the resulting catch numbers (CANUM), there was a very high agreement between the previous and the updated method (Pearson correlation: 0.996, R^2: 0.985; Fig. 4). Further, the total catch number for NSAS was calculated to be 9.8% higher with the updated method than the previous method. This difference corresponds to 5% of the total CANUM in Division 3.a. The difference in CANUM was largest for ages 0-2.

Using the identifiable version of the updated method, there was still an overall good agreement in stock composition estimates between the previous and updated estimation procedures, but with fewer outliers than before (Pearson correlation: 0.876, R^2: 0.699; Fig. 5). By visual comparison, the estimates for quarters 1, 3, and 4 did not change much compared to the first model. Likewise, the agreement was strong when scaling to CANUM per age, area and quarter (Pearson correlation: 0.997, R^2: 0.987; Fig. 6). When combining to total catch numbers, the updated method would have allocated 9.35% more to NSAS than the previous method. Again, the difference in CANUM was largest for younger ages.

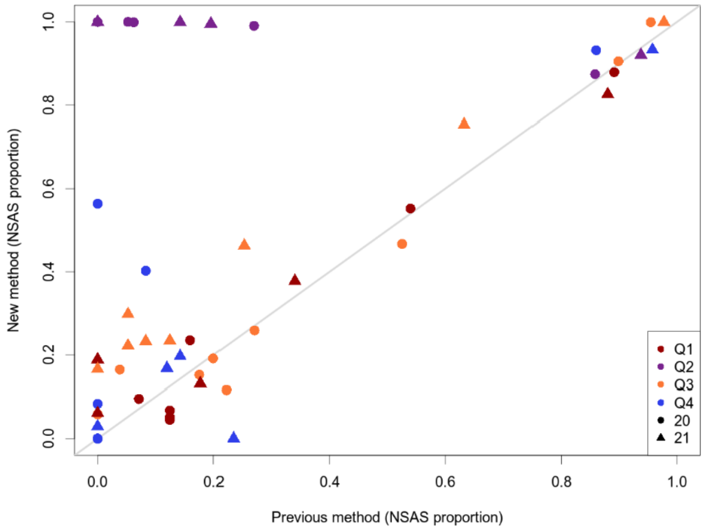

Figure 2: Comparison of estimated stock composition by age, quarter, and area for 2020 with the previous and the new method.

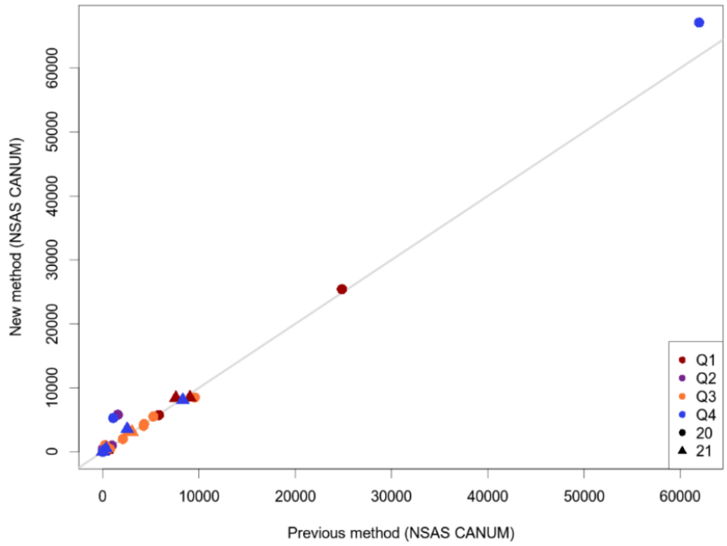

Figure 3: Comparison of CANUM by age, quarter, and area for 2020 with the previous and the new method.

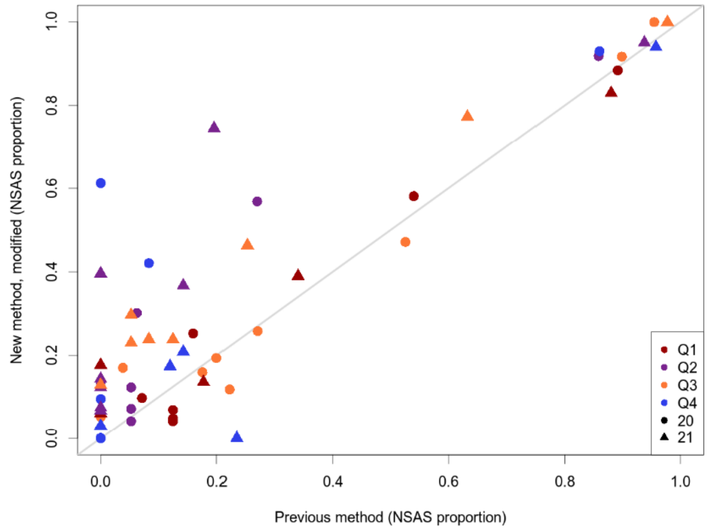

Figure 4: Comparison of estimated stock composition by age, quarter, and area for 2020 with the previous and the new method modified to be identifiable meaning that some parameters could not be estimated from the available data.

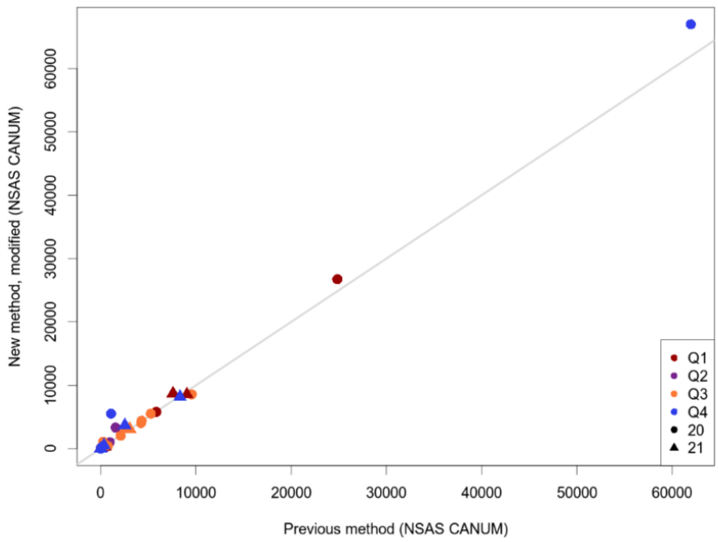

Figure 5: Comparison of CANUM by age, quarter, and area for 2020 with the previous and the new method modified to be identifiable meaning that some parameters could not be estimated from the available data.

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. Therefore, it was 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 judgment 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.

Genetic analyses have revealed that more herring stocks mix in larger areas of the region than previously 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 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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2022 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey

P. Polte, S. Haase, P. Kotterba
Thünen Institute of Baltic Sea Fisheries (TI-OF), Germany

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.

2022 N20 index results:

The regular Rügen-herring larvae Survey started on February 28th and continued weekly for 16 weeks until June 15th 2022 including a total of 595 stations/hauls. An additional cruise in mid-February (winter control) had to be cancelled due to ice cover. An additional cruise in November (autumn control) was performed from 14.11. to 25.11. 2022.

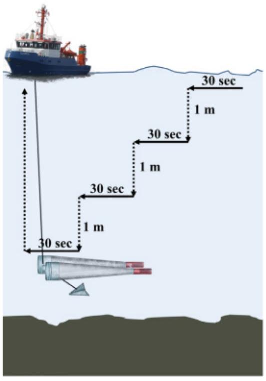

Figure 2. Schematic Bongo net sampling in the RHLS. Note that min. water depth is 4 m (10 m max.). Limit of the haul depth is 1 m above ground. Towing speed is 2 knt.

With an estimated product of **6603 million** larvae, the 2022 *N20* recruitment index is more than 25 times higher than that of the record low in 2020 and the highest value since 2010 (Table 1, Figure 2).

2022 additional survey observations:

According to former observations on the impact of winter SST on spawning phenology and herring early life stage survival (Gröger et al. 2014, Polte et al. 2021), the reasons for the higher N20 index compared to the previous year can be speculated being related to relatively cold February-temperatures, most probably resulting in a comparatively positive spawning phenology. Additionally, the fishery was almost closed in the area. This might have increased the amount of eggs spawned in the area, however, it does not necessarily explain improved survival of larvae throughout their critical period.

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**

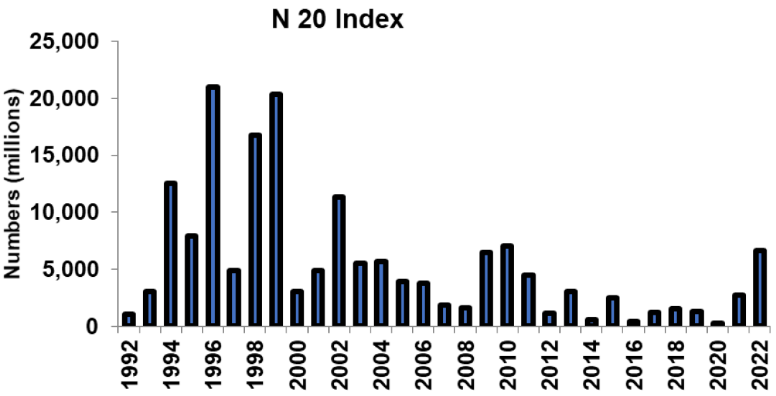

Figure 2 Time series of the N20 index (1992-2022). Time series average: 5,400 millions.

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.

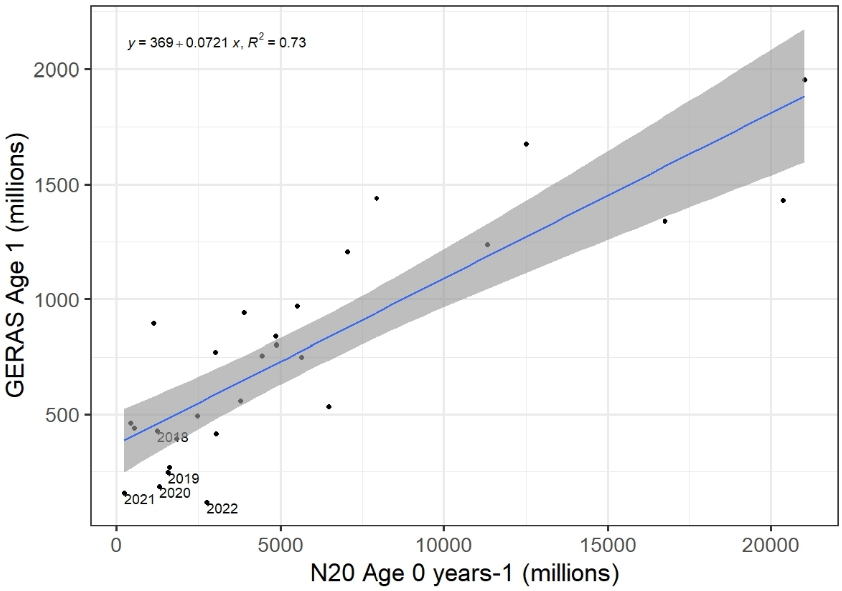

Figure 3 Correlation of N20 larvae index (1993-2021, excl. 2000) with the 1-wr herring from GERAS (1994-2022 excl. 2001 as SD 23 was not covered in that year). Note the one-year lag phase between indices, i.e. the

exceptionally low N20 year 2020 is represented by the GERAS 1-wr index 2021. The years 2018-2022 are labelled.

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Annex 5: Audit reports

Her.27.20-24

Review of ICES Scientific Report, (HAWG) *(2023)* (23.03.2023)

Reviewers: Norbert Rohlf

Expert group Chair: Cecilie Kvamme, Aaron Brazier

Secretariat representative: Sarah Louise Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Consistent with last year's advice, continued to be zero catch advice when MSY approach is applied. Stock is well below Blim with a slight upward trend. There is a strong decline in fishing mortality in recent years. Recruitment is slightly increasing from historic low levels.

For single-stock summary sheet advice

Stock: her.27.20-24

The WBSS stock is caught in several management units, in Subdivision 20-24 and in Sub-area 4a. Catches consists of a mixture of WBSS and NSAS herring. The stock was last benchmarked in 2018.

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: multi-fleet SAM
5) Consistency: consistent with last year's assessment. Model was applied as per stock annex. Catches in the transfer area have increased considerably in 2023.
6) Stock status: SSB is below Blim. Recruitment has slightly increased from record low level in 2020.
7) Management plan: There is no agreed management plan for this stock.

General comments

In 2022, 100% of herring quotas in the human consumption fishery can be transferred from 3.a into 4.a., compared to 50% in previous years. The catches of WBSS in 2023 are expected to continue to be larger in the North Sea than in subdivisions 20-24.

The stock is caught in different management unit. Recovery will be impaired if catches are not minimized in all units.

Technical comments

None

Conclusions

The assessment has been performed correctly and considered adequate as the basis for TAC advice. All information is available on Stockassessment.org.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct.

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under “Other options”.

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☐ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

Her.6aS7bc

Reviewers: Joseph Ribeiro, Kirsten Birch Håkansson

Expert group Chair: Cecilie Kvamme, Aaron Brazier

Secretariat representative: Sarah Louise Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock **her.27.6aS7bc**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: category three method 2.2 – constant harvest rate (the chr rule). Implemented at benchmark in 2022 (WKNSCS)
5) Consistency: Using robust (genetically) split Malin Shelf Herring Acoustic Survey.
6) Stock status: No biomass reference points defined but biomass in a depleted state. F below FMSYproxy
7) Management plan: NA.

General comments

It is counterintuitive that the advice is increasing in the face of a decrease in the biomass index relative to last year, this was discussed extensively by the group. This is a hangover from the initial advice which was limited by the stability clause. The catch advice is again limited by the stability clause as the advice from the CHR calculation is more than 20% above the previously advised catch.

Technical comments

The lack of consistency between caught and surveyed (MSHAS) proportions at age still remains an issue in 2022, after 2021, and should be investigated.

There have been ongoing minor decreases in the mean lengths and weights, which should not be ignored. This was attributed to changeable amounts of mixing between larger spring spawners and autumn spawners in a changing climate. Ongoing genetics work should provide evidence for that.

Conclusions

No concerns about the application of the rule or the presented advice.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status N/A

☐ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☐ Check if the labels for the years are correct.

☐ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

<u>**Basis of catch options table**</u>:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

<u>**Catch options table: N/A**</u>

☐ The forecast should be re-run to ensure all values are correct.

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☐ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☐ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☐ For all the options given in the table calculate the percentage of change in SSB and TAC.

☐ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☐ Compare different catch options; higher F should result in lower SSB

☐ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment N/A

☐ Are the units in plots correct?

☐ Are the titles in the plots correct including F (age range) recruitment (age).

☐ The red line correspond to the year of assessment (except F which is year of assessment -1)

☐ Each plot should have five lines.

☐ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders N/A

☐ If no information is available the standard sentence should be "There is no **additional** available information"

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table: N/A

☐ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☒ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

Her.6aN

Stock: Autumn-spawners herring in Division 6.a North

Short description of the assessment as follows (examples in grey text):

8) Assessment type: update following benchmark in 2022, Category 3
9) Assessment: accepted
10) Forecast: Not relevant
11) Assessment model: Category 3, Method 2.2 Constant Harvest Rate using indices for 6aN herring from Malin Shelf Herring Acoustic Survey

(MSHAS) and commercial catches above the 56°N line (total catch and length frequencies)

12) Consistency: Method used as agreed at the benchmark
13) Stock status: Fishing pressure on the stock is below $F_{MSYproxy}$ since 2017 and SSB index is above the MSY Btrigger ($I_{trigger} = 1.4*I_{loss}$) since 2020
14) Management plan: Not relevant

General comments

The assessment and advice was performed in adequacy with what was decided at the 2022 benchmark. The 2024 advice of 1 454 t is entirely driven by the stability clause of the chr rule that constrains the advice to not exceed 20% of the previous advice (here the average 3-year catch). Without the stability clause the advice would have been significantly larger (5 583 t). Given that the previous combined stock (6aN+6aS7bc) advice was zero in 2022, using the stability clause is deemed appropriate. It has to be noted that both stocks have now a positive catch advice given the downgrade to category 3, which does not allow zero catch advice if applied.

Technical comments

- The ICES 2023c reference needs to be updated. It's still including the information for the HAWG 2022 report.
- Stock annex: Reference to multifleet SAM model should be replaced by Nielsen et al. 2021 (https:doi.org/10.1093/icesjms/fsab078). Nielsen et al. 2012 as used currently is referring to a genetic paper not related to the multifleet model.
-

Conclusions

The assessment was performed correctly and according to procedure.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☐ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☒ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☒ Check if the labels for the years are correct.

☒ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

<u>**Basis of catch options table**</u>:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

<u>**Catch options table:**</u>

☐ The forecast should be re-run to ensure all values are correct.

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☐ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

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☐ For all the options given in the table calculate the percentage of change in SSB and TAC.

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☐ Compare different catch options; higher F should result in lower SSB

☐ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☐ Are the units in plots correct?

☐ Are the titles in the plots correct including F (age range) recruitment (age).

☐ The red line correspond to the year of assessment (except F which is year of assessment -1)

☐ Each plot should have five lines.

☐ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders

☐ If no information is available the standard sentence should be “There is no **additional** available information”

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☐ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☐ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

Her.27.irls

Review of ICES Scientific Report, Herring Assessment Working Group (HAWG) 2023, 14-22 March

Reviewers: Henrik Mosegaard & Cindy van Damme

Expert group Chair: Cecilie Kvamme & Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The assessment has had a strong retrospective pattern for several years, but the trend is declining and is now almost entirely driven by the 2018 values. For SSB the Mohns Rho (0.87) is still high, but because the

stock is below Blim, the assessment is accepted since applying the ICES MSY approach the advice results in zero catch for 2024.
The spawning-stock biomass (SSB) has decreased significantly in the last decade and has been below B_{lim} since 2016. The fishing mortality (F) has been above F_{pa} (=F_{msy}) between 2014 and 2019, but has been below F_{pa} since 2020. Recruitment has been below average, since 2013 and has recently been overestimated both historically and in the retrospective peels. The assessment of the SSB has had a substantial historical retrospective revision in the last years. However, in order to continue to monitor the stock development a continued monitoring TAC of 869 tonnes is assumed, the same as last year.

For single-stock summary sheet advice

Stock **her.27.irls**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted, considered biased, but does not affect the advice outcome
3) Forecast: accepted
4) Assessment model: Analytical assessment using ASAP (as defined at WKWEST (2015) and WKPELA (2018)), tuned to a single acoustic survey (Celtic Sea herring acoustic survey) using ages 2-7 (2002-2022) and catch data (1958-2022)
5) Consistency: Last year's and this year's assessment accepted. SSB is consistently overestimated, and fishing mortality had been underestimated until the current year. R is overestimated in recent years giving a high historic retrospective.
6) Stock status: B<Blim since 2016. No catch options, including F=0 in 2024, will rebuild the stock above Blim in 2025; F<Fpa since regulation by the introduction of a monitoring TAC in 2020.
7) Management plan: The long-term management strategy for Celtic Sea herring that was proposed by the Pelagic Advisory Council in 2011 was re-evaluated by ICES in 2018. ICES advised that the harvest control rule is no longer consistent with the precautionary approach. The management strategy results in a greater than 5% probability of the stock falling below Blim in several years throughout the 20-year simulated period. In October 2019, ICES advised on a monitoring catch for the stock (ICES, 2019).

General comments
This was a well-documented, and well presented. It was easy to follow and interpret. It is carried out in line with the description in the stock annex.

Technical comments
It was clarified with the stock assessor that in Table 8 in the advice sheet the column Unallocated/misreported accounts for discrepancies between Totals and sum of catches in country & discard columns.

Conclusions
The assessment has been performed correctly in line with the description in the stock annex. Appropriate procedures are followed to provide advice and technical services.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table. Ok

☒ The advised value of catches should be the same as presented in the catch options table. OK

☒ Check the years for which the advice is given. OK

New section added: ICES advice on conservation aspects

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet). OK

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2...); relative index OK

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded. OK

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP. OK

☒ Check if the legend of the plots is consistent with what is shown in the plots. OK

☒ Check that the graphs match the data in table of stock assessment results. OK

Stock and exploitation status

This section has been removed from the Advice sheet since 2021.

☐ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☐ Check if the labels for the years are correct.

☐ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct, OK

☒ The value is correct, OK

☒ The notes are correct and OK

☒ The sources are correct. OK

Catch options table:

☒ The forecast should be re-run to ensure all values are correct. Done and OK

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder) OK

☒ The wanted catch and SSB values should be given in tonnes (t); OK

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct. OK

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points. Not applicable for this stock, as it is below Blim

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct. NA

☒ For all the options given in the table calculate the percentage of change in SSB and TAC. OK

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under “Other options”. OK

☒ Compare different catch options; higher F should result in lower SSB OK

☒ Check if SSB change is in line with F. OK

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section. OK

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.) No management plan that ICES is aware of

Quality of the assessment

☒ Are the units in plots correct? OK

☒ Are the titles in the plots correct including F (age range) recruitment (age). OK

☒ The red line correspond to the year of assessment (except F which is year of assessment -1) OK, though not red lines anymore, but colour the same for other advice sheets

☒ Each plot should have five lines. OK

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots. OK

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet. OK

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year. OK, no changes

Basis of the assessment

☒ If there is no change from the previous year the table should be the same. No changes, except for the reference to the HAWG report

☒ Ensure there is no typos wrong acronyms for the surveys OK

☒ Assessment type- check that the standard text is used. OK

Information from stakeholders

This section is not on the advice sheet, wasn't there last year either

☐ If no information is available the standard sentence should be "There is no **additional** available information"

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years. OK

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes). OK

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table. OK

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100% OK

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown. OK

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added) OK

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected. OK

☒ Check if the column names are correct mainly recruitment age and age range for F. OK

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock" NA

Sources and references

☒ Ensure all references are correct. OK

☒ Ensure all references in the advice sheet are referenced in this section OK

Her.27.nirs

Review of ICES Scientific Report: Herring Assessment working Group (HAWG), 14-22 March 2023

Reviewer: Coby Needle

Expert group Chairs: Cecilie Kvamme and Aaron Brazier

Secretariat representative: Sarah-Louise Millar

General
This assessment for this stock is an update, applying the assessment and forecast method agreed by the last benchmark in 2017. This appears to have been done correctly, although there remain some issues with the report section.

For single-stock summary sheet advice

Stock**: Northern Irish Sea herring**

Short description of the assessment as follows (examples in grey text):

15) Assessment type: update.
16) Assessment: accepted.
17) Forecast: accepted.
18) Assessment model: SAM assessment model, accepted by benchmark in 2017 – tuning by one acoustic survey.
19) Consistency: consistent approach applied this year compared with last year.
20) Stock status: $B > B_{lim}$ since 2005; $F < F_{msy}$ since 2002, although the estimate is very uncertain with wide confidence intervals; recent recruitment has been good with the 2021 year-class the highest estimated recruiting abundance at age 1 in 2022.
21) Management plan: there is currently no agreed management plan for this stock, and advice is provided using the ICES MSY approach.

General comments

- In common with several other stocks in HAWG, mean weights-at-age show a steady decline through the observed time period (across all ages).
- The assessment shows some indications of retrospective in fishing mortality (Mohn's rho = 0.222), but the peels are all well within confidence intervals, and

there are no commensurate issues with SSB or recruitment retrospectives. Both analytical and historical retrospective analyses show similar patterns.

- The fishing mortality estimates are very uncertain and look rather too smooth, and this should be considered in a future benchmark.
- The version of SAM used in the assessment is bespoke, and the standard implementation does not yet include elements specific to this stock. This makes review and evaluation more difficult than would otherwise be the case, and should also be considered in a future benchmark.
- The recruitment assumption used in the forecast may be underestimating recruitment, based on the last three estimates, but these are relatively uncertain and a precautionary assumption seems reasonable.
- In common with several other herring stocks assessed at HAWG, there remain issues over stock identity and genetic differentiation – this assessment is likely representing a mixture of Irish and Celtic Sea herring. It would be beneficial for this area to be included as part of a wider future workshop on herring stock identity.

Technical comments

- Minor comment: there are a number of double spaces in the report text which should be removed. More generally, sections of the text would benefit from additional proof-reading to pick up the occasional typo (some of these look to have been caused by editing with track changes left on and visible).
- Section 7.1: the years in which ICES gave these advices should be noted (2021 and 2022 respectively).
- When I downloaded the report file for the audit (on 25 March), the text and tables were present, but the figures were not.
- Table 7.1.1 – there is repeated text in the table caption (actually this seems to be the case for many of the tables). I also think this table would be easier to read if the data were in columns, with a row for each year.
- Table 7.2.2 – it would be helpful to tidy up the formatting of this table, particularly for the most recent 2 columns.
- Table 7.3.2 – this could be fit onto one page by removing the header bar between 2007 and 2008.
- Tables 7.6.3.2 to 7.6.3.4 – the captions refer to Irish Sea herring, not Northern Irish Sea.
- Table 7.6.3.4 – these Ms are time invariant, so this information could be presented as one vector.
- The report section is missing references, although there are citations within the text.
- Given time, it would be beneficial to shorten the text by removing information that could be considered to be out of date – for example, there is a long list of changes that were made in the last benchmark 5 years ago, which aren't relevant given that the assessment has been accepted since. Similarly, section 7.9 presents information from 2017 as being new, and this should be reworded.
- Tables 7.7.1 and onwards are missing.

Conclusions

The Stock Annex stipulations for the assessment and forecast appear to have been implemented correctly, although there has not been time during this audit for a full run of the relevant code. The report would benefit from some attention, however, as the figures were missing at the time of writing, the final two tables were also missing, the text could so with some further proof-reading, and there are sections that I would suggest are no longer needed, as they relate specifically to the 2017 benchmark.

Her.3a47d

Reviewers: Valerio Bartolino

Expert group Chair: Cecilie Kvamme (IMR) and Aaron Brazier (CEFAS)

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: her.27.3a47

Short description of the assessment as follows (examples in grey text):

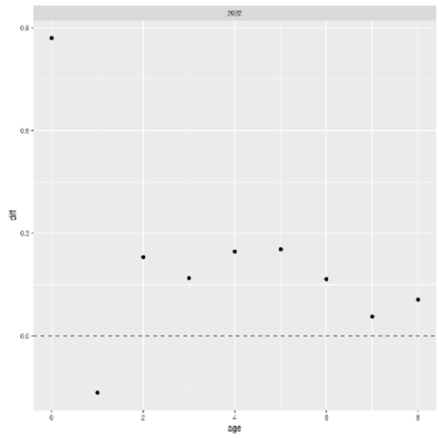
1) Assessment type: updated assessment
2) Assessment: accepted
3) Forecast: accepted, based on a multi-fleet implementation of the single-fleet assessment model
4) Assessment model: age-based single fleet assessment with SAM (modelling framework adopted for this stock since many years). Commercial catches + Five indices with partial age overlap.
5) Consistency: Overall consistent with previous years, but it is noted an up-scaling of SSB in 2021 and in particular 2022 distributed among most ages (age2-6). Recruitment in 2022 is estimated 87% higher than in last year assessment
6) Stock status: $B > B_{lim}$ for more than 2 decades; $F < F_{pa}$
7) Management plan: the stock has been managed according to a long-term management plan for many years. Since 2019 there is no agreed LTMP and the advice has been based on the ICES MSY approach.

General comments

The assessment is well documented and consistent with description in the stock annex.

The upscaling in SSB is related to an upscale of multiple ages contribute to this pattern (see figures below). The issue has been closely investigated but it was not possible to identify one single dataset as only driver.

The +87% upscale of the 2022 recruitment (2021 year class) should be interpreted considering that the last year estimate was inherently very uncertain as based only on the MIK observation while the IBTSQ3 (0-wr) and IBTSQ1 (1-wr) were available this year to track the 2021 year class.



Technical comments
All the codes to run the assessment and forecast are available in the TAF framework. They have been checked for consistency with the code used in the last year assessment and tested. Results on stock dynamics and forecasts are entirely reproducible
https://github.com/ices-taf/2023_her.27.3a47d_assessment
https://github.com/ices-taf/2023_her.27.3a47d_forecast

Conclusions
The assessment has been performed correctly.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be un-shaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Catch scenarios

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☒ The forecast should be re-run to ensure all values are correct.

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

History of advice, catch, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

NA

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

There is a reference on the Council Regulation which I cannot find referenced in the text. Moreover, it refers to Jan 2022.

Reviewers: Alex Holdgate

Expert group Chair(s): Cecilie Kvamme; Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: **Her.27.3a47d**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: single-fleet SAM assessment with commercial catches and five indicies
5) Consistency: consistent with last year's assessment albeit with an upscaling of
6) Stock status: $B > B_{lim}$ and $F < F_{pa}$
7) Management plan: no agreed LTMP since 2019 with advice based on the ICES MSY approach

General comments

It is extremely beneficial that the scripts used to run the assessment and forecasts are available on TAF. I was able to reproduce both the single-fleet and multi-fleet assessments. I was able to run the forecasts without issue and reproduce the results published in the advice sheet. The assessment methods are well documented in both the report and the stock annex.

Technical comments

I was unable to run the retrospective analysis locally on my machine, however, other HAWG members were able to reproduce the results of the retrospective analysis and so this is likely an issue in R rather than the assessment itself.

For the last two catch scenarios, the option with C- and D-fleet transfers has a higher total $F_{ages(wr)\ 0\text{-}1}$ than the option without C- and D-fleet transfers, but also has higher SSB values in 2024 and 2025. This is counterintuitive when displayed on the advice sheet i.e. higher F should result in lower SSB for comparable catch scenarios. We were not able to identify the source of the issue despite extensive investigation. It is worth noting that the SSB discrepancy between the two options is negligible (~0.002%).

Conclusions

This years' assessment has been carried out correctly according to the methods described in the stock annex.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☐ ~~Compare with the previous year's advice sheet. The years in common should have the same status (symbol).~~

☐ ~~Check if the labels for the years are correct.~~

☐ ~~Compare the status table with the F and SSB plots they should show the same information.~~

☒ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☒ The forecast should be re-run to ensure all values are correct.

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

Rationale' now 'ICES advice basis'

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there are no typos or wrong acronyms used for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders

☒ If no information is available the standard sentence should be "There is no **additional** available information"

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

~~☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"~~

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

San.sa.1r

Reviewers: Aaron Brazier

Expert group Chairs: Aaron Brazier (UK), and Cecilie Kvamme (NO).

Secretariat representative: Sarah Louise Millar (ICES).

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed).

For single-stock summary sheet advice

Stock: San.sa.1r

Short description of the assessment as follows (examples in grey text):

22) **Assessment type**: Update.
23) **Assessment**: Accepted.
24) **Forecast**: Accepted.
25) **Assessment model**: Analytical assessment based on SMS. Assumes a relationship between *F* and fishing effort for 1 fleet (commercial) and 1 survey (dredge). Two timesteps per year: Jan-Jun, and Jul-Dec.
26) **Consistency**: Accepted – consistent with last year.
27) **Stock status**: SSB > MSY $B_{escapement}$, B_{pa}, and B_{lim}.
28) **Management plan**: No management plan agreed for sandeel area 1r.

General comments:

- ICES (2023) reference needs completing.
- Conservation status section raised questions on the sections understandability of the standard sentence.

Technical comments:
There is retrospective bias in the assessment – especially in SSB and recruitment. Minor retrospective pattern in F.

Conclusions:
Assessment accepted as being appropriate for giving advice.

Reviewers: Valerio Bartolino

Expert group Chair: Cecilie Kvamme (IMR) and Aaron Brazier (CEFAS)

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Assessment and forecasts conform to the procedure described in the stock annex
- internal consistency of the age0-1 indices from the dredge survey is low (R^2=0.17) and it has been progressively deteriorating (R^2(2022)=0.2, R^2(2021)=0.2, R^2(2020)=??, R^2(2019)=0.22, R^2(2018)=0.25)
- Analytical retrospective shows particularly strong patterns for SSB (Mohn's ρ=0.56) and R (ρ=1.09)
- The advised catch is in line with predicted recruitment and stock development. Despite R in 2022 is below the average the predicted age composition suggests that it will contribute for >40% of the yields in 2023. Moreover, expected contribution of age2, 3, 4+ is approx. 30%, 10%, 10% which is much higher than the observed catches in 2022 likely as a result of the low F in 2022 following a monitoring TAC.
- Uncertainty on the terminal year R is very high which contributes to uncertainty in the forecasts
- There is a general increase in the weight-at-age which is more pronounced for age2+.

For single-stock summary sheet advice

Stock: san.sa.1r

Short description of the assessment as follows:

29) Assessment type: update
30) Assessment: accepted
31) Forecast: accepted
32) Assessment model: analytical assessment based on SMS assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey (+ 1

monitoring CPUE with almost no influence on the assessment), two timesteps per year (Jan-Jun and Jul-Dec).

33) Consistency:
    i. The assessment has a strong retrospective pattern on SSB and R with a general downward revision of both. The important reduction in the 2022 SSB from last year assessment is mainly the result of a downscaling of the number at age2 which results from a -44% downscale of the 2020 year-class. The reasons for such rescaling remain unclear. Exception to the general retrospective pattern is the first peel of R, this year model predicts a +47% increase in the 2021 recruitment.
    ii.
    iii. Catchabilities of commercial fleet and survey are generally consistent with the last year assessment.
    iv. The estimated variances of commercial fleet and survey are overall comparable with last year with some moderate increase that may suggest a deterioration of the model. In the specific an increase in the CVs compared to the last year are estimated for age0 in the dredge survey (0.49 -> 0.51) and all ages in the season 1 commercial fleet (age0: 1.655 -> 1.72; age1-2: 0.343 -> 0.402; age3-4+ 0.657 -> 0.682).
34) Stock status: SSB has been progressively increasing since the 2020 low and it is estimated just above MSY Bpa at the beginning of 2023. 2022 recruitment is estimated below the long-term geometric mean but it is still higher than in the two previous years.
35) Management plan: no MP is in place for SA1r.

Technical comments

The RTM (monitoring CPUE) was not calculated for 2022 because of the low effort resulting from the monitoring TAC.

Conclusions

The assessment has been performed correctly and according to procedure. The retrospective pattern remains problematic and limitedly understood.

San.sa.2r

Review of ICES Scientific Report, (HAWG) *(2023)* (06.02.2023)

Reviewers: Norbert Rohlf

Expert group Chair: Cecilie Cvamme, Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: san.sa.2r

The stock is separated in seven management areas. Fishing takes place in five of these seven areas (sandeel area 1r-3r, 4 and 6). The stock was last benchmarked in 2016.

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Age-based SMS-effort model, half-yearly time steps. Tuned by dredge survey. Since 2020, density-dependency catchability included in the model to account for overestimation of recruitment and SSB. Natural mortalities not updated with latest SMS runs as the update is not likely to affect the used long-term averages.
5) Consistency: consistent with last year's assessment. Mohn's Rho on 5-year-average relatively high for SSB and R. Reasons may be survey overestimation in R, lower as expected catchability in the fishery of young cohorts or the overestimation of mean weight-at-age in some years.
6) Stock status: SSB is slightly increasing, above B_{lim}, but below B_{pa} resp. $MSYB_{escapement}$. F varies much in last 10 years, and is high in 2022. Recruitment is above average in 2021 and 2022.
7) Management plan: There is no agreed management plan for this stock.

General comments

The report is very concise and documents all decisions and settings made in the assessment well.

Technical comments

None

Conclusions

The assessment has been performed correctly and considered adequate as the basis for TAC advice. A management plan needs to be developed.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☐ ~~Compare with the previous year's advice sheet. The years in common should have the same status (symbol).~~

☐ ~~Check if the labels for the years are correct.~~

☐ ~~Compare the status table with the F and SSB plots they should show the same information.~~

☐ ~~Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.~~

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct.

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients (EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The coloured line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders

~~☐ If no information is available the standard sentence should be "There is no **additional** available information"~~

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section

Review of ICES Scientific Report, (HAWG) *(2023)* (06.02.2023)

Reviewers: Thomas Regnier

Expert group Chair: Cecilie Cvamme, Aaron Brazier

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: san.sa.2r

The stock is separated in seven management areas. Fishing takes place in five of these seven areas (sandeel area 1r-3r, 4 and 6). The stock was last benchmarked in 2016.

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Age-based SMS-effort model, half-yearly time steps. Tuned by dredge survey. Since 2020, density-dependency catchability included in the model to account for overestimation of recruitment and SSB. Natural mortalities not updated with latest SMS runs as the update is not likely to affect the used long-term averages.
5) Consistency: consistent with last year's assessment. Mohn's Rho on 5-year-average relatively high for SSB and R. Reasons may be survey overestimation in R, lower as expected catchability in the fishery of young cohorts or the overestimation of mean weight-at-age in some years.
6) Stock status: SSB is slightly increasing, above B_{lim}, but below B_{pa} resp. $MSYB_{escapement}$. F varies much in last 10 years, and is high in 2022. Recruitment is above average in 2021 and 2022.
7) Management plan: There is no agreed management plan for this stock.

General comments

The report is very concise and documents all decisions and settings made in the assessment well.

Technical comments

None

Conclusions

The assessment has been performed correctly and considered adequate as the basis for TAC advice. A management plan needs to be developed.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

Not sure what the grey line above the plots in Figure 2 is, it starts with 2022… like in last year's assessment (should it be 2023?)

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☐ ~~Compare with the previous year's advice sheet. The years in common should have the same status (symbol).~~

☐ ~~Check if the labels for the years are correct.~~

☐ ~~Compare the status table with the F and SSB plots they should show the same information.~~

☐ ~~Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.~~

Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☒ The year is correct,

☒ The value is correct,

☒ The notes are correct and

☒ The sources are correct.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct. I can't do that

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder) data folder empty

☒ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct. F_{lim}; F_{pa} not defined for SA2r

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

SSB of the forecast year = Bpa

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC. Values checked and correct (**rounded** to the nearest integer)

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients (EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The coloured line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines. Not sure what is meant here? Horizontal lines? SSB and F have 4, Recruitment 3, or is it 5 lines as in figure size?

☒ Ensure the reference points lines (in the SSB plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

Basis of the assessment

☒ If there is no change from the previous year the table should be the same.

☒ Ensure there is no typos wrong acronyms for the surveys

☒ Assessment type- check that the standard text is used.

Information from stakeholders

~~☐ If no information is available the standard sentence should be "There is no **additional** available information"~~

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years. In Table 6 should the catches for SA2r and total catches have the *** for preliminary?

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

Should the SSB values for 2023 have "**"

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

ICES. 2023. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 5:XX. http://doi.org/10.17895/ices.pub should be updated when available

☒ Ensure all references in the advice sheet are referenced in this section

San.sa.3r

Review of ICES Scientific Report, HAWG 2023, 24-27 January

Reviewer: Claus R. Sparrevohn

Expert group Chair: Cecilie Kvamme and Aaron Brazier.

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

It is worth noticing that there is an ongoing benchmark process for sandeel in the North sea. The intention was that this benchmark would have provided the foundation for the 2023 advice, but as the benchmark is still pending HAWG chose to continue with the 2016 benchmark settings.

For single-stock summary sheet advice

Sandeel in area SA3r

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: *Analytical assessment based on the SMS-model run in single-species mode. Assumes a relationship between F and fishing effort. There is one single commercial fleet, one dredge survey and acoustic index. The acoustic index is estimated during the fishing season.*
5) Consistency: *Accepted – consistent with last year.*
6) Stock status: SSB is above biomass reference points Blim, Bpa and Bescapement. There are no F reference points for the escapement strategy (with Fcap) which is used for the stock.
7) Management plan: No

General comments

Because of two years with low recruitment, the stock is declining. SSB has been upscaled compared to the 2022 assessment. Unlike, at least, then three previous advice this year's advice is not capped by the Fcap.

Technical comments

Conclusions

The assessment has been performed correctly and according to procedure.

Review of ICES Scientific Report, HAWG (Sandeel) 2023, 24-26 January

Reviewers: Cecilie Kvamme

Expert group Chair: Cecilie Kvamme and Aaron Brazier

Secretariat representative: Sarah Louise Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Sandeel SA3r

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update assessment (benchmark have started but not finished yet)
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Analytical assessment with SMS (single species mode, half-year time steps), natural mortality from North Sea multi-species model (northern?), fisheries dependent input data: catch@age, CPUE, effort, fisheries independent input data: dredge survey indices, acoustic survey indices.
5) Consistency: both last year's and this year's assessment accepted. SSB upscaled and F(1-2) downscaled in this year's assessment
6) Stock status: $B > B_{pa}$ ($=B_{escapement}$) after 2014, $B > B_{lim}$ after 2013; R estimated to be well below long-term average in 2021 and 2022.
7) Management plan: ICES is not aware of any management plan.

General comments
The advice is thoroughly checked, and no errors were found. The report is well written and well structured. The assessment and forecast follow the stock annex. SSB has been upscaled and F downscaled in the 2023 assessment compared to the 2022 assessment.

Technical comments
The Blim scenario from Table 2 in the advice sheet is missing in the scenario table in the report (Table 9.4.12). Also, Table 9.4.12 would benefit for some more information about the basis (as given in Table 2 in the advice)

Conclusions
The assessment and forecast have been done correctly and according to the stock annex.

San.sa.4

Review of ICES Scientific Report, HAWG 2023, 24-27 January

Reviewers: Ole Henriksen

Expert group Chair: Cecilie Kvamme and Aaron Brazier.

Secretariat representative:

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock san.sa.4

Short description of the assessment as follows (examples in grey text):

1) **Assessment type:** Update
2) **Assessment: Accepted**
3) **Forecast: Accepted**
4) **Assessment model:** Analytical assessment based on the SMS-model run in single-species mode. Assumes a relationship between *F* and fishing effort. There is one singe fleet (commercial) and 1 survey split into two periods (dredge survey). Each year has two time steps (half-year): Jan-Jun, and Jul-Dec.
5) **Consistency:** Accepted – consistent with last year.
6) **Stock status:** $B < B_{pa}$, but $B > B_{lim}$. Since 2010, the SSB seem to have stabilised at a level between B_{pa} and B_{lim} with normal fluctuations around this point, but with a slight upward trend. Recruitment seem to be similar, having an upward trend the last decade.
7) **Management plan:** No management plan are in place for SA4, but a closed area have been in place since 2000.

General comments

A general comment that are evident yearly, is that the dredge survey covers the closed area off the coast of Scotland, but does not cover much of the actual fished area (this year the coverage were expanded to cover some of the fished area). The dredge survey have previously been adjusted to account for skewness in the spatial coverage. Thus, there seems to be poor overlap with commercial catches, which is of concern. It should be encouraged to look into whether this is a problem, and how well banks correlate to each other in terms of recruitment and stock fluctuations. One may suspect that spatial heterogeneity in the population dynamics and survival may affect the assessment, perception of the stock and lead to some added uncertainty for the advice. This may be one of the reason for the retrospective downscaling of the SSB. Another concern I that the population seem to have stabilised around a point between B_{pa} and B_{lim}, which may indicate that new reference points are needed for this stock (ongoing MSE in benchmark should solve this).

Technical comments

Conclusions

The assessment has been performed correctly and according to procedure. The retrospective downscaling of the SSB is of high concern.

Review of ICES Scientific Report, HAWG 2023, 24-27 January

Reviewers: Espen Johnsen

Expert group Chair: Cecilie Kvamme and Aaron Brazier.

Secretariat representative:

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock san.sa.4

Short description of the assessment as follows (examples in grey text):

1) **Assessment type:** *Update*
2) **Assessment:** *Accepted*
3) **Forecast:** *Accepted*
4) **Assessment model:** *Analytical assessment based on the SMS-model run in single-species mode. Assumes a relationship between F and fishing effort. There is one single commercial fleet, and one old dredge survey (199-2003) and a new dredge survey (2008-2022). Each year has two time steps (half-year): Jan-Jun, and Jul-Dec.*
5) **Consistency:** *Accepted – consistent with last year.*
6) **Stock status:** $B < B_{pa}$, but $B > B_{lim}$. After a long period with low SSB, the SSB has fluctuated from a level between B_{pa} and B_{lim} with several years above Bpa. The recruitment has also fluctuated in since 2009, with some very strong years classes.
7) **Management plan:** No management plan are in place for SA4, but a closed area have been in place since 2000.

General comments
No catch in many years, and several years with low fishing mortality make the assessment uncertain due to little input data from the commercial fishery. In addition, the research vessel used for the dredge survey is not allowed to sail all the distance to the main fishing grounds and it a concern that the dredge survey area does not cover the main fishing areas in SA4. It is not clear if recruitment and density structures are homogeneous within the SA4, or if there are spatial differences between the fishing grounds and the more inshore dredge survey areas. There are strong retrospective patterns for both recruitment and SSB in recent years, and it seems like the dredge survey estimates may overestimate the year class strength.

Technical comments

Conclusions
The assessment has been performed correctly and according to procedure. The retrospective downscaling of the SSB is of high concern.

San.sa.5r
NA

San.sa.6
NA

San.sa.7r
NA

Spr.27.7de

Reviewers: TBA (official), Sven Sebastian Uhlmann (inofficial)

Expert group Chair: Cecilie Kvamme (IMR), Aaron Brazier (Cefas)

Secretariat representative: Sarah Louise Millar (ICES)

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock**: spr.7.de**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update; catch advice based on ICES category 3 (Constant harvest rate [CHR] rule for short lived stocks – method 3.2; ICES, 2020), following an interbenchmark that was conducted in 2021.
2) Assessment: accepted, based on acoustic PELTIC survey biomass trends
3) Forecast: not presented, NA
4) Assessment model: There is no assessment model for this stock.
5) Consistency: This advice is consistent with last year's assessment, following ICES category 3 rules using an adjusted CHR (8.57%).
6) Stock status: No reference points for this stock, but substantial decrease in survey biomass.
7) Management plan: There is no agreed management plan for this stock.

General comments

The assessment was done according to the guidelines of the interbenchmark in 2021. The draft report and catch advice are clear.

- In the plots, lower right plot of stock-size index of acoustic biomass estimates (thousand tonnes): the dashed line seems more like green but not blue as stated in the legend.
- The tabulated values for catches of most years prior to 2018 do not match between the tables. If there is an explanation, it should be made clear in the text.

Year	Table 5	Table 4	Table 7
1988	5476	5500	5475
1989	3622	3600	3421
1990	2249	2200	2195
1991	2567	2600	2567
1992	7215	7200	7214
1993	1801	1800	1801
1994	6789	6800	6750
1995	3600	3600	3599
1996	1791	1800	1791
1997	2867	2900	2867
1998	5714	5700	5714
1999	6623	6600	6623
2000	1695	1700	1695
2001	1349	1300	1349
2002	1196	1200	1196
2003	1442	1400	1442
2004	842	800	842
2005	1635	1600	1635
2006	1976	2000	1976
2007	2706	2700	2706
2008	3367	3400	3367
2009	2776	2800	2776
2010	4411	4400	4411
2011	3176	3100	3176
2012	4474	4400	4474
2013	3795	3800	3795
2014	3674	3633	3674
2015	3012	3000	3012
2016	3334	3340	3334
2017	2762	2767	2762
2018	2279	2252	2279
2019	1573	1573	1573
2020	873	873	873
2021	49	49	49
2022	12	12	12

Technical comments

The assessment appears to be done according to the guidelines and the stock annex.

Spr.27.3a4

Review of ICES Scientific Report, (*HAWG*) *(2023)* (*14-22 March 2023*): **Sprat (Sprattus sprattus) in Division 3.a and Subarea 4 (Skagerrak, Kattegat, and North Sea)**

Reviewers: Pia Schuchert and Edward Farrell

Expert group Chair: Cecilie Kvamme and Aaron Brazier

Secretariat representative: Sarah-louise Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
The assessment appears to have been performed correctly and according to procedure.

For single-stock summary sheet advice

Stock = Sprat (Sprattus sprattus) in Division 3.a and Subarea 4 (Skagerrak, Kattegat, and North Sea)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update
2) Assessment: Accepted
3) Forecast: Accepted
4) Assessment model: Age-based analytical assessment (SMS), quarterly time-steps that uses catches in the model. Benchmarked in 2018 (WKSPRAT). Commercial catches (international catches, ages and length frequencies from catch sampling), three survey indices (IBTS Q1 [G1022], IBTS Q3 [G2829], HERAS [A5092]), constant maturity based on long term average from IBTS Q1 survey (ICES, 2018a), and natural mortalities from the multispecies model.
5) Consistency: Consistent with last years assessment.
6) Stock status: Spawning stock is above $MSY_{Bescapement}$, B_{pa}, and B_{lim}. No reference points for fishing pressure have been defined for this stock.
7) Management plan: None

General comments
The assessment was performed according to the 2018 benchmarked approach apart for one change, which is detailed in the technical comments.

The large increase of 109% in advised catch this year is due to a combination of an above average recruitment in 2022 and increases in mean weights for all age-groups. The assessments over the last five years show fairly consistent trends. The coverage of the HERAS survey was reduced in 2022. The stratum not covered accounts on average for 7% of older ages (2+).

Technical comments
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. The model converged and fitted the catches of the main ages caught in the main seasons (the periods with most samples) reasonably well. The retrospective pattern in SSB and recruitment (5-years Mohn´s rho of 0.12 and 0.14, respectively) is below the advised limit of 0.3. There

appears to be a systematic pattern in the catch residuals of model season 1 (quarter 3), which remains unexplained. The model gets very little information of catches (high CV's), which should be investigated further.

In 2023, it was noticed that the model had issues with convergence revealed by a high maximum gradient of 81.52. The problem was tracked back to the 2019 assessment, where the power model was implemented for the first time. SMS has convergence problems when the catchability parameters are very different in magnitude, and this is solved in SMS by scaling all numbers by a fixed factor per survey. Therefore, a small hack was applied to estimate 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, which then were scaled differently, 0.1e-7 and 0.1, respectively. Scaling was said to have no effect on the model results and forecast.

Conclusions
The assessment appears to have been performed correctly and according to procedure.

Spr.67a-cf-k

Review of ICES Scientific Report, Herring Assessment Working Group (HAWG) 2023, 14-22 March

Reviewers: Afra Egan

Expert group Chair: Cecilie Kvamme, Aaron Brazier

Secretariat representative: Sarah Millar

General

This stock has no assessment and is considered as category 5 with biennial advice following the precautionary approach. A precautionary buffer was last applied in 2021 and has not been applied in 2023 for advice in 2024 and 2025. The stock structure of sprat populations in these subareas and divisions is not clear.

For single-stock summary sheet advice

Stock **Sprat.67-a-cf-k (West of Scotland, southern Celtic Seas)**

Short description of the assessment as follows:

1) Assessment type: Update
2) Assessment: accepted
3) Forecast: presented: Not relevant
4) Assessment model: No assessment
5) Consistency: Precautionary buffer not applied. Same advice given.
6) Stock status: Unknown
7) Management plan: There is no management plan for sprat in Subarea 6 and divisions 7.a–c and 7.f–k

General comments
Landings are referred to in the report chapter and catches in the advice sheet.

Technical comments
Some minor edits to text and corrections to tables were directed to the author.

Conclusions
The assessment was performed correctly and according to the agreed procedure and most recent guidelines.

Review of ICES Scientific Report, Herring Assessment Working Group (HAWG) 2023, 14th to 22nd of March.

Reviewers: Eleanor MacLeod

Expert group Chair: Cecile Kvamme, Aaron Brazier

Secretariat representative: Sarah Miller

General
This stock has no advice as it falls under ICES category 5 with biennial advice following the precautionary approach. The precautionary buffer was not applied in 2021, which means that it is not applied for advice in 2024-2025 and advice remains the same.

For single-stock summary sheet advice

Stock **Sprat.67a-cf-k (West of Scotland and Celtic Seas)**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: **Update**
2) Assessment: **Accepted**
3) Forecast: **Not relevant**
4) Assessment model: **Not assessed**
5) Consistency: **Same advice as in 2021, no change to advice as precautionary buffer not applied**
6) Stock status: **Unknown**
7) Management plan: **None**

General comments

The decision to not apply the precautionary buffer this year is correct.

Technical comments
Some minor edits to the report text were suggested to the author

Conclusions
This assessment has been conducted correctly and the advice given is correct.