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

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Contents

i Executive summary

The ICES herring assessment working group (HAWG) met online for four days in May 2022 to assess the state of six herring stocks. Advice for two sprat stocks that have an advice schedule from 1st July–30th June was prepared in April. HAWG also provided advice for eight sandeel stocks in February. 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 2021.

The North Sea autumn spawning herring (her.27.3a47d). SSB in 2021 was estimated at 1.35 mill tonnes while F2–6 in 2021 was estimated at 0.20, which is below FMSY. Recruitment in 2021 is the lowest since 2017 and within the low recruitment regime observed since 2015. Year classes since 2002 are estimated to be consistently weak with year classes 2014 and 2016 some of the weakest on record. ICES considers that the stock is still in a low productivity phase.

The **Western Baltic spring-spawning herring (her.27.20-24)** assessment was updated. The SSB and recruitment in 2021 are at low levels. SSB is estimated to be around 62 800 tonnes which is below both B_{pa} and B_{lim}. Recruitment has been low since 2006 and it has been further deteriorating with time. Fishing mortality decreased in 2018 and is now well below F_{MSY} (0.31) at 0.15. 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.

The **Celtic Sea autumn and winter spawning stock (her.27.irls)** is estimated to be at a very low level. SSB is currently estimated to be increasing from the lowest level in the time-series and has been below B_{lim} (34 000 t) since 2016. Mean $F_{(2–5 \text{ rings})}$ was estimated at 0.069 in 2021, having decreased from the peak of 1.2 in 2018. Recruitment has been consistently below average since 2013.

Irish Sea autumn spawning herring (her.27.nirs) assessment shows an increase in SSB in 2021 to 30 792 tonnes which is the highest in the current time series. The stock has experienced large incoming year classes in recent years. Fishing mortality ($F_{4–6}$) has been stable between 0.2 and 0.21 since 2009 and is below F_{MSY} (0.266).

6aN autumn spawning herring (her.27.6aN) were part of a combined assessment with herring in 6.a South and 7.b-c since 2015. Following a benchmark meeting in 2022, these two stocks are now assessed separately. This was made possible by the development of a genetically split acoustic survey index. The Malin Shelf herring estimate of SSB for autumn spawning herring in 6.aN in 2021 is 43 886 tonnes. Although estimates have increased from the minimum value in 2019, it should be noted that numbers of herring to the West of Scotland are low compared to historical estimates. Indicators show that 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).

Herring in 6.aS/7.b, c (her.27.6aS7bc) are now assessed separately from autumn spawning herring in 6aN, following a benchmark in 2022. This was made possible by the development of a genetically split acoustic survey index. The survey index for herring in 6aS, 7b,c has been increasing since the lowest point in 2016 (36,707 t) and in 2021 was estimated to be 189,856 t, which is the second highest point in the current time series. 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 well above MSY $B_{trigger\ proxy}$ (51 390 t).

North Sea and 3.a sprat (spr.27.3a4) were combined into a single assessment unit during the 2018 benchmark. Perception of the status of the stock is dominated by the dynamics in Subarea 4 where most of the catches occur. Fishing mortality in the last years has fluctuated at high levels between 0.6–2.2. Low recruitment the last two years have contributed to a decrease in SSB well below MSY $B_{escapement}$. The estimates for 2022 show an SSB of 100 000 t which is below B_{pa} (125 000 t).

Catch advice for **sprat in the English Channel (7.d, e) (spr.27.7de)** was based on criteria for ICES category 3 stocks using the acoustic survey. The stock went through an interbenchmark in 2021 and a new basis for advice was recommended. The catch advice is now based on the latest biomass index multiplied by a constant harvest rate of 8.57%. Since sprat is a short-lived species and given the timing of the survey in October, an advice period, valid from 1st July to 30st June in the following year, has been adopted for this stock starting in 2022.

Catch advice for **sprat in the Celtic Seas and West of Scotland (spr.27.67a-cf-k)** was given for 2022 and 2023 using the ICES category 5 based method where only landings data are available. The precautionary buffer was applied and a 20% decrease in catch is advised.

The HAWG reviewed the category 1 assessments performed on four sandeel stocks (SA 1r-3r, 4) and the category 3-6 assessments of four more sandeel stocks (SA 5r, 6, 7r, Div. 6a) and updated the related advice. Section 9 of this report contains the assessments of sandeel in Division 3.a and Subarea 4.

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

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

ii Expert group information

Expert group name	Herring Assessment Working Group for the Area South of 62° N (HAWG))
Expert group cycle	Annual
Year cycle started	2022
Reporting year in cycle	1/1
Chairs	Afra Egan, Ireland
	Cecilie Kvamme, Norway
Meeting venues and dates	25-27 January 2022, virtual meeting (13 participants)
	March-May 2022, by correspondence (13 participants)
	9-12 May and 18 May 2022, virtual meetings, (35 participants)

1 Introduction

1.1 HAWG 2022 Terms of Reference

2020/2/FRSG03 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Afra Egan, Ireland, and Cecilie Kvamme, Norway will meet: online 25th –27th 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 online 9th –12th May 2022 and the 18th of May 2022 to:

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

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

Material and data relevant for the meeting must be available to the group on the dates specified in the 2022 ICES data call.

HAWG will report by 11th February (sandeel), 30th April (sprat) and 23rd May (herring) 2022 for the attention of ACOM.

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

Stock Name	Stock Coord.	Assesss. Coord.	Assessment Method
Sandeel in Divisions 4b-c, SA1r (central and southern North Sea, Dogger Bank)	Denmark	Denmark	SMS-effort
Sandeel in Divisions 4b-c and SD20, SA2r (central and southern North Sea)	Denmark	Denmark	SMS-effort
Sandeel in Divisions 4b-c and SD20, SA3r (northern and central North Sea, Skagerrak)	Denmark / Norway	Denmark	SMS-effort
Sandeel in Divisions 4a-b, SA4 (northern and central North Sea)	Denmark	Denmark	SMS-effort
Sandeel in Division 4a, SA5r (northern North Sea, Viking and Bergen banks)	Denmark / Norway		No assessment
Sandeel in SD20-22, SA6 (Skagerrak, Kattegat and Belt Sea)	Denmark		No assessment
Sandeel in Division 4a, SA7r (northern North Sea, Shetland)	Denmark / UK (Scotland)		No assessment
Sandeel in Division 6a (West of Scotland)	ICES		No assessment
Herring in Subdivisions 20–24 (Western Baltic Spring spawners)	Denmark	Denmark	SAM
Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	The Netherlands	SAM

Stock Name	Stock Coord.	Assesss. Coord.	Assessment Method
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 Western Channel	UK (E&W)	UK(E&W)	Survey biomass
Sprat in the Celtic Seas	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 inter-benchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

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

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

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

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

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

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

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

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

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

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks in SID;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2023 for conclusion in 2024;
iii) determine the prioritization score for benchmarks proposed for 2023–2024;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

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

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

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

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

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

1.3 Reviews of groups or projects important for the WG

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

1.3.1 Meeting of the Chairs of Assessment Related Expert Groups (WGCHAIRS)

WGCHAIRS met online in January 2022 in preparation for the new year of advice and science working group activities. This was the second 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 27th 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.

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 inter-benchmarks 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.

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 online on Teams 24th–28th January 2022. 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 2022 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2022 pelagic acoustic surveys are available from the WGIPS report (ICES 2022, WGIPS). The following text refers only to the surveys of relevance to HAWG.

<u>**North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys (HERAS) in 2021:**</u> 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 lower than in the previous year at 1.5 million tonnes (2020: 1.7 million tonnes) with a further decrease in the number of mature fish (2020: 8 915 million fish, 2021: 8 170 million fish).

The 2021 estimate of **Western Baltic Spring Spawning herring** 3+ group is 82 000 tonnes and 639 million. Compared to the 2020 estimates of 103 000 tonnes and 667 million fish, this equals a decrease of 20% in biomass.

The **West of Scotland herring** estimate (6.a.N) of SSB in 2021 is 147 000 tonnes and 871 million individuals, which is a ~7% decrease in both biomass and abundance compared to the 158 000 tonnes and 943 million herring estimate in 2020.

The 2021 SSB estimate for **the Malin Shelf area (6.a and 7.b, c combined)** is 278 000 tonnes and 1 827 million individuals. This is higher than the 2020 estimates (226 000 tonnes and 1 435 million herring). There were again low numbers of herring found in the northern strata (to the north of Scotland and east to the 4˚W line) in 2021, which is similar to 2020. There were significant numbers of herring distributed south of 56°N again in 2021, including large numbers of immature herring.

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 2021 was estimated at 56 200 million individuals and the biomass at 420 000 tonnes. This is a decrease from last year, and around the long-term average of the time series, in terms of both abundance and biomass. The estimate is dominated by 1-year-old sprat (75% 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 2021 is estimated at 623 million individuals and the biomass at 6 200 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 (70% below) and biomass (76% below). The estimate is dominated by 1- and 2-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 lower 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 Oct-Nov 2021. For the fifth year, the survey was extended beyond UK waters to also include the French waters of western English Channel and for the second time Cardigan Bay in the southern Irish Sea. The pelagic fish objectives of the survey were successfully completed. In total 2181 nautical miles of acoustic sampling units were collected and supplemented with 41 valid trawls. Sprat were mainly found in Lyme Bay, showing a more offshore distribution than in 2020. The biomass in Lyme Bay, which is the core area sampled since 2013 and is relevant to the stock assessment of sprat in 7de, was 107,355 t which is more than three times higher than the 2020 estimate of 33,798 t and the highest of the time series. This was comprised of 0-gr sprat.

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

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

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

As biological parameters are among the main input data for most stock assessment and mixed fishery modelling, these activities are considered to have a very high priority. The main link between assessment working groups and WGBIOP is through the benchmark process. WGBIOP works in close association with the BSG (ICES benchmark steering 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 newly proposed ICES benchmark prioritization system. WGBIOP has a close working relationship with WGSMART (The Working Group on SmartDots Governance) and in cooperation will further develop the SmartDots tool as a platform for supporting the provision of quality assured data to the end-users.

The last WGBIOP (October 2021) reviewed the following activities falling within its remit and of interest for HAWG:

- There are no workshop or exchange planned for herring (*Clupea harengus*) and sprat (*Sprattus sprattus)* stocks assessed by HAWG. Prior to the benchmark of Sandeel (*Ammodytes*) 2022 an age reading exchange was conducted.
- A workshop on the identification of clupeid larvae (WKIDCLUP2) was conducted on 30 August – 3 September 2021 in Bremerhaven, Germany, to identify problem areas in clupeid identification. SmartDots was expanded with a fish larvae module specific for this workshop. The module allowed sharing of images of various clupeid larvae of different spawning areas (from the Portuguese coast to the Baltic) and other species co-occurring with the clupeid larvae. Within SmartDots each participant could measure, count myotomes and identify the larvae to species. This first test of the module was promising and will be further developed and used for fish larvae calibration exercises in the future. The results of this short workshop were promising as the agreement in larvae identification was higher compared to the 2014 workshop.

Other clupeid stocks

- An otolith exchange was held for sprat in the Baltic Sea and NEA mackerel, resulting in an overall agreement between readers of 59.0% and 64.7%, respectively.

Planning of future workshops and exchanges

- WGBIOP is planning to organise a workshop in 2023 on the comparison between age reading methods of NSSH using scales and otoliths. WGIPS is requested to collect samples in 2022. The focus is on NSSH but 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 SA1 and sandeel SA3. 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). 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 inter-benchmarks.

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

Main changes to input data 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 SA1 and SA3) 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 2022.

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

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 have been delineated based on the results of genetic stock identification for the first time, thus enabling separate assessments for the 6.a.S, 7.b.c stock and the 6.a.N autumn spawning stock. The development of operational methods to enable estimation of proportion contribution from different stock in catches and survey indices throughout the management areas for herring assessed by HAWG is a topic that HAWG continues to have high on the list of issues to solve to improve upon assessments. Several ICES workshops have been held to progress this topic, most recently WKMIXHER in 2018 and WKSIDAC in 2017. HAWG recommend another meeting of WKSIDAC in 2023. An update on progress of those projects dealing with stock identification and mixing of relevance to HAWG is provided below.

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

Atlantic herring west of Scotland and northwest of Ireland comprise at least two reproductively isolated biological populations. The 6.a.N herring spawn off Cape Wrath in northwest Scotland in Autumn (September/October) and the 6.a.S, 7.b-c herring spawn off Donegal in northwest Ireland in winter and early spring (November to March). The stocks are believed to form mixed feeding aggregations west of the Hebrides in summer, where they are targeted by the Malin Shelf Herring Acoustic Survey (MSHAS), conducted annually by the Marine Institute and Marine Scotland. The MSHAS survey index is a primary input into the stock assessments of the two stocks. Up to now it has not been possible to separate the data from the MSHAS into population/stock of origin, therefore only a combined index is available and hence a combined assessment (ICES, 2015). Based on the combined assessment, ICES has provided combined advice for the two areas and stocks since 2015 and has recommended a zero TAC for the last seven years. Scientific samples are obtained during the scientific monitoring fisheries in 6.a.S, 7.b-c and industry surveys in 6.a.N.

In response to the WKWEST (ICES, 2015) report a programme of stock identification research was developed (see summary in ICES HAWG, 2021). The programme initially relied on industry and national institute funding (2016-2018) before the European Commission's Executive Agency for Small and Medium-sized Enterprises (EASME) funded a 36-month project (2018-2020) entitled 'Herring in Divisions 6.a, 7.b and 7.c: Scientific Assessment of the Identity of the Southern and Northern Stocks through Genetic and Morphometric Analysis'. This project comprised an extensive review of the history of the existing stock delineations, comprehensive sampling for both genetics and morphometrics, genetic marker development, genetic screening of samples, the establishment of a genetic protocol for large scale sample screening, morphometric analyses and comparative analyses of both methods (see Farrell et al., 2021). One of the main conclusions of the EASME project was that morphometrics was not suitable to discriminate between mixed herring along the Malin Shelf. Although the use of body and otolith shape showed potential in discriminating between 6.a.N and 6.a.S stocks initially, the method was not powerful enough to discriminate mixed herring samples due to the complex temporal-spatial mixing of these two stocks along the Malin Shelf. The genetic markers and assignment methods constitute a tool that can be used for the assignment of herring caught in mixed survey and commercial catches in Division 6.a into their population of origin with a high level of accuracy (>90%).

The results of this project together with the previous industry and institute funded programme component were compiled into a final project report (Farrell et al., 2021), which was reviewed by the Stock Identification Methods Working Group (SIMWG). The SIMWG concluded that '*the study should serve as an example of good practice for optimal use of existing resources and result reproducibility*', '*the methodology is rigorous throughout*' and '*there is no doubt in SIMWG that the* (genetic) *approaches presented can be used to*':

1. *Distinguish the 6aS late winter spawners from the 6aN autumn spawners;*
2. *Distinguish, more subtly, the spring-spawning contingent in 6aN from 6aS (even though the relatedness between these two is high);*
3. *Confirm essentially the 'North Sea nature' of the 6aN autumn spawners;*
4. *Assess the mixed MSHAS catches (which appear primarily composed of 6aS fish, with the proportion of autumn-spawning fish increasing as one moves north-east towards Cape Wrath and the Orkneys).*

Subsequent to the completion of the EASME funded component of the 6.a stock identification programme and prior to the WKNSCS benchmark it was possible to undertake additional genetic analyses in order to fill any potential data gaps identified during the EASME project. As detailed in the 2021 HAWG report (ICES, 2021) a short-term project extension was developed with the existing project partners. During this extension additional spawning baseline samples were added to the baselines and using the same approaches as specified in Farrell et al. (2021) the 2020 and 2021 MSHAS samples were genetically assigned to their stock of origin. A detailed summary of the genetic approaches underpinning the splitting of the MSHAS data is provided in O'Malley *et al*. (2021), the full stock identification project report in Farrell et al. (2021) and a draft manuscript of the genetic baseline based on the updated baseline in Farrell et al. (in review),

In short, the baseline genetic analyses indicated that herring in ICES Division 6.a comprise at least three distinct populations; 6.a.S herring, 6.a.N autumn spawning herring and 6.a.N spring spawning herring. The 6.a.S 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.a.S herring. No baseline spawning samples could be collected in Divisions 7.b or 7c therefore the relationship between the herring that spawn in this area and those that spawn in 6.a.S is unknown. The 6.a.N spring spawning herring are distinct from the 6.a.N autumn herring and spawn in the Minch in

February and March. This population is not currently subject to stock assessment or specific management measures. There is no historical or contemporary evidence to support the differentiation of 6.a.N autumn spawning herring and North Sea autumn spawning herring. The Downs herring were confirmed to be distinct from the North Sea autumn spawning herring though it could not be reliably discriminated from the Celtic Sea and Irish Sea samples with the current panel of markers. 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. For the purposes of developing an assignment model only the populations confirmed as being present in Division 6.a were included in the baseline assignment dataset; 6.a.S, 6.a.N autumn and 6.a.N spring.

Across the eight years of MSHAS samples that were genetically assigned (2014-2021), there was a consistent pattern of a higher proportion of 6.a.S herring in the samples than 6.a.N autumn spawning herring. The 6.a.S assigned fish were distributed across the survey area both south and north of the current stock delineation line of 56°N latitude, confirming that this geographic delineator for the collation of survey data is not appropriate. The highest proportions of 6.a.S fish were observed in the hauls closest to the Irish coast. The highest proportions of 6.a.N autumn spawning fish were observed in the most northerly hauls adjacent to the 4°W stock delineator. Potential 6.a.N spring spawning herring comprised a significant proportion of the MSHAS hauls west of the Hebrides.

The assignment of non-baseline putatively mixed samples from Divisions 6.a,7.b-c collected outside of the MSHAS period also provided useful information. Analysis of a subset of the hauls on the Q1 2019 Scottish West Coast International Bottom Trawl Survey (SWC-IBTS) indicated a high degree of mixing of the 6.a populations within the hauls. Analysis of Q3 samples from the 6.a.N. industry acoustic survey indicated that juveniles in the northern Minch area most likely belonged to the 6.a.S or 6.a.N spring populations and samples from the Cape Wrath area were composed of a mix of the 6.a populations.

Analysis of the Q4 samples from the 6.a.S monitoring fishery indicated the samples comprised primarily 6.a.S herring. Samples of herring from Lough Foyle were shown to be genetically and biologically 6.a.S herring, though they are currently defined as 6.a.N autumn spawning herring according to the ICES stock delineation. Non-spawning herring caught in Division 7.b assigned genetically to the 6.a.S population.

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. *unpublished*). Based on recent work, robust genetic assays to split mixed-stock aggregations have been developed and implemented (Bekkevold et al. *unpublished*; Farrell et al. *in review*). 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); between Faroese autumn spawning herring, FASH, and NSAS; and between Norwegian spring spawning herring, NSS, her.27.1-24a514a, and WBSS (Bekkevold et al. *unpublished*). 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 and Norwegian commercial catches and their parts of HERAS, and Danish IBTS. Currently, information about additionally occurring stocks in 4ab/3a, such as NSS, Baltic Sea Autumn Spawning herring and Baltic Sea spring spawning herring is not currently 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 north-eastern 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, in comparison with traditionally implemented phenotyping methods, has been demonstrated for different approaches (Berg et al. 2021; Farrell et al. in review, Bekkevold et al. *unpublished*).

Updates on the analyses of the WKMixHer sample

The 2018 workshop on mixing of western and central Baltic herring stocks (WKMixHer) recommended coordinated sampling of spring spawning herring with the objective to further evaluate mixing of herring stocks in the western-central Baltic and to implement operational methods for separation.

Samples were collected by Sweden, Germany, Poland, and Lithuania during the 2019 and 2020 spawning peak on 7 coastal spawning grounds in the Hanö Bay, Bay of Lübeck, Greifswald Bay, Pomeranian Bay, Kolozbreg, Vistula Lagoon and Klaipéda (Figure 1.2.7.2).

Herring were collected at spawning time from spawning aggregations, resulting in samples from late March till early May as the spawning peak showed a seasonal progression through the region from west to east. Sampling was restricted to ripe and running individuals corresponding to maturity stages 5 to 7. 592 individuals were sampled, covering ages 2-13 winter rings, and stock separation by growth function was applied. Otolith shapes were extracted, and preliminary analyses conducted on 449 of these herring (ages 4-7).

A Canonical Analysis of Principal Coordinates performed on the standardized wavelet coefficients from the otolith shapes showed that herring from the sampled locations group into two well distinct clusters, with a clear geographical longitudinal separation (Figure 1.2.7.3). Samples from part of the Polish coast in SD25 (station “SWI-31” and “ROW”) group with the western Baltic cluster.

Among the classifiers tested (both traditional techniques and machine learning algorithms), Random Forest (with k-fold cross validation) provided the best overall accuracy in the discrimination between the two clusters based on otolith shape analysis with overall assignment accuracy of ~70%. When using the growth analysis on the WKMixHer samples (growth is currently used for separating western and central Baltic herring in SD22-24 in the GERAS survey) assignment accuracy to one of the two clusters yield ~97%.

Further work in progress:

- Combine otolith shape and growth analysis when conducting assignments;
- Adding genetic analysis to evaluate the number of components present and validate results from the otolith shape;
- Collect samples of spawning herring from the central part of the Polish coast to evaluate the gradient of differentiation along the southern Baltic coast.

Further information on this is work is available from Valerio Bartolino (valerio.bartolino@slu.se).

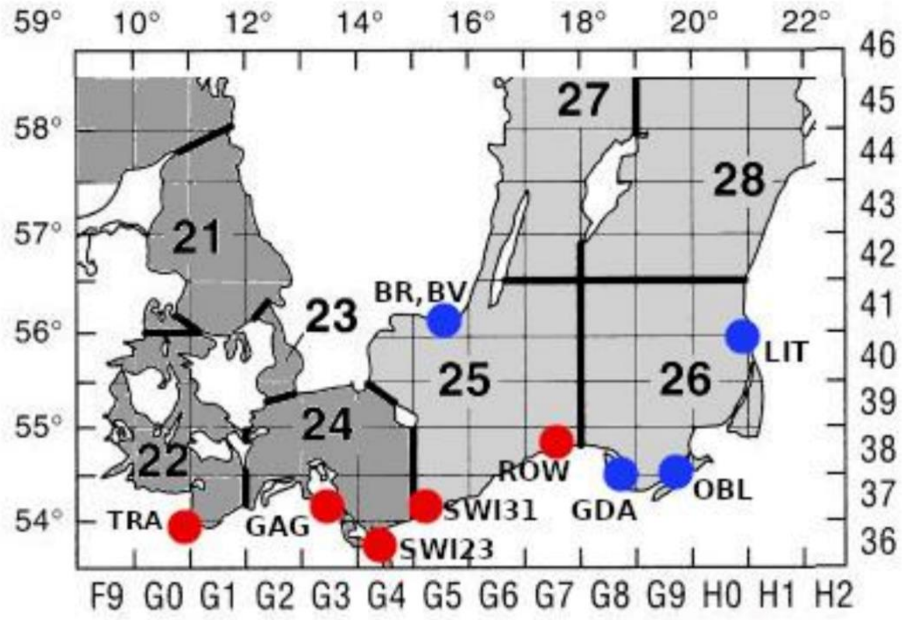

Figure 1.2.7.2. Map with sampling locations of spawning herring during spring 2019-2020. Colours correspond to the two clusters identifies in the Canonical Analysis of Principal Coordinates (See Figure 1.2.7.3).

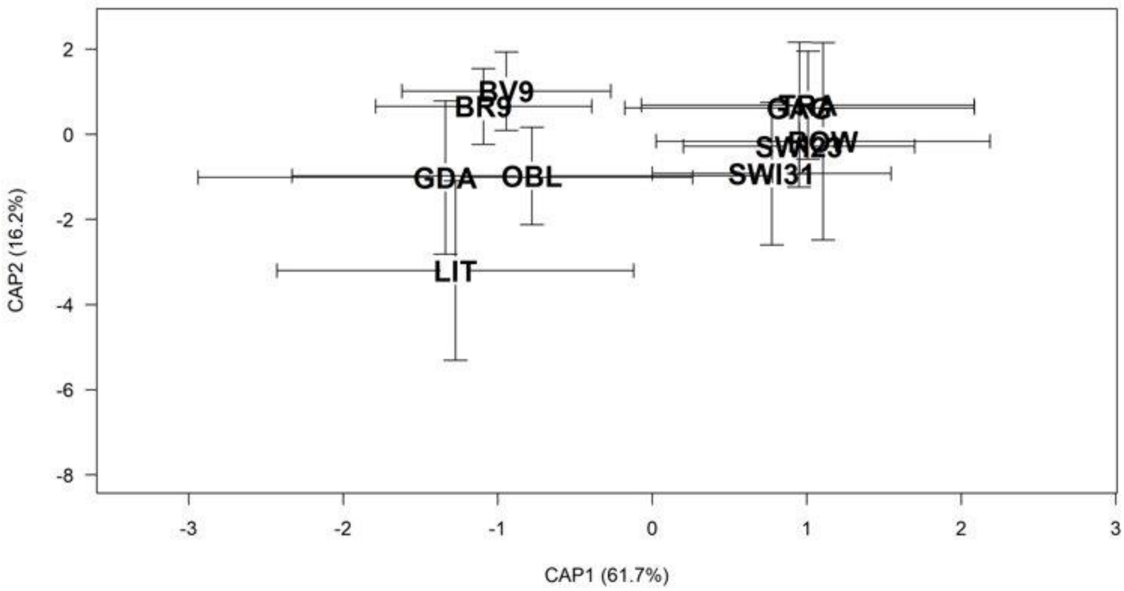

Figure 1.2.7.3. Plot of the first and second Principal Components from the analysis of standardized Wavelet coefficients. The black labels show the centroid for each spawning location. TRA: Bay of Lübeck (GER), GAG: Bay of Greifswald (GER), SWI23: Pomeranian Bay (POL), SWI31: Kolobrzeg (POL), ROW: Rowy (POL), GDA: Gulf of Gdansk (POL), OBL Vistula lagoon (POL), LIT: Klaipėda (LTU), BR9 - BV9: Hanö Bay (SWE).

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 inter-benchmark, an annual MSE was not able to investigate within-year processes. A novel intra-annual MSE (Mildenberger et al., 2021) was parameterised for the stock, accounting for seasonal growth and exploitation. The timing and lag between events within the year (e.g., survey observation, implementation of advice, recruitment) affect the performance of Harvest Control Rules (HCR). WKDLSSLS3 concluded that the inter-benchmark decision of 8.57% Constant Harvest Rate (CHR) seems to be appropriate. The group examined the effect of applying an 80% uncertainty cap (UC) to the CHRs. The conclusion from this was an UC resulted in minimal risk reduction for CHR's below the 5% risk threshold. It did reduce risk for CHR's that are too high but could not bring them below the ICES risk threshold. The only significant difference between CHR and CHR+UC was a decrease in interannual variability in the stock. The group found that unconstrained CHRs appear robust to past fishing history, initial stock status and advice schedule but are sensitive to survey catchability. No recommendations from the WKDLSSLS were made in regard to applying a UC to CHR's.

1.3.8 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 the 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 IBTSQ3. In the 2018-2021 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again low: 4.4%, <1%, 1.2%, 0.6%, and zero, 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 generally lower in IBTS Q3 compared to Q1, and it is found to be particularly low in 2021 in both the quarters and among all the ages. Swedish commercial samples from 2021 confirm low levels of infection (≤1%) in both the Kattegat and Skagerrak 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.

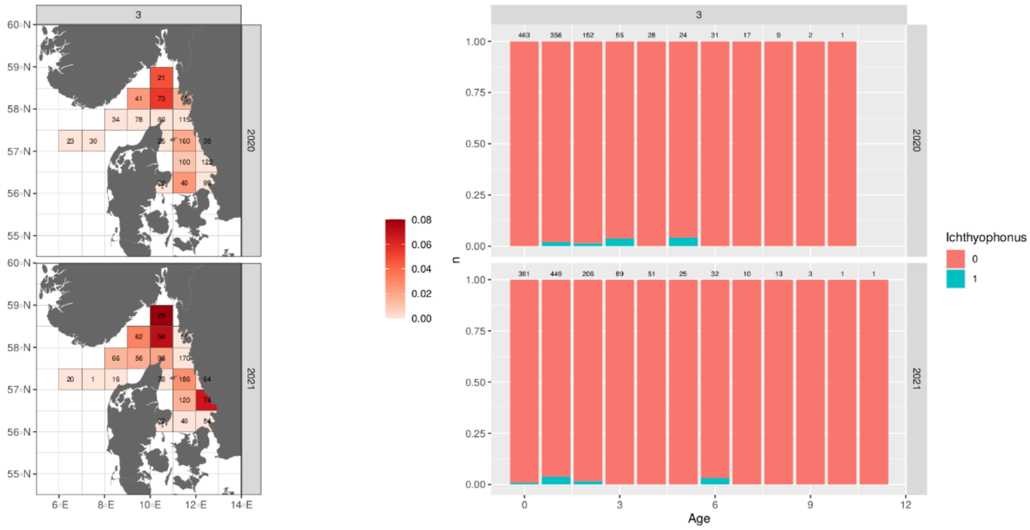

Figure 1.2.14.3 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ3 2020-2021. Left map with distribution of the proportion of infested herring and number of samples in each rectangle; right distribution of infestation among ages.

Regional Database and Estimation System (RDBES)

The RDBES is still under development, but the part of the data model that stores population data, commercial effort, and landings statistics, are considered ready for production in 2022. The commercial sampling part of the data model is planned to be in production in 2023. In 2022, ICES will launch a data call including commercial effort statistic, landings statistics and sample data for all species.

In 2022, two workshops will be held in relation to the RDBES, WKRDB-INTRO and WKRDBES-RAISE&TAF (Workshop on Raising Data using the RDBES and TAF). The latter will be held in autumn and supports the migrating of present estimation routines to TAF. Furter, an ICES working grouping developing a R package from estimation with the RDBES format, main design-based, was formed in

Further information about the RDBES status and roadmap can be found in ICES (2020). The report from 2021 is still not published by ICES.

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 7th March 2022. Not all countries delivered their data in due time.

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

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

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

1.4.2 Sampling

Quality of sampling for the whole area

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

Area	Working Group Catch	Sampled Catch	Age Readings	Age Readings per 1000t
4.a(E)	88253	88740	2338	26
4.a(W)	181445	143883	4618	25
4.b	58826	39199	1074	18
4.c	9188	5805	196	21
7.d	26902	17509	305	11
7.a(N)	7208	6329	1680	233
3.a	13318	11520	2551	192
SD22-24	1601	1360	2683	1675
7g, 7.j, 7aS	745	745	1094	1468
6.aN	1115	671	43	39
6.aS, 7.b and 7.c	1821	1821	2037	1119

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

1.4.3 Terminology

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

1.5 Methods Used

1.5.1 SAM

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

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.

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, for sprat in the North Sea and 3.a. The model is run in single species mode for these stock assessments. Major difference 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).

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 difference between B_{lim} and MSY $B_{escapement}$ is not compatible with the ICES F_{MSY} criteria (i.e., that the average probability in the long-term of getting below B_{lim} should be no more than 5% per year). F_{cap} is calculated/optimized using a management strategy evaluation framework (MSE).

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

New reference points were calculated for North Sea Herring during the 2021 inter-benchmark meeting (ICES, 2021). This resulted in a downward revision of the estimate of B_{lim} and $MSYB_{trigger}$ 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 time periods and stock–recruitment models used.

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

Proxy reference points were derived for the category 3 stocks - herring in 6aS, 7b,c and 6aN at the benchmark in 2022 (ICES, 2022). $F_{proxyMSY}$ for both stocks was calculated using data from 2014-2021. This will be updated annually as new data becomes available. 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 a repository system was set up in 2009. Within this repository, all stocks own a subfolder where they store their data and code used to run the assessments presented in this report and used as base for the advice. At the same time, there is one common folder, used by all assessments, that ensures that the FLR libraries used are identical for all stocks, as well as the output generated to evaluate the performance of the assessment.

The repository was moved from google code to github in 2016 and is now available as a branch of the ICES github site. https://github.com/ICES-dk/wg_HAWG. Contributing to the repository is not possible for outsiders as a password is required. Downloading data and code is possible to the public. The repository is maintained by members of the WG and the ICES Secretariat.

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-dependency, 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 time-periods) is incorporated in its fish stock assessments, MSE operating models and management advice products for the following six categories (relevant variables in parentheses) 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 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, may replace its role or the system may shift in a more dramatic way. Likewise, large numbers of herring can have a predatory impact on species with pelagic egg and larval stages.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Sandeel is targeted by a highly seasonal industrial fishery which has experienced a progressive change towards fewer larger vessels owing most of the quota since the introduction of ITQ in 2004. Time and area restrictions and bycatch limits represent the main management measures.

Although the fishery has little bycatch of protected species, competition with other predators is a central aspect of the sandeel management within an ecosystem approach.

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

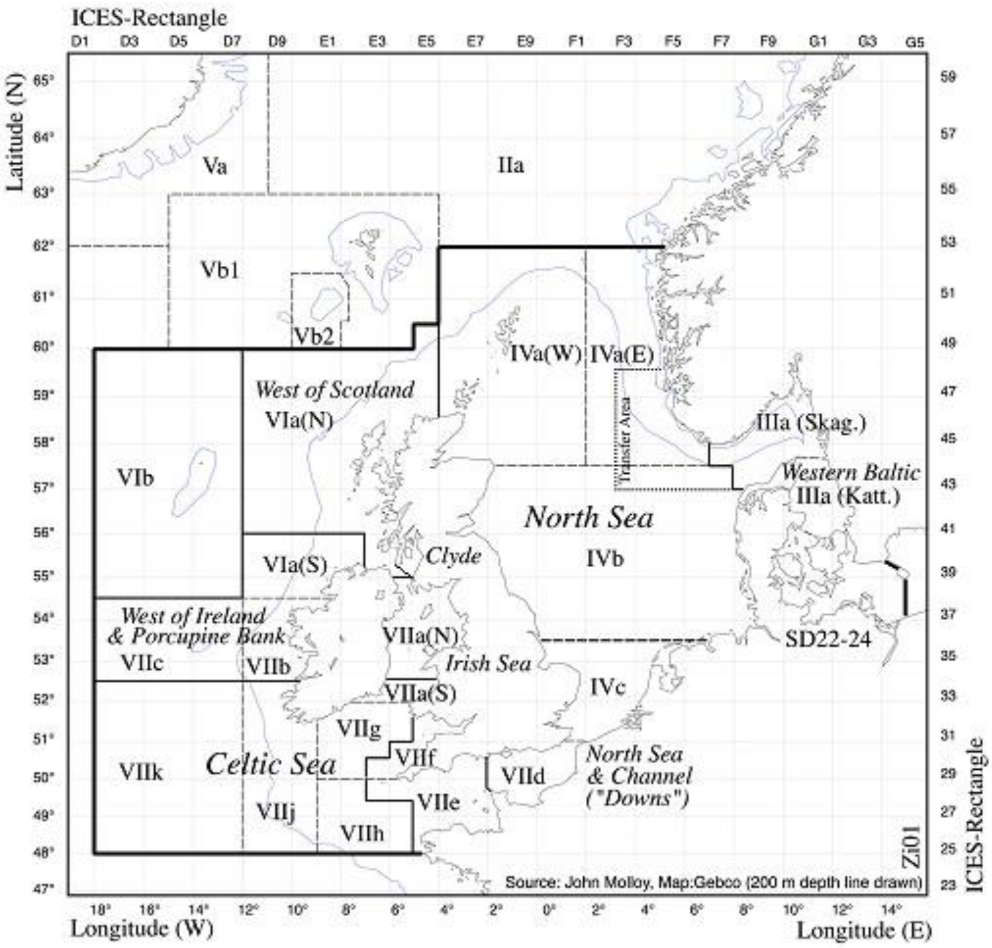

Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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. Based on the WG assessment the stock was classified as being at full reproductive capacity and harvested sustainably at F_{MSY} and under the management plan target for several years. Since 2019, no management plan is in place for North Sea Herring.

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 (54 388 t) and 2020 recruitment (550 822 thousand) are record low. The estimate of SSB in 2021 (62 765 t) is considered low, below both B_{pa} and B_{lim}. Fishing mortality ($F_{3–6}$) was reduced from 0.58 in 2008 to 0.31 in 2011. It had then remained above F_{MSY} (0.31) until 2015 (0.34-0.43) but showed an increase in 2016-2018 with an estimated F_{3-6} above 0.49. $F_{3–6}$ then decreased since 2019 below F_{MSY} from 0.30 to 0.15 in 2021, which is the lowest $F_{3–6}$ on records. The 2023 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 71 011 t in 2022 to 80 978 t in 2023. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2024 (95 882 t). A medium-term forecast to 2025 showed that SSB can increased to 111 989 t if F=0 in 2023-2024 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 11 680 t in 2020, which is well below B_{pa} (at 54 000 t) and B_{lim} (34 000 t). Recruitment has been below average since 2013. An increase in recruitment can be seen in 2021 however the assessment is highly uncertain, and recruitment has been consistently overestimated in recent years. Fishing mortality ($F_{2–5}$) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. F decreased in 2020 in line with greatly reduced catches and is slightly higher in 2021. This year's assessment estimates a fishing mortality, $F_{2–5}$ = 0.069 in 2021 which is well below all reference points (F_{MSY} is 0.26 and F_{lim} is 0.45). Short-term projections predict SSB to increase to 19 349 t in 2022.

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 2014-2021 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 2021 is 43 886 tonnes. 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). 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 2015-2021. 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 2014-2021 into the component stocks means that separate advice is now possible. The survey index for herring in 6aS, 7b,c has been increasing since the lowest point in 2016 (36,707 t) and in 2021 was estimated to be 189,856 t, which is the second highest point in the current time series. 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 3 winter ring and accounted for 58% of the catch numbers at age in 2021.

Herring in the Irish Sea (her.27.nirs): comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its decline from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability of spawning migrations and mixing with the Celtic Sea stock. 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 2021, SSB and recruitment have been estimated at 30 792 t and 196 418 thousand respectively. F_{4-6} is estimated at 0.21 in 2021 with estimates of F stable since 2009. Under the MSY approach the stock is expected to show a decrease to 23 076 t in 2023.

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 2022 show an SSB of 100 000 t which is below 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 68 690 t which represents a 36% decrease on the last year advice. The reduction is due to the decrease in stock size following the low recruitment observed in 2021.

Sprat in the English Channel (7.d and 7.e) (spr.27.7de): 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 Sea 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. The advice provided is based on the application of a constant harvest rate of 8.57%

to the 2021 acoustic survey biomass estimate. The advised catch of 9 200 t for 2023 is 217.6% higher compared to last year. Since sprat is a short-lived species and given the timing of the survey (October), an advice period, valid from 1 July to 30 June in the following year, has been adopted for this stock starting in 2022. This will mitigate the problem of the lag between the survey information and the advice year which occurred previously. This has also been extended to the TAC which will also run from 1 July to 30 June. The fishing season for sprat runs from August to February.

Sprat in the Celtic Seas (spr.27.67a-cf-k): The stock structure of sprat populations in this ecoregion (subareas 6 and 7 (excluding 7.d and 7.e)) is not clear, and further work for the identification of management units for sprat is required. Most sprat in the Celtic Seas ecoregion are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. The quality of information available for sprat is heterogeneous across this composite area. There is evidence from different survey sources of significant interannual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., 6.a and 7.a), while Irish acoustic surveys started in 1991, with some gaps in the time-series provide sprat estimates but their validity to provide a reliable sprat index is questionable because they do not always cover the core of sprat distribution in the area. Acoustic estimates in the Irish Sea are more reliable. The state of the stock of sprat in the Celtic Seas ecoregion is uncertain. ICES advice a catch of no more than 2240 tonnes for 2022 and 2023 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 fishery of sandeel in the North Sea. The catches are largely represented by age 1 fish. Analytical assessments are performed in four of the management areas (A1r–4) where most of the fishery takes place and data are available. Note that a benchmark in 2016 revised most of the area definitions.

A1: SSB has been above B_{pa} (145 000 t) in 2016-2018 and dropped to 71 000 t in 2019, 61 000 t in 2020, and 127 000 t in 2021. The forecasting indicates that SSB will increase to a level above B_{lim} (110 000 t), but below B_{pa}, in 2022. Recruitment in 2021 was below the geometric mean of the time-series, and lower than in 2020. 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 for the last four years (~ 0.5) but dropped in 2021.

A2: SSB has been below B_{lim} (56 000 t) since 2004, with few exceptions. SSB increased in 2018 above B_{pa} as the result of the exceptionally high 2016-year class and decreased again in 2019. SSB in 2021 is estimated at 35 000 t The 2021 year class is estimated to be high above the long-term average.

A3: 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). SSB had a peak of more than 440 000 t in 2018 and is estimated to 375 000 t in 2021. The recruitments in 2016 and 2019 were among the five highest on record. Forecast indicates an SSB in 2022 of 210 000 t. Fishing mortality (F) declined in the early 2000s and has been low until 2018. F has been increasing in the last couple of years.

A4: Fishing mortality (F) has been low since 2005 but increased in 2018 before decreasing again in 2019-2020 before increasing to a close-to record high level in 2021. SSB has fluctuated above precautionary reference points (B_{lim}) since 2011 with the exception of 2015 and 2020. Recruitment was low in 2018, high in 2019 and around the long-term average in 2020. Recruitment in 2021 is expected to be slightly lower than in 2020.

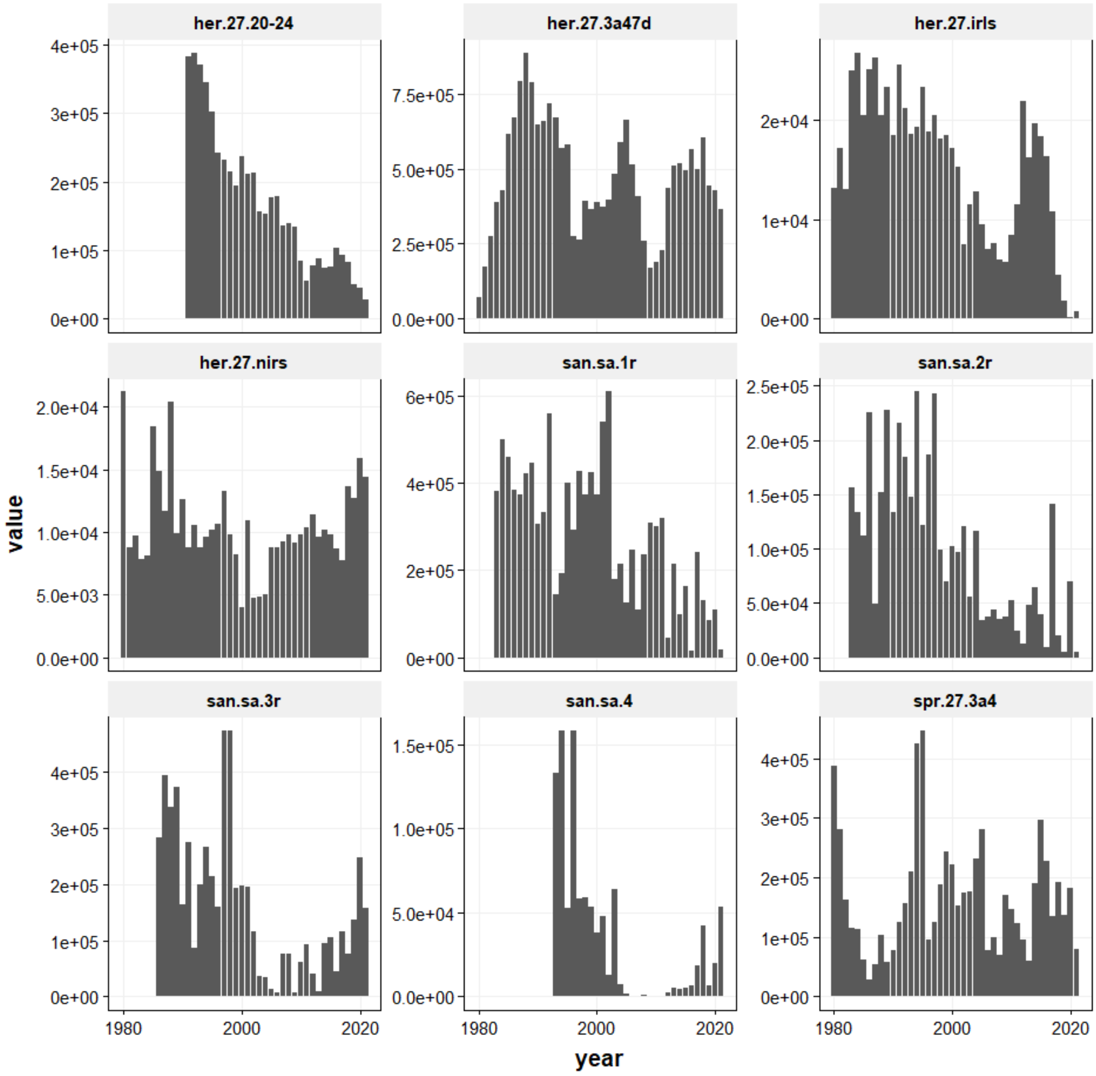

Figure 1.7.2 WG estimates of catch/landings (yield) of the category 1 herring, sprat and sandeel stocks presented in HAWG 2022

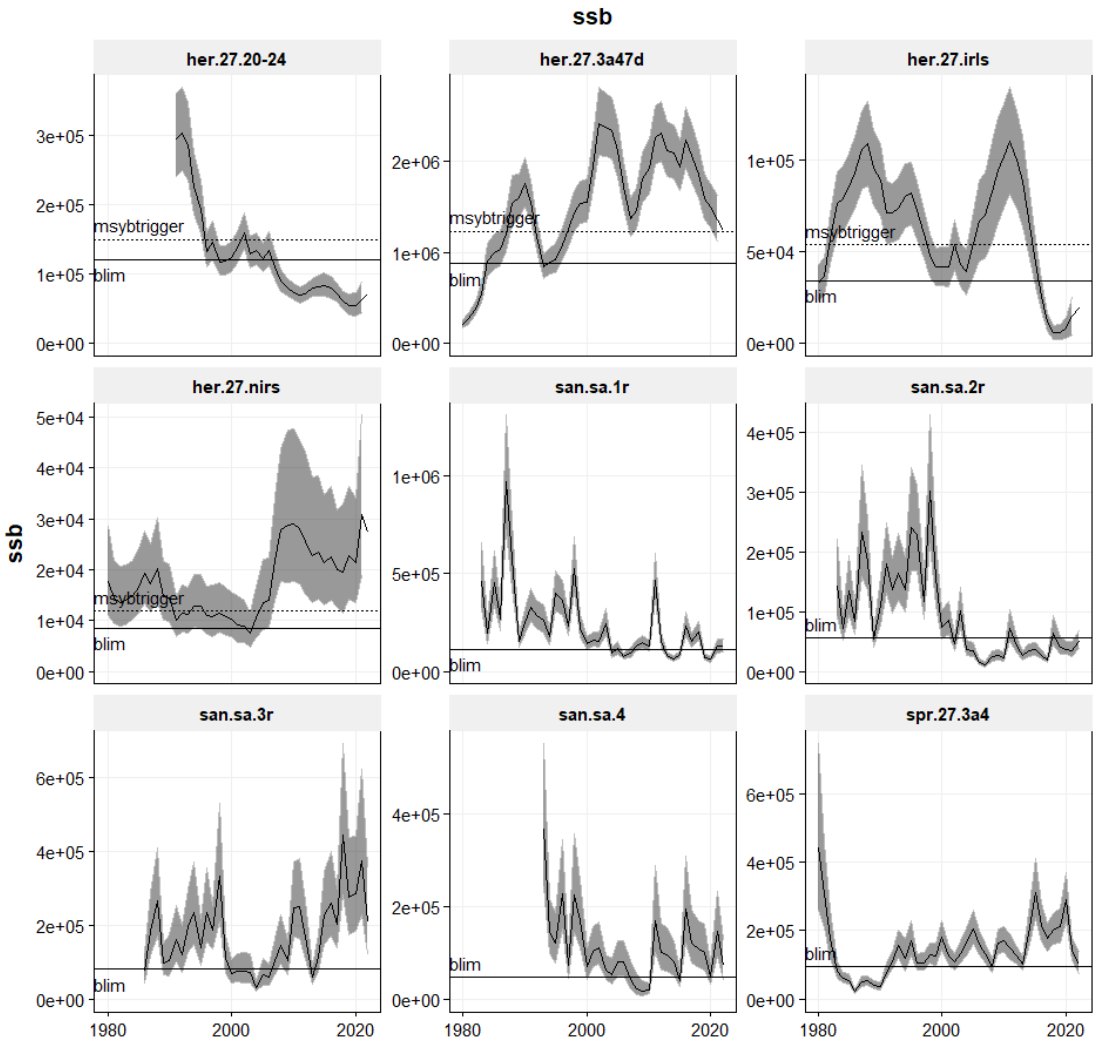

Figure 1.7.3 Spawning-stock biomass estimates for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2022.

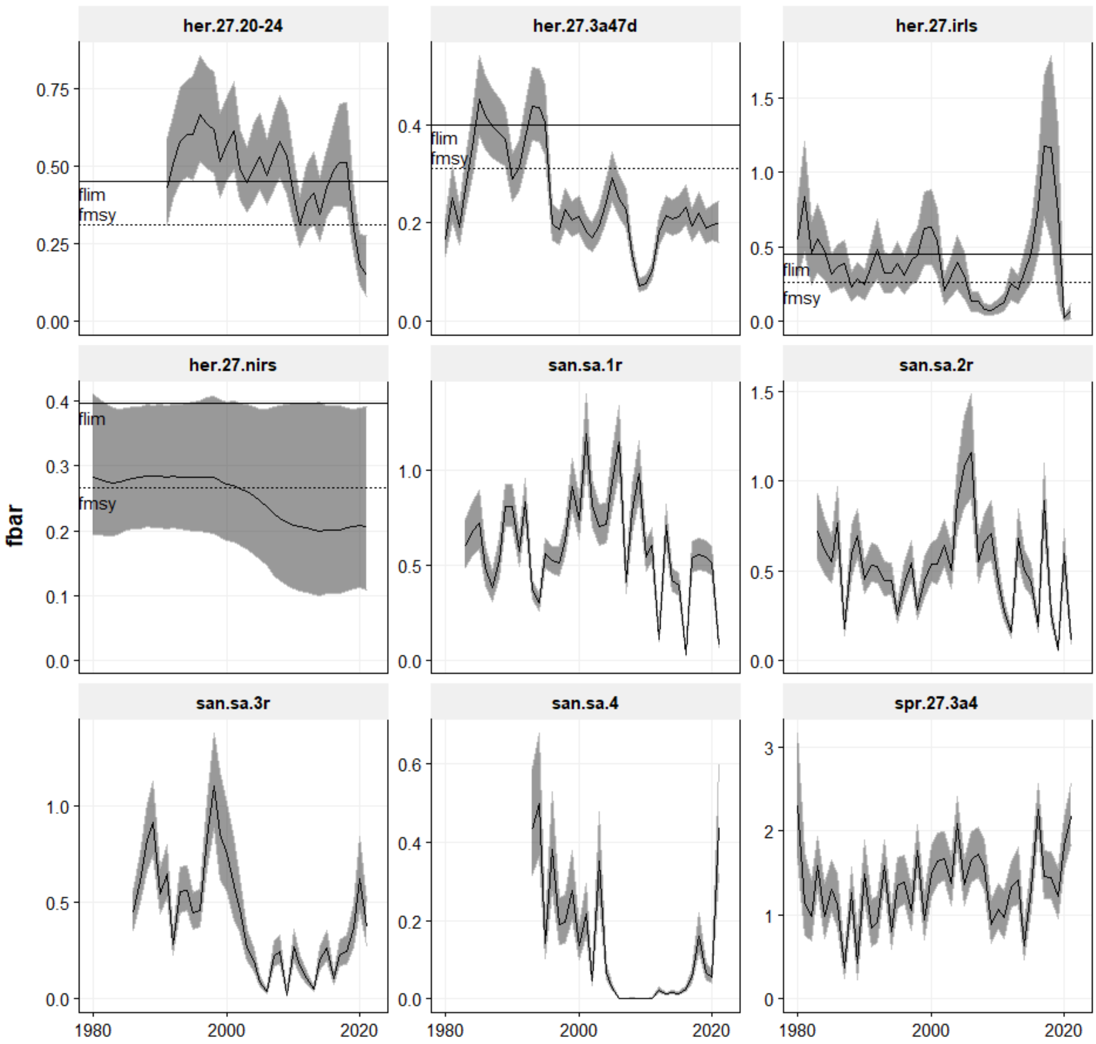

Figure 1.7.4 Estimates of mean F for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2022.

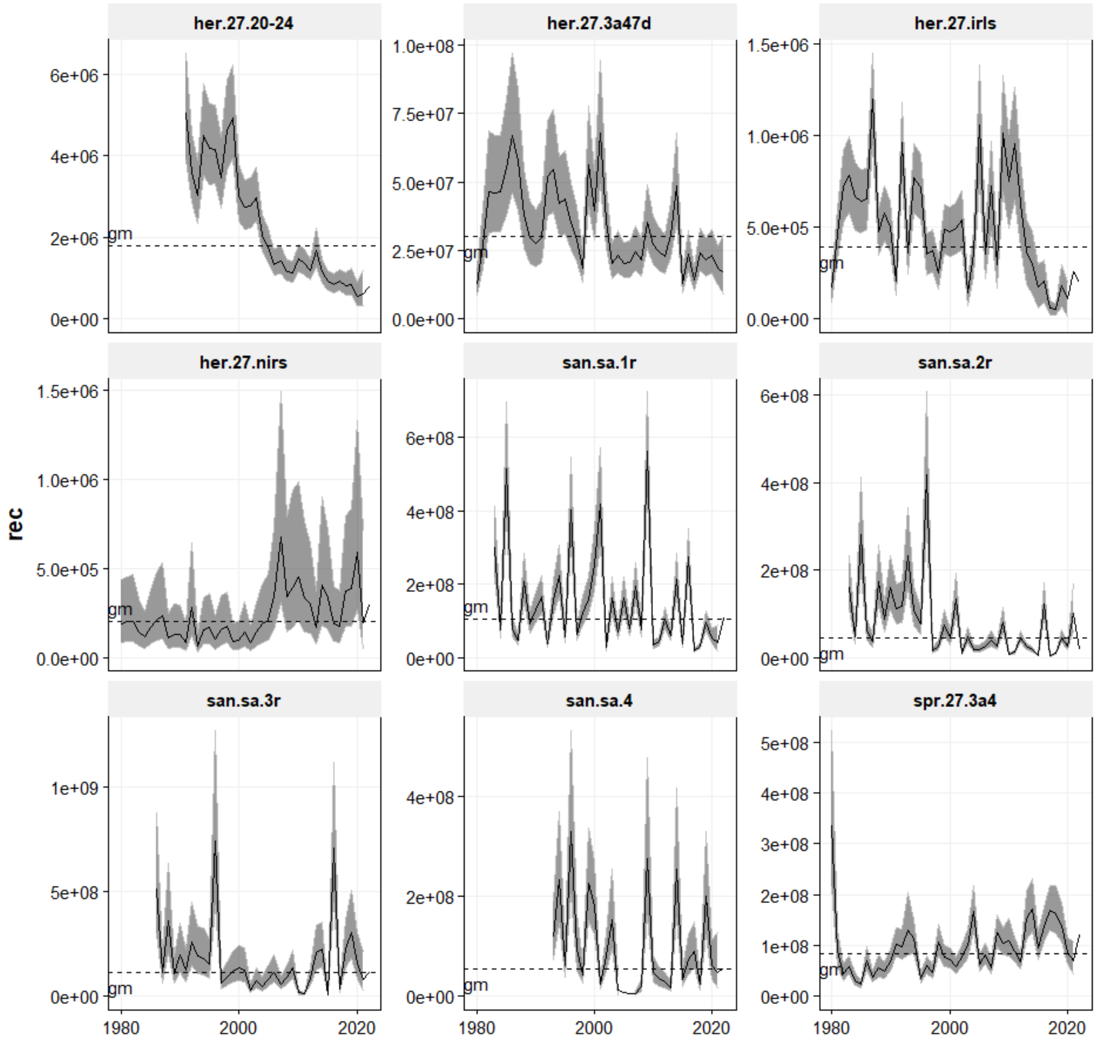

Figure 1.7.5 Estimates of recruitment for the category 1 sprat, herring and sandeel stocks assessed at HAWG 2022.

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).

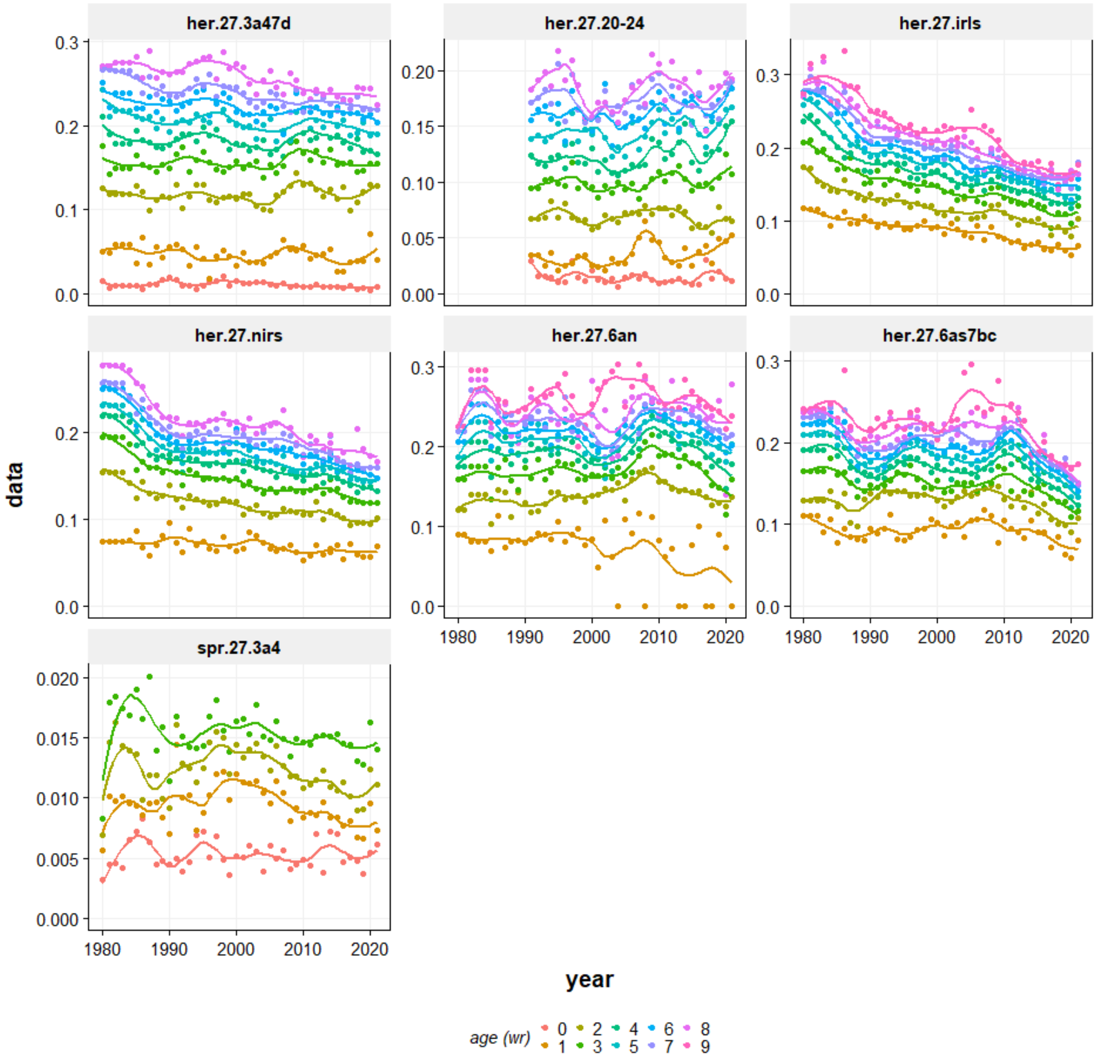

Figure 1.7.6 Time-series of herring mean individual weight in the catch.

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[1]:

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

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.

[1] 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	2021	5	-0.140	No	0.208	No	0.111
her.27.3a47d*	2021	5	-9.498	No	7.305	No	-10.269
her.27.irls	2021	5	-0.41	No	1.34	No	3.02
her.27.nirs	2021	5	-0.159	No	0.093	No	-0.309
san.sa.1r	2021	5	-0.10	No	0.43	No	0.87
san.sa.2r	2021	5	-0.13	No	0.55	No	0.37
san.sa.3r	2021	5	0.20	No	-0.12	No	0.01
san.sa.4	2021	5	-0.16	No	0.54	No	1.12
spr.27.3a4	2021	5	-0.05	Yes	0.25	No	0.27

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 (prepared at the benchmark in 2022)
9. Herring west of Scotland and Ireland (her.27.6aS7bc) WKLIFE method 2.2 chr (prepared at the benchmark in 2022)
10. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment (Update in progress 2022)
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 Interbechmark in the next 12 months	Further planning	Comments
NSAS herring	1	2018 Interbenchmark 2021	No	Exploration of M scaling methodologies, model configuration, new M values	Issue list available
WBSS herring	1.2	2018	Perhaps	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	Issue list and roadmap for next benchmark available, likely need for a benchmark in 2024 or 2025
6aN herring	3	2022	No	Continue genetic sampling on the acoustic survey. Start genetic sampling of the catches. Further investigate additional survey indices. Explore stock identity issues. Further work on model development.	Issue list in 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 in prep
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 2021 and 2022

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 2021 was 364 107 tonnes for Area 4 and Division 7.d, where no more than 34 793 t should be caught in Division 4.c and 7.d. For 2022, the total TAC is 453 802 t (427 628 t for the A-Fleet), including a TAC of 47 039 t for Division 4.c and 7.d.

The bycatch TAC for the B-Fleet in the North Sea (and Division 2.a) was 7 750 t in 2021 and has increased by 6% to 8 174 t in 2022. 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 2021

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 364 615 t in 2021. Official catches by the human consumption fishery were 355 665 t, relatively close to the TAC for the human consumption fishery (356 357 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 36 091 t. The separate TAC for this area was 34 793 t, so the TAC in Division 4.c and 7.d was 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 8 788 tonnes in 2021. The bycatch ceiling for the B-Fleet was 7 750 t. Since the introduction of yearly bycatch ceilings in 1996, these ceilings have fully been taken in 2014, 2016 and since 2020.

The total North Sea TAC and catch estimates for the years 2016 to 2021 are shown in the table below (adapted from Table 2.1.6).

Year	2016	2017	2018	2019	2020	2021
TAC HC ('000 t)	518	482	601	385	385	356
"Official" landings HC ('000 t) *	545	485	594	439	415	356
Working Group catch HC ('000 t)	545	485	594	440	417	356
Excess of landings over TAC HC ('000 t)	27	3	-7	55	32	0
Bycatch ceiling ('000 t) **	13	11	10	13	9	8
Reported bycatches ('000 t) ***	15	7	8	5	10	9
Working Group catch North Sea ('000 t)	560	492	602	446	427	365

HC = human consumption fishery
*** Landings might be provided by WG members to HAWG; they may differ from the 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 2022, half of the EU quota for Division 3a (HER/03A.) can be taken in UK waters of the North Sea (HER/*4-UK) and 21 038 tonnes of the EU quota can be taken in 4b (HER/*4b-EU). In total, the transfer of 3.a quota into the North Sea is getting close to 100%. Catches in Division 3a are limited to 1 136 tonnes.

In the North Sea, Norway can take up to 2 700 tonnes of its quota in UK and EU waters in divisions 4.a and 4.b (HER/*4AB-C). 2 700 tonnes of the EU quota can be taken within 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 2022, 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.

Having implemented the Brexit, access into UK waters was partly restricted in 2021. Norwegian vessels were not allowed to fish in UK waters and vice versa. This may have resulted in an increase in fishing effort in some rectangle in 4.a, along the Norwegian-UK maritime border. However, this effect is not clearly analysed yet. For 2022, there are mutual agreements put into place.

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.aW, in the order of 50% of the total. Subdivision 4.aE provided 24% of the catches in 2021 and catches in Division 4.b contributed 16%.

The bycatch ceiling for the small-meshed fishery (B-Fleet) has fully been taken in 2021. Catches were distributed in 4.aW (41%) and 4.b (58%). Only 1% were caught in 4.c. In former years, most of the catches in the B-Fleet were taken in Division 4.b (70% in 2019).

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

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in tables 2.2.1–2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, for Western Baltic spring spawners (only in 4.aE), 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 2006–2021 (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 2011–2021.

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 2.6 billion fish and NSAS amounts to 2.65 billion fish in 2021. The proportion of 0- and 1-ringers of herring taken in the North Sea is 24% of the total catch in numbers (Table 2.2.5), compared to 49% in 2020. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0-ringers amount to 52% of the total catch in numbers in 4.b.

The proportion of 3+ winter ring herring has re-increased to 62% of the total catch in numbers taken in the North Sea (compared to 39% in 2020).

In terms of biomass, the contribution of different age-groups is relatively homogeneous in 2021 (each 2-, 3-, 5- ,7- and 8-ringers contributed 13 to 19%).

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 2006–2021. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 365 351 tonnes.

Area	Allocated	Unallocated	BMS/Discard	Total
4.a West	181 381		64	181 445
4.a East	88 235		18	88 253
4.b	58 826			58 826
4.c/7.d	35 992		99	36 091
	Total catch in the North Sea			364 615
	Autumn spawners caught in Division 3.a (SOP)			4 243
	Baltic spring spawners caught in the North Sea (SOP)			-3 505
	Total catch NSAS used for the assessment			365 351

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 (East) 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, they have been 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 2021 was set at 10 tonnes and reported catches amount to 2 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 2021, 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 96 tonnes in 2021. 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 2021 North Sea herring fishery. However, discards occurred in demersal fisheries not targeting on herring. These discards were 67 tonnes in 2021.

The sampling of commercial landings covers 81% 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 108 different reported métiers, 31 were sampled in 2021. The sampling level of more than 1 sample per 1000 t catch has been met for only 17 métiers. With regards to age readings, 20 métiers appear to be sampled sufficiently (>25 fish aged per 1000 t catch).

However, some of the métiers yielded very little catch. In 69 métiers, the catch is below 1000 t. The total catch in these métiers sums to 11 595 t, so the remaining 39 métiers represent 352 956 t of the working group catch (97%). Of these 39 métiers, 16 were sampled. 8 métiers have more than 1 sample per 1000 t catch and also 11 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 2021

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 2021). 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 time-series of abundance of North Sea autumn spawning herring is given in Table 2.3.1.3. The 2021 estimate of North Sea autumn spawning herring SSB (spawning-stock biomass) is lower than in the previous year at 1.5 million tonnes (2020: 1.7 million tonnes) with a further decrease in the number of mature fish (2020: 8 915 million fish, 2021: 8 170 million fish). The mean weight of mature fish is lower than last year at 183.7 g, contributing stronger than the concurrent decrease in numbers to the decrease in biomass. The spawning stock is dominated by fish of age 2, 3 and 7 wr. In the 2020 survey 2, 5 and 6 wr dominated.

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 lower compared to recent surveys in the North Sea area.

The abundance of immature fish in the stock has increased by 57% since last year from 14 851 million in 2020 to million 23 311 in 2021. 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 74%, the proportion mature at 2 winter rings in 2021 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 again comparable to the long-term average with 99% of 3 winter ringers and 100% maturity for all ages 4 and above (Table 5.2). Since 2015, observed maturities are reported for all age groups. Previously maturity had been fixed at 100% for ages above 4 wr.

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

Six survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2021–2022. 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 2021 and January 2022 (Figures 2.3.2.1–2.3.2.3).

The survey around the Orkneys revealed higher quantities of newly hatched larvae, compared to relatively low numbers in the two preceding years. In the Buchan and the central North Sea, larvae hatched in lower quantities, and concentrated in two areas, while the remaining stations contributed only low numbers of larvae (Figure 2.3.2.1).

The two surveys in the southern North Sea showed comparable quantities. However, the survey in December was influenced by some hot spots, yielding high numbers of larvae. This pattern is not uncommon when compared to the survey history, thus all stations were included in further calculations.

As in former years, the abundance of young larvae is high when hatching started in December, but their spatial distribution is limited. With progressing spawning season, also the spatial distribution gets broader.

No survey was planned for the second half of January 2022. Instead, an additional MIK sampling is scheduled for March–April 2022 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.

During the most recent 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.

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 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 2022 survey (corresponding to the 2021 year-class) is 47.8. This is one of the lowest values in the time-series, with only 4 other year-classes being even lower (2003, 2007, 2014 & 2016).

The 2022 MIK-IBTS survey was faced with numerous challenges. Most importantly, very severe weather conditions prevailed throughout most of the survey period. In addition, several cases of Covid-19 on RV Walther Herwig III delayed the German survey for 15 days, and the

Scottish survey had to be cancelled after 5 days due to mechanical issues on RV Scotia. Furthermore, minor technical issues also occurred on the Dutch RV Tridens and the Danish RV Dana, resulting in the need to go back to harbor for some minor repairs. All these various issues had severe impacts on the MIK sampling, and only 433 depth-integrated hauls were completed with the MIK-net, which is 250 MIK hauls less than in 2021. For the 2022 MIK 0-ringer index (corresponding to the 2021 year-class), all hauls north of 51° N were used, in total 410 hauls, which is 253 less than in 2020.

As a total of 714 MIK hauls were planned according to the 2022 NSIBTS Q1 program (the target is 4 hauls per ICES rectangle), only approximately 60% of the planned MIK-stations were sampled. However, there has been an increase in the number of MIK hauls throughout the time-series, and the 433 MIK hauls achieved in 2022 are still more hauls than were conducted in the early years of the time-series. Besides, thanks to intensive coordination between participants during the survey and more decent weather in the final part of the survey period, at least 1 MIK haul could be conducted in most ICES rectangles and the majority of rectangles was covered with 2 or more hauls. Nevertheless, 24 rectangles were not covered at all by the MIK sampling, but these were mainly located in the north-western parts of the survey area, which usually only yield low numbers of herring larvae. Thus, the majority of the main herring larvae distribution area could be covered.

In order to investigate whether the poor sampling coverage may have had an influence on the 0-ringer index from the 2022 survey, two data tests were conducted. In the first test, the entire 0-ringer index time-series from 1992 to 2021 was re-calculated without the 24 rectangles which were not covered in 2022 and compared to the existing, normal 0-ringer time-series. For most years, the deviances between the two time-series were max. 5% or less, except for one year with a deviance of about 10%. Furthermore, when plotting the two time-series together in the same figure, it became evident that the overall time-series trends were not affected at all and the discrepancy between the two time-series was negligible. In the second test, the entire time-series since 1992 was calculated with only 1 and 2 randomly chosen MIK hauls per rectangle, conducting 100 different runs per year. For the test with only 1 random MIK haul per rectangle a relatively high variability of the index values was observed, whereas the test with 2 random hauls per rectangle only resulted in a low variability of the index. The overall trends, however, were not seriously affected in both runs. Thus, as the majority of rectangles was covered by at least 2 or more MIK hauls, the impact of the poor MIK sampling coverage during the 2022 survey on the resulting 0-ringer index seems negligible. In summary, despite the encountered issues and low overall number of MIK hauls, it can be assumed that the 2022 MIK survey provides a representative 0-ringer index.

Figure 2.3.3.1.1 shows the size distribution of MIK larvae in 2022. Herring larvae measured between 7 and 44 mm standard length (SL). Again, and as in most years, the smallest larvae <12 mm were the most numerous and the larvae between 7 to 11 mm made up almost 50% of the total number of larvae. Larger larvae >18 mm SL were rarer, making up about 10% of all larvae, and were caught in lower densities than last year. An interesting feature in the 2022 length distribution is the peak at 15 mm SL. Figure 2.3.3.1.2 illustrates the spatial distribution of 0-ringers in 2020, 2021 and 2022. The smallest larvae were chiefly caught in 7.d and in the Southern Bight. The large larvae appeared in moderate to high quantities in both the central, western and southern parts of the North Sea. In the southeastern and eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was lower than last year.

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 2020 is shown in Table 2.3.3.2. The index from the 2022 survey (corresponding to the 2020 year-class) is 806. This is less than half of the long-term average of the time series, and only 3 other year-classes were even lower (1997, 2014 & 2016).

Figure 2.3.3.2.1 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2020, 2021, and 2022. As in previous years, the majority of the 1-ringers of the 2020 year-class were found in the Kattegat/Skagerrak area, however at much lower abundance. In addition, 1-ringers were also found in the south-eastern parts of the North Sea as well as in the Moray Firth.

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 again corresponded well 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 seems rather low compared to the 0-ringer value.

This leads to the question if there may be an issue with the 1-ringer index for the 2020 year-class, which could e.g., be related to the various challenges during the 2022 survey described above (see section 2.3.3.1). Due to these challenges, a total number of 33 ICES rectangles were not covered by GOV hauls in 2022. However, the uncovered rectangles are mainly located in the north-western North Sea, which is an area that usually did not yield relevant catches of 1-ringers in previous years. Besides, the ICES rectangles in the north-western areas that actually were covered did not yield relevant catches of 1-ringers during the 2022 survey, indicating that the unsampled rectangles would not have yielded any relevant catches either. Thus, the poor spatial coverage in these areas in 2022 does not seem to have an influence on the 1-ringer index, which is mainly driven by catches in Kattegat, Skagerrak and the German Bight, i.e. areas that were decently covered in 2022.

However, the adverse weather conditions during much of the 2022 survey may have had a more general influence on the catchability of 1-ringers, e.g., by reducing the schooling effect due to low visibility in the water. Besides, it should be kept in mind that the 1-ringer index is based on hauls with a GOV Trawl, i.e., a bottom trawl which might not be ideal to catch pelagic species like herring. Furthermore, differences in vertical net opening between participating vessels in the Q1 IBTS may also have an influence on catchability. Germany did e.g., report a relatively high vertical net opening while Norway reports a relatively low vertical net opening, which may result in higher and lower catchability of pelagic species, respectively. As Germany only conducted 10 out of their 67 planned GOV hauls in 2022, this may have had an effect on the total numbers of 1-ringer herring, but it is not clear if such an effect did indeed occur, nor can its magnitude be estimated. However, it should be kept in mind that the 1-ringer abundance from the 2022 survey, corresponding to the 2020 year-class, may be underestimated.

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 3rd 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 1996 to 2020 for comparison. The data for 2020 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 weight at age observed in recent years in the acoustic survey and, but less pronounced, in the catch in the 3rd quarter (Figure 2.4.1.1), seems to be turned since 2020. This is especially the case for age 2 and 3 Almost all ages, in both the acoustic survey and the catch, had higher mean weight at age compared to 2019, with the only exception of 5-wr fish in the catch and 8-wr in the catch and the survey.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2021 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.

Maturity of 2 winter ringers was at an all-time low in 2018 at 37%. In 2019, the proportion mature at 2 winter rings was at 59%, still low when compared to the long term. In 2020 and 2022, 2 winter ringers were to 75% and 74% mature respectively, much more in line with previous years. Maturities for winter ringers 3 (989) and 4 (100%) are also comparable to the long-term average. 100% maturity was achieved by age 4.

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, explaining only 26 % recruitment variability (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.

The most recent data that can be compared between 0-ringers and 1-ringers are for the 2020 year-class, corresponding to the 0-ringers from the 2021 MIK survey and the 1-ringers from the 2022 GOV survey. Generally, the 0-ringer and 1-ringer data for the 2020 year-class correspond better than for the 2019 year-class, but in contrast to the vast majority of other years in the time-series, the 1-ringer value is rather low in relation to the 0-ringer value (Figure 2.3.3.2.2). This may reflect some severe mass mortality among the larger herring larvae or young juveniles, in particular if one bears in mind that there are increasing numbers of mackerel in the North Sea during summer in recent years, which may prey heavily on the 0-group herring. However, this could also be a "sampling artefact" related to adverse weather conditions and several other challenges during the 2022 Q1 IBTS, which may have affected the catchability of 1-ringers of the 2020 year-class, but it is not clear if such an effect did indeed occur, nor can its magnitude be estimated (for further details see section 2.3.3). However, it should be kept in mind that the 1-ringer abundance from the 2022 survey, corresponding to the 2020 year-class, may be underestimated.

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 74%, 99%, and 100% 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 2021 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 2020), 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 2021 is estimated at approximately 1.35 million tonnes and still decreasing of the stock observed since 2016. As for recruitment, the 2022 estimates are substantially lower than estimated during 2021. Recruitment of the 2020- and 2021-year classes are estimated to be weak. Mean F2–6 in 2020 is estimated at approximately 0.20.

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 2.6.1.13 and 2.6.1.14). This likely indicates a trade-off in model fit to either the age 7 or age 8+ catch information. There is a methodological need however to link age 7 and age 8+ together in the stock assessment model. The residuals are very small and are not considered an issue for the performance of the assessment. The fitting of the LAI index is poor due to the intrinsic noise to the larvae survey. However, this survey is the only one able to provide information on the strength of the different spawning components. Given the low impact of this survey on the overall assessment, this is not considered an issue.

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

A feature of the assessment model is the estimation of an observation variance parameter for each dataset (Table 2.6.2.1, Figure 2.6.2.6). Overall, all data sources are associated with low observation variances. The catch-at-ages 1–5 stands out as the most precise data source while the LAI indices, IBTSQ3 age 0 and HERAS age 1 to be the noisiest data. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch-at-age 0 is some- what high (Figure 2.6.2.7). However, the CV quantities do not indicate a lack of convergence of the assessment model.

The analytical retrospective analysis (Table 2.6.2.5, Figure 2.6.2.9) has mean Mohn's rho values with a 5-year peel of: -9% (F_{bar}), -10% (rec), and 7% (SSB).

Figure 2.6.1.49 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 (Figure 2.6.2.10-2.6.2.12).

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). It is important to note that fleet B and D are combined because of their similarity. More details on the model configuration exploration are provided in the 2018 benchmark report (ICES WKPELA, 2018). 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 2.6.2.3 to Figure 2.6.2.5. The observation variance is shown in Figure 2.6.2.6, with high levels for fleet B and D. 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 2.6.2.7 and 2.6.2.8 respectively.

The analytical retrospective for the multi-fleet model is shown in in Figure 2.6.2.9 and is slightly higher than for the single fleet model. The fishing selectivity for the A fleet are shown in Figure 2.6.3.10 and present similar patterns to the single fleet model. This is expected as fleet A is the main fleet harvesting the stock. The development of selectivity patterns for the other fleets (C and B and D combined) are presented in Figure 2.6.3.11 and 2.6.3.12.

2.6.4 State of the Stock

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as is being harvested sustainably. Fishing mortality is below the estimated F_{MSY} (0.31).

The SSB in autumn 2021 was estimated at 1.35 million tonnes, which is above B_{pa} (0.96 million t) and MSY $B_{trigger}$(1.23 million t).

Since the strong 2013-year class, recruitment of herring has been low. The 2020-year class is estimated at 84% and the 2021-year class at 76% of the 10 year geometric mean recruitment.

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

2.7 Short-term predictions

Short-term predictions for the years 2021, 2022, and 2023 were done with 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 2023 and 2024 following the same recruitment regime since 2002 (weighted mean of the past 10 year classes, weighted by the uncertainty in the estimate). The recruitment estimate of the 2021 year class, obtained from the assessment (informed by the 2022 IBTS0 survey) served as the estimate for 2022.

For the intermediate year (2022), no overshoot for the A fleet was assumed. Negotiations between the EU, Norway, and UK for 2022 resulted in the allowance of 100% of the C-fleet and 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 2022 were estimated as follows:

- A-fleet: fleet TAC (427 628 t) + what is transferred from the C-fleet in 3a to the North Sea (23 885 t) scaled by the 3-year average proportion of NSAS in A-fleet catch (98.6%, 2019-2021)
- B-fleet: fleet TAC (8 174 t) + a 50% transfer from the D-fleet TAC (6 659 t) in 3a to the North Sea scaled with the fleet uptake in 2021 (78%)
- C-fleet: catches corresponding to 1 136 t catch in 3.a scaled by the 3-year average proportion of NSAS in the C-fleet catch (35.5%, 2019-2021)
- D-fleet: catches set at 0 t because considered negligible compared to the other fleets

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 2023, 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 2023. 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.

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, 2021), the MSY AR stipulates a fishing mortality of $F_{MSY} = 0.31$ when the stock is above MSY $B_{trigger}$ (1 232 828 tonnes) and a linear decline in F when the stock is below MSY $B_{trigger}$. With the forecasted values in 2023, the SSB is calculated below MSY $B_{trigger}$ which results in a target $F_{(wr)\ 2–6} = 0.281$ (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.

All predictions are for North Sea autumn spawning herring only.

2.7.1 Comments on the short-term projections

While the HAWG 2021 forecast (REF) suggested that the steep decline of the stock since 2016 has stalled, the new assessment and forecast in HAWG 2022 concludes that the stock is still declining. Expanding the (deterministic) short term forecast for a limited number of years, suggested that the decline in stock size may halt around 2024-2025. Choosing a lower target fishing mortality than Fmsy=0.31, is expected to lead to a quicker recovery of the stock to above MSY Btrigger.

2.7.2 Exploratory short-term projections

A direct comparison of the forecast results with the last two assessments (2021 and 2020) is given in 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 2023 relative to 2022.

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 2021 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 2024–2028 (Figure 2.7.2.4). This projection resulted catch of ~375 000 tonnes by 2026. 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[2]). 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 and 2018.

New reference points were calculated during the 2021 interbenchmark meeting (ICES WKNSHERRING, 2021) 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 2021 assessment, the fishing pressure remains below F_{MSY} while the SSB is above MSY $B_{Trigger}$.

2.10 Quality of the assessment

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

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 contribute-tors. 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.

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 appropri-ate-ate 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 B_{lim} 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.

Table 2.1.1. Herring caught in the North Sea. Total catch (tonnes) by country, 2017–2021. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2017	2018	2019	2020	2021
Belgium	13	32	60	119	47
Denmark *	110 318	132 231	91 680	95 615	62 943
Faroe Islands	442	497	614	804	0
France	28 801	31 505	25 288	19 768	25 070
Germany	43 707	51 636	37 699	29 439	25 741
Netherlands	84 914	111 302	79 465	75 036	66 402
Norway	134 132	162 594	128 614	115 879	95 061
Lithuania	0	0	0	0	466
Sweden *	18 518	19 408	13 184	13 149	18 765
Ireland	868	515	3	235	414
UK (England)	16 997	19 591	12 685	16 241	13 174
UK (Scotland)	49 514	66 005	50 771	49 692	51 194
UK (N.Ireland)	3 469	6 916	3 938	2 681	5 176
Unallocated landings	0	0	0	0	0
Total landings	491 693	602 232	444 001	424 800	364 453
Discards/BMS	-	96	1 630	2 522	162
Total catch	491 693	602 328	445 631	427 321	364 615
Estimates of the parts of the catches which have been allocated to spring-spawning stocks					
WBSS	632	2 164	8 832	6 802	3 505
Thames estuary **	0	0	-	-	2
Norw. Spring Spawners ***	83	310	5	88	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	2017	2018	2019	2020	2021
Denmark *	76277	90763	54820	56676	37970
Faroe Islands	405	496	611	794	0
France	11064	14745	13344	7688	13795
Germany	32736	35884	19851	16694	16590
Lithuania	-	-	-	2789	466
Netherlands	55832	56990	44071	50363	48510
Norway	57744	78647	53254	35674	7119
Sweden	12447	14132	8557	7718	11100
Ireland	868	515	3	235	414
UK (England)	12072	12313	5640	11439	9487
UK (Scotland)	49012	64424	50771	42581	33416
UK (N. Ireland)	3469	5582	3938	2681	2514
Total Landings	311926	374491	254860	235330	181381
Discards/BMS	-	-	-	284	64
Total catch	**311926**	**374491**	**254860**	**235613**	**181445**

*** 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	2017	2018	2019	2020	2021
Denmark *	3928	751	0	62	18
Netherlands	0	0	100	0	0
Norway	74216	73452	64592	58535	87756
Sweden	705	377	0	0	479
Total landings	78849	74580	64692	58597	88253
Discards/BMS	-	-	-	-	-
Total catch	78849	74580	64692	58597	88253
Norw. Spring Spawners **	85	310	5	88	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	2017	2018	2019	2020	2021
Belgium	0	0	0	11	1
Denmark*	30045	4067	36750	38842	24903
Faroe Islands	37	1	3	10	0
France	7423	6090	1359	5092	1569
Germany	2048	4964	8568	4197	3869
Netherlands	15739	34491	20700	8814	691
UK (N. Ireland)	0	1334	0	0	2662
Norway	2172	10495	10768	21671	186
Sweden*	5366	4899	4627	5431	7166
UK (England)	2435	3262	2750	919	4
UK (Scotland)	502	1581	0-	7082	17775
Unallocated landings	0	0	0	0	0
Total landings	65767	107794	85525	95422	58826
Discards	-	1	800	-	-
Total catch	65767	107795	86325	95422	58826

*** 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	2017	2018	2019	2020	2021
Belgium	13	32	60	108	46
Denmark*	68	40	110	36	53
France	10314	10670	10585	6988	9705
Germany	8923	10788	9280	8548	5282
Netherlands	13343	19821	14594	15859	17202
Sweden	0	0	0	0	21
UK (England)	2490	4016	4295	3883	3682
UK (Scotland)	-	-	-	30	2
Unallocated landings	0	0	0	0	0
Total landings	35151	45367	38924	35451	35992
Discards/BMS	-	95	830	2238	99
Total catch	35151	45462	39754	37689	36091
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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Subarea 4 and Division 7.d: TAC (4 and 7.d)													
Agreed Divisions 4.a,b	149.0	173.5	360.4	427.7	418.3	396.3	461.2	428.7	534.5	342.7	342.7	321.6	380.6
Agreed Div. 4.c, 7.d	15.3	26.5	44.6	50.3	51.7	49.0	57.0	53.0	66.0	42.4	42.4	34.8	47.0
Bycatch ceiling in the small mesh fishery *	13.6	16.5	17.9	14.4	13.1	15.7	13.4	11.4	9.7	13.2	9.0	7.8	8.2
CATCH (4 and 7.d)													
National catch Divisions 4.a,b **	148.1	191.7	387.2	453.8	465.9	439	514.0	456.5	556.9	405.1	389.3	328.5	
Unallocated catch Divisions 4.a,b	0.0	0.0	-3.0	0.0	3.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.a,b ***	0.0	-	-	-	0.0	-	0.1	-	0.0	0.8	0.3	0.1	
Total catch Divisions 4.a,b #	148.1	191.7	384.2	453.9	469.2	440.5	514.1	456.5	556.9	405.9	389.6	328.5	
National catch Divisions 4.c, 7.d **	26.5	26.7	37.1	44.7	38.2	41.1	45.8	35.2	45.4	38.9	35.5	36.0	
Unallocated catch Divisions 4.c,7.d	0.0	0.0	3.3	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	
Total catch Divisions 4.c, 7.d	26.5	26.7	40.4	44.7	38.2	41.1	45.8	35.2	45.5	39.8	37.7	36.1	
Total catch 4 and 7.d as used by ICES #	174.6	218.4	424.6	498.5	507.5	481.6	559.9	491.7	602.3	445.6	427.3	364.6	
CATCH BY FLEET/STOCK (4 and 7.d) ##													
North Sea autumn spawners directed fisheries (Fleet A)	164.8	209.2	411.8	489.9	490.5	471.5	543.6	484.1	591.7	440.5	417.5	352.3	
North Sea autumn spawners industrial (Fleet B)	9.1	8.9	10.6	8.1	14.0	7.9	14.5	7.0	8.5	5.2	9.9	8.8	

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
North Sea autumn spawners in 4 and 7.d total	173.9	218.1	422.5	498.1	504.5	479.4	558.1	491.1	600.2	436.8	420.5	361.1	
Baltic-3.a-type spring spawners in 4	0.8	0.3	2.1	0.5	3.0	2.2	1.8	0.6	2.2	8.8	6.8	3.5	
Coastal-type spring spawners	0.1	0.0	0.1	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 ###	56.9	12.2	9.6	3.2	2.3	2.2	0.2	0.1	0.3	0.0	0.1	0.0	
Division 3.a: TAC (3.a)													
Agreed herring TAC	33.9	30.0	45.0	55.0	46.8	43.6	51.1	50.7	48.4	29.3	24.5	21.6	25.0
Bycatch ceiling in the small mesh fishery	7.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
CATCH (3.a)													
National catch	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	13.3	
Catch as used by ICES	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	13.3	
CATCH BY FLEET/STOCK (3.a) ##													
Autumn spawners human consumption (Fleet C)	12.0	6.6	7.8	11.8	9.5	10.2	4.1	7.4	3.2	5.8	6.0	4.1	
Autumn spawners mixed clupeoid (Fleet D)	1.8	1.8	4.4	1.6	3.3	4.4	1.4	0.2	0.2	0.3	0.4	0.1	
Autumn spawners in 3.a total	13.8	8.4	12.2	13.4	12.8	14.7	5.5	7.6	3.4	6.1	6.4	4.2	
Spring spawners human consumption (Fleet C)	23.0	10.8	14.5	16.6	15.4	11.3	23.3	19.0	19.7	8.8	10.9	9.0	
Spring spawners mixed clupeoid (Fleet D)	0.5	0.8	1.0	1.3	0.6	1.8	1.1	0.2	0.2	0.0	0.5	0.0	
Spring spawners in 3.a total	23.5	11.6	15.5	17.9	16.1	13.1	24.4	19.2	19.9	8.8	11.4	9.1	
North Sea autumn spawners Total as used by ICES	187.6	226.5	434.6	511.4	517.3	494.1	563.6	498.7	603.5	442.9	426.9	365.4	

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 2021. Catch in numbers (millions) at age (CANUM), by quarter and division.

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

Quarters: 1-4

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	6.9	0.0	0.0	0.0	124.7	390.6	11.8	0.0	515.3	11.8	534.1	527.2
1	15.7	1.4	0.4	1.0	22.9	72.9	0.0	0.1	96.7	0.1	112.4	97.2
2	36.3	122.2	1.1	121.	227.7	16.5	0.0	5.7	365.3	5.7	407.	372.1
3	2.8	96.7	2.8	93.9	206.4	82.2	11.2	23.3	382.5	34.5	419.8	419.8
4	1.5	51.2	7.3	43.9	79.2	19.4	13.5	21.7	142.5	35.2	179.2	185.0
5	0.8	86.4	4.5	81.9	117.7	17.6	13.1	34.9	217.1	48.0	265.9	269.6
6	0.5	26.9	1.9	25.1	67.3	9.2	4.4	11.8	101.6	16.1	118.2	119.6
7	0.1	60.5	1.1	59.4	170.3	54.4	9.2	27.	284.0	36.	320.8	321.7
8	0.1	54.9	1.8	53.2	89.3	43.7	3.8	20.	186.1	24.	210.	211.9
9+	0.0	24.6	0.5	24.1	33.4	13.7	1.2	8.5	71.2	9.7	80.9	81.3
Sum	64.8	524.8	21.3	503.5	1138.7	720.0	68.2	153.7	2362.3	221.9	2648.9	2605.5

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	0.2	0.0	0.0	0.2	0.0	0.2	0.2
1	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0
2	25.4	0.0	0.0	0.0	18.2	0.0	0.0	0.0	18.2	0.0	43.6	18.3
3	0.8	0.0	0.0	0.0	19.1	0.0	0.3	1.1	19.1	1.4	21.3	20.6
4	0.0	0.0	0.0	0.0	4.1	0.0	0.5	1.3	4.1	1.7	5.9	5.9
5	0.0	0.0	0.0	0.0	1.9	0.0	0.8	6.6	1.9	7.4	9.4	9.4
6	0.0	0.0	0.0	0.0	3.2	0.0	0.7	1.7	3.2	2.4	5.6	5.6
7	0.0	0.0	0.0	0.0	6.5	0.0	1.9	2.6	6.5	4.4	10.9	10.9
8	0.0	0.0	0.0	0.0	3.7	0.0	0.2	0.6	3.7	0.8	4.5	4.5
9+	0.0	0.0	0.0	0.0	2.2	0.0	0.1	0.0	2.2	0.1	2.2	2.2
Sum	28.8	0.1	0.0	0.0	58.9	0.2	4.5	13.8	59.1	18.3	106.2	77.5

Quarter: 2

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
0	0.0	0.0	0.0	0.0	2.1	36.0	0.0	0.0	0.2	0.1	38.1	38.1
1	1.1	1.2	0.4	0.9	0.7	6.1	0.0	0.0	7.6	0.0	8.7	8.0
2	2.6	117.7	1.0	116.	60.3	0.6	0.0	0.0	177.6	0.0	180.	178.7
3	0.1	89.8	2.6	87.2	46.8	1.0	0.0	0.0	135.1	0.0	135.2	137.7
4	0.0	45.1	6.8	38.3	13.6	0.2	0.0	0.0	52.2	0.0	52.2	59.0
5	0.0	64.3	4.1	60.1	13.6	0.2	0.0	0.0	73.9	0.0	74.0	78.1
6	0.0	21.6	1.7	19.9	5.1	0.1	0.0	0.0	25.1	0.0	25.1	26.8
7	0.0	37.1	1.0	36.0	10.5	0.7	0.0	0.0	47.3	0.0	47.3	48.3
8	0.0	36.7	1.4	35.4	7.7	0.7	0.0	0.0	43.7	0.0	43.8	45.1
9+	0.0	14.7	0.4	14.3	1.7	0.2	0.0	0.0	16.2	0.0	16.2	16.6
Sum	3.9	428.3	19.3	409.0	162.1	45.8	0.1	0.1	579.0	0.3	620.9	636.3

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	0.0	0.0	0.0	0.0	9.2	280.5	1.3	0.0	289.6	1.3	290.9	290.9
1	10.3	0.1	0.0	0.0	3.6	53.9	0.0	0.0	57.5	0.0	67.8	57.6
2	7.6	3.0	0.1	3.0	130.5	15.1	0.0	0.0	148.5	0.0	156.	148.6
3	1.7	4.8	0.2	4.6	122.5	76.6	0.0	0.0	203.7	0.0	205.4	203.9
4	1.1	4.8	0.6	4.2	48.9	17.8	0.0	0.0	70.9	0.0	72.0	71.5
5	0.4	16.9	0.3	16.6	93.1	14.7	0.0	0.0	124.3	0.0	124.8	124.7
6	0.3	4.1	0.1	3.9	54.7	7.9	0.0	0.0	66.5	0.0	66.8	66.6
7	0.1	19.3	0.1	19.2	129.8	45.4	0.0	0.0	194.4	0.0	194.	194.5
8	0.0	15.4	0.1	15.3	71.5	40.0	0.0	0.0	126.8	0.0	126.	126.9
9+	0.0	7.9	0.0	7.8	27.0	12.3	0.0	0.0	47.1	0.0	47.1	47.2
Sum	21.4	76.1	1.6	74.5	690.8	564.1	1.3	0.0	1329.4	1.3	1352.1	1332.3

Quarter: 4

0	6.9	0.0	0.0	0.0	113.5	74.0	10.5	0.0	187.5	10.5	**204.9**	**198.0**
1	1.8	0.0	0.0	0.0	18.6	12.8	0.0	0.1	31.5	0.1	**33.3**	**31.6**
2	0.7	1.4	0.0	1.4	18.7	0.8	0.0	5.7	20.9	5.7	**27.4**	**26.6**
3	0.2	2.1	0.0	2.1	18.0	4.6	10.8	22.2	24.7	33.0	**57.9**	**57.7**
4	0.4	1.3	0.0	1.3	12.5	1.4	13.0	20.4	15.2	33.4	**49.1**	**48.7**
5	0.3	5.2	0.0	5.2	9.1	2.7	12.3	28.3	16.9	40.5	**57.8**	**57.5**
6	0.2	1.2	0.0	1.2	4.3	1.3	3.7	10.1	6.8	13.7	**20.7**	**20.5**
7	0.1	4.2	0.0	4.2	23.4	8.3	7.3	24.	35.9	32.	**68.1**	**68.0**
8	0.1	2.8	0.3	2.5	6.4	3.0	3.5	19.	11.9	23.	**35.2**	**35.4**
9+	0.0	2.0	0.1	2.0	2.5	1.1	1.2	8.5	5.6	9.6	**15.3**	**15.3**
Sum	**10.7**	**20.3**	**0.4**	**19.9**	**227.0**	**110.0**	**62.3**	**139.8**	**356.8**	**202.1**	**569.6**	**559.3**

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 2021. 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	**0.011**	**0.000**	**0.000**	**0.004**	**0.008**	**0.008**	**0.007**	**0.008**	**0.008**	**0.004**	**0.004**
1	**0.047**	**0.120**	**0.119**	**0.079**	**0.040**	**0.037**	**0.000**	**0.041**	**0.000**	**0.071**	**0.082**
2	**0.071**	**0.136**	**0.138**	**0.138**	**0.133**	**0.143**	**0.100**	**0.134**	**0.101**	**0.130**	**0.136**
3	**0.116**	**0.149**	**0.149**	**0.160**	**0.157**	**0.168**	**0.125**	**0.155**	**0.139**	**0.155**	**0.155**
4	**0.159**	**0.162**	**0.160**	**0.174**	**0.173**	**0.189**	**0.141**	**0.169**	**0.159**	**0.171**	**0.170**
5	**0.174**	**0.178**	**0.168**	**0.195**	**0.199**	**0.210**	**0.173**	**0.191**	**0.183**	**0.189**	**0.189**
6	**0.192**	**0.180**	**0.174**	**0.216**	**0.214**	**0.225**	**0.189**	**0.205**	**0.199**	**0.214**	**0.213**
7	**0.206**	**0.200**	**0.181**	**0.218**	**0.225**	**0.231**	**0.192**	**0.220**	**0.202**	**0.219**	**0.219**
8	**0.186**	**0.203**	**0.194**	**0.239**	**0.226**	**0.241**	**0.188**	**0.219**	**0.196**	**0.238**	**0.237**
9+	**0.000**	**0.220**	**0.205**	**0.246**	**0.240**	**0.253**	**0.205**	**0.233**	**0.211**	**0.247**	**0.246**

Quarter: 1

0	0.000	0.000	0.000	0.002	0.000	0.008	0.000	0.000	0.000	**0.002**	**0.002**
1	0.025	0.116	0.116	0.016	0.000	0.034	0.000	0.001	0.000	**0.025**	**0.029**
2	0.055	0.134	0.134	0.080	0.084	0.112	0.100	0.084	0.112	**0.055**	**0.100**
3	0.073	0.145	0.145	0.117	0.109	0.140	0.093	0.109	0.104	**0.123**	**0.132**
4	0.107	0.155	0.155	0.116	0.135	0.162	0.107	0.135	0.121	**0.133**	**0.134**
5	0.081	0.163	0.163	0.106	0.160	0.183	0.120	0.160	0.127	**0.130**	**0.131**
6	0.000	0.168	0.168	0.142	0.166	0.182	0.140	0.166	0.152	**0.162**	**0.162**
7	0.000	0.176	0.176	0.149	0.182	0.204	0.138	0.182	0.000	**0.162**	**0.162**
8	0.155	0.182	0.182	0.160	0.198	0.216	0.145	0.198	0.000	**0.189**	**0.189**
9+	0.000	0.193	0.193	0.180	0.190	0.223	0.173	0.190	0.222	**0.182**	**0.182**

Quarter: 2

0	0.000	0.000	0.000	0.002	0.008	0.008	0.000	0.008	0.000	**0.002**	**0.002**
1	0.030	0.116	0.116	0.044	0.074	0.034	0.000	0.081	0.000	**0.089**	**0.093**
2	0.058	0.134	0.134	0.140	0.126	0.128	0.100	0.131	0.128	**0.129**	**0.130**
3	0.073	0.145	0.145	0.151	0.142	0.162	0.093	0.144	0.111	**0.147**	**0.146**
4	0.096	0.155	0.155	0.167	0.162	0.171	0.107	0.157	0.126	**0.164**	**0.163**
5	0.000	0.163	0.163	0.176	0.163	0.184	0.119	0.163	0.136	**0.172**	**0.172**
6	0.000	0.168	0.168	0.191	0.184	0.190	0.146	0.171	0.168	**0.186**	**0.185**
7	0.000	0.176	0.176	0.206	0.189	0.223	0.138	0.179	0.197	**0.199**	**0.198**
8	0.000	0.182	0.182	0.215	0.207	0.238	0.142	0.187	0.197	**0.204**	**0.203**
9+	0.000	0.193	0.193	0.230	0.206	0.251	0.173	0.194	0.235	**0.218**	**0.217**

Quarter: 3

0	0.000	0.000	0.000	0.004	0.008	0.008	0.007	0.008	0.008	**0.004**	**0.004**
1	0.054	0.158	0.158	0.075	0.069	0.038	0.000	0.070	0.000	**0.071**	**0.076**
2	0.125	0.187	0.187	0.145	0.143	0.143	0.000	0.144	0.000	**0.145**	**0.146**
3	0.134	0.202	0.202	0.168	0.170	0.168	0.000	0.171	0.000	**0.169**	**0.170**
4	0.159	0.214	0.214	0.184	0.179	0.189	0.000	0.181	0.000	**0.184**	**0.184**
5	0.172	0.224	0.224	0.213	0.205	0.207	0.000	0.208	0.000	**0.212**	**0.212**
6	0.196	0.232	0.232	0.229	0.219	0.225	0.000	0.220	0.000	**0.231**	**0.230**
7	0.206	0.241	0.241	0.237	0.233	0.229	0.000	0.234	0.000	**0.239**	**0.238**
8	0.201	0.248	0.248	0.251	0.231	0.241	0.000	0.233	0.000	**0.252**	**0.251**
9+	0.000	0.263	0.263	0.275	0.248	0.252	0.000	0.250	0.000	**0.271**	**0.270**

Quarter: 4

0	0.011	0.000	0.000	0.004	0.008	0.008	0.007	0.008	0.008	**0.005**	**0.004**
1	0.049	0.154	0.154	0.080	0.033	0.035	0.000	0.033	0.000	**0.076**	**0.079**
2	0.105	0.176	0.176	0.123	0.130	0.146	0.153	0.134	0.153	**0.124**	**0.125**
3	0.145	0.190	0.190	0.154	0.153	0.168	0.126	0.156	0.139	**0.142**	**0.142**
4	0.167	0.201	0.201	0.163	0.172	0.187	0.142	0.174	0.160	**0.162**	**0.162**
5	0.177	0.210	0.210	0.167	0.200	0.231	0.176	0.203	0.193	**0.178**	**0.178**
6	0.186	0.216	0.216	0.182	0.217	0.224	0.199	0.216	0.205	**0.193**	**0.193**
7	0.205	0.226	0.226	0.188	0.209	0.237	0.206	0.211	0.213	**0.202**	**0.202**
8	0.185	0.232	0.232	0.203	0.203	0.239	0.191	0.210	0.198	**0.229**	**0.229**
9+	0.000	0.248	0.248	0.252	0.219	0.256	0.207	0.229	0.213	**0.237**	**0.236**

Table 2.2.3. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2021. 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.**	**7.7**	**9.9**	**9.9**	**9.8**	9.9	**9.9**	**7.6**
1	**n.d.**	**23.0**	**n.d.**	**20.5**	**16.6**	**16.4**	**0.0**	16.7	**0.0**	**20.2**
2	**n.d.**	**24.2**	**n.d.**	**24.8**	**24.8**	**25.1**	**24.3**	24.6	**24.3**	**24.4**
3	**n.d.**	**25.1**	**n.d.**	**25.5**	**26.1**	**26.8**	**24.6**	25.9	**25.3**	**25.4**
4	**n.d.**	**25.8**	**n.d.**	**26.2**	**26.9**	**27.9**	**25.5**	26.5	**26.4**	**26.1**
5	**n.d.**	**26.6**	**n.d.**	**27.6**	**27.9**	**28.7**	**27.1**	27.4	**27.6**	**27.2**
6	**n.d.**	**26.9**	**n.d.**	**28.4**	**28.8**	**29.4**	**27.9**	28.3	**28.3**	**28.2**
7	**n.d.**	**27.9**	**n.d.**	**28.4**	**29.1**	**29.4**	**28.2**	28.8	**28.5**	**28.4**
8	**n.d.**	**28.0**	**n.d.**	**29.5**	**29.1**	**29.8**	**28.3**	28.8	**28.6**	**29.3**
9+	**n.d.**	**28.9**	**n.d.**	**30.1**	**29.9**	**30.5**	**28.3**	29.5	**28.6**	**29.8**
Quarter: 1										
0	n.d.	0.0	n.d.	6.9	0.0	9.9	0.0	0.0	0.0	**6.9**
1	n.d.	22.8	n.d.	12.0	0.0	16.1	0.0	0.0	0.0	**13.4**
2	n.d.	24.1	n.d.	21.7	22.0	23.3	24.3	22.0	23.3	**22.7**
3	n.d.	24.9	n.d.	25.0	24.3	25.3	24.9	24.3	25.0	**25.3**
4	n.d.	25.5	n.d.	25.1	26.1	26.7	25.9	26.1	26.1	**25.4**
5	n.d.	26.0	n.d.	24.9	27.5	27.8	26.5	27.5	26.7	**25.6**
6	n.d.	26.4	n.d.	27.0	27.8	27.8	28.1	27.8	28.0	**27.3**
7	n.d.	26.9	n.d.	27.4	28.6	28.8	27.9	28.6	28.3	**27.6**
8	n.d.	27.2	n.d.	28.0	29.3	29.4	28.8	29.3	29.0	**28.6**
9+	n.d.	27.9	n.d.	29.2	29.3	29.8	30.0	29.3	29.8	**29.2**

Quarter: 2

0	n.d.	0.0	n.d.	6.9	9.9	9.9	0.0	9.9	0.0	**6.9**
1	n.d.	22.8	n.d.	14.8	19.6	16.1	0.0	20.1	0.0	**20.4**
2	n.d.	24.1	n.d.	24.2	24.0	23.9	24.3	24.1	23.9	**23.5**
3	n.d.	24.9	n.d.	24.8	25.1	25.8	24.9	25.0	25.1	**24.5**
4	n.d.	25.5	n.d.	25.6	26.1	26.4	25.9	25.6	26.0	**25.4**
5	n.d.	26.0	n.d.	26.1	26.4	27.0	26.5	26.1	26.6	**25.9**
6	n.d.	26.4	n.d.	26.9	27.3	27.2	28.3	26.6	27.8	**26.6**
7	n.d.	26.9	n.d.	27.6	27.6	28.7	27.8	27.1	0.0	**27.2**
8	n.d.	27.2	n.d.	28.0	28.2	29.3	28.6	27.4	0.0	**27.5**
9+	n.d.	27.9	n.d.	28.8	28.2	30.0	30.0	27.9	30.0	**28.1**

Quarter: 3

0	n.d.	0.0	n.d.	7.8	9.9	9.9	9.8	0.0	9.9	**7.8**
1	n.d.	24.7	n.d.	19.9	19.2	16.5	0.0	19.2	0.0	**19.4**
2	n.d.	26.4	n.d.	25.4	25.5	25.1	0.0	25.5	0.0	**25.2**
3	n.d.	27.2	n.d.	26.0	26.7	26.8	0.0	26.7	0.0	**26.1**
4	n.d.	27.8	n.d.	26.7	26.9	27.9	0.0	27.0	0.0	**26.7**
5	n.d.	28.3	n.d.	28.4	28.1	28.5	0.0	28.1	0.0	**28.3**
6	n.d.	28.7	n.d.	29.0	28.9	29.4	0.0	28.9	0.0	**28.9**
7	n.d.	29.2	n.d.	28.8	29.2	29.3	0.0	29.2	0.0	**29.0**
8	n.d.	29.5	n.d.	29.8	29.2	29.8	0.0	29.3	0.0	**29.9**
9+	n.d.	30.2	n.d.	30.7	30.0	30.4	0.0	30.1	0.0	**30.5**

Quarter: 4

0	n.d.	0.0	n.d.	7.8	9.9	9.9	9.8	9.9	9.9	**7.8**
1	n.d.	25.9	n.d.	20.8	16.0	16.2	0.0	16.0	0.0	**20.6**
2	n.d.	27.4	n.d.	24.3	25.3	25.4	26.2	25.5	26.2	**24.3**
3	n.d.	28.1	n.d.	25.7	26.8	26.7	24.5	26.9	25.3	**25.2**
4	n.d.	28.7	n.d.	26.1	27.7	28.1	25.5	27.8	26.5	**26.2**
5	n.d.	29.3	n.d.	26.7	28.9	30.0	27.2	29.0	28.0	**27.0**
6	n.d.	29.6	n.d.	27.7	29.8	30.0	27.9	29.7	28.4	**27.6**
7	n.d.	30.1	n.d.	28.1	29.3	30.2	28.3	29.4	28.8	**28.1**
8	n.d.	30.5	n.d.	29.7	29.0	29.6	28.3	29.3	28.5	**29.3**
9+	n.d.	31.3	n.d.	29.1	29.7	30.7	28.2	30.3	28.5	**29.3**

Table 2.2.4. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2021. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	0.1	0.0	0.0	0.0	0.5	3.1	0.1	0.0	3.6	0.1	3.8	3.7
1	0.7	0.2	0.0	0.1	1.8	2.9	0.0	0.0	4.8	0.0	5.6	4.9
2	2.6	16.6	0.2	16.4	31.4	2.2	0.0	0.6	50.1	0.6	53.2	50.8
3	0.3	14.4	0.4	14.0	32.9	12.9	1.9	2.9	59.8	4.8	64.9	65.0
4	0.2	8.3	1.2	7.1	13.8	3.4	2.5	3.0	24.2	5.6	30.1	31.0
5	0.1	15.4	0.7	14.6	23.0	3.5	2.8	6.0	41.1	8.8	50.0	50.6
6	0.1	4.8	0.3	4.5	14.5	2.0	1.0	2.2	21.0	3.2	24.3	24.5
7	0.0	12.1	0.2	11.9	37.1	12.2	2.1	5.3	61.3	7.4	68.7	68.9
8	0.0	11.1	0.3	10.8	21.3	9.8	0.9	3.8	42.0	4.7	46.7	47.0
9+	0.0	5.4	0.1	5.3	8.2	3.3	0.3	1.7	16.8	2.0	18.8	18.9
Sum	4.2	88.3	3.5	84.8	184.6	55.3	11.6	25.6	324.7	37.2	366.1	365.3

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	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**	**0.0**
2	1.4	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.5	0.0	**0.0**	**1.5**
3	0.1	0.0	0.0	0.0	2.2	0.0	0.0	0.1	2.2	0.1	**2.4**	**2.4**
4	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.1	0.5	0.2	**0.7**	**0.7**
5	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.8	0.2	0.9	**1.1**	**1.1**
6	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.2	0.5	0.4	**0.8**	**0.8**
7	0.0	0.0	0.0	0.0	1.0	0.0	0.4	0.4	1.0	0.7	**1.7**	**1.7**
8	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.1	0.6	0.1	**0.7**	**0.7**
9+	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	**0.4**	**0.4**
Sum	**1.5**	**0.0**	**0.0**	**0.0**	**6.8**	**0.0**	**0.9**	**1.7**	**6.8**	**2.6**	**8.0**	**9.3**

Quarter: 2

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	0.1	0.0	0.1	0.0	0.5	0.0	0.0	0.6	0.0	**0.6**	**0.6**
2	0.2	15.8	0.1	15.6	8.4	0.1	0.0	0.0	24.1	0.0	**24.3**	**24.3**
3	0.0	13.0	0.4	12.7	7.1	0.1	0.0	0.0	19.8	0.0	**19.9**	**20.2**
4	0.0	7.0	1.0	5.9	2.3	0.0	0.0	0.0	8.3	0.0	**8.3**	**9.3**
5	0.0	10.5	0.7	9.8	2.4	0.0	0.0	0.0	12.2	0.0	**12.2**	**12.9**
6	0.0	3.6	0.3	3.3	1.0	0.0	0.0	0.0	4.3	0.0	**4.3**	**4.6**
7	0.0	6.5	0.2	6.3	2.2	0.1	0.0	0.0	8.6	0.0	**8.6**	**8.8**
8	0.0	6.7	0.2	6.4	1.7	0.1	0.0	0.0	8.2	0.0	**8.2**	**8.5**
9+	0.0	2.8	0.1	2.8	0.4	0.0	0.0	0.0	3.2	0.0	**3.2**	**3.3**
Sum	**0.2**	**66.1**	**3.1**	**63.0**	**25.4**	**1.4**	**0.0**	**0.0**	**89.7**	**0.0**	**90.0**	**92.8**

Quarter: 3

0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	2.3	0.0	**2.3**	**2.3**
1	0.6	0.0	0.0	0.0	0.3	3.7	0.0	0.0	4.0	0.0	**4.6**	**4.0**
2	0.9	0.6	0.0	0.0	19.0	2.2	0.0	0.0	21.1	0.0	**22.6**	**21.7**
3	0.2	1.0	0.0	0.0	20.6	13.0	0.0	0.0	33.6	0.0	**34.7**	**34.5**
4	0.2	1.0	0.1	0.0	9.0	3.2	0.0	0.0	12.2	0.0	**13.3**	**13.2**
5	0.1	3.8	0.1	3.7	19.8	3.0	0.0	0.0	26.5	0.0	**26.6**	**26.6**
6	0.1	0.9	0.0	0.0	12.5	1.7	0.0	0.0	14.3	0.0	**15.2**	**15.2**
7	0.0	4.6	0.0	4.6	30.8	10.6	0.0	0.0	46.0	0.0	**46.0**	**46.0**
8	0.0	3.8	0.0	3.8	17.9	9.2	0.0	0.0	31.0	0.0	**31.0**	**31.0**
9+	0.0	2.1	0.0	2.1	7.4	3.1	0.0	0.0	12.5	0.0	**12.5**	**12.5**
Sum	**2.1**	**17.8**	**0.4**	**14.2**	**137.3**	**52.0**	**0.0**	**0.0**	**203.5**	**0.0**	**208.8**	**207.1**

Quarter: 4

0	0.1	0.0	0.0	0.0	0.5	0.6	0.1	0.0	1.0	0.1	**1.2**	**1.1**
1	0.1	0.0	0.0	0.0	1.5	0.4	0.0	0.0	1.9	0.0	**2.0**	**1.9**
2	0.1	0.3	0.0	0.0	2.3	0.1	0.0	0.9	2.4	0.9	**3.6**	**3.5**
3	0.0	0.4	0.0	0.0	2.8	0.7	1.8	2.8	3.5	4.6	**8.5**	**8.5**
4	0.1	0.3	0.0	0.3	2.0	0.2	2.4	2.9	2.5	5.3	**7.9**	**7.9**
5	0.1	1.1	0.0	1.1	1.5	0.5	2.8	5.0	3.1	7.8	**11.0**	**10.9**
6	0.0	0.3	0.0	0.3	0.8	0.3	0.8	2.0	1.3	2.8	**4.2**	**4.1**
7	0.0	0.9	0.0	0.9	4.4	1.7	1.7	5.1	7.1	6.9	**13.9**	**13.9**
8	0.0	0.6	0.1	0.6	1.3	0.6	0.8	3.8	2.5	4.6	**7.1**	**7.2**
9+	0.0	0.5	0.0	0.5	0.6	0.2	0.3	1.8	1.4	2.0	**3.4**	**3.4**
Sum	**0.5**	**4.4**	**0.1**	**3.6**	**17.7**	**5.5**	**10.9**	**24.2**	**26.8**	**35.0**	**62.9**	**62.5**

Table 2.2.5. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2020. Percentage age composition (based on numbers, 3+ group summarized), by quarter and division.

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

Quarters: 1-4

0	**10.7%**	**0.0%**	**0.0%**	**0.0%**	**11.0%**	**54.2%**	**17.4%**	**0.0%**	**21.8%**	**5.3%**	**20.2%**	**20.2%**
1	**24.2%**	**0.3%**	**1.8%**	**0.2%**	**2.0%**	**10.1%**	**0.0%**	**0.1%**	**4.1%**	**0.0%**	**4.2%**	**3.7%**
2	**56.1%**	**23.3%**	**5.1%**	**24.1%**	**20.0%**	**2.3%**	**0.0%**	**3.7%**	**15.5%**	**2.6%**	**15.4**	**14.3**
3	**4.3%**	**18.4%**	**13.1%**	**18.6%**	**18.1%**	**11.4%**	**16.4%**	**15.2%**	**16.2%**	**15.5%**	**15.8%**	**16.1%**
4	**2.3%**	**9.8%**	**34.4%**	**8.7%**	**7.0%**	**2.7%**	**19.8%**	**14.1%**	**6.0%**	**15.9%**	**6.8%**	**7.1%**
5	**1.2%**	**16.5%**	**21.0%**	**16.3%**	**10.3%**	**2.4%**	**19.2%**	**22.7%**	**9.2%**	**21.6%**	**10.0%**	**10.3%**
6	**0.7%**	**5.1%**	**8.8%**	**5.0%**	**5.9%**	**1.3%**	**6.4%**	**7.7%**	**4.3%**	**7.3%**	**4.5%**	**4.6%**
7	**0.2%**	**11.5%**	**5.2%**	**11.8%**	**15.0%**	**7.5%**	**13.4%**	**17.9**	**12.0%**	**16.5**	**12.1**	**12.3**
8	**0.2%**	**10.5%**	**8.3%**	**10.6%**	**7.8%**	**6.1%**	**5.5%**	**13.2**	**7.9%**	**10.8**	**7.9%**	**8.1%**
9+	**0.0%**	**4.7%**	**2.3%**	**4.8%**	**2.9%**	**1.9%**	**1.8%**	**5.5%**	**3.0%**	**4.4%**	**3.1%**	**3.1%**
Sum 3+	**9.0%**	**76.5%**	**93.0%**	**75.8%**	**67.0%**	**33.3%**	**82.6%**	**96.2%**	**58.6%**	**92.0%**	**60.2%**	**61.8%**

Quarter: 1

0	0.0%	0.0%	0.0%	0.0%	0.0%	70.3%	0.0%	0.0%	0.3%	0.0%	**0.1%**	**0.2%**
1	8.9%	0.3%	0.0%	100.0	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	**2.4%**	**0.0%**
2	88.2%	27.5%	13.5%	0.0%	30.9%	3.8%	0.7%	0.0%	30.8%	0.2%	**41.1%**	**23.6**
3	2.7%	21.0%	18.1%	0.0%	32.4%	5.5%	7.5%	7.9%	32.3%	7.8%	**20.1%**	**26.5%**
4	0.2%	10.5%	9.8%	0.0%	7.0%	1.1%	10.0%	9.3%	7.0%	9.5%	**5.6%**	**7.6%**
5	0.0%	15.0%	34.6%	0.0%	3.3%	0.7%	18.5%	47.9%	3.2%	40.6%	**8.8%**	**12.1%**
6	0.0%	5.1%	6.3%	0.0%	5.5%	0.7%	15.2%	12.3	5.5%	13.0	**5.3%**	**7.3%**
7	0.0%	8.6%	0.0%	0.0%	11.0%	2.8%	41.1%	18.7	10.9%	24.2	**10.3**	**14.1**
8	0.0%	8.6%	17.7%	0.0%	6.2%	2.2%	5.5%	4.0%	6.2%	4.4%	**4.2%**	**5.8%**
9+	0.0%	3.4%	0.0%	0.0%	3.7%	0.9%	1.4%	0.0%	3.7%	0.3%	**2.1%**	**2.9%**
Sum 3+	**2.9%**	**72.2%**	**86.5%**	**0.0%**	**69.1%**	**14.0%**	**99.3%**	**100.0%**	**68.9%**	**99.8%**	**56.3%**	**76.2%**

Quarter: 2

0	0.0%	0.0%	0.0%	0.0%	1.3%	78.6%	0.0%	0.0%	0.0%	52.1%	**6.1%**	**6.0%**
1	29.0%	0.3%	1.9%	0.2%	0.4%	13.3%	0.0%	0.0%	1.3%	0.0%	**1.4%**	**1.3%**
2	68.2%	27.5%	5.2%	28.5%	37.2%	1.3%	0.4%	0.0%	30.7%	0.1%	**29.0**	**28.1**
3	2.5%	21.0%	13.3%	21.3%	28.9%	2.3%	3.9%	9.4%	23.3%	3.3%	**21.8%**	**21.6%**
4	0.3%	10.5%	35.0%	9.4%	8.4%	0.5%	5.2%	10.6%	9.0%	3.9%	**8.4%**	**9.3%**
5	0.0%	15.0%	21.3%	14.7%	8.4%	0.5%	19.6%	45.5%	12.8%	16.1%	**11.9%**	**12.3%**
6	0.0%	5.0%	8.8%	4.9%	3.2%	0.1%	13.9%	11.6	4.3%	6.1%	**4.0%**	**4.2%**
7	0.0%	8.7%	5.3%	8.8%	6.5%	1.5%	49.3%	18.5	8.2%	15.6	**7.6%**	**7.6%**
8	0.0%	8.6%	7.1%	8.6%	4.8%	1.5%	6.9%	4.3%	7.6%	2.6%	**7.0%**	**7.1%**
9+	0.0%	3.4%	2.0%	3.5%	1.0%	0.4%	0.7%	0.2%	2.8%	0.2%	**2.6%**	**2.6%**
Sum 3+	**2.8%**	**72.2%**	**92.9%**	**71.2%**	**61.1%**	**6.8%**	**99.6%**	**100.0%**	**68.0%**	**47.8%**	**63.4%**	**64.7%**

Quarter: 3

0	0.0%	0.0%	0.0%	0.0%	1.3%	49.7%	100.0%	0.0%	21.8%	100.0%	**21.5%**	**21.8%**
1	47.8%	0.1%	1.9%	0.0%	0.5%	9.6%	0.0%	0.0%	4.3%	0.0%	**5.0%**	**4.3%**
2	35.4%	4.0%	5.2%	0.0%	18.9%	2.7%	0.0%	0.0%	11.2	0.0%	**11.5**	**11.2**
3	8.0%	6.3%	13.2%	0.0%	17.7%	13.6	0.0%	0.0%	15.3%	0.0%	**15.2**	**15.3**
4	5.0%	6.2%	35.0%	0.0%	7.1%	3.2%	0.0%	0.0%	5.3%	0.0%	**5.3%**	**5.4%**
5	2.1%	22.2%	21.4%	0.0%	13.5%	2.6%	0.0%	0.0%	9.4%	0.0%	**9.2%**	**9.4%**
6	1.3%	5.4%	8.8%	0.0%	7.9%	1.4%	0.0%	0.0%	5.0%	0.0%	**4.9%**	**5.0%**
7	0.3%	25.3%	5.3%	0.0%	18.8%	8.0%	0.0%	0.0%	14.6	0.0%	**14.4**	**14.6**
8	0.1%	20.2%	7.2%	0.0%	10.4%	7.1%	0.0%	0.0%	9.5%	0.0%	**9.4%**	**9.5%**
9+	0.0%	10.3%	2.0%	0.0%	3.9%	2.2%	0.0%	0.0%	3.5%	0.0%	**3.5%**	**3.5%**
Sum 3+	**16.8%**	**95.9%**	**92.9%**	**0.0%**	**79.3%**	**38.0%**	**0.0%**	**0.0%**	**62.7%**	**0.0%**	**61.9%**	**62.7%**

Quarter: 4

0	64.7%	0.0%	0.0%	0.0%	50.0%	67.3%	16.9%	0.0%	52.5%	5.2%	**36.0%**	**35.4%**
1	16.4%	0.2%	0.0%	0.2%	8.2%	11.7%	0.0%	0.1%	8.8%	0.0%	**5.9%**	**5.6%**
2	6.9%	7.0%	0.0%	7.1%	8.2%	0.7%	0.0%	4.1%	5.9%	2.8%	**4.8%**	**4.8%**
3	1.8%	10.2%	0.0%	10.4%	7.9%	4.2%	17.4%	15.9%	6.9%	16.3%	**10.2%**	**10.3%**
4	3.6%	6.6%	2.8%	6.7%	5.5%	1.3%	20.9%	14.6%	4.3%	16.5%	**8.6%**	**8.7%**
5	3.2%	25.7%	0.0%	26.2%	4.0%	2.4%	19.7%	20.2%	4.7%	20.1%	**10.1%**	**10.3%**
6	1.6%	6.1%	10.2%	6.0%	1.9%	1.2%	5.9%	7.2%	1.9%	6.8%	**3.6%**	**3.7%**
7	0.7%	20.5%	0.0%	20.9%	10.3%	7.5%	11.7%	17.8	10.1%	15.9	**12.0**	**12.2**
8	0.9%	13.8%	70.6%	12.7%	2.8%	2.7%	5.7%	14.1	3.3%	11.5	**6.2%**	**6.3%**
9+	0.0%	10.0%	16.4%	9.9%	1.1%	1.0%	1.9%	6.1%	1.6%	4.8%	**2.7%**	**2.7%**
Sum 3+	**12.0%**	**92.8%**	**100.0%**	**92.6%**	**33.6%**	**20.3%**	**83.1%**	**95.9%**	**32.8%**	**91.9%**	**53.4%**	**54.2%**

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.

2020	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Winter rings	Numbers	Mean weight	Numbers	Mean weight Mean	Numbers	Mean weight Mean	Numbers	Mean weight	Numbers	Mean weight Mean
0	0.0	0.004	527.2	0.008	6.9	0.011	0.0	0.000	534.1	0.008
1	10.1	0.074	86.6	0.033	13.9	0.048	1.8	0.045	112.4	0.039
2	367.4	0.136	3.6	0.116	36.0	0.071	0.3	0.067	407.4	0.130
3	414.8	0.156	2.2	0.135	2.8	0.116	0.0	0.000	419.8	0.155
4	176.1	0.171	1.6	0.163	1.5	0.159	0.0	0.000	179.2	0.171
5	264.4	0.189	0.7	0.174	0.8	0.173	0.0	0.000	265.9	0.189
6	117.6	0.214	0.2	0.162	0.5	0.193	0.0	0.000	118.2	0.213
7	318.2	0.219	2.4	0.181	0.1	0.206	0.0	0.000	320.8	0.219
8	209.3	0.238	0.8	0.189	0.1	0.186	0.0	0.000	210.2	0.238
9+	80.6	0.247	0.3	0.193	0.0	0.000	0.0	0.000	80.9	0.247
TOTAL	1'958.5		625.6		62.6		2.1		2'648.9	
SOP catch		359.8		8,7		4,1		0.1		372.7

Table 2.2.7. Catch-at-age (numbers in millions) of North Sea herring, 2006–2021.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421
2010	526	84	243	234	124	84	63	34	59	56	1508
2011	575	124	306	271	218	130	63	52	60	66	1865
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

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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

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, 2006–2021.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2
2010	0.0	0.0	0.0	0.5	1.0	0.4	0.5	0.3	0.3	0.7	3.8
2011	0.0	0.0	0.1	0.4	0.4	0.2	0.1	0.1	0.1	0.2	1.6
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

Table 2.2.9. Catch-at-age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2006–2021.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2006	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
2007	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
2008	85.7	86.6	72.0	1.9	0.3	0.1	0.1	0.3	0.1	247.0
2009	116.8	77.5	7.0	0.4	0.2	0.0	0.0	0.0	0.1	202.0
2010	48.6	197.0	43.3	0.3	0.1	0.1	0.0	0.1	0.0	289.6
2011	203.8	35.4	61.5	3.2	0.3	0.2	0.1	0.1	0.0	304.6
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

Table 2.2.10. Catch-at-age (numbers in millions) of the total NSAS stock 2006–2021.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794
2011	779	160	368	274	218	130	63	52	60	65	2168
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

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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

Table 2.2.11. Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Division) and NSAS caught in Division 3.a in 2010–2020

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
	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	-
4.a(E)	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
	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

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	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
4.a(W)	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
	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
	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
4.b	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.240	0.268
	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

Table 2.2.11 continued: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Division) and NSAS caught in Division 3.a in 2011-2021.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
4.a & 4.b	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
	2012	0.132	0.171	0.185	0.207	0.222	0.239	0.243	0.248
	2013	0.132	0.158	0.198	0.198	0.217	0.234	0.235	0.244
	2014	0.138	0.174	0.187	0.216	0.213	0.227	0.246	0.243
	2015	0.129	0.157	0.190	0.203	0.223	0.219	0.228	0.245
	2016	0.134	0.159	0.185	0.210	0.218	0.235	0.226	0.242
	2017	0.116	0.159	0.176	0.190	0.217	0.223	0.231	0.230
	2018	0.117	0.152	0.187	0.195	0.220	0.238	0.245	0.254
	2019	0.136	0.153	0.173	0.208	0.210	0.220	0.239	0.251
	2020	0.136	0.159	0.173	0.192	0.215	0.221	0.238	0.249
	2021	0.134	0.155	0.169	0.191	0.205	0.220	0.219	0.233
4.c & 7.d	2011	0.122	0.154	0.179	0.189	0.195	0.205	0.209	0.217
	2012	0.119	0.165	0.186	0.202	0.212	0.234	0.209	0.226
	2013	0.126	0.144	0.180	0.196	0.206	0.216	0.218	0.226
	2014	0.119	0.148	0.166	0.183	0.208	0.222	0.227	0.233
	2015	0.114	0.127	0.154	0.157	0.183	0.197	0.204	0.210
	2016	0.114	0.127	0.137	0.166	0.177	0.199	0.193	0.216
	2017	0.100	0.122	0.146	0.165	0.186	0.193	0.220	0.241
	2018	0.113	0.116	0.144	0.156	0.164	0.189	0.196	0.209
	2019	0.118	0.126	0.153	0.165	0.185	0.196	0.203	0.223
	2020	0.116	0.127	0.153	0.177	0.188	0.199	0.229	0.216
	2021	0.100	0.125	0.141	0.173	0.189	0.192	0.188	0.205
Total	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240
North Sea	2012	0.130	0.171	0.185	0.206	0.222	0.239	0.239	0.247
Catch	2013	0.131	0.156	0.198	0.198	0.215	0.233	0.234	0.241
	2014	0.137	0.173	0.186	0.215	0.212	0.226	0.244	0.241
	2015	0.123	0.154	0.188	0.200	0.221	0.217	0.226	0.243
	2016	0.132	0.155	0.180	0.206	0.215	0.231	0.221	0.239

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2017	0.114	0.156	0.173	0.189	0.215	0.220	0.230	0.231
	2018	0.117	0.145	0.184	0.192	0.215	0.234	0.242	0.249
	2019	0.135	0.148	0.169	0.204	0.208	0.219	0.236	0.248
	2020	0.136	0.155	0.170	0.189	0.213	0.219	0.237	0.246
	2021	0.133	0.154	0.169	0.192	0.208	0.220	0.219	0.233

Table 2.2.12. Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2021 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 meas-ured	>1 sample per 1 kt catch
Belgium	1	3	0	0%	14	0	0	0	n
	2	2	0	0%	0	0	0	0	n
	4	3	0	0%	32	0	0	0	n
total		8	0	0%	47	0	0	0	n
Denmark (A)	1	2	1	100%	6387	5	134	646	n
	2	2	0	0%	3264	0	0	0	n
	3	2	2	100%	37390	30	777	3244	n
	4	2	1	75%	7500	3	80	390	n
total		8	4	91%	54541	38	991	4280	n
Denmark (B)	1	3	0	0%	345	0	0	0	n
	2	2	0	0%	490	0	0	0	n
	3	3	2	94%	3767	33	367	761	y
	4	4	0	0%	3800	0	0	0	n
total		12	2	42%	8403	33	367	761	y
France	1	2	1	15%	1884	3	73	601	y
	2	4	1	100%	3363	12	299	2502	y
	3	3	0	0%	11815	0	0	0	n
	4	4	0	0%	8075	0	0	0	n

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
total		13	2	14%	25136	15	372	3103	n
Germany	2	2	0	0%	4893	0	0	0	n
	3	2	1	86%	11155	29	247	11355	y
	4	3	2	77%	9748	11	337	1295	y
total		7	3	66%	25797	40	584	12650	y
Ireland	1	1	0	0%	3	0	0	0	n
	4	1	0	0%	411	0	0	0	n
total		2	0	0%	414	0	0	0	n
Netherlands	1	2	1	56%	1241	3	75	419	y
	2	1	1	100%	483	2	49	278	y
	3	2	1	100%	44047	35	870	5213	n
	4	4	3	97%	20630	11	273	1585	n
total		9	6	98%	66402	51	1267	7495	n
Norway	1	1	0	0%	16	0	0	0	n
	2	3	2	100%	70882	42	1999	2707	n
	3	2	2	100%	18574	10	406	515	n
	4	3	2	99%	5590	4	159	721	n
total		9	6	100%	95061	56	2564	3943	n
UK (Scot)	1	1	0	0%	31	0	0	0	n
	2	1	1	100%	2553	3	99	421	y
	3	2	2	100%	47905	29	1213	4462	n
	4	3	0	0%	705	0	0	0	n
total		7	3	99%	51194	32	1312	4883	n
Sweden	2	3	0	0%	3605	0	0	0	n
	3	3	0	0%	14224	0	0	0	n
	4	3	0	0%	551	0	0	0	n
total		9	0	0%	18380	0	0	0	n
Sweden (B)	2	1	0	0%	33	0	0	0	n

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish meas-ured	>1 sample per 1 kt catch
	3	1	0	0%	142	0	0	0	n
	4	2	0	0%	210	0	0	0	n
total		4	0	0%	385	0	0	0	n
UK (NI)	1	1	0	0%	4	0	0	0	n
	3	2	0	0%	4975	0	0	0	n
	4	1	0	0%	198	0	0	0	n
total		4	0	0%	5176	0	0	0	n
Lithuania	4	1	0	0%	466	0	0	0	n
total		1	0	0%	466	0	0	0	n
UK (E+W)	1	3	1	99%	294	1	24	100	y
	2	4	1	99%	923	1	125	896	y
	3	4	1	100%	8099	5	875	3753	n
	4	4	2	19%	3898	2	50	208	n
total		15	5	76%	13214	9	1074	4957	n
Period total	**1**	19	4	75%	10219	12	306	1766	y
Period total	**2**	25	6	86%	90490	60	2571	6804	n
Period total	**3**	26	11	84%	202091	171	4755	29303	n
Period total	**4**	38	10	64%	61815	31	899	4199	n
Total 2021		108	31	81%	364615	274	8531	42072	n
Human Cons. Only		92	29	82%	355827	241	8164	41311	n
Total 2019		104	29	83%	445633	376	7781	57198	n
Total 2020		117	28	82%	427321	347	8226	66700	n
HC 2020		101	26	83%	417457	320	7909	65583	n

2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2021. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IRL) EIGB	30 June – 20 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	7 – 26 July	MSHAS,WoS, NSAS, Sprat NS	1, 91 (north of 58°30'N), 111, 121
Johan Hjort (NOR) LDGJ	25 June – 12 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NED) PBVO	26 June – 12 July	NSAS, Sprat NS	81, 91 (south of 58°30'N), 101
Solea (GER) DBFH	30 June – 20 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	21 June – 06 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 2021. 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	17500	78	0.00	4.4	8.5
1	5196	248	0.02	47.7	17.9
2	2803	340	0.74	121.3	23.9
3	1800	299	0.99	165.8	26.4
4	773	148	1.00	191.0	27.4
5	877	178	1.00	203.4	27.9
6	915	202	1.00	220.8	28.7
7	1021	238	1.00	233.1	29.0
8	388	93	1.00	240.0	29.2
9+	208	57	1.00	272.1	30.4
Immature	23311	379		16.2	10.9
Mature	8170	1501		183.7	27.0
Total	31481	1880	0.26	59.7	15.1

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2021. 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

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

	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.**
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
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

	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.
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	

Table 2.3.3.2. North Sea herring – International herring larvae surveys summary 2021/2022.

International Herring Larvae Surveys (IHLS)

Nation:	Vessel:	Dates
Germany	Dana #09-21	20 September – 01 October 2021
Netherlands	Tridens 2	20 September – 29 September 2021
Netherlands	Tridens 2	20 December – 23 December 2021
Germany	WH #452	05 January – 13 January 2022

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.):	All six survey areas could be sampled as scheduled. The survey around the Orkneys revealed higher quantities of newly hatched larvae, compared to relatively low numbers in the two preceding years. In the Buchan and the central North Sea, newly hatched larvae concentrated in two areas. There are some issues with larvae patchiness in the Downs area. One station yielded > 90% of the total catch in December. However, such a pattern has been seen also in the history of the survey time-series. Thus, all stations were included in further calculations.

	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, 413 plankton samples were taken during the IHLS surveys between September 2021 and January 2022. They contained 118,968 herring larvae.

Stations fished

ICES Divisions	Strat.	Gear	Tows planned	Valid	Add.	Inv.	% stations fished	comments
4a,b	N/A	Gulf	274	274	0	0	100 %	Extra hauls taken when abundance was dense.
7d	N/A	Gulf	141	139	0	0	100 %	Extra hauls taken when abundance was dense.
total	N/A	Gulf	415	413	0	0	100 %	

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 2021 year classes by areas are density estimates in numbers per square metre according to the new index calculation algorithm. Total abundance is found by multiplying density by area and summing up. Data for the period 1976 to 1990, calculated with the old algorithm, are stored in the stock annex.

Area	North-west	North-east	Central west	Central east	South-west	South-east	Division 3.a	South'Bight	IBTS-0 index
Area m^2 x 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
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

Area	North-west	North-east	Central west	Central east	South-west	South-east	Division 3.a	South'Bight	IBTS-0 index
Area m² x 10⁹	83	34	86	102	37	93	31	31	
Year class									no. in 10⁹
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	0.449	0.079	0.328	0.256	0.055	0.304	95.2
2021	0.010	0.002	0.109	0.050	0.251	0.102	0.031	0.412	47.8

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2020 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

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
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	3128	487	0.16	256	0.08	0.51
2020	2022	806	401	0.50	396	0.49	0.08

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	
Year	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS
1996	0.015	0.006	0.018	0.054	0.112	0.130	0.156	0.199	0.188	0.227	0.204	0.234	0.212	0.274	0.261	0.301	0.281	0.327
1997	0.015	0.005	0.044	0.049	0.108	0.123	0.148	0.183	0.195	0.230	0.227	0.237	0.226	0.257	0.235	0.280	0.255	0.310
1998	0.021	0.006	0.051	0.047	0.114	0.116	0.145	0.187	0.183	0.241	0.219	0.264	0.238	0.284	0.247	0.287	0.288	0.308
1999	0.009	0.006	0.045	0.051	0.115	0.116	0.151	0.179	0.171	0.226	0.207	0.256	0.233	0.273	0.245	0.276	0.268	0.278
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
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
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
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
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
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
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
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
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
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
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
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
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
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

age	0		1		2		3		4		5		6		7		8	
Year	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS	catch	HE-RAS
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
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
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
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
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
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
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
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

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 2021. 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

Year \ Ring	2	3	4	5	6	7+
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

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	1972–2021	1973–2021
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2022	1984–2022
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2021	1998–2021
Acoustic (+trawl)	1 wr	1995–2021	1997–2021
	2-9+ wr	1984–2021	1989–2021
IBTS0	0wr	1977–2022	1992–2022

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

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	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1948	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1949	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1950	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1951	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1952	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1953	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1954	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1955	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1956	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1957	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1958	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1959	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1960	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216

1961	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1962	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1963	0.712	0.498	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1964	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1965	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1966	0.712	0.497	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1967	0.712	0.498	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1968	0.713	0.5	0.303	0.273	0.252	0.232	0.221	0.215	0.215
1969	0.712	0.495	0.302	0.272	0.252	0.232	0.222	0.216	0.216
1970	0.712	0.495	0.302	0.272	0.252	0.233	0.222	0.216	0.217
1971	0.712	0.498	0.303	0.273	0.252	0.232	0.222	0.216	0.216
1972	0.713	0.503	0.304	0.273	0.251	0.232	0.221	0.214	0.214
1973	0.715	0.509	0.305	0.274	0.25	0.231	0.219	0.213	0.212
1974	0.71	0.472	0.296	0.269	0.255	0.235	0.227	0.222	0.223
1975	0.71	0.493	0.302	0.273	0.253	0.233	0.223	0.217	0.218
1976	0.712	0.512	0.306	0.275	0.251	0.231	0.219	0.213	0.212
1977	0.718	0.527	0.31	0.276	0.248	0.228	0.216	0.208	0.207
1978	0.725	0.541	0.312	0.276	0.245	0.225	0.212	0.203	0.202
1979	0.734	0.551	0.314	0.276	0.242	0.222	0.208	0.199	0.197
1980	0.745	0.56	0.314	0.274	0.238	0.219	0.204	0.195	0.192
1981	0.758	0.565	0.313	0.272	0.234	0.215	0.201	0.191	0.187
1982	0.771	0.568	0.312	0.269	0.23	0.211	0.197	0.187	0.183
1983	0.791	0.569	0.309	0.264	0.225	0.207	0.193	0.184	0.178
1984	0.818	0.566	0.306	0.258	0.22	0.202	0.189	0.18	0.173
1985	0.839	0.562	0.301	0.252	0.215	0.198	0.185	0.176	0.169
1986	0.849	0.553	0.294	0.244	0.208	0.191	0.18	0.172	0.164
1987	0.856	0.541	0.284	0.233	0.201	0.184	0.174	0.168	0.159
1988	0.858	0.53	0.277	0.225	0.196	0.179	0.169	0.164	0.155
1989	0.853	0.522	0.274	0.222	0.195	0.178	0.167	0.162	0.152
1990	0.842	0.513	0.272	0.22	0.196	0.178	0.165	0.159	0.151
1991	0.832	0.506	0.271	0.219	0.197	0.178	0.163	0.158	0.15
1992	0.82	0.499	0.273	0.221	0.197	0.179	0.162	0.156	0.149
1993	0.803	0.493	0.277	0.225	0.198	0.18	0.162	0.156	0.15
1994	0.791	0.488	0.28	0.228	0.199	0.181	0.162	0.155	0.15
1995	0.78	0.483	0.282	0.228	0.197	0.18	0.161	0.154	0.149
1996	0.772	0.479	0.285	0.229	0.196	0.179	0.16	0.153	0.149
1997	0.773	0.485	0.289	0.232	0.197	0.179	0.16	0.153	0.15
1998	0.779	0.495	0.293	0.235	0.197	0.178	0.161	0.154	0.15
1999	0.787	0.506	0.299	0.239	0.2	0.179	0.163	0.155	0.152
2000	0.8	0.527	0.307	0.246	0.207	0.184	0.168	0.159	0.155
2001	0.818	0.556	0.318	0.256	0.216	0.19	0.174	0.164	0.16
2002	0.833	0.575	0.326	0.263	0.224	0.196	0.18	0.169	0.164
2003	0.846	0.585	0.332	0.27	0.234	0.205	0.188	0.177	0.17
2004	0.862	0.594	0.338	0.279	0.245	0.216	0.199	0.186	0.178
2005	0.875	0.598	0.342	0.284	0.253	0.224	0.207	0.194	0.184
2006	0.887	0.591	0.341	0.284	0.255	0.227	0.211	0.199	0.189
2007	0.9	0.578	0.337	0.281	0.254	0.23	0.215	0.204	0.193
2008	0.908	0.566	0.333	0.279	0.253	0.231	0.217	0.207	0.197
2009	0.91	0.555	0.327	0.275	0.25	0.23	0.217	0.209	0.198
2010	0.91	0.542	0.32	0.269	0.245	0.228	0.215	0.209	0.199
2011	0.905	0.531	0.315	0.265	0.241	0.227	0.215	0.209	0.2
2012	0.895	0.522	0.31	0.262	0.24	0.226	0.215	0.21	0.202
2013	0.881	0.512	0.306	0.26	0.238	0.225	0.214	0.211	0.203
2014	0.863	0.503	0.302	0.258	0.236	0.225	0.214	0.211	0.203
2015	0.84	0.495	0.298	0.257	0.235	0.224	0.213	0.211	0.204
2016	0.813	0.488	0.294	0.256	0.234	0.224	0.212	0.211	0.204
2017	0.781	0.481	0.291	0.256	0.233	0.223	0.212	0.21	0.204
2018	0.745	0.475	0.289	0.256	0.234	0.224	0.211	0.21	0.205
2019	0.704	0.469	0.286	0.258	0.235	0.224	0.211	0.209	0.205
2020	0.777	0.481	0.292	0.256	0.234	0.224	0.212	0.21	0.204
2021	0.761	0.478	0.29	0.256	0.234	0.224	0.212	0.21	0.205

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

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

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

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

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	95.24
2022	47.8

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	1052162
1985	1438636
1986	1654723
1987	3131778
1988	1487032
1989	1590320
1990	748258
1991	1072699
1992	1115786
1993	1818610
1994	2693135
1995	2102680
1996	1232257
1997	810884
1998	1446955
1999	704653
2000	2045844
2001	1567634
2002	1728823
2003	1327143
2004	762760
2005	905552
2006	725340
2007	859629
2008	713383
2009	705677
2010	856535
2011	1493897
2012	780486
2013	488298
2014	1620037
2015	1898773
2016	547781
2017	1340025
2018	667212
2019	958262
2020	1128416
2021	1210091
2022	630186

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	727669	463847	311107	92832	24483	11615
1999	4630197	296398	208814	124016	51023	18470
2000	1766609	771168	264562	119618	70400	18078
2001	1866630	321968	221010	95618	42999	26435
2002	2218582	1964691	441635	348862	82343	32929
2003	894458	478345	562350	150629	113711	19506
2004	2134639	393302	288331	424585	97809	51754
2005	1081092	387909	113423	83421	99818	31971
2006	1018646	292225	191814	78830	46527	53927
2007	2221506	137614	94241	101137	50850	31366
2008	567239	155700	114972	60800	36224	19573
2009	2799984	204902	95646	64972	27949	12674
2010	1333303	512783	176419	83611	37534	15920
2011	824623	324510	176616	100918	51010	22176
2012	769386	212991	91167	68462	39084	22588
2013	1803294	268269	142736	125246	86498	40667
2014	7408163	446599	195329	90049	81147	46104
2015	517000	734980	353384	128905	68406	46758
2016	1700293	176710	368183	214059	69038	43720
2017	855004	280153	76755	198683	129606	41777
2018	1918412	326201	113774	48347	86827	39799
2019	1441818	136877	65129	41782	23046	36679
2020	1013689	316659	263582	74298	65070	26556
2021	771966	279941	106525	71502	24587	17024

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

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

Table 2.6.1.13 North Sea herring input data. LAI index from the IHLS larvae survey for the Bunchan component. The columns corresponds 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

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

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	0.426	0.1286	0.3311	0.5482
catch unique	1	0.426	0.1286	0.3311	0.5482
catch unique	2	0.1285	0.1601	0.09391	0.1759
catch unique	3	0.1285	0.1601	0.09391	0.1759
catch unique	4	0.1285	0.1601	0.09391	0.1759
catch unique	5	0.1285	0.1601	0.09391	0.1759
catch unique	6	0.1285	0.1601	0.09391	0.1759
catch unique	7	0.1911	0.1889	0.132	0.2768
catch unique	8	0.1911	0.1889	0.132	0.2768
HERAS	1	0.468	0.1516	0.3477	0.6299
HERAS	2	0.2597	0.1486	0.1941	0.3475
HERAS	3	0.1579	0.1908	0.1086	0.2294
HERAS	4	0.2202	0.1021	0.1803	0.269
HERAS	5	0.2202	0.1021	0.1803	0.269
HERAS	6	0.2202	0.1021	0.1803	0.269
HERAS	7	0.2925	0.126	0.2285	0.3745
HERAS	8	0.2925	0.126	0.2285	0.3745
IBTS-Q1	1	0.282	0.1482	0.2109	0.3771
IBTS0	0	0.348	0.163	0.2529	0.479
IBTS-Q3	0	0.477	0.1333	0.3673	0.6194
IBTS-Q3	1	0.477	0.1333	0.3673	0.6194
IBTS-Q3	2	0.3176	0.09655	0.2628	0.3837
IBTS-Q3	3	0.3176	0.09655	0.2628	0.3837
IBTS-Q3	4	0.3176	0.09655	0.2628	0.3837
IBTS-Q3	5	0.3176	0.09655	0.2628	0.3837
LAI-ORSH	0	1.183	0.04349	1.087	1.289
LAI-BUN	0	1.183	0.04349	1.087	1.289
LAI-CNS	0	1.183	0.04349	1.087	1.289
LAI-SNS	0	1.183	0.04349	1.087	1.289

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.968	0.0667	0.8494	1.103
HERAS	2	0.968	0.0667	0.8494	1.103
HERAS	3	1.09	0.05781	0.973	1.221
HERAS	4	1.09	0.05781	0.973	1.221
HERAS	5	1.09	0.05781	0.973	1.221
HERAS	6	1.09	0.05781	0.973	1.221
HERAS	7	1.09	0.05781	0.973	1.221
HERAS	8	1.09	0.05781	0.973	1.221
IBTS-Q1	1	0.1052	0.06811	0.09205	0.1202
IBTS0	0	3.346e-06	0.08816	2.815e-06	3.978e-06
IBTS-Q3	0	0.09625	0.1183	0.07633	0.1214
IBTS-Q3	1	0.04721	0.1143	0.03773	0.05907
IBTS-Q3	2	0.0414	0.08635	0.03496	0.04904
IBTS-Q3	3	0.03787	0.08574	0.03201	0.0448
IBTS-Q3	4	0.03189	0.08713	0.02688	0.03782
IBTS-Q3	5	0.02489	0.08829	0.02094	0.02959
LAI-ORSH	0	0.01649	0.1076	0.01335	0.02036
LAI-BUN	0	0.01649	0.1076	0.01335	0.02036
LAI-CNS	0	0.01649	0.1076	0.01335	0.02036
LAI-SNS	0	0.01649	0.1076	0.01335	0.02036

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	34933554	16750702	14490579	5423092	7277324	4453630	3915909	2071498	6319257
1948	33243309	16221925	9583273	8612213	3644469	5079250	2950462	2231630	4882860
1949	27876772	15566854	11550001	7235240	4210657	2289138	3244335	1873501	4263513
1950	39549436	12159066	9017771	9314252	5169144	2357593	1449141	1814152	3242114
1951	38332357	19029721	6535331	6047993	6786509	3608745	1480655	841990	2800243
1952	38183068	17622460	10442050	3886831	3575412	3786266	2160460	939413	2270950
1953	43326920	17336166	9210950	5728392	2630118	2112936	2222262	1229146	1767003
1954	40294149	20101839	8874450	5237374	3109415	1709393	1244009	1281118	1706085
1955	34319467	18105723	10545639	5104408	2668613	1789946	1051784	664431	1414205
1956	25365753	16053919	8587718	6056072	2879033	1469658	1046068	582345	1384933
1957	57941798	10815015	8076891	3760931	3530365	1678679	930799	649820	1173638
1958	24823836	32665560	4749523	4527459	1889153	2234186	926352	543526	1012704
1959	28315691	11029413	19137104	2172396	2336678	1102504	1162459	566145	1187421
1960	12460158	14293760	4969153	10525480	1063269	1151505	605307	617544	1084114
1961	53119421	4197022	7218722	2370104	7072617	669446	792869	344630	872784
1962	28426460	27202408	1610898	3178407	1367899	4356276	424565	512571	711428
1963	34277972	13050781	15943248	1008114	1256825	678448	2248744	203730	693138
1964	34446126	14839182	6538573	9334804	661347	736150	505280	1537733	546836
1965	17177153	16506154	6210836	3394472	5376256	388814	425117	319560	1376045
1966	18451668	7917792	7492025	2149051	1365889	2314821	168803	188424	841350
1967	25572686	7834922	3595817	3142321	847396	651335	866841	100650	465112
1968	21982231	11614820	3112561	1849306	1149058	290821	246354	277898	164702
1969	12706227	9868176	4251836	662988	302903	348942	78391	65203	95485
1970	21921266	5810635	4121588	1518130	209414	99023	108736	16351	42947
1971	17176447	10086083	2333942	1211179	372826	51578	31454	29903	17516
1972	12632049	7668466	3279469	755936	312756	95410	14044	1056	6522
1973	6847350	5392983	2660773	1126502	291222	121030	47185	7453	4447
1974	10823529	2755727	1556355	732910	263104	97399	40041	11395	5254
1975	2561527	5313981	921729	433685	231737	80650	26982	11712	5868
1976	3325786	841432	1789769	210720	92591	61321	13656	6294	2474
1977	4383451	1394653	286928	607670	50001	24770	18488	4576	2127
1978	4276395	1863273	702705	222359	247617	30688	11498	10051	3186
1979	7834683	1685761	903650	406122	175791	122141	20605	7054	7302
1980	12618730	3220679	750215	474825	227801	154155	62976	16853	8134
1981	27336674	4677829	1600157	326454	220273	137949	119000	54332	20137
1982	46487835	8063380	1849834	1023545	199109	120952	76776	70552	39221
1983	46119251	14951591	3224090	1055868	502295	125543	102301	52378	82393
1984	46255876	13367152	6138490	1794983	669672	272040	79384	66932	80800
1985	55006798	14820009	5716973	3572935	993563	357757	124464	46848	74909

1986	66844177	19860582	5445445	2984789	1550815	428735	169200	54518	60829
1987	57661607	26274204	8706425	2609121	1547580	778002	222942	76810	50548
1988	37652038	18959787	10050459	4592095	1338574	807741	390630	112390	67102
1989	29611643	12888931	6934775	5554904	2664252	698459	404046	194334	90504
1990	27465205	9857242	4495247	3943422	3642063	1561336	376025	219009	163601
1991	29856193	10530441	4149228	2343879	2321844	2162410	885567	216041	199571
1992	5.2e+07	10282115	4504702	1795850	1337450	1343835	1302252	525554	246915
1993	54689598	16674800	3745112	2016635	945253	735740	744835	642274	408663
1994	42327104	16811767	5838155	1447165	864484	406880	347474	341570	471698
1995	43745924	13817403	6051275	2613477	728336	372122	200980	174118	378548
1996	35378362	13970262	5184166	3071063	1102238	344960	153321	98300	269320
1997	28927930	13509114	6405793	2978269	1670211	670610	212569	89827	226471
1998	18436245	12011287	8839724	3213652	1484205	898754	438271	131883	176761
1999	56283952	8122439	5546603	5401270	1692304	760061	439214	228270	152671
2000	39546582	22457135	5420257	2934597	3177196	1040824	476998	272387	197853
2001	68068660	15777978	11250149	3542535	1718236	1782524	557881	281973	227785
2002	35673589	29125325	7893451	8118569	1923596	934392	1089603	325320	313193
2003	20127944	13920998	17218059	4501413	4963506	1076005	574388	658836	341733
2004	23308892	7642338	6213499	10915475	2999148	2997472	552164	369260	502317
2005	20454449	9705310	3813917	3854986	6490639	1774794	1614331	271667	408701
2006	20763428	7220553	4941222	2461745	2399797	4119341	865663	725118	284594
2007	24591328	7487152	3213040	2900682	1556714	1374907	2312071	447827	466839
2008	21498765	8681156	4325035	2108169	1708632	1e+06	872024	1481509	569530
2009	35475263	8563576	5311325	2615811	1422456	1132023	679065	634139	1623528
2010	27173952	12845581	5483190	3880858	1923674	1055304	994431	521361	1758939
2011	24406725	11239901	6649073	3550780	2462286	1241626	720823	650681	1490209
2012	22665108	9037588	5847068	4984827	2625737	1718247	804125	469699	1192615
2013	30689037	8435583	4534053	4083282	3438190	1967384	1190979	505407	1029528
2014	48616427	13605561	5331309	3145942	3325471	2302585	1245089	699224	756156
2015	13098673	19159546	9563115	2988164	1955459	2069393	1374982	718480	809788
2016	23503414	5086683	11693633	6896740	1848987	1238975	1168489	694860	715163
2017	14150971	8698012	2511203	8319615	4812222	1230894	638039	551515	592739
2018	24124008	5763090	4172696	1916534	5932524	3400924	808623	427695	691501
2019	21552500	9393374	2451477	2687129	1430825	3721252	2062891	436141	575063
2020	23368085	8800232	5640556	1583206	1819341	1043994	2261921	1064712	512158
2021	18346146	9669912	4556242	2793510	1035442	1208272	711464	1233519	851830
2022	16619677	7202844	5519567	2894602	1683718	618927	712826	430366	1067022

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	0.0001206	0.001042	0.03891	0.09561	0.1111	0.1482	0.2434	0.2704	0.2704
1948	9.736e-05	0.0008166	0.03313	0.08715	0.1057	0.1398	0.2099	0.2397	0.2397
1949	0.0002424	0.002305	0.04996	0.1097	0.1258	0.1592	0.2562	0.3052	0.3052
1950	0.0005909	0.006347	0.07413	0.1365	0.1486	0.1642	0.2185	0.2374	0.2374
1951	0.001797	0.02248	0.1299	0.2017	0.2129	0.2094	0.2351	0.2272	0.2272
1952	0.003093	0.04168	0.1607	0.211	0.2196	0.2257	0.2829	0.3073	0.3073
1953	0.004633	0.06601	0.1906	0.2331	0.2279	0.2338	0.2827	0.2987	0.2987
1954	0.006567	0.1009	0.2341	0.2751	0.2575	0.272	0.3645	0.3791	0.3791
1955	0.007049	0.1204	0.2509	0.2664	0.2351	0.24	0.2699	0.2344	0.2344
1956	0.007242	0.1352	0.2753	0.2687	0.2291	0.2312	0.2458	0.2389	0.2389
1957	0.008021	0.1485	0.286	0.2765	0.2419	0.2609	0.2859	0.2725	0.2725
1958	0.008706	0.1502	0.2943	0.2765	0.2306	0.2369	0.204	0.173	0.173
1959	0.01471	0.2124	0.3497	0.3145	0.27	0.2705	0.291	0.2882	0.2882
1960	0.01674	0.191	0.3089	0.2577	0.215	0.2119	0.2385	0.2688	0.2688
1961	0.01917	0.1963	0.3272	0.294	0.2545	0.2406	0.2528	0.2375	0.2375
1962	0.01236	0.131	0.2748	0.3155	0.3005	0.306	0.3768	0.3493	0.3493
1963	0.01233	0.1166	0.2353	0.2256	0.1804	0.1694	0.131	0.144	0.144
1964	0.01852	0.1941	0.3409	0.3404	0.288	0.2733	0.2255	0.2171	0.2171
1965	0.02425	0.2885	0.5223	0.5824	0.5233	0.5198	0.5044	0.5123	0.5123
1966	0.0245	0.2534	0.4919	0.5609	0.4967	0.5119	0.4133	0.5122	0.5122
1967	0.02927	0.2897	0.5693	0.7359	0.6712	0.7091	0.7666	0.9543	0.9543
1968	0.04943	0.535	0.9886	1.287	1.002	0.9658	1.153	1.216	1.216
1969	0.02798	0.2983	0.6933	0.8832	0.8042	0.8527	1.191	1.068	1.068
1970	0.04683	0.4224	0.8143	1.019	0.9319	0.8556	1.178	0.9108	0.9108
1971	0.06892	0.5655	0.8859	1.088	1.073	1.133	2.916	1.722	1.722
1972	0.0689	0.4572	0.6979	0.7291	0.6012	0.5316	0.5386	0.318	0.318

1973	0.102	0.634	0.9082	1.021	0.8637	0.8636	1.074	0.705	0.705
1974	0.1149	0.5446	0.8413	0.9424	0.8429	0.939	0.9563	0.8424	0.8424
1975	0.1758	0.6789	1.008	1.244	1.116	1.287	1.289	1.615	1.615
1976	0.1487	0.4447	0.7274	1.009	0.8765	0.9483	0.8077	1.148	1.148
1977	0.06804	0.1275	0.2636	0.3893	0.3323	0.4025	0.2734	0.4571	0.4571
1978	0.07747	0.1131	0.2157	0.2815	0.2358	0.266	0.1404	0.2526	0.2526
1979	0.1094	0.1297	0.2106	0.2492	0.1947	0.2008	0.08303	0.1526	0.1526
1980	0.1619	0.1564	0.2146	0.2345	0.1734	0.1571	0.05095	0.09138	0.09138
1981	0.3278	0.2681	0.2517	0.2814	0.2507	0.2652	0.2128	0.3782	0.3782
1982	0.2976	0.2368	0.2211	0.2511	0.2051	0.1756	0.1071	0.1543	0.1543
1983	0.3035	0.2713	0.2433	0.2904	0.2865	0.2778	0.2569	0.3388	0.3388
1984	0.2206	0.2624	0.2618	0.3443	0.3878	0.3863	0.3908	0.4949	0.4949
1985	0.1899	0.3271	0.3237	0.4356	0.4972	0.4795	0.5223	0.5882	0.5882
1986	0.1469	0.3027	0.3093	0.3803	0.4361	0.4428	0.5168	0.582	0.582
1987	0.1805	0.3814	0.3262	0.3586	0.415	0.4261	0.4549	0.4571	0.4571
1988	0.1677	0.387	0.3134	0.328	0.3956	0.421	0.4543	0.4684	0.4684
1989	0.1638	0.3852	0.3211	0.324	0.3892	0.4031	0.4154	0.4228	0.4228
1990	0.1193	0.2798	0.2796	0.2654	0.3049	0.312	0.2855	0.303	0.303
1991	0.1595	0.3376	0.3436	0.3081	0.3213	0.3075	0.2838	0.2578	0.2578
1992	0.2302	0.4137	0.3947	0.3598	0.3777	0.3562	0.3757	0.3548	0.3548
1993	0.267	0.4537	0.4457	0.4448	0.465	0.4034	0.4243	0.4061	0.4061
1994	0.217	0.3597	0.4158	0.4775	0.5035	0.3994	0.3712	0.323	0.323
1995	0.1897	0.2924	0.343	0.4286	0.447	0.402	0.393	0.3152	0.3152
1996	0.07065	0.1069	0.1735	0.2183	0.2198	0.2122	0.1676	0.1144	0.1144
1997	0.03404	0.06005	0.138	0.1923	0.2087	0.2103	0.1851	0.1344	0.1344
1998	0.03851	0.07578	0.1617	0.2294	0.2464	0.2512	0.241	0.1475	0.1475
1999	0.03838	0.06594	0.145	0.2219	0.2332	0.232	0.1976	0.1216	0.1216
2000	0.04355	0.06866	0.1382	0.2141	0.2482	0.2529	0.2165	0.1339	0.1339
2001	0.03537	0.04866	0.1029	0.1679	0.2077	0.2259	0.1987	0.1387	0.1387
2002	0.03217	0.04144	0.09098	0.1471	0.191	0.2157	0.1996	0.1685	0.1685
2003	0.0361	0.04457	0.0916	0.1498	0.2132	0.266	0.2512	0.2089	0.2089
2004	0.04401	0.04823	0.09543	0.1565	0.2382	0.3241	0.3979	0.3396	0.3396
2005	0.06811	0.06996	0.1154	0.1757	0.2701	0.3671	0.5241	0.5645	0.5645
2006	0.05753	0.05426	0.1035	0.1621	0.2455	0.3186	0.417	0.5017	0.5017
2007	0.05101	0.0474	0.09877	0.1578	0.229	0.287	0.3607	0.4423	0.4423
2008	0.04935	0.04138	0.08777	0.11	0.1454	0.1735	0.1664	0.2112	0.2112
2009	0.02909	0.02194	0.05631	0.06073	0.07814	0.09458	0.06872	0.09505	0.09505
2010	0.03404	0.02524	0.06305	0.0724	0.08433	0.09876	0.07062	0.07959	0.07959
2011	0.03788	0.02709	0.06925	0.09256	0.1101	0.1289	0.1026	0.1052	0.1052
2012	0.05501	0.04408	0.09791	0.1519	0.1904	0.2255	0.2445	0.2556	0.2556
2013	0.04613	0.03823	0.09039	0.1509	0.212	0.2714	0.3489	0.3942	0.3942
2014	0.05236	0.03568	0.08533	0.1476	0.2148	0.2702	0.3184	0.3866	0.3866
2015	0.05409	0.02759	0.06802	0.1214	0.192	0.2786	0.41	0.5617	0.5617
2016	0.06936	0.02927	0.06881	0.1415	0.2143	0.295	0.4437	0.6762	0.6762
2017	0.05827	0.02239	0.06036	0.139	0.2064	0.2517	0.3096	0.4733	0.4733
2018	0.06073	0.02057	0.06287	0.1431	0.2268	0.2905	0.3782	0.5479	0.5479
2019	0.05178	0.01706	0.06238	0.1344	0.1867	0.2402	0.3191	0.4773	0.4773
2020	0.08256	0.02711	0.09941	0.1764	0.2043	0.2238	0.2779	0.4597	0.4597
2021	0.06317	0.02274	0.1035	0.1899	0.2208	0.2441	0.2312	0.4023	0.4023
2022	0.06327	0.02278	0.1036	0.1901	0.221	0.2442	0.2313	0.4026	0.4026

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

year	ssb	fbar	rec
2011	12.91	-14.32	14.82
2012	22.71	-29.56	26.8
2013	20.77	-27.18	18.02
2014	13.21	-16.09	5.518
2015	11.72	-12.95	3.548
2016	10.13	-10.44	-20.31
2017	18.29	-25.61	-4.868
2018	11.12	-13.43	-13.14
2019	4.783	-7.027	-12.93
2020	-0.4952	-0.4827	-10.37
2021	0	0	0
av_5y	7.305	-9.498	-10.27

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	34933554	19714707	61900650	8576788	6512605	11295219	5285579	3810441	7331788	851394	730285	992587	0.1275	0.08932	0.1819	581760	1.461
1948	33243309	19786422	55852320	7388921	5652180	9659309	4498149	3272582	6182684	660189	575156	757795	0.1151	0.08188	0.1619	502100	1.333
1949	27876772	16764967	46353471	6810234	5282618	8779603	4068639	2993728	5529503	724543	631895	830775	0.1402	0.1008	0.1949	508500	1.45
1950	39549436	24255781	64485983	6431334	5067687	8161919	3813584	2861275	5082848	648230	576651	728695	0.1484	0.1095	0.2012	491700	1.307
1951	38332357	23699211	6.2e+07	6287798	5037726	7848067	3376462	2565481	4443804	775407	694440	865815	0.1978	0.1497	0.2613	600400	1.324
1952	38183068	23776916	61317735	6040922	4875702	7484612	3193191	2444769	4170729	835136	750997	928701	0.22	0.1673	0.2893	664400	1.272
1953	43326920	27815630	67488027	5816252	4715276	7174296	2960946	2271310	3859977	836261	751752	930269	0.2336	0.1785	0.3059	698500	1.198
1954	40294149	25958593	62546474	5670449	4611746	6972194	2705410	2062689	3548400	948972	847912	1062077	0.2806	0.213	0.3697	762900	1.251
1955	34319467	22244721	52948552	5414280	4398895	6664042	2715493	2080562	3544188	844032	747356	953214	0.2525	0.1922	0.3316	806400	1.06
1956	25365753	16429985	39161412	5052878	4117322	6201015	2622714	2013775	3415790	832719	737944	939667	0.25	0.1914	0.3266	675200	1.271
1957	57941798	37216611	90208427	4947768	4044996	6052021	2376734	1824592	3095960	785195	700322	880352	0.2702	0.2065	0.3536	682900	1.158
1958	24823836	16214946	3.8e+07	4951743	4030397	6083707	2017862	1550502	2626096	733374	623420	862722	0.2485	0.1916	0.3223	670500	1.167
1959	28315691	18005602	44529385	5522135	4541749	6714148	2920802	2258668	3777042	1166274	1002624	1356635	0.2991	0.2311	0.3872	784500	1.519
1960	12460158	8003503	19398450	4625901	3806254	5622052	2513467	1949591	3240432	807088	702204	927636	0.2464	0.1919	0.3164	696200	1.183
1961	53119421	34234520	82421861	4782644	3971940	5758819	2527008	1988151	3211914	765899	677009	866459	0.2738	0.2168	0.3459	696700	1.135
1962	28426460	18682408	43252649	4467036	3710703	5377529	1768353	1374072	2275770	727198	629814	839640	0.3147	0.2482	0.3991	627800	1.171
1963	34277972	22650190	51875033	5164800	4320178	6174551	2784064	2229825	3476064	595439	509533	695828	0.1884	0.1521	0.2333	716000	0.8602
1964	34446126	22907288	51797295	5109984	4419237	5908697	2515254	2081115	3039959	902315	783335	1039368	0.2936	0.2443	0.3529	871200	1.066
1965	17177153	11414094	25850024	4607510	4067501	5219213	1989648	1675745	2362351	1299992	1140647	1481596	0.5304	0.4485	0.6274	1168800	1.15
1966	18451668	12338825	27592908	3457613	3065711	3899615	1592304	1351658	1875794	933131	828545	1050920	0.4949	0.4219	0.5806	895500	1.071
1967	25572686	17013798	38437171	2678503	2387164	3005398	957998	822337	1116038	836664	742667	942559	0.6904	0.5973	0.7981	695500	1.176
1968	21982231	14748061	32764882	2266832	1989204	2583208	523533	448185	611548	906941	774428	1062128	1.079	0.9505	1.225	717800	1.255
1969	12706227	8408837	19199824	1688584	1457715	1956018	478525	392552	583327	503434	427093	593421	0.8848	0.7722	1.014	546700	0.9674
1970	21921266	14512163	33113043	1660625	1440182	1914810	455974	373764	556266	548051	468827	640661	0.9598	0.8427	1.093	563100	0.9657
1971	17176447	11500502	25653692	1468756	1248833	1727408	286537	236666	346916	525590	424540	650693	1.419	1.256	1.604	520100	1.075
1972	12632049	8396307	1.9e+07	1321327	1133850	1539802	328789	271220	398579	392358	317543	484799	0.6197	0.5359	0.7166	497500	0.9197
1973	6847350	4564992	10270819	1105924	966310	1265710	279135	232988	334422	444151	371972	530336	0.9461	0.8306	1.078	484000	0.9575
1974	10823529	7100393	16498915	776456	674870	893334	191486	160775	228064	271535	232284	317417	0.9044	0.7914	1.034	275100	0.968
1975	2561527	1667370	3935192	611797	511176	732223	105622	87307	127779	269111	213655	338960	1.189	1.025	1.379	312800	0.9343
1976	3325786	2097481	5273397	450493	375936	539836	143885	109186	189611	158173	133100	187968	0.8738	0.6841	1.116	174800	0.953
1977	4383451	2700203	7116001	317785	250486	403165	109516	79724	150441	51938	43857	61509	0.3322	0.2424	0.4553	46000	1.198
1978	4276395	2606804	7015316	377528	289078	493041	136468	100197	185870	45596	26303	79039	0.2279	0.143	0.3632	11000	.
1979	7834683	4951098	12397706	496249	394135	624820	186007	142742	242387	59108	33509	104261	0.1877	0.1165	0.3023	25100	.
1980	12618730	8456379	18829852	667953	548659	813183	209548	167415	262285	80070	62695	102261	0.1661	0.1317	0.2096	70764	1.094
1981	27336674	18395329	40624103	1090375	891211	1334047	269982	216354	336903	147151	113020	191589	0.2524	0.2014	0.3161	174879	1.008
1982	46487835	31348781	68937891	1706265	1384933	2102151	383091	310940	471984	238674	173599	328141	0.192	0.1558	0.2366	275079	0.9786
1983	46119251	31793569	66899860	2347934	1949408	2827931	547774	447921	669888	383898	285267	516632	0.271	0.2234	0.3287	387202	1.077
1984	46255876	31962845	66940414	3114638	2648438	3662903	901656	736690	1103562	477340	386744	589158	0.3542	0.2949	0.4253	428631	1.054
1985	55006798	37917617	79797942	3548570	3047802	4131616	989672	817413	1198233	636843	541921	748392	0.4517	0.3769	0.5412	613780	1.042
1986	66844177	45922405	97297692	3955160	3376781	4632604	1029021	855136	1238263	716702	577083	890100	0.4171	0.3477	0.5003	671488	1.137
1987	57661607	39673313	83805981	3942296	3392562	4581111	1207748	1004741	1451771	764493	627288	931709	0.3962	0.3319	0.4728	792058	1.017

1988	37652038	25974716	54579076	3826700	3332815	4393772	1541445	1287040	1846136	879558	723253	1069643	0.3824	0.3223	0.4539	887686	1.164
1989	29611643	20436111	42906861	3469840	3077328	3912418	1598124	1370868	1863053	808260	697083	937170	0.3706	0.3157	0.435	787899	1.034
1990	27465205	18894393	39923881	3469308	3075697	3913292	1748337	1503453	2033109	632743	550472	727310	0.2895	0.2454	0.3414	645229	1.052
1991	29856193	20572305	43329721	3332392	2958663	3753331	1551746	1339736	1797306	683584	587303	795650	0.3129	0.2658	0.3683	658008	1.02
1992	5.2e+07	37359725	72383331	3303140	2925184	3729931	1180619	1016213	1371624	707534	603801	829089	0.3728	0.3164	0.4393	716799	0.995
1993	54689598	39114535	76466515	3070263	2684876	3510969	839871	715566	985770	708460	596273	841754	0.4367	0.3692	0.5164	671397	1.023
1994	42327104	30161861	59398980	2962976	2559298	3430326	892915	759487	1049783	713172	574512	885298	0.4335	0.3663	0.513	568234	1.05
1995	43745924	31080084	61573383	2787853	2413852	3219801	924912	780587	1095922	612227	518744	722558	0.4027	0.3372	0.4811	579371	1.008
1996	35378362	25205039	49657868	2742054	2357713	3189049	1085584	917372	1284639	267798	233000	307791	0.1983	0.1646	0.2388	275098	0.9987
1997	28927930	20553933	40713625	2831966	2452377	3270310	1252705	1063560	1475489	275865	243199	312919	0.1869	0.1555	0.2245	264313	1.001
1998	18436245	13370771	25420760	3112829	2716010	3567625	1432476	1227208	1672079	377052	333100	426804	0.2259	0.1886	0.2707	391628	1.002
1999	56283952	40815555	77614606	3164390	2774768	3608721	1530535	1311863	1785656	353352	312772	399197	0.2059	0.1728	0.2454	363163	1
2000	39546582	28860529	54189309	3771568	3283155	4332639	1552473	1331880	1809602	381332	337657	430657	0.214	0.1793	0.2553	388157	1
2001	68068660	49065310	94432143	4242716	3693984	4872962	1947136	1671744	2267896	372273	330833	418902	0.1806	0.1512	0.2158	374065	0.9901
2002	35673589	25885695	49162478	5065178	4397274	5834531	2406200	2065151	2803571	395188	350972	444973	0.1689	0.1415	0.2016	394709	0.9974
2003	20127944	14666299	27623474	5339794	4653374	6127469	2368340	2045541	2742078	484773	434072	541395	0.1944	0.1634	0.2312	482281	1.015
2004	23308892	16944697	32063390	4675290	4120377	5304936	2334587	2021031	2696790	588510	528307	655574	0.2424	0.2034	0.2889	587698	0.9985
2005	20454449	14975215	27938463	3873255	3432543	4370551	2108713	1814999	2449957	663286	595140	739236	0.2905	0.2444	0.3452	663813	1.003
2006	20763428	15148108	28460316	3255288	2883237	3675348	1722082	1484514	1997668	511608	459065	570166	0.2493	0.2095	0.2968	514597	0.995
2007	24591328	17798533	33976587	2716905	2398548	3077517	1369887	1177015	1594364	398270	357308	443928	0.2266	0.1897	0.2708	406482	1.006
2008	21498765	15520784	29779223	2757036	2412019	3151406	1461007	1257237	1697803	257392	230133	287880	0.1366	0.1144	0.1631	257870	1.004
2009	35475263	25650484	49063180	3220317	2802121	3700926	1808626	1553415	2105767	165536	147955	185207	0.0717	0.05979	0.08597	168443	1.002
2010	27173952	19735017	37416926	3854517	3357642	4424921	1920666	1645128	2242352	186468	166989	208219	0.07783	0.06506	0.09311	187611	1.003
2011	24406725	17795559	33473982	3853478	3382970	4389425	2257511	1958276	2602471	228763	205830	254252	0.1007	0.08471	0.1197	226478	0.9938
2012	22665108	16510193	31114543	3778821	3339167	4276361	2303866	2e+06	2654129	431402	388561	478966	0.182	0.1534	0.216	434710	1.011
2013	30689037	22211446	42402328	3679047	3265025	4145569	2112765	1836572	2430494	498634	449764	552815	0.2147	0.1811	0.2547	511416	1.001
2014	48616427	34867440	67786939	3920594	3470073	4429607	2083311	1809165	2398999	507606	457758	562884	0.2073	0.1747	0.2459	517356	1.003
2015	13098673	9423319	18207517	4102674	3596183	4680501	1936797	1678528	2234804	486387	437680	540513	0.214	0.1794	0.2553	494099	1.002
2016	23503414	17105641	32294052	4060267	3554844	4637551	2232275	1923541	2590560	550065	495669	610431	0.2327	0.1949	0.2777	563610	1
2017	14150971	10235594	19564080	3525551	3093115	4018444	2064512	1770303	2407617	466630	416208	523162	0.1934	0.1624	0.2303	498437	1.001
2018	24124008	17514666	33227453	3347823	2947549	3802453	1852687	1584320	2166513	550382	488579	620001	0.2203	0.1849	0.2625	603536	1.001
2019	21552500	15552764	29866735	2853541	2514411	3238412	1589952	1361873	1856230	427794	381970	479115	0.1886	0.1575	0.2258	442138	1.002
2020	23368085	16636212	32824021	2764224	2419085	3158605	1499912	1280028	1757567	415594	371484	464941	0.1964	0.1636	0.2357	426900	1.003
2021	18346146	12542176	26835940	2573507	2205925	3002340	1352809	1129011	1620970	360261	319730	405931	0.1979	0.1608	0.2436	365356	1
2022	16619677	9095169	30369274	2444795	1943895	3074767	1334034	1009913	1762178	330994	181739	602826	0.198	0.1027	0.3817	.	.

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 May 02 09:53:59 2022"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2022         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	1.223	0.1772	0.864	1.73
catch A	2	0.1679	0.1157	0.1338	0.2106
catch A	3	0.1679	0.1157	0.1338	0.2106
catch A	4	0.1679	0.1157	0.1338	0.2106
catch A	5	0.1679	0.1157	0.1338	0.2106
catch A	6	0.1679	0.1157	0.1338	0.2106
catch A	7	0.1764	0.2219	0.1142	0.2724
catch A	8	0.1764	0.2219	0.1142	0.2724
catch BD	0	0.4282	0.1837	0.2987	0.6137
catch BD	1	0.3473	0.2759	0.2022	0.5964
catch BD	2	1.428	0.09082	1.195	1.706
catch BD	3	1.428	0.09082	1.195	1.706
catch BD	4	1.428	0.09082	1.195	1.706
catch BD	5	1.428	0.09082	1.195	1.706
catch C	1	0.762	0.1897	0.5254	1.105
catch C	2	0.5315	0.1606	0.388	0.7282
catch C	3	0.6717	0.09392	0.5588	0.8075
catch C	4	0.6717	0.09392	0.5588	0.8075
catch C	5	0.6717	0.09392	0.5588	0.8075
catch C	6	0.6717	0.09392	0.5588	0.8075
HERAS	1	0.4709	0.151	0.3502	0.6331
HERAS	2	0.2505	0.1518	0.186	0.3372
HERAS	3	0.1541	0.1976	0.1046	0.227
HERAS	4	0.2267	0.102	0.1856	0.2769
HERAS	5	0.2267	0.102	0.1856	0.2769
HERAS	6	0.2267	0.102	0.1856	0.2769
HERAS	7	0.3102	0.1215	0.2445	0.3935
HERAS	8	0.3102	0.1215	0.2445	0.3935
IBTS-Q1	1	0.2893	0.1443	0.2181	0.3838
IBTS0	0	0.3499	0.1616	0.2549	0.4803
IBTS-Q3	0	0.4802	0.1318	0.3709	0.6217

IBTS-Q3	1	0.4802	0.1318	0.3709	0.6217
IBTS-Q3	2	0.3123	0.09664	0.2584	0.3774
IBTS-Q3	3	0.3123	0.09664	0.2584	0.3774
IBTS-Q3	4	0.3123	0.09664	0.2584	0.3774
IBTS-Q3	5	0.3123	0.09664	0.2584	0.3774
LAI-ORSH	0	1.185	0.04353	1.088	1.291
LAI-BUN	0	1.185	0.04353	1.088	1.291
LAI-CNS	0	1.185	0.04353	1.088	1.291
LAI-SNS	0	1.185	0.04353	1.088	1.291

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.974	0.06472	0.858	1.106
HERAS	2	0.974	0.06472	0.858	1.106
HERAS	3	1.096	0.05653	0.981	1.224
HERAS	4	1.096	0.05653	0.981	1.224
HERAS	5	1.096	0.05653	0.981	1.224
HERAS	6	1.096	0.05653	0.981	1.224
HERAS	7	1.096	0.05653	0.981	1.224
HERAS	8	1.096	0.05653	0.981	1.224
IBTS-Q1	1	0.1061	0.06743	0.093	0.1211
IBTS0	0	3.4e-06	0.08689	2.867e-06	4.031e-06
IBTS-Q3	0	0.09727	0.1175	0.07725	0.1225
IBTS-Q3	1	0.04763	0.1139	0.0381	0.05955
IBTS-Q3	2	0.04176	0.08427	0.0354	0.04926
IBTS-Q3	3	0.03804	0.0838	0.03228	0.04483
IBTS-Q3	4	0.03183	0.08528	0.02693	0.03762
IBTS-Q3	5	0.02509	0.08652	0.02118	0.02973
LAI-ORSH	0	0.01648	0.1074	0.01335	0.02034
LAI-BUN	0	0.01648	0.1074	0.01335	0.02034
LAI-CNS	0	0.01648	0.1074	0.01335	0.02034
LAI-SNS	0	0.01648	0.1074	0.01335	0.02034

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	36093932	13591337	11395641	4908659	6777687	4281618	3787658	2027407	6166295
1948	33922411	16752169	7752809	7084872	3233361	4628207	2818194	2145713	4714114
1949	29597819	15763209	10851381	6319931	3828679	2079292	2976617	1773298	4059964
1950	40627635	13074607	9033028	8791989	4719749	2238395	1317643	1659497	3031759
1951	39440118	19345219	7081018	6115954	6427695	3347964	1417880	766015	2593261
1952	39202102	18112677	10821930	4179763	3606880	3701136	2042192	888887	2113747
1953	43036414	17856733	9661115	5984202	2698213	2115634	2176856	1161805	1661387
1954	4e+07	20315640	9292090	5398021	3233641	1714175	1243424	1247435	1625343
1955	34619911	17932899	10913570	5264622	2767472	1839013	1040662	661174	1369763
1956	25968979	16111660	8445230	6172460	2917568	1529044	1074515	579813	1367085
1957	62093137	10988363	8089546	3827082	3537414	1694566	947070	661837	1169426
1958	26115891	34116757	4770550	4441642	1928697	2181839	946780	553022	1018277
1959	28657528	11569021	19492580	2222328	2332883	1107674	1171629	575195	1200850
1960	12186191	14312061	5247995	10791132	1096748	1201637	608142	623417	1101960
1961	55563221	4231482	7032921	2517921	7040539	677632	814066	348424	887227
1962	28262748	28263813	1722745	3126909	1386615	4306990	422336	528385	724653
1963	32170955	1.3e+07	16514904	1032285	1308222	707785	2298998	207437	713749
1964	34142629	14283094	6632125	9634320	668880	759170	510074	1570891	562289
1965	17859019	16422385	5928575	3427110	5315554	393020	428820	323572	1397370
1966	17969166	8123565	7531218	2142467	1384520	2265497	176603	190049	850704
1967	23777353	7705972	3635946	3202601	840670	657642	877591	102969	468618
1968	23298271	10652581	3019696	1703701	1164918	291128	253371	275757	166455
1969	12696599	10354073	4296609	676195	306856	347754	78215	64905	95111
1970	23081631	5754218	4157793	1475367	204378	96889	113035	16236	42981
1971	18967092	10535473	2390802	1240220	377970	55176	29722	30400	17448
1972	12824572	8546123	3327981	756248	307919	95343	14444	1057	6489
1973	6901059	5492126	2628245	1153130	294057	123269	45461	7653	4444

1974	10626801	2775191	1545086	752559	267336	97046	40158	11357	5336
1975	2595192	5059081	903094	438887	229808	79604	28455	11867	5933
1976	3292902	880028	1766813	211617	90143	60425	14692	6454	2527
1977	4042815	1371839	340732	591155	53620	25430	18687	4906	2283
1978	4535163	1714301	671194	246346	252203	32794	11975	10263	3565
1979	8428613	1724651	834975	393659	183959	128376	22152	7379	7831
1980	13137089	3299201	774788	468326	226857	151110	68695	18070	8698
1981	27450227	4886313	1682681	356634	229257	138319	114842	57962	21465
1982	46179507	8006515	2018527	1032261	207138	128644	78383	70529	41850
1983	45190849	14309825	3299279	1128107	518755	129835	103002	53646	84703
1984	45580424	12820462	6010621	1820908	677128	274300	81431	67946	82659
1985	56719079	14511193	5564990	3446713	985011	357650	127032	47734	75823
1986	69322285	20573763	5333129	2889673	1544397	435509	168613	55044	61441
1987	60793072	26940860	8769729	2599526	1519937	773014	222983	76567	50915
1988	38026105	20370553	10222666	4633033	1344343	799214	391989	112821	67306
1989	30342238	12957247	6934689	5561702	2640442	698753	403776	195454	90599
1990	27295514	10224493	4464887	3938244	3588363	1534310	374933	217499	162029
1991	29157687	10377183	4003870	2317560	2308353	2136860	873027	212489	199141
1992	50157281	10021545	4492528	1803150	1324970	1323148	1271884	522898	244181
1993	52043143	15915540	3742534	2016902	941601	721785	726571	628101	405593
1994	41472045	15825546	5851877	1447285	838583	411246	341241	328396	463493
1995	42144693	13734935	6273150	2603126	720603	364235	201727	168233	371736
1996	33388610	13561510	5549514	3060271	1115802	342822	156343	98241	259507
1997	28057040	12799161	6004862	3086726	1601461	655322	206763	96514	211751
1998	18544104	11718955	8411975	3151426	1505249	862461	433443	133136	174976
1999	57325166	8156944	5509842	5184407	1686532	777231	433239	235239	155952
2000	37429320	23385625	5369332	2976281	3029250	980879	480432	265422	219525
2001	69204784	14296436	11616089	3553038	1709986	1655709	505698	273267	285010
2002	35081327	29902550	7611166	8035545	1933771	949655	1017145	305267	312130
2003	19127720	13651690	17372256	4464005	5011228	1073689	587083	631754	328812
2004	23203294	7174352	6041317	10769701	3001723	3023204	569924	371540	485166
2005	20310298	9834511	3661965	3919014	6449787	1779337	1643769	284944	414800
2006	20874443	7178287	4976327	2462757	2436192	4062207	876600	738159	296709
2007	25178929	7574760	3235952	2813243	1535664	1391711	2218910	449686	479237
2008	21984090	8983101	4376722	2123298	1670102	972559	851972	1408050	572281
2009	34450991	8771121	5268406	2667886	1412544	1095018	661329	622572	1542317
2010	27158438	12676152	5536618	3810141	1938466	1055592	908716	501809	1666071
2011	24342085	11082069	6666382	3568876	2450547	1245040	723495	611245	1424802
2012	23086179	9132739	5909094	4887641	2660066	1704182	810710	479497	1158651
2013	31571200	8546778	4487891	4092999	3412174	1952820	1171666	505382	1021916
2014	48305720	13723189	5361500	3155122	3257603	2293909	1236784	689425	759765
2015	12656662	18828828	9498180	3067648	1974414	2066491	1373933	718136	818192
2016	22792622	4882009	11635360	6892883	1922687	1228474	1168492	704490	732921
2017	13604031	8501195	2496961	7980134	4833325	1288961	628341	557159	612391
2018	23215739	5512549	4203423	1921539	5737006	3323673	819068	413273	708399
2019	19791826	9130981	2375612	2708081	1448638	3538641	2001803	439935	578116
2020	23548414	8042883	5398558	1597030	1850789	1072051	2137581	1059337	510839
2021	18229682	9877931	4298044	2719718	1053321	1172985	712748	1176763	845096
2022	16404915	7196801	5653978	2714118	1626468	629993	691110	424975	1025744

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	0.002569	0.04853	0.1061	0.1216	0.1566	0.247	0.2767	0.2767
1948	0	0.002492	0.0461	0.1036	0.1205	0.1526	0.222	0.2507	0.2507
1949	0	0.002841	0.05685	0.1204	0.1404	0.1755	0.2779	0.3255	0.3255
1950	0	0.003362	0.07389	0.1399	0.1569	0.1779	0.2389	0.2586	0.2586
1951	0	0.004443	0.1135	0.1894	0.2045	0.2122	0.2509	0.2476	0.2476
1952	0	0.005123	0.1412	0.205	0.2161	0.231	0.3026	0.3308	0.3308
1953	0	0.005725	0.1672	0.2222	0.2197	0.2322	0.2922	0.3154	0.3154
1954	0	0.006715	0.2137	0.2662	0.2518	0.2689	0.371	0.3959	0.3959
1955	0	0.006943	0.2245	0.2524	0.224	0.2295	0.2587	0.2362	0.2362
1956	0	0.007618	0.2588	0.2661	0.2266	0.2281	0.2458	0.2421	0.2421
1957	0	0.007962	0.2766	0.2796	0.2415	0.2527	0.28	0.2703	0.2703
1958	0	0.00809	0.2832	0.2744	0.226	0.2254	0.1989	0.1709	0.1709
1959	0	0.008829	0.3241	0.3107	0.2644	0.2654	0.2922	0.2868	0.2868
1960	0	0.007879	0.2714	0.2524	0.2142	0.2162	0.2389	0.2647	0.2647

1961	0	0.008322	0.2955	0.284	0.2433	0.2361	0.2417	0.2321	0.2321
1962	0	0.008239	0.2906	0.3226	0.2936	0.2994	0.3565	0.341	0.341
1963	0	0.006642	0.2075	0.2134	0.1776	0.1723	0.1301	0.1403	0.1403
1964	0	0.008528	0.3053	0.3227	0.275	0.264	0.2139	0.2093	0.2093
1965	0	0.01223	0.5336	0.592	0.516	0.5002	0.5024	0.5103	0.5103
1966	0	0.01142	0.4796	0.5567	0.4882	0.4891	0.4262	0.5062	0.5062
1967	0	0.01291	0.5796	0.7334	0.6653	0.6865	0.7911	0.9434	0.9434
1968	0	0.01833	0.9982	1.235	0.9927	0.9472	1.195	1.223	1.223
1969	0	0.01517	0.7433	0.9231	0.8246	0.8471	1.197	1.063	1.063
1970	0	0.01589	0.7992	0.992	0.8901	0.8532	1.194	0.9142	0.9142
1971	0	0.01705	0.8909	1.129	1.092	1.177	2.858	1.749	1.749
1972	0	0.01321	0.5989	0.68	0.571	0.5324	0.52	0.314	0.314
1973	0	0.01675	0.8665	1.018	0.8613	0.86	1.044	0.7047	0.7047
1974	0	0.01612	0.8171	0.9599	0.8434	0.8976	0.9374	0.83	0.83
1975	0	0.01858	1.019	1.272	1.114	1.215	1.323	1.603	1.603
1976	0	0.01496	0.7284	0.9886	0.8545	0.9013	0.823	1.113	1.113
1977	0	0.007451	0.2469	0.3678	0.3266	0.3818	0.2597	0.4116	0.4116
1978	0	0.006319	0.1912	0.2636	0.2288	0.2508	0.1317	0.2202	0.2202
1979	0	0.005988	0.176	0.227	0.1858	0.1882	0.07856	0.1332	0.1332
1980	0	0.006018	0.1775	0.2156	0.167	0.1517	0.0516	0.08511	0.08511
1981	0	0.006784	0.2138	0.2751	0.2516	0.2638	0.206	0.355	0.355
1982	0	0.005911	0.1726	0.2204	0.1916	0.1747	0.1027	0.1476	0.1476
1983	0	0.006661	0.2079	0.2739	0.2747	0.2723	0.2397	0.326	0.326
1984	0	0.007494	0.2497	0.3407	0.3729	0.375	0.3795	0.4874	0.4874
1985	0	0.008715	0.3158	0.4291	0.4773	0.4671	0.5182	0.5876	0.5876
1986	0	0.00844	0.3007	0.3861	0.4383	0.4441	0.5175	0.5819	0.5819
1987	0	0.008108	0.2828	0.3447	0.4014	0.4116	0.4415	0.4536	0.4536
1988	0	0.007817	0.2674	0.3162	0.3825	0.4052	0.4455	0.4676	0.4676
1989	0	0.007921	0.2734	0.3097	0.3708	0.3848	0.4074	0.4227	0.4227
1990	0	0.007351	0.2438	0.2604	0.2991	0.305	0.2865	0.3063	0.3063
1991	0	0.008273	0.2935	0.2984	0.3158	0.3009	0.2748	0.258	0.258
1992	0	0.008992	0.3347	0.3523	0.3745	0.3526	0.3714	0.3567	0.3567
1993	0	0.009888	0.3887	0.4384	0.4597	0.4051	0.4381	0.4162	0.4162
1994	0	0.009624	0.3737	0.465	0.4847	0.3983	0.3875	0.3365	0.3365
1995	0	0.008131	0.2881	0.4032	0.4299	0.3869	0.3946	0.3285	0.3285
1996	0	0.004871	0.1302	0.1941	0.2063	0.1965	0.1478	0.1119	0.1119
1997	0	0.004309	0.1079	0.173	0.1873	0.1817	0.1412	0.109	0.109
1998	0	0.004968	0.1341	0.222	0.238	0.2356	0.2134	0.1385	0.1385
1999	0	0.004626	0.119	0.2125	0.2272	0.223	0.1844	0.114	0.114
2000	0	0.004374	0.1082	0.203	0.2312	0.2323	0.1911	0.1234	0.1234
2001	0	0.003642	0.08092	0.1614	0.1998	0.2193	0.1942	0.1644	0.1644
2002	0	0.003279	0.06828	0.1388	0.1823	0.2089	0.1901	0.1693	0.1693
2003	0	0.00325	0.06694	0.1433	0.203	0.2505	0.2431	0.21	0.21
2004	0	0.003116	0.06262	0.1434	0.2211	0.2965	0.3622	0.3206	0.3206
2005	0	0.003458	0.07254	0.1625	0.2583	0.3524	0.5146	0.5452	0.5452
2006	0	0.003652	0.07814	0.1643	0.2484	0.3225	0.4386	0.5055	0.5055
2007	0	0.003563	0.07423	0.1523	0.222	0.281	0.3633	0.4352	0.4352
2008	0	0.003307	0.06533	0.1099	0.1464	0.1768	0.172	0.2165	0.2165
2009	0	0.002628	0.04558	0.06686	0.08475	0.1025	0.07577	0.1037	0.1037
2010	0	0.002709	0.04774	0.07154	0.08484	0.09952	0.07032	0.08362	0.08362
2011	0	0.002986	0.05573	0.09158	0.1104	0.1289	0.1008	0.1092	0.1092
2012	0	0.003786	0.08042	0.1482	0.1869	0.2216	0.2378	0.2549	0.2549
2013	0	0.003498	0.07121	0.1465	0.2065	0.2642	0.34	0.3929	0.3929
2014	0	0.003317	0.06679	0.1425	0.2064	0.2625	0.32	0.3877	0.3877
2015	0	0.002876	0.05502	0.1242	0.1929	0.2727	0.3985	0.5475	0.5475
2016	0	0.002864	0.05596	0.14	0.2134	0.2944	0.4489	0.6665	0.6665
2017	0	0.002517	0.04631	0.1278	0.1929	0.2468	0.3127	0.4641	0.4641
2018	0	0.002702	0.05216	0.1412	0.218	0.2842	0.3806	0.5539	0.5539
2019	0	0.002572	0.04865	0.1256	0.1804	0.2406	0.3196	0.4864	0.4864
2020	0	0.003617	0.08261	0.1731	0.205	0.2361	0.2884	0.4635	0.4635
2021	0	0.00398	0.09663	0.1948	0.219	0.2442	0.2448	0.4109	0.4109
2022	0	0.00398	0.09663	0.1948	0.219	0.2442	0.2448	0.4109	0.4109

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	0.001131	0.001155	0.000438	0.0007473	0.0007473	0.0007473	0	0	0
1948	0.001096	0.001063	0.0004183	0.000732	0.000732	0.000732	0	0	0
1949	0.001696	0.003307	0.0007567	0.0009864	0.0009864	0.0009864	0	0	0
1950	0.00251	0.009171	0.001303	0.001298	0.001298	0.001298	0	0	0
1951	0.00358	0.02307	0.002149	0.001673	0.001673	0.001673	0	0	0
1952	0.004573	0.04357	0.003022	0.001942	0.001942	0.001942	0	0	0
1953	0.0054	0.06714	0.003796	0.00215	0.00215	0.00215	0	0	0
1954	0.006461	0.09436	0.004532	0.002317	0.002317	0.002317	0	0	0
1955	0.006854	0.1356	0.005516	0.00252	0.00252	0.00252	0	0	0
1956	0.006419	0.1397	0.005653	0.002497	0.002497	0.002497	0	0	0
1957	0.007176	0.1673	0.00616	0.002578	0.002578	0.002578	0	0	0
1958	0.007762	0.1523	0.005891	0.002495	0.002495	0.002495	0	0	0
1959	0.01187	0.1836	0.006426	0.00254	0.00254	0.00254	0	0	0
1960	0.01744	0.1966	0.006569	0.002481	0.002481	0.002481	0	0	0
1961	0.01789	0.1394	0.00547	0.002255	0.002255	0.002255	0	0	0
1962	0.01261	0.1015	0.004484	0.002037	0.002037	0.002037	0	0	0
1963	0.01637	0.1429	0.005321	0.002189	0.002189	0.002189	0	0	0
1964	0.02021	0.2457	0.007047	0.002572	0.002572	0.002572	0	0	0
1965	0.01965	0.2403	0.006982	0.002602	0.002602	0.002602	0	0	0
1966	0.02615	0.2575	0.007158	0.002662	0.002662	0.002662	0	0	0
1967	0.03342	0.3209	0.007892	0.002812	0.002812	0.002812	0	0	0
1968	0.03595	0.3376	0.008162	0.002867	0.002867	0.002867	0	0	0
1969	0.02888	0.3116	0.007783	0.00279	0.00279	0.00279	0	0	0
1970	0.04222	0.353	0.008308	0.002891	0.002891	0.002891	0	0	0
1971	0.0584	0.5584	0.01046	0.003235	0.003235	0.003235	0	0	0
1972	0.07545	0.6194	0.01117	0.003358	0.003358	0.003358	0	0	0
1973	0.08743	0.6501	0.01137	0.003394	0.003394	0.003394	0	0	0
1974	0.113	0.5534	0.01037	0.003239	0.003239	0.003239	0	0	0
1975	0.1415	0.5178	0.009877	0.003164	0.003164	0.003164	0	0	0
1976	0.1162	0.2442	0.006521	0.002546	0.002546	0.002546	0	0	0
1977	0.11	0.1482	0.004843	0.002162	0.002162	0.002162	0	0	0
1978	0.134	0.134	0.004674	0.002104	0.002104	0.002104	0	0	0
1979	0.1611	0.1257	0.004627	0.00208	0.00208	0.00208	0	0	0
1980	0.1935	0.1143	0.004534	0.002049	0.002049	0.002049	0	0	0
1981	0.3584	0.2159	0.006175	0.002327	0.002327	0.002327	0	0	0
1982	0.3599	0.2117	0.006176	0.002307	0.002307	0.002307	0	0	0
1983	0.3491	0.2367	0.006673	0.002387	0.002387	0.002387	0	0	0
1984	0.2342	0.2176	0.006597	0.002386	0.002386	0.002386	0	0	0
1985	0.1649	0.2782	0.007861	0.002611	0.002611	0.002611	0	0	0
1986	0.133	0.2836	0.008388	0.002665	0.002665	0.002665	0	0	0
1987	0.1617	0.3673	0.01019	0.002921	0.002921	0.002921	0	0	0
1988	0.159	0.4611	0.01215	0.003159	0.003159	0.003159	0	0	0
1989	0.1483	0.3947	0.01223	0.003132	0.003132	0.003132	0	0	0
1990	0.1286	0.3404	0.01258	0.00312	0.00312	0.00312	0	0	0
1991	0.1569	0.2846	0.01319	0.00316	0.00316	0.00316	0	0	0
1992	0.2388	0.3333	0.01573	0.003438	0.003438	0.003438	0	0	0
1993	0.2626	0.3104	0.0167	0.003561	0.003561	0.003561	0	0	0
1994	0.195	0.1725	0.01346	0.003207	0.003207	0.003207	0	0	0
1995	0.1749	0.1481	0.01342	0.003202	0.003202	0.003202	0	0	0
1996	0.09644	0.093	0.01154	0.002921	0.002921	0.002921	0	0	0
1997	0.04043	0.03453	0.00814	0.002431	0.002431	0.002431	0	0	0
1998	0.03333	0.03114	0.008275	0.002395	0.002395	0.002395	0	0	0
1999	0.03528	0.02247	0.007659	0.002316	0.002316	0.002316	0	0	0
2000	0.03997	0.02351	0.007895	0.002098	0.002098	0.002098	0	0	0
2001	0.03036	0.009731	0.005271	0.001581	0.001581	0.001581	0	0	0
2002	0.03735	0.02208	0.008123	0.001537	0.001537	0.001537	0	0	0
2003	0.04082	0.03278	0.009029	0.001142	0.001142	0.001142	0	0	0
2004	0.04949	0.0383	0.009689	0.0009545	0.0009545	0.0009545	0	0	0
2005	0.06584	0.04952	0.009561	0.0006437	0.0006437	0.0006437	0	0	0
2006	0.05464	0.02588	0.006404	0.0004516	0.0004516	0.0004516	0	0	0
2007	0.04085	0.01425	0.003372	0.0001712	0.0001712	0.0001712	0	0	0
2008	0.04152	0.01432	0.002531	9.77e-05	9.77e-05	9.77e-05	0	0	0
2009	0.03639	0.01422	0.002467	0.0001255	0.0001255	0.0001255	0	0	0
2010	0.03767	0.01371	0.00274	0.0002387	0.0002387	0.0002387	0	0	0
2011	0.04255	0.01602	0.00253	0.0002305	0.0002305	0.0002305	0	0	0
2012	0.04579	0.02216	0.00343	0.0003164	0.0003164	0.0003164	0	0	0
2013	0.03747	0.01931	0.003357	0.0003041	0.0003041	0.0003041	0	0	0

2014	0.04587	0.01996	0.003135	0.000277	0.000277	0.000277	0	0	0
2015	0.06133	0.02184	0.002402	0.0001595	0.0001595	0.0001595	0	0	0
2016	0.07802	0.02451	0.002315	0.0001579	0.0001579	0.0001579	0	0	0
2017	0.0671	0.01677	0.00139	8.47e-05	8.47e-05	8.47e-05	0	0	0
2018	0.06789	0.01135	0.001016	9.063e-05	9.063e-05	9.063e-05	0	0	0
2019	0.05849	0.007761	0.0009039	0.0001416	0.0001416	0.0001416	0	0	0
2020	0.06512	0.005598	0.00106	0.0002877	0.0002877	0.0002877	0	0	0
2021	0.06306	0.009093	0.001533	0.0004647	0.0004647	0.0004647	0	0	0
2022	0.0631	0.0091	0.001533	0.0004648	0.0004648	0.0004648	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	0.0002746	0.0008232	3.348e-07	2.512e-07	2.512e-07	2.512e-07	0	0
1948	0	0.0002708	0.0008147	3.243e-07	2.436e-07	2.436e-07	2.436e-07	0	0
1949	0	0.0003121	0.0009048	4.472e-07	3.322e-07	3.322e-07	3.322e-07	0	0
1950	0	0.0003591	0.001004	6.147e-07	4.515e-07	4.515e-07	4.515e-07	0	0
1951	0	0.0004122	0.001111	8.404e-07	6.105e-07	6.105e-07	6.105e-07	0	0
1952	0	0.0004707	0.001226	1.136e-06	8.167e-07	8.167e-07	8.167e-07	0	0
1953	0	0.0005346	0.001347	1.516e-06	1.079e-06	1.079e-06	1.079e-06	0	0
1954	0	0.0006054	0.001477	2.008e-06	1.415e-06	1.415e-06	1.415e-06	0	0
1955	0	0.0006854	0.001618	2.66e-06	1.856e-06	1.856e-06	1.856e-06	0	0
1956	0	0.0007744	0.001771	3.506e-06	2.423e-06	2.423e-06	2.423e-06	0	0
1957	0	0.0008711	0.001931	4.573e-06	3.132e-06	3.132e-06	3.132e-06	0	0
1958	0	0.0009788	0.002104	5.951e-06	4.038e-06	4.038e-06	4.038e-06	0	0
1959	0	0.001097	0.002289	7.7e-06	5.178e-06	5.178e-06	5.178e-06	0	0
1960	0	0.001228	0.002486	9.918e-06	6.611e-06	6.611e-06	6.611e-06	0	0
1961	0	0.001368	0.002691	1.265e-05	8.36e-06	8.36e-06	8.36e-06	0	0
1962	0	0.001517	0.002902	1.594e-05	1.045e-05	1.045e-05	1.045e-05	0	0
1963	0	0.001706	0.003165	2.081e-05	1.352e-05	1.352e-05	1.352e-05	0	0
1964	0	0.001912	0.003442	2.69e-05	1.732e-05	1.732e-05	1.732e-05	0	0
1965	0	0.002134	0.003731	3.445e-05	2.199e-05	2.199e-05	2.199e-05	0	0
1966	0	0.00237	0.00403	4.362e-05	2.761e-05	2.761e-05	2.761e-05	0	0
1967	0	0.002629	0.004347	5.504e-05	3.456e-05	3.456e-05	3.456e-05	0	0
1968	0	0.00293	0.004708	7.031e-05	4.377e-05	4.377e-05	4.377e-05	0	0
1969	0	0.003253	0.005084	8.898e-05	5.493e-05	5.493e-05	5.493e-05	0	0
1970	0	0.003606	0.005484	0.0001122	6.872e-05	6.872e-05	6.872e-05	0	0
1971	0	0.003997	0.005914	0.0001414	8.591e-05	8.591e-05	8.591e-05	0	0
1972	0	0.004435	0.006384	0.0001789	0.0001078	0.0001078	0.0001078	0	0
1973	0	0.00489	0.006858	0.0002227	0.0001331	0.0001331	0.0001331	0	0
1974	0	0.005372	0.007346	0.000275	0.0001632	0.0001632	0.0001632	0	0
1975	0	0.005885	0.007852	0.0003372	0.0001987	0.0001987	0.0001987	0	0
1976	0	0.006407	0.008352	0.0004076	0.0002386	0.0002386	0.0002386	0	0
1977	0	0.006937	0.008847	0.0004861	0.0002827	0.0002827	0.0002827	0	0
1978	0	0.008	0.009846	0.0006745	0.0003879	0.0003879	0.0003879	0	0
1979	0	0.009175	0.01091	0.0009243	0.0005254	0.0005254	0.0005254	0	0
1980	0	0.0104	0.01199	0.001232	0.0006929	0.0006929	0.0006929	0	0
1981	0	0.01188	0.01324	0.001676	0.0009387	0.0009387	0.0009387	0	0
1982	0	0.01373	0.01476	0.002356	0.001311	0.001311	0.001311	0	0
1983	0	0.01567	0.0163	0.003204	0.001779	0.001779	0.001779	0	0
1984	0	0.01784	0.01796	0.004343	0.002404	0.002404	0.002404	0	0
1985	0	0.02076	0.02013	0.006183	0.0034	0.0034	0.0034	0	0
1986	0	0.0231	0.0218	0.007889	0.004314	0.004314	0.004314	0	0
1987	0	0.02542	0.02341	0.00981	0.005344	0.005344	0.005344	0	0
1988	0	0.02712	0.02454	0.01128	0.006116	0.006116	0.006116	0	0
1989	0	0.02886	0.02569	0.01294	0.006962	0.006962	0.006962	0	0
1990	0	0.02999	0.0264	0.01395	0.007428	0.007428	0.007428	0	0
1991	0	0.03267	0.02819	0.0171	0.008971	0.008971	0.008971	0	0
1992	0	0.0338	0.02889	0.01844	0.00957	0.00957	0.00957	0	0
1993	0	0.03575	0.03014	0.02118	0.01084	0.01084	0.01084	0	0
1994	0	0.03688	0.03087	0.0231	0.0117	0.0117	0.0117	0	0
1995	0	0.03814	0.0316	0.02506	0.01254	0.01254	0.01254	0	0
1996	0	0.03727	0.03092	0.02338	0.01155	0.01155	0.01155	0	0
1997	0	0.03588	0.03003	0.02128	0.01036	0.01036	0.01036	0	0
1998	0	0.03237	0.02756	0.01593	0.007825	0.007825	0.007825	0	0
1999	0	0.0304	0.0264	0.01399	0.006747	0.006747	0.006747	0	0
2000	0	0.02854	0.02525	0.01228	0.005768	0.005768	0.005768	0	0

2001	0	0.01532	0.01554	0.002516	0.001052	0.001052	0.001052	0	0
2002	0	0.009766	0.01106	0.0008565	0.0003715	0.0003715	0.0003715	0	0
2003	0	0.01693	0.0173	0.003825	0.001835	0.001835	0.001835	0	0
2004	0	0.01685	0.01748	0.00392	0.001888	0.001888	0.001888	0	0
2005	0	0.0171	0.01759	0.003803	0.001555	0.001555	0.001555	0	0
2006	0	0.01432	0.01528	0.002428	0.0008904	0.0008904	0.0008904	0	0
2007	0	0.01054	0.01203	0.001109	0.0003766	0.0003766	0.0003766	0	0
2008	0	0.007676	0.0095	0.000553	0.0001817	0.0001817	0.0001817	0	0
2009	0	0.00525	0.007154	0.0002441	8.59e-05	8.59e-05	8.59e-05	0	0
2010	0	0.004677	0.006669	0.0001998	6.709e-05	6.709e-05	6.709e-05	0	0
2011	0	0.00634	0.008766	0.0005363	0.0001714	0.0001714	0.0001714	0	0
2012	0	0.006805	0.009463	0.0007347	0.0002318	0.0002318	0.0002318	0	0
2013	0	0.006421	0.009278	0.0007343	0.0002139	0.0002139	0.0002139	0	0
2014	0	0.006815	0.01004	0.001079	0.0003103	0.0003103	0.0003103	0	0
2015	0	0.008908	0.01274	0.002698	0.0008476	0.0008476	0.0008476	0	0
2016	0	0.00579	0.009205	0.001004	0.0003068	0.0003068	0.0003068	0	0
2017	0	0.006693	0.01039	0.001505	0.0004417	0.0004417	0.0004417	0	0
2018	0	0.005684	0.009259	0.001076	0.0002932	0.0002932	0.0002932	0	0
2019	0	0.004511	0.007794	0.0006261	0.0001467	0.0001467	0.0001467	0	0
2020	0	0.006705	0.01092	0.002064	0.0005449	0.0005449	0.0005449	0	0
2021	0	0.006896	0.01135	0.002483	0.000754	0.000754	0.000754	0	0
2022	0	0.006897	0.01135	0.002484	0.0007542	0.0007542	0.0007542	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	36093932	20750964	62781272	7806700	6115230	9966031	4783956	3561853	6425373	852843	731764	993954	0.1367	0.09944	0.1878	581760
1948	33922411	20543216	56015083	6761523	5333341	8572150	3961873	2975042	5276038	666626	579015	767493	0.1297	0.09565	0.1758	502100
1949	29597819	18081727	48448407	6409820	5111458	8037979	3712925	2822158	4884849	730549	634505	841131	0.1551	0.1153	0.2088	508500
1950	40627635	25311507	65211634	6214591	5012141	7705519	3587598	2771509	4643989	648487	570728	736839	0.1587	0.12	0.21	491700
1951	39440118	24747664	62855343	6211033	5069713	7609292	3301723	2578337	4228065	751339	660716	854391	0.1958	0.1501	0.2553	600400
1952	39202102	24781685	62013731	6090145	4985950	7438877	3199364	2502030	4091049	837855	742819	945049	0.2212	0.17	0.2877	664400
1953	43036414	27909105	66363036	5900935	4838324	7196920	3013831	2349901	3865345	835273	739918	942916	0.229	0.1759	0.2982	698500
1954	4e+07	26126913	61254368	5755651	4724400	7012004	2765201	2135657	3580321	953183	842371	1078571	0.2769	0.2109	0.3636	762900
1955	34619911	22763194	52652463	5501984	4503231	6722246	2798729	2163949	3619717	841968	733879	965976	0.2408	0.1834	0.3161	806400
1956	25968979	17059605	39531269	5085817	4176056	6193772	2641803	2044607	3413431	837557	731539	958939	0.2481	0.1897	0.3243	675200
1957	62093137	40422899	95380532	5042123	4154980	6118682	2392825	1851678	3092120	800448	702187	912459	0.2693	0.2059	0.3521	682900
1958	26115891	17252338	39533178	5036873	4129668	6143372	2017832	1563482	2604218	745782	628547	884884	0.2447	0.1881	0.3182	670500
1959	28657528	18538553	44299784	5621867	4616942	6845526	2984292	2310032	3855356	1148571	963972	1368520	0.2946	0.2275	0.3815	784500
1960	12186191	7886906	18829087	4736854	3906133	5744247	2601400	2026196	3339894	820539	702398	958551	0.2419	0.1875	0.3121	696200
1961	55563221	36047405	85644764	4826076	4021122	5792166	2552188	2017234	3229007	733169	633660	848305	0.2631	0.2074	0.3338	696700
1962	28262748	18770736	42554695	4525951	3780100	5418967	1773922	1390483	2263098	713231	616139	825622	0.3153	0.2487	0.3997	627800
1963	32170955	21649861	47804940	5263581	4396523	6301636	2899811	2315315	3631862	600576	503602	716223	0.1832	0.1468	0.2286	716000
1964	34142629	2.3e+07	50674338	5171348	4473157	5978515	2603409	2153249	3147679	911783	776372	1070811	0.2799	0.2308	0.3393	871200
1965	17859019	12037346	26496252	4572139	4034166	5181853	1959759	1650930	2326360	1278052	1109727	1471909	0.5326	0.4471	0.6344	1168800
1966	17969166	12186880	26494963	3463416	3059421	3920758	1600123	1353461	1891738	931170	812184	1067588	0.4918	0.4155	0.5822	895500
1967	23777353	16145329	35017094	2667372	2376179	2994251	964368	824310	1128223	860297	751767	984494	0.6954	0.5962	0.8109	695500
1968	23298271	15784272	34389261	2202290	1935132	2506330	511241	436339	599001	819977	707699	950069	1.078	0.9426	1.233	717800
1969	12696599	8509512	18943933	1722488	1480694	2003766	467714	379942	575762	538552	450039	644474	0.9113	0.7905	1.051	546700
1970	23081631	15495273	34382206	1672354	1440617	1941369	457474	370264	565224	534022	449851	633942	0.9502	0.8271	1.092	563100
1971	18967092	12805037	28094460	1533986	1303646	1805024	287656	235431	351466	549383	442878	681502	1.435	1.267	1.624	520100
1972	12824572	8651831	19009807	1374682	1170496	1614487	345782	281208	425183	425157	335495	538781	0.5861	0.4998	0.6873	497500
1973	6901059	4669081	10199997	1112375	965289	1281873	282030	233238	341028	447492	371216	539439	0.9359	0.8138	1.076	484000
1974	10626801	7074419	15962994	777312	674640	895609	192645	160441	231313	275134	233389	324346	0.8967	0.7775	1.034	275100
1975	2595192	1718950	3918101	597433	501848	711225	103686	85384	125911	248600	199937	309107	1.194	1.027	1.389	312800
1976	3292902	2111802	5134575	448129	369375	543675	141736	106349	188897	152782	125376	186179	0.8639	0.676	1.104	174800
1977	4042815	2535823	6445384	317952	254294	397546	113902	82658	156957	54202	45074	65178	0.3209	0.2334	0.4411	46000
1978	4535163	2788080	7377014	375401	294295	478860	138961	103508	186557	48860	31926	74776	0.2177	0.1336	0.3548	11000
1979	8428613	5402990	13148557	498125	400762	619143	183352	142155	236487	60571	39662	92503	0.176	0.1078	0.2873	25100
1980	13137089	8936495	19312170	683425	564546	827337	213538	171016	266632	79982	62708	102015	0.1579	0.1236	0.2016	70764
1981	27450227	18640594	40423334	1123375	924057	1365684	284251	228112	354205	147857	114971	190150	0.2482	0.1975	0.312	174879
1982	46179507	31548502	67595822	1731447	1419892	2111364	408065	331007	503061	247305	180797	338277	0.1792	0.1444	0.2225	275079
1983	45190849	31391200	65056859	2333065	1954868	2784429	571394	467064	699029	379442	289046	498107	0.2614	0.2142	0.3191	387202
1984	45580424	31914549	65098053	3061456	2614637	3584633	893442	729572	1094120	469514	388575	567313	0.3522	0.292	0.4249	428631
1985	56719079	39554113	81332982	3512723	3023449	4081174	962028	796377	1162135	620070	529873	725620	0.4519	0.3759	0.5434	613780
1986	69322285	48270038	99556150	4001766	3427586	4672132	1000966	833509	1202067	741974	600663	916531	0.4291	0.3565	0.5166	671488
1987	60793072	42314279	87341618	4003144	3453628	4640095	1211476	1007591	1456618	768372	636025	928259	0.39	0.3248	0.4684	792058

1988	38026105	26617608	54324366	3925626	3419273	4506963	1561678	1305377	1868301	958261	777056	1181723	0.3785	0.317	0.452	887686
1989	30342238	21222837	43380223	3475715	3088307	3911720	1600704	1377271	1860384	811312	699123	941504	0.3655	0.3086	0.4328	787899
1990	27295514	19059205	39091090	3462435	3078666	3894043	1724868	1487289	2e+06	675060	580688	784770	0.2959	0.2486	0.3522	645229
1991	29157687	20417792	41638720	3276983	2916766	3681687	1525114	1319749	1762435	670407	581244	773247	0.3156	0.2652	0.3756	658008
1992	50157281	36361750	69186790	3250500	2884590	3662825	1166146	1005388	1352610	691748	596592	802081	0.3775	0.3172	0.4493	716799
1993	52043143	37443145	72336039	2995019	2628535	3412599	824909	702943	968037	671620	576809	782015	0.4483	0.375	0.5358	671397
1994	41472045	29776970	57760428	2886604	2498625	3334826	880451	749793	1033877	626099	532560	736068	0.4443	0.3717	0.5311	568234
1995	42144693	30152157	58907069	2793145	2415751	3229497	931536	786521	1103288	573780	494810	665353	0.404	0.3345	0.4879	579371
1996	33388610	24072349	46310364	2753448	2376702	3189914	1104248	934102	1305386	284224	244091	330956	0.1969	0.1613	0.2402	275098
1997	28057040	20097033	39169836	2739853	2383987	3148842	1227831	1044893	1442797	264169	230710	302480	0.1778	0.1462	0.2162	248023
1998	18544104	13548403	25381869	3032252	2654084	3464303	1395001	1198220	1624098	363151	318196	414457	0.2251	0.1862	0.2721	385577
1999	57325166	41809047	78599607	3133522	2755437	3563486	1502576	1291213	1748537	351407	306974	402270	0.2083	0.1731	0.2505	370877
2000	37429320	27453528	51030017	3766491	3281901	4322632	1530044	1315958	1778958	364028	320238	413807	0.207	0.1718	0.2493	382794
2001	69204784	50171172	95459243	4189548	3658685	4797437	1952112	1678835	2269873	349723	307959	397151	0.1774	0.1468	0.2143	358657
2002	35081327	25677026	47929986	5029686	4380141	5775554	2367734	2038580	2750034	374505	328987	426321	0.1628	0.1349	0.1965	371955
2003	19127720	14039542	26059944	5334304	4658571	6108054	2375503	2057385	2742808	477853	421173	542162	0.1892	0.1576	0.2271	480107
2004	23203294	1.7e+07	31676550	4616741	4076342	5228779	2338856	2031217	2693089	562971	496012	638968	0.2251	0.1869	0.2711	570865
2005	20310298	14962250	27569931	3875858	3439402	4367700	2124185	1835073	2458847	647947	570412	736020	0.2796	0.2329	0.3356	666404
2006	20874443	15323186	28436800	3262684	2894901	3677193	1720898	1487726	1990615	515942	455186	584807	0.256	0.2131	0.3075	524366
2007	25178929	18329712	34587476	2696293	2386090	3046823	1354354	1168274	1570071	381440	336365	432556	0.2222	0.1843	0.2679	408528
2008	21984090	15952790	30295654	2754883	2416814	3140243	1443327	1245725	1672273	246991	219533	277883	0.1368	0.1134	0.165	259031
2009	34450991	25110514	47265889	3191925	2787145	3655491	1776606	1529237	2063989	172196	152960	193851	0.07719	0.06363	0.09363	172685
2010	27158438	19871035	37118386	3794013	3315856	4341122	1877237	1611156	2187262	177592	157888	199755	0.0769	0.06355	0.09305	187508
2011	24342085	17880524	33138688	3824287	3368957	4341157	2239366	1948964	2573038	227127	201891	255518	0.1001	0.08334	0.1202	224148
2012	23086179	16918487	31502325	3775423	3346466	4259364	2301383	2005261	2641232	416621	369392	469890	0.1781	0.1485	0.2135	437236
2013	31571200	22987715	43359712	3669010	3264597	4123523	2106892	1837927	2415217	484998	430478	546423	0.2087	0.1743	0.2498	511733
2014	48305720	34924132	66814618	3910370	3471007	4405347	2079890	1812586	2386614	489338	435072	550373	0.2028	0.1693	0.2431	517593
2015	12656662	9192676	17425948	4095304	3603970	4653623	1946063	1692792	2237228	489486	435179	550570	0.2128	0.177	0.2559	494072
2016	22792622	16712055	31085562	4058123	3561287	4624272	2240807	1937000	2592265	550756	489030	620274	0.2333	0.1938	0.2809	564880
2017	13604031	9911096	18672976	3480735	3061887	3956878	2052594	1767702	2383402	447546	392381	510467	0.1883	0.1566	0.2264	499145
2018	23215739	16959447	31779961	3287728	2897787	3730141	1825019	1565915	2126996	533923	465103	612925	0.2177	0.181	0.2619	604449
2019	19791826	14334239	27327323	2784406	2457601	3154669	1557280	1338373	1811991	421732	369244	481681	0.185	0.1529	0.2238	451542
2020	23548414	16746655	33112750	2691893	2361023	3069131	1471011	1257982	1720114	406600	358551	461089	0.2003	0.165	0.2433	434000
2021	18229682	12459331	26672482	2521102	2166633	2933564	1310003	1094101	1568510	367132	324083	415899	0.2037	0.1634	0.2539	373167
2022	16404915	8957164	30045363	2406412	1925598	3007285	1300630	987661	1712774	340192	183379	631098	0.2037	0.1018	0.4075	.

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 May 02 09:53:59 2022"

Slot "range":
     min      max plusgroup   minyear   maxyear   minfbar   maxfbar
       0        8         8      1947      2022         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 10 10 10 -1 -1 -1
  catch C  -1 11 12 13 14 14 14 -1 -1
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  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  4  4  4 -1 -1 -1
  catch C  -1  5  6  7  7  7  7 -1 -1
  HERAS    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q1  -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS0    -1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-ORSH -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  -1 -1 -1 -1 -1 -1 -1 -1 -1
  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  5  5  5 -1 -1 -1
  catch C  -1  6  7  8  8  8  8 -1 -1
  HERAS    -1  9 10 11 12 12 12 13 13
  IBTS-Q1  -1 14 -1 -1 -1 -1 -1 -1 -1
  IBTS0    15 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3  16 16 17 17 17 17 -1 -1 -1
  LAI-ORSH 18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  18 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  18 -1 -1 -1 -1 -1 -1 -1 -1
  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
```

```
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Levels: ID AR US

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

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

Slot "residuals":
[1] TRUE

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

Table 2.7.1. North Sea herring. Intermediate year (2022) assumptions for the stock.

Variable	Value	Notes
Fages (wr) 2–6 (2022)	0.278	Based on estimated catch 2021
SSB (2022)	1 233 347	Calculated based on catch constraint (in tonnes)
Rage (wr) 0 (2022)	16 619 677	Estimated by assessment model (in thousands)
Rage (wr) 0 (2023)	22 556 738	Weighted mean over 2011–2020 (in thousands)
Total catch (2022)	451 651	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 (2021), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	427 628	
	B-fleet TAC	8 174	
	C-fleet TAC	25 021	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	0.9546	Taken from ImY as % of C-fleet TAC
	C-fleet transfer ImY	23 885	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	0.0136	Value from terminal year
	B-fleet uptake	0.78	Average over the last 3 years (2018-2020)
	C-fleet NSAS/WBSS split	0.3551	Average over the last 3 years (2018-2020)
	D-fleet NSAS/WBSS split	0.7	Average over the last 3 years (2018-2020)
	D-fleet uptake	0.0707	Average over the last 3 years (2018-2020)
F by fleet and total	$F_{(wr)\ 2–6}$ A-fleet	0.269	
	$F_{(wr)\ 0–1}$ B-fleet	0.048	
	$F_{(wr)\ 1–3}$ C-fleet	0	
	$F_{(wr)\ 0–1}$ D-fleet	0	
	$F_{(wr)\ 2–6}$	0.27	
	$F_{(wr)\ 0–1}$	0.051	
NSAS catches by fleet	Catches A-fleet	445371	Fleet TAC (427628 t) + what is transferred from the C fleet in 3a to the North sea (23885 t) scaled by the 3 year average proportion of NSAS in A fleet catch (98.6%, 2019-2021)
	Catches B-fleet	7099	Fleet TAC (8174 t) + a 50% transfer from the F fleet TAC (6659 t) in 3a to the North Sea scaled with the fleet uptake in 2021 (78%).
	Catches C-fleet	403	Catches corresponding to 1136 t catch in 3a scaled by the 3 year average proportion of NSAS in the C fleet catch (35.5%, 2019-2021)
	Catches D-fleet	0	Total catch set at 0 t because considered negligible

value	description	basis
0.9546	C-fleet transfer FcY (%)	Taken from ImY as % of C-fleet TAC
23885	C-fleet transfer ImY (tonnes)	Value for the Intermediate year
0.5	D-fleet transfer ImY (tonnes)	Value for the Intermediate year
0.3551	C-fleet NSAS/WBSS split	Average over the last 3 years
0.7	D-fleet NSAS/WBSS split	Average over the last 3 years
0.0136	WBSS/NSAS split in the north sea	Value from terminal year
0.78	B-fleet uptake	Average over the last 3 years
0.0707	D-fleet uptake	Average over the last 3 years

Table 2.7.3. North Sea herring. reference points.

wg	fmsy	Fsq	Flim	Fpa	Blim	Bpa	msyBtrigger
IBPNSherring2021	0.31	.	0.4	0.31	874198	956483	1232828
WKPELA2018	0.26	.	0.34	0.3	8e+05	9e+05	1400000

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

TACs to catches variables.

value	description	basis
0.9546	C-fleet transfer FcY (%)	Taken from ImY as % of C-fleet TAC
23885	C-fleet transfer ImY (tonnes)	Value for the Intermediate year
0.5	D-fleet transfer ImY (tonnes)	Value for the Intermediate year
0.3551	C-fleet NSAS/WBSS split	Average over the last 3 years
0.7	D-fleet NSAS/WBSS split	Average over the last 3 years
0.0136	WBSS/NSAS split in the north sea	Value from terminal year
0.78	B-fleet uptake	Average over the last 3 years
0.0707	D-fleet uptake	Average over the last 3 years

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
intermediate year	0.1847	0.03036	0.003506	0.001744	0.1864	0.03559	360884	6103	3330	350.6	1383486	.
fmsyAR_transfer	0.3143	0.05042	0.003278	0.002043	0.3161	0.05692	529663	8653	3330	350.6	1275260	1274284
fmsyAR_transfer_Btarget	0.3144	0.04291	0.003278	0.002034	0.3161	0.0494	529761	7396	3330	350.6	1275250	1274562
fmsyAR_no_transfer	0.307	0.05044	0.006308	0.002044	0.31	0.05854	519293	8653	6405	350.6	1280821	1281588
fmsyAR_no_transfer_Btarget	0.307	0.04191	0.006307	0.002034	0.31	0.05	519391	7224	6405	350.6	1280819	1281919
mpA	0.2173	0.03454	0.003509	0.001735	0.2191	0.04004	378230	7613	3615	301	1367895	1445014
mpAC	0.2173	0.03454	0.003509	0.001735	0.2191	0.04004	378230	7613	3615	301	1367895	1445014
mpAD	0.2173	0.03454	0.003509	0.001735	0.2191	0.04004	378230	7613	3615	301	1367895	1445014
mpB	0.2219	0.03693	0.003509	0.001734	0.2236	0.04247	385226	8128	3613	300.5	1363333	1436118
fmsy	0.307	0.05044	0.006308	0.002044	0.31	0.05854	519293	8653	6405	350.6	1280821	1281588
nf	0	0	0	0	0	0	0	0	0	0	1614283	1998030
tacro	0.1968	0.03234	0.006206	0.002018	0.1997	0.03943	356357	5619	6405	350.6	1387630	1481508
-15%	0.1638	0.02691	0.006175	0.00201	0.1666	0.0337	302903	4694	6405	350.6	1422072	1551168
+15%	0.2313	0.03801	0.006238	0.002026	0.2342	0.04542	409811	6577	6405	350.6	1352893	1413893
fsq	0.1836	0.03017	0.006194	0.002015	0.1864	0.03714	335257	5250	6405	350.6	1401261	1508758
fpa	0.307	0.05044	0.006308	0.002044	0.31	0.05854	519293	8653	6405	350.6	1280821	1281588
flim	0.3968	0.06521	0.006391	0.002065	0.4	0.07413	636961	11072	6405	350.6	1201995	1148262
bpa	0.7391	0.1214	0.006701	0.002145	0.7428	0.1335	991541	19849	6405	350.6	956483	797441
blim	0.8822	0.145	0.006828	0.002179	0.8861	0.1583	1107178	23328	6405	350.6	874198	698338
MSYBtrigger	0.3607	0.05927	0.006358	0.002056	0.3638	0.06787	591183	10106	6405	350.6	1232828	1199070

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	total_catch	SSB1	SSB2	SSB_change	TAC_change	advice_change
fmsyAR_no_transfer	0.31	0.051	0	0	0.31	0.053	523438	8745	0	0	532183	1280829	1286757	-7.4	46.9	45.7
fmsy	0.31	0.051	0	0	0.31	0.053	523438	8745	0	0	532183	1280829	1286757	-7.4	46.9	45.7
nf	0	0	0	0	0	0	0	0	0	0	0	1614283	1998030	16.7	-100	-100
tacro	0.197	0.032	0.006	0.002	0.2	0.039	356357	5619	6405	351	368732	1387630	1481508	0.3	0	-0.8
fsq	0.186	0.031	0	0	0.186	0.032	339749	5334	0	0	345083	1401049	1513391	1.3	-4.7	-5.5
fpa	0.31	0.051	0	0	0.31	0.053	523438	8745	0	0	532183	1280829	1286757	-7.4	46.9	45.7
flim	0.4	0.066	0	0	0.4	0.069	640910	11169	0	0	652079	1202140	1153649	-13.1	79.9	78.3
bpa	0.743	0.122	0	0	0.744	0.128	995805	19986	0	0	1015791	956483	802300	-30.9	179.4	177.1
blim	0.886	0.146	0	0	0.887	0.153	1111504	23480	0	0	1134984	874198	703021	-36.8	211.9	209.3
MSYBtrigger	0.364	0.06	0	0	0.364	0.063	595343	10204	0	0	605547	1232828	1204229	-10.9	67.1	65.7
fmsyAR_no_transfer_Btarget	0.31	0.047	0	0	0.31	0.05	523477	8162	0	0	531639	1280829	1286893	-7.4	46.9	45.7
fmsyAR_transfer_sq TAC C&D	0.314	0.05	0.003	0.002	0.316	0.057	529663	8653	3330	351	541997	1275260	1274284	-7.8	48.6	47.4
fmsyAR_no_transfer_sq C&D	0.307	0.05	0.006	0.002	0.31	0.059	519293	8653	6405	351	534702	1280821	1281588	-7.4	45.7	44.5

Table 2.7.6. 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	0.279	0.031	0	0	0.28	0.034	391050	8700	0	0	399750	1113013	1012309	-9.8	-8.6	-25.3
fmsy	0.309	0.034	0	0	0.31	0.038	426243	9610	0	0	435853	1089257	969866	-11.7	-0.3	-18.6
nf	0	0	0	0	0	0	0	0	0	0	0	1365644	1551302	10.7	-100	-100
tacro	0.311	0.035	0.011	0.001	0.317	0.045	427628	9650	8885	330	446493	1083444	954653	-12.2	0	-18.3
fsq	0.278	0.031	0	0	0.278	0.034	388860	8644	0	0	397504	1114485	1014983	-9.6	-9.1	-25.7
fpa	0.309	0.034	0	0	0.31	0.038	426243	9610	0	0	435853	1089257	969866	-11.7	-0.3	-18.6
flim	0.399	0.044	0	0	0.4	0.048	524742	12297	0	0	537039	1021782	856285	-17.2	22.7	0.2
bpa	0.493	0.055	0	0	0.494	0.06	618010	15059	0	0	633069	956483	755742	-22.4	44.5	18.1
blim	0.623	0.069	0	0	0.624	0.075	732695	18799	0	0	751494	874198	641331	-29.1	71.3	40
MSYBtrigger	0.138	0.015	0	0	0.139	0.017	209423	4369	0	0	213792	1232828	1247135	0	-51	-60
fmsyAR_no_transfer_Btarget	0.279	0.047	0	0	0.28	0.05	390696	13096	0	0	403792	1113016	1011268	-9.8	-8.6	-25.4
fmsyAR_transfer_sq TAC C&D	0.295	0.03	0	0.001	0.295	0.035	408945	8522	0	330	417797	1100972	990705	-10.7	-4.4	-21.9
fmsyAR_no_transfer_sq C&D	0.274	0.03	0.011	0.001	0.28	0.04	383924	8522	8885	330	401661	1112962	1007229	-9.8	-10.2	-26.7

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

Framework ^	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)

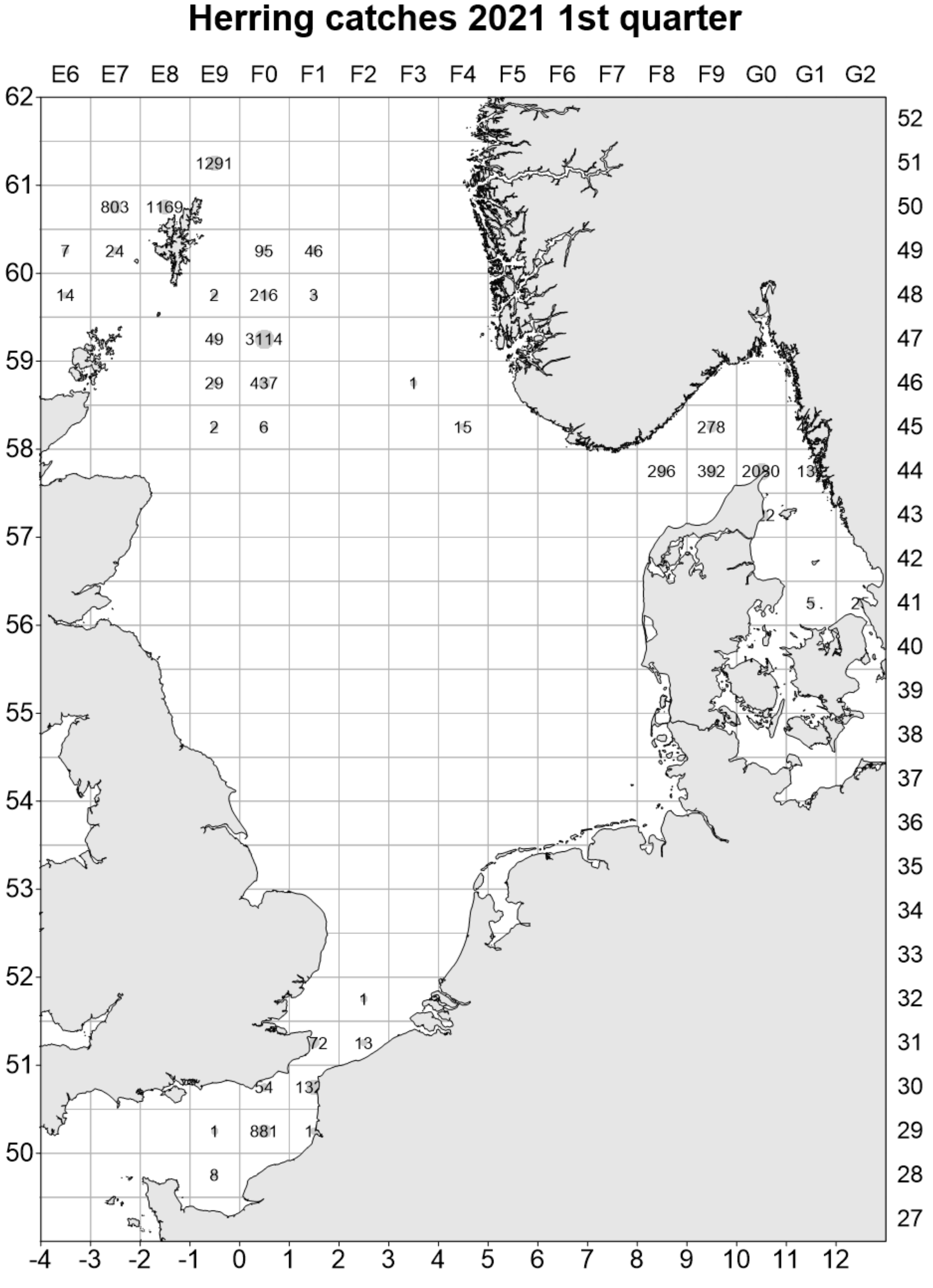


Figure 2.1.1a. Herring catches in the North Sea in the 1st quarter of 2021 (in tonnes) by statistical rectangle.

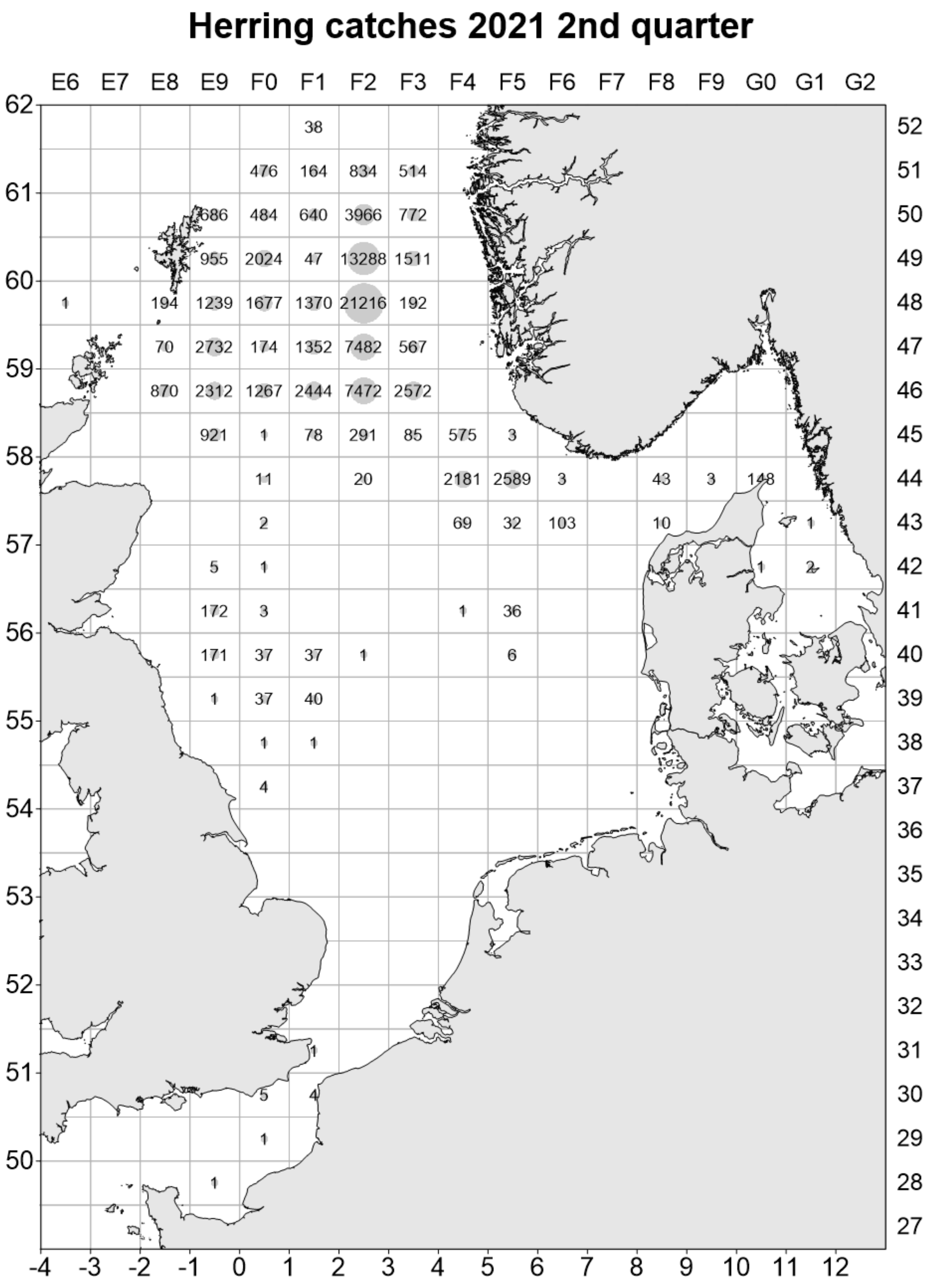


Figure 2.1.1b. Herring catches in the North Sea in the second quarter of 2021 (in tonnes) by statistical rectangle.

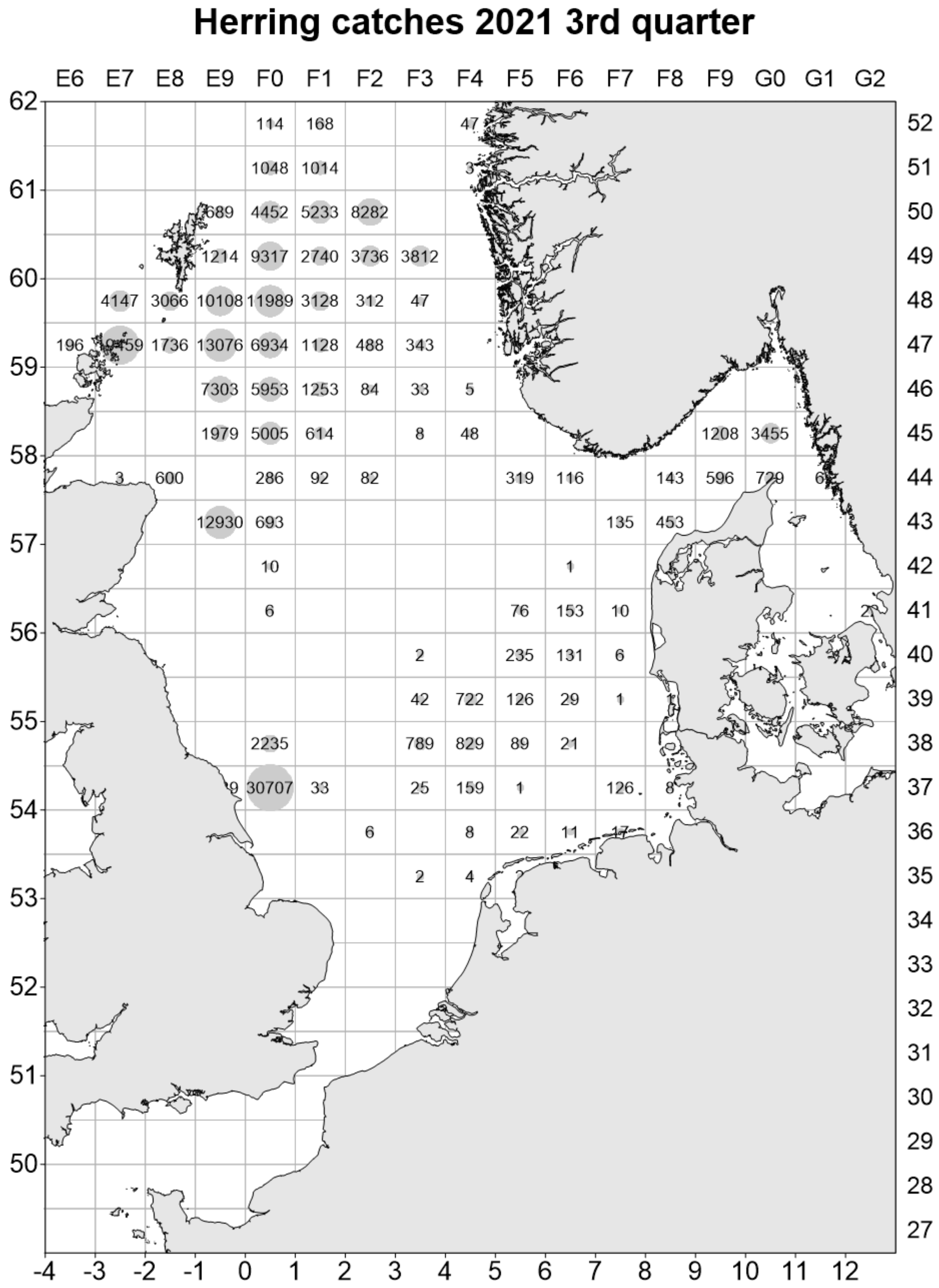


Figure 2.1.1c. Herring catches in the North Sea in the 3rd quarter of 2021 (in tonnes) by statistical rectangle.

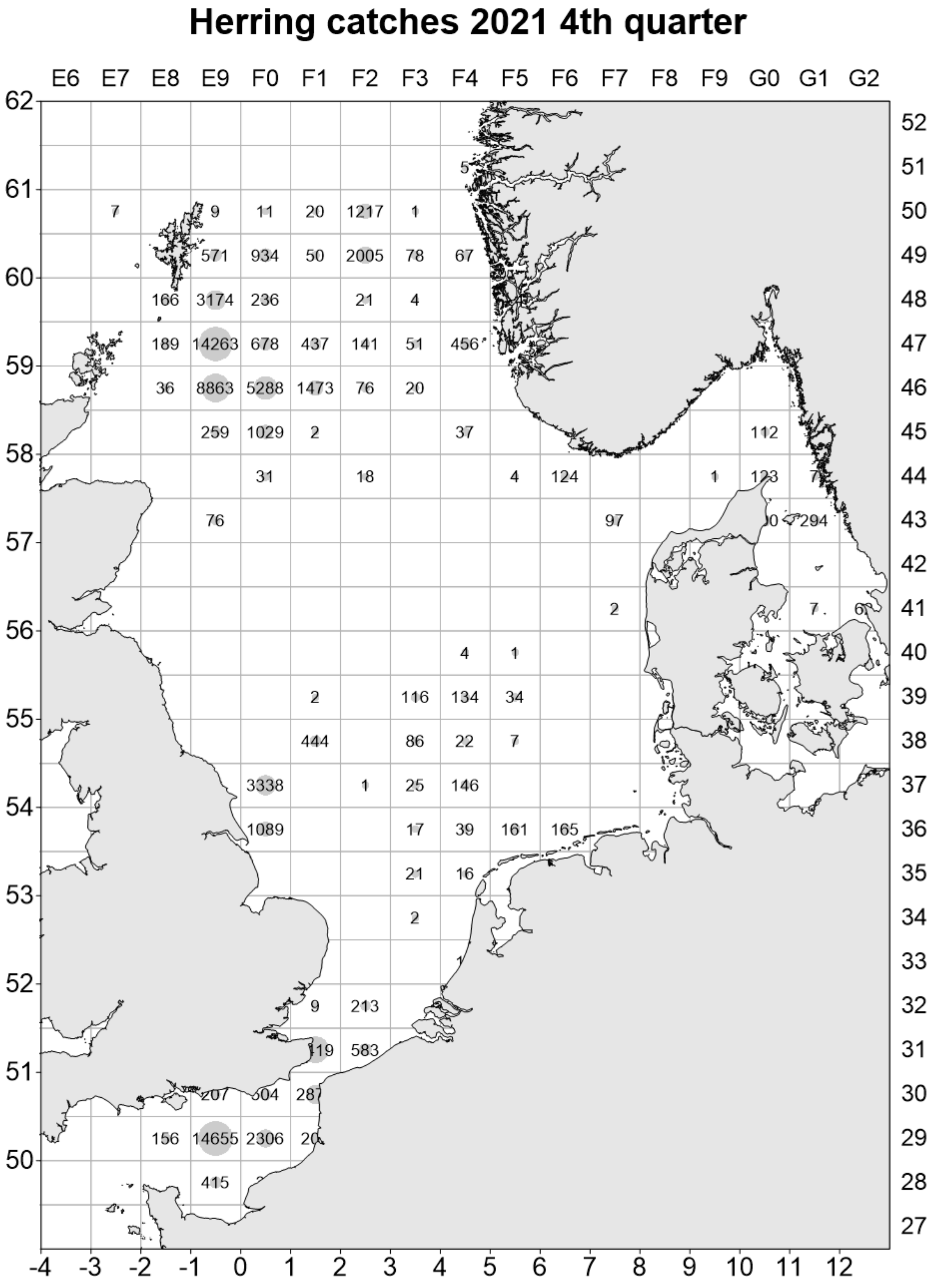


Figure 2.1.1d. Herring catches in the North Sea in the 4th quarter of 2021 (in tonnes) by statistical rectangle.

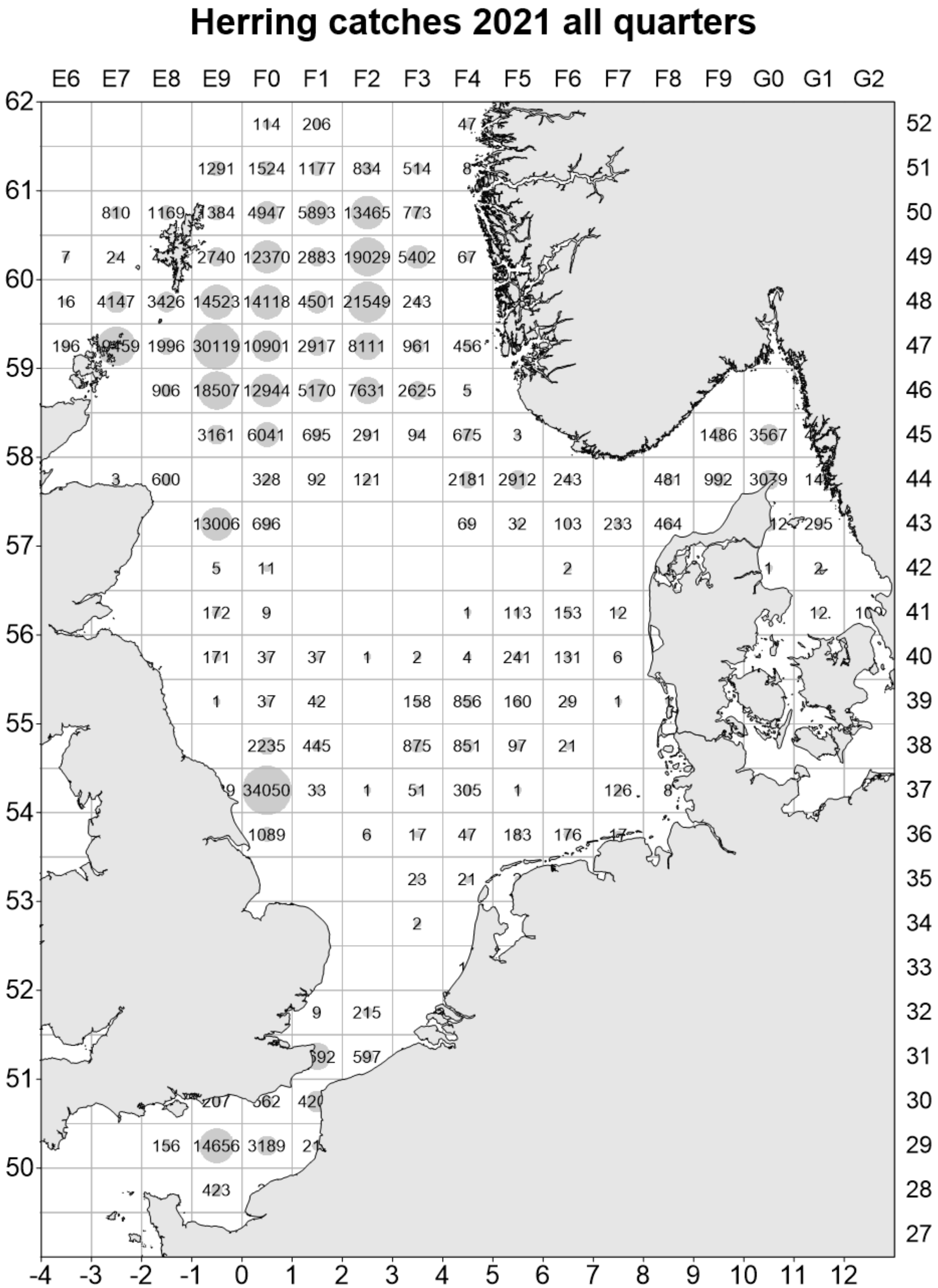


Figure 2.1.1e. Herring catches in the North Sea in all quarters of 2021 (in tonnes) by statistical rectangle.

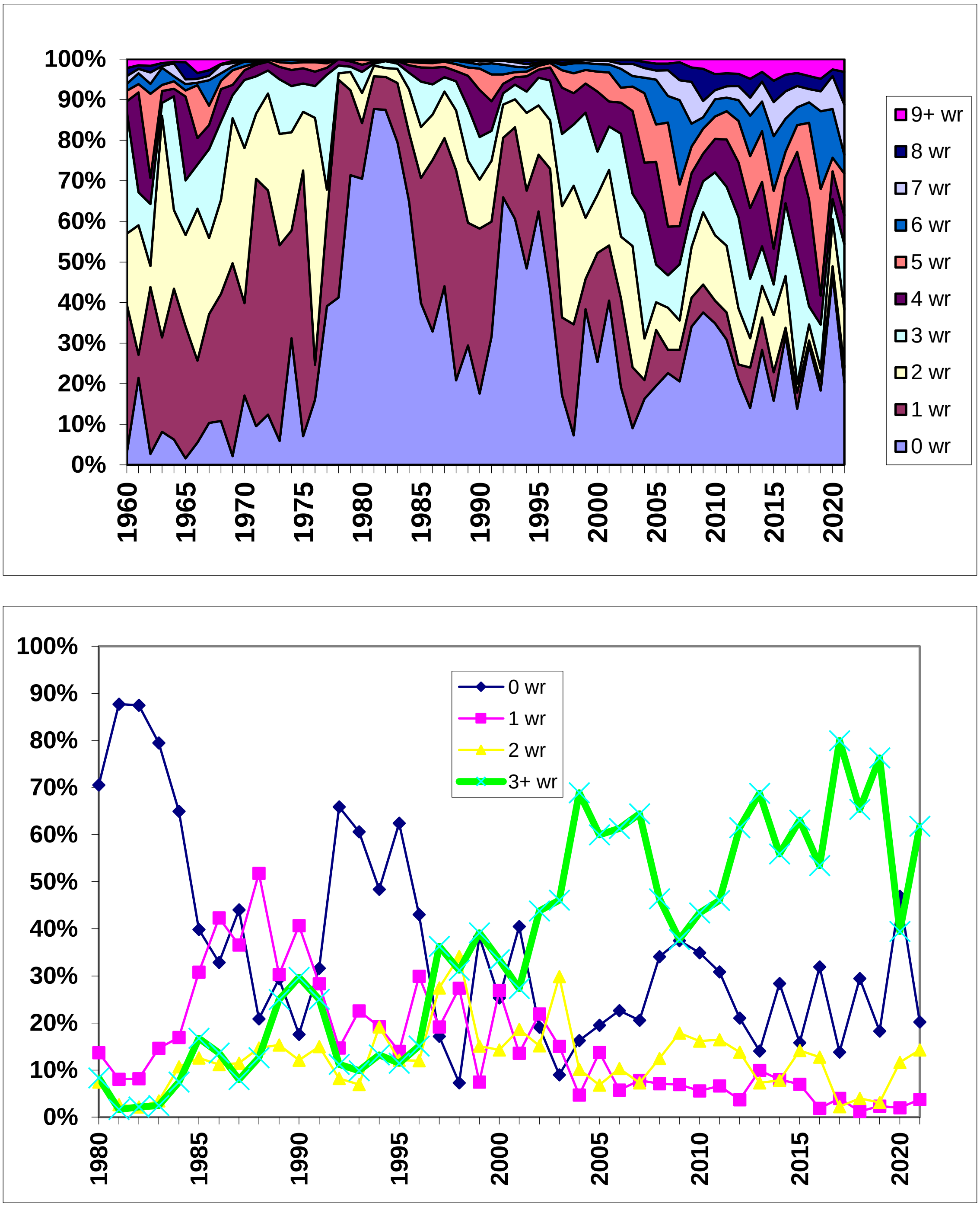


Figure 2.2.1. Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2021, and lower panel, 1980–2021).

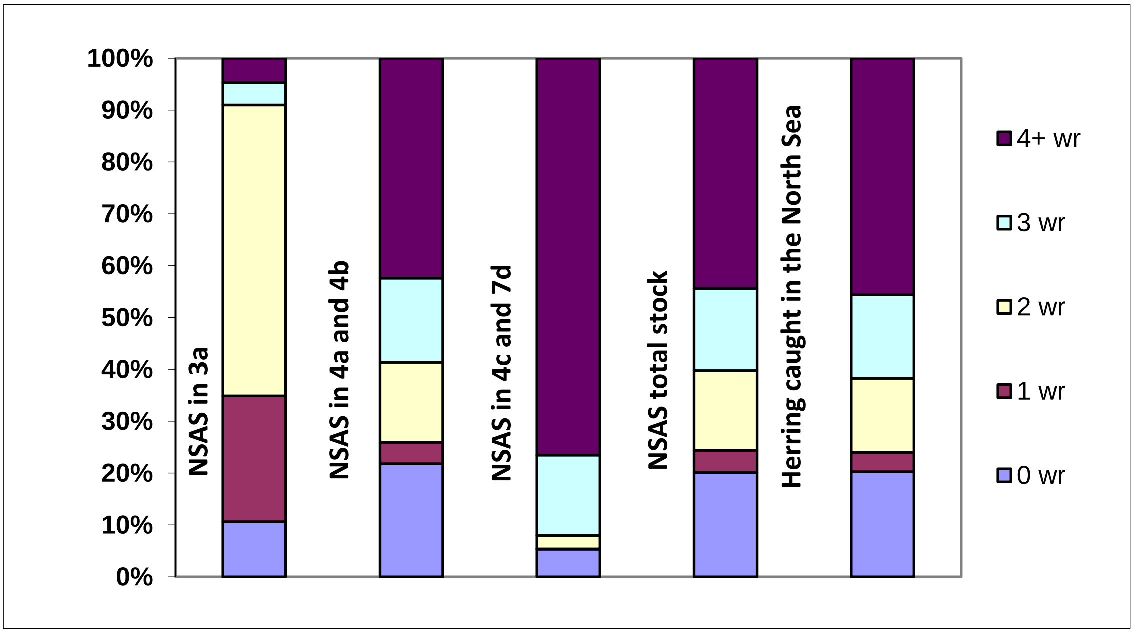


Figure 2.2.2. Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2021.

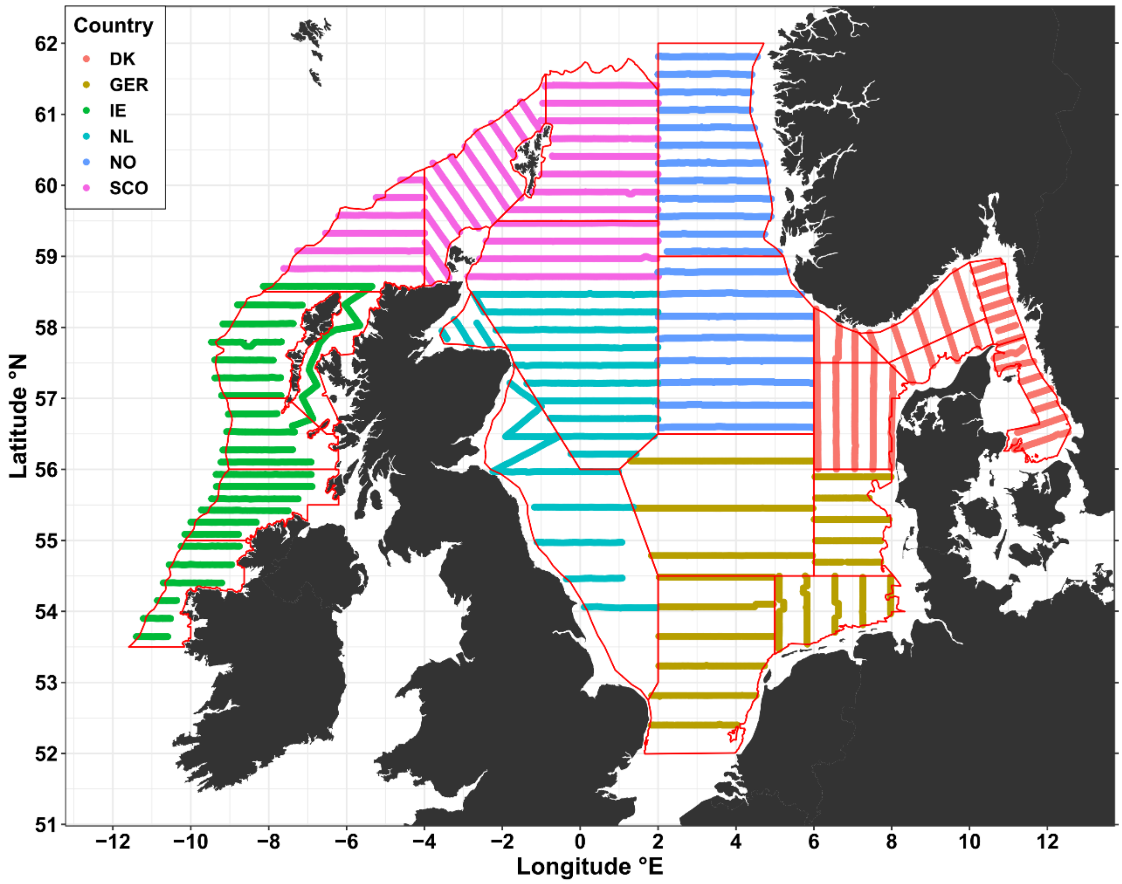


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2021 by nation.

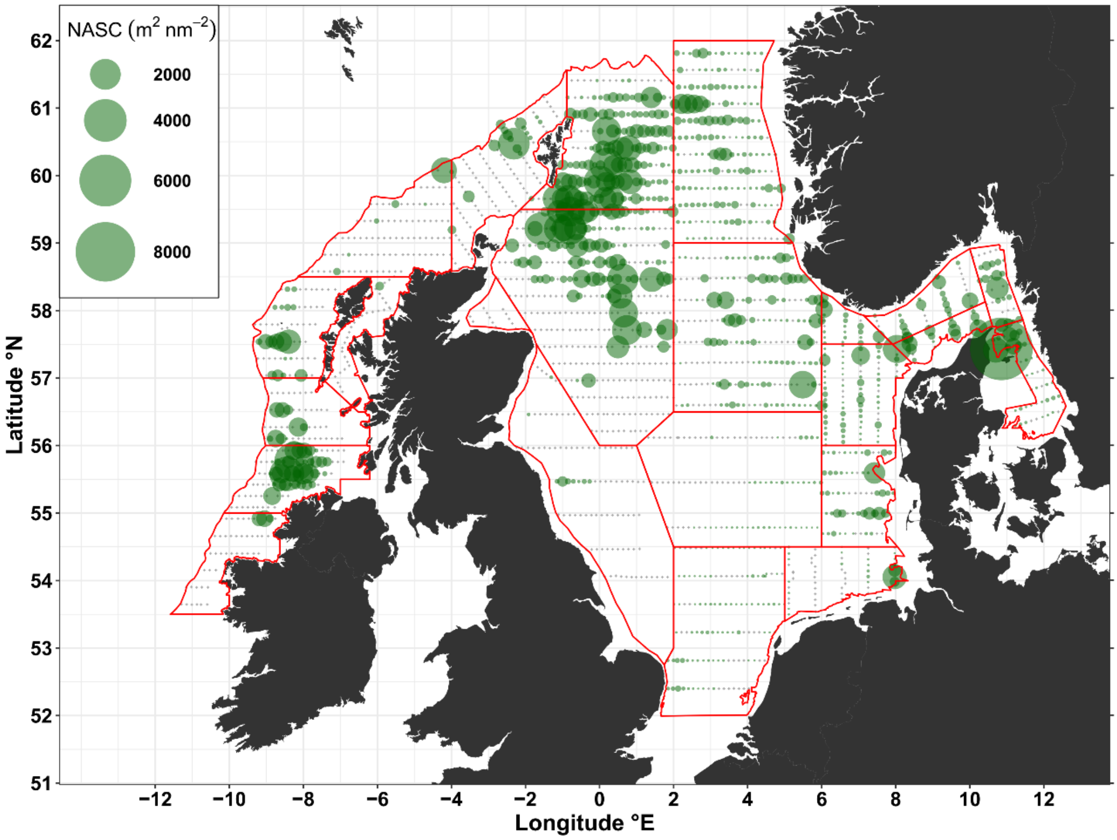


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2021. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

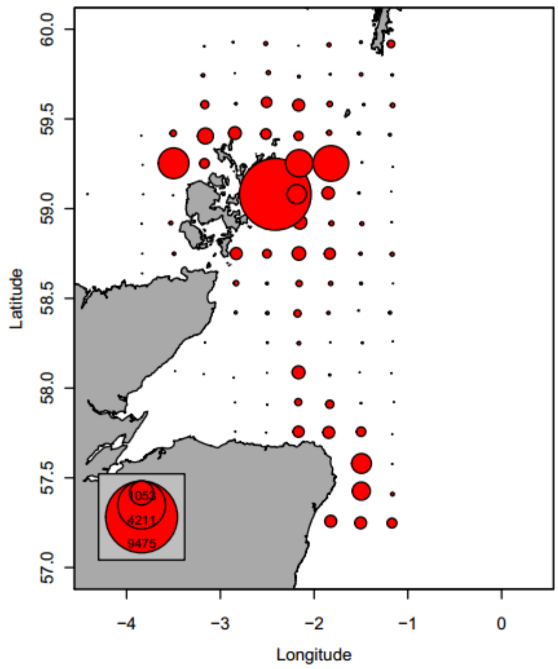


Figure 2.3.2.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands and northern Buchan area, second half of September 2021 (maximum circle size = 9 475 n/m²).

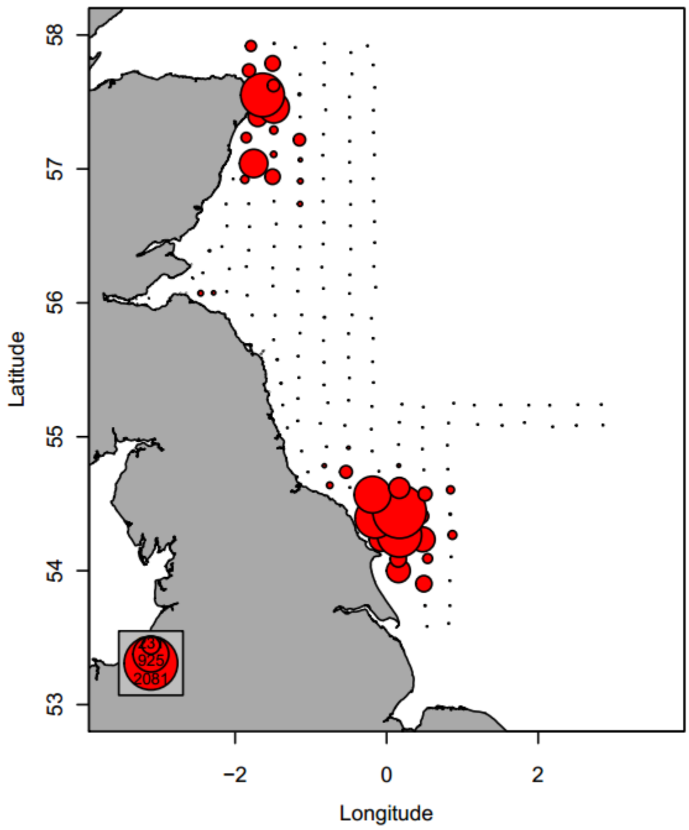


Figure 2.3.2.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan area and the central North Sea, second half of September 2021 (maximum circle size = 2 081 n/m²).

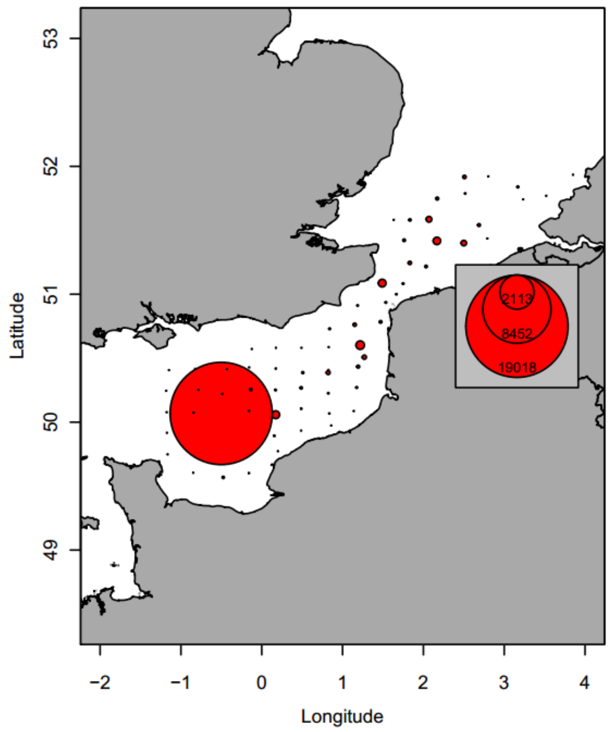


Figure 2.3.2.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2021 (maximum circle size = 19 018 n/m²).

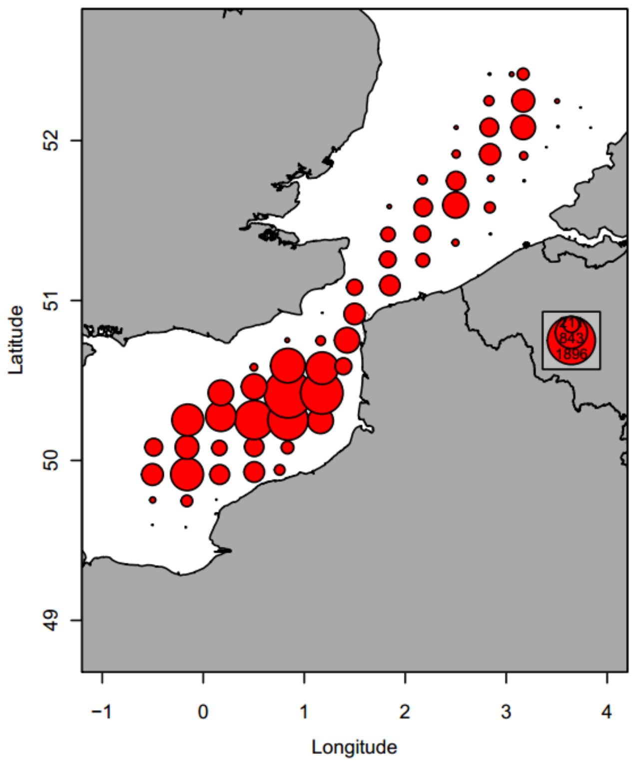


Figure 2.3.2.4. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2022 (maximum circle size = 1 900n/m²).

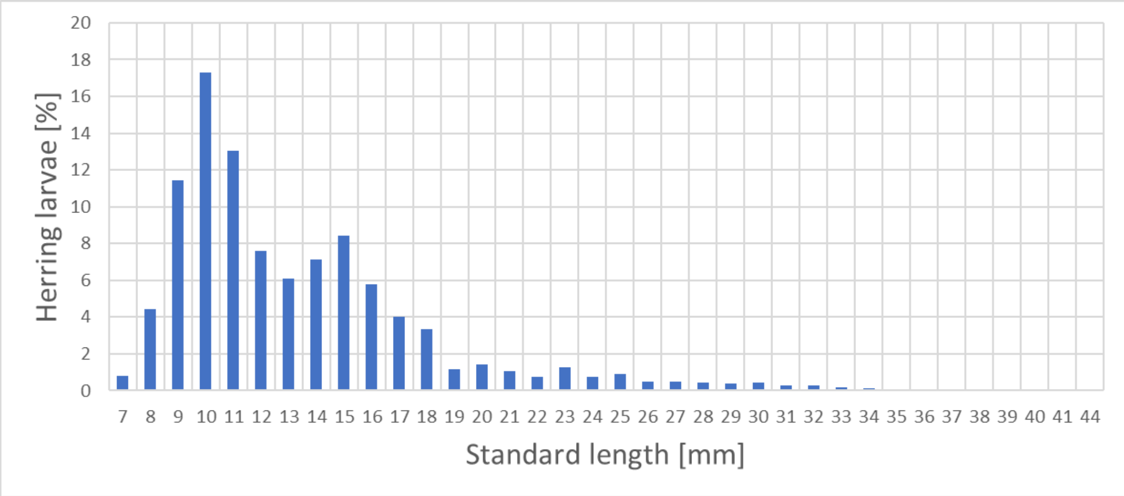


Figure 2.3.3.1.1 North Sea herring. Length distribution of all herring larvae caught in the MIK during the 2022 Q1 IBTS.

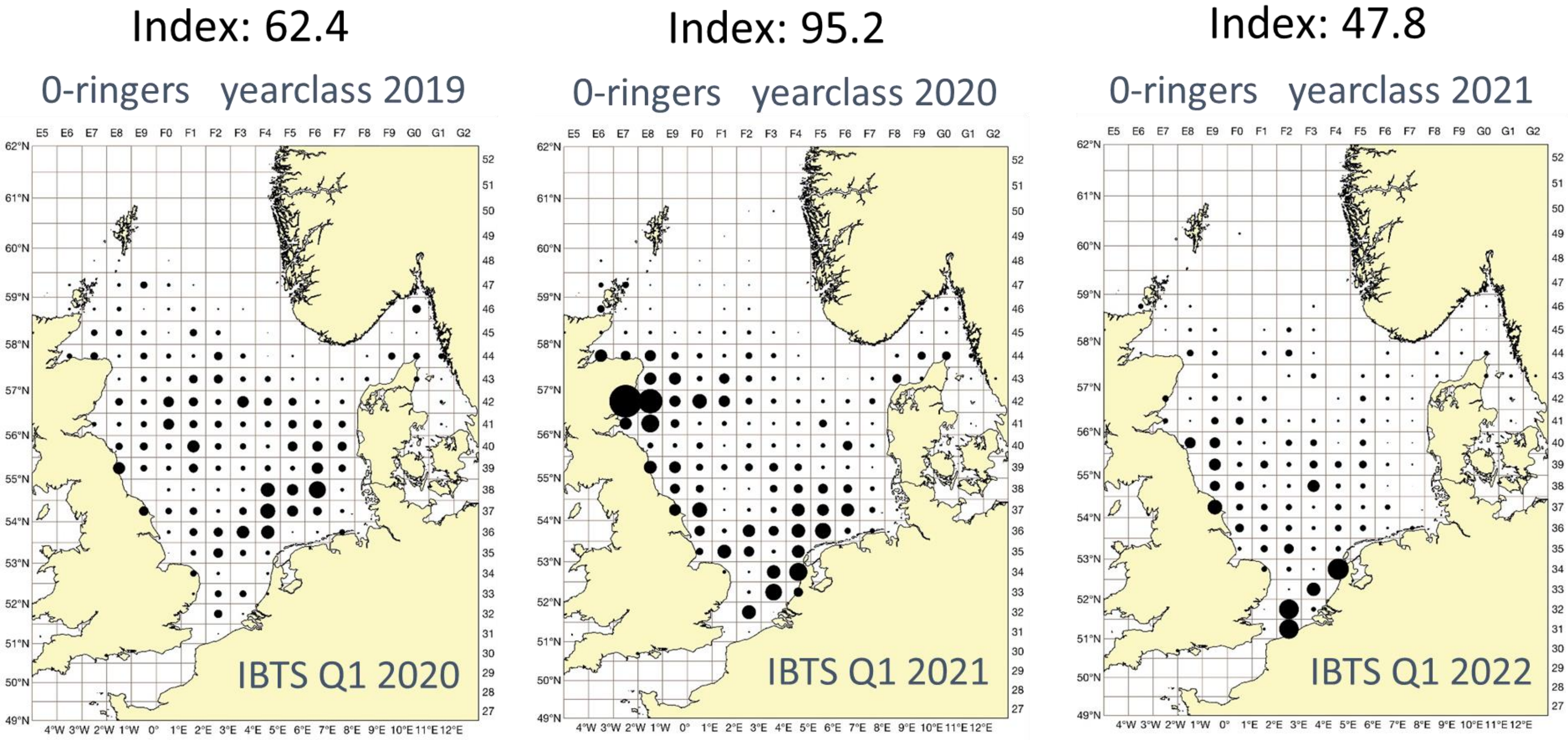


Figure 2.3.3.1.2 North Sea herring. Distribution of 0-ringer herring, year classes 2019–2021. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2020–2022. Areas of filled circles illustrate densities in no m-2, the area of the largest circle represents a density of 3.82 m-2. All circles are scaled to the same order of magnitude of the square root transformed densities.

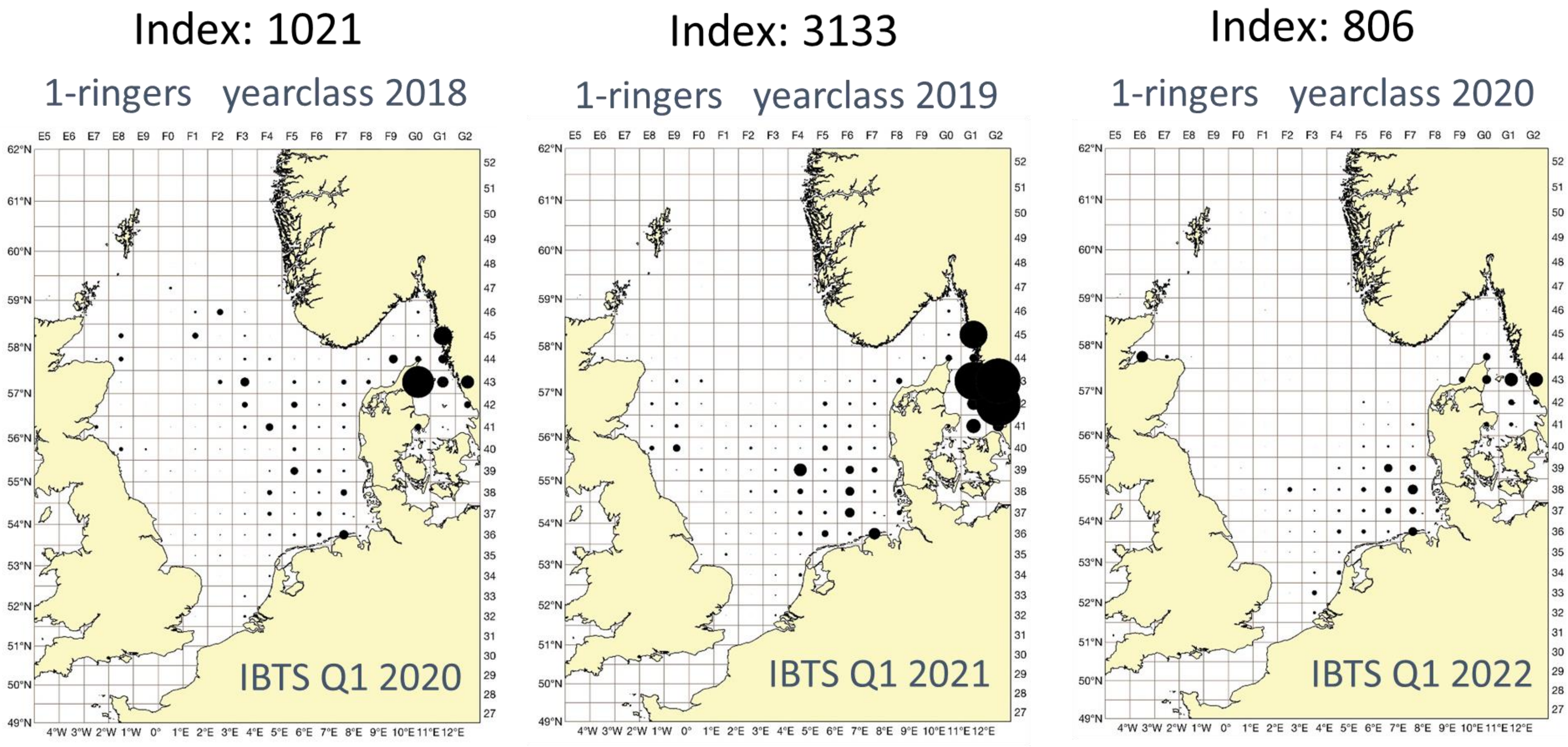


Figure 2.3.3.2.1 North Sea herring. Distribution of 1-ringer herring, year classes 2018–2020. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2020–2022. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data, the area of the largest circle extending across the boundary of a rectangle represents 201,826 h-1.

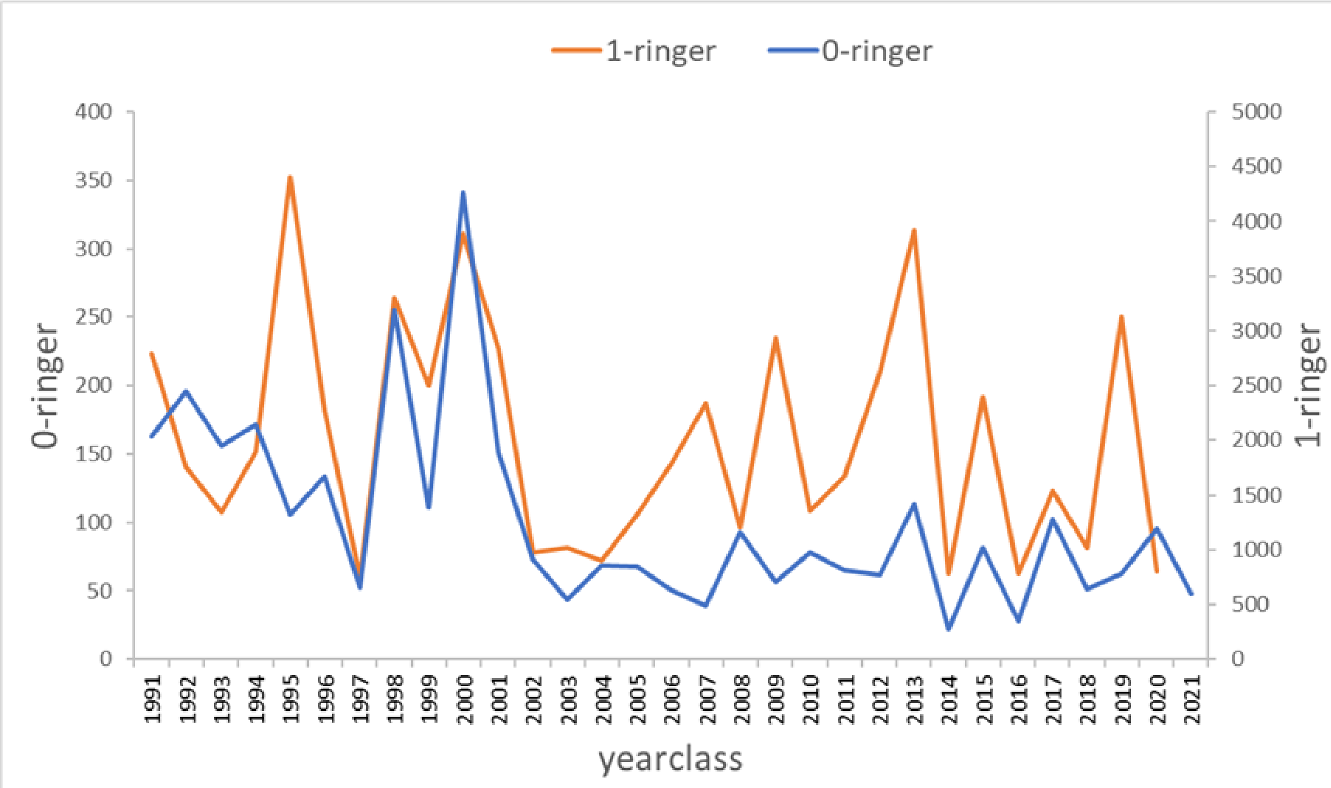


Figure 2.3.3.2.2 North Sea herring. Time series of 0-ringer (blue) and 1-ringer indices (orange). Year-classes 1991 to 2021 for 0-ringers, year-classes 1991–2020 for 1-ringers.

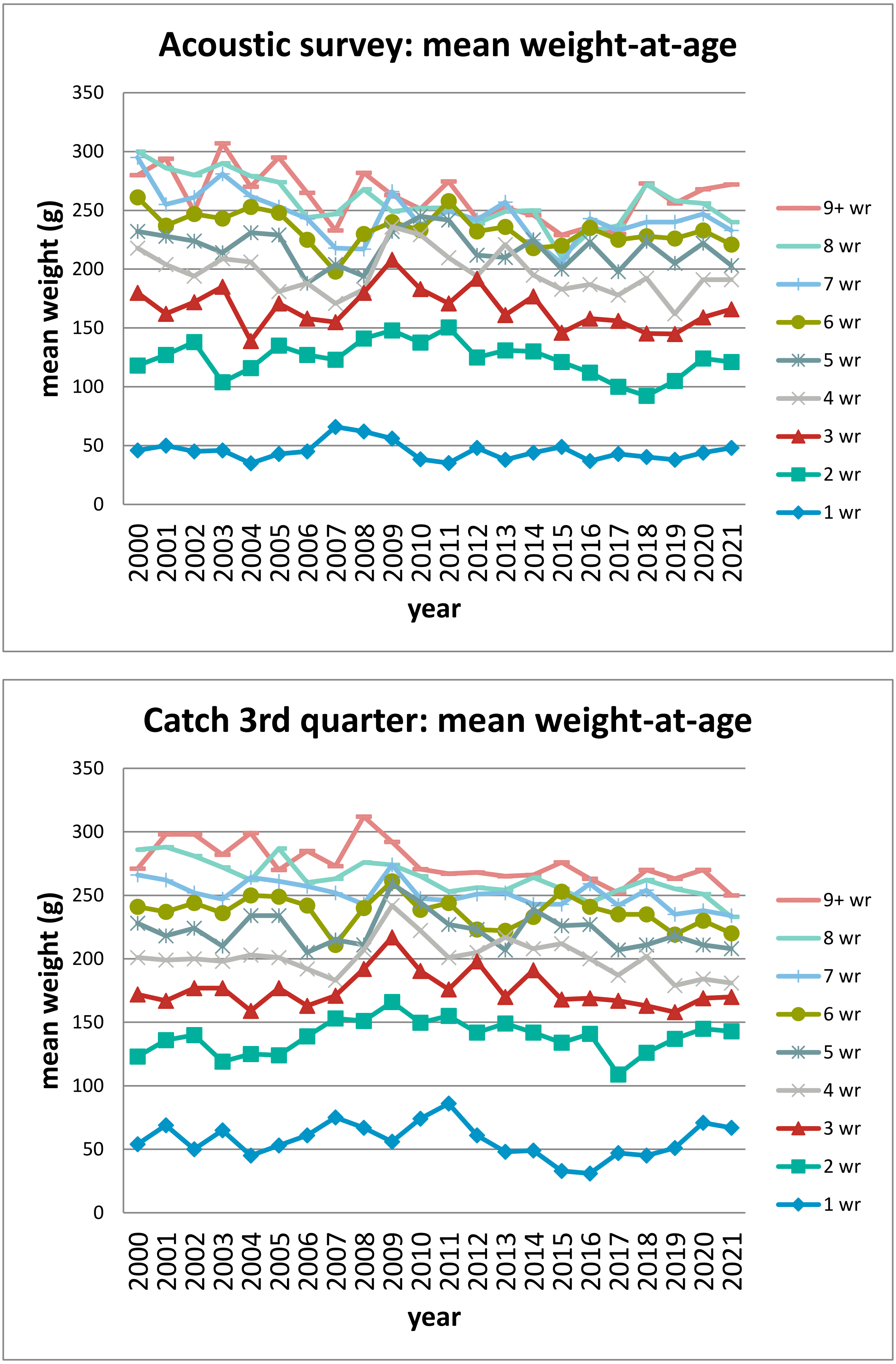


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

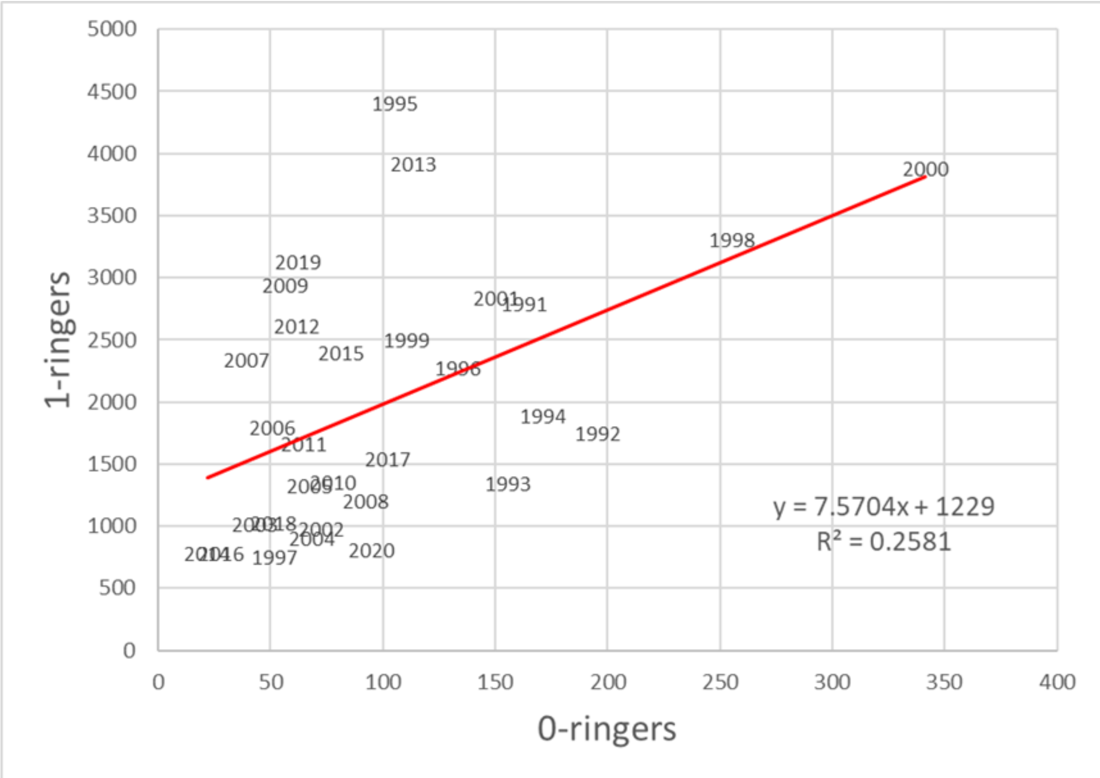


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers, calculated with the new algorithm, and 1-ringers for year-classes 1991 to 2020.

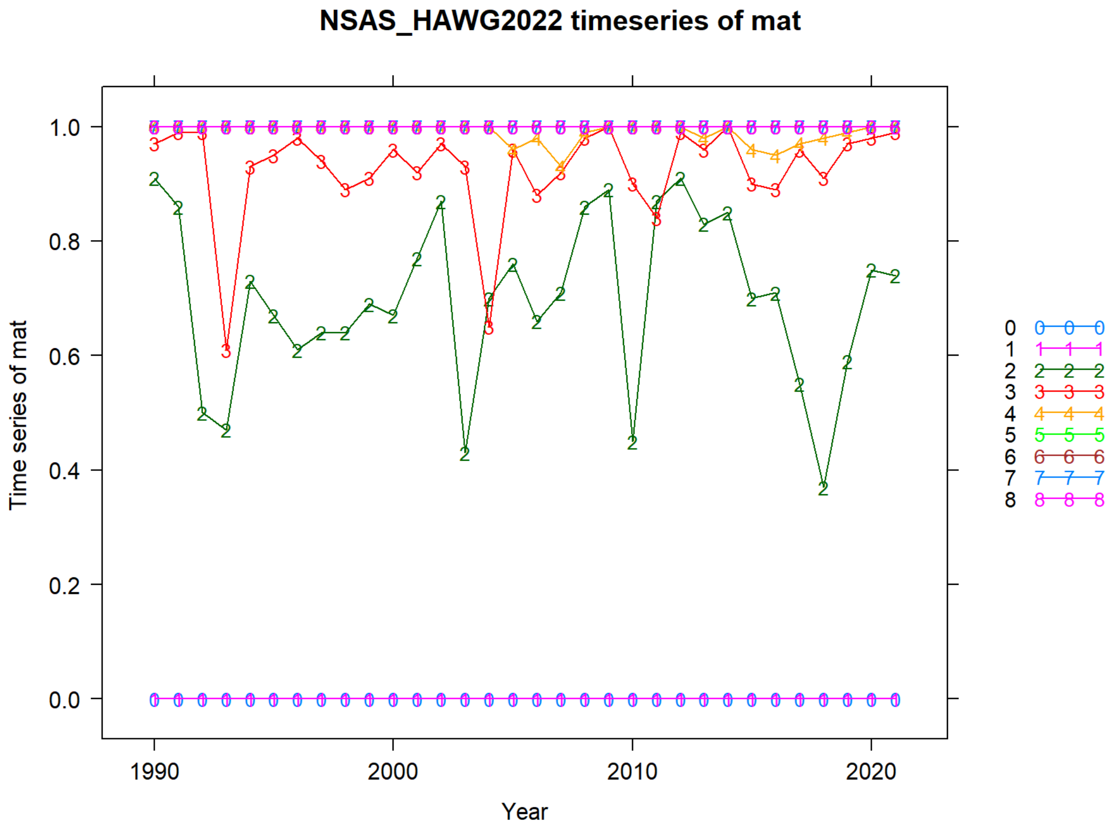


Figure 2.6.1.1. North Sea Herring. Time-series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

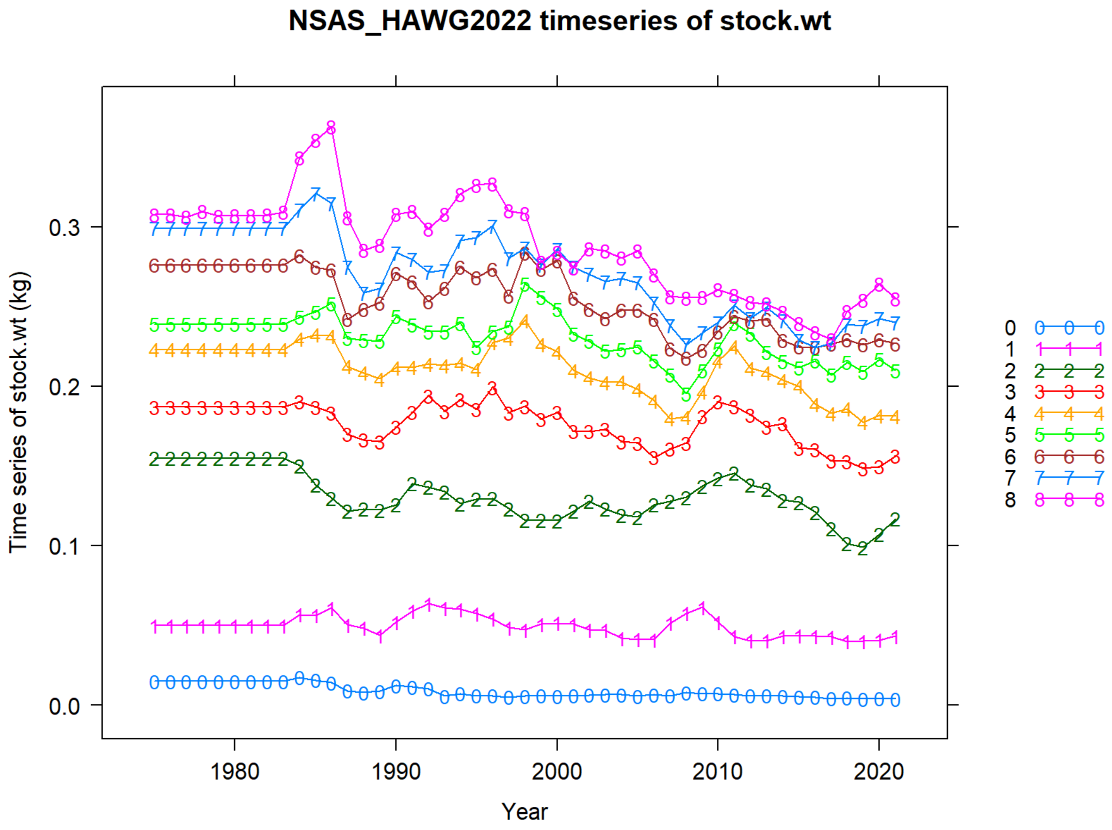


Figure 2.6.1.2. North Sea Herring. Time-series of stock weight at ages 0 to 8+ as used in the North Sea herring assessment.

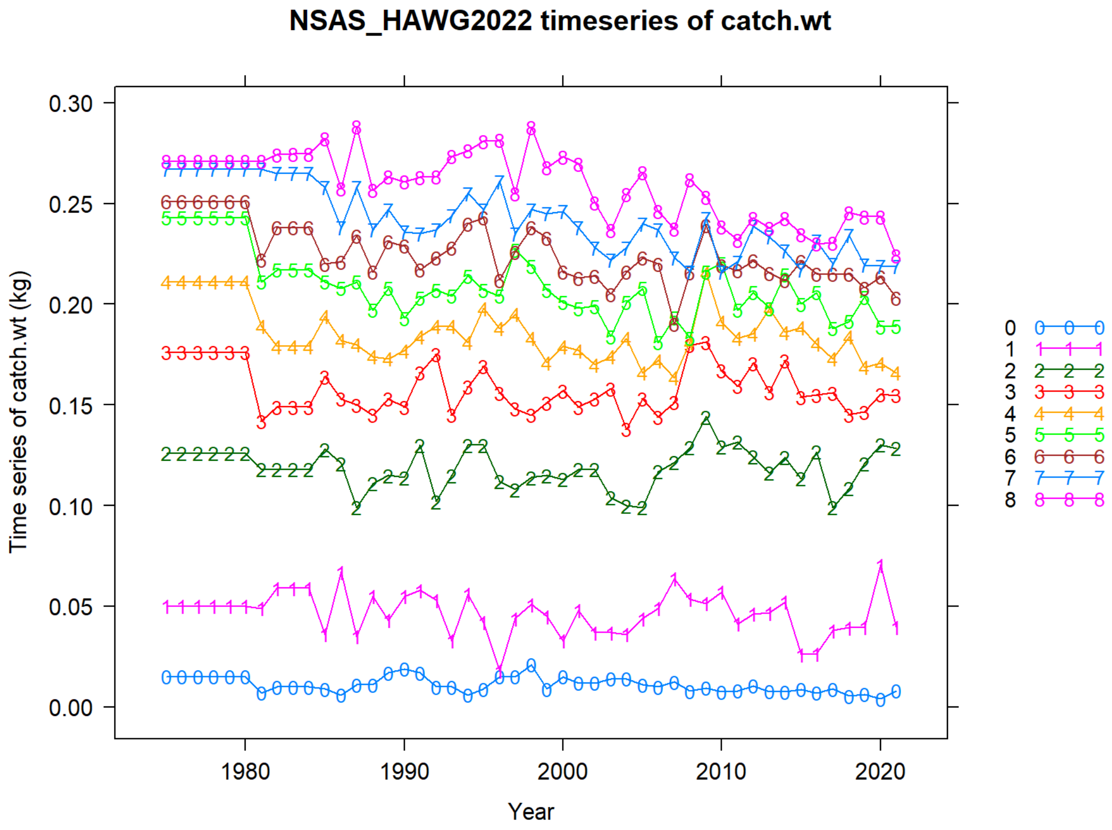


Figure 2.6.1.3. North Sea Herring. Time-series of catch weight at ages 0 to 8+ as used in the North Sea herring assessment.

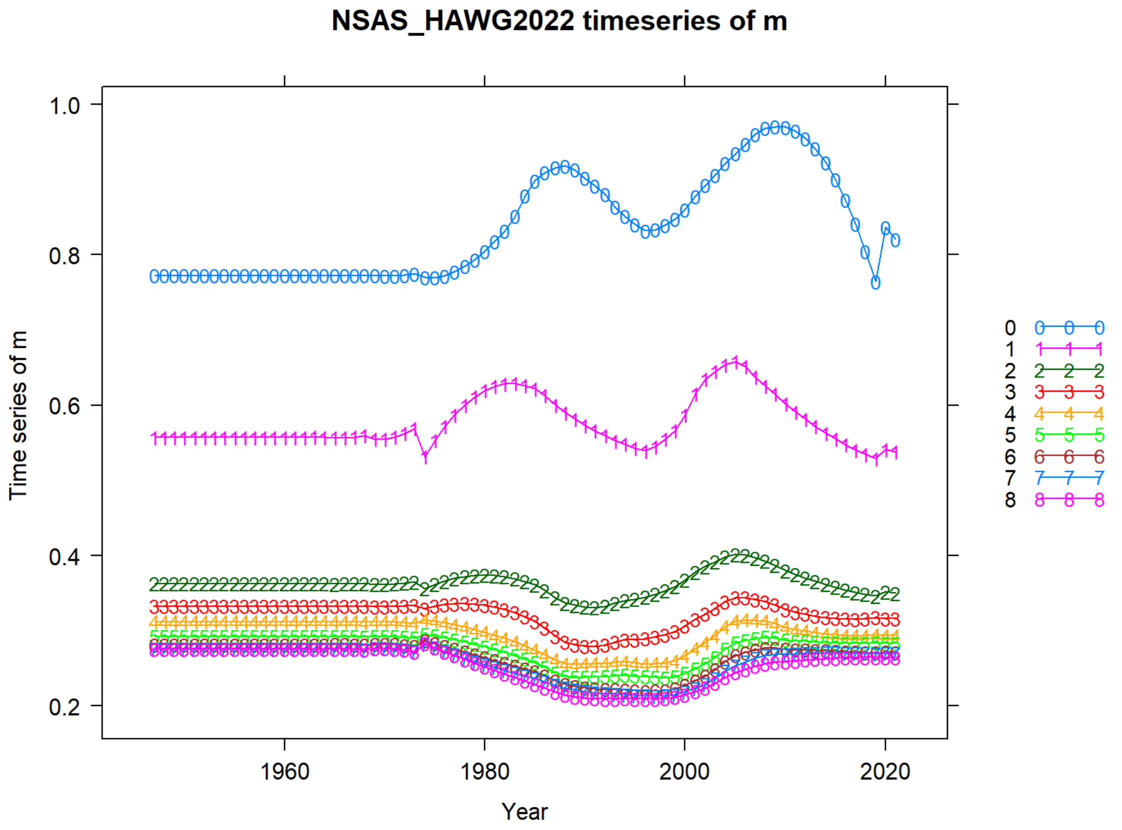


Figure 2.6.1.4. North Sea Herring. Time-series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2019 North Sea key-run (ICES WGSAM, 2021)

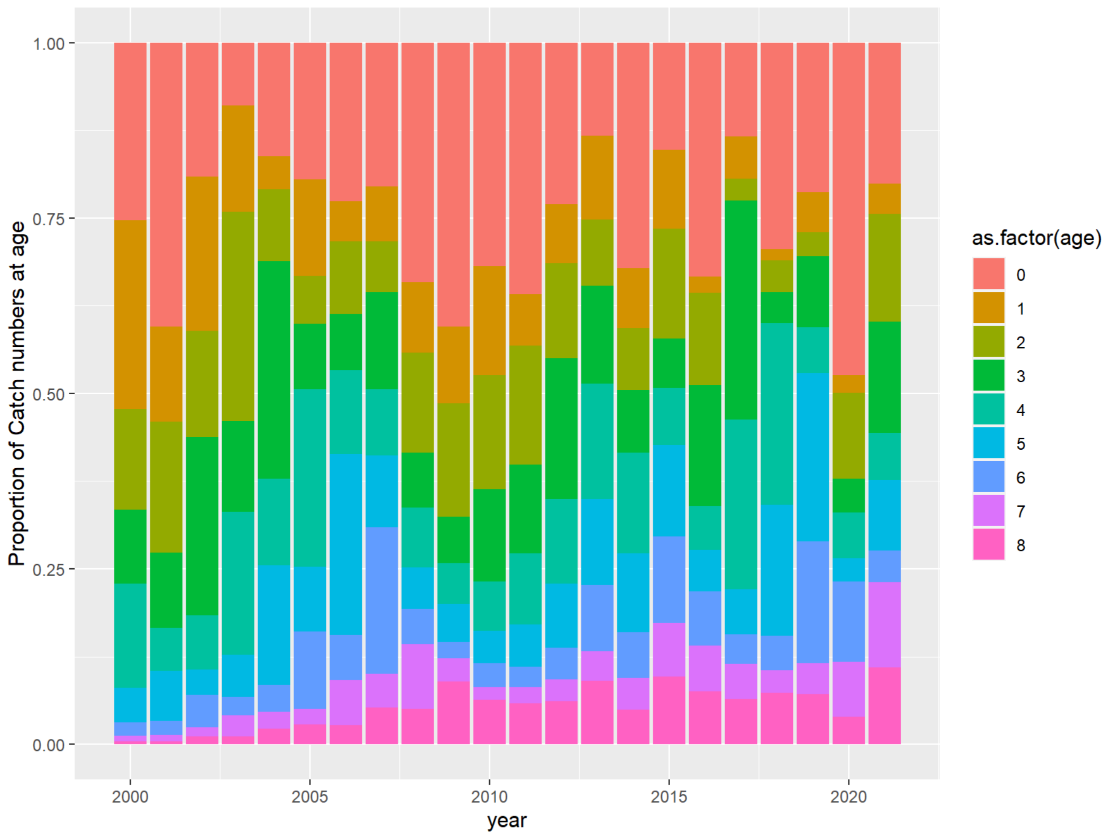


Figure 2.6.1.5. North Sea Herring. Proportion of catch at age since 2000.

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

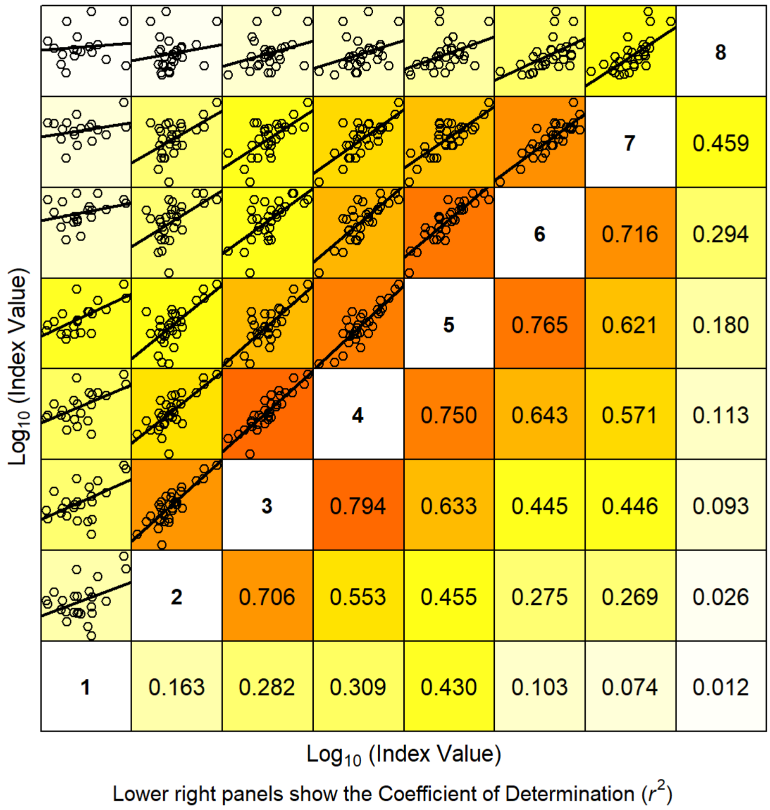


Figure 2.6.1.7. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

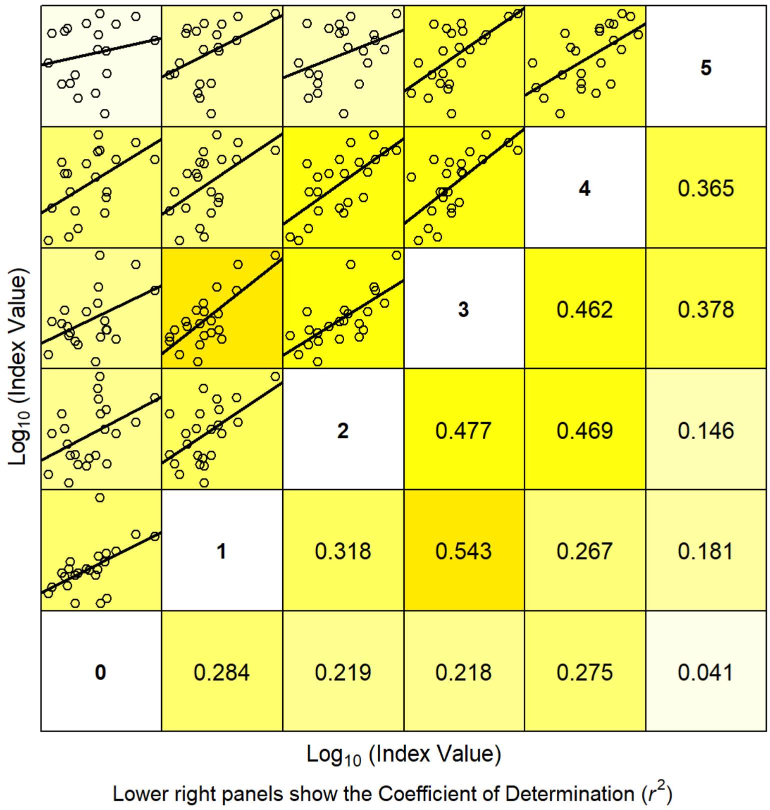


Figure 2.6.1.8. North Sea herring. Internal consistency plot of the IBTS in quarter 3. Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

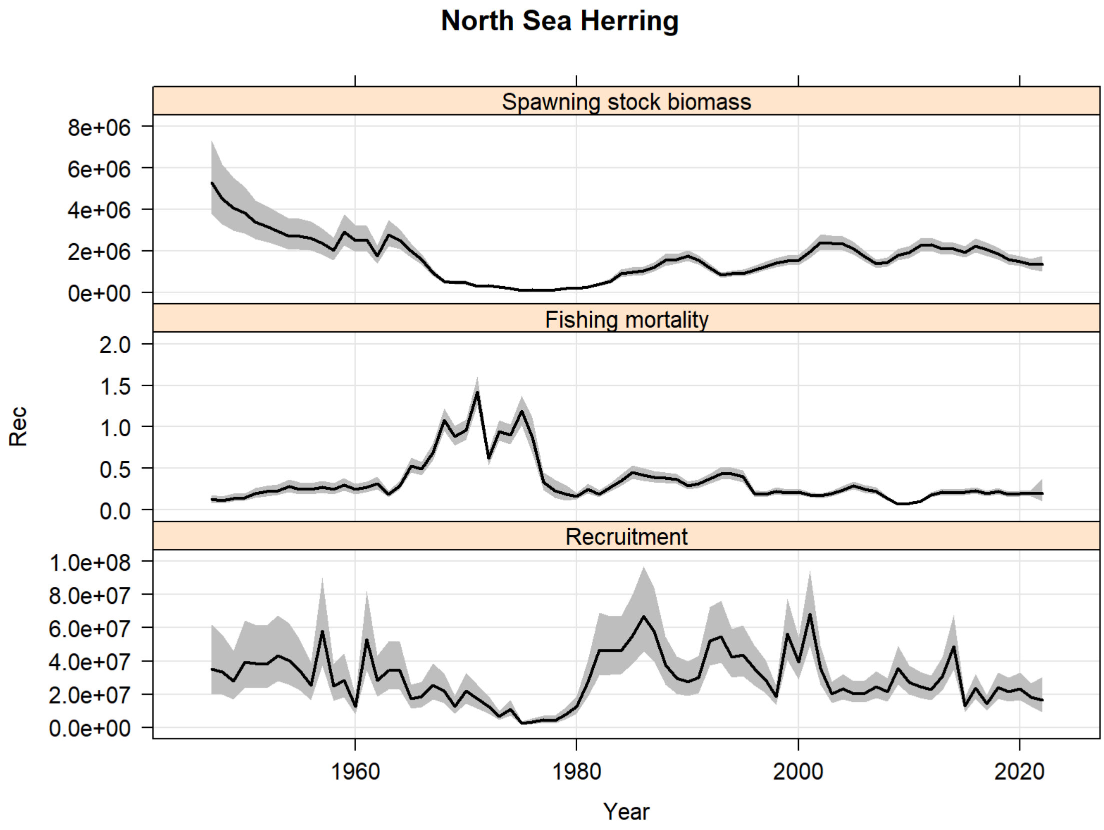


Figure 2.6.2.1. North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

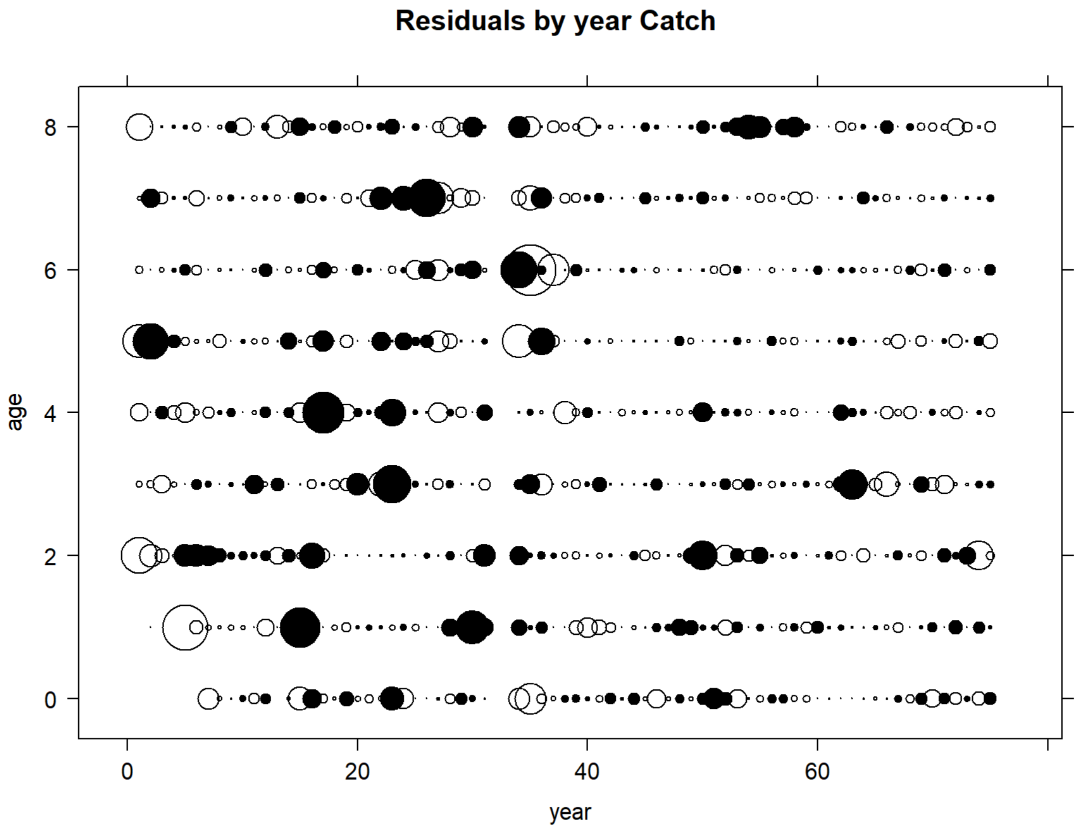


Figure 2.6.2.2. North Sea herring. Bubble plot of standardized catch residual at age.

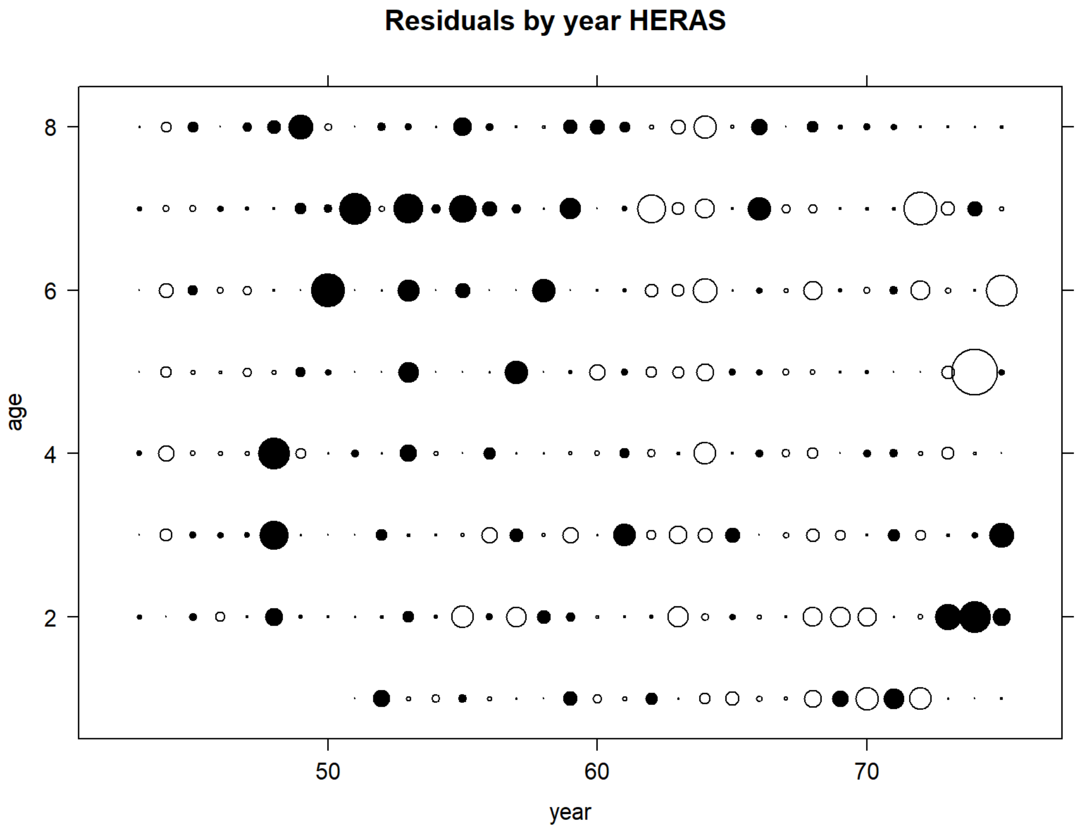


Figure 2.6.2.3. North Sea herring. Bubble plot of standardized acoustic survey residuals at age.

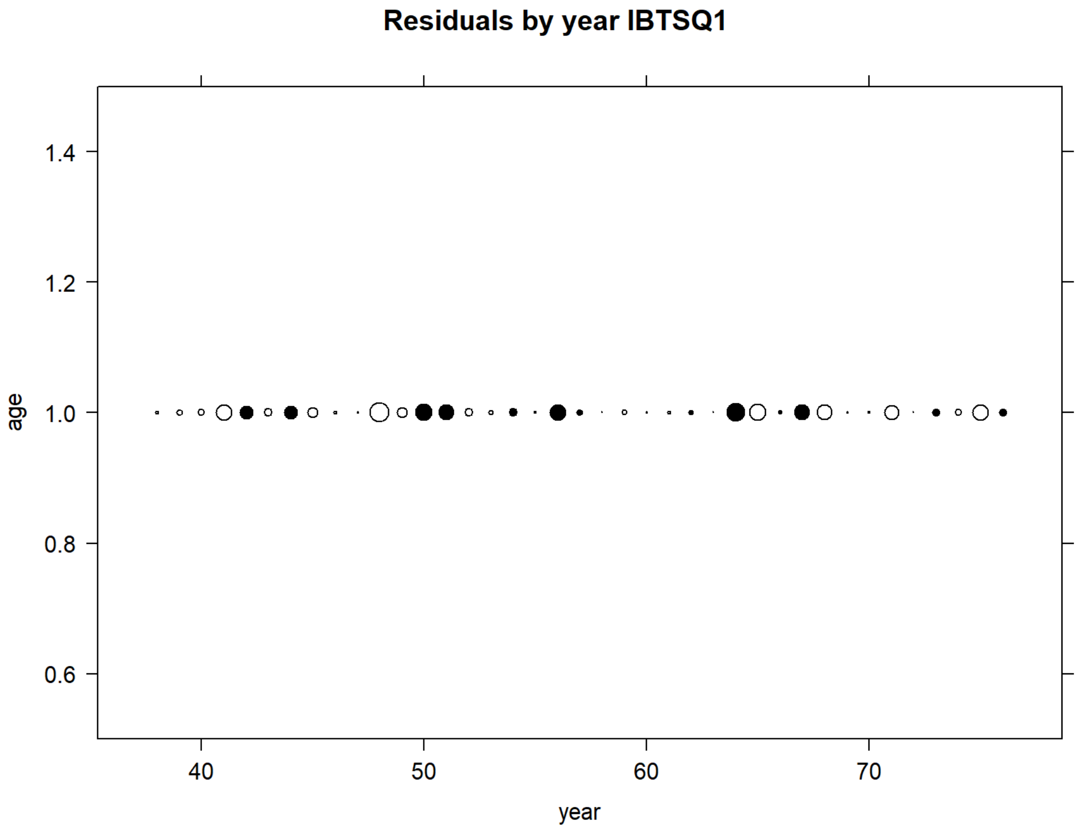


Figure 2.6.2.4. North Sea herring. Bubble plot of standardized IBTSQ1 residuals at age.

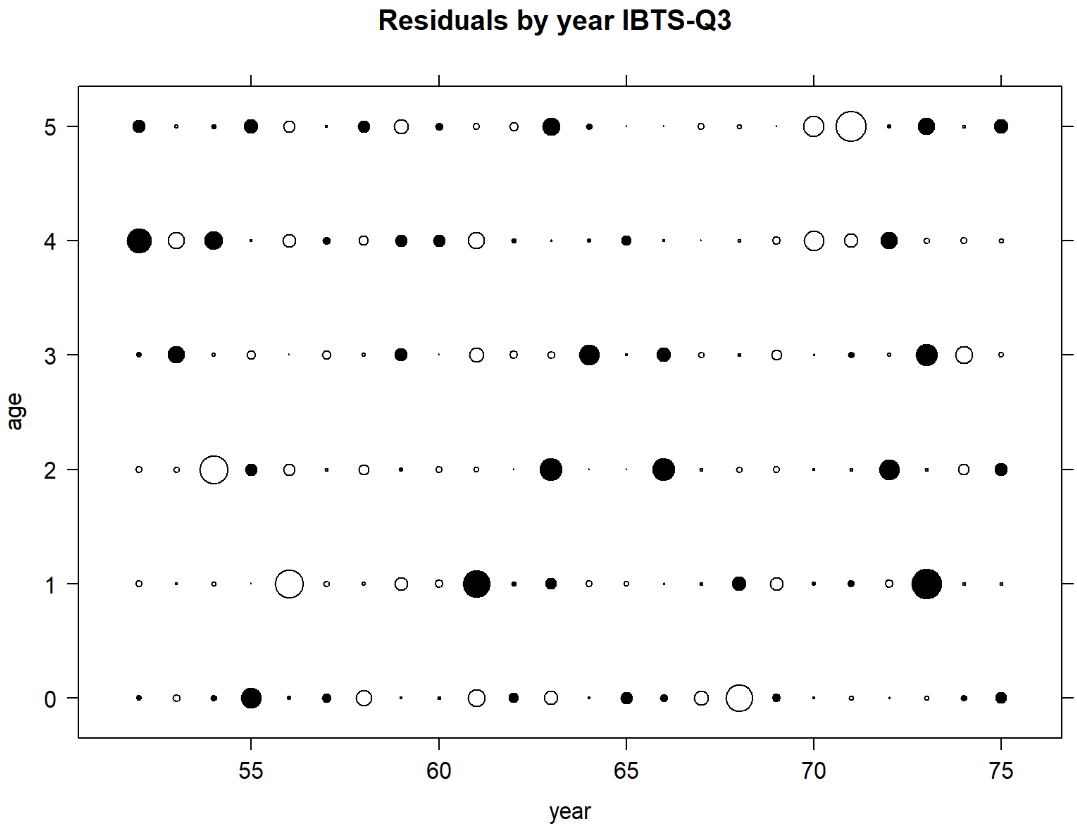


Figure 2.6.2.5. North Sea herring. Bubble plot of standardized IBTSQ3 residuals at age.

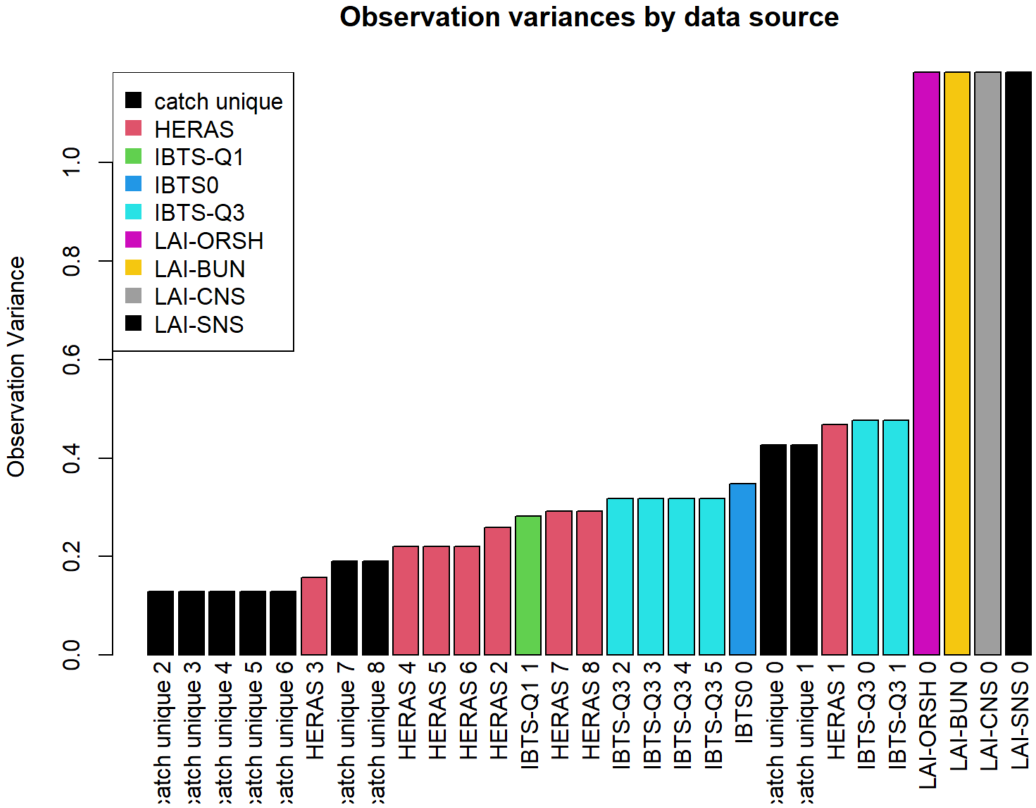


Figure 2.6.2.6. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby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

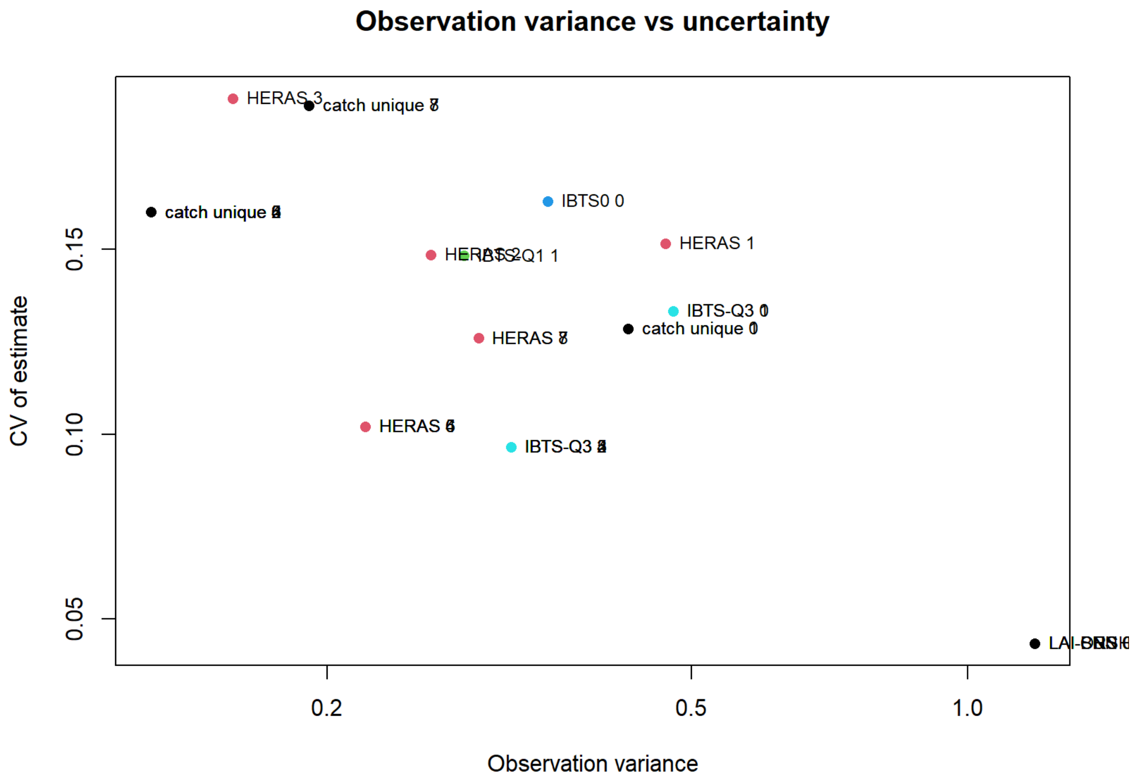


Figure 2.6.2.7. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

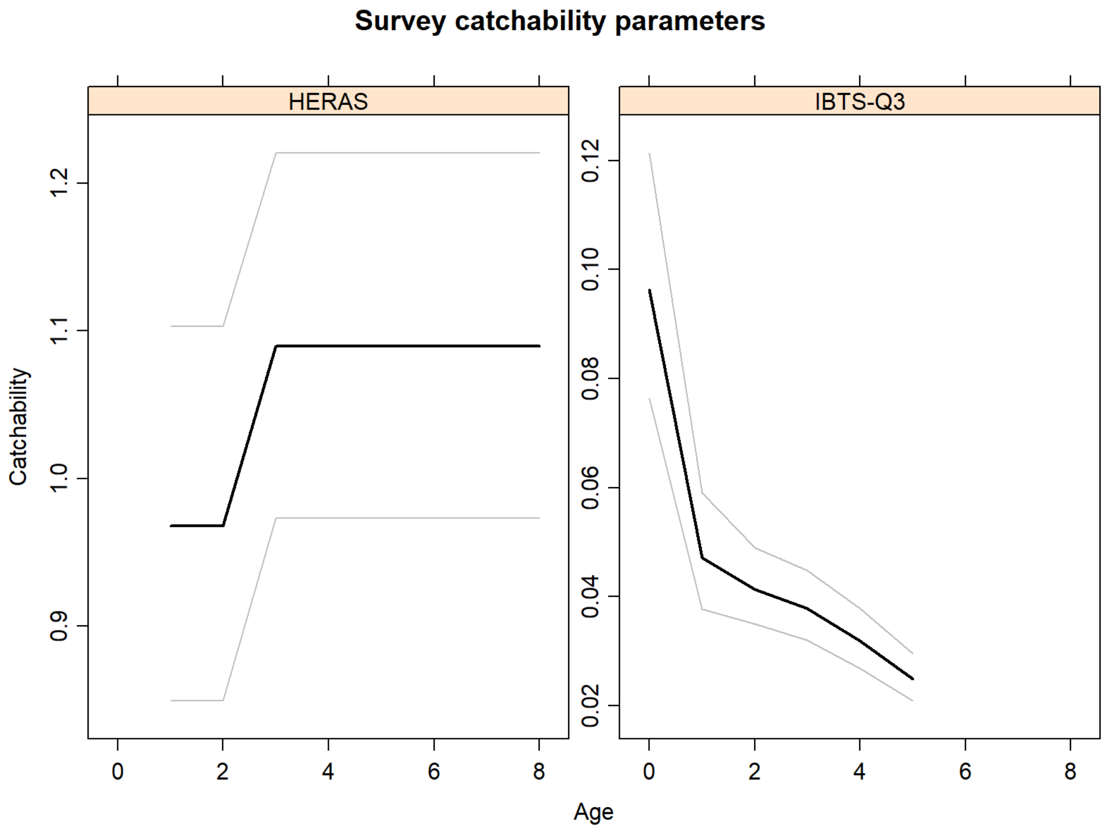


Figure 2.6.2.8. North Sea herring. Catchability at age for the HERAS and IBTSQ3 surveys.

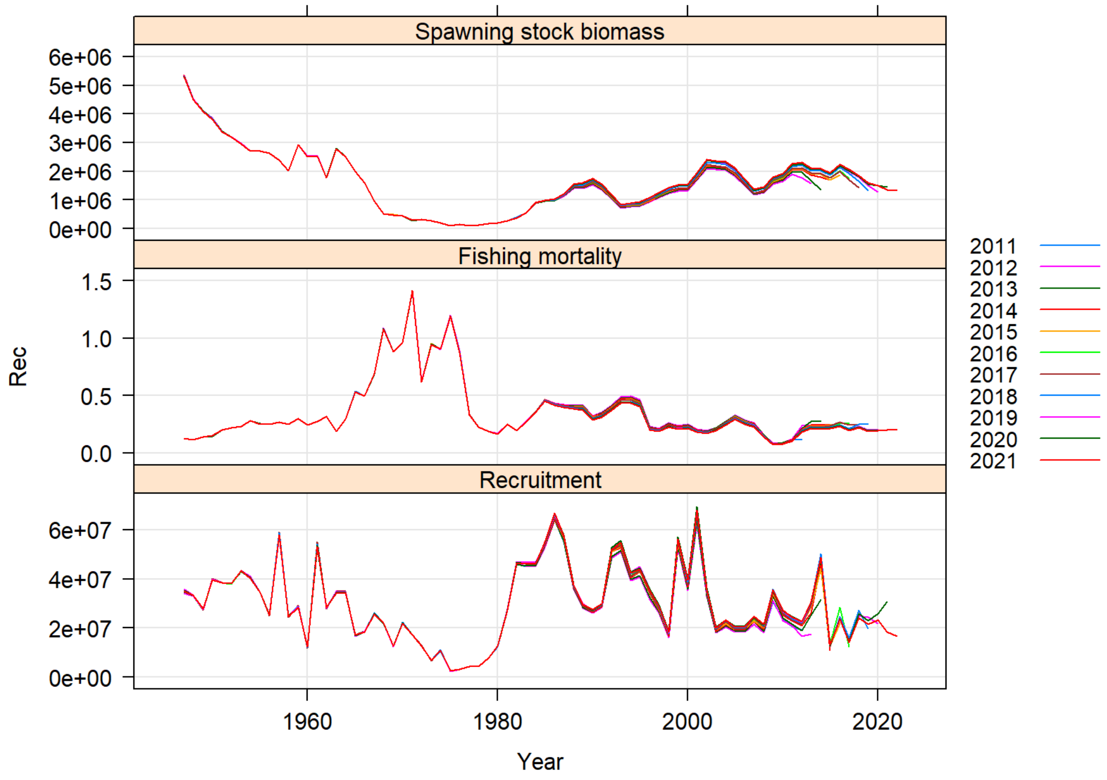


Figure 2.6.2.9. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

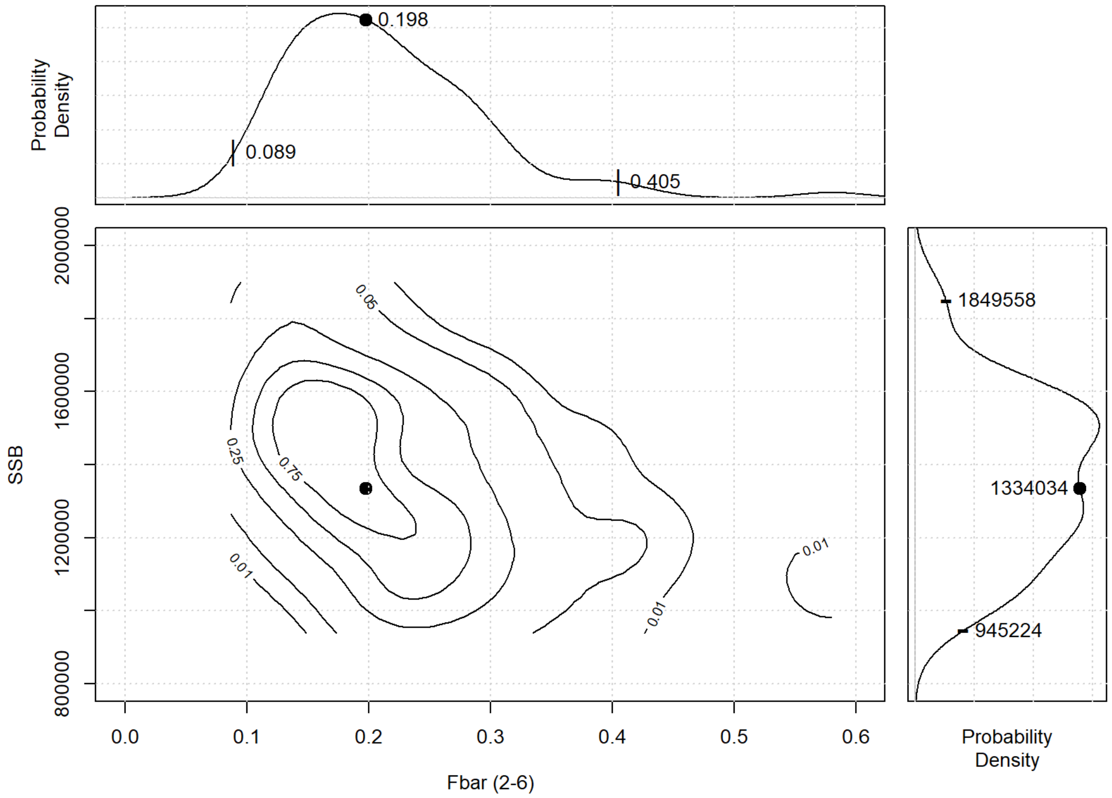


Figure 2.6.2.10. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance/covariance estimates from the model.

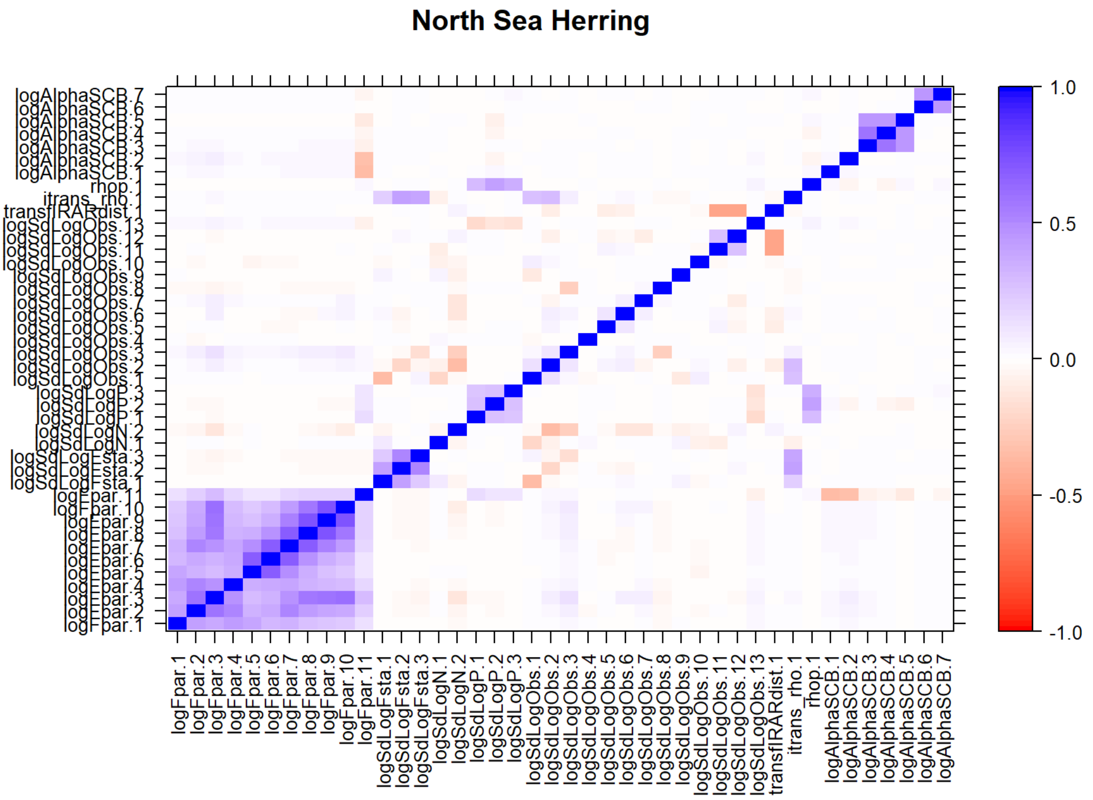


Figure 2.6.2.11. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

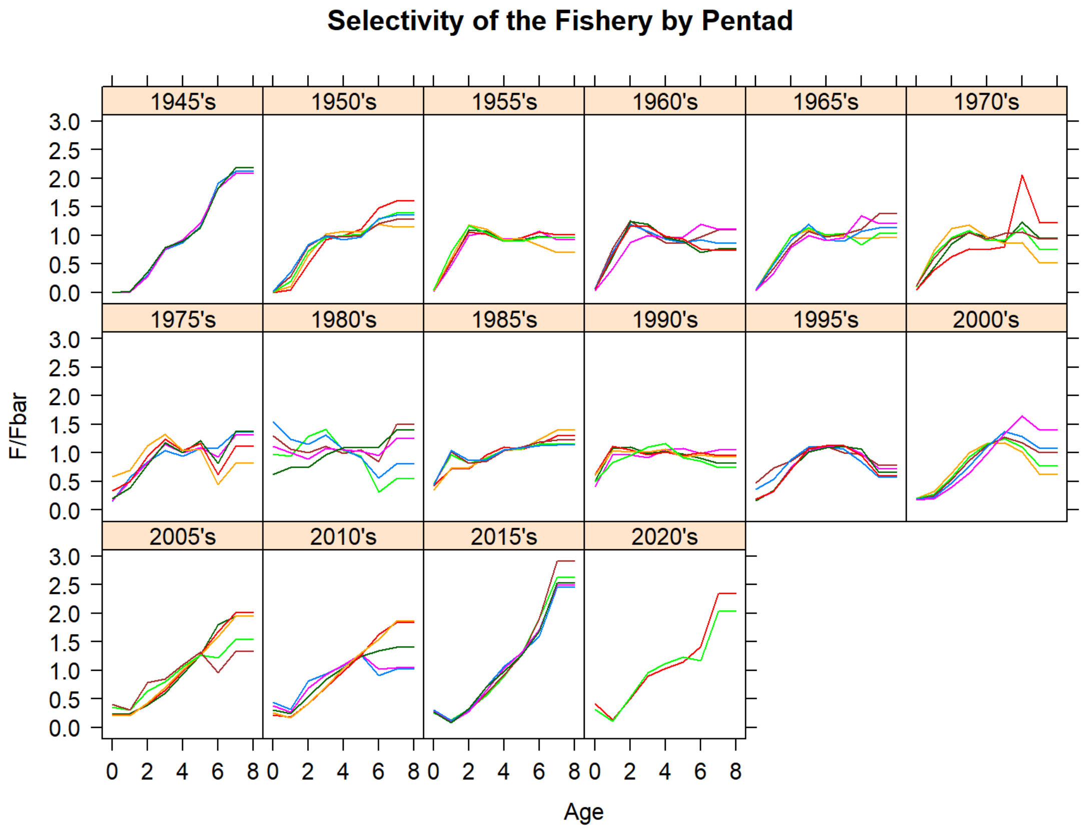


Figure 2.6.2.12. North Sea herring. Fishing selectivity by pentad.

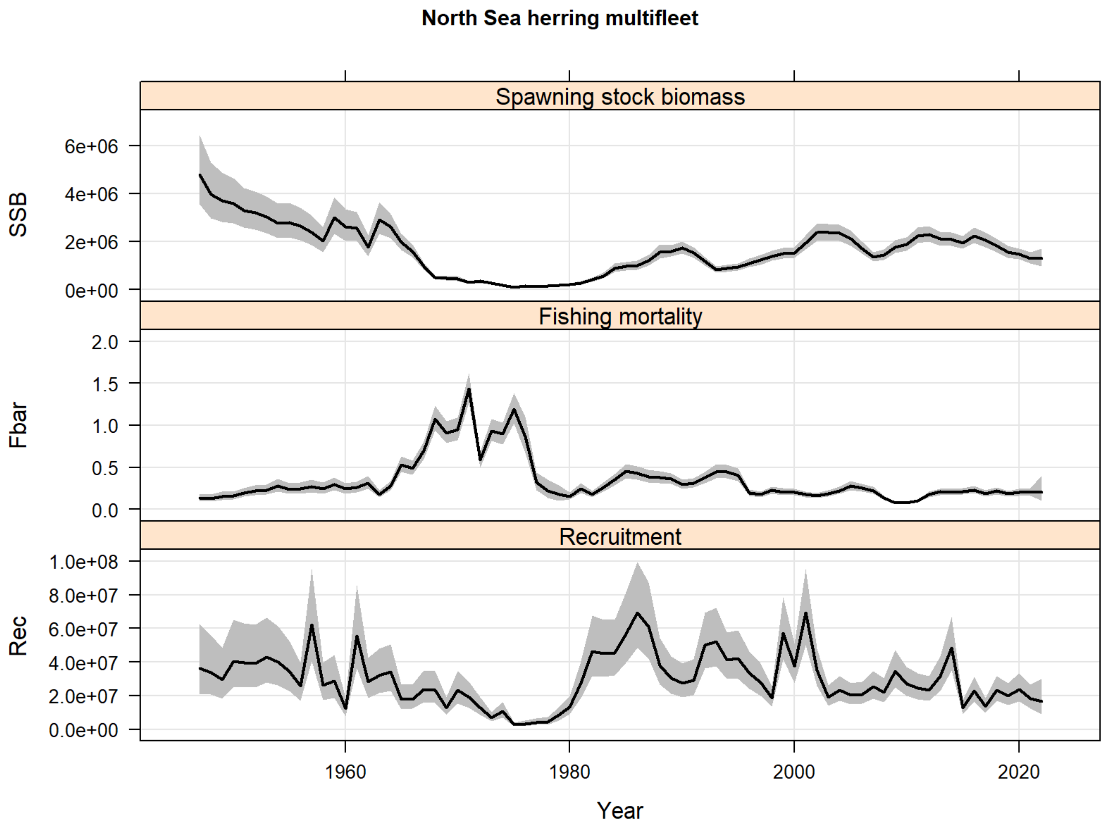


Figure 2.6.3.1 North Sea herring multi-fleet model. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

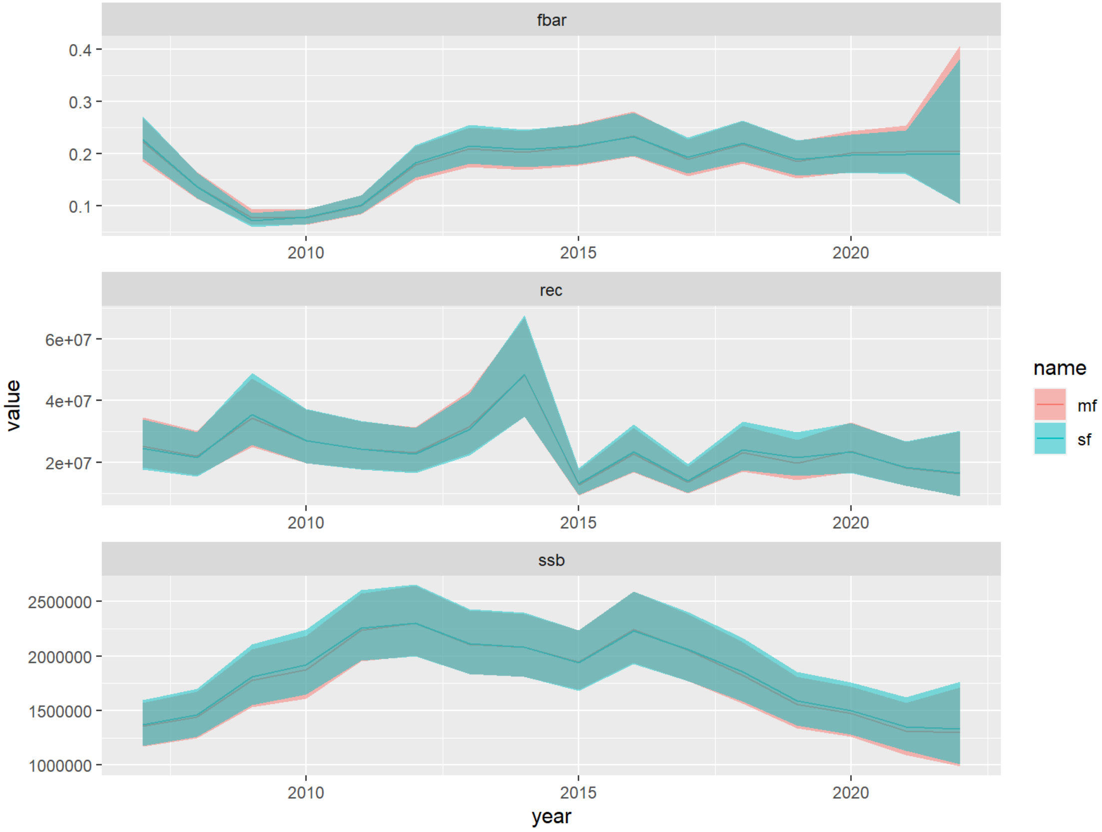


Figure 2.6.3.2 North Sea herring multi-fleet model. Comparison between single fleet and multi-fleet assessment models for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

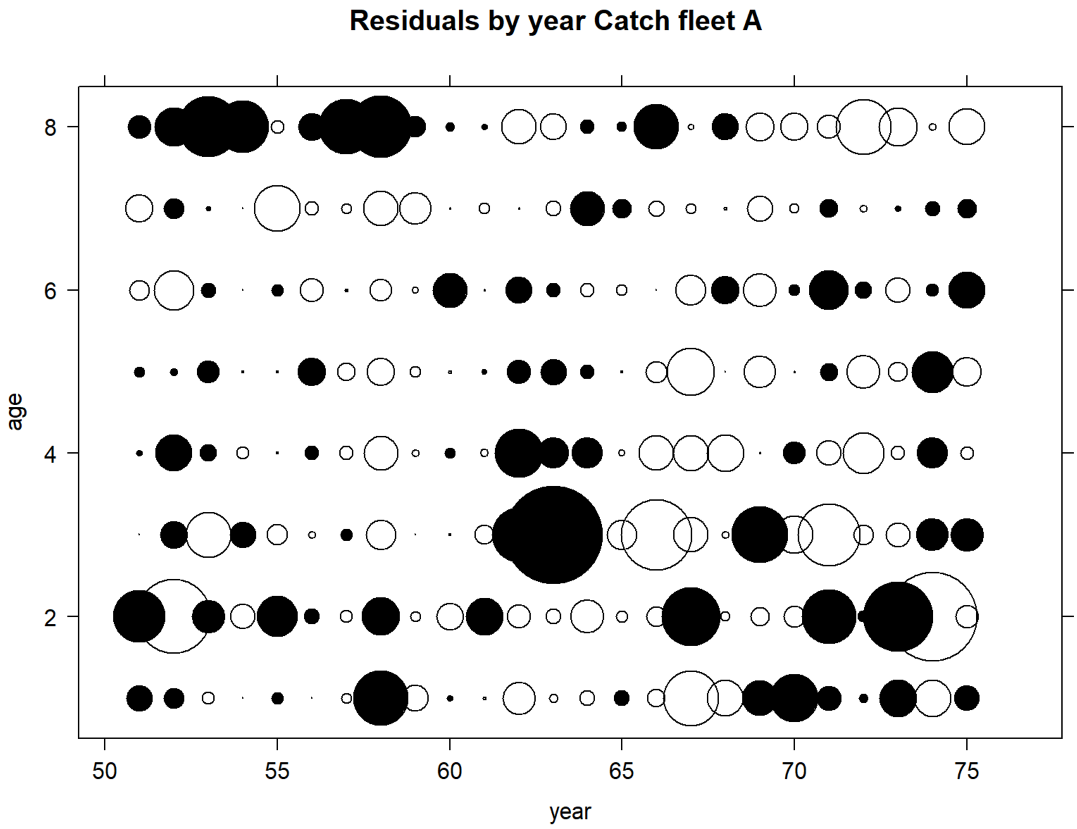


Figure 2.6.3.3. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet A.

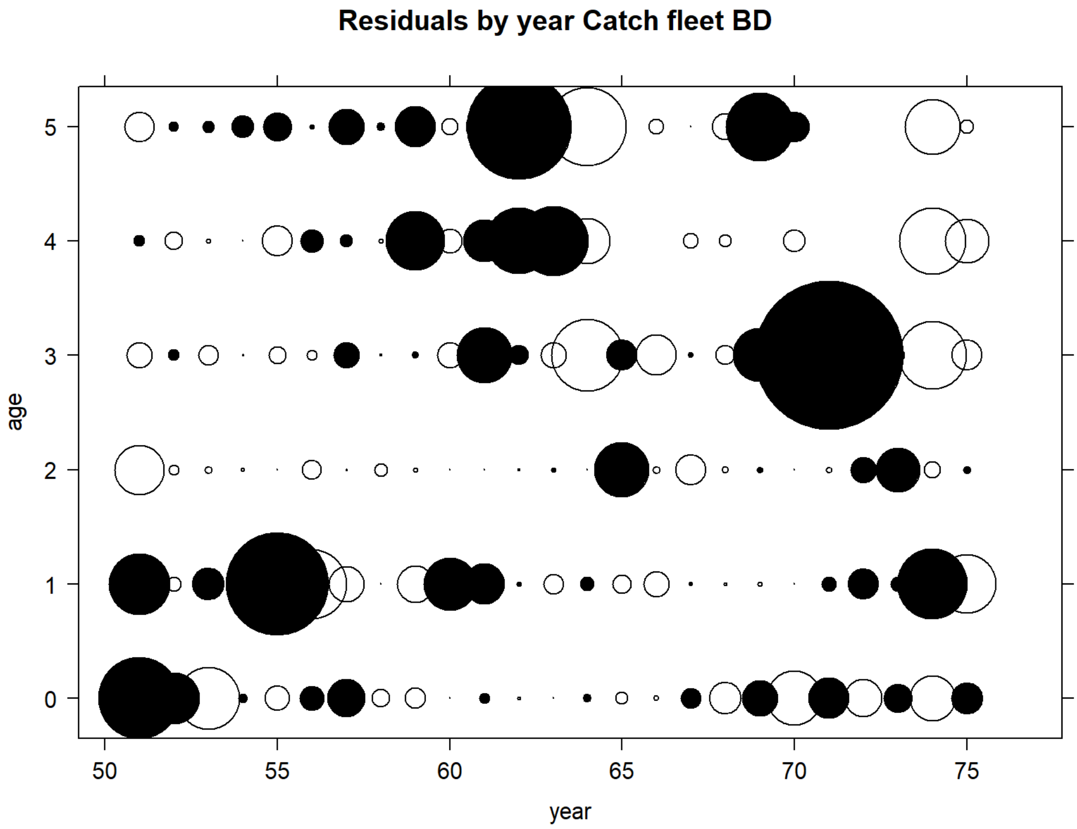


Figure 2.6.3.4. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet B&D.

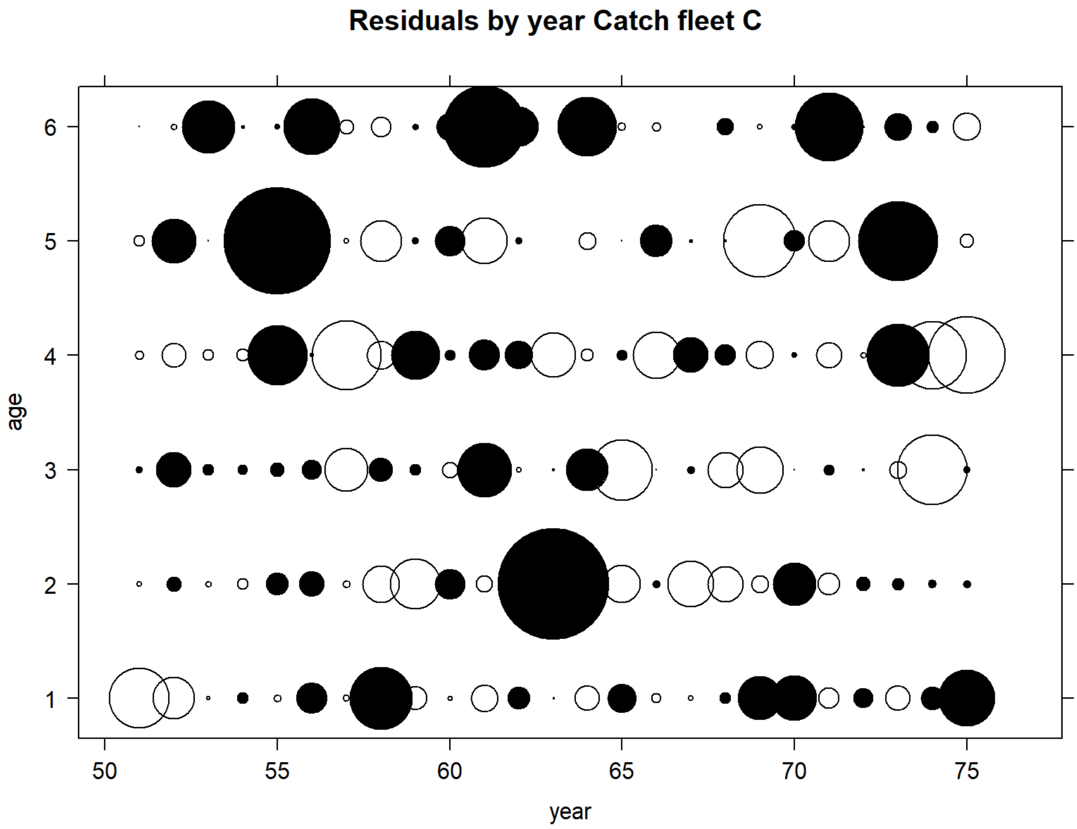


Figure 2.6.3.5. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet C.

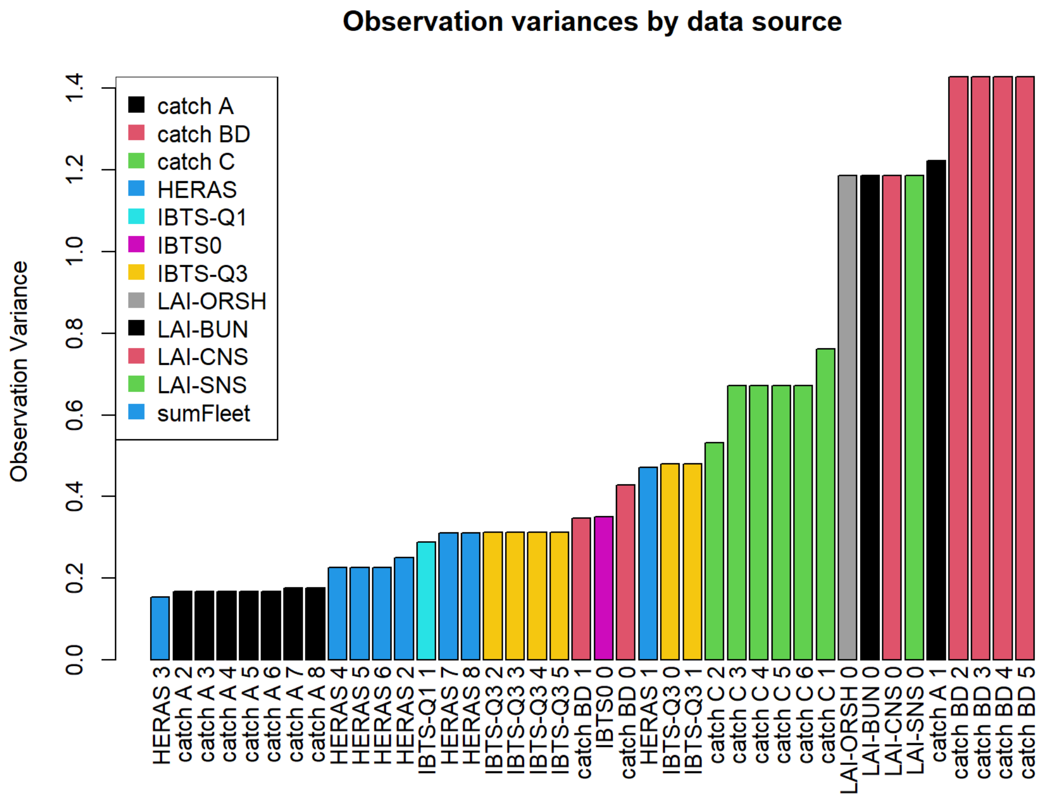


Figure 2.6.3.6. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for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

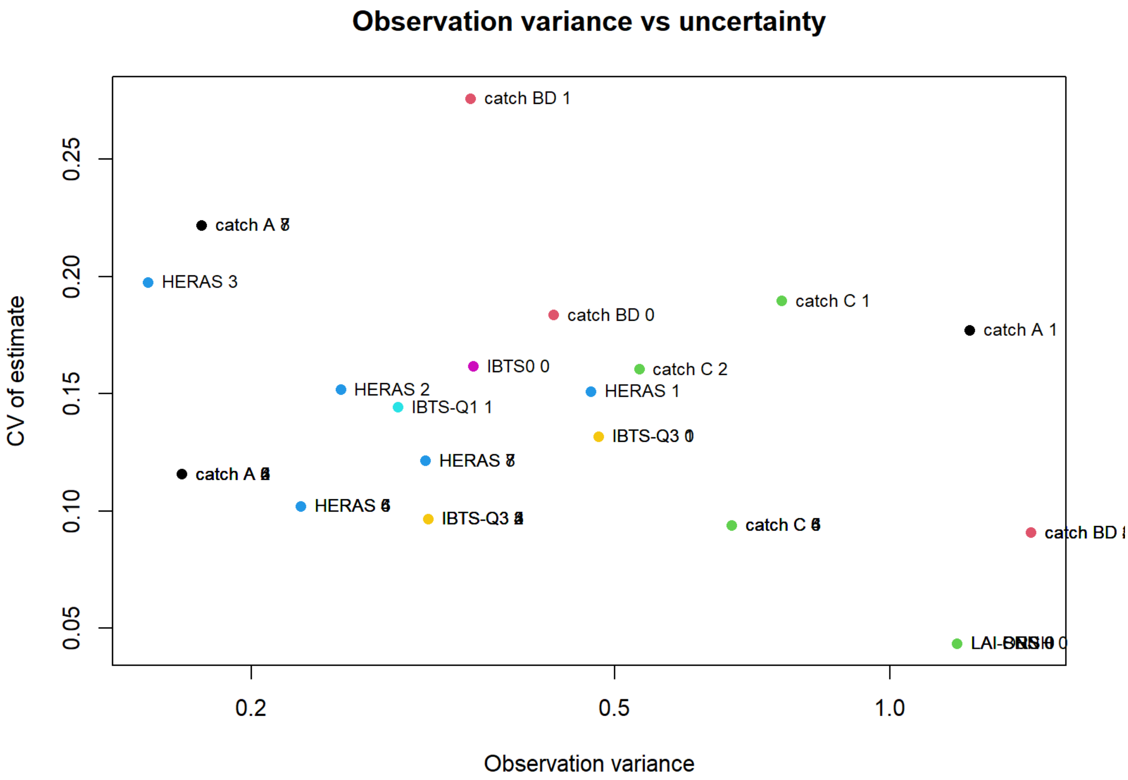


Figure 2.6.3.7. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

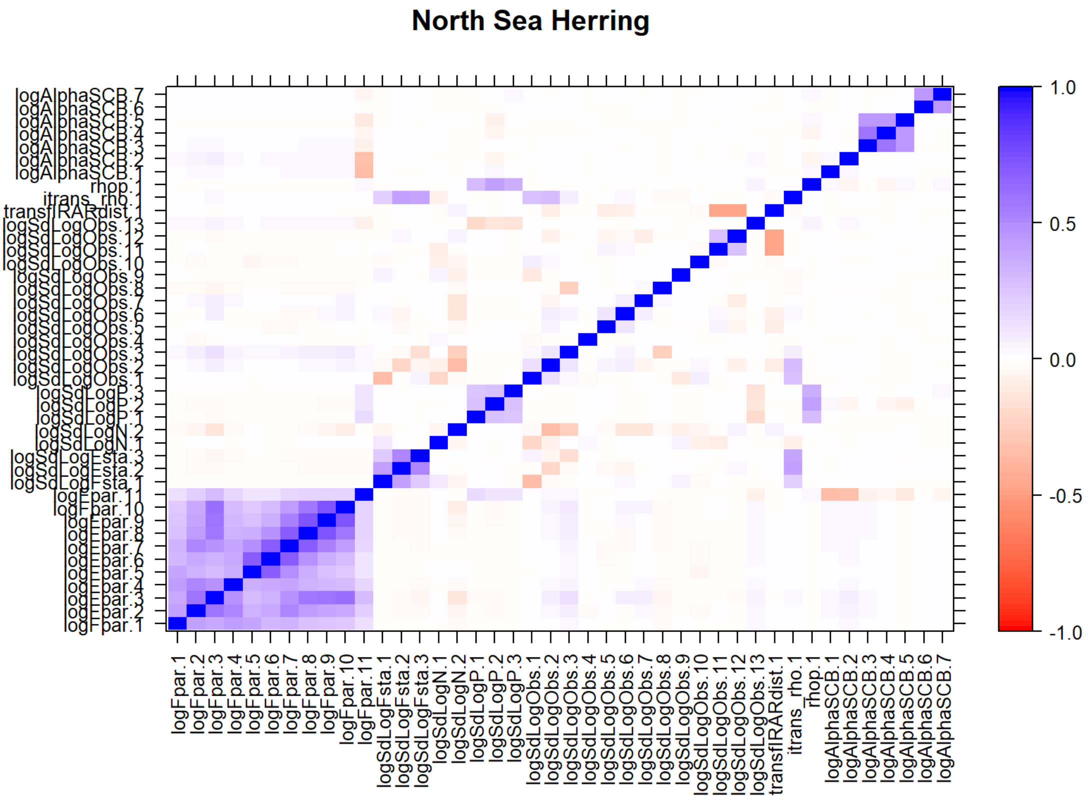


Figure 2.6.3.8. North Sea multifleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

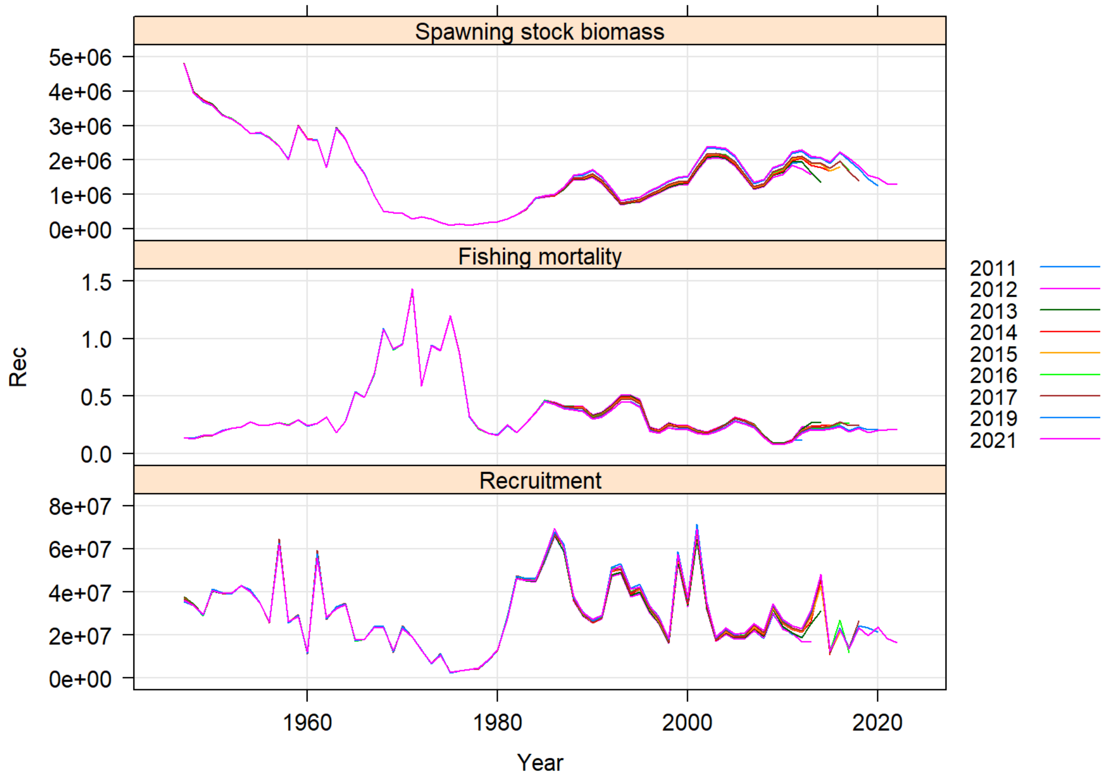


Figure 2.6.3.9. North Sea herring multifleet assessment model. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

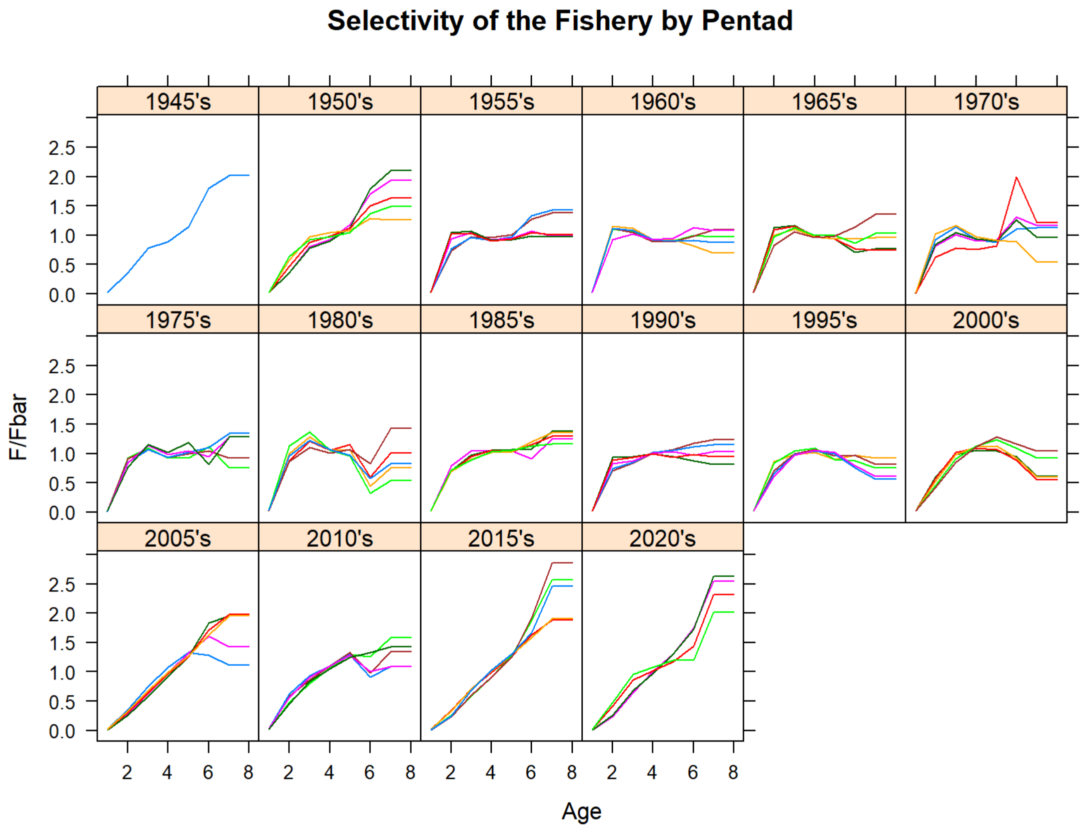


Figure 2.6.3.10. North Sea herring multifleet assessment model. Fishing selectivity fleet A.

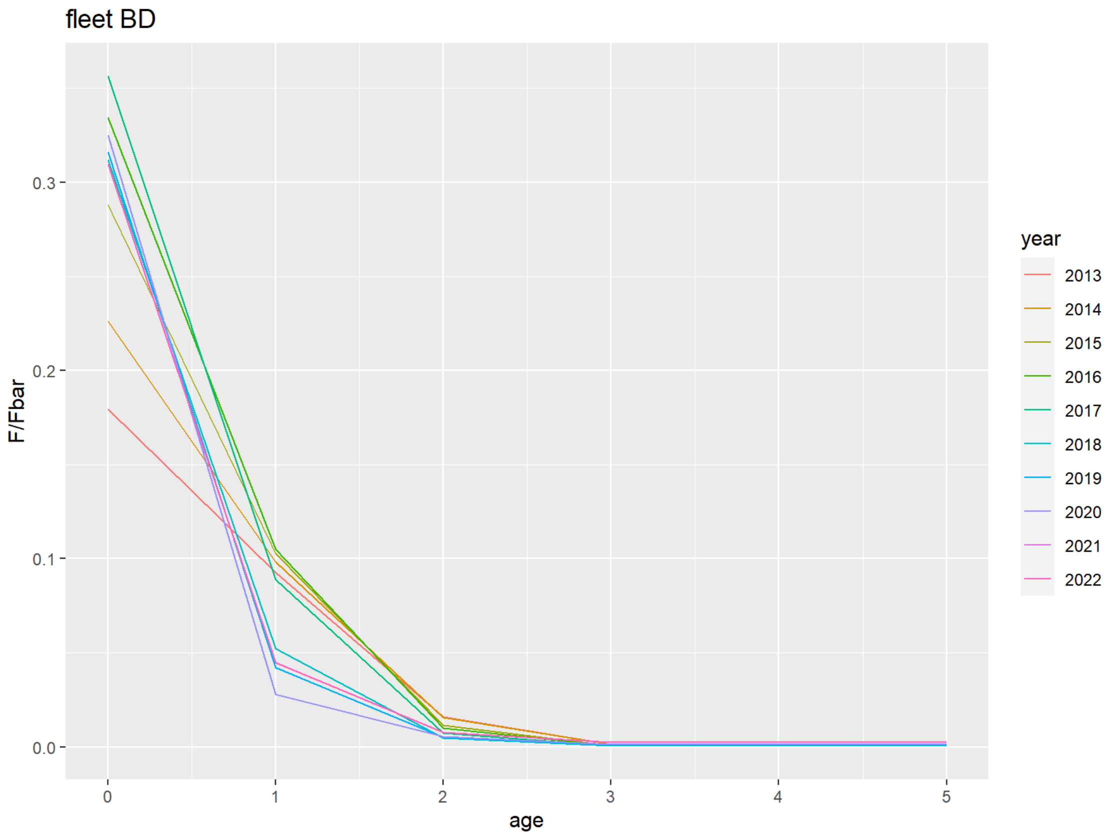


Figure 2.6.3.11. North Sea herring multifleet assessment model. Fishing selectivity fleet B and D combined.

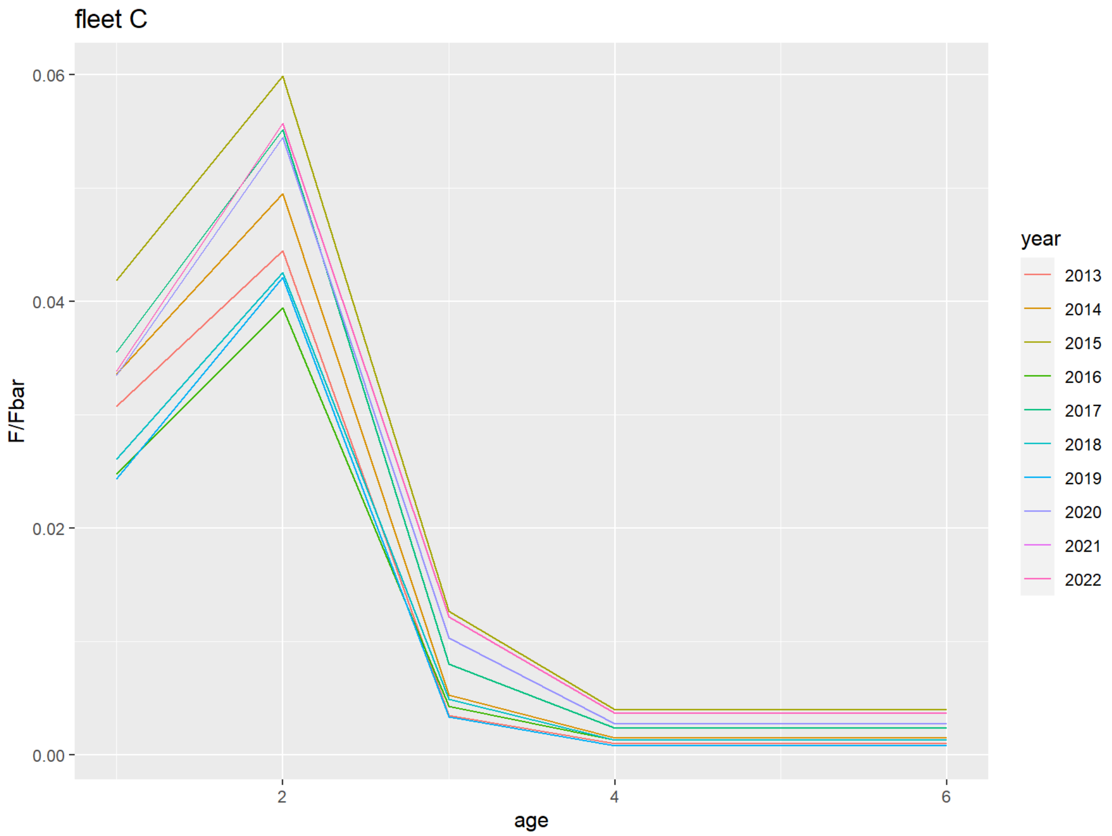


Figure 2.6.3.12. North Sea herring multifleet assessment model. Fishing selectivity fleet C.

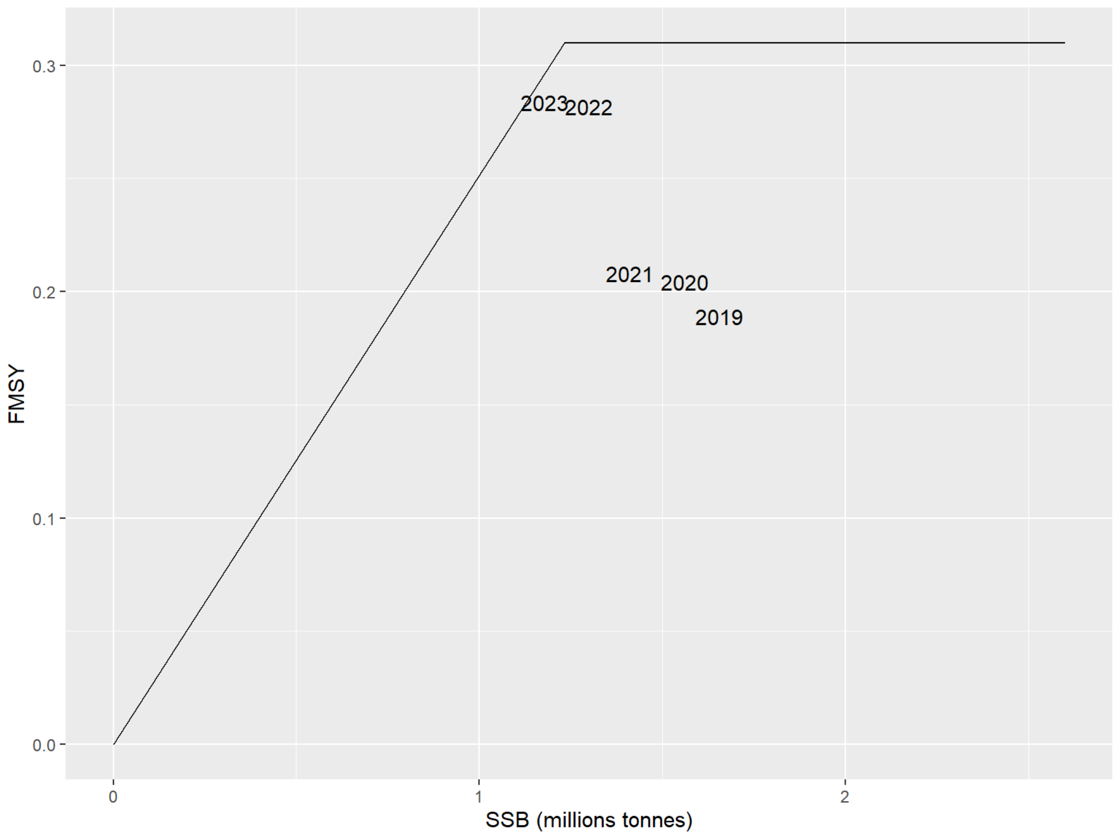


Figure 2.7.1.1. North Sea herring. FMSY advice rule and SSB/Fbar data point since 2019.

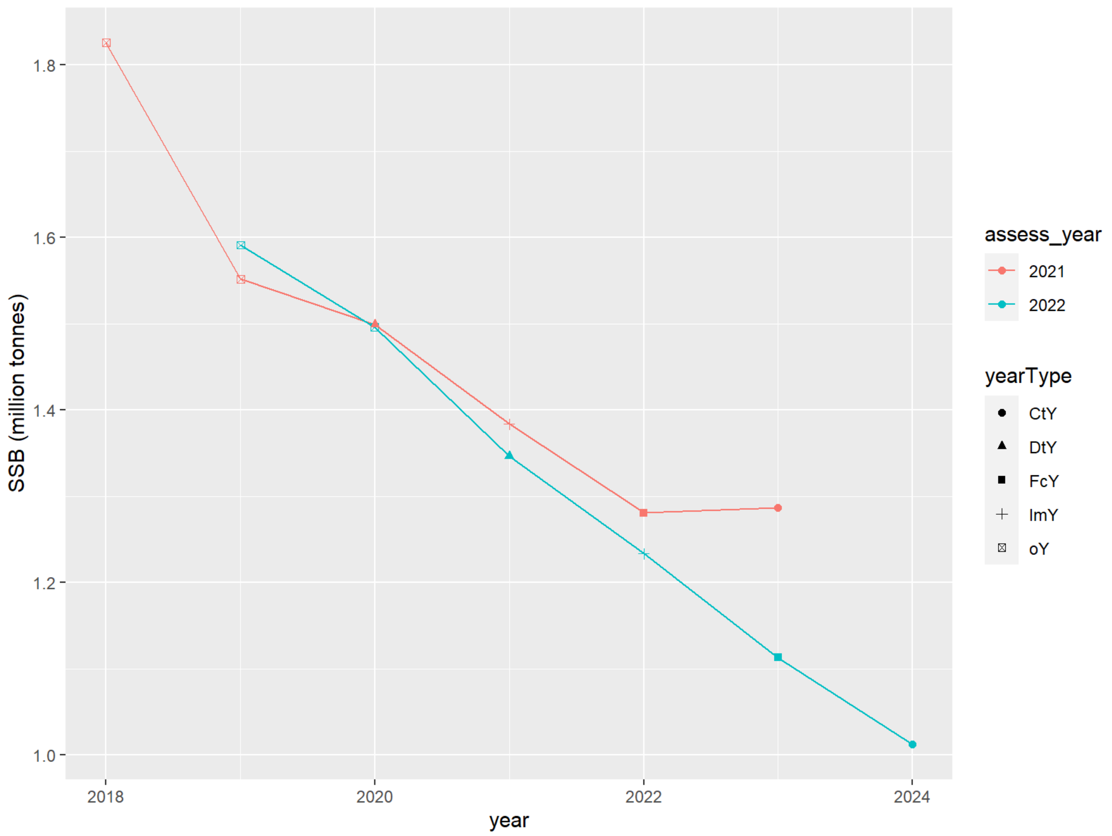


Figure 2.7.2.1. North Sea herring. comparison of SSB trajectory between short term forecasts applied to HAWG2021 and HAWG2022 data. oY: old years (prior to data year). DtY: data year. ImY: intermadiate year. FcY: forecast year. CtY: continuation year.

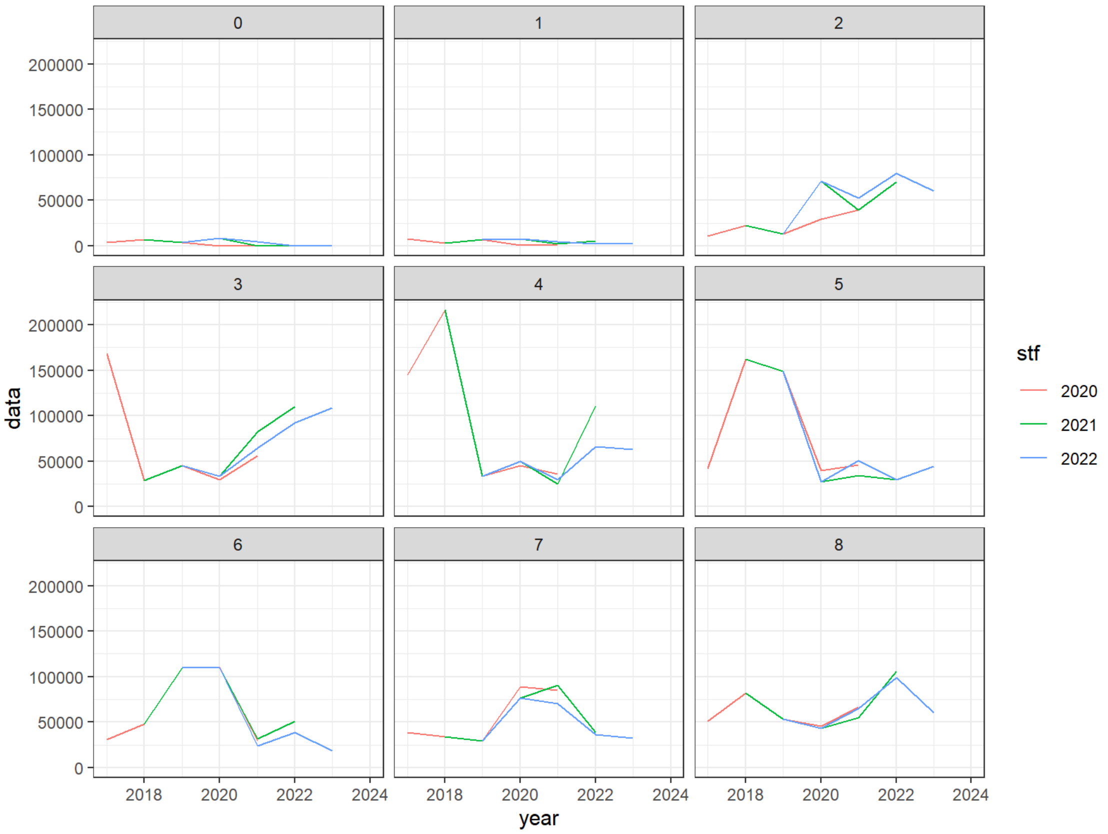


Figure 2.7.2.2. North Sea Herring. Realized and projected catch (in weight) by age (wr) between 2020 assessment (2021 as forecast year), 2021 assessment (2022 as forecast year) and 2022 assessment (2023 as forecast year).

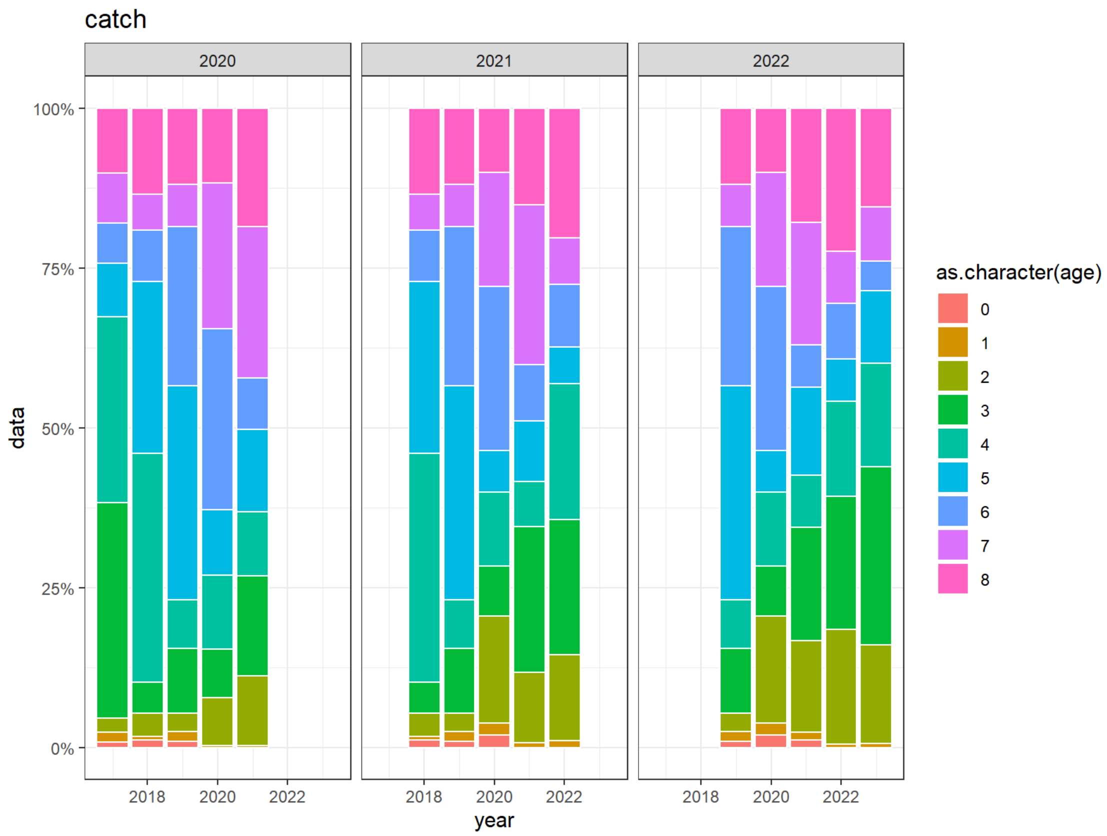


Figure 2.7.2.3. North Sea Herring. Catch proportions for the different ages between the 2020 short-term forecast (2021 as forecast year), 2021 short-term forecast (2022 as forecast year) and 2022 short term forecast (2023 as forecast year).

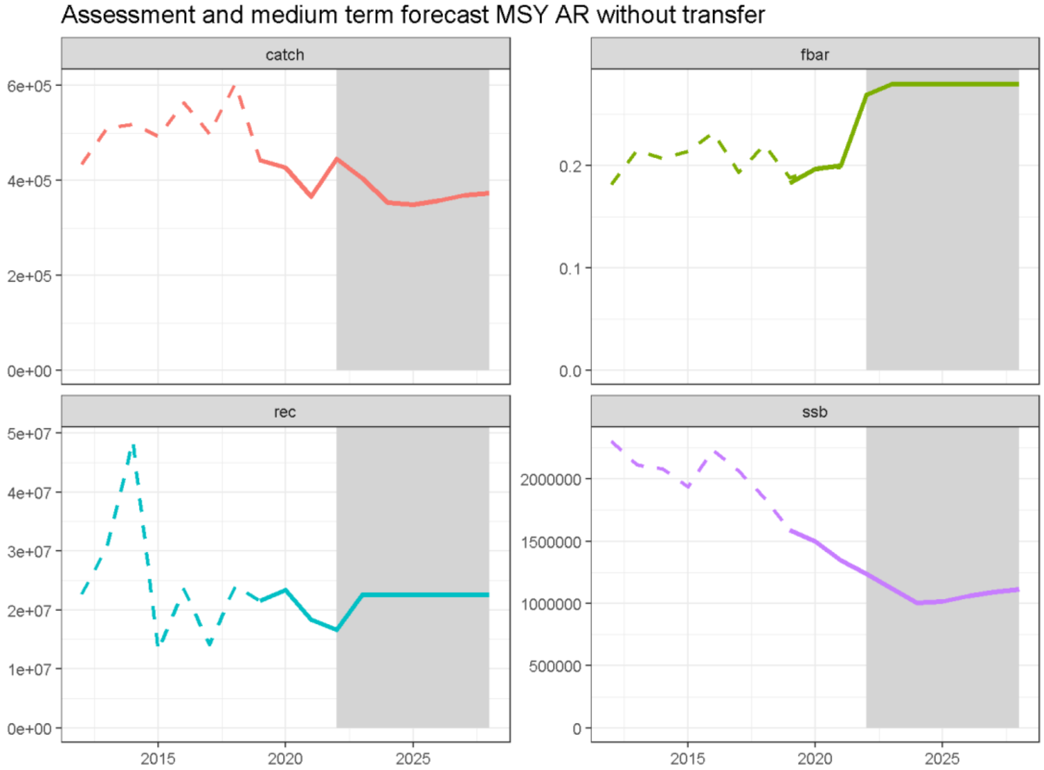


Figure 2.7.2.4. North Sea Herring. Short-term projections using an F status quo from TAC year (i.e. advice year). Intermediate year is in 2022 and the TAC year is 2023.

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.

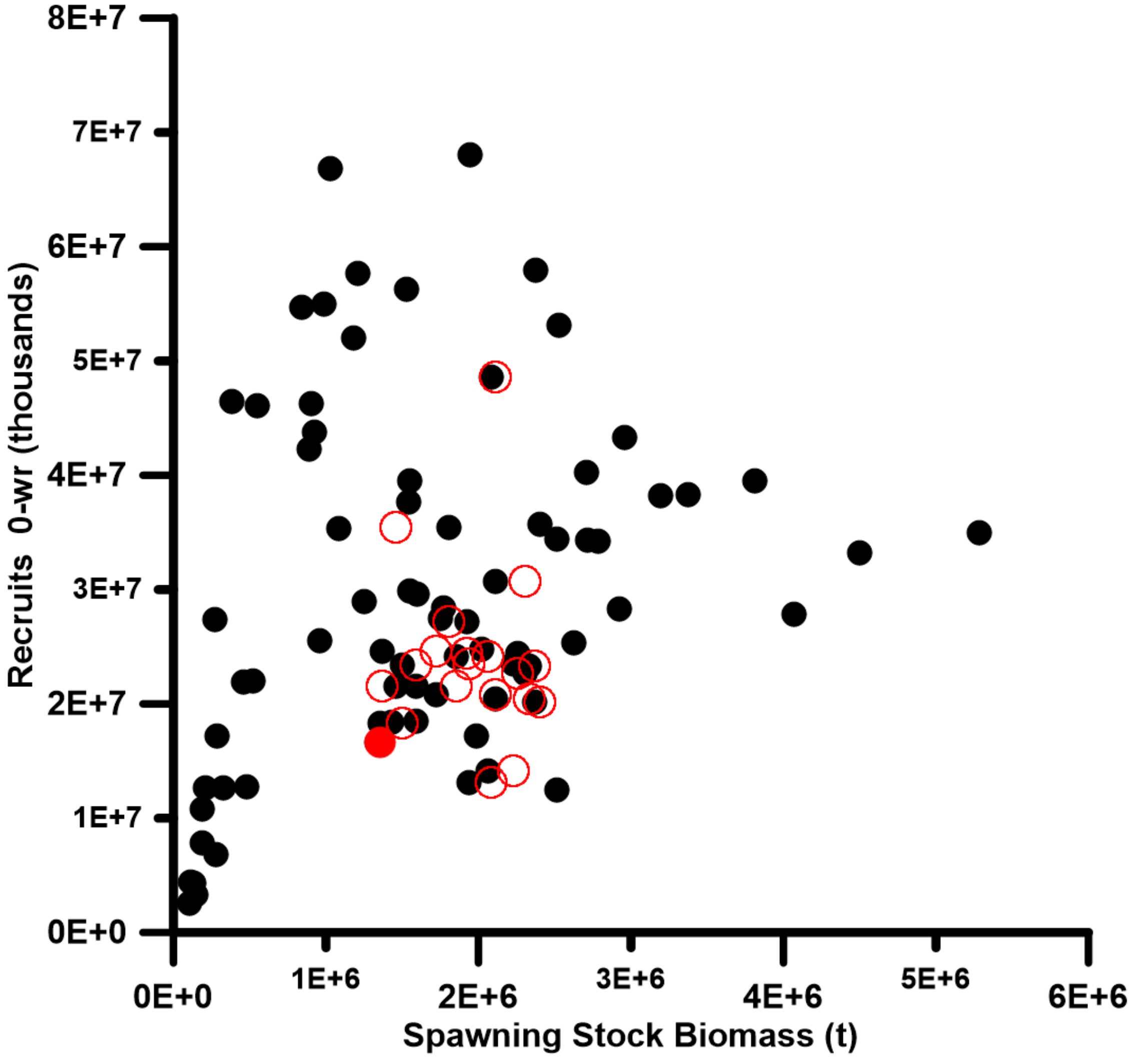


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning-stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent low recruitment. The most recent year class is plotted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

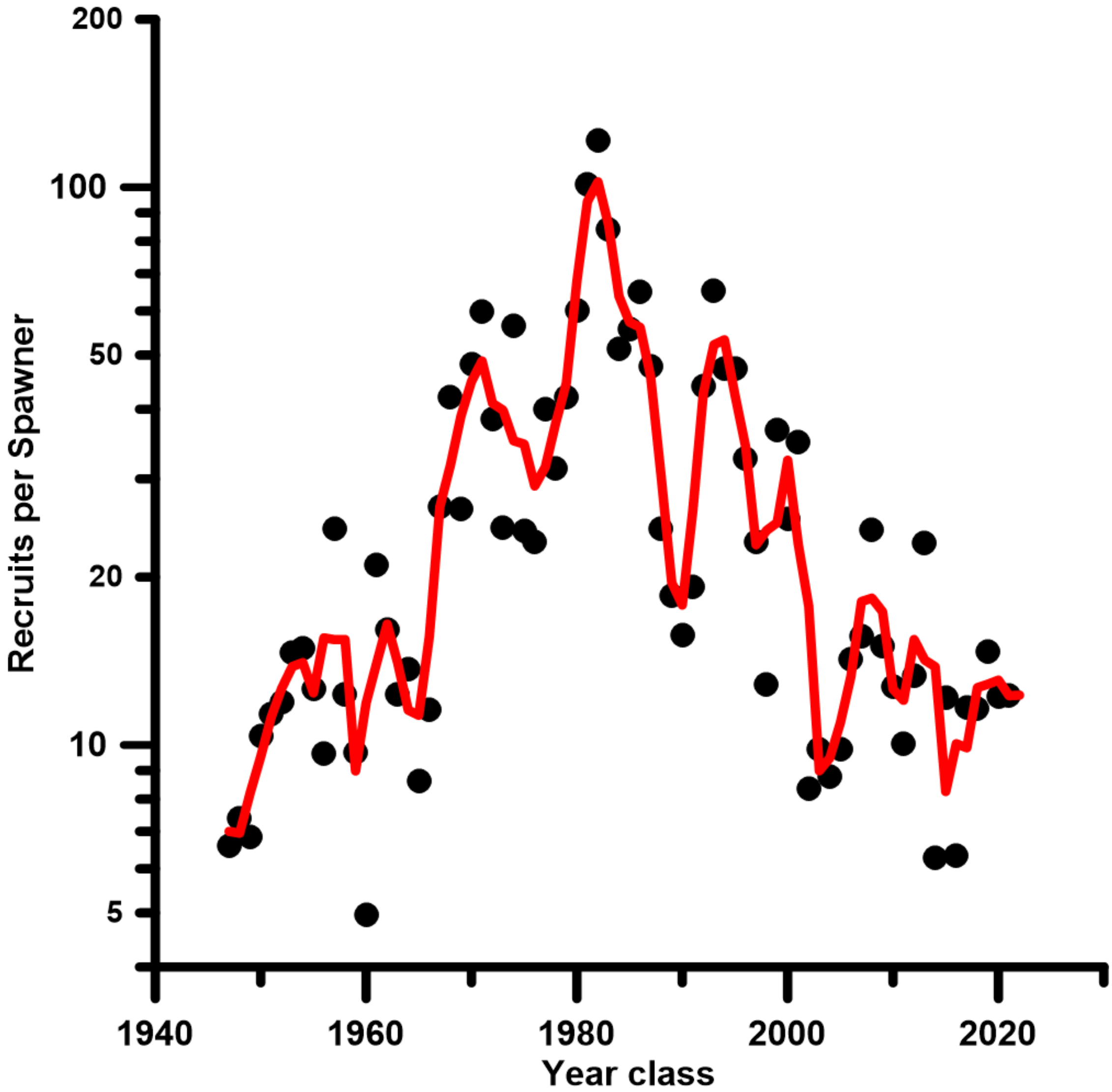


Figure 2.13.2. North Sea Autumn Spawning Herring time-series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black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

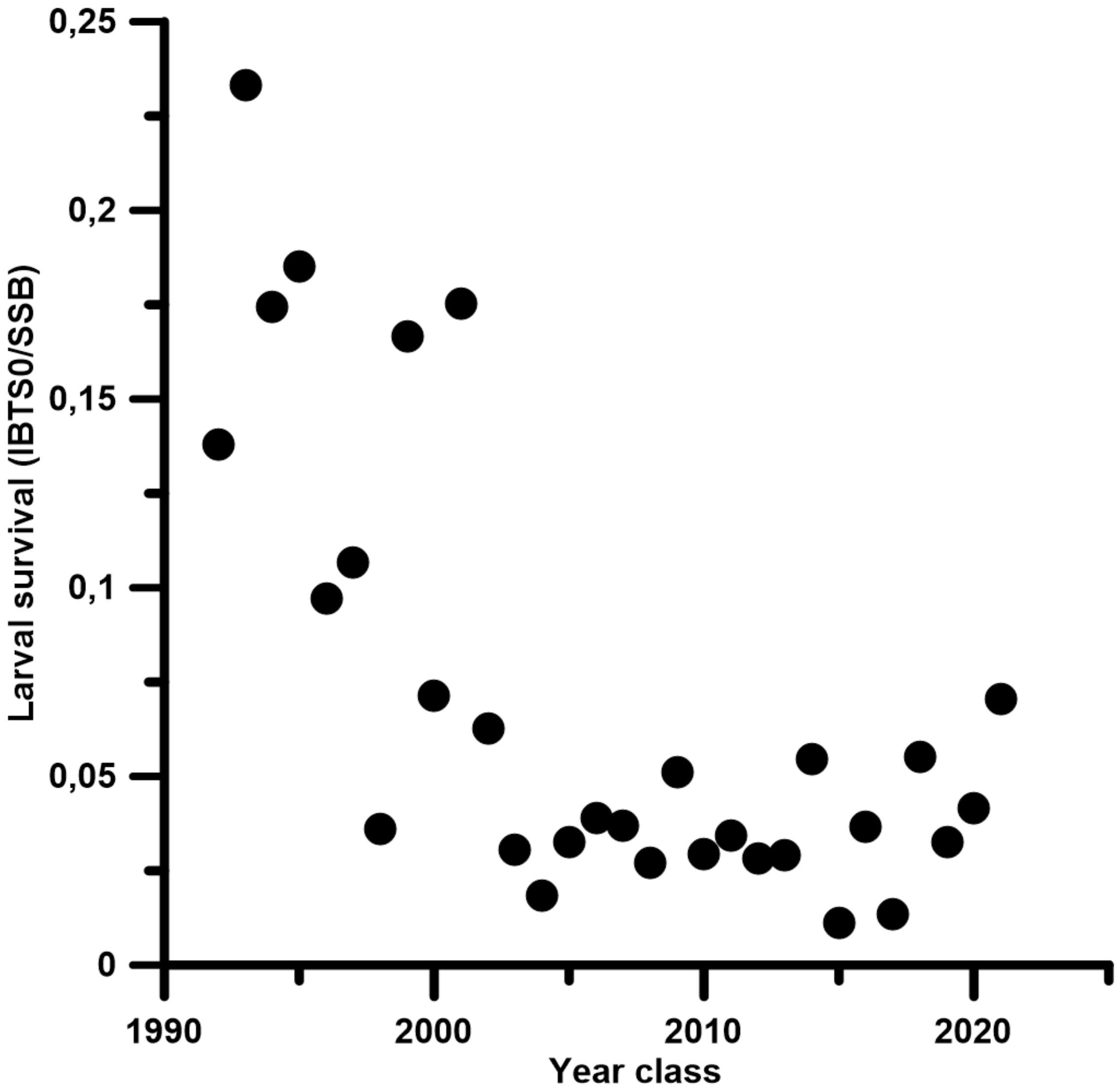


Figure 2.13.3. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is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

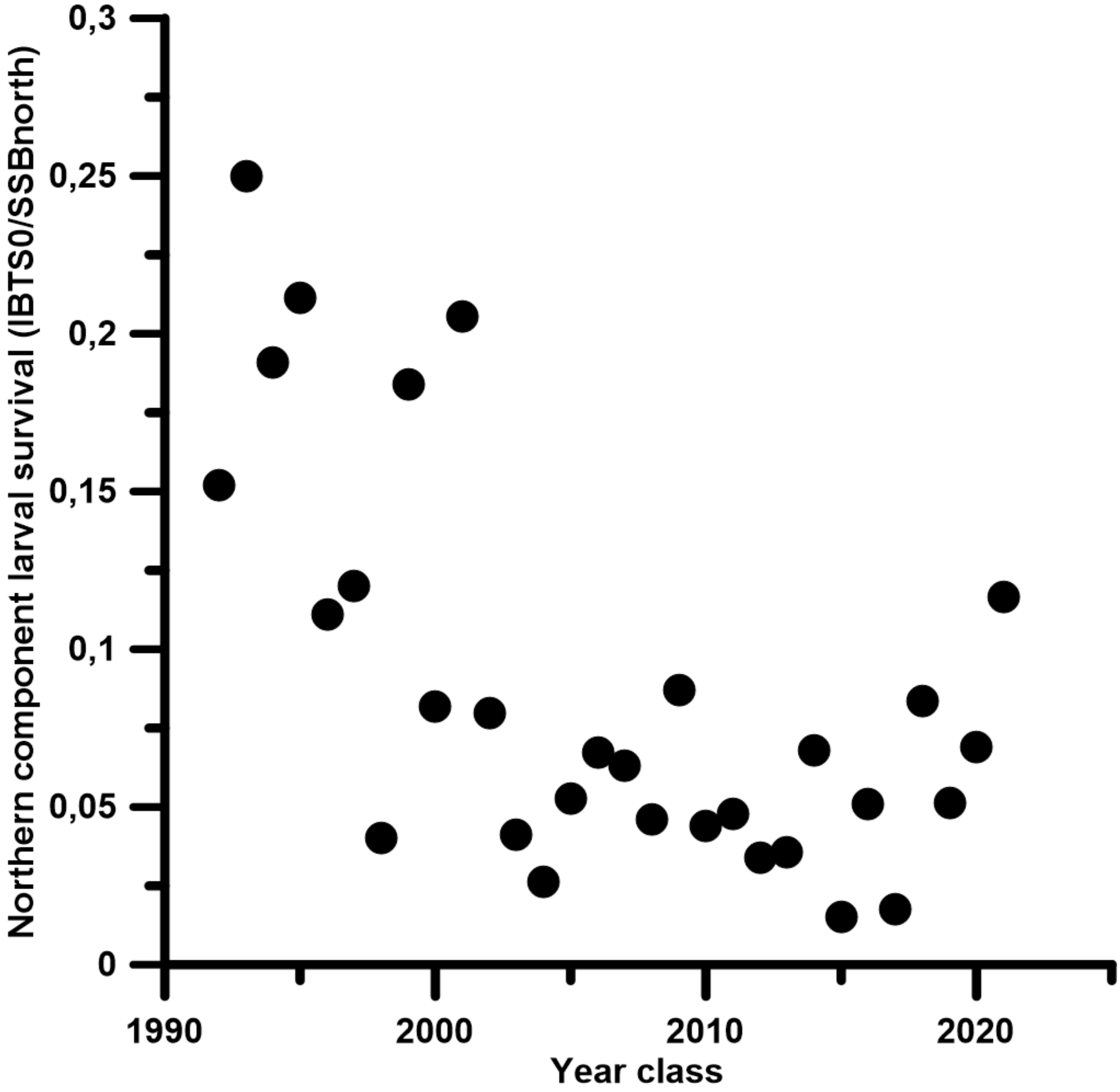


Figure 2.13.4. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the larvae indices for these components (representing larvae less than 10–11 mm) and the IBTS0 index (representing 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 2021 and 2022

ICES advised in 2021 on the basis of the MSY approach. This corresponds to zero catch in 2022 (ICES 2021).

The EU and Norway agreement on a herring TAC for 2021 was 21 604 t in Division 3.a for the human consumption fleet and a bycatch ceiling of 6659 t to be taken in the small mesh fishery. For 2022, the EU and Norway agreed on herring TACs in Division 3.a corresponding to 25021 t for the human consumption fleet (21684 t for EU and 3337 t for Norway) and a bycatch ceiling of 6659 t for the small mesh fishery (only EU). The agreement also states that of these overall fishing opportunities no more than 1136 t of herring would be taken in Division 3.a with 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) 2021/1888) for more specifics on area limitations on the transfer within the North Sea).

Prior to 2006, no separate TAC for subdivisions 22–24 was set. In 2021, a TAC of 1 575 t was set on the Western Baltic stock component. The TAC for 2022 was set at 788 t.

3.1.2 Landings in 2021

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 2021 are given in Table 3.1.1 and Figure 3.1.1. In 2021, the total landings in Division 3.a and subdivisions 22–24 have decreased to 14 918 t. Landings in 2021 decreased by 29% in the Skagerrak, by 6% in the Kattegat and by 60% in subdivisions 22–24. As in previous years the 2021 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.

In Table 3.1.2 the landings are given for 2004 to 2021 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
2021								
Div. 3.a fleet-C	21 604	9 800	145			9 498	18 723	2 881
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22–24 fleet-F	1 575	221	869	0	205	280	1 575	
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwegian waters								-50%
% of 3.a fleet-D can be taken in 4	50%							
	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%							

3.1.4 Regulations and their effects

Before 2009, HAWG has calculated a substantial part of the catch reported as taken in Division

3.a in fleet C actually has been 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 suggest that this pattern of misreporting of catches into Division 3.a does no longer occur. Therefore, no catches were moved out of Division 3.a to the North Sea for catches taken in 2020.

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 and 2022, 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, EU and Norway committed to limit overall herring catches in Division 3.a to 969 t and 167 t, respectively.

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 2021 the amount of WBSS taken was 35 t, which is the lowest recorded catch. However, the TAC utilization was 2.1% 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

Tables 3.2.1 and 3.2.2 show the total catch in numbers and mean weight-at-age in the catch for herring by quarter and fleet landed from Skagerrak and Kattegat, respectively. The total catch in numbers and mean weights-at-age for herring landed from subdivisions 22–24 are shown in Table 3.2.3.

The 14 918 t of landed herring were submitted stratified by area, fleet, and quarter, resulting in 57 strata with landings. 22 of these strata were sampled - accounting for 86% of the landings. Some strata with relatively large amounts of landings were unsampled, but the main problem being that fleet C only was sampled in the third quarter in Skagerrak (Table 3.2.4). Furter, it seems like it is getting more and more difficult for countries to sample the trawler landings in the F fleet. Unsampled strata accounted in total for 2 038 t and samples from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 3.2.5).

Based on the proportions of spring- and autumn-spawners in the landings, catches were split between NSAS and WBSS (Table 3.2.6 and the stock annex for more details).

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat, Skagerrak, and the sum of the two (Division 3.a) respectively were then estimated by quarter and fleet (Tables 3.2.7–3.2.12).

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 2020 was estimated to be 12 579 t, which represents a decrease of 31% compared to 2020 (Table 3.2.13).

Total catches of WBSS from the North Sea, Division 3.a, and subdivisions 22–24 by quarter, were estimated to be 14 180 for 2021 (Table 3.2.14). 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 1993–2021, are presented in tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division 3.a amounted to 4 244 t in 2021, which represents the second lowest value in the 28-year time-series (Table 3.2.17).

The catches of WBSS from Subdivision 4.aE and the catches of NSAS from Division 3.a in 2021 were reallocated to the appropriate stocks as shown in the text table below:

Stock	Catch reallocation	Tonnes
WBSS	4.aE (A-fleet)	3 505
NSAS	3.a (C+D-fleet)	4244

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 2021 is assumed to be insignificant, as in previous years.

Table 3.2.4 shows the number of fishes aged by country, area, fishery, and quarter. The overall sampling in 2021 meets the recommended level of one sample per 1000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size). Occasional lack of national sampling of catches by quarter and area has been covered by similar fisheries in other countries, but as mentioned in the section before, only a single quarter and area combination was sampled in the D fleet.

Splitting of catches into WBSS (Spring spawners) and NSAS (Autumn spawners) in Division 3.a were based on Swedish analyses of otolith micro-structure (OM) of hatch type and genetic analyses for Danish catches from 2022. Different components of NSAS herring spawn at different times of the year, the three northern components spawn in autumn and are assigned to OM hatch month 9, whereas the Downs components spawning during winter in the Eastern Channel assigned to OM hatch month 12. Herring are predominantly spawning during spring in the western Baltic, the Kattegat and the Skagerrak and are assigned to the OM hatch month 4, however smaller stock components from the Western Baltic Sea and Baltic Sea also spawn in autumn and winter, which leads to an assignment to OM hatch month 9 and 12, respectively. This would hence lead to an erroneous assumption that these Western Baltic Sea and Baltic Sea autumn and winter spawners belonged to the NSAS stock. Moreover, winter-hatched individuals have traditionally been assigned differently in Danish and Swedish samples, where OM hatch month 12 has been assigned to WBSS in Sweden and to NSAS in Denmark. The samples from the IBTS have been split according to the Danish perception of stock affiliation. However, since the implementation of splitting by genetic markers, these issues have been resolved.

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 model included wr, subdivision, quarter, and cruise as fixed effects and had a random intercept varying by trip/haul[1]. Both commercial and survey samples from both countries were used in the analysis. Total composition estimates per wr, quarter, and subdivision were calculated as a weighted average of the country-wise estimates. Total estimates were only calculated for combinations of wr, quarter, and subdivision with catches. For combinations with Danish or Swedish catches, the country-wise estimates were weighted by the catches. For combinations without Danish and Swedish catches, country-wise estimates were weighted by the sum of catches for the relevant quarter and subdivision.

Random samples of 175 individual herring from Norwegian commercial catches in the "transfer area" in 4.aE are analyzed for size at age distribution and stock affiliation based on a genetic stock identification method using an extended SNP panel (82 markers where 53 are included also in the panel used for Danish samples). A common baseline with small deviations was used for stock identification for Danish and Norwegian samples. Based on expected 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 88 253 tonnes of herring was caught in the transfer area in 2021, with catches constituting 74% in quarter 2 and 20% in quarter 3, however with only four samples (40, 42, 45, and 48 fish) from quarter 2 being available for calculating stock proportions.

For quarter 2 and 3, the same split was applied based on the combined samples from HERAS and the fishery in the transfer area (251 fish). This was done under the assumption that the fishery is restricted to the same period as HERAS in June and July and would catch similar proportions of the two stocks in this period. The 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 lack of sampling data in 2021 the split for quarters 1 and 4 had to be carried over from 2020. Quarter 1 and 4 estimates from 2020 were based on data from the time-series of samples

1In 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.

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, 3505 tonnes of WBSS herring were caught in the transfer area in 2021.

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 8–28 October 2021 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 2020-2021 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). 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.

The age-length distribution of herring in SD 21 and in SD 22 in 2021 indicated also some contribution of fish of CBH origin. Besides the standard procedure to use the SF in SD 24 and in SD 23/39G2 (since biological samples of that rectangle were also used to raise the corresponding mean NASC values in the SD 24 area of the rectangle), the SF was accordingly also applied in SD 21 and SD 22 in 2021.

Haul 32 (41G2, SD 23) targeting a large aggregation of herring yielded a substantial sample of almost exclusively large herring that were spawning (maturity 6). Since the herring could not be allocated to WBSS, both the hydroacoustic data from that aggregation as well as the biological data from haul 32 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 in 2021 was estimated to be 0.8 x 10^9 fish or about 29.3 x 10^3 tonnes in subdivisions 21–24. The biomass index in 2021 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 21 June to 6 July 2021 and covered the Skagerrak and the Kattegat and the North Sea. The 2020 estimate of Western Baltic spring-spawning herring was 105 x 10^3 tonnes and 0.911 million herring. Compared to the values in 2020, the 2021 estimates represent a decrease of 48 % in numbers and of 35% in biomass. The stock biomass is dominated by 2-4 winter ring (79%). The present numbers of older herring (3+ group) in the stock only represent 45% of the average of the whole times series till 2020 (2021: 649 million; mean 1991–2020: 1411 million). 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 2021 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 2 751 million larvae, the 2021 N20 recruitment index is more than 10 times higher than that of the record low in 2020 and the highest value since 2015 (for further details see WD Polte and Gröhsler, HAWG 2021).

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 these splitting are based on otolith microstructure from the IBTS samples by assuming that only OM4 (Spring-spawning) contribution to the WBSS fraction, while OM9 and OM12 (Autumn and Winter spawning) are considered non-WBSS. The following equation describes the model considered for both 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 3.2.14).

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 2021 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 = 0.75, 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 lies below the long-term average (1992–2021: 5 389 million). The 2021 N20 recruitment index is more than 10 times higher than that of the record low in 2020 and the highest value since 2015 (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 2021 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 also 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.

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 1991–2021. 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 highly 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_2022) and the single fleet (WBSS_HAWG_2022_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 in 2020. However, this year, this was not enough to solve convergence problems.

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

There was no problem of convergence in 2022 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 2021 is 62 765 [44 766, 88 002 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.149 [0.080, 0.277 (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 69.3 kt. SSB has only slightly increased in the following period up to 83.7 kt in 2015 and then has declined to 54.4 kt in 2019, which is the lowest SSB of the time-series. A slight increase in SSB was then estimated since 2020 to around 62.8 kt in 2021.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of 0.66 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 0.40 and 0.31 yr-1, respectively. It stabilized between 0.31 and 0.43 yr-1 for few years until it increased again above 0.49 yr-1 from 2016 to 2018. $F_{3\text{-}6}$ then decreased to 0.30 yr-1 in 2019, 0.18 yr-1 in 2020 and then 0.15 in 2021, which is the lowest estimated $F_{3\text{-}6}$ of the entire time series (Table 3.6.11, Figure 3.6.4.2).

Recruitment was the highest (~3-5 billion) at the beginning of the time-series (1991-1999) and has been decreasing overall since 1999. The 2020 estimate of 550 822 thousands is the lowest on record and the estimate in 2021 has slightly increased to 609 230 thousands (Tables 3.6.11, Figure 3.6.4.3). 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 2021 recruitment has varied from about 1.5 billion to less than 1 billion at SSB between 54 kt and 110 kt, with a trend of declining recruitment in 2017-2020 and some slight increased recruitment in 2021.

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. This year, the 2021 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 (wr) respectively (Figure 3.6.4.7). The fishing mortality increases in the recent years for the A-fleet. The C-fleet shows a variable F over time with a peak in F in 2017-2018 and a decrease in F since. There is a clear decrease in F for the D- and F-fleet in recent years. The selectivity pattern for the D-fleet has a tendency of shifting its highest selectivity from age 2 to age 3 (wr) in later years. Total fishing mortality on the WBSS stock increased with herring age (Figure 3.6.4.8). It decreased overall over time but showed an increase in 2014-2018 and a decrease again up to 2021, well below F_{MSY} in 2020-2021.

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. 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 (Figure 3.6.4.9). Interpretation of the different catchability patterns is complex, and likely, a number of 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 2018-2020 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 amount of catches in the fleets with increasingly better fit from A-fleet, D-fleet, C-fleet to the F-fleet (Figures 3.6.4.13–3.6.4.17). 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 (i.e., 2009 and 2018-2021 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 3.6.13 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 which is 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 21% (compared to 20% in 2021) 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 = -14% compared to -13% in the 2021 assessment, Figure 3.6.4.25). The retrospective for recruitment is acceptable having a Mohn's rho = 11% (7% in 2021, Figure 3.6.4.26). Retrospective is very small for total catch (Figure 3.6.4.27).

This year the age composition for the A-fleet was taken directly from the transfer area rather than from the entire Division 4aE given that samples were available in the Norwegian catches. Sensitivity runs were performed for both the single and multifleet models and are available on stockassessment.org (WBSS_HAWG_2022_sf_4aE, WBSS_HAWG_2022_4aE respectively). No makeable differences were present for the multifleet models and the age composition from the Norwegian catches (main fleet) is believed to be more representative of the composition available in the transfer area than the one in Division 4aE. It was therefore agreed to take the assessment with age compositions from the transfer area forwards as final assessment.

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 2021 and continue to show the largest contribution to the estimated SSB level, the small SSB increase in 2021 appear independent from any individual specific survey (Figures 3.6.4.28–31).

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 2021 is showing a small sign of recovery.

The 2018 benchmark calculated a new F_{MSY} of 0.31. Fishing mortality ($F_{3\text{–}6}$) was reduced between 2008 and 2011 from 0.58 to 0.31 (Tables 3.6.11, Figure 3.6.4.2). $F_{3\text{–}6}$ has then remained stable above F_{MSY} until 2015 (0.34-0.43) but showed an increase in 2016-2018 with an estimated $F_{3\text{–}6}$ between 0.49 and 0.51. $F_{3\text{–}6}$ has decreased since 2019 from 0.30 to 0.15 in 2021, which is the lowest $F_{3\text{–}6}$ on records.

Recruitment has been declining since 2014 with a historical low value in 2020 of 550 822 thousands (Tables 3.6.11, Figure 3.6.4.3). Recruitment increased to 609 230 thousands in 2021, possibly due to a cold winter in 2020-2021. Despite the increase in 2021, recruitment is still low compared to the average of the time series. 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 2021 data resulted in a negative change in the perception of the stock back in time compared to last year assessment of around 6-7%. The recent estimates of recruitment have however drastically increased by 19 % in the current assessment and F appears to be larger than previously estimated in 2019 (+3.9%) but smaller in 2020 (-5.5%).

Parameter	Assessment in 2021	Assessment in 2022	Difference (2022-
SSB (t) 2019	57 841	54 388	-6.35%
$F_{(3-6)}$ 2019	0.288	0.300	3.94%
Recr. ('000) 2019	676 518	839 747	19.4%
SSB (t) 2020	58 434	54 606	-7.01%
$F_{(3-6)}$ 2020	0.193	0.182	-5.52%

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 2022 assessment, recruitment for the forecasts was calculated on the period 2016–2020, 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 (2017–2021). Based on earlier considerations in HAWG, the different periods were chosen to reflect recent levels in recruitment and weights.

3.9.2 Intermediate year 2022

A catch constraint was assumed for the intermediate year (2022). Predicted 2022 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 2022 NSAS+WBSS (t)	Predicted 2022 WBSS catch (t)	Predicted 2022 WBSS catch explained (t)
A	427 628	6 142	1.36% (427628+25021-(969+167))
C	25 021	733	64.5% (969+167)
D	6 659	0	Considered negligible
F	788	788	100% 2022 TAC
Total	460 096	7 663	

In the past assessments, 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. This year, it was chosen to make the assumption for the A-fleet in 2022 consistent with what is usually assumed for the NSAS advice. This assumption results in a total catch of WBSS herring of 6 142 t corresponding to the sum of the A-fleet TAC (427 628 t) and what is transferred from the C-fleet in Division 3.a to the North Sea (23 885 t), scaled by the 3-year average proportion of WBSS in A-fleet catch (1.36%, 2019-2021).

In 2022, 100% of the 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 2021. This is discussed further in part 3.12. The Council Regulation (EU) 2022/109 stipulates that the catches in Division 3.a should be limited to 1 136 t (969 t of EU catches + 167 t of Norwegian catches) in 2022 as the sum of directed and bycatch fisheries. Given the recent downward trends in the observed D-fleet catches, ICES considers that the bycatch in the D-fleet will be negligible in 2022 and it was therefore set to zero in the forecast. The 1136 t are assumed to be taken by the C-fleet in 2022 and was scaled by the 3-year average proportion of WBSS in the C-fleet catch (64.5%, 2019-2021).

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 7 663 t of WBSS herring in 2022.

3.9.3 Catch scenarios for 2023–2025

The inputs and outputs of the short-term predictions are based on a catch constraint in the intermediate year 2022 of 7 663 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. In the past forecasts, 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. This year, 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 2023 (advice year) to 2025

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because the forecasted SSB in 2024 is below B_{lim} even when F=0, ICES advises a zero catch for 2023.

None of the catch scenarios for 2023, including zero catch, is expected to bring SSB above B_{lim} in 2024. For the past 2 years, besides requested standard scenarios HAWG also calculated the potential development of the stock projections until 2025 with different low F scenarios, where F2024 = F2023. None of these scenarios, even when F = 0, can bring the SSB above B_{lim} in 2025.

Since 2020, two new scenarios were requested by ACOM for zero catch advice stocks: (1) the "Catch for bycatch fleets only" scenario, 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 2021), this can be easily done because SSB in 2023 only depends on F in 2022 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 2023 and the F in 2023 can be estimated to obtain a SSB in 2024 equal to 2023. 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 2023 is in fact the result of catches assumed (agreed TACs) for the intermediate year (2022) and some catches in the first months of 2023. In other words, the SSB in 2023 depends on F in 2022 but also on a fraction of the F in 2023, which is the advice year. What to assume for the first months of 2023 is the real issue here. For instance, if a zero catch is assumed in 2023 according to the advice, it will be uninformative because the table of advice would still only show the average F in 2023 (so F = 0). If an F that makes SSB 2023 = SSB 2022 is assumed for 2023, it will be an unrealistic high F needed to compensate for the low catches assumed in 2022. Given the reasons described above, the constant SSB between 2023 and 2024 scenario could not be meaningfully run for WBSS herring and is not included among the catch scenarios presented by the EG.

Table	Basis	Total catch	F_{3-6}	SSB* (2023)	SSB* (2024)	% SSB change	% advice
ICES advice basis							
3.9.2	MSY approach: zero	0	0	80 978	95 882	18	0
Other scenarios							
3.9.3	MAP^: F = FMSY ×	19 391	0.147	79 256	79 224	0	
3.9.4	MAP^: F = FMSY lower ×	14 025	0.102	79 772	83 745	5	
3.9.5	MAP^: F = FMSY upper ×	23 085	0.179	78 880	76 152	-3	
3.9.6	F= FMSY	36 088	0.310	77 401	65 861	-15	
3.9.7	F = Fpa	44 481	0.410	76 296	59 278	-22	
3.9.8	F = Flim	47 526	0.450	75 860	56 930	-25	
	SSB (2022) = Blim ^^						
	SSB (2022) = Bpa ^^						
	SSB (2022) = MSY Btrigger ^^						
3.9.9	F = F_{2022}	9 073	0.064	80 221	88 093	10	
3.9.15	Catch for bycatch	6 142	0.039	80 475	90 852	13	

* 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 (2024) relative to SSB (2023).

*** The advised catch in 2021 was 0 tonnes.

^ Because SSB_{2022} is below MSY Btrigger, the FMSY, FMSY lower, and FMSY upper values in the MAP are adjusted by the SSB_{2022}/MSY Btrigger ratio.

^^ Blim and Bpa cannot be achieved in 2024, even with zero catch advice.

^^^ Only the A-fleet that targets North Sea autumn-spawning (NSAS) herring and therefore catches WBSS herring as bycatch in the eastern part of the North Sea, assuming the same catch as in the intermediate year 2022. The D-fleet that is bycatch fleet has zero catch because of the intermediate year assumption (C- and F-fleets are directed WBSS fisheries so have zero catch in this scenario).

Table	Basis	Total catch (2023)	Total catch (2024)	F3–6 (2023)	SSB* (2023)	SSB* (2024)	SSB* (2025)	% SSB change (2023–2024)	% SSB change (2024–2025)
Medium-term catch scenarios									
3.9.10	F = 0	0	0	0	80 978	95 882	111 989	18	17
3.9.17	F = 0.01	1 488	1 856	0.010	80 859	94 594	109 348	17	16
3.9.16	F = 0.025	3 670	4 466	0.025	80 681	92 713	105 581	15	14
3.9.11	F = 0.05	7 177	8 395	0.050	80 385	89 708	99 777	12	11
3.9.12	F = 0.01	13 742	14 913	0.100	79 799	84 145	89 698	5	7
3.9.13	F = 0.15	19 767	20 008	0.150	79 218	79 114	81 275	0	3
3.9.14	Constant catch 2022–2024 **	7 662	7 662	0.054	80 345	89 405	100 170	11	12

* 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' 2022 catches are kept constant for 2023–2024.

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 last year, the 2022 assessment is very consistent with the 2021 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 is currently unknown but 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 2022 advice

This year assessment shows an SSB consistent with last year's assessment. Recruitment is still low but has slightly increased in 2021 (609 230 thousands). Under these conditions the stock is not expected to increase above B_{lim} in the short-term (2024) nor in the medium-term (2025) for any level of fishing mortality (SSB_{2025} = 111 989 t assuming F = 0).

To explore the potential development of the stock, projections until 2025 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 units, and recovery will be impaired if catches of this stock are not minimized in all units. Based on agreed catches for 2022 and assumptions on stock mixing, it is predicted that around 80% of the total WBSS catches will be taken in Division 4.a in 2022. For the other two areas, catch shares in 2022 are predicted to be around 10% for subdivisions 20–21 and 10% for subdivisions 22–24.

The Council Regulation (EU) 2022/109 stipulates that the catches in Division 3.a should be limited to 1136 t in 2022 as the sum of directed and bycatch fisheries. Given the recent downward trends in the observed D-fleet catches, ICES considers that the bycatch in the D-fleet will be negligible in 2022 and it was therefore set to zero in the forecast. The 1136 t are assumed to be taken by the C-fleet in 2022.

In 2022, 100% of the 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 2021. The predicted catch for the C-fleet in 2022, which has been the fleet catching most of WBSS herring in the past 2 years, is drastically reduced compared to 2021. The A-fleet is now predicted to catch most of WBSS herring in 2022 and this is carried forward in the catch projections. Predicted catches of WBSS herring by the A-fleet are particularly uncertain, notably if the quotas are transferred from Division 3.a to the eastern part of the North Sea where both WBSS and North Sea autumn-spawning (NSAS) herring mix.

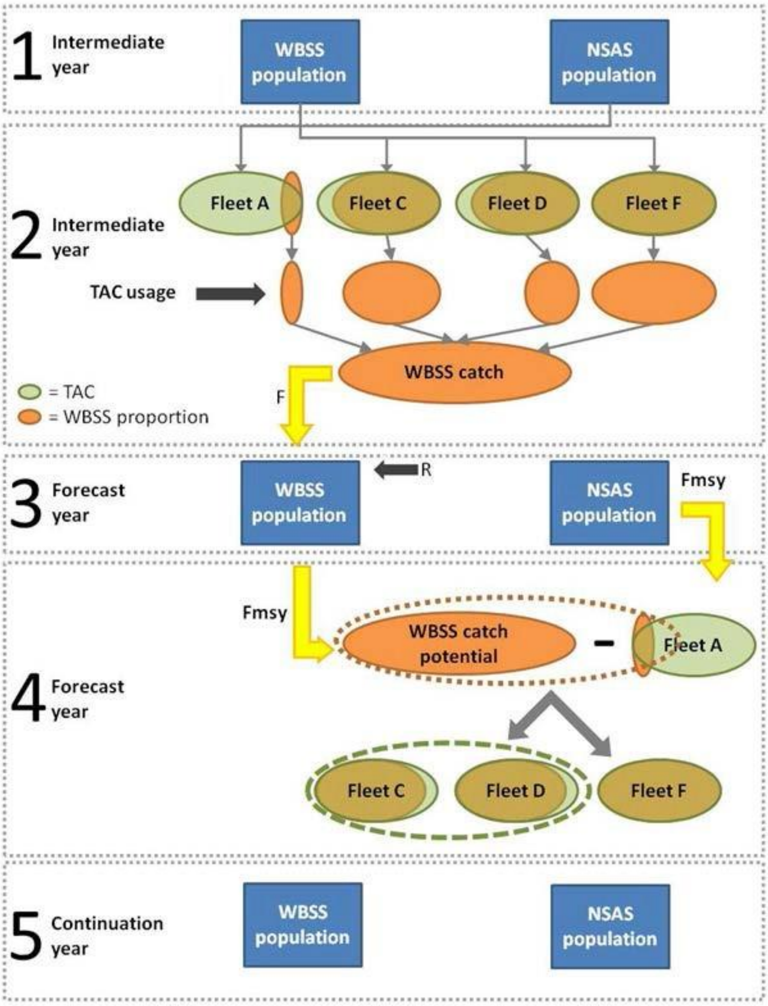
3.13 Management Considerations

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. ICES assumes that most of the quotas in Division 3.a will be transferred in 2022 resulting in a maximum catch of NSAS and WBSS herring of 1 136 t in Division 3.a (cf. part 3.9).

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 is presented:



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.

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), however at the moment there is no understanding of the mechanisms driving this relationship. At the current stage there are no indications of systematic changes in growth or age at maturity that could be related to environmental variability, as well as there is no clear study that link WBSS recruitment to the abundance of prey and/or predators. The low recruitment phase appears to have been initiated before the observed occurrence of Mnemiopsis leidyi (Ctenophore) in the Western Baltic (Kube et al., 2007). The specific reasons for this low recruitment are unknown. Further investigation of the causes of the poor recruitment will require targeted research projects.

3.14.2 Predation

Predation on larval herring by gelatineous 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 remain 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.

Table 3.1.1 Western Baltic spring spawning herring. Total catch (both WBSS and NSAS) in 1989–2021 (1000 tonnes). (Data provided by Working Group members in HAWG 2022).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Skagerrak																
Denmark	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3	10.3	10.1	16.0	16.2	26.0	15.5	11.8
Faroe Islands																
Germany															0.7	0.5
Lithuania																
Norway	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8	8.0	7.4	9.7				
Sweden	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9	46.9	36.4	45.8	30.8	26.4	25.8	21.8
Total	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0	65.2	53.9	71.5	47.0	52.3	42.0	34.1
Kattegat																
Denmark	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8	23.7	17.9	18.9	18.8	18.6	16.0	7.6
Sweden	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0	29.9	14.6	17.3	16.2	7.2	10.2	9.6
Total	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8	53.6	32.5	36.2	35.0	25.9	26.2	17.2
Subdivisions 22+24																
Denmark	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5	30.1	32.5	32.6	28.3	13.1	6.1	7.3
Germany	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8	9.0	9.8	9.3	11.4	22.4	18.8	18.5
Poland	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9	6.5	5.3	6.6	9.3		4.4	5.5
Sweden	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5	4.3	2.6	4.8	13.9	10.7	9.4	9.9
Total	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7	49.9	50.2	53.3	62.9	46.2	38.7	41.2
Subdivision 23																
Denmark	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2	0.4	0.5	0.9	0.6	4.6	2.3	0.1
Sweden	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1	0.3	0.1	0.1	0.2		0.2	0.3
Total	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3	0.7	0.6	1.0	0.8	4.6	2.6	0.4
Grand Total	**286.4**	**279.9**	**257.8**	**311.4**	**294.9**	**234.4**	**231.0**	**172.7**	**149.8**	**169.4**	**137.2**	**162.0**	**145.7**	**128.9**	**109.5**	**92.8**

Year	2005	2006**	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021*
Skagerrak																	
Denmark	14.8	5.2	3.6	3.9	12.7	5.3	3.6	3.2	4.9	6.4	4.1	3.6	2.7	0.9	0.6	3.2	2.9
Faroe Islands	0.4			0.0	0.6	0.4					0.5	0.3	0.4	0.1			

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Germany	0.8	0.6	0.5	1.6	0.3	0.1	0.1	0.6	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1
Lithuania						0.4											
Nether-lands											0.03						
Norway			3.5	4.0	3.3	3.3	0.1	0.4	3.0	2.0	2.5	3.9	3.3	3.4	2.5	2.1	1.1
Sweden	32.5	26.0	19.4	16.5	12.9	17.4	9.5	16.2	16.7	12.6	12.9	13.3	11.9	11.3	8.5	9.1	6.1
Total	48.5	31.8	26.9	26.0	29.7	27.0	13.2	20.5	24.8	21.2	20.1	21.2	18.5	16.0	11.7	14.5	10.3
Kattegat																	
Denmark	11.1	8.6	9.2	7.0	4.9	7.6	5.2	6.3	3.9	4.3	4.0	2.4	0.9	1.3	1.5	0.7	0.2
Sweden	10.0	10.8	11.2	5.2	3.6	2.7	1.7	0.8	2.6	3.4	3.8	6.2	7.4	6.0	1.7	2.6	2.8
Germany					0.6	0.0											
Total	21.1	19.4	20.3	12.2	9.1	10.3	6.8	7.1	6.5	7.7	7.7	8.7	8.3	7.3	3.2	3.2	3.1
Subdivi-sions 22+24																	
Denmark	5.3	1.4	2.8	3.1	2.1	0.8	3.1	4.1	5.1	4.3	4.5	5.7	5.6	4.5	2.0	0.6	0.1
Finland														0.001			
Germany	21.0	22.9	24.6	22.8	16.0	12.2	8.2	11.2	14.6	10.2	13.3	14.4	14.7	11.3	5.6	2.1	0.8
Poland	6.3	5.5	2.9	5.5	5.2	1.8	1.8	2.4	3.1	2.4	2.6	2.9	3.3	1.8	1.1	0.6	0.2
Sweden	9.2	9.6	7.2	7.0	4.1	2.0	2.2	2.7	2.1	1.1	1.5	1.7	2.3	0.9	0.7	0.2	0.1
Total	41.8	39.4	37.6	38.5	27.4	16.8	15.3	20.4	24.8	18.0	21.9	24.7	25.9	18.5	9.5	3.5	1.3
Subdivi-sion 23																	
Denmark	1.8	1.8	2.9	5.3	2.8	0.1***	0.03	0.04	0.04	0.05	0.03	0.03	0.3	0.1	0.01	0.001	0.01
Sweden	0.4	0.7		0.3	0.8	0.9	0.5	0.7	0.6	0.3	0.2	0.3	0.4	0.4	0.4	0.5	0.3
Total	2.2	2.5	2.9	5.7	3.6	1.0	0.6	0.7	0.7	0.4	0.2	0.4	0.6	0.5	0.4	0.5	0.3
Grand To-tal	**113.6**	**93.0**	**87.7**	**82.3**	**69.9**	**55.2**	**35.9**	**48.8**	**56.7**	**47.2**	**50.0**	**55.0**	**53.3**	**42.2**	**24.7**	**21.7**	**14.9**

***Preliminary data**

****2000 t of Danish catches are missing (HAWG 2007)**

*****3103 t officially reported catches (HAWG 2011)**

Table 3.1.2 Western Baltic spring spawning herring. Catch (SOP) in 2004-2021 by fleet & quarter (1000 t). (both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24	Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total			Fleet C	Fleet D	Fleet F	Total
2004	1	13.5	2.8	20.4	36.7	2013	1	8.5	0.8	11.7	20.9
	2	2.8	3.3	10.4	16.5		2	1.7	0.6	8.5	10.8
	3	8.2	10.8	2.4	21.4		3	8.4	1.0	1.1	10.4
	4	5.9	5.0	8.6	19.4		4	9.8	0.5	4.3	14.7
	Total	30.3	22.0	41.7	93.9		Total	28.4	2.9	25.5	56.7
2005	1	16.6	6.1	20.4	43.1	2014	1	6.2	0.2	10.8	17.3
	2	3.4	1.9	15.6	20.9		2	2.3	0.5	2.3	5.1
	3	23.4	3.4	1.9	28.7		3	10.7	2.4	0.8	14.0
	4	12.0	2.6	5.8	20.5		4	5.7	0.8	4.4	10.9
	Total	55.4	14.1	43.7	113.3		Total	24.9	4.0	18.3	47.2
2006	1	15.3	5.9	15.1	36.2	2015	1	9.0	1.9	14.2	25.1
	2	2.6	0.1	17.2	19.9		2	1.0	0.1	2.8	3.9
	3	15.7	0.8	3.0	19.5		3	7.5	1.5	0.9	9.9
	4	8.3	2.4	6.5	17.3		4	4.1	2.8	4.3	11.1
	Total	41.9	9.3	41.9	93.0		Total	21.6	6.3	22.1	50.0
2007	1	7.7	3.0	18.8	29.5	2016	1	7.9	0.7	15.5	24.0
	2	3.8	0.1	10.5	14.4		2	0.4	0.3	3.5	4.1
	3	22.4	0.8	1.7	24.9		3	15.7	1.3	1.4	18.5
	4	7.7	1.8	9.5	18.9		4	3.4	0.3	4.7	8.3
	Total	41.6	5.7	40.5	87.7		Total	27.4	2.5	25.1	55.0
2008	1	8.2	3.9	18.4	30.5	2017	1	7.5	0.0	16.8	24.3
	2	2.7	0.3	11.3	14.3		2	0.2	0.1	3.4	3.6
	3	14.9	0.6	6.0	21.5		3	12.1	0.1	1.0	13.2
	4	6.5	1.0	8.4	16.0		4	6.6	0.3	5.3	12.2
	Total	32.3	5.9	44.1	82.3		Total	26.4	0.4	26.5	53.3
2009	1	11.1	2.7	19.5	33.2	2018	1	10.0	0.0	12.0	21.9
	2	3.1	0.1	6.8	10.1		2	0.2	0.1	3.4	3.8
	3	14.3	0.9	1.4	16.6		3	10.2	0.1	0.2	10.6
	4	6.0	0.7	3.3	10.0		4	2.5	0.1	3.4	6.0
	Total	34.5	4.3	31.0	69.9		Total	22.9	0.4	19.0	42.2
2010	1	8.4	1.1	10.2	19.8	2019	1	4.4	0.1	6.0	10.5
	2	3.9	0.7	5.4	10.1		2	0.5	0.0	0.4	1.0

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24	Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total			Fleet C	Fleet D	Fleet F	Total
	3	13.4	0.4	0.4	14.3		3	6.5	0.2	0.3	7.0
	4	9.2	0.1	1.8	11.1		4	3.1	0.0	3.1	6.3
	Total	35.0	2.3	17.9	55.2		Total	14.6	0.4	9.8	24.7
2011	1	7.0	0.5	7.8	15.3	2020	1	4.3	0.0	2.0	6.3
	2	0.5	0.2	4.1	4.8		2	0.3	0.1	0.2	0.6
	3	6.5	1.0	0.8	8.3		3	9.5	0.6	0.4	10.5
	4	3.4	0.9	3.2	7.4		4	2.7	0.2	1.4	4.4
	Total	17.4	2.6	15.8	35.9		Total	16.9	0.9	4.0	21.7
2012	1	4.5	1.8	14.0	20.3	2021	1	4.4	0.0	0.5	4.9
	2	0.3	0.7	2.5	3.5		2	1.1	0.0	0.2	1.3
	3	12.3	1.7	1.1	15.0		3	6.5	0.1	0.1	6.7
	4	5.2	1.1	3.5	9.9		4	1.1	0.1	0.9	2.0
	Total	22.3	5.4	21.1	48.8		Total	13.2	0.1	1.6	14.9

Table 3.2.1 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t). by age as W-ringers and quarter (both WBSS and NSAS).

Division: Skagerrak **Year: 2021** **Country: ALL**

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.76	25.6			1.76	25.6
	2	31.73	58.4			31.73	58.4
	3	3.36	73.1			3.36	73.1
	4	0.30	96.0			0.30	96.0
	5						
	6						
	7						
	8+	0.11	154.5			0.11	155
	Total	37.26		0.00		37.26	
	SOP		2,190		0		2,190
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0				45.3	1.18	30.1
	1	0.91	25.6	0.27	45.3	16.55	58.4
	2	16.48	58.4	0.07	67.3	1.75	73.1

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	3	1.75	73.1			0.15	96.0
	4	0.15	96.0				
	5						
	6						
	7					0.06	154.5
	8+	0.06	154.5			0.0004	130.0
	Total	19.35		0.34		19.69	
	SOP		1,137		17		1,154
Quarter	W-rings	**Fleet C**		**Fleet D**		**Total**	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0						
	1	10.03	55.0	0.81	45.3	10.84	54.3
	2	14.64	126.3	0.20	67.3	14.85	125.5
	3	7.76	133.9			7.76	133.9
	4	7.52	159.4			7.52	159.4
	5	3.85	171.6			3.85	171.6
	6	3.18	196.5			3.18	196.5
	7	1.34	206.5			1.34	206.5
	8+	1.53	201.3			1.53	201.3
	Total	49.84		1.02		50.86	
	SOP		6,507		51		6,557
Quarter	W-rings	**Fleet C**		**Fleet D**		**Total**	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	8.39	10.8			8.39	10.8
	1	1.65	51.7	0.06	45.3	1.71	51.4
	2	0.60	119.8	0.02	67.3	0.61	118.4
	3	0.20	136.2			0.20	136.2
	4	0.19	161.9			0.19	161.9
	5	0.11	174.2			0.11	174.2
	6	0.10	203.8			0.096	203.8
	7	0.04	226.3			0.04	226.3
	8+	0.03	189.1			0.03	189.1
	Total	11.30		0.08		11.38	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	SOP		359		4		363

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	8.39	10.8			8.39	10.8
	1	14.35	49.1	1.15	45.3	15.50	48.8
	2	63.45	74.6	0.29	67.3	63.74	74.6
	3	13.07	110.2			13.07	110.2
	4	8.16	156.0			8.16	156.0
	5	3.96	171.6			3.96	171.6
	6	3.27	196.8			3.27	196.8
	7	1.38	207.1			1.38	207.1
	8+	1.73	196.5			1.73	196.5
	Total	117.75		1.43		119.2	
	SOP		10,192		71		10,263

Table 3.2.2 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers and quarter (both WBSS and NSAS).
Division: Kattegat Year: 2021 Country: ALL

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.91	22.8	0.08	45	0.98	24.5
	2	34.80	51.4	0.02	67	34.82	51.4
	3	4.16	73.4			4.16	73.4
	4	0.64	112.9			0.64	112.9
	5	0.09	81.1			0.09	81.1
	6						
	7						
	8+						
	Total	40.59		0.10		40.68	
	SOP		2,193.542		5		2,198.272

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0						
	1	0.0048	22.8	0.03	45.3	0.0387	42.5

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	2	0.1857	51.4	0.01	67.3	0.1941	52.1
	3	0.0222	73.4			0.0222	73.4
	4	0.00340	112.9			0.0034	112.9
	5	0.00048	81.1			0.0005	81.1
	6						
	7						
	8+						
	Total	0.2166		0.04		0.2588	
	SOP		11.7		2		14
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0						
	1						
	2						
	3	0.00	193.9			0.00	193.9
	4	0.03	169.8			0.03	169.8
	5	0.05	177.5			0.05	177.5
	6	0.03	181.6			0.03	181.6
	7	0.01	194.8			0.01	194.8
	8+	0.01	183.3			0.01	183.3
	Total	0.13		0.00		0.13	
	SOP		24		0		24
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0						
	1			0.97	45.3	0.97	45.3
	2			0.24	67.3	0.24	67.3
	3	0.07	193.9			0.07	193.9
	4	0.92	169.8			0.92	169.8
	5	1.63	177.5			1.63	177.5
	6	1.06	181.6			1.06	181.6
	7	0.35	194.8			0.35	194.8
	8+	0.21	183.3			0.212	183.3

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	Total	4.24		1.21		5.46	
	SOP		759		60		819

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0						
	1	0.91	22.8	1.08	45.3	1.99	35.0
	2	34.99	51.4	0.27	67.3	35.26	51.5
	3	4.25	75.5			4.25	75.5
	4	1.59	146.9			1.59	146.9
	5	1.77	172.6			1.77	172.6
	6	1.09	181.6			1.09	181.6
	7	0.36	194.8			0.36	194.8
	8+	0.22	183.3			0.219	183.3
	Total	45.18		1.35		46.53	
	SOP		2,987		67		3,055

Table 3.2.3 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers and quarter (<u>WBSS</u>).

Subdivisions: 22–24 Year: 2021 Country: ALL

Quarter	W-rings	Sub-division 22 Numbers	Sub-division 22 Mean W.	Sub-division 23 Numbers	Sub-division 23 Mean W.	Sub-division 24 Numbers	Sub-division 24 Mean W.	Total Numbers	Total Mean W.
1	0								
	1	0.002	16.2			0.35	16.2	0.35	16.2
	2	0.004	52.5	0.02	133.1	0.64	52.5	0.67	55.4
	3	0.005	74.9	0.12	149.7	0.73	73.4	0.85	83.9
	4	0.009	120.1	0.14	164.2	0.40	121.6	0.54	132.2
	5	0.04	147.4	0.06	165.9	0.33	131.9	0.43	138.0
	6	0.03	155.7	0.01	187.3	0.53	178.3	0.57	177.3
	7	0.00	164.7	0.01	212.7	0.35	180.5	0.36	181.4
	8+	0.01	169.9	0.01	172.4	0.40	184.5	0.43	183.7
	Total	0.10		0.37		3.73		4.21	
	SOP		15		60		416		491

Quarter	W-rings	Sub-division 22 Numbers	Sub-division 22 Mean W.	Sub-division 23 Numbers	Sub-division 23 Mean W.	Sub-division 24 Numbers	Sub-division 24 Mean W.	Total Numbers	Total Mean W.

Quarter	W-rings	Sub-division 22		Sub-division 23		Sub-division 24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00003	16.2			0.054	16.2	0.054	16.2
	2	0.002	56.0	0.002	133.1	0.12	52.1	0.13	53.6
	3	0.011	77.8	0.01	149.7	0.16	71.1	0.18	76.2
	4	0.007	95.2	0.01	164.2	0.11	111.4	0.13	115.5
	5	0.01	113.7	0.006	165.9	0.14	135.6	0.16	135.1
	6	0.01	145.8	0.001	187.3	0.21	160.4	0.22	159.9
	7	0.01	154.9	0.001	212.7	0.19	157.5	0.19	157.7
	8+	0.008	164.1	0.001	172.4	0.29	167.1	0.30	167.0
	Total	0.05		0.035		1.27		1.36	
	SOP		7		5.5		161		173
Quarter	W-rings	Sub-division 22		Sub-division 23		Sub-division 24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.0000	20.1			0.00	20.1	0.00	20.1
	1	0.00001	38.4			0.01	38.4	0.01	38.4
	2	0.0002	62.5	0.02	133.1	0.06	83.1	0.07	93.7
	3	0.0005	71.7	0.07	149.7	0.11	106.7	0.19	123.7
	4	0.0006	106.2	0.09	164.2	0.09	135.2	0.17	149.4
	5	0.001	122.6	0.04	165.9	0.04	149.8	0.08	157.1
	6	0.001	157.3	0.01	187.3	0.03	170.6	0.04	173.6
	7	0.0008	164.4	0.01	212.7	0.02	181.8	0.03	189.8
	8+	0.001	169.7	0.01	172.4	0.01	185.6	0.02	177.7
	Total	0.006		0.24		0.36		0.60	
	SOP		0.9		38		44		83
Quarter	W-rings	Sub-division 22		Sub-division 23		Sub-division 24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.000002	20.1			0.04	19.1	0.04	19.1
	1	0.00001	38.4			0.18	38.2	0.18	38.2
	2	0.0003	57.4	0.07	133.1	0.83	81.3	0.90	85.5
	3	0.001	74.3	0.35	149.7	1.62	105.6	1.98	113.5
	4	0.003	121.8	0.41	164.2	1.27	134.0	1.68	141.3
	5	0.009	142.0	0.19	165.9	0.64	148.2	0.83	152.1
	6	0.02	160.3	0.04	187.3	0.45	169.0	0.50	170.1
	7	0.01	165.4	0.04	212.7	0.29	176.8	0.34	180.5

Quarter	W-rings	Sub-division 22		Sub-division 23		Sub-division 24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	8+	0.02	169.6	0.04	172.4	0.13	180.8	0.19	178.1
	Total	0.05		1.14		5.45		6.64	
	SOP		9		182		663		853

Quarter	W-rings	Sub-division 22		Sub-division 23		Sub-division 24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.000004	20.1			0.04	19.1	0.04	19.1
	1	0.002	16.3			0.59	23.0	0.59	23.0
	2	0.006	54.0	0.12	133.1	1.65	67.9	1.77	72.2
	3	0.017	76.6	0.55	149.7	2.62	94.6	3.19	104.1
	4	0.020	111.3	0.64	164.2	1.87	130.0	2.53	138.6
	5	0.06	139.3	0.29	165.9	1.15	142.0	1.50	146.5
	6	0.06	155.2	0.06	187.3	1.22	171.7	1.33	171.6
	7	0.02	162.5	0.06	212.7	0.85	174.2	0.93	176.3
	8+	0.04	168.5	0.06	172.4	0.83	177.9	0.92	177.1
	Total	0.22		1.78		10.81		12.81	
	SOP		31		286		1,284		1,601

Table 3.2.4 Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2021 available to the Working Group. 1/2

Area	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**C**	**1**	0.032	No data available		
		C	**2**	0.175	No data available		
		C	**3**	2.529	7	584	297
		C	**4**	0.059	No data available		
	Total	**Total**		2.794	7	584	297
	Denmark	**D**	**1**	0.000		-	
		D	**2**	0.017	No data available		
		D	**3**	0.051	2	10	10
		D	**4**	0.004	No data available		
	Total	**Total**		0.071	2	10	10
	Germany	**C**	**1**	0.000		-	
		C	**2**	0.000		-	

Area	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
		C	3	0.000		-	
		C	4	0.143		No data available	
	Total	Total		0.143			
	Norway	C	1	0.142		No data available	
		C	2	0.949		No data available	
		C	3	0.000		-	
		C	4	0.031		No data available	
	Total	Total		1.122	0	0	0
	Faroe Islands	C	1	0.000		-	
		C	2	0.000		-	
		C	3	0.000		-	
		C	4	0.000		-	
	Total	Total		0.000	0	0	0
	Sweden	C	1	2.016	5	620	619
		C	2	0.013		No data available	
		C	3	3.978	6	430	428
		C	4	0.126	8	262	262
	Total	Total		6.133	19	1,312	1,309
Kattegat	Denmark	C	1	0.129		No data available	
		C	2	0.011		No data available	
		C	3	0.001		No data available	
		C	4	0.002		No data available	
	Total	Total		0.143	0	0	0
	Denmark	D	1	0.005		No data available	
		D	2	0.002		No data available	
		D	3	0.000		No data available	
		D	4	0.060		No data available	
	Total	Total		0.067	0	0	0
	Sweden	C	1	2.064	13	875	875
		C	2	0.001		No data available	
		C	3	0.023		No data available	
		C	4	0.757	1	60	60
	Total	Total		2.845	14	935	935

Table 3.2.4 (continued) Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2021 available to the Working Group. 2/2

Area	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**F**	**1**	0.0004		No data available	
		F	**2**	0.002	1	100	100
		F	**3**	0.001		No data available	
		F	**4**	0.006		No data available	
	Total	**Total**		0.009	1	100	100
	Sweden	**F**	**1**	0.000		-	
		F	**2**	0.000		-	
		F	**3**	0.000		-	
		F	**4**	0.000		-	
	Total	**Total**		0.000	0	0	0
	Germany	**F**	**1**	0.014	5	1,094	169
		F	**2**	0.004	3	958	145
		F	**3**	0.000		No data available	
		F	**4**	0.003		No data available	
	Total	**Total**		0.022	8	2,052	314
Subdivision 23	**Denmark**	**F**	**1**	0.000		No data available	
		F	**2**	0.004		-	
		F	**3**	0.0001		-	
		F	**4**	0.001		-	
	Total	**Total**		0.005	0	0	0
	Sweden	**F**	**1**	0.060		No data available	
		F	**2**	0.002		No data available	
		F	**3**	0.038		No data available	
		F	**4**	0.181	1	61	61
	Total	**Total**		0.281	1	61	61
Subdivision 24	**Denmark**	**F**	**1**	0.107	2	243	102
		F	**2**	0.009	4	681	212
		F	**3**	0.000	2	301	102
		F	**4**	0.022	6	982	327
	Total	**Total**		0.138	14	2207	743
	Finland	**F**	**1**	0.000		-	
		F	**2**	0.000		-	

Area	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
		F	3	0.000		-	
		F	4	0.000		-	
	Total	Total		0.000	0	0	0
	Germany	F	1	0.246	9	1,598	312
		F	2	0.087	5	1,051	171
		F	3	0.00005		No data available	
		F	4	0.488	6	1,624	640
	Total	Total		0.8217	20	4,273	1,123
	Poland	F	1	0.061	2	490	117
		F	2	0.065	3	625	160
		F	3	0.044		-	
		F	4	0.079		-	
	Total	Total		0.249	5	1115	277
	Sweden	F	1	0.002		No data available	
		F	2	0.000		-	
		F	3	0.0003		No data available	
		F	4	0.073	1	65	65
	Total	Total		0.075	1	65	65
Total	**Skagerrak**	**C**	**1-4**	**10.192**	**26**	**1,896**	**1,606**
		D	**1-4**	**0.071**	**2**	**10**	**10**
	Kattegat	**C**	**1-4**	**2.987**	**14**	**935**	**935**
		D	**1-4**	**0.067**	**0**	**0**	**0**
	Subdivision 22	**F**	**1-4**	**0.031**	**9**	**2,152**	**414**
	Subdivision 23	**F**	**1-4**	**0.286**	**1**	**61**	**61**
	Subdivision 24	**F**	**1-4**	**1.284**	**40**	**7,660**	**2,208**
	Total	**Total**	**1-4**	**14.918**	**92**	**12,714**	**5,234**

Table 3.2.5. Western Baltic spring spawning herring. Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2021. 1/2

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	**1**	**C**	Sweden 27.3.a.20 fleetC Q1
		2	**C**	Sweden 27.3.a.20 fleetC Q1
		3	**C**	Sampling
		4	**C**	Denmark 27.3.a.20 fleetC Q3
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	Denmark 27.3.a.20 fleetC Q3
	Sweden	**1**	**C**	Sampling
		2	**C**	Sweden 27.3.a.20 fleetC Q1
		3	**C**	Sampling
		4	**C**	Sampling
	Denmark	**1**	**D**	No landings
		2	**D**	Denmark 27.3.a.20 fleetD Q3
		3	**D**	Sampling
		4	**D**	Denmark 27.3.a.20 fleetD Q3
	Netherlands	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Faroe Islands	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Norway	**1**	**C**	Sweden 27.3.a.20 fleetC Q1
		2	**C**	Sweden 27.3.a.20 fleetC Q1
		3	**C**	Denmark 27.3.a.20 fleetC Q3
		4	**C**	Denmark 27.3.a.20 fleetC Q3
Kattegat	**Denmark**	**1**	**C**	Sweden 27.3.a.21 fleetC Q1
		2	**C**	Sweden 27.3.a.21 fleetC Q1
		3	**C**	Sweden 27.3.a.21 fleetC Q4
		4	**C**	Sweden 27.3.a.21 fleetC Q4
	Sweden	**1**	**C**	Sampling

	Country	Quarter	Fleet	Sampling
		2	**C**	Sweden 27.3.a.21 fleetC Q1
		3	**C**	Sweden 27.3.a.21 fleetC Q4
		4	**C**	Sampling
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Denmark	**1**	**D**	Denmark 27.3.a.20 fleetD Q3
		2	**D**	Denmark 27.3.a.20 fleetD Q3
		3	**D**	No landings
		4	**D**	Denmark 27.3.a.20 fleetD Q3
Subdivision 22	**Denmark**	**1**	**F - active**	No landings
		2	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		3	**F - active**	No landings
		4	**F - active**	No landings
	Denmark	**1**	**F - passive**	Germany 27.3.c.22 fleetF - passive Q1
		2	**F - passive**	Sampling
		3	**F - passive**	Germany 27.3.c.22 fleetF - passive Q3
		4	**F - passive**	Germany 27.3.c.22 fleetF - passive Q4
	Sweden	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	No landings
		4	**F**	No landings
	Germany	**1**	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		2	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		3	**F - active**	National imputation (see WD)
		4	**F - active**	National imputation (see WD)
	Germany	**1**	**F - passive**	Sampling
		2	**F - passive**	Sampling
		3	**F - passive**	National imputation (see WD Gröhsler)
		4	**F - passive**	National imputation (see WD Gröhsler)

Fleet C = Human consumption, Fleet D= Industrial catch, Fleet F= All catch from Subdivisions 22–24.

Table 3.2.5. (continued) Western Baltic spring spawning herring. Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2021. 2/2

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	**1**	**F - passive**	No landings
		2	**F - passive**	Sweden 27.3.b.23 fleetF Q4
		3	**F - passive**	Sweden 27.3.b.23 fleetF Q4
		4	**F - passive**	Sweden 27.3.b.23 fleetF Q4
	Sweden	**1**	**F**	Sweden 27.3.b.23 fleetF Q4
		2	**F**	Sweden 27.3.b.23 fleetF Q4
		3	**F**	Sweden 27.3.b.23 fleetF Q4
		4	**F**	Sampling
Subdivision 24	**Denmark**	**1**	**F - active**	Sampling
		2	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		3	**F - active**	Germany 27.3.d.24 fleetF - active Q4
		4	**F - active**	Sampling
	Denmark	**1**	**F - passive**	No landings
		2	**F - passive**	Sampling
		3	**F - passive**	Sampling
		4	**F - passive**	Sampling
	Finland	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	No landings
		4	**F**	No landings
	Germany	**1**	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		2	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		3	**F - active**	No landings
		4	**F - active**	Sampling
		1	**F - passive**	Sampling
		2	**F - passive**	Sampling
		3	**F - passive**	National imputation (see WD Gröhsler)
		4	**F - passive**	National imputation (see WD Gröhsler)
	Poland	**1**	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		2	**F - active**	Denmark 27.3.d.24 fleetF - active Q1
		3	**F - active**	Germany 27.3.d.24 fleetF - active Q4
		4	**F - active**	Germany 27.3.d.24 fleetF - active Q4

Poland	**1**	**F - passive**	Sampling
	2	**F - passive**	Sampling
	3	**F - passive**	No landings
	4	**F - passive**	No landings
Sweden	**1**	**F**	Denmark 27.3.d.24 fleetF - active Q1
	2	**F**	No landings
	3	**F**	Germany 27.3.d.24 fleetF - active Q4
	4	**F**	Sampling

Fleet C = Human consumption, Fleet D= Industrial catch, Fleet F = All catch from Subdivisions 22–24.

Table 3.2.6 Western Baltic spring spawning herring. Proportion of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) given in % in Skagerrak and Kattegat by age as W-ringers and quarter.
Year: 2021

		Skagerrak			Kattegat		
Quarter	**W-rings**	**NSAS**	**WBSS**	**n**	**NSAS**	**WBSS**	**n**
1	1	95.36%	4.64%	105	89.82%	10.18%	70
	2	44.11%	55.89%	121	32.75%	67.25%	99
	3	11.72%	88.28%	112	9.15%	90.85%	61
	4	6.09%	93.91%	23	4.82%	95.18%	17
	5			4	4.61%	95.39%	2
	6			8			0
	7			4			0
	8+	8.51%	91.49%	4			0
		Skagerrak			**Kattegat**		
Quarter	**W-rings**	**NSAS**	**WBSS**	**n**	**NSAS**	**WBSS**	**n**
2	1	91.64%	8.36%	19	81.69%	18.31%	0
	2	15.76%	84.24%	12	9.85%	90.15%	0
	3	5.54%	94.46%	9	3.93%	96.07%	0
	4	7.10%	92.90%	10	5.31%	94.69%	0
	5			3	6.44%	93.56%	0
	6			2			0
	7			0			0
	8+	0.00%	100.00%	0			0
		Skagerrak			**Kattegat**		
Quarter	**W-rings**	**NSAS**	**WBSS**	**n**	**NSAS**	**WBSS**	**n**
3	0			71			58
	1	94.56%	5.44%	285			82

Quarter	W-rings	Skagerrak			Kattegat		
		NSAS	WBSS	n	NSAS	WBSS	n
	2	51.04%	48.96%	207			66
	3	22.16%	77.84%	149	11.46%	88.54%	49
	4	14.09%	85.91%	87	7.89%	92.11%	23
	5	11.48%	88.52%	41	6.33%	93.67%	11
	6	8.81%	91.19%	31	4.27%	95.73%	16
	7	5.11%	94.89%	14	1.78%	98.22%	4
	8	1.66%	98.34%	19	0.47%	99.53%	5
Quarter	W-rings	Skagerrak			Kattegat		
		NSAS	WBSS	n	NSAS	WBSS	n
4	0	82.33%	17.67%	52			0
	1	65.23%	34.77%	22	65.74%	34.26%	0
	2	87.75%	12.25%	0	80.35%	19.65%	0
	3	81.20%	18.80%	0	42.32%	57.68%	1
	4	63.85%	36.15%	0	29.23%	70.77%	11
	5	44.51%	55.49%	0	17.91%	82.09%	20
	6	39.88%	60.12%	0	12.90%	87.10%	13
	7	62.07%	37.93%	0	15.04%	84.96%	4
	8	95.18%	4.82%	0	33.62%	66.38%	2

Table 3.2.7 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet.

North Sea Autumn spawners **Division: Kattegat** **Year: 2021** **Country: All**

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.82	22.8	0.07	45.3	0.88	24.5
	2	11.40	51.4	0.01	67.3	11.40	51.4
	3	0.38	73.4			0.38	73.4
	4	0.03	112.9			0.03	112.9
	5	0.004	81.1			0.004	81
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	12.63		0.07		12.70	
	SOP		636.0		3.5		639.5

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	0					0.00	
	1	0.0040	22.8	0.03	45.3	0.03	42.5
	2	0.0183	51.4	0.001	67.3	0.02	52.1
	3	0.00087	73.4			0.0009	73.4
	4	0.00018	112.9			0.0002	112.9
	5	0.00003	81.1			0.00003	81.1
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	0.023		0.03		0.05	
	SOP		1.12		1.3		2.4
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1					0.00	
	2					0.00	
	3	0.0003	193.9			0.0003	193.9
	4	0.002	169.8			0.002	169.8
	5	0.003	177.5			0.003	177.5
	6	0.001	181.6			0.001	181.6
	7	0.0002	194.8			0.0002	194.8
	8+	0.00003	183.3			0.00003	183.3
	Total	0.01		0.00		0.01	
	SOP		1.3		0.0		1.3
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.00	
	1			0.64	45	0.64	45.3
	2			0.20	67	0.20	67.3
	3	0.03	193.9			0.03	193.9
	4	0.27	169.8			0.27	169.8

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	5	0.29	177.5			0.29	177.5
	6	0.136	181.6			0.14	181.6
	7	0.05	194.8			0.05	194.8
	8+	0.071	183.3			0.07	183.3
	Total	0.85		0.83		1.69	
	SOP		151.4		42.1		193.5
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		0.00		0.00	
	1	0.82	22.8	0.73	45.3	1.55	33.4
	2	11.41	51.4	0.20	67.3	11.62	51.7
	3	0.41	82.4	0.00		0.41	82.4
	4	0.30	164.0	0.00		0.30	164.0
	5	0.30	176.2	0.00		0.30	176.2
	6	0.14	181.6	0.00		0.14	181.6
	7	0.05	194.8	0.00		0.05	194.8
	8+	0.07	183.3	0.00		0.07	183.3
	Total	13.51		0.94		14.44	
	SOP		790		47		837

Table 3.2.8 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet.

North Sea Autumn spawners **Division: Skagerrak** **Year: 2021** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.68	25.6			1.68	25.6
	2	14.00	58.4			14.00	58.4
	3	0.39	73.1			0.39	73.1
	4	0.02	96.0			0.02	96.0
	5					0.00	
	6					0.00	
	7					0.00	
	8+	0.01	154.5			0.01	154.5
	Total	16.10		0.00		16.10	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	SOP		892.4		0.0		892.4
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	0					0.00	
	1	0.84	25.6	0.25	45.3	1.09	30.1
	2	2.60	58.4	0.01	67.3	2.61	58.4
	3	0.10	73.1			0.10	73.1
	4	0.011	96.0			0.01	96.0
	5					0.00	
	6					0.00	
	7					0.00	
	8+	0.000000003	154.5			0.000000003	154.5
	Total	3.54		0.26		3.80	
	SOP		181.2		11.9		193.1
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	9.48	55.0	0.77	45.3	10.25	54.3
	2	7.47	126.3	0.10	67.3	7.58	125.5
	3	1.72	133.9			1.72	133.9
	4	1.06	159.4			1.06	159.4
	5	0.44	171.6			0.44	171.6
	6	0.28	196.5			0.28	196.5
	7	0.07	206.5			0.07	206.5
	8+	0.03	201.3			0.03	
	Total	20.55		0.87		21.43	
	SOP		2,014.5		41.8		2,051.2
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	6.91	10.8			6.91	10.8
	1	1.07	51.7	0.04	45.3	1.11	51.4
	2	0.53	119.8	0.01	67.3	0.54	
	3	0.17	136.2			0.17	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	4	0.12	161.9			0.12	
	5	0.05	174.2			0.05	
	6	0.04	203.8			0.04	
	7	0.02	226.3			0.02	
	8+	0.03	189.1			0.03	
	Total	8.93		0.05		8.99	
	SOP		262.2		2.7		131.9

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	6.91	10.8	0.00		6.91	10.8
	1	13.07	49.1	1.06	45.3	14.13	48.8
	2	24.59	80.3	0.13	67.3	24.72	80.3
	3	2.38	121.5	0.00		2.38	121.5
	4	1.21	158.1	0.00		1.21	158.1
	5	0.49	171.8	0.00		0.49	171.8
	6	0.32	197.4	0.00		0.32	197.4
	7	0.09	211.7	0.00		0.09	211.7
	8+	0.06	188.8	0.00		0.06	188.8
	Total	49.12		1.18		50.31	
	SOP		3,350.3		56.5		3,407

Table 3.2.9 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet.

Western Baltic Spring spawners **Division: Kattegat** **Year: 2021** **Country: All**

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.09	22.8	0.01	45.3	0.10	24.5
	2	23.40	51.4	0.01	67.3	23.42	51.4
	3	3.78	73.4			3.78	73.4
	4	0.61	112.9			0.61	112.9
	5	0.09	81.1			0.09	81.1
	6					0.00	
	7					0.00	
	8+					0.00	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	Total	27.96		0.02		27.98	
	SOP		1,557.5		1.2		1,558.7

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.0009	22.8	0.01	45.3	0.01	42.5
	2	0.17	51.4	0.01	67.3	0.18	52.1
	3	0.02	73.4			0.02	73.4
	4	0.00	112.9			0.00	112.9
	5	0.0004	81.1			0.0004	81.1
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	0.193		0.01		0.21	
	SOP		10.59		0.8		11.4

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1					0.00	
	2					0.00	
	3	0.00	193.9			0.00	193.9
	4	0.03	170			0.03	169.8
	5	0.05	178			0.05	177.5
	6	0.03	182			0.03	181.6
	7	0.01	195			0.01	
	8+	0.01	183			0.01	183.3
	Total	0.12		0.00		0.12	
	SOP		22.3		0.0		20.2

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.00	
	1			0.33	45.3	0.33	45
	2			0.05	67.3	0.05	67
	3	0.04	193.9			0.04	194

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	4	0.65	169.8			0.65	170
	5	1.34	177.5			1.34	178
	6	0.92	181.6			0.92	182
	7	0.30	194.8			0.30	195
	8+	0.14	183.3			0.14	183
	Total	3.39		0.38		3.77	
	SOP		607		18		625.5

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0	0.00		0.00		0.00	
	1	0.09	22.8	0.35	45.3	0.44	40.5
	2	23.57	51.4	0.07	67.3	23.64	51.4
	3	3.84	74.8	0.00		3.84	74.8
	4	1.28	142.8	0.00		1.28	142.8
	5	1.47	171.9	0.00		1.47	171.9
	6	0.95	181.6	0.00		0.95	181.6
	7	0.31	194.8	0.00		0.31	194.8
	8+	0.15	183.3	0.00		0.15	183.3
	Total	31.67116		0.41		32.09	
	SOP		2,197.6		20.3		2,217.9

Table 3.2.10 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W- ringers, quarter and fleet.

Western Baltic Spring spawners **Division: Skagerrak** **Year: 2021** **Country: All**

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.08	25.6			0.08	25.6
	2	17.74	58.4			17.74	58.4
	3	2.97	73.1			2.97	73.1
	4	0.28	96.0			0.28	96.0
	5					0.00	
	6					0.00	
	7					0.00	
	8+	0.10	154.5			0.10	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	Total	21.16		0.00		21.16	
	SOP		1,297.3		0		1,281.3

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.08	25.6	0.02	45.3	0.10	30.1
	2	13.88	58.4	0.06	67.3	13.94	58.4
	3	1.65	73.1			1.65	73.1
	4	0.14	96.0			0.14	96.0
	5					0.00	
	6					0.00	
	7					0.00	
	8+	0.06	154.5			0.0585	154.5
	Total	15.81		0.08		15.89	
	SOP		955.8		4.9		960.7

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	0.55	55.0	0.04	45.3	0.59	54.3
	2	7.17	126.3	0.10	67.3	7.27	125.5
	3	6.04	133.9			6.04	133.9
	4	6.46	159.4			6.46	159.4
	5	3.41	171.6			3.41	171.6
	6	2.90	196.5			2.90	196.5
	7	1.27	206.5			1.27	206.5
	8+	1.50	201.3			1.50	201.3
	Total	29.29		0.14		29.43	
	SOP		4,492.3		8.7		4,501.0

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	1.48	10.8			1.48	10.8
	1	0.57	51.7	0.02	45.3	0.59	51.4
	2	0.07	119.8	0.00	67.3	0.08	118.4
	3	0.04	136.2			0.04	136.2

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	4	0.07	161.9			0.07	161.9
	5	0.06	174.2			0.06	174.2
	6	0.06	203.8			0.06	203.8
	7	0.01	226.3			0.01	226.3
	8+	0.00	189.1			0.00	189.1
	Total	2.37		0.02		2.39	
	SOP		96.5		1.1		94.3

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.48	10.8	0.00		1.48	10.8
	1	1.28	49.9	0.09	45.3	1.36	49.6
	2	38.86	71.0	0.16	67.3	39.02	71.0
	3	10.69	107.7	0.00		10.69	107.7
	4	6.95	155.6	0.00		6.95	155.6
	5	3.47	171.6	0.00		3.47	171.6
	6	2.95	196.7	0.00		2.95	196.7
	7	1.28	206.7	0.00		1.28	206.7
	8+	1.66	196.8	0.00		1.66	196.8
	Total	68.63		0.25		68.88	
	SOP		6,841.9		14.6		6,857

Table 3.2.11 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet.

North Sea Autumn spawners **Division: 3.a** **Year: 2021** **Country: All**

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	2.49	24.7	0.07	45.3	2.56	25.2
	2	25.39	55.3	0.01	67.3	25.40	55.3
	3	0.77	73.2			0.77	73.2
	4	0.05	106.7			0.05	106.7
	5	0.00	81.1			0.00	81.1
	6					0.00	
	7					0.00	
	8+	0.01	154.5			0.01	154.5

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	Total	28.72		0.07		28.80	
	SOP		1,528.4		3.5		1,531.9

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	0					0.00	
	1	0.84	25.6	0.28	45.3	1.12	30.5
	2	2.61	58.4	0.01	67.3	2.63	58.4
	3	0.10	73.1			0.10	73.1
	4	0.011	96.3			0.01	96.3
	5	0.000	81.1			0.00	81.1
	6					0.00	
	7					0.00	
	8+	0.000000003	154.5			0.000000003	154.5
	Total	3.56		0.29		3.85	
	SOP		182.3		13.3		195.6

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	9.48	55.0	0.77	45.3	10.25	54.3
	2	7.47	126.3	0.10	67.3	7.58	125.5
	3	1.72	133.9			1.72	133.9
	4	1.062	159.4			1.06	159.4
	5	0.45	171.6			0.45	171.6
	6	0.28	196.5			0.28	196.5
	7	0.07	206.5			0.07	206.5
	8+	0.03	201.3			0.03	201.3
	Total	20.56		0.87		21.43	
	SOP		2,015.8		41.8		2,057.6

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	6.91	10.8			6.91	10.8
	1	1.07	51.7	0.68	45.3	1.75	49.2
	2	0.53	119.8	0.21	67.3	0.73	104.8

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	3	0.20	145.2			0.20	145.2
	4	0.39	167.3			0.39	167.3
	5	0.34	177.0			0.34	177.0
	6	0.17	186.46			0.17	186.5
	7	0.08	204.68			0.08	204.7
	8+	0.10	184.95			0.10	185.0
	Total	9.78		0.89		10.67	
	SOP		413.7		44.8		458.4

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0	6.91	10.8	0.00		6.91	10.8
	1	13.89	47.5	1.79	45.3	15.69	47.3
	2	36.01	71.2	0.33	67.3	36.34	71.1
	3	2.79	115.8	0.00		2.79	115.8
	4	1.51	159.3	0.00		1.51	159.3
	5	0.79	173.5	0.00		0.79	173.5
	6	0.46	192.6	0.00		0.46	192.6
	7	0.15	205.5	0.00		0.15	205.5
	8+	0.13	185.9	0.00		0.13	185.9
	Total	62.63		2.12		64.75	
	SOP		4,140.1		103.4		4,244

Table 3.2.12 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W- ringers, quarter and fleet.

Western Baltic Spring spawners **Division: 3.a** **Year: 2021** **Country: All**

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.17	24.1	0.01	45.3	0.18	25.0
	2	41.14	54.4	0.01	67.3	41.15	54.4
	3	6.74	73.3			6.74	73.3
	4	0.88	107.6			0.88	107.6
	5	0.09	81.1			0.09	81.1
	6					0.00	
	7					0.00	

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	8+	0.10	154.5			0.10	154.5
	Total	49.13		0.02		49.15	
	SOP		2,854.8		1.2		2,856.0

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.08	25.6	0.03	45.3	0.11	30.9
	2	14.05	58.3	0.06	67.3	14.11	58.4
	3	1.67	73.1			1.67	73.1
	4	0.15	96.4			0.15	96.4
2	5	0.0004	81.1			0.0004	81.1
	6					0.00	
	7					0.00	
	8+	0.06	154.5			0.0585	154.5
	Total	16.00		0.09		16.09	
	SOP		966.4		5.6		972.1

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.00	
	1	0.55	55.0	0.04	45.3	0.59	54.3
	2	7.17	126.3	0.10	67.3	7.27	125.5
	3	6.04	134.0			6.04	134.0
	4	6.49	159.5			6.49	159.5
3	5	3.46	171.6			3.46	171.6
	6	2.93	196.4			2.93	196.4
	7	1.28	206.4			1.28	206.4
	8+	1.51	201.2			1.51	201.2
	Total	29.41		0.14		29.56	
	SOP		4,515		8.7		4,523.2

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	1.48	10.8			1.48	10.8
	1	0.57	51.7	0.35	45.3	0.93	49.2
	2	0.07	119.8	0.05	67.3	0.12	98.6

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	3	0.08	166.1			0.08	166.1
	4	0.72	169.0			0.72	169.0
	5	1.40	177.4			1.40	177.4
	6	0.98	182.9			0.98	182.9
	7	0.31	196.3			0.31	196.3
	8+	0.14	183.4			0.14	183.4
	Total	5.76		0.40		6.16	
	SOP		703.7		19.4		723.1

Quarter	W-rings	**Fleet C**		**Fleet D**		Total	
		Numbers	**Mean W.**	**Numbers**	**Mean W.**	Numbers	Mean W.
Total	0	**1.48**	**10.8**	**0.00**		1.48	10.8
	1	**1.37**	**48.0**	**0.43**	**45.3**	1.80	47.4
	2	**62.43**	**63.6**	**0.23**	**67.3**	62.66	63.6
	3	**14.53**	**99.0**	**0.00**		14.53	99.0
	4	**8.23**	**153.6**	**0.00**		8.23	153.6
	5	**4.94**	**171.7**	**0.00**		4.94	171.7
	6	**3.91**	**193.0**	**0.00**		3.91	193.0
	7	**1.59**	**204.4**	**0.00**		1.59	204.4
	8+	**1.81**	**195.7**	**0.00**		1.81	195.7
	Total	100.30		0.66		100.96	
	SOP		**9,039.4**		**34.9**		9,074

multifleet assessment input

Table 3.2.13 Western Baltic spring spawning herring. Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of Western Baltic Spring spawners in Division 3.a and the North Sea in the years 1993–2021.

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1,292.03
	Mean W.	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	
	SOP	2,435	9,612	25,696	27,936	14,120	10,167	8,027	4,541	1,966	104,498
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	
	SOP	1,225	6,524	24,767	27,206	19,686	13,043	8,642	3,022	1,898	106,013
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	
	SOP	902	12,551	19,970	13,517	14,823	6,065	4,404	2,747	1,696	76,674
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	
	SOP	1,748	6,296	28,618	10,197	6,665	5,714	2,568	1,402	1,241	64,449
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	
	SOP	498	3,648	12,176	22,913	4,656	2,489	879	337	480	48,075
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	
	SOP	1,009	8,980	22,542	10,287	7,804	1,922	1,695	403	481	55,121
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	
	SOP	2,601	10,145	20,357	10,756	7,131	3,189	1,288	249	294	56,010
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	
	SOP	1,096	1,875	15,863	12,093	4,657	3,371	1,852	780	492	42,079
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1,027.26
	Mean W.	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	
	SOP	709	11,795	13,162	15,848	7,632	2,046	1,435	481	435	53,544
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.0	37.4	76.5	113.3	132.7	142.2	153.5	169.9	162.2	
	SOP	678	2,355	13,957	7,416	8,540	3,053	961	740	294	37,994

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
2004	**Numbers**	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	
	SOP	695	9,047	7,869	11,005	2,652	2,651	769	279	111	35,078
2005	**Numbers**	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.51
	Mean W.	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	
	SOP	1,341	5,319	17,415	9,163	6,961	1,519	2,028	618	282	44,645
2006 c	**Numbers**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
	Mean W.	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	**Numbers**	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.22
	Mean W.	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	
	SOP	41	6,816	7,723	4,269	4,265	2,035	1,802	1,114	567	28,632
2008	**Numbers**	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.80
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.02
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368
2009	**Numbers**	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.63
	Mean W.	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	90.89
	SOP	199	7,783	11,946	5,436	4,094	1,974	1,669	1,757	1,371	36,230
2010	**Numbers**	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.38
	Mean W.	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	106.71
	SOP	75	2,878	8,991	5,870	3,445	1,686	1,311	1,696	1,513	27,465
2011	**Numbers**	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.56
	Mean W.	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	72.57
	SOP	52	2,797	2,660	2,522	1,878	1,020	554	222	237	11,941
2012	**Numbers**	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.68
	Mean W.	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	98.24
	SOP	14	1,434	7,180	2,780	1,570	1,290	858	495	1,931	17,553
2013	**Numbers**		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.62
	Mean W.		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	119.29
	SOP		716	4,872	9,409	1,830	848	290	118	242	18,325
2014	**Numbers**	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.42
	Mean W.	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	114.98
	SOP	236	1,647	2,203	3,332	7,942	1,513	964	524	659	19,020
2015	**Numbers**	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.10
	Mean W.	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	84.28

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
	SOP	53	1,838	4,067	2,418	2,150	2,521	939	532	830	15,348
2016	**Numbers**	23.9	27.2	161.7	43.0	13.3	12.1	13.2	3.6	6.6	304.65
	Mean W.	7.1	40.1	63.8	126.1	160.7	175.1	200.8	212.8	235.0	86.08
	SOP	170	1,091	10,312	5,426	2,142	2,119	2,661	765	1,539	26,224
2017	**Numbers**	1.4	48.4	42.2	42.8	34.2	10.2	10.9	7.4	2.9	200.41
	Mean W.	30.5	44.1	61.3	113.2	141.8	162.8	171.2	182.9	169.9	98.93
	SOP	44	2,137	2,585	4,848	4,844	1,668	1,863	1,345	493	19,827
2018	**Numbers**	0.3	20.5	179.1	17.6	15.2	22.3	6.8	3.9	3.1	268.88
	Mean W.	10.3	55.7	55.3	109.3	154.4	179.7	195.0	194.9	206.4	82.07
	SOP	3	1,140	9,902	1,927	2,346	4,007	1,334	761	647	22,066
2019	**Numbers**	5.3	38.2	59.2	21.0	8.2	9.7	11.1	3.0	2.6	158.51
	Mean W.	20.0	52.8	85.0	118.9	138.4	166.1	183.3	193.9	211.4	98.35
	SOP	106	2,019	5,036	2,502	1,138	1,619	2,035	577	557	15,589
2020	**Numbers**	10.8	36.6	54.9	23.3	17.1	7.8	13.6	8.3	5.7	178.18
	Mean W.	13.6	47.1	67.1	132.5	160.7	180.8	186.1	199.3	204.8	101.94
	SOP	146	1,723	3,681	3,094	2,753	1,406	2,536	1,663	1,160	18,163
2021	**Numbers**	1.5	2.2	63.8	17.3	15.6	9.4	5.8	2.7	4.1	122.29
	Mean W.	10.8	60.2	64.9	107.1	156.4	169.8	186.8	194.9	196.1	102.87
	SOP	16	132	4,138	1,856	2,436	1,597	1,082	525	796	12,579

Data for 1995 to 2001 was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.14 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Western Baltic Spring spawners (values from the North Sea, see tables 2.2.1–2.2.5)
North Sea + Div. 3.a + SD 22–24 Year: 2021 Country: All

Quarter	W-rings	Division IV		Division IIIa		Subdivision 22-24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	0							0.00	
	1	0.00001	116.00	0.18	25.02	0.35	16.17	0.54	19.18
	2	0.004	134.00	41.15	54.42	0.67	55.44	41.83	54.45
	3	0.006	145.00	6.74	73.27	0.85	83.90	7.59	74.51
	4	0.003	155.00	0.88	107.59	0.54	132.16	1.43	117.04
	5	0.011	163.00	0.09	81.10	0.43	138.04	0.53	129.30
	6	0.002	168.00			0.57	177.32	0.58	177.29
	7					0.36	181.41	0.36	181.41
	8+	0.006	182.00	0.10	154.50	0.43	183.71	0.53	178.06
	Total	0.031		49.15		4.21		53.39	
	SOP		4.9		2,856.0		491.1		3,352.0
Quarter	**W-rings**	**Division IV**		**Division IIIa**		**Subdivision 22-24**		**Total**	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.363	116.00	0.11	30.93	0.05	16.17	0.52	88.39
	2	1.009	134.00	14.11	58.36	0.13	53.64	15.25	63.33
	3	2.576	145.00	1.67	73.10	0.18	76.17	4.43	115.06
	4	6.764	155.00	0.15	96.37	0.13	115.55	7.04	153.05
	5	4.115	163.00	0.00	81.10	0.16	135.10	4.27	161.96
	6	1.704	168.00			0.22	159.88	1.92	167.08
	7	1.015	176.00			0.19	157.74	1.21	173.06
	8+	1.756	184.43	0.06	154.50	0.30	167.04	2.11	181.17
	Total	19.301		16.09		1.36		36.75	
	SOP		3,058.6		972.1		172.9		4,203.6
Quarter	**W-rings**	**Division IV**		**Division IIIa**		**Subdivision 22-24**		**Total**	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.002	20.10	0.002	20.10
	1	0.03	158.00	0.59	54.26	0.01	38.38	0.63	59.16
	2	0.08	187.00	7.27	125.47	0.07	93.69	7.42	125.84
	3	0.21	202.00	6.04	133.95	0.19	123.72	6.44	135.90
	4	0.56	214.00	6.49	159.46	0.17	149.35	7.22	163.45
	5	0.34	224.00	3.46	171.64	0.08	157.07	3.88	175.97

Quarter	W-rings	Division IV		Division IIIa		Subdivision 22-24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	6	0.14	232.00	2.93	196.38	0.04	173.61	3.11	197.73
	7	0.08	241.00	1.28	206.41	0.03	189.76	1.39	208.18
	8+	0.15	251.32	1.51	201.25	0.02	177.74	1.67	205.45
	Total	1.60		29.56		0.60		31.76	
	SOP		350.6		4,523.2		83.2		4,957.1
Quarter	W-rings	**Division IV**		**Division IIIa**		**Subdivision 22-24**		**Total**	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			1.48	10.80	0.04	19.06	1.52	11.02
	1			0.93	49.24	0.18	38.20	1.10	47.46
	2			0.12	98.58	0.90	85.53	1.02	87.10
	3			0.08	166.13	1.98	113.49	2.06	115.54
	4	0.011	200.70	0.72	169.05	1.68	141.31	2.41	149.83
	5			1.40	177.36	0.83	152.05	2.23	167.91
	6	0.040	215.90	0.98	182.91	0.50	170.13	1.52	179.56
	7			0.31	196.28	0.34	180.49	0.65	188.08
	8+	0.341	234.92	0.14	183.36	0.19	178.09	0.67	208.16
	Total	0.392		6.16		6.64		13.20	
	SOP		90.9		723.1		853.4		1,667.4
Quarter	W-rings	**Division IV**		**Division IIIa**		**Subdivision 22-24**		**Total**	
		Numbers	**Mean W.**	Numbers	Mean W.	**Numbers**	**Mean W.**	Numbers	Mean W.
Total	0	**0.00**		1.48	10.80	**0.04**	**19.10**	1.525	11.03
	1	**0.39**	**119.26**	1.80	47.36	**0.59**	**23.02**	2.790	52.34
	2	**1.10**	**138.01**	62.66	63.64	**1.77**	**72.19**	65.524	65.11
	3	**2.79**	**149.32**	14.53	98.99	**3.19**	**104.11**	20.520	106.64
	4	**7.34**	**159.58**	8.23	153.61	**2.53**	**138.56**	18.105	153.93
	5	**4.47**	**167.69**	4.94	171.68	**1.50**	**146.52**	10.909	166.58
	6	**1.89**	**173.81**	3.91	193.00	**1.33**	**171.64**	7.124	183.93
	7	**1.10**	**181.02**	1.59	204.41	**0.93**	**176.35**	3.619	190.12
	8+	**2.25**	**196.47**	1.81	195.67	**0.92**	**177.14**	4.984	192.60
	Total	21.33		100.96		12.81		135.100	
	SOP		**3,505.1**		9,074.4		**1,600.5**		14,180.0

single fleet assessment input

multifleet assessment input

Table 3.2.15 Western Baltic spring spawning herring. Total catch in numbers (mill) of Western Baltic Spring Spawners in North Sea + Div. 3.a + SD 22–24 in the years 1993–2021.

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	Total
1993	Div. 4+Div. 3.a	161.3	371.5	315.8	219.0	94.1	59.4	41.0	21.7	8.2	1130.8
	Subdiv. 22-24	44.9	159.2	180.1	196.1	166.9	151.1	61.8	42.2	16.3	973.7
1994	Div. 4+Div. 3.a	60.6	153.1	261.1	221.6	131.0	77.3	44.4	14.4	8.6	911.6
	Subdiv. 22-24	202.6	96.3	103.8	161.0	136.1	90.8	74.0	35.1	24.5	721.6
1995	Div. 4+Div. 3.a	50.3	302.5	204.2	97.9	90.9	30.6	21.3	12.0	7.2	816.9
	Subdiv. 22-24	491.0	1,358.2	233.9	128.9	104.0	53.6	38.8	20.9	13.2	1951.5
1996	Div. 4+Div. 3.a	166.2	228.1	317.7	75.6	40.4	30.6	12.6	6.7	5.6	883.6
	Subdiv. 22-24	4.9	410.8	82.8	124.1	103.7	99.5	52.7	24.0	19.5	917.1
1997	Div. 4+Div. 3.a	26.0	73.4	158.7	180.1	30.2	14.2	4.8	1.8	2.3	491.3
	Subdiv. 22-24	350.8	595.2	130.6	96.9	45.1	29.0	35.1	19.5	21.8	973.2
1998	Div. 4+Div. 3.a	36.3	175.1	315.1	94.5	54.7	11.2	8.7	2.2	2.1	700.0
	Subdiv. 22-24	513.5	447.9	115.8	88.3	92.0	34.1	15.0	13.2	12.0	818.4
1999	Div. 4+Div. 3.a	41.3	190.3	155.7	122.3	43.2	22.2	4.4	3.0	2.4	584.8
	Subdiv. 22-24	528.3	425.8	178.7	123.9	47.1	33.7	11.1	6.5	3.7	830.5
2000	Div. 4+Div. 3.a	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.6
	Subdiv. 22-24	37.7	616.3	194.3	86.7	77.8	53.0	30.1	12.4	9.3	1079.9
2001	Div. 4+Div. 3.a	121.7	36.6	208.1	111.1	32.1	19.7	9.8	4.2	2.4	545.6
	Subdiv. 22-24	634.6	486.5	280.7	146.8	76.0	48.7	29.3	14.1	4.3	1721.0
2002	Div. 4+Div. 3.a	69.6	577.7	168.3	134.6	53.1	12.0	7.5	2.4	2.0	1027.3

Year	W-rings Area	0	1	2	3	4	5	6	7	8+	Total
	Subdiv. 22-24	80.6	81.4	113.6	186.7	119.2	45.1	31.1	11.4	6.3	675.4
2003	**Div. 4+Div. 3.a**	52.1	63.0	182.5	64.0	62.2	20.3	5.9	3.8	1.6	455.5
	Subdiv. 22-24	1.4	63.9	82.3	95.8	125.1	82.2	22.9	13.1	7.0	493.6
2004	**Div. 4+Div. 3.a**	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	466.7
	Subdiv. 22-24	217.9	248.4	101.8	70.8	75.0	74.4	44.5	13.4	10.4	856.5
2005	**Div. 4+Div. 3.a**	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.5
	Subdiv. 22-24	11.6	207.6	115.9	102.5	83.5	51.3	54.2	27.8	11.2	665.5
2006 c	**Div. 4+Div. 3.a**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Subdiv. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	**Div. 4+Div. 3.a**	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2008	**Div. 4+Div. 3.a**	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2009	**Div. 4+Div. 3.a**	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Subdiv. 22-24	5.9	31.5	110.7	55.5	45.5	37.2	31.9	13.2	7.2	338.7
2010	**Div. 4+Div. 3.a**	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.4
	Subdiv. 22-24	3.3	26.5	31.3	39.3	28.5	22.4	13.9	8.0	7.5	180.6
2011	**Div. 4+Div. 3.a**	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.6
	Subdiv. 22-24	5.6	15.5	16.4	17.8	35.9	21.6	19.6	11.2	8.2	152.0
2012	**Div. 4+Div. 3.a**	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.7

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	Total
	Subdiv. 22-24	0.5	46.3	36.5	43.8	37.8	28.4	14.0	9.0	8.4	224.6
2013	Div. 4+Div. 3.a		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.6
	Subdiv. 22-24	1.0	60.6	37.1	43.3	55.9	28.7	25.3	11.5	11.0	274.5
2014	Div. 4+Div. 3.a	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.4
	Subdiv. 22-24	5.8	35.3	37.7	42.1	37.5	19.0	11.2	6.5	6.2	201.4
2015	Div. 4+Div. 3.a	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.1
	Subdiv. 22-24	26.7	46.2	72.8	38.5	48.4	29.8	14.9	7.9	9.1	294.3
2016	Div. 4+Div. 3.a	23.9	27.2	161.7	43.0	13.3	12.1	13.2	3.6	6.6	304.6
	Subdiv. 22-24	20.0	22.3	37.2	93.9	45.7	30.5	17.4	10.5	8.3	285.8
2017	Div. 4+Div. 3.a	1.4	48.4	42.2	42.8	34.2	10.2	10.9	7.4	2.9	200.4
	Subdiv. 22-24	0.1	9.4	32.8	38.5	78.3	38.5	26.9	13.5	10.2	248.3
2018	Div. 4+Div. 3.a	0.3	20.5	179.1	17.6	15.2	22.3	6.8	3.9	3.1	268.9
	Subdiv. 22-24	0.4	48.4	18.5	34.6	23.1	51.3	16.3	8.8	4.5	205.8
2019	Div. 4+Div. 3.a	5.3	38.2	59.2	21.0	8.2	9.7	11.1	3.0	2.6	158.5
	Subdiv. 22-24	0.3	6.9	20.7	15.6	13.3	10.3	15.9	6.0	3.5	92.4
2020	Div. 4+Div. 3.a	10.8	36.6	54.9	23.3	17.1	7.8	13.6	8.3	5.7	178.2
	Subdiv. 22-24	0.0	1.7	2.5	4.6	4.7	6.7	4.1	5.3	1.6	31.2
2021	Div. 4+Div. 3.a	1.5	2.2	63.8	17.3	15.6	9.4	5.8	2.7	4.1	122.3
	Subdiv. 22-24	0.0	0.6	1.8	3.2	2.5	1.5	1.3	0.9	0.9	12.8

Data for 1995–2001 for the North Sea and Division 3.a was revised in 2003.

C values have been corrected in 2007.

Table 3.2.16 Western Baltic spring spawning herring. Mean weight (g) and SOP (t) of Western Baltic Spring Spawners in North Sea + Div. 3.a + SD22–24 in the years 1993–2021.

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	SOP
1993	Div. 4+Div. 3.a	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104,498
	Subdiv. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80,512
1994	Div. 4+Div. 3.a	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106,013
	Subdiv. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66,425
1995	Div. 4+Div. 3.a	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76,674
	Subdiv. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74,157
1996	Div. 4+Div. 3.a	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64,449
	Subdiv. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56,817
1997	Div. 4+Div. 3.a	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48,075
	Subdiv. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67,513
1998	Div. 4+Div. 3.a	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55,121
	Subdiv. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51,911
1999	Div. 4+Div. 3.a	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47,179
	Subdiv. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50,060
2000	Div. 4+Div. 3.a	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56,010
	Subdiv. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53,904
2001	Div. 4+Div. 3.a	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42,079
	Subdiv. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63,724
2002	Div. 4+Div. 3.a	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53,544

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	SOP
	Subdiv. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52,647
2003	Div. 4+Div. 3.a	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37,075
	Subdiv. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40,315
2004	Div. 4+Div. 3.a	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35,078
	Subdiv. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41,736
2005	Div. 4+Div. 3.a	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	50,765
	Subdiv. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	37,013
2006 c	Div. 4+Div. 3.a	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	25,965
	Subdiv. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	70,911
2007	Div. 4+Div. 3.a	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28,632
	Subdiv. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39,548
2008	Div. 4+Div. 3.a	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	25,368
	Subdiv. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116
2009	Div. 4+Div. 3.a	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	36,230
	Subdiv. 22-24	10.5	28.3	48.1	90.5	123.7	145.2	160.4	171.2	181.8	31,032
2010	Div. 4+Div. 3.a	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	27,465
	Subdiv. 22-24	12.2	22.2	52.2	87.1	119.8	154.8	170.6	191.9	194.1	17,917
2011	Div. 4+Div. 3.a	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	11,941
	Subdiv. 22-24	12.4	23.0	55.1	78.1	113.2	136.6	147.6	161.2	168.0	15,830
2012	Div. 4+Div. 3.a	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	17,553

Year	W-rings Area	0	1	2	3	4	5	6	7	8+	SOP
	Subdiv. 22-24	18.1	15.9	55.0	95.4	115.1	150.3	167.6	177.4	191.2	21,095
2013	Div. 4+Div. 3.a		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	18,325
	Subdiv. 22-24	13.7	17.8	54.1	86.8	129.4	136.9	145.3	159.1	179.8	25,504
2014	Div. 4+Div. 3.a	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	19,020
	Subdiv. 22-24	16.5	30.0	59.0	82.3	122.1	158.4	156.0	163.0	175.5	18,338
2015	Div. 4+Div. 3.a	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	15,348
	Subdiv. 22-24	7.1	15.9	50.4	79.3	107.6	144.7	170.6	135.6	149.4	22,144
2016	Div. 4+Div. 3.a	7.1	40.1	63.8	126.1	160.7	175.1	200.8	212.8	235.0	26,224
	Subdiv. 22-24	10.3	34.1	51.7	84.6	95.0	129.5	160.4	168.1	169.2	25,073
2017	Div. 4+Div. 3.a	30.5	44.1	61.3	113.2	141.8	162.8	171.2	182.9	169.9	19,827
	Subdiv. 22-24	18.1	34.3	57.7	82.8	117.9	123.5	137.6	147.5	139.8	26,513
2018	Div. 4+Div. 3.a	10.3	55.7	55.3	109.3	154.4	179.7	195.0	194.9	206.4	22,066
	Subdiv. 22-24	15.9	14.5	51.8	87.2	108.4	142.7	143.4	157.7	170.1	18,992
2019	Div. 4+Div. 3.a	20.0	52.8	85.0	118.9	138.4	166.1	183.3	193.9	211.4	15,589
	Subdiv. 22-24	16.7	30.7	56.9	83.7	123.6	139.6	165.6	138.3	166.7	9,831
2020	Div. 4+Div. 3.a	13.6	47.1	67.1	132.5	160.7	180.8	186.1	199.3	204.8	18,163
	Subdiv. 22-24	18.5	38.3	69.1	87.3	111.3	145.5	155.9	172.1	171.0	3,966
2021	Div. 4+Div. 3.a	10.8	60.2	64.9	107.1	156.4	169.8	186.8	194.9	196.1	12,579
	Subdiv. 22-24	19.1	23.0	72.2	104.1	138.6	146.5	171.6	176.3	177.1	1,601

Data for 1995–2001 for the North Sea and Division 3.a was revised in 2003.

[C] values have been corrected in 2007.

Table 3.2.17 Western Baltic spring spawning herring. Transfers of North Sea autumn spawners from Div. 3.a to the North Sea. Numbers (millions) and mean weight (g), SOP (tonnes) in 1993–2021.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1993	Number	2,795.4	2,032.5	237.6	26.5	7.7	3.6	2.7	2.2	0.7	5,109.0
	Mean W.	12.5	28.6	79.7	141.4	132.3	233.4	238.5	180.6	203.1	
	SOP	34,903	58,107	18,939	3,749	1,016	850	647	390	133	118,734
1994	Number	481.6	1,086.5	201.4	26.9	6.0	2.9	1.6	0.4	0.2	1,807.5
	Mean W.	16.0	42.9	83.4	110.7	138.3	158.6	184.6	199.1	213.9	
	SOP	7,723	46,630	16,790	2,980	831	460	287	75	37	75,811
1995	Number	1,144.5	1,189.2	161.5	13.3	3.5	1.1	0.6	0.4	0.3	2,514.4
	Mean W.	11.2	39.1	88.3	145.7	165.5	204.5	212.2	236.4	244.3	
	SOP	12,837	46,555	14,267	1,940	573	225	133	86	65	76,680
1996	Number	516.1	961.1	161.4	17.0	3.4	1.6	0.7	0.4	0.3	1,661.9
	Mean W.	11.0	23.4	80.2	126.6	165.0	186.5	216.1	216.3	239.1	
	SOP	5,697	22,448	12,947	2,151	565	307	145	77	66	44,403
1997	Number	67.6	305.3	131.7	21.2	1.7	0.8	0.2	0.1	0.1	528.7
	Mean W.	19.3	47.7	68.5	124.4	171.5	184.7	188.7	188.7	192.4	
	SOP	1,304	14,571	9,025	2,643	285	146	40	16	25	28,057
1998	Number	51.3	745.1	161.5	26.6	19.2	3.0	3.1	1.2	0.5	1,011.6
	Mean W.	27.4	56.4	79.8	117.8	162.9	179.7	197.2	178.9	226.3	
	SOP	1,409	41,994	12,896	3,137	3,136	547	608	211	108	64,045
1999	Number	598.8	303.0	148.6	47.2	13.4	6.2	1.2	0.5	0.5	1,119.4
	Mean W.	10.4	50.5	87.7	113.7	137.4	156.5	188.1	187.3	198.8	
	SOP	6,255	15,297	13,037	5,369	1,841	974	230	90	92	43,186
2000	Number	235.3	984.3	116.0	21.9	22.9	7.5	3.3	0.6	0.1	1,391.8
	Mean W.	21.3	28.5	76.1	108.8	163.1	190.3	183.9	189.4	200.2	
	SOP	5,005	28,012	8,825	2,377	3,731	1,436	601	114	13	50,115
2001	Number	807.8	563.6	150.0	17.2	1.4	0.3	0.5	0.0	0.0	1,540.8
	Mean W.	8.7	49.4	75.3	108.2	130.1	147.1	219.1	175.8	198.1	
	SOP	7,029	27,849	11,300	1,856	177	43	109	8	5	48,376
2002	Number	478.5	362.6	56.7	5.6	0.7	0.2	0.1	0.0	0.0	904.5
	Mean W.	12.2	38.0	100.6	121.5	142.7	160.9	178.7	177.4	218.6	
	SOP	5,859	13,790	5,705	684	106	26	21	8	5	26,205
2003	Number	21.6	445.0	182.3	13.0	16.2	1.8	1.1	1.2	0.2	682.4
	Mean W.	20.5	33.7	67.0	123.2	150.3	163.5	190.2	214.6	186.8	

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
	SOP	442	14,992	12,219	1,606	2,436	293	213	264	33	32,498
2004	**Number**	88.4	70.9	179.9	20.7	6.0	9.7	1.8	2.0	0.9	380.4
	Mean W.	22.5	55.3	70.2	120.6	140.9	151.7	170.6	186.6	178.5	
	SOP	1,993	3,921	12,638	2,498	851	1,479	312	367	154	24,214
2005	**Number**	96.4	307.5	159.2	16.2	5.4	2.4	2.3	0.5	0.2	589.9
	Mean W.	16.5	50.5	71.0	105.9	154.6	173.5	184.5	200.2	208.9	
	SOP	1,595	15,527	11,304	1,712	828	412	420	95	34	31,927
2006	**Number**	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
	Mean W.	14.3	53.5	79.2	117.6	140.2	185.5	190.4	215.6	206.9	
	SOP	503	8,035	3,975	1,200	456	620	107	81	37	15,015
2007	**Number**	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
	Mean W.	26.7	62.6	71.1	108.1	124.4	151.7	183.7	174.7	153.8	
	SOP	1,807	11,857	5,464	224	55	219	48	110	3	19,788
2008	**Number**	85.7	86.6	72.0	1.9	0.3	0.1	0.1	0.3	0.1	247.0
	Mean W.	16.2	57.6	86.4	109.1	138.7	167.7	175.4	203.1	197.7	
	SOP	1,386	4,986	6,222	205	35	25	10	67	13	12,949
2009	**Number**	116.8	77.5	7.0	0.4	0.2	0.0	0.0	0.0	0.1	202.0
	Mean W.	9.4	59.8	101.0	81.3	206.4	0.0	0.0	0.0	268.5	
	SOP	1,095	4,635	710	29	46	0	0	0	28	6,542
2010	**Number**	48.6	197.0	43.3	0.3	0.1	0.1	0.0	0.1	0.0	289.6
	Mean W.	7.5	50.6	76.8	122.3	149.3	191.3	221.5	216.3	204.5	
	SOP	364	9,975	3,325	35	22	19	4	13	3	13,759
2011	**Number**	203.8	35.4	61.5	3.2	0.3	0.2	0.1	0.1	0.0	304.6
	Mean W.	7.5	35.1	83.6	113.3	133.9	191.5	193.2	234.3	248.3	
	SOP	1,524	1,244	5,137	364	37	33	23	22	5	8,388
2012	**Number**	145.83	174.74	43.05	1.85	1.14	0.19	0.20	0.11	0.03	367.1
	Mean W.	12.29	39.70	66.75	123.69	169.16	174.56	199.39	219.78	215.93	
	SOP	1,792	6,937	2,873	229	193	33	39	24	6	12,128
2013	**Number**	0.90	86.19	85.82	2.39	0.36	0.28				175.9
	Mean W.	33.66	75.39	74.64	133.88	160.14	200.37				
	SOP	30	6,498	6,405	320	57	56				13,367
2014	**Number**	284.74	61.13	80.21	5.90	0.54	0.50	0.17	0.03	0.06	433.3
	Mean W.	8.98	56.96	73.62	108.56	162.38	190.94	209.02	221.12	227.82	
	SOP	2,557	3,482	5,905	641	88	95	36	6	13	12,823

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
2015	**Number**	30.71	169.58	97.57	6.96	1.25	4.89	1.11	1.20	0.35	313.6
	Mean W.	15.79	29.72	68.01	132.87	157.09	179.85	195.87	197.22	214.93	
	SOP	485	5,040	6,636	925	197	880	218	238	75	14,692
2016	**Number**	133.30	23.33	47.56	5.95	0.53	0.30	0.22	0.03	0.06	211.3
	Mean W.	6.74	37.42	59.01	123.13	149.08	156.65	207.97	209.50	234.59	
	SOP	899	873	2,807	733	79	47	46	7	15	5,506
2017	**Number**	0.15	75.99	34.43	6.91	2.97	1.20	0.07	0.05	0.03	121.8
	Mean W.	30.81	48.55	67.62	102.48	138.67	172.88	170.96	184.78	161.99	
	SOP	5	3,690	2,328	709	412	208	12	8	5	7,375
2018	**Number**	14.51	19.17	28.49	1.13	1.79	1.04	0.18	0.12	0.09	66.5
	Mean W.	10.05	48.67	57.48	102.82	155.48	179.69	189.49	186.69	202.12	
	SOP	146	933	1,638	116	279	187	35	22	17	3,372
2019	**Number**	23.72	101.32	19.84	4.56	0.10	0.13	0.07	0.01	0.003	149.8
	Mean W.	11.66	41.00	62.01	84.37	116.20	118.10	164.56	202.20	158.50	
	SOP	277	4,154	1,230	385	12	15	11	2	0.4	6,087
2020	**Number**	79.43	26.58	44.16	5.27	2.18	0.30	0.61	0.80	0.001	159.3
	Mean W.	13.49	36.49	65.71	138.58	168.38	174.62	199.24	216.74	137.84	
	SOP	1,072	970	2,902	730	367	53	122	173	0.1	6,388
2021	**Number**	6.91	15.69	36.34	2.79	1.51	0.79	0.46	0.15	0.135	64.8
	Mean W.	10.80	47.26	71.13	115.75	159.30	173.46	192.63	205.52	185.88	
	SOP	75	741	2,585	323	241	137	88	30	25.0	4,244

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 1993–2021 (September/October).

								*	**			***	***	***
Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
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
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
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
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
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
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
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
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
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
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+ 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
W-rings/Biomass ('000 tonnes)														
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
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
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
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
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
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
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
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
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
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
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
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
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
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

							*	**			***	***	***
Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
W-rings/Numbers in millions														
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
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
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
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
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
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
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

	***	***	***	***	***	***	***	****	*****	***	***	&	&&	&&&
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
W-rings/Numbers in millions														
0	2,150.306	2,821.022	4,561.405	2,929.434	4,103.180	8,996.225	5,473.400	888.081	2,638.277	1,290.650	2,635.830	1,816.647	1,028.745	439.285
1	392.737	270.959	534.633	1,206.762	755.034	893.837	769.320	440.738	493.366	463.940	428.530	247.870	185.814	158.368
2	165.347	95.866	305.540	360.354	294.242	456.204	242.590	509.769	155.417	145.360	89.280	122.948	82.236	144.638
3	166.301	43.553	214.539	210.455	193.974	307.567	279.650	221.344	196.061	123.230	41.160	47.727	66.046	49.942
4	102.018	17.761	107.364	115.984	124.548	262.908	332.660	129.795	60.953	137.500	20.240	24.244	21.600	22.420
5	82.174	9.016	85.635	57.840	70.135	87.114	317.240	95.579	30.490	46.550	17.570	17.488	15.890	9.390
6	29.727	3.227	47.140	50.844	45.017	32.684	211.600	86.150	14.980	21.230	4.940	16.802	7.590	2.780
7	11.443	1.947	25.021	29.234	22.520	22.565	85.630	47.093	3.300	2.130	1.060	1.540	3.210	3.180
8+	9.262	1.704	15.309	14.774	21.404	11.300	56.590	37.886	0.000	1.790	1.100	0.600	1.370	0.240
Total	3,109.314	3,265.055	5,896.586	4,975.682	5,630.054	11,070.405	7,768.680	2,456.435	3,592.844	2,232.380	3,239.710	2,295.867	1,412.500	830.243
3+ group	400.924	77.208	495.007	479.131	477.597	724.139	1,283.370	617.846	305.784	332.430	86.070	108.402	115.706	87.952
W-rings/Biomass ('000 tonnes)														
0	23.699	29.449	36.791	35.064	46.955	85.185	61.640	8.179	24.072	13.623	32.010	23.081	12.550	4.784
1	17.602	10.473	21.336	46.384	29.825	38.404	30.369	16.822	18.553	18.296	18.825	9.767	7.617	6.855
2	10.446	7.069	24.593	29.560	20.380	30.587	21.490	38.573	10.579	10.159	5.797	6.761	5.313	9.002
3	15.297	4.433	23.540	24.382	22.068	27.349	32.448	22.841	18.068	11.511	3.323	3.630	5.413	4.337
4	11.077	1.961	15.193	16.361	18.653	27.350	58.819	15.196	5.859	17.427	1.785	2.700	2.207	2.454
5	11.584	1.385	15.433	9.867	11.450	10.934	63.755	14.581	3.417	6.711	2.239	2.625	2.009	1.186
6	4.823	0.616	9.018	8.391	7.985	4.849	45.705	14.304	1.723	3.175	0.719	2.673	1.134	0.336
7	1.756	0.384	4.728	5.295	4.448	3.751	18.709	8.433	0.450	0.257	0.182	0.260	0.497	0.350

Year	1994	1995	1996	1997	1998	1999	2000	2001 *	2002 **	2003	2004	2005 ***	2006 ***	2007 ***
W-rings/Numbers in millions														
8+	1.303	0.284	3.013	3.015	3.876	1.821	13.498	7.108	0.000	0.190	0.203	0.060	0.230	0.038
Total	97.588	56.055	153.646	178.320	165.640	230.231	346.433	146.035	82.722	81.349	65.083	51.557	36.969	29.342
3+ group	45.840	9.064	70.926	67.312	68.480	76.055	232.933	82.462	29.518	39.271	8.451	11.948	11.490	8.701
W-rings/Mean weight (g)														
0	11.0	10.4	8.1	12.0	11.4	9.5	11.3	9.2	9.1	10.6	12.1	12.7	12.2	10.9
1	44.8	38.7	39.9	38.4	39.5	43.0	39.5	38.2	37.6	39.4	43.9	39.4	41.0	43.3
2	63.2	73.7	80.5	82.0	69.3	67.0	88.6	75.7	68.1	69.9	64.9	55.0	64.6	62.2
3	92.0	101.8	109.7	115.9	113.8	88.9	116.0	103.2	92.2	93.4	80.7	76.1	82.0	86.8
4	108.6	110.4	141.5	141.1	149.8	104.0	176.8	117.1	96.1	126.7	88.2	111.4	102.2	109.5
5	141.0	153.6	180.2	170.6	163.3	125.5	201.0	152.5	112.1	144.2	127.4	150.1	126.4	126.4
6	162.2	190.9	191.3	165.0	177.4	148.4	216.0	166.0	115.0	149.5	145.6	159.1	149.4	120.7
7	153.5	197.4	189.0	181.1	197.5	166.2	218.5	179.1	136.4	120.5	172.0	168.7	154.9	110.0
8+	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-	106.4	184.2	100.3	167.9	156.7
Total	31.4	17.2	26.1	35.8	29.4	20.8	44.6	59.5	23.0	36.4	20.1	22.5	26.2	35.3

small revision in 2015 **small revision in 2017**

*incl. mean for Sub-division 23, which was not covered by RV SOLEA (<0.5 %)

**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 and excl. hydroacoustic data/biological data from haul 32 (41G2, SD 23), incl. almost exclusively large herring that were spawning (stage=6).

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 1991–2021 (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 tonnnes)																
0		34.3	1	8.7												
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	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

Year	1991	1992 *	1993 *	1994 *	1995 *	1996 *	1997	1998	1999 **	2000	2001	2002	2003	2004	2005	2006
W-rings/Numbers in millions																
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
W-rings/Numbers in millions															
0		112				1		314	2	203	1		2	9	0
1	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106	418	815	26
2	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224	591	274	245
3	933	843	205	254	259	236	525	176	446	381	661	271	315	225	275
4	499	333	161	115	163	87	53	248	224	99	401	175	109	180	203
5	154	274	82	65	70	76	30	28	171	40	94	169	67	74	52
6	34	176	86	24	53	33	12	37	82	40	53	50	52	77	49
7	26	45	39	28	22	14	8	26	89	12	52	35	19	64	22
8+	14	44	65	34	46	60	15	42	115	28	92	44	13	46	39
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**
3+ group	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**	**1,353**	**744**	**575**	**666**	**640**

Year	1991	1992 *	1993 *	1994 *	1995 *	1996 *	1997	1998	1999 **	2000	2001	2002	2003	2004	2005	2006
W-rings/Numbers in millions																
W-rings/Biomass ('000 tonnnes)																
0						0.0		1.0	0.03	1.0	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	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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	

* 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	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037
2011	4,444
2012	1,140
2013	3,021
2014	539
2015	2,478
2016	442
2017	1,247
2018	1,563
2019	1,317
2020	239
2021	2,751

* small revision during HAWG 2010

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

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

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

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

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

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

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

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

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
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

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
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

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
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

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
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

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
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
2021	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
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

TABLE 3.6.8.b WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Survey indices: GerAS (number in thousands)**

	1	2	3	4
1994	415730	883810	559720	443730
1995	1675340	328610	357960	353850
1996	1439460	590010	434090	295170
1997	1955400	738180	394530	162430
1998	801350	678530	394070	236830
1999	1338710	287240	232510	155950
2000	1429880	453980	328960	201590
2001	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
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

TABLE 3.6.8.c WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Survey indices: N20 (number in millions)**

	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
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

TABLE 3.6.8.d WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Survey indices: IBTS+BITS-Q1 (number per hour)**

	1	2	3
2002	1045654	54550	10678
2003	642200	118519	3053
2004	290805	66533	11892
2005	187588	108625	6635
2006	144891	28465	5965
2007	222906	30955	3039
2008	161902	29000	3669
2009	571168	35698	1047
2010	291304	72528	8501
2011	147210	63866	11249
2012	291325	71455	3422
2013	184291	68128	12154
2014	143235	17888	2725
2015	244250	54514	1924
2016	195417	90784	5460
2017	447070	67306	11218
2018	96400	59785	2453
2019	391309	37485	4605
2020	357498	80377	5143
2021	345683	127508	7099

TABLE 3.6.8.e WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Survey indices: IBTS+BITS-Q3.4 (number per hour)**

	2	3
2002	3197	1400
2003	6542	1487
2004	3457	1225
2005	3581	631.5
2006	2643	1201
2007	3637	622.3
2008	2271	1217
2009	3277	565.7
2010	4033	1251
2011	2701	660.3
2012	5626	792
2013	5499	1439
2014	1341	1413
2015	9467	1321
2016	8869	2069
2017	5674	1542
2018	5832	1089
2019	9943	3234
2020	9124	2527
2021	8641	1760

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 1/2
***Multi fleet/*SAM configuration settings**

Configuration saved: Tue Feb 13 12:34:28 2018
Where a matrix is specified rows corresponds to fleets and columns to ages.
Same number indicates same parameter used
Numbers (integers) starts from zero and must be consecutive
#
$minAge
The minimium age class in the assessment
0
$maxAge
The maximum age class in the assessment
8
$maxAgePlusGroup
Is last age group considered a plus group (1 yes, or 0 no).
1
$keyLogFsta
Coupling of the fishing mortality states (nomally only first row is used).
-1 0 1 2 3 4 5 6 6
7 8 9 10 11 12 13 14 14
15 16 17 18 19 20 21 22 22
23 24 25 26 27 28 29 30 30
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
0 2 2 2
$keyLogFpar
Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	-1	-1	0	1	2	3
	-1	-1				
-1	4	5	6	7	-1	-1
	-1	-1				
8	-1	-1	-1	-1	-1	-1
	-1	-1				
-1	9	10	11	-1	-1	-1
	-1	-1				
-1	-1	12	13	-1	-1	-1
	-1	-1				
-1	-1	-1	-1	-1	-1	-1
	-1	-1				

$keyQpow
Density dependent catchability power parameters (if any).
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1

continued

TABLE 3.6.10 - WESTERN BALTIC SPRING SPAWNING HERRING 2/2
$keyVarF

```
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
 -1  0  0  0  0  0  0  0  0
  1  1  1  1  1  1  1  1  1
  2  2  2  2  2  2  2  2  2
  3  3  3  3  3  3  3  3  3
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
    -1    0    1    1    1    1
    1     1    1
    2     3    4    4    4    4
    4     4    4
    5     6    6    6    6    6
    6     6    6
    7     8    8    8    8    8
    8     8    8
    -1    -1   -1   9    9    9
    9     -1   -1
    -1    10   10   10   10   -1
    -1    -1   -1
    11    -1   -1   -1   -1   -1
    -1    -1   -1
    -1    12   12   12   -1   -1
    -1    -1   -1
    -1    -1   13   13   -1   -1
    -1    -1   -1
    -1    -1   -1   -1   -1   -1
    -1    -1   -1
$obsCorStruct# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "AR" "ID" "AR" "AR" "AR" "ID" "AR" "US" "NA"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
 NA  NA  NA  NA  NA  NA  NA  NA
 3  3  3  3  4  4  4  4
 NA  NA  NA  NA  NA  NA  NA  NA
 3  3   3  3  4  4  4  4
 -1 -1 -1  0  0  1 -1 -1
 -1  2  1  0 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
 -1  2  1 -1 -1 -1 -1 -1
 -1 -1  NA -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.
$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
$fbarRange
# lowest and higest age included in Fbar
 3 6
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
```

```
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN"
$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0
```

TABLE 3.6.11 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Stock summary - Estimated recruitment (1000), spawning stock biomass (SSB) (tons), average fishing mortality and total stock biomass (TSB) (tons).**

Year	R(age 0)	Low	High	SSB	Low	High	Fbar (3-6)	Low	High	TSB	Low	High
1991	5037767	3883893	6534448	294145	240485	359778	0.429	0.311	0.590	591282	499712	699631
1992	3616981	2870641	4557363	301866	247819	367698	0.508	0.392	0.658	520728	441025	614834
1993	3024804	2343977	3903383	285247	234948	346314	0.580	0.447	0.752	453282	382161	537639
1994	4505757	3512008	5780695	225394	185870	273322	0.601	0.467	0.775	371093	313624	439092
1995	4177252	3303589	5281963	193228	158414	235693	0.600	0.455	0.791	313442	264433	371534
1996	4163472	3306420	5242679	132731	110050	160086	0.664	0.514	0.856	277023	237031	323763
1997	3473011	2703111	4462194	145701	120967	175493	0.635	0.492	0.819	276843	235928	324853
1998	4610783	3626141	5862794	117839	98741	140632	0.618	0.476	0.802	261908	225187	304617
1999	4948162	3922340	6242272	118531	99288	141503	0.515	0.397	0.670	266321	229353	309248
2000	3027959	2408357	3806967	123786	103914	147458	0.571	0.453	0.721	258256	222182	300187
2001	2746047	2208664	3414180	136674	115870	161213	0.614	0.488	0.771	279314	241566	322961
2002	2775373	2219597	3470312	159829	135505	188518	0.489	0.388	0.618	285590	246919	330318
2003	2983774	2386756	3730129	129623	109287	153743	0.445	0.352	0.561	222581	191989	258047
2004	2064899	1649260	2585285	134779	114065	159255	0.497	0.386	0.640	229826	198719	265802
2005	1762657	1401261	2217260	122478	103601	144795	0.531	0.422	0.668	215088	185124	249900
2006	1345815	1057685	1712435	134187	112186	160501	0.468	0.375	0.585	227319	193139	267547
2007	1404787	1102204	1790437	110775	92390	132817	0.533	0.425	0.668	179160	151522	211839
2008	1152732	914390	1453199	89997	75629	107095	0.580	0.463	0.727	156201	132897	183593
2009	1129287	905064	1409059	79847	67731	94129	0.528	0.409	0.682	138902	119583	161341
2010	1462341	1169351	1828742	73802	62903	86589	0.402	0.309	0.523	122489	106277	141175
2011	1354293	1083599	1692610	69344	58404	82333	0.311	0.240	0.401	113416	97100	132474
2012	1187034	950561	1482334	72453	61583	85242	0.386	0.293	0.507	124128	107179	143758
2013	1683600	1276677	2220223	80066	68156	94057	0.411	0.310	0.545	135979	117774	156996

Year	R(age 0)	Low	High	SSB	Low	High	Fbar (3-6)	Low	High	TSB	Low	High
2014	1146962	883669	1488703	82432	68629	99011	0.344	0.257	0.461	139635	119850	162687
2015	919966	707551	1196150	83726	68518	102309	0.431	0.336	0.552	142713	119648	170225
2016	832966	632450	1097055	79359	64556	97558	0.486	0.372	0.634	123340	101068	150521
2017	924380	699933	1220799	72396	60263	86973	0.510	0.372	0.700	113555	95190	135464
2018	813549	588524	1124615	60775	49335	74869	0.509	0.368	0.703	95351	78921	115202
2019	839747	570178	1236763	54388	41386	71476	0.300	0.215	0.417	97063	76077	123836
2020	550822	332631	912136	54606	40314	73964	0.182	0.118	0.281	92971	70274	122999
2021	609230	315073	1178016	62765	44766	88002	0.149	0.080	0.277	97357	70477	134490

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	0.026	0.205	0.323	0.357	0.406	0.450	0.502	0.548	0.548
1992	0.026	0.221	0.354	0.405	0.475	0.536	0.617	0.686	0.686
1993	0.034	0.260	0.391	0.453	0.540	0.612	0.714	0.797	0.797
1994	0.041	0.287	0.411	0.469	0.561	0.632	0.743	0.826	0.826
1995	0.068	0.367	0.442	0.479	0.559	0.626	0.735	0.812	0.812
1996	0.046	0.317	0.444	0.509	0.615	0.702	0.829	0.923	0.923
1997	0.047	0.307	0.429	0.486	0.582	0.669	0.802	0.923	0.923
1998	0.052	0.317	0.434	0.479	0.567	0.652	0.774	0.917	0.917
1999	0.035	0.243	0.382	0.412	0.474	0.542	0.634	0.759	0.759
2000	0.028	0.236	0.400	0.442	0.524	0.604	0.716	0.861	0.861
2001	0.032	0.254	0.412	0.461	0.560	0.649	0.784	0.926	0.926
2002	0.026	0.200	0.346	0.375	0.446	0.517	0.620	0.735	0.735
2003	0.024	0.185	0.321	0.343	0.406	0.467	0.562	0.668	0.668
2004	0.025	0.204	0.338	0.374	0.455	0.523	0.637	0.755	0.755
2005	0.017	0.179	0.340	0.393	0.491	0.558	0.682	0.811	0.811
2006	0.016	0.174	0.343	0.368	0.437	0.487	0.581	0.685	0.685
2007	0.013	0.170	0.362	0.409	0.501	0.559	0.663	0.763	0.763
2008	0.013	0.178	0.385	0.437	0.543	0.614	0.727	0.822	0.822
2009	0.015	0.191	0.386	0.404	0.491	0.555	0.663	0.747	0.747
2010	0.007	0.119	0.292	0.310	0.375	0.420	0.504	0.570	0.570
2011	0.005	0.087	0.228	0.241	0.290	0.323	0.389	0.441	0.441
2012	0.005	0.097	0.241	0.278	0.358	0.408	0.498	0.561	0.561
2013	0.006	0.103	0.248	0.290	0.380	0.437	0.535	0.609	0.609
2014	0.005	0.088	0.226	0.253	0.318	0.364	0.442	0.514	0.514
2015	0.006	0.120	0.278	0.306	0.392	0.463	0.562	0.680	0.680
2016	0.006	0.116	0.304	0.344	0.433	0.525	0.642	0.808	0.808
2017	0.005	0.101	0.302	0.356	0.444	0.554	0.688	0.901	0.901
2018	0.004	0.097	0.293	0.349	0.437	0.555	0.695	0.963	0.963
2019	0.002	0.064	0.211	0.226	0.262	0.315	0.397	0.593	0.593
2020	0.001	0.054	0.184	0.163	0.172	0.174	0.220	0.348	0.348
2021	0.001	0.042	0.157	0.140	0.147	0.140	0.167	0.264	0.264

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	0.019	0.016	0.018	0.017	0.016	0.016
1992	0.000	0.000	0.004	0.019	0.016	0.018	0.017	0.018	0.018
1993	0.000	0.000	0.004	0.019	0.016	0.017	0.019	0.019	0.019
1994	0.000	0.000	0.004	0.018	0.017	0.017	0.020	0.021	0.021
1995	0.000	0.000	0.004	0.019	0.018	0.018	0.021	0.022	0.022
1996	0.000	0.000	0.004	0.018	0.018	0.020	0.023	0.025	0.025
1997	0.000	0.000	0.004	0.018	0.018	0.020	0.023	0.032	0.032
1998	0.000	0.000	0.004	0.018	0.019	0.022	0.023	0.039	0.039
1999	0.000	0.000	0.004	0.019	0.019	0.025	0.025	0.045	0.045
2000	0.000	0.000	0.004	0.018	0.022	0.028	0.029	0.048	0.048
2001	0.000	0.000	0.004	0.017	0.022	0.029	0.032	0.048	0.048
2002	0.000	0.000	0.003	0.016	0.021	0.027	0.030	0.047	0.047
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	0.013	0.018	0.018	0.024	0.039	0.039
2006	0.000	0.000	0.001	0.010	0.014	0.016	0.022	0.042	0.042
2007	0.000	0.000	0.001	0.007	0.010	0.009	0.017	0.029	0.029
2008	0.000	0.000	0.001	0.004	0.008	0.006	0.013	0.023	0.023
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	0.004	0.007	0.004	0.013	0.024	0.024
2011	0.000	0.000	0.000	0.003	0.006	0.003	0.013	0.018	0.018
2012	0.000	0.000	0.000	0.003	0.006	0.003	0.016	0.016	0.016
2013	0.000	0.000	0.000	0.004	0.006	0.004	0.018	0.020	0.020
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	0.044	0.044
2016	0.000	0.000	0.001	0.008	0.011	0.012	0.027	0.050	0.050
2017	0.000	0.000	0.001	0.009	0.013	0.013	0.026	0.057	0.057
2018	0.000	0.000	0.002	0.011	0.019	0.019	0.035	0.100	0.100
2019	0.000	0.000	0.003	0.014	0.025	0.025	0.048	0.140	0.140
2020	0.000	0.000	0.003	0.016	0.035	0.026	0.057	0.152	0.152
2021	0.000	0.000	0.003	0.016	0.038	0.030	0.053	0.133	0.133

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	0.037	0.143	0.109	0.087	0.079	0.074	0.075	0.075
1992	0.001	0.037	0.144	0.110	0.088	0.079	0.074	0.075	0.075
1993	0.001	0.038	0.145	0.111	0.088	0.080	0.075	0.076	0.076
1994	0.001	0.039	0.150	0.115	0.091	0.082	0.078	0.078	0.078
1995	0.001	0.040	0.155	0.119	0.095	0.085	0.080	0.081	0.081
1996	0.001	0.040	0.156	0.119	0.095	0.086	0.081	0.082	0.082
1997	0.001	0.041	0.158	0.121	0.096	0.087	0.082	0.083	0.083
1998	0.001	0.043	0.167	0.128	0.102	0.092	0.087	0.087	0.087
1999	0.001	0.046	0.177	0.136	0.108	0.097	0.092	0.093	0.093
2000	0.001	0.048	0.185	0.141	0.113	0.102	0.096	0.097	0.097
2001	0.001	0.046	0.178	0.136	0.108	0.098	0.092	0.093	0.093
2002	0.001	0.046	0.176	0.134	0.107	0.097	0.091	0.092	0.092
2003	0.001	0.042	0.162	0.124	0.099	0.089	0.084	0.085	0.085
2004	0.001	0.037	0.145	0.110	0.088	0.079	0.075	0.076	0.076
2005	0.001	0.040	0.154	0.118	0.094	0.085	0.080	0.081	0.081
2006	0.001	0.044	0.168	0.129	0.103	0.092	0.087	0.088	0.088
2007	0.001	0.046	0.176	0.134	0.107	0.097	0.091	0.092	0.092
2008	0.001	0.048	0.183	0.140	0.112	0.101	0.095	0.096	0.096
2009	0.001	0.050	0.192	0.146	0.117	0.105	0.099	0.100	0.100
2010	0.001	0.047	0.182	0.139	0.111	0.100	0.094	0.095	0.095
2011	0.001	0.040	0.154	0.118	0.094	0.085	0.080	0.081	0.081
2012	0.001	0.036	0.138	0.106	0.084	0.076	0.072	0.072	0.072
2013	0.001	0.034	0.129	0.099	0.079	0.071	0.067	0.068	0.068
2014	0.001	0.035	0.134	0.102	0.081	0.073	0.069	0.070	0.070
2015	0.001	0.038	0.147	0.112	0.089	0.081	0.076	0.077	0.077
2016	0.001	0.047	0.180	0.137	0.110	0.099	0.093	0.094	0.094
2017	0.001	0.051	0.198	0.151	0.121	0.109	0.103	0.104	0.104
2018	0.001	0.050	0.192	0.147	0.117	0.106	0.100	0.101	0.101
2019	0.001	0.042	0.163	0.125	0.099	0.090	0.084	0.085	0.085
2020	0.001	0.041	0.159	0.121	0.097	0.087	0.082	0.083	0.083
2021	0.001	0.038	0.147	0.112	0.090	0.081	0.076	0.077	0.077

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	0.014	0.042	0.017	0.008	0.004	0.003	0.004	0.003	0.003
1992	0.012	0.032	0.013	0.007	0.003	0.003	0.004	0.003	0.003
1993	0.017	0.046	0.018	0.009	0.004	0.003	0.004	0.004	0.004
1994	0.024	0.066	0.026	0.012	0.006	0.004	0.006	0.005	0.005
1995	0.051	0.146	0.054	0.023	0.010	0.007	0.009	0.007	0.007
1996	0.027	0.073	0.027	0.011	0.005	0.004	0.005	0.005	0.005
1997	0.030	0.076	0.027	0.011	0.005	0.004	0.005	0.004	0.004
1998	0.035	0.092	0.032	0.012	0.006	0.004	0.005	0.005	0.005
1999	0.022	0.056	0.021	0.008	0.004	0.003	0.004	0.003	0.003
2000	0.014	0.036	0.013	0.005	0.002	0.002	0.003	0.003	0.003
2001	0.018	0.052	0.022	0.009	0.005	0.005	0.009	0.010	0.010
2002	0.016	0.051	0.020	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.058	0.032	0.014	0.009	0.008	0.009	0.008	0.008
2004	0.016	0.068	0.044	0.022	0.014	0.012	0.012	0.009	0.009
2005	0.008	0.035	0.024	0.011	0.006	0.005	0.004	0.003	0.003
2006	0.009	0.051	0.044	0.022	0.013	0.013	0.011	0.009	0.009
2007	0.005	0.032	0.030	0.014	0.007	0.008	0.007	0.007	0.007
2008	0.005	0.035	0.034	0.013	0.005	0.006	0.005	0.005	0.005
2009	0.008	0.065	0.054	0.016	0.004	0.004	0.003	0.004	0.004
2010	0.002	0.021	0.015	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	0.016	0.016	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	0.032	0.031	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.021	0.021	0.002	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	0.007	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

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	0.126	0.159	0.221	0.298	0.350	0.407	0.453	0.453
1992	0.013	0.152	0.192	0.270	0.368	0.437	0.522	0.590	0.590
1993	0.016	0.176	0.224	0.314	0.431	0.512	0.616	0.698	0.698
1994	0.016	0.182	0.231	0.324	0.447	0.528	0.640	0.722	0.722
1995	0.016	0.180	0.228	0.319	0.437	0.516	0.624	0.701	0.701
1996	0.018	0.204	0.257	0.360	0.496	0.592	0.720	0.812	0.812
1997	0.017	0.190	0.240	0.336	0.463	0.558	0.691	0.804	0.804
1998	0.016	0.182	0.231	0.321	0.441	0.533	0.659	0.786	0.786
1999	0.012	0.141	0.180	0.250	0.343	0.416	0.513	0.618	0.618
2000	0.013	0.152	0.198	0.278	0.387	0.473	0.588	0.714	0.714
2001	0.013	0.156	0.209	0.299	0.424	0.518	0.651	0.776	0.776
2002	0.009	0.104	0.146	0.217	0.314	0.391	0.495	0.593	0.593
2003	0.007	0.085	0.124	0.189	0.279	0.348	0.442	0.532	0.532
2004	0.008	0.098	0.147	0.226	0.335	0.412	0.526	0.634	0.634
2005	0.009	0.104	0.161	0.251	0.374	0.451	0.574	0.689	0.689
2006	0.006	0.079	0.129	0.207	0.307	0.366	0.461	0.546	0.546
2007	0.007	0.092	0.155	0.254	0.376	0.445	0.547	0.635	0.635
2008	0.008	0.095	0.168	0.280	0.419	0.501	0.614	0.698	0.698
2009	0.006	0.076	0.140	0.237	0.362	0.440	0.547	0.613	0.613
2010	0.004	0.051	0.094	0.165	0.257	0.315	0.396	0.450	0.450
2011	0.003	0.035	0.067	0.119	0.190	0.235	0.297	0.343	0.343
2012	0.004	0.049	0.094	0.169	0.268	0.329	0.410	0.472	0.472
2013	0.004	0.054	0.103	0.186	0.295	0.362	0.450	0.520	0.520
2014	0.003	0.040	0.079	0.145	0.228	0.284	0.350	0.412	0.412
2015	0.004	0.049	0.100	0.186	0.293	0.372	0.460	0.559	0.559
2016	0.004	0.049	0.103	0.197	0.313	0.414	0.522	0.664	0.664
2017	0.003	0.046	0.099	0.195	0.310	0.431	0.559	0.739	0.739
2018	0.003	0.044	0.095	0.190	0.302	0.431	0.560	0.762	0.762
2019	0.001	0.019	0.043	0.087	0.138	0.200	0.264	0.367	0.367
2020	0.000	0.005	0.012	0.025	0.041	0.061	0.080	0.113	0.113
2021	0.000	0.003	0.006	0.012	0.020	0.029	0.038	0.054	0.054

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	5037767	4152778	2239405	1862514	911484	552464	162679	48586	17471
1992	3616981	3678060	2039685	1331057	1065594	493743	286494	81333	31694
1993	3024804	2613813	1820583	1160759	734482	541210	234687	126478	46702
1994	4505757	2125920	1220799	1030078	595191	356466	238525	93840	63764
1995	4177252	3250180	974352	651334	545249	269338	157759	92122	56231
1996	4163472	2882002	1372791	515736	326682	253669	117700	62026	53977
1997	3473011	2951702	1266816	732587	254314	143062	100889	41997	38294
1998	4610783	2414609	1313562	676886	372650	116532	60610	36131	26194
1999	4948162	3255370	1053379	690433	345108	174883	49380	23238	19985
2000	3027959	3592662	1552176	582806	370368	177661	83383	21561	16553
2001	2746047	2153338	1726248	864024	301813	179311	78829	33835	13145
2002	2775373	1956179	989075	940780	458408	138649	77355	28793	15425
2003	2983774	1989547	972501	565107	528195	242975	66992	34143	17346
2004	2064899	2194123	1006436	582702	328116	285598	124875	31355	21498
2005	1762657	1475163	1099716	598788	327059	170573	138030	54387	20318
2006	1345815	1286753	732135	645666	340977	161972	81578	56435	27295
2007	1404787	970641	660367	423381	362093	184187	78626	38920	34023
2008	1152732	1039066	488296	377572	228986	178658	88045	33020	28098
2009	1129287	838937	535355	271283	196606	110295	77871	35312	22072
2010	1462341	812239	419821	295943	149795	99535	52179	31757	22589
2011	1354293	1084369	432245	254364	176318	84095	54134	26031	24847
2012	1187034	997377	614624	281027	161848	107610	49906	30065	26749
2013	1683600	863737	542561	405647	174044	92688	57884	25063	26565
2014	1146962	1279410	460539	343726	252354	95835	49269	27715	23428
2015	919966	844825	737972	300941	217459	145261	55348	25751	25566
2016	832966	672344	451363	471612	182513	119665	72387	25952	21634
2017	924380	610232	361438	264258	283448	98103	58273	30378	17463
2018	813549	691398	334816	217889	144543	154834	47149	23740	15594
2019	839747	599352	378496	201297	127075	76002	73095	19691	11957
2020	550822	630942	340672	247216	126752	82485	45375	40514	14276
2021	609230	402039	371783	230754	170687	85325	57280	29710	31433

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	113689.08	642575.03	612280.36	556371.63	299755.72	197116.86	63248.50	20208.01	7266.73
1992	81278.90	608531.20	604953.29	442208.19	398834.38	202630.35	130566.87	40041.95	15603.34
1993	87330.67	504343.69	591924.43	424814.09	304616.57	245793.18	119116.45	69241.46	25567.25
1994	156993.37	451218.37	416244.86	389270.12	255449.85	166271.59	124884.72	52838.65	35903.53
1995	239281.94	876402.85	358540.05	252560.21	234586.43	125313.98	82453.97	51530.71	31454.37
1996	162578.11	671920.36	501510.14	208794.98	150529.14	128036.50	66656.98	37744.30	32846.14
1997	139583.64	669355.49	449348.32	285317.56	112554.92	69849.22	55952.59	25684.43	23420.08
1998	202806.54	566561.22	472764.65	261340.21	162314.64	56092.20	32914.63	22215.18	16105.64
1999	148314.85	593466.78	336823.46	235086.49	130627.93	73481.46	23316.77	12671.04	10897.39
2000	72865.74	634280.36	515984.95	210709.91	152296.56	81453.33	43197.30	12858.31	9871.63
2001	76484.51	408986.76	591451.00	323335.39	130863.44	86841.58	43722.32	21218.92	8243.64
2002	60849.38	297098.17	288294.34	294216.02	165043.12	56172.63	36065.49	15368.76	8233.52
2003	60341.74	281332.76	265170.34	163417.60	175451.96	90538.43	28926.75	16951.39	8612.29
2004	43585.44	339435.91	289343.46	182438.71	119662.25	116030.53	58896.31	16827.26	11537.74
2005	25418.77	200807.12	316094.58	194428.53	126493.56	72573.86	68261.94	30663.83	11455.29
2006	18375.32	171400.01	213108.21	199133.68	120674.30	62465.78	36092.22	28601.46	13832.99
2007	15841.59	125764.24	201331.98	142698.77	142630.26	78663.62	38254.37	21105.98	18450.54
2008	13188.00	140934.02	157798.14	134735.04	96164.03	81832.69	45642.83	18784.80	15984.52
2009	14334.76	122196.00	174147.69	90588.46	76266.62	46844.76	37872.97	18948.73	11844.23
2010	9168.06	74237.16	103593.24	77470.16	46174.90	33544.16	20456.12	13833.74	9839.80
2011	5521.18	73040.20	84336.50	52522.40	43008.33	22462.44	17039.32	9132.00	8716.66
2012	5562.90	74395.38	126787.82	66249.58	47393.88	34906.90	19170.29	12670.73	11273.28
2013	8360.12	68581.00	115862.73	99315.15	53502.94	31804.81	23506.48	11246.38	11920.29
2014	4606.59	87480.83	89580.30	74287.69	66589.80	28318.12	17275.42	11041.43	9333.79
2015	5108.76	78142.88	175785.90	77709.81	69062.11	52717.82	23595.22	12821.20	12729.30
2016	4130.51	60435.30	116403.27	135574.72	63596.17	48513.88	34478.32	14800.82	12338.46
2017	3616.42	47347.40	91685.09	78609.18	101367.80	41743.60	29332.34	18818.85	10818.18
2018	3032.46	51671.30	82569.29	63603.11	51199.17	66186.91	24018.32	15738.03	10337.58
2019	1666.58	29598.61	67940.88	39172.06	28612.44	20144.37	23948.47	9317.76	5657.87
2020	701.09	26535.26	53293.58	34979.14	19135.58	12605.31	8724.94	12064.15	4251.10
2021	483.41	12970.53	49589.80	28087.27	22025.68	10541.36	8447.08	6766.22	7158.59

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	10.46	8149.37	31695.61	13023.30	9088.34	2428.05	710.24	255.40
1992	0.00	9.27	7436.91	22232.77	15200.33	7843.94	4505.69	1301.68	507.23
1993	0.00	6.59	6571.66	19720.69	10782.78	8509.60	3920.73	2183.73	806.34
1994	0.00	5.36	4414.66	17019.67	9353.20	5594.28	4276.40	1740.48	1182.64
1995	0.00	8.19	3514.03	10933.65	8722.31	4399.55	3039.11	1839.09	1122.58
1996	0.00	7.26	4903.76	8567.62	5297.56	4447.24	2401.48	1409.11	1226.24
1997	0.00	7.44	4512.55	12060.90	4156.45	2597.20	2121.86	1184.94	1080.48
1998	0.00	6.08	4727.41	10950.43	6311.82	2344.33	1260.59	1260.06	913.52
1999	0.00	8.20	3806.70	11549.27	6012.46	3975.78	1095.77	926.19	796.55
2000	0.00	9.05	5577.05	9511.70	7251.02	4428.54	2132.71	916.63	703.72
2001	0.00	6.10	5683.05	13017.96	6004.13	4571.88	2228.51	1440.71	559.72
2002	0.00	4.87	2620.21	13703.07	8504.57	3306.86	2094.63	1211.51	649.04
2003	0.00	4.72	1715.16	7681.89	9071.04	4995.28	1619.24	1310.80	665.96
2004	0.00	5.40	2115.18	8187.20	5351.60	5254.59	2693.70	1012.98	694.56
2005	0.00	4.11	2011.44	7102.63	5225.18	2769.18	2982.49	1887.57	705.15
2006	0.00	4.37	955.94	5712.52	4438.30	2323.20	1590.86	2100.04	1015.68
2007	0.00	3.32	493.23	2548.67	3296.07	1544.53	1207.94	996.23	870.89
2008	0.00	3.80	270.39	1487.91	1605.21	994.84	1039.29	675.99	575.22
2009	0.00	3.53	261.67	1036.06	1438.78	568.16	1012.90	964.59	602.93
2010	0.00	4.19	143.92	963.53	967.41	400.72	632.74	696.13	495.15
2011	0.00	6.17	127.47	755.19	980.27	259.76	616.00	419.88	400.79
2012	0.00	6.93	170.46	806.36	863.61	253.06	725.61	426.78	379.71
2013	0.00	8.13	198.39	1344.52	987.71	368.01	950.00	459.46	486.99
2014	0.00	18.31	265.69	1551.56	1915.63	597.86	1020.06	800.08	676.34
2015	0.00	17.72	473.43	1613.58	1848.22	1323.75	1263.62	1001.64	994.46
2016	0.00	20.47	402.79	3241.34	1747.10	1262.46	1718.18	1144.63	954.20
2017	0.00	26.91	371.63	2264.30	3240.74	1171.91	1331.13	1535.56	882.73
2018	0.00	49.94	529.21	2154.28	2409.52	2615.16	1460.05	2056.79	1351.01
2019	0.00	72.99	964.96	2563.14	2836.12	1702.26	3129.12	2338.02	1419.68
2020	0.00	99.73	1041.45	3477.71	3910.67	1924.91	2290.22	5183.75	1826.62
2021	0.00	70.08	1135.69	3228.27	5705.83	2318.84	2681.00	3350.52	3544.82

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	2910.42	119313.74	271443.40	175237.17	69119.24	37920.68	10546.04	3181.20	1143.95
1992	2098.12	106098.16	248175.39	125718.57	81121.54	34023.29	18645.87	5346.37	2083.34
1993	1771.08	76094.36	223453.92	110609.18	56417.53	37631.00	15412.38	8389.14	3097.67
1994	2727.51	63949.35	154554.11	101299.78	47198.88	25591.63	16175.07	6427.15	4367.21
1995	2619.90	101232.82	127481.76	66235.48	44728.54	20005.75	11069.27	6528.22	3984.83
1996	2620.27	90069.67	180187.35	52616.98	26886.98	18904.21	8285.85	4410.06	3837.76
1997	2215.78	93493.31	168394.91	75709.51	21205.24	10801.76	7196.14	3025.37	2758.65
1998	3112.34	80832.57	183948.93	73767.50	32787.93	9286.80	4563.58	2747.46	1991.87
1999	3541.67	115421.59	155682.90	79497.27	32103.98	14739.27	3932.61	1869.03	1607.41
2000	2260.65	132751.74	238436.68	69805.12	35859.66	15587.64	6913.72	1805.40	1386.05
2001	1969.88	76515.40	255654.22	99692.72	28135.89	15144.63	6291.37	2727.25	1059.55
2002	1970.89	68825.03	145128.53	107525.13	42325.35	11597.81	6114.25	2298.56	1231.41
2003	1952.95	64620.17	132371.12	59824.41	45127.15	18799.80	4896.92	2520.80	1280.71
2004	1204.02	63616.90	123053.90	55304.06	25100.17	19776.34	8166.98	2071.40	1420.27
2005	1095.10	45523.20	142634.00	60347.64	26585.81	12554.52	9596.68	3819.64	1426.93
2006	913.92	43332.10	103102.75	70763.01	30172.37	12983.25	6178.20	4317.39	2088.09
2007	996.64	34119.75	96817.20	48347.06	33402.67	15395.08	6210.03	3105.16	2714.48
2008	852.40	38037.49	74361.19	44821.12	21970.88	15535.45	7235.42	2741.10	2332.48
2009	872.23	32048.13	84835.62	33539.99	19658.55	9997.17	6671.32	3055.84	1910.11
2010	1073.70	29528.54	63523.28	34901.16	14277.65	8597.96	4259.68	2618.85	1862.76
2011	840.78	33441.06	56032.91	25621.82	14325.46	6187.56	3762.70	1827.85	1744.72
2012	661.79	27671.42	72079.17	25564.98	11862.57	7139.76	3127.29	1903.40	1693.48
2013	879.13	22467.44	59841.92	34672.56	11978.42	5773.32	3404.81	1489.50	1578.75
2014	618.52	34352.52	52354.86	30295.96	17915.52	6158.49	2990.25	1699.45	1436.62
2015	544.46	24857.20	91511.33	28974.27	16879.83	10210.64	3675.25	1727.58	1715.20
2016	604.18	24152.63	67546.19	54993.01	17199.12	10221.41	5844.05	2116.66	1764.52
2017	738.40	24091.10	59065.78	33715.08	29263.01	9185.04	5158.26	2716.50	1561.60
2018	631.06	26523.10	53274.31	27049.73	14514.11	14097.75	4058.28	2064.33	1355.96
2019	552.49	19566.99	51780.55	21417.95	10913.23	5913.54	5374.08	1462.66	888.14
2020	352.12	20024.27	45381.44	25599.76	10590.70	6243.46	3245.18	2927.39	1031.54
2021	361.38	11855.52	46202.94	22264.17	13277.40	6010.91	3812.09	1997.72	2113.57

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	62342.05	133877.68	34226.10	13844.96	3358.65	1504.29	603.22	150.56	54.14
1992	37461.87	92100.15	24760.65	7934.89	3209.03	1123.40	913.56	221.48	86.31
1993	45158.63	93020.37	30151.19	9188.44	2873.35	1570.00	944.82	429.50	158.59
1994	92455.42	107037.38	28280.12	10904.09	3046.38	1320.87	1209.87	395.30	268.60
1995	179949.24	349667.57	46610.69	13301.79	5049.56	1716.81	1318.03	614.09	374.84
1996	96508.84	160188.86	32760.50	5329.16	1598.10	903.72	577.03	255.29	222.16
1997	88128.35	170388.51	30124.38	7211.98	1168.12	480.76	469.94	167.65	152.87
1998	137401.47	166982.35	37411.74	7496.29	1874.03	424.37	301.24	155.25	112.55
1999	93291.27	140226.89	19484.80	4984.14	1146.18	434.04	171.42	72.20	62.10
2000	36821.38	100543.52	18809.46	2747.47	824.57	305.47	206.82	49.51	38.01
2001	43223.68	85761.80	33541.74	7108.95	1488.74	861.15	654.45	292.27	113.55
2002	37953.83	75999.18	18194.76	6016.49	1518.03	358.25	248.03	73.91	39.59
2003	40136.07	88871.50	27953.79	7302.97	4139.84	1696.37	558.91	233.39	118.58
2004	27912.83	113499.13	39438.16	11716.62	4002.56	3062.29	1344.94	262.04	179.67
2005	11401.21	39961.96	23250.88	5826.40	1697.58	709.18	491.56	140.37	52.44
2006	10005.88	50641.65	28719.50	12964.50	3852.74	1873.54	809.46	456.57	220.82
2007	5922.69	24343.28	17701.10	5403.14	2375.09	1361.53	528.12	245.56	214.66
2008	4814.97	28321.13	14631.40	4524.05	1068.98	922.17	380.76	161.20	137.17
2009	7588.93	41474.97	25718.87	3831.73	739.32	408.45	199.01	113.02	70.65
2010	3062.77	13045.63	5591.75	715.91	52.77	26.04	6.78	5.27	3.75
2011	1459.83	10046.54	2922.35	218.27	11.63	3.96	1.42	1.10	1.05
2012	1000.96	8892.75	4689.13	232.51	7.82	3.73	0.96	1.02	0.91
2013	1506.41	10500.87	7578.15	698.13	16.79	6.24	1.78	1.30	1.38
2014	948.30	13432.38	5112.95	391.92	13.64	5.03	1.10	1.07	0.90
2015	1596.66	21264.16	20177.35	769.14	31.21	28.12	3.47	2.39	2.37
2016	871.79	10912.74	8394.35	643.75	13.81	17.42	3.85	2.23	1.85
2017	154.21	1731.88	1310.86	66.03	4.38	3.29	1.11	1.19	0.69
2018	117.49	1736.66	1099.13	54.88	2.55	5.77	1.17	1.23	0.81
2019	79.27	1019.27	852.86	42.84	2.59	3.43	2.26	1.15	0.70
2020	152.55	3699.95	3084.38	263.72	19.32	28.88	9.54	11.55	4.07
2021	16.20	207.79	239.79	13.82	1.63	2.18	1.11	0.98	1.03

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	48436.61	389373.15	298461.49	335593.89	214254.53	148603.55	49671.19	16166.01	5813.24
1992	41718.91	410323.62	324580.34	286321.96	299303.48	159639.72	106501.75	33172.42	12926.46
1993	40400.96	335222.37	331747.66	285295.78	234542.91	198082.58	98838.52	58239.09	21504.65
1994	61810.44	280226.28	228995.97	260046.58	195851.39	133764.81	103223.38	44275.72	30085.08
1995	56712.80	425494.27	180933.57	162089.29	176086.02	99191.87	67027.56	42549.31	25972.12
1996	63449.00	421654.57	283658.53	142281.22	116746.50	103781.33	55392.62	31669.84	27559.98
1997	49239.51	405466.23	246316.48	190335.17	86025.11	55969.50	46164.65	21306.47	19428.08
1998	62292.73	318740.22	246676.57	169125.99	121340.86	44036.70	26789.22	18052.41	13087.70
1999	51481.91	337810.10	157849.06	139055.81	91365.31	54332.37	18116.97	9803.62	8431.33
2000	33783.71	400976.05	253161.76	128645.62	108361.31	61131.68	33944.05	10086.77	7743.85
2001	31290.95	246703.46	296571.99	203515.76	95234.68	66263.92	34547.99	16758.69	6510.82
2002	20924.66	152269.09	122350.84	166971.33	112695.17	40909.71	27608.58	11784.78	6313.48
2003	18252.72	127836.37	103130.27	88608.33	117113.93	65046.98	21851.68	12886.40	6547.04
2004	14468.59	162314.48	124736.22	107230.83	85207.92	87937.31	46690.69	13480.84	9243.24
2005	12922.46	115317.85	148198.26	121151.86	92984.99	56540.98	55191.21	24816.25	9270.77
2006	7455.52	77421.89	80330.02	109693.65	82210.89	45285.79	27513.70	21727.46	10508.40
2007	8922.26	67297.89	86320.45	86399.90	103556.43	60362.48	30308.28	16759.03	14650.51
2008	7520.63	74571.60	68535.16	83901.96	71518.96	64380.23	36987.36	15206.51	12939.65
2009	5873.60	48669.37	63331.53	52180.68	54429.97	35870.98	29989.74	14815.28	9260.54
2010	5031.59	31658.80	34334.29	40889.56	30877.07	24519.44	15556.92	10513.49	7478.14
2011	3220.57	29546.43	25253.77	25927.12	27690.97	16011.16	12659.20	6883.17	6570.10
2012	3900.15	37824.28	49849.06	39645.73	34659.88	27510.35	15316.43	10339.53	9199.18
2013	5974.58	35604.56	48244.27	62599.94	40520.02	25657.24	19149.89	9296.12	9853.17
2014	3039.77	39677.62	31846.80	42048.25	46745.01	21556.74	13264.01	8540.83	7219.93
2015	2967.64	32003.80	63623.79	46352.82	50302.85	41155.31	18652.88	10089.59	10017.27
2016	2654.54	25349.46	40059.94	76696.62	44636.14	37012.59	26912.24	11537.30	9617.89
2017	2723.81	21497.51	30936.82	42563.77	68859.67	31383.36	22841.84	14565.60	8373.16
2018	2283.91	23361.60	27666.64	34344.22	34272.99	49468.23	18498.82	11615.68	7629.80
2019	1034.82	8939.36	14342.51	15148.13	14860.50	12525.14	15443.01	5515.93	3349.35
2020	196.42	2711.31	3786.31	5637.95	4614.89	4408.06	3180.00	3941.46	1388.87
2021	105.83	837.14	2011.38	2581.01	3040.82	2209.43	1952.88	1417.00	1499.17

TABLE 3.9.1 WESTERN BALTIC SPRING SPAWNING HERRING. Input table for short term predictions.

2021						
wr	N	M	Mat	PM	PF	SWt
0	609230	0.3	0.00	0.25	0.1	0.0001
1	402040	0.5	0.00	0.25	0.1	0.0192
2	371783	0.2	0.20	0.25	0.1	0.0544
3	230754	0.2	0.75	0.25	0.1	0.0745
4	170687	0.2	0.90	0.25	0.1	0.1170
5	85325	0.2	1.00	0.25	0.1	0.1293
6	57280	0.2	1.00	0.25	0.1	0.1773
7	29710	0.2	1.00	0.25	0.1	0.1814
8+	31433	0.2	1.00	0.25	0.1	0.1781
2022						
wr	N	M	Mat	PM	PF	SWt
0	792293	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	0.0513
3		0.2	0.75	0.25	0.1	0.0788
4		0.2	0.90	0.25	0.1	0.1134
5		0.2	1.00	0.25	0.1	0.1399
6		0.2	1.00	0.25	0.1	0.1645
7		0.2	1.00	0.25	0.1	0.1741
8+		0.2	1.00	0.25	0.1	0.1821
2023						
wr	N	M	Mat	PM	PF	SWt
0	792293	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	0.0513
3		0.2	0.75	0.25	0.1	0.0788
4		0.2	0.90	0.25	0.1	0.1134
5		0.2	1.00	0.25	0.1	0.1399
6		0.2	1.00	0.25	0.1	0.1645
7		0.2	1.00	0.25	0.1	0.1741
8+		0.2	1.00	0.25	0.1	0.1821

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_{2021} wr 0–8+: Populations numbers from the assessment
$N_{2022/2023}$ wr 0: Average of wr 0 for the years 2016–2020
Natural Mortality (M): Constant
Weight in the Stock 2022–2023 (SWt): Average for 2017–2021

TABLE 3.9.2 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. MSY approach (zero catch, F = 0)**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.000	0.000	0.000
fbar:low	0.149	0.064	0.000	0.000	0.000
fbar:high	0.149	0.064	0.000	0.000	0.000
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80978	95882	111989
ssb:low	62765	71011	80978	95882	111989
ssb:high	62765	71011	80978	95882	111989
catch:Estimate	15546	7662	0	0	0
catch:low	15546	7662	0	0	0
catch:high	15546	7662	0	0	0

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	0	0	0
Fleet C : Estimate	10119	733	0	0	0
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	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**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.147	0.164	0.164
fbar:low	0.149	0.064	0.147	0.164	0.164
fbar:high	0.149	0.064	0.147	0.164	0.164
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	79256	79224	80143
ssb:low	62765	71011	79256	79224	80143
ssb:high	62765	71011	79256	79224	80143
catch:Estimate	15546	7662	19391	21686	22149
catch:low	15546	7662	19391	21686	22149
catch:high	15546	7662	19391	21686	22149

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	15618	17363	17747
Fleet C : Estimate	10119	733	1764	2059	2143
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	2008	2265	2258

TABLE 3.9.4 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. MAP 2018: F=FMSYlower(0.216)*SSBy-1/MSYBtrigger**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.102	0.115	0.121
fbar:low	0.149	0.064	0.102	0.115	0.121
fbar:high	0.149	0.064	0.102	0.115	0.121
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	79772	83745	87795
ssb:low	62765	71011	79772	83745	87795
ssb:high	62765	71011	79772	83745	87795
catch:Estimate	15546	7662	14025	16849	18865
catch:low	15546	7662	14025	16849	18865
catch:high	15546	7662	14025	16849	18865

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	11323	13590	15280
Fleet C : Estimate	10119	733	1254	1516	1683
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	1448	1744	1902

TABLE 3.9.5 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. MAP 2018: F=FMSYupper(0.379)*SSBy-1/MSYBtrigger**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.179	0.199	0.192
fbar:low	0.149	0.064	0.179	0.199	0.192
fbar:high	0.149	0.064	0.179	0.199	0.192
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	78880	76152	75303
ssb:low	62765	71011	78880	76152	75303
ssb:high	62765	71011	78880	76152	75303
catch:Estimate	15546	7662	23085	24572	23643
catch:low	15546	7662	23085	24572	23643
catch:high	15546	7662	23085	24572	23643

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	18562	19567	18801
Fleet C : Estimate	10119	733	2127	2422	2415
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	2396	2582	2428

TABLE 3.9.6 WESTERN BALTIC SPRING SPAWNING HERRING

Multi fleet/**Forecast table. F=FMSY=0.31**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.310	0.310	0.310
fbar:low	0.149	0.064	0.310	0.310	0.310
fbar:high	0.149	0.064	0.310	0.310	0.310
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	77401	65861	61838
ssb:low	62765	71011	77401	65861	61838
ssb:high	62765	71011	77401	65861	61838
catch:Estimate	15546	7662	36088	30159	28128
catch:low	15546	7662	36088	30159	28128
catch:high	15546	7662	36088	30159	28128

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	28829	23560	21780
Fleet C : Estimate	10119	733	3482	3372	3408
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	3777	3227	2941

TABLE 3.9.7 WESTERN BALTIC SPRING SPAWNING HERRING

Multi fleet/**Forecast table. F=Fpa=0.41**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.410	0.410	0.410
fbar:low	0.149	0.064	0.410	0.410	0.410
fbar:high	0.149	0.064	0.410	0.410	0.410
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	76296	59278	53441
ssb:low	62765	71011	76296	59278	53441
ssb:high	62765	71011	76296	59278	53441
catch:Estimate	15546	7662	44481	33646	30065
catch:low	15546	7662	44481	33646	30065
catch:high	15546	7662	44481	33646	30065

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	35369	25892	22796
Fleet C : Estimate	10119	733	4430	4115	4101
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	4681	3640	3169

TABLE 3.9.8 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. F=Flim=0.45**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.450	0.450	0.450
fbar:low	0.149	0.064	0.450	0.450	0.450
fbar:high	0.149	0.064	0.450	0.450	0.450
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	75860	56930	50619
ssb:low	62765	71011	75860	56930	50619
ssb:high	62765	71011	75860	56930	50619
catch:Estimate	15546	7662	47526	34667	30569
catch:low	15546	7662	47526	34667	30569
catch:high	15546	7662	47526	34667	30569

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	37724	26522	22992
Fleet C : Estimate	10119	733	4791	4383	4349
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	5012	3763	3228

TABLE 3.9.9 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. F=F2022=0.064**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.064	0.064	0.064
fbar:low	0.149	0.064	0.064	0.064	0.064
fbar:high	0.149	0.064	0.064	0.064	0.064
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80221	88093	96763
ssb:low	62765	71011	80221	88093	96763
ssb:high	62765	71011	80221	88093	96763
catch:Estimate	15546	7662	9073	10387	11843
catch:low	15546	7662	9073	10387	11843
catch:high	15546	7662	9073	10387	11843

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	7341	8436	9702
Fleet C : Estimate	10119	733	799	886	964
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	934	1065	1177

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

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.000	0.000	0.000
fbar:low	0.149	0.064	0.000	0.000	0.000
fbar:high	0.149	0.064	0.000	0.000	0.000
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80978	95882	111989
ssb:low	62765	71011	80978	95882	111989
ssb:high	62765	71011	80978	95882	111989
catch:Estimate	15546	7662	0	0	0
catch:low	15546	7662	0	0	0
catch:high	15546	7662	0	0	0

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	0	0	0
Fleet C : Estimate	10119	733	0	0	0
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	0	0	0

TABLE 3.9.11 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. F=0.05**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.050	0.050	0.050
fbar:low	0.149	0.064	0.050	0.050	0.050
fbar:high	0.149	0.064	0.050	0.050	0.050
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80385	89708	99777
ssb:low	62765	71011	80385	89708	99777
ssb:high	62765	71011	80385	89708	99777
catch:Estimate	15546	7662	7177	8395	9739
catch:low	15546	7662	7177	8395	9739
catch:high	15546	7662	7177	8395	9739

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	5811	6833	8004
Fleet C : Estimate	10119	733	628	704	771
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	738	858	964

TABLE 3.9.12 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. F=0.1**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.100	0.100	0.100
fbar:low	0.149	0.064	0.100	0.100	0.100
fbar:high	0.149	0.064	0.100	0.100	0.100
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	79799	84145	89698
ssb:low	62765	71011	79799	84145	89698
ssb:high	62765	71011	79799	84145	89698
catch:Estimate	15546	7662	13742	14913	16319
catch:low	15546	7662	13742	14913	16319
catch:high	15546	7662	13742	14913	16319

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	11096	12042	13257
Fleet C : Estimate	10119	733	1228	1330	1424
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	1418	1541	1639

TABLE 3.9.13 WESTERN BALTIC SPRING SPAWNING HERRING

***Multi fleet/*Forecast table. F=0.15**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.150	0.150	0.150
fbar:low	0.149	0.064	0.150	0.150	0.150
fbar:high	0.149	0.064	0.150	0.150	0.150
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	79218	79114	81275
ssb:low	62765	71011	79218	79114	81275
ssb:high	62765	71011	79218	79114	81275
catch:Estimate	15546	7662	19767	20008	20840
catch:low	15546	7662	19767	20008	20840
catch:high	15546	7662	19767	20008	20840

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	15918	16027	16731
Fleet C : Estimate	10119	733	1801	1893	1988
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	2048	2088	2120

TABLE 3.9.14 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. Constant 2022 TAC**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.054	0.046	0.039
fbar:low	0.149	0.064	0.054	0.046	0.039
fbar:high	0.149	0.064	0.054	0.046	0.039
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80345	89405	100170
ssb:low	62765	71011	80345	89405	100170
ssb:high	62765	71011	80345	89405	100170
catch:Estimate	15546	7662	7662	7662	7662
catch:low	15546	7662	7662	7662	7662
catch:high	15546	7662	7662	7662	7662

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	6142	6142	6142
Fleet C : Estimate	10119	733	733	733	733
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	788	788	788

TABLE 3.9.15 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. Catch for bycatch fleets only**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.039	0.033	0.027
fbar:low	0.149	0.064	0.039	0.033	0.027
fbar:high	0.149	0.064	0.039	0.033	0.027
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80475	90852	102935
ssb:low	62765	71011	80475	90852	102935
ssb:high	62765	71011	80475	90852	102935
catch:Estimate	15546	7662	6142	6142	6142
catch:low	15546	7662	6142	6142	6142
catch:high	15546	7662	6142	6142	6142

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	6142	6142	6142
Fleet C : Estimate	10119	733	0	0	0
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	0	0	0

TABLE 3.9.16 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. F = 0.025**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.025	0.025	0.025
fbar:low	0.149	0.064	0.025	0.025	0.025
fbar:high	0.149	0.064	0.025	0.025	0.025
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80681	92713	105581
ssb:low	62765	71011	80681	92713	105581
ssb:high	62765	71011	80681	92713	105581
catch:Estimate	15546	7662	3670	4466	5354
catch:low	15546	7662	3670	4466	5354
catch:high	15546	7662	3670	4466	5354

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	2976	3650	4426
Fleet C : Estimate	10119	733	318	362	403
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	376	454	525

TABLE 3.9.17 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. F = 0.01**

Year	2021	2022	2023	2024	2025
fbar:Estimate	0.149	0.064	0.010	0.010	0.010
fbar:low	0.149	0.064	0.010	0.010	0.010
fbar:high	0.149	0.064	0.010	0.010	0.010
rec:Estimate	609230	792293	792293	792293	792293
rec:low	609230	792293	792293	792293	792293
rec:high	609230	792293	792293	792293	792293
ssb:Estimate	62765	71011	80859	94594	109348
ssb:low	62765	71011	80859	94594	109348
ssb:high	62765	71011	80859	94594	109348
catch:Estimate	15546	7662	1488	1856	2272
catch:low	15546	7662	1488	1856	2272
catch:high	15546	7662	1488	1856	2272

Per fleet

Year	2021	2022	2023	2024	2025
Fleet A : Estimate	3508	6142	1208	1520	1885
Fleet C : Estimate	10119	733	128	148	166
Fleet D : Estimate	24	0	0	0	0
Fleet F : Estimate	1895	788	152	188	222

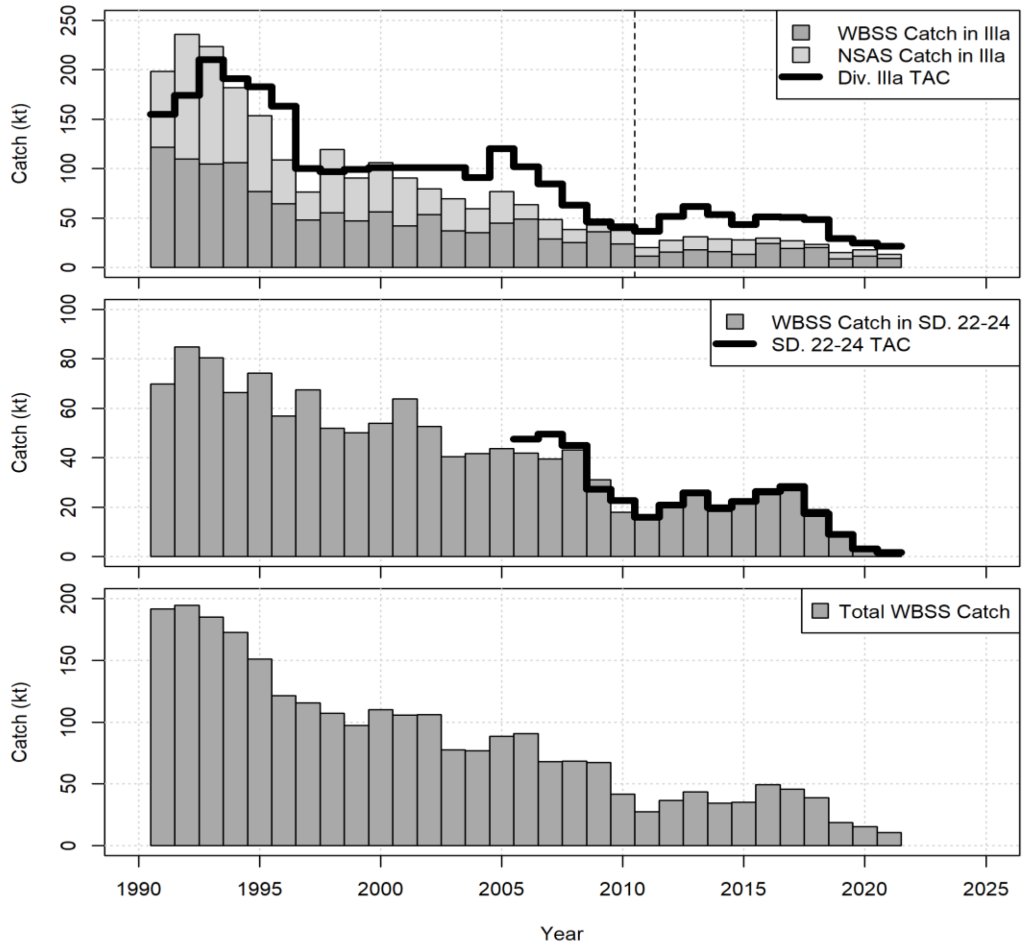


Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for Division 3.a excludes the by-catch TAC, while the CATCH includes the by-catch.

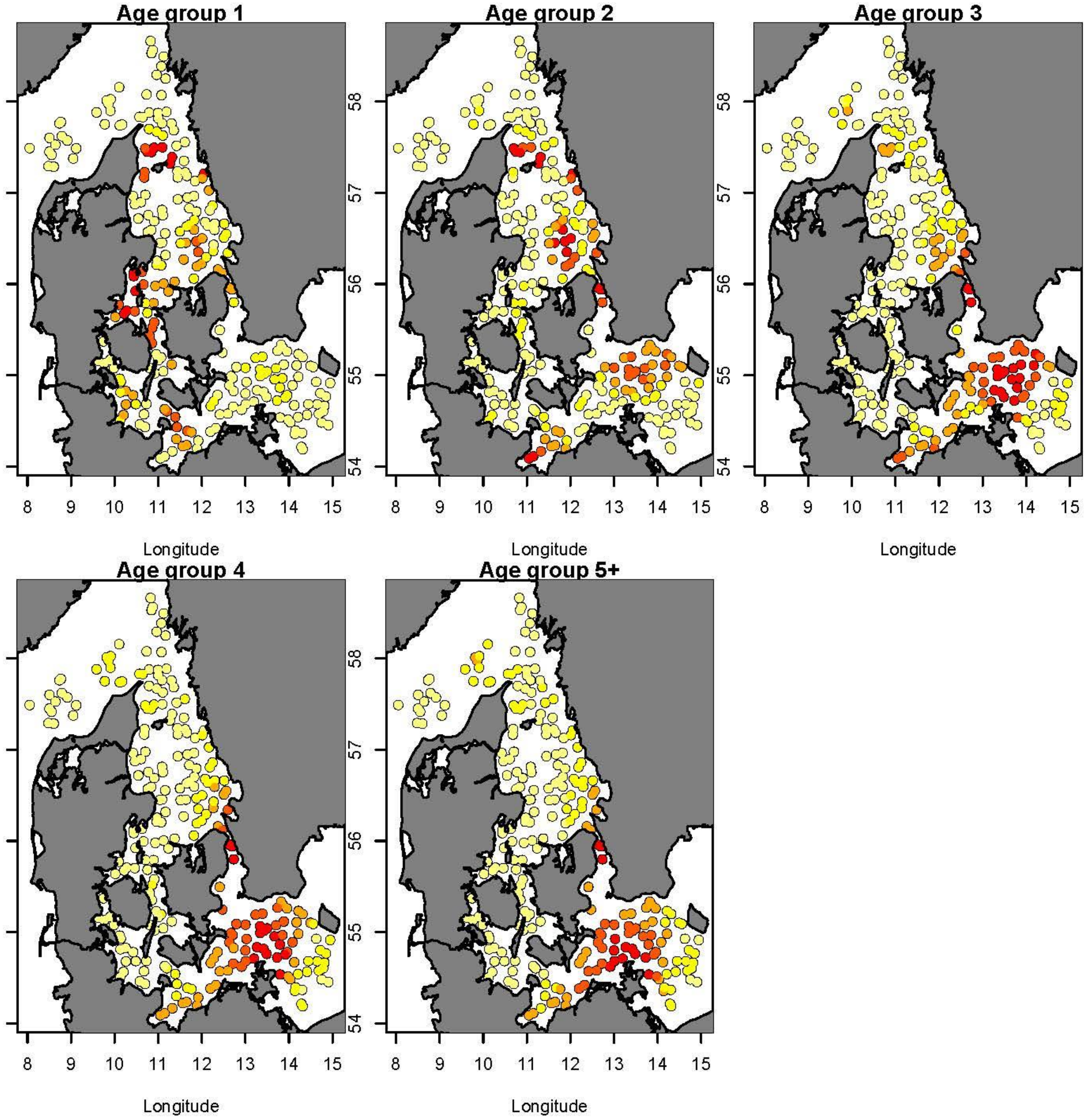


Figure 3.3.1 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q1 survey.

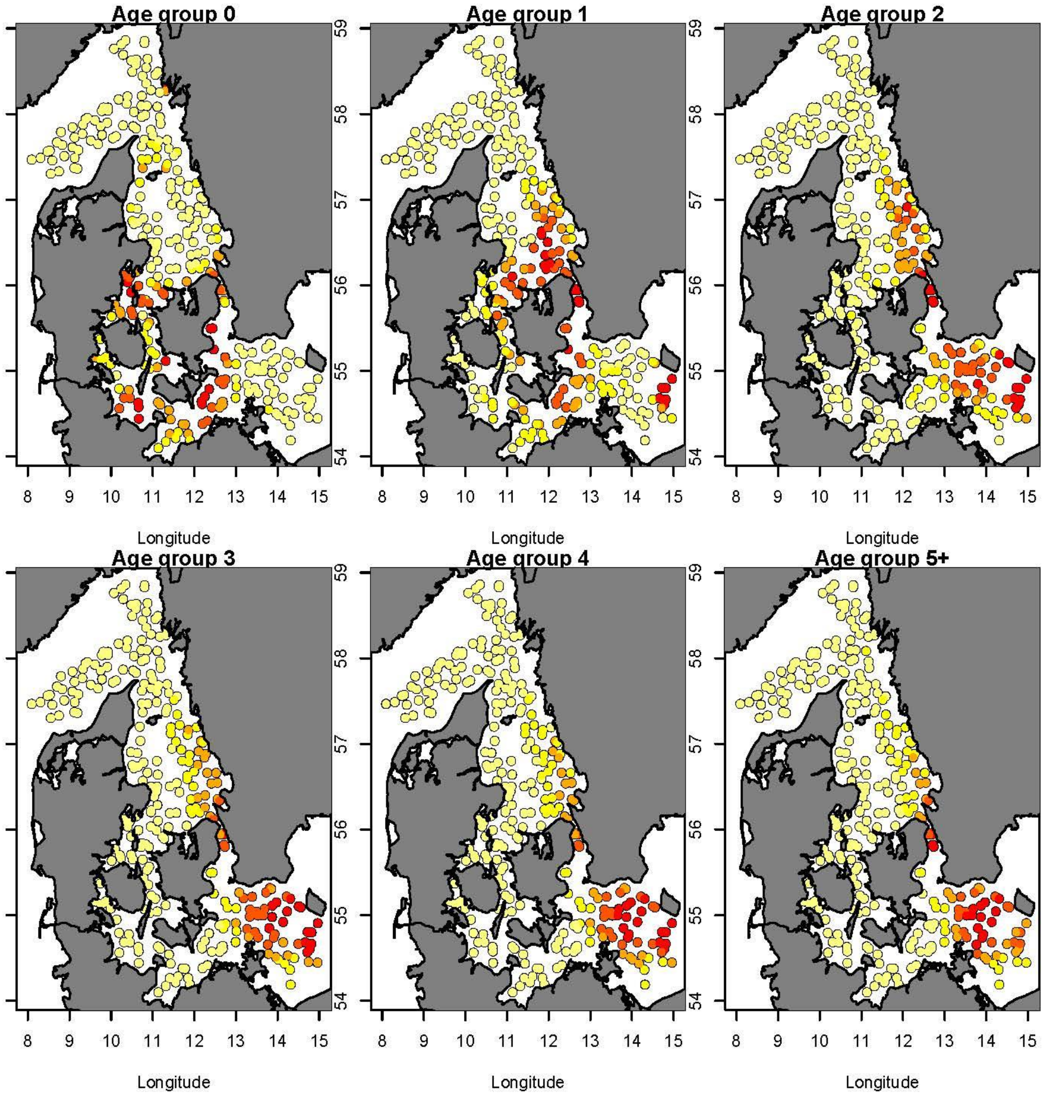


Figure 3.3.2 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q3.4 survey.

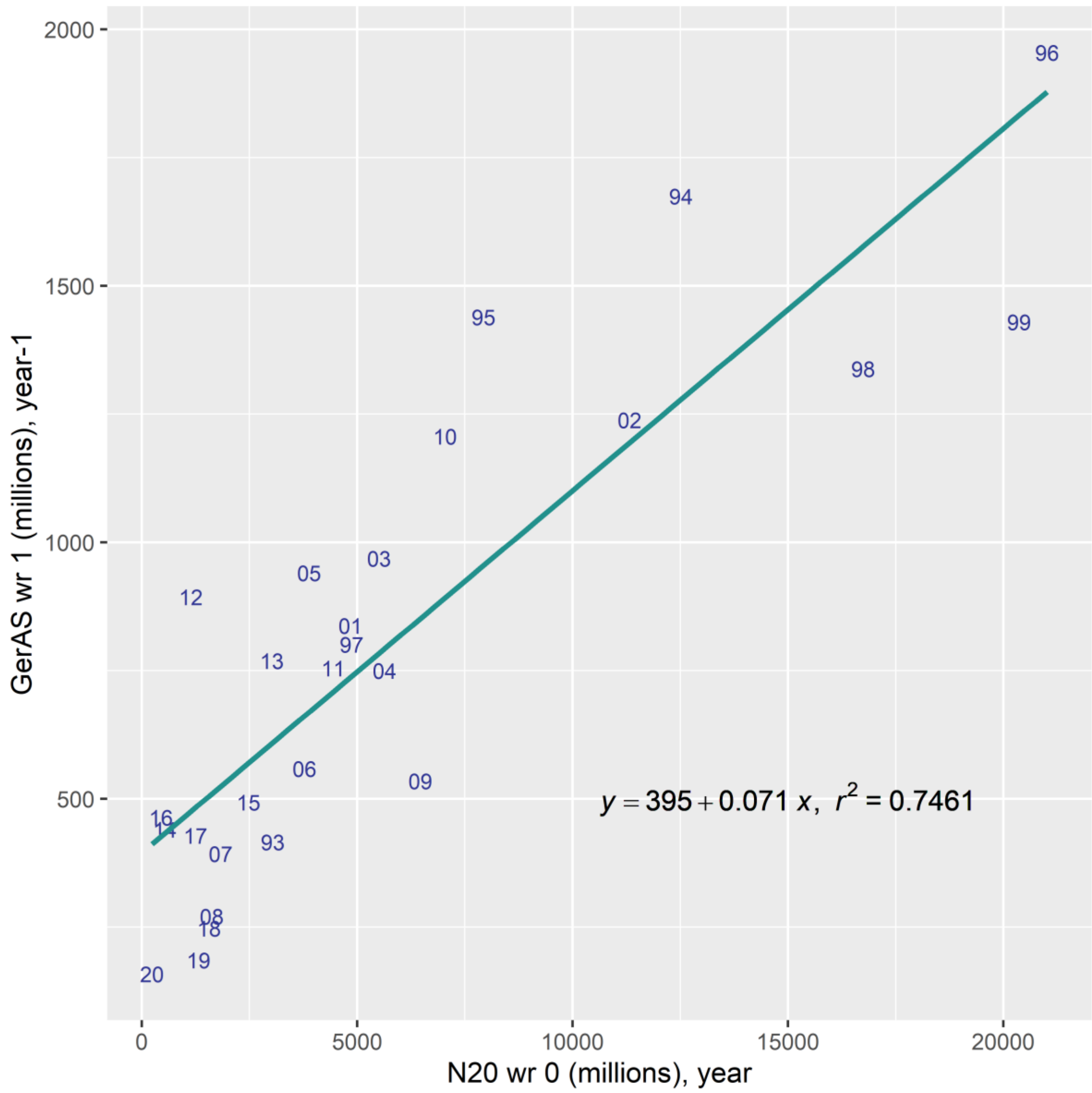


Figure 3.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N20.

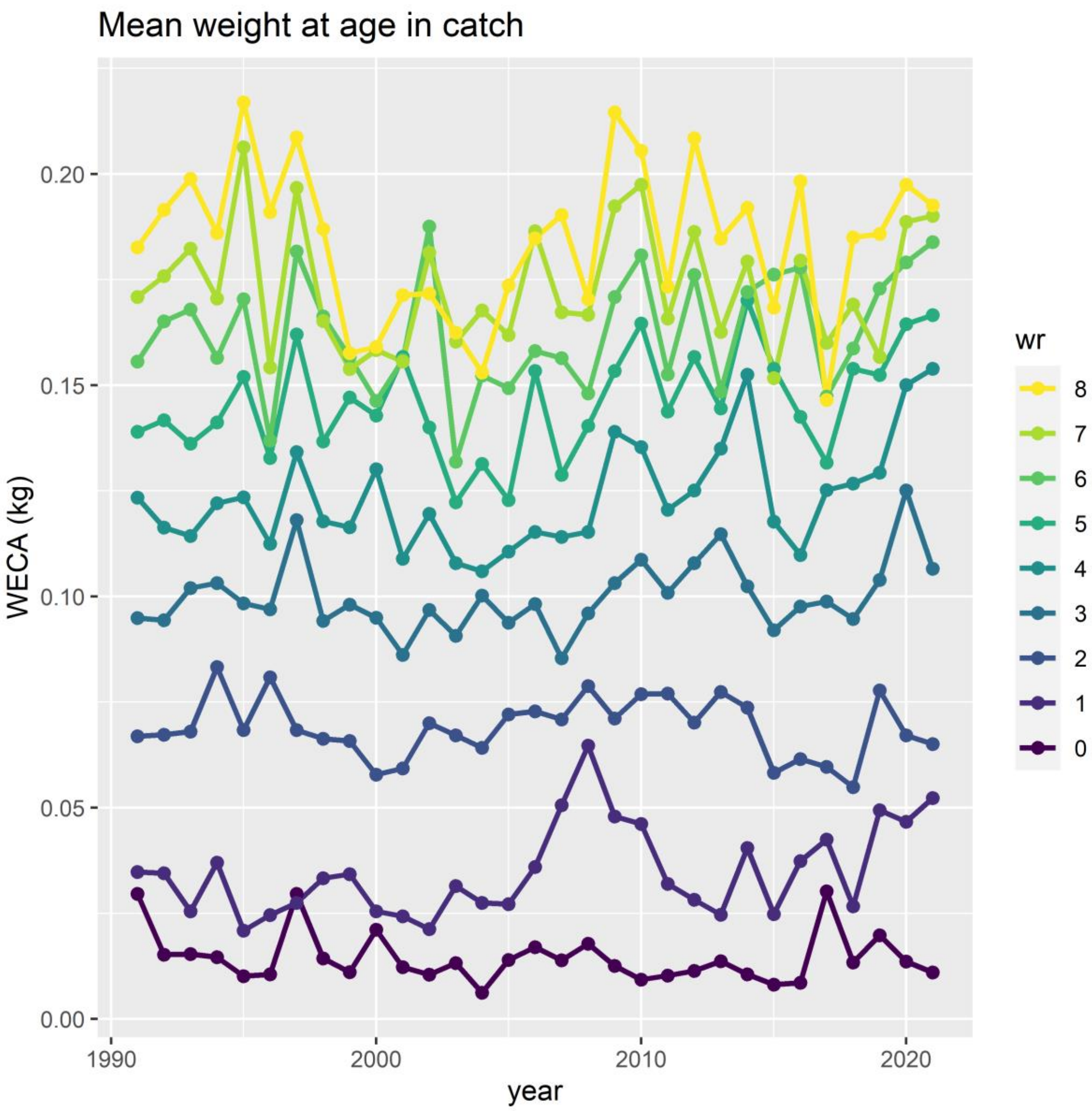


Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WECA).

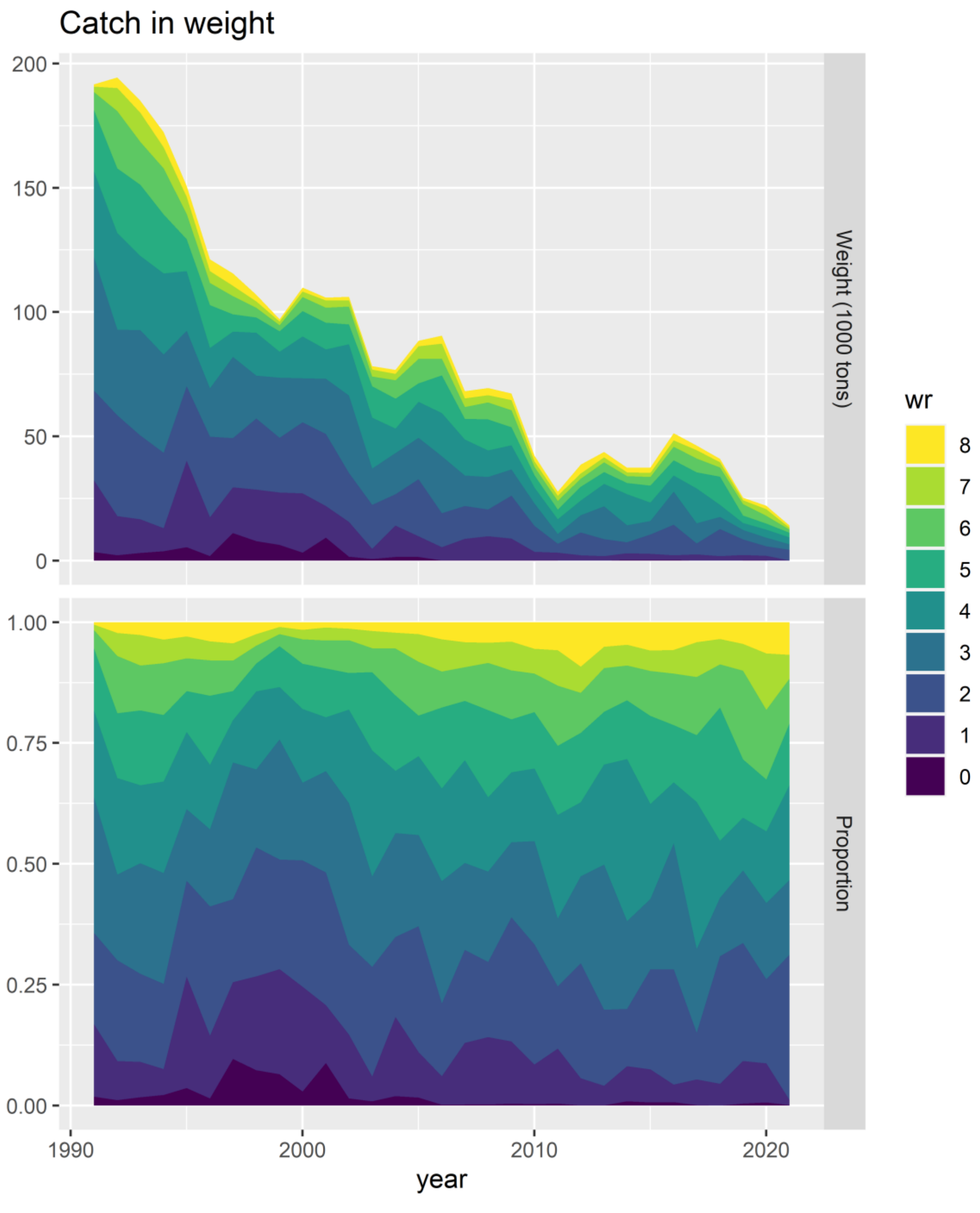


Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in weight. Upper panel: Catch in weight (1000 tons) at age as W-ringers (wr). Lower panel: Proportion (by weight) of a given age as W-ringers (wr) in the catch.

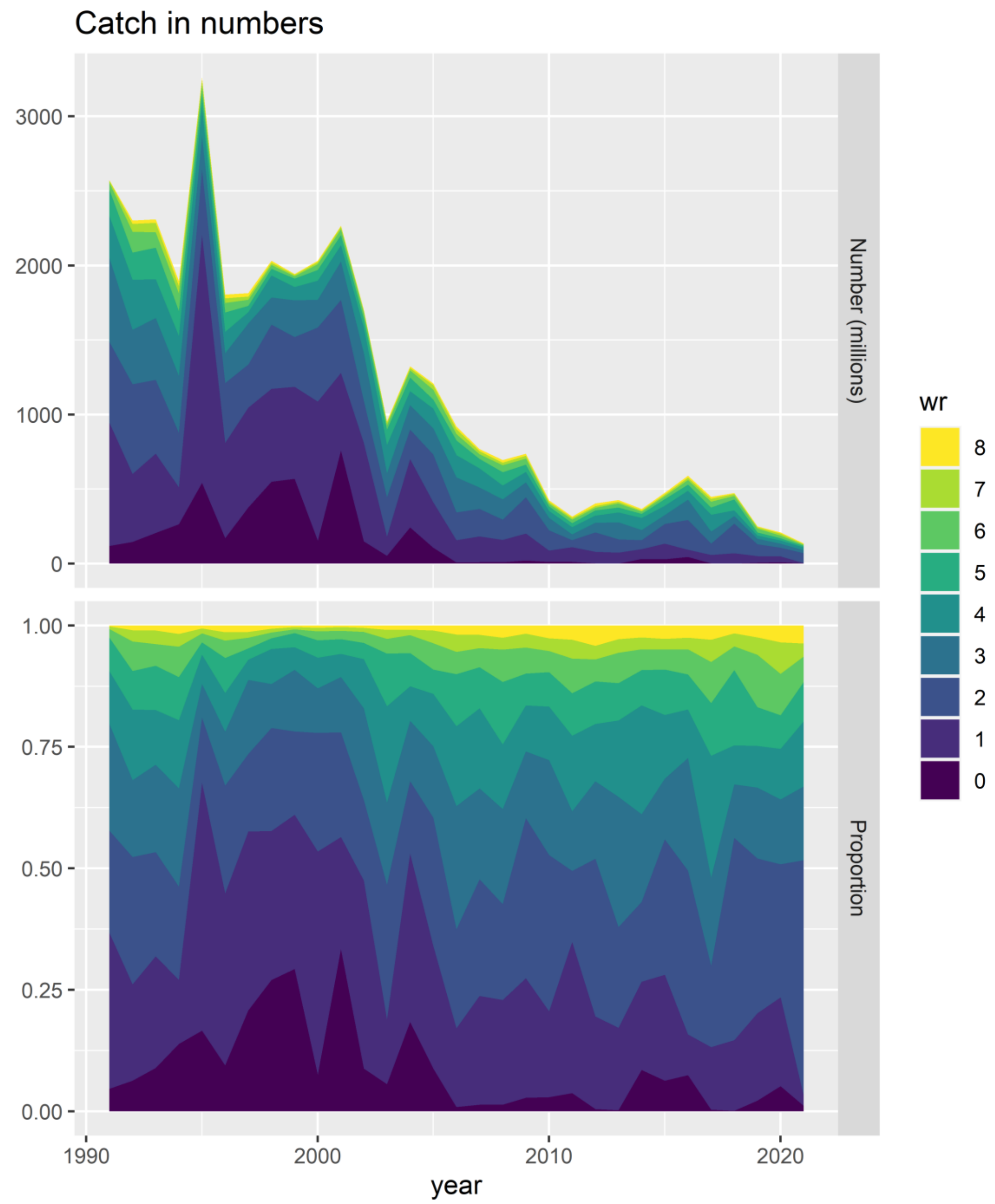


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in Numbers. Upper panel: Catch in numbers (millions) at age as W-ringers (wr). Lower panel: Proportion (by number) of a given age as W-ringers (wr) in the catch.

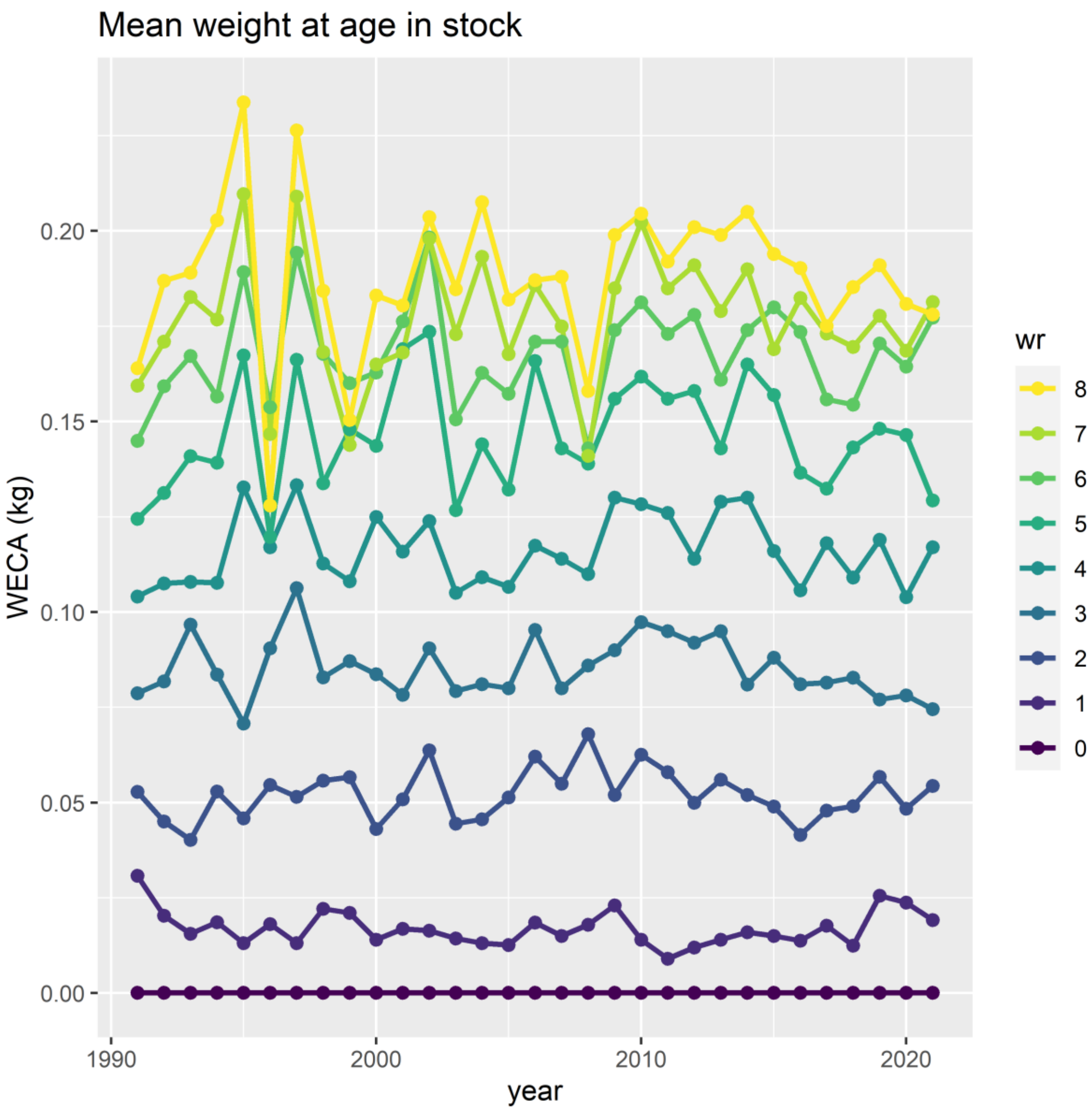


Figure 3.6.1.4 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the stock (WEST).

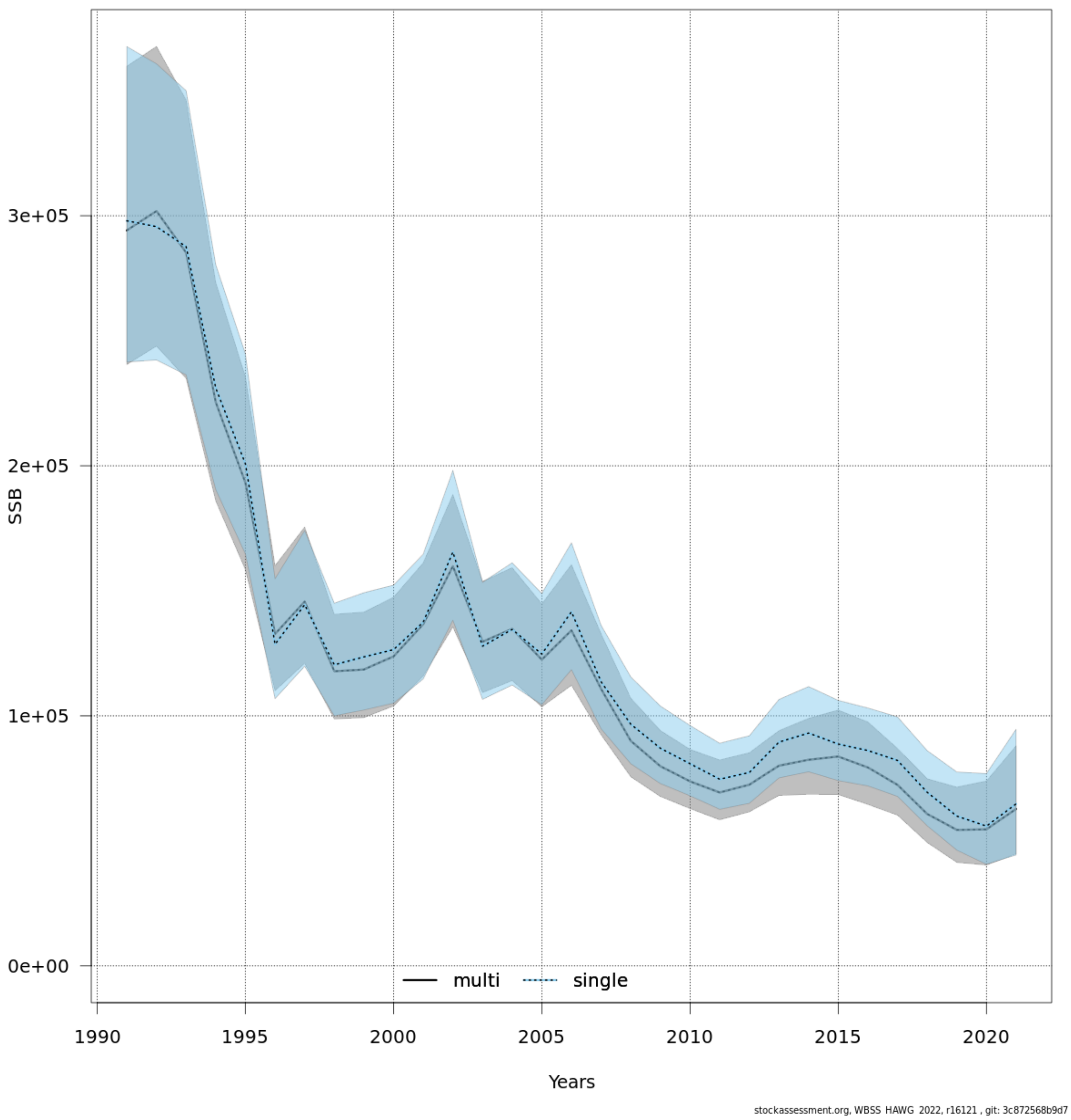


Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Spawning stock biomass (SSB). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

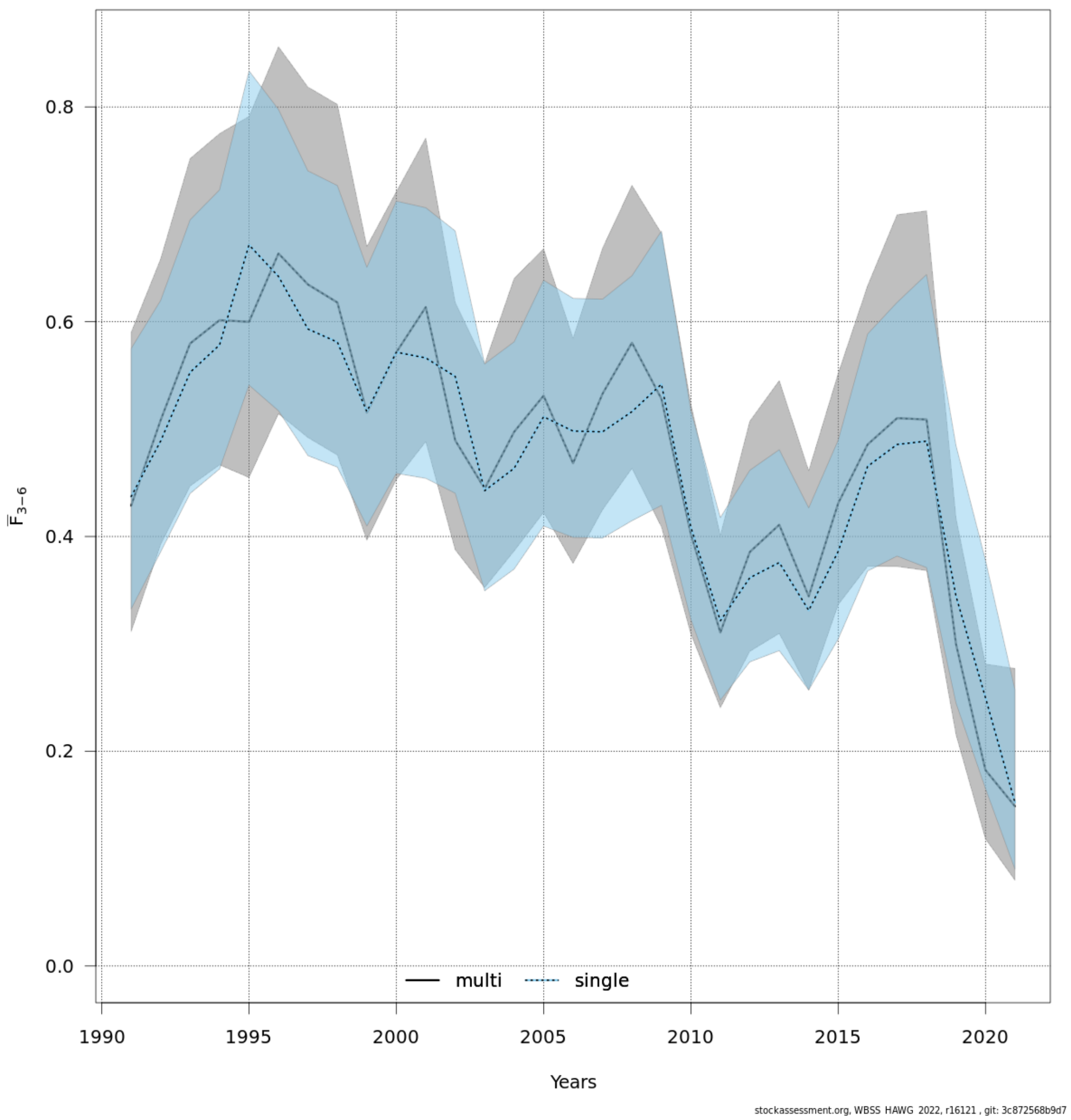


Figure 3.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Average fishing mortality (F) for the shown age range. Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

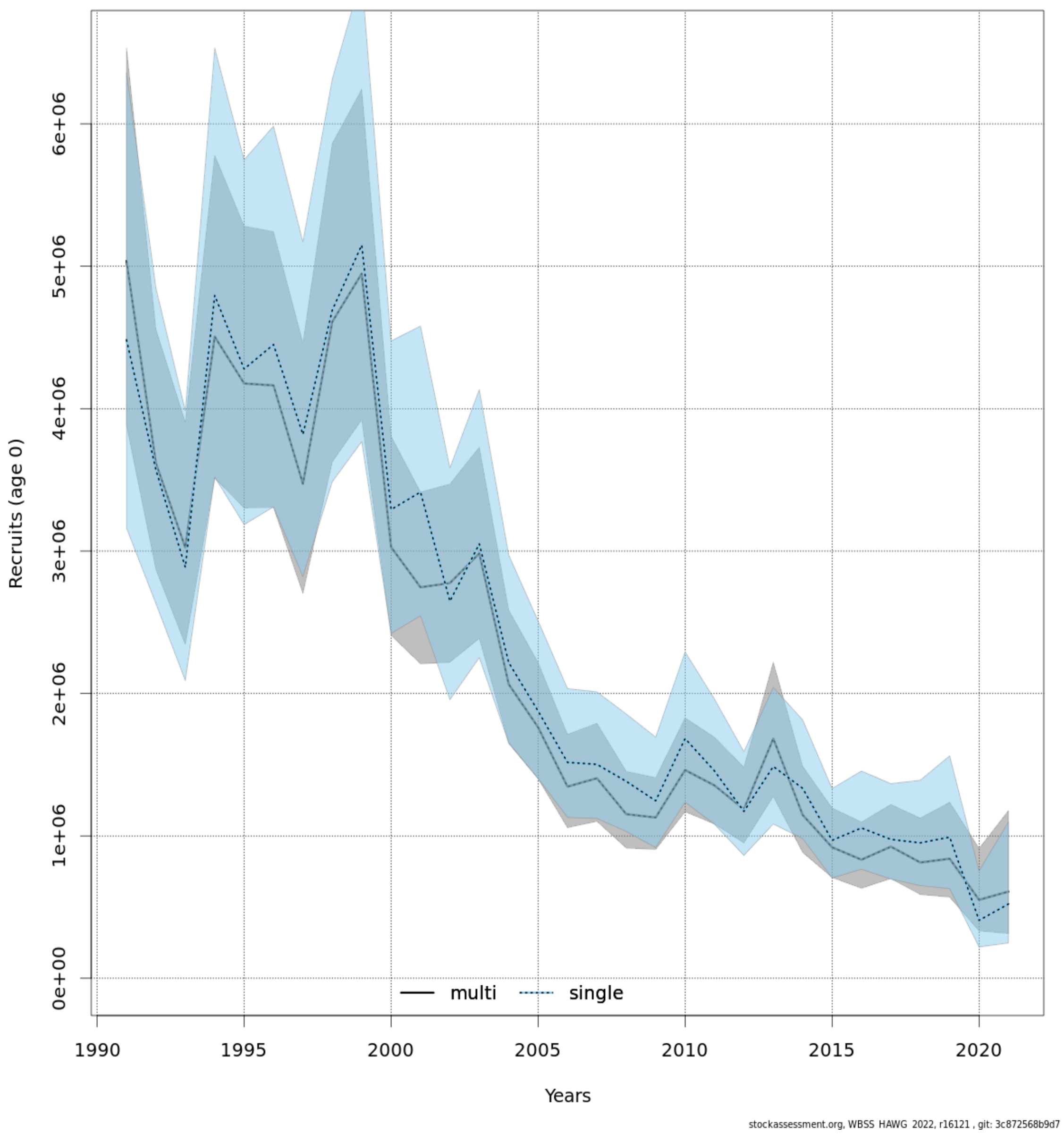


Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

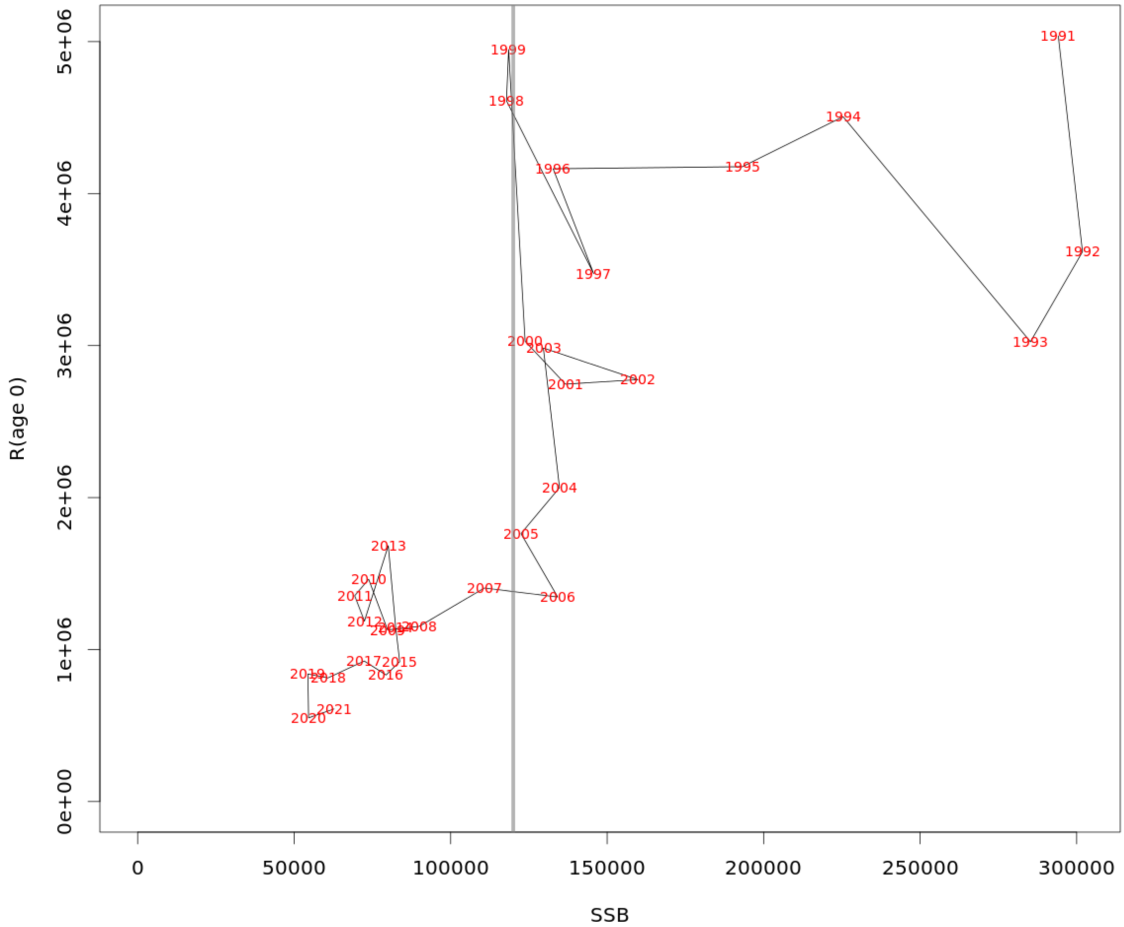


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

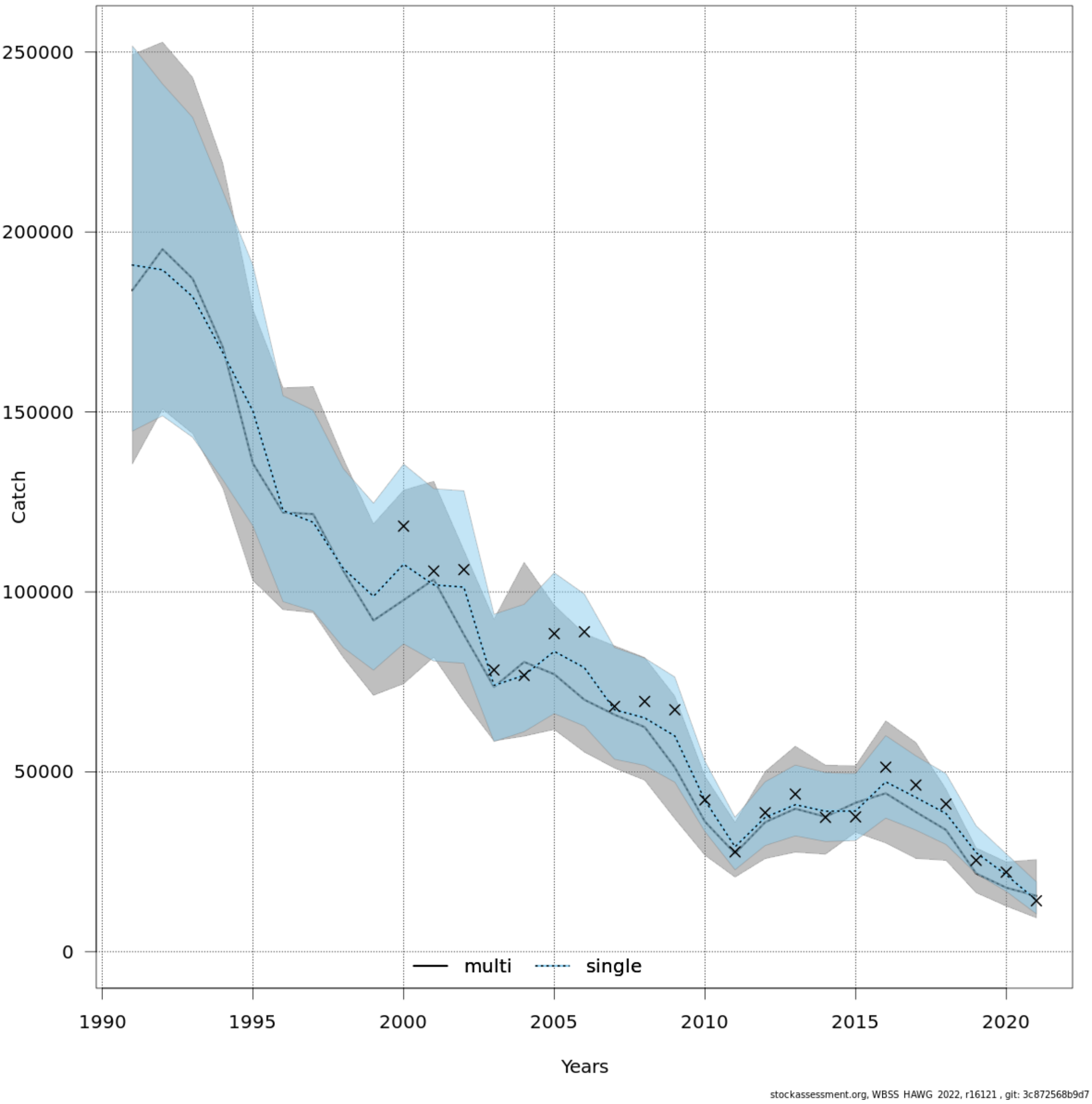


Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tonnes). Prediction from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area. The yearly observed total catch weight (crosses)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

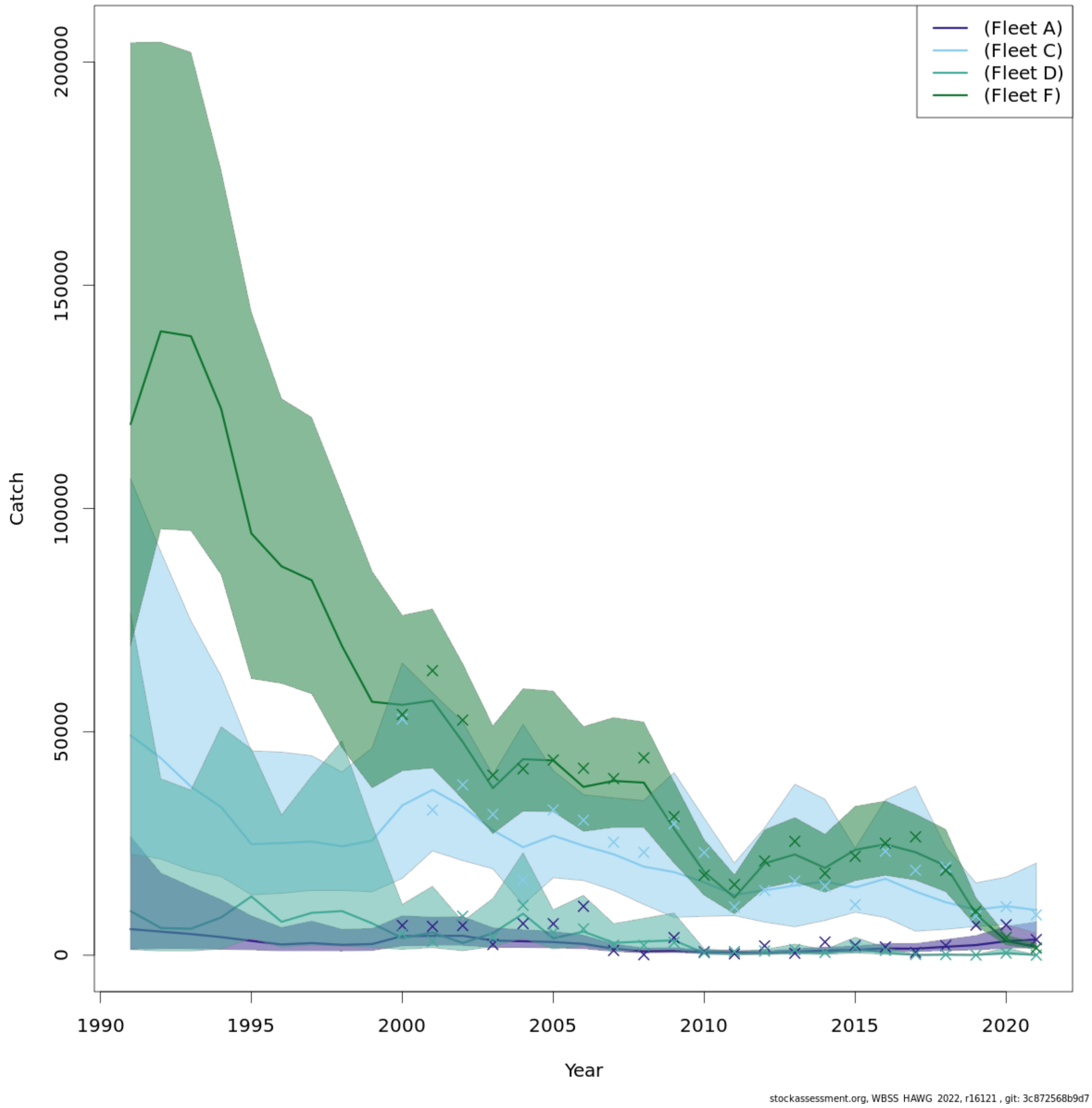


Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tonnes) by fleet. Prediction from the WBSS multi fleet assessment run and point wise 95% confidence intervals are shown by line and shaded area. The plot also shows the observed total catch weight per fleet (crosses).

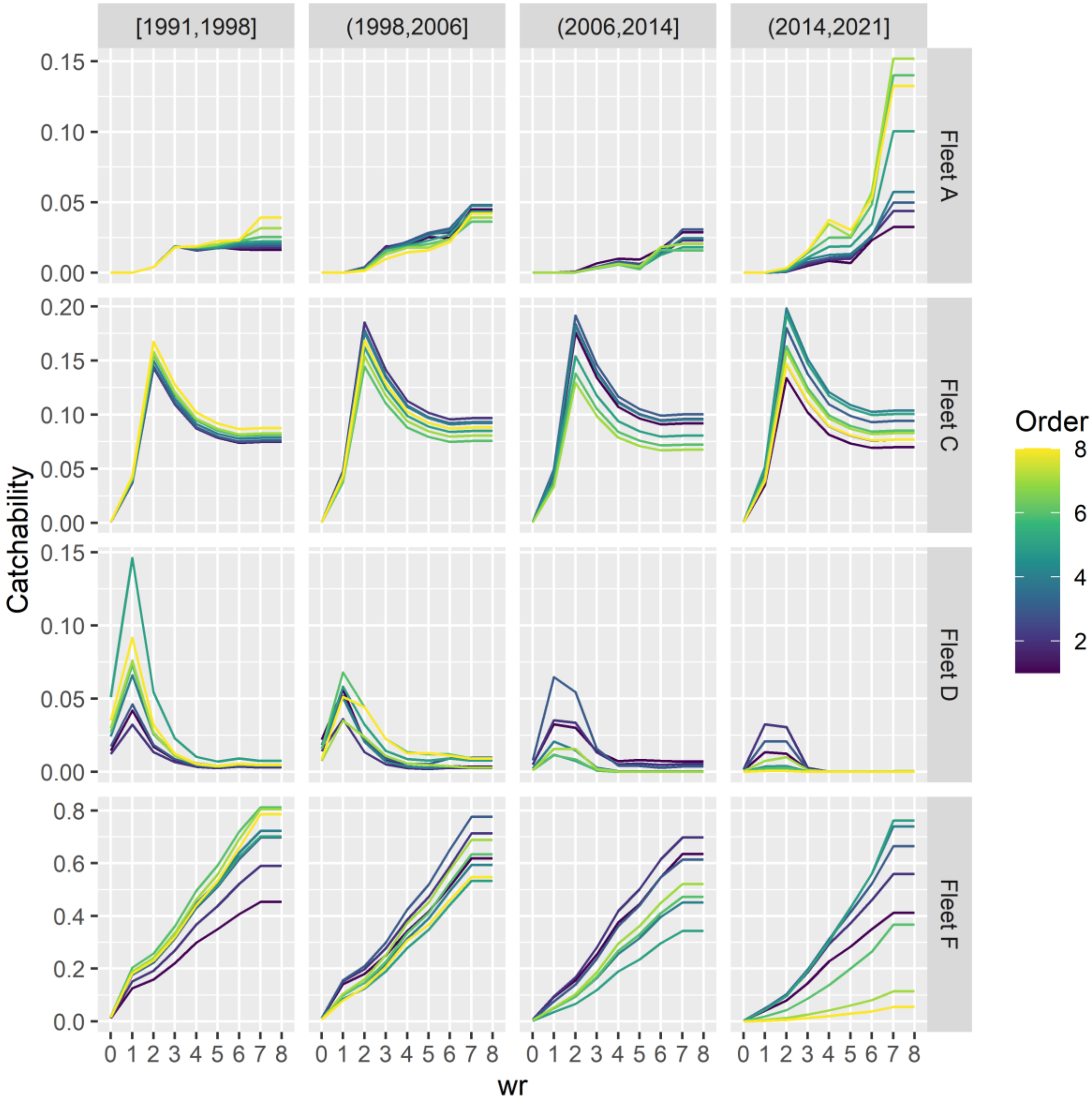


Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated selection pattern at age as W-ringers (wr) per fleet and year. Order: 1 equal 1st year in the respective time span.

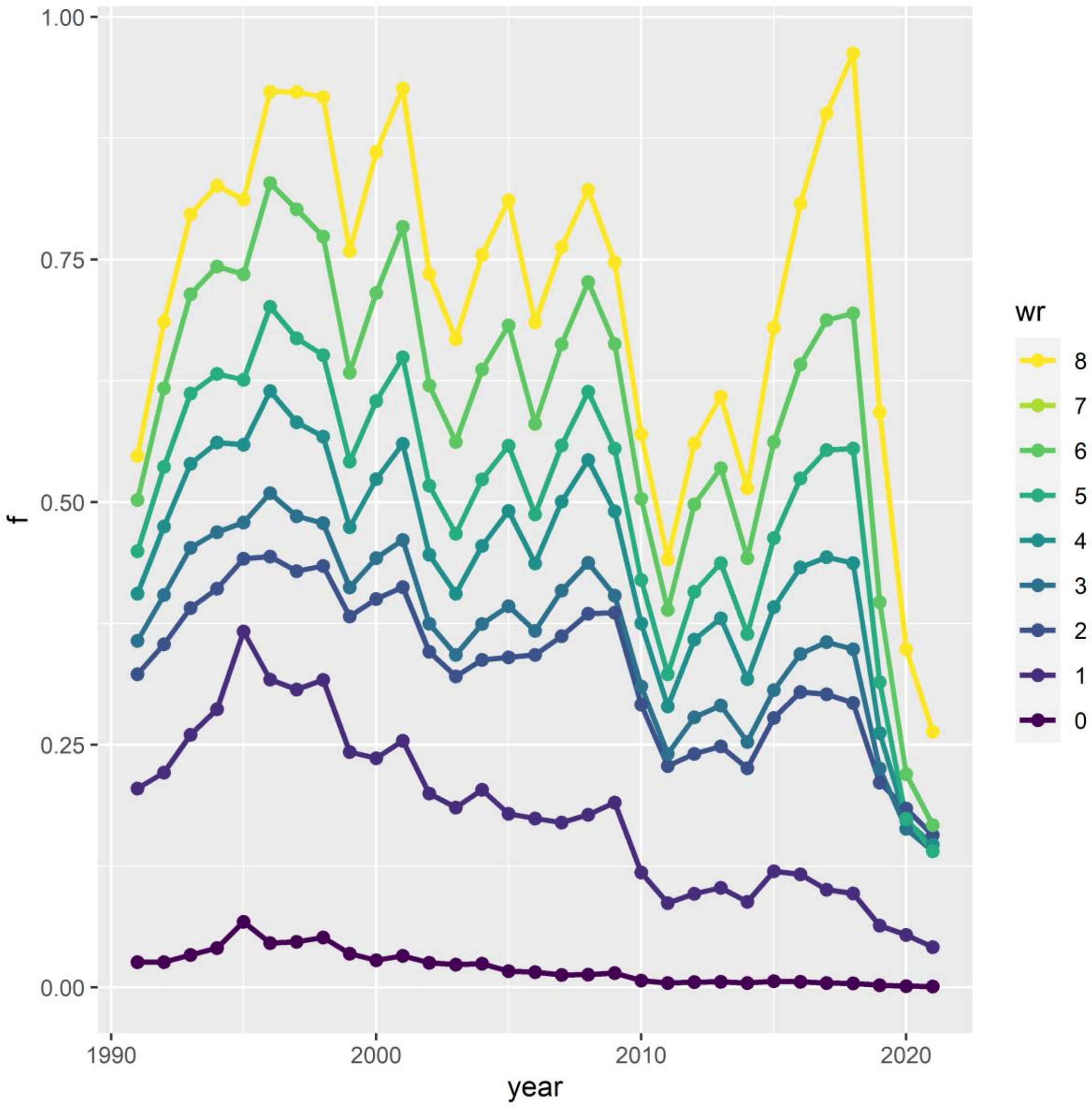


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr).

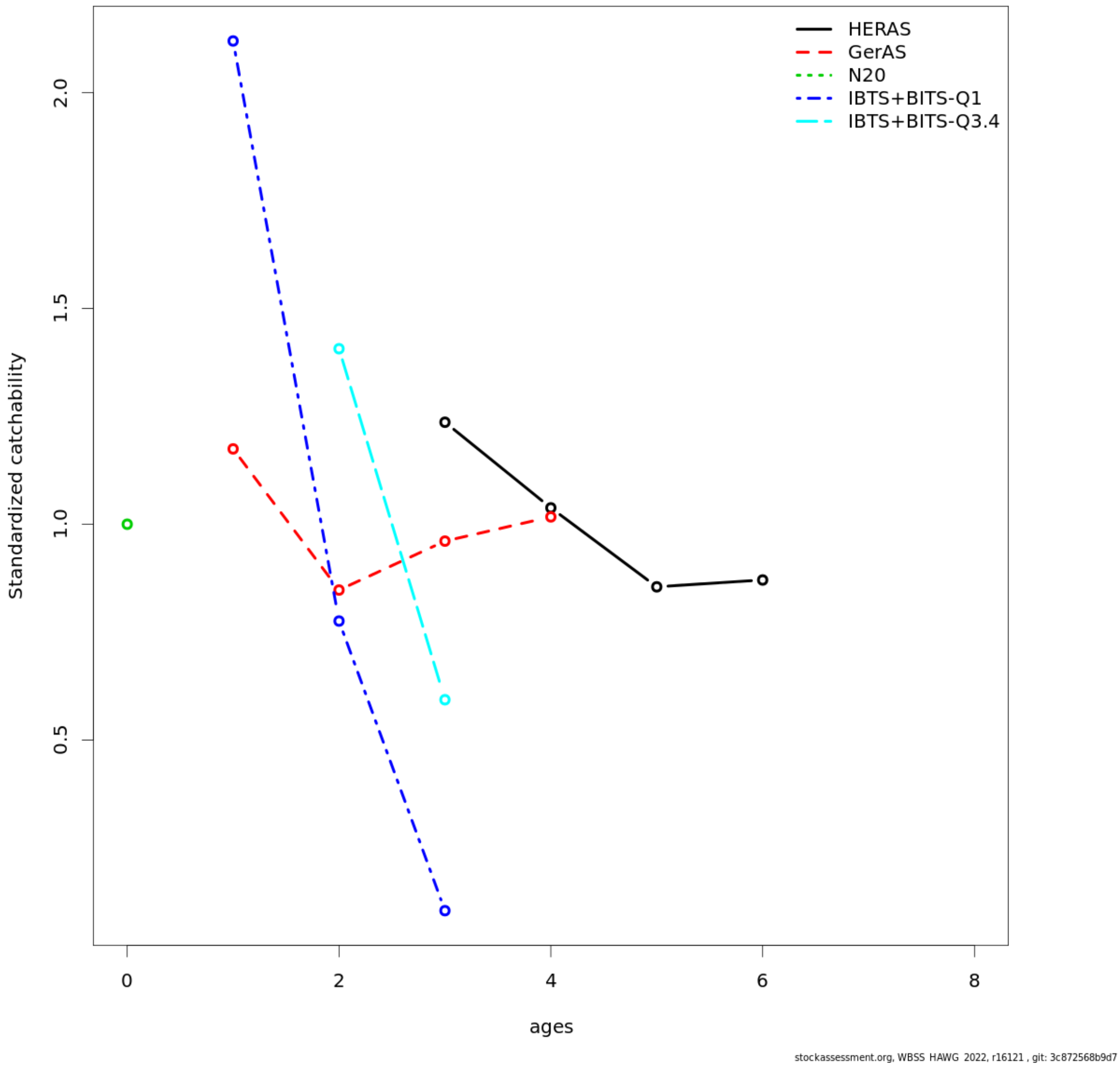


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Estimated survey catchabilities. N20 only covers age 0 (wr) and therefore only shows one point.

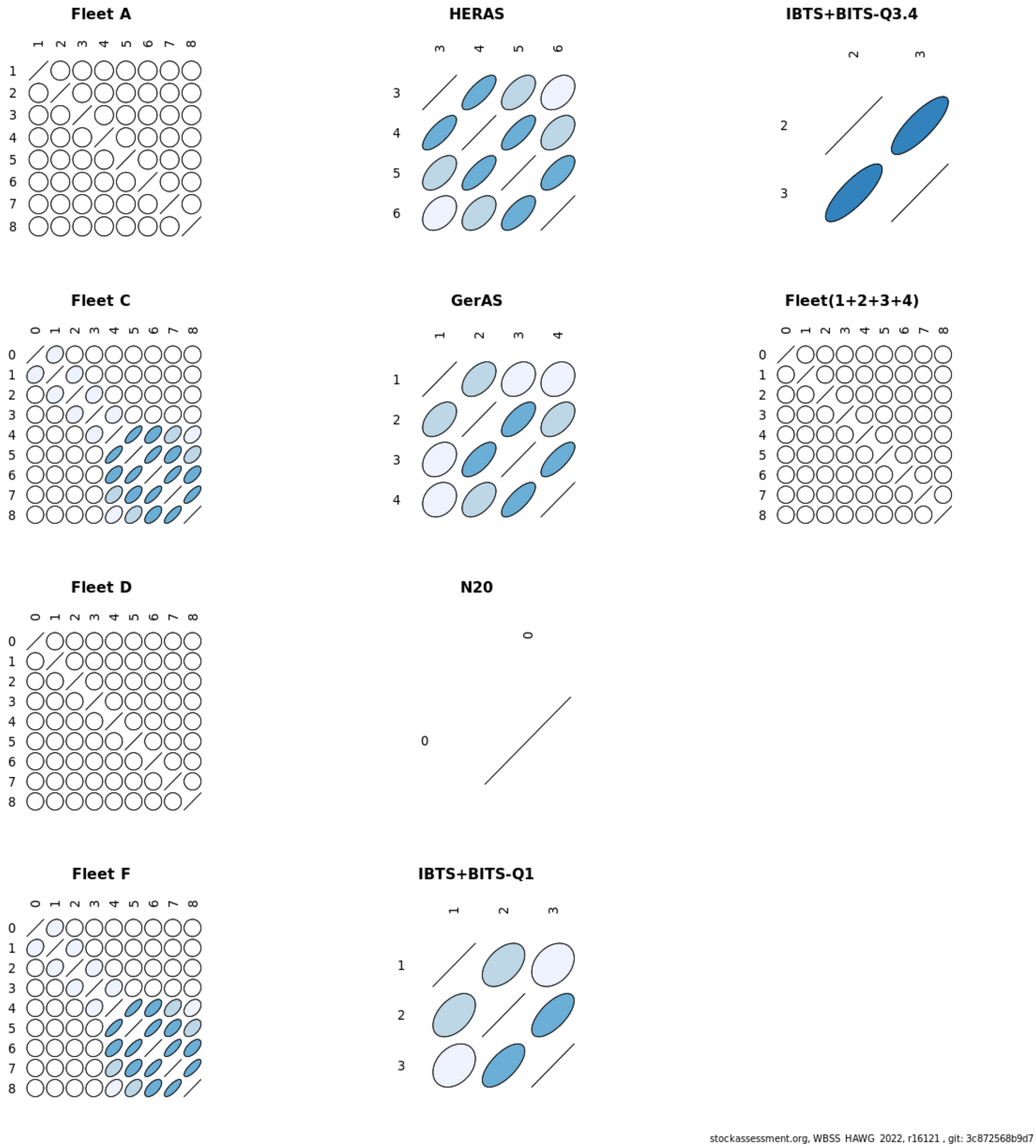


Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. Estimates correlations between age groups (wr) for each fleet.

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

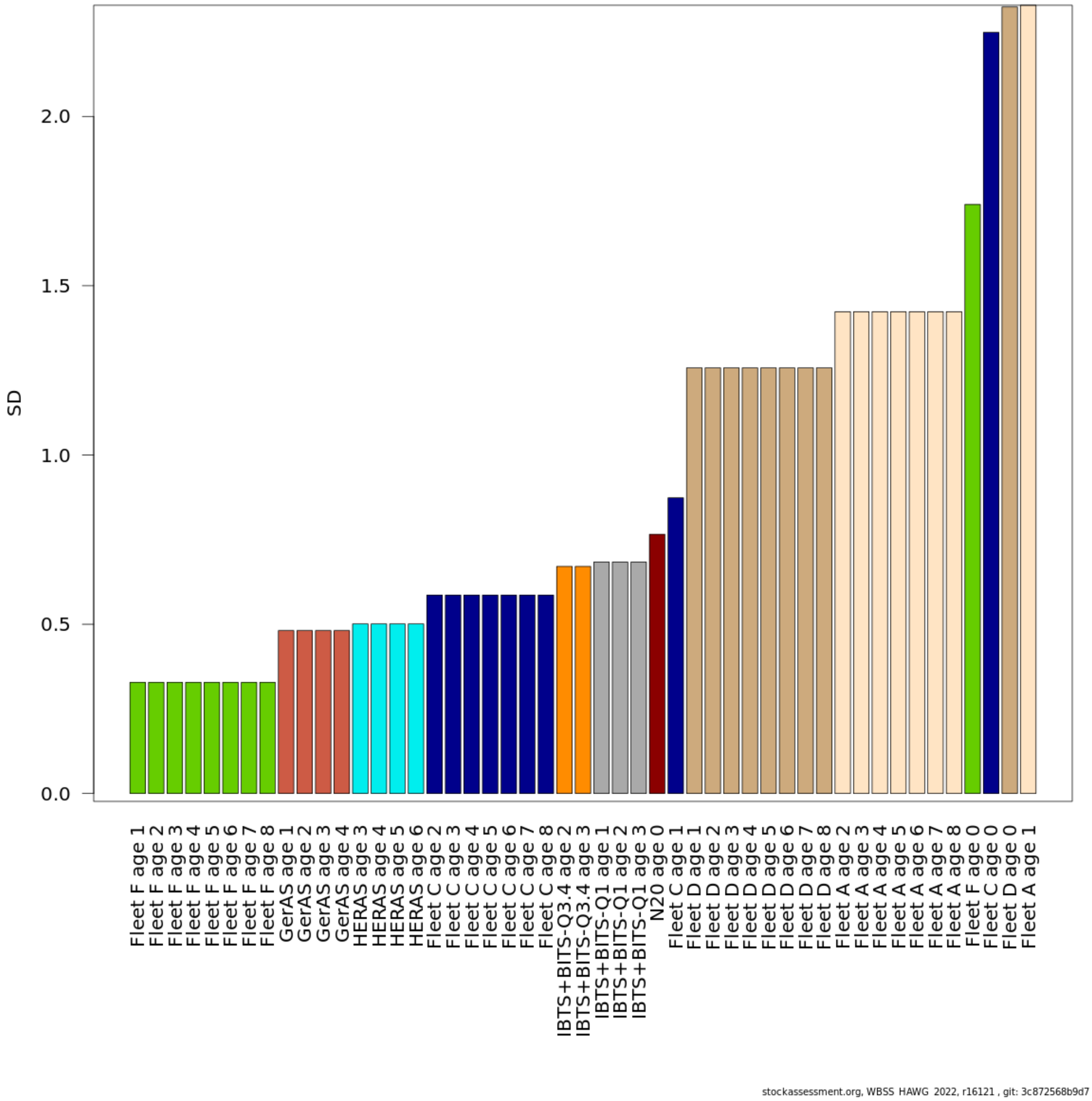


Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated observation variance in the WBSS multi fleet assessment run.

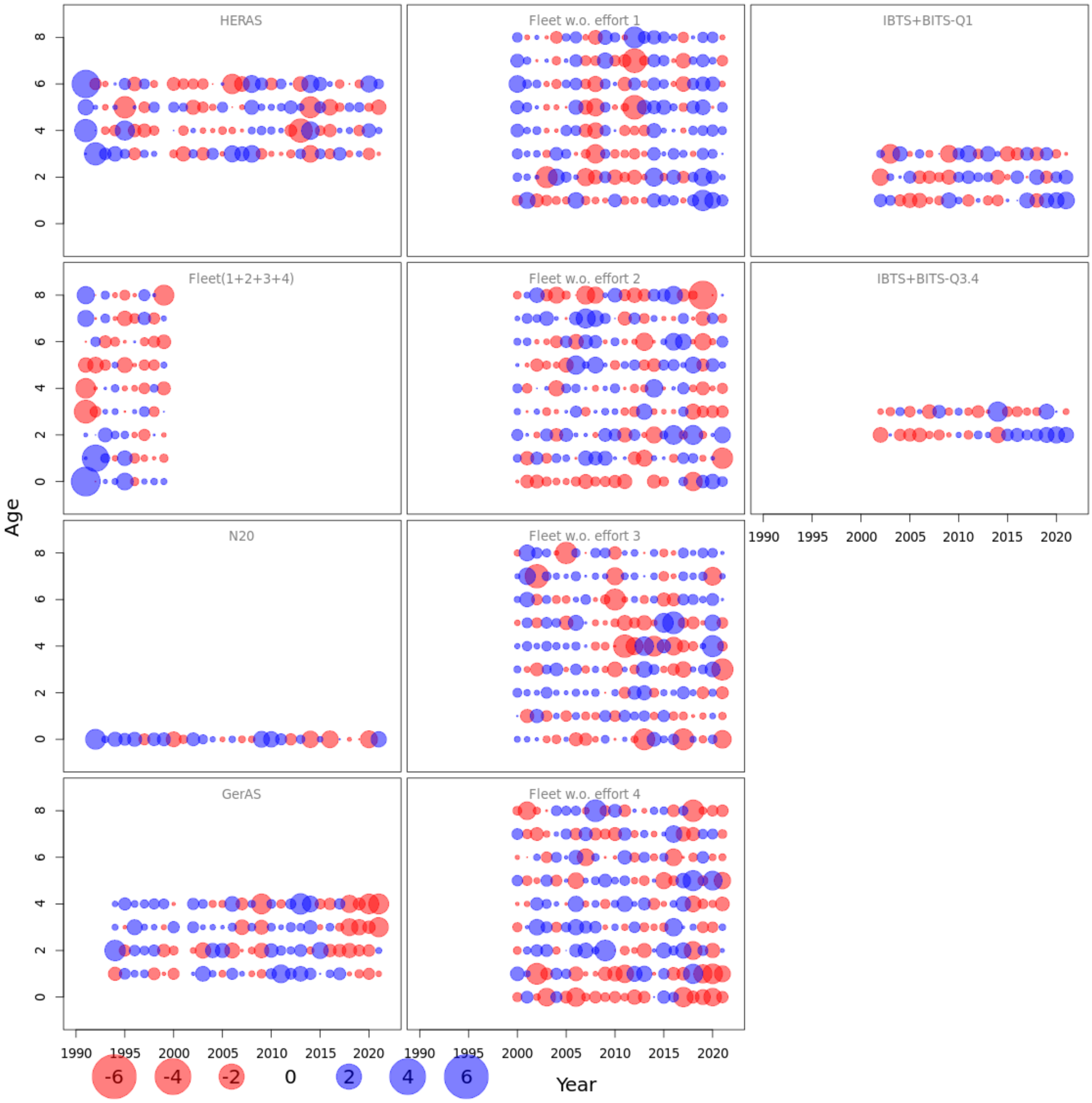


Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. BUBBLE PLOT. Standardized one-observation-ahead residuals from multi fleet run.

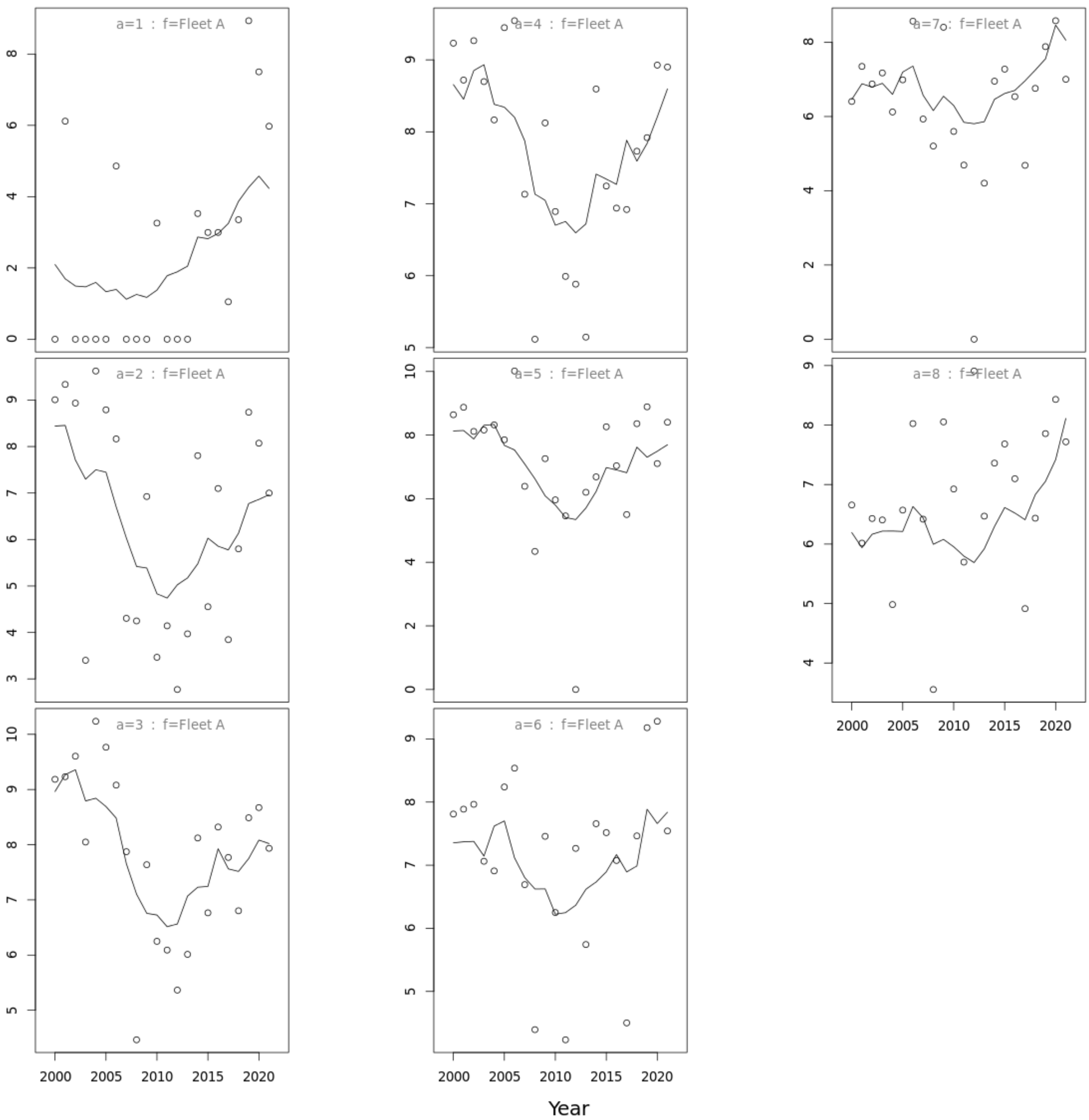


Figure 3.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet A. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

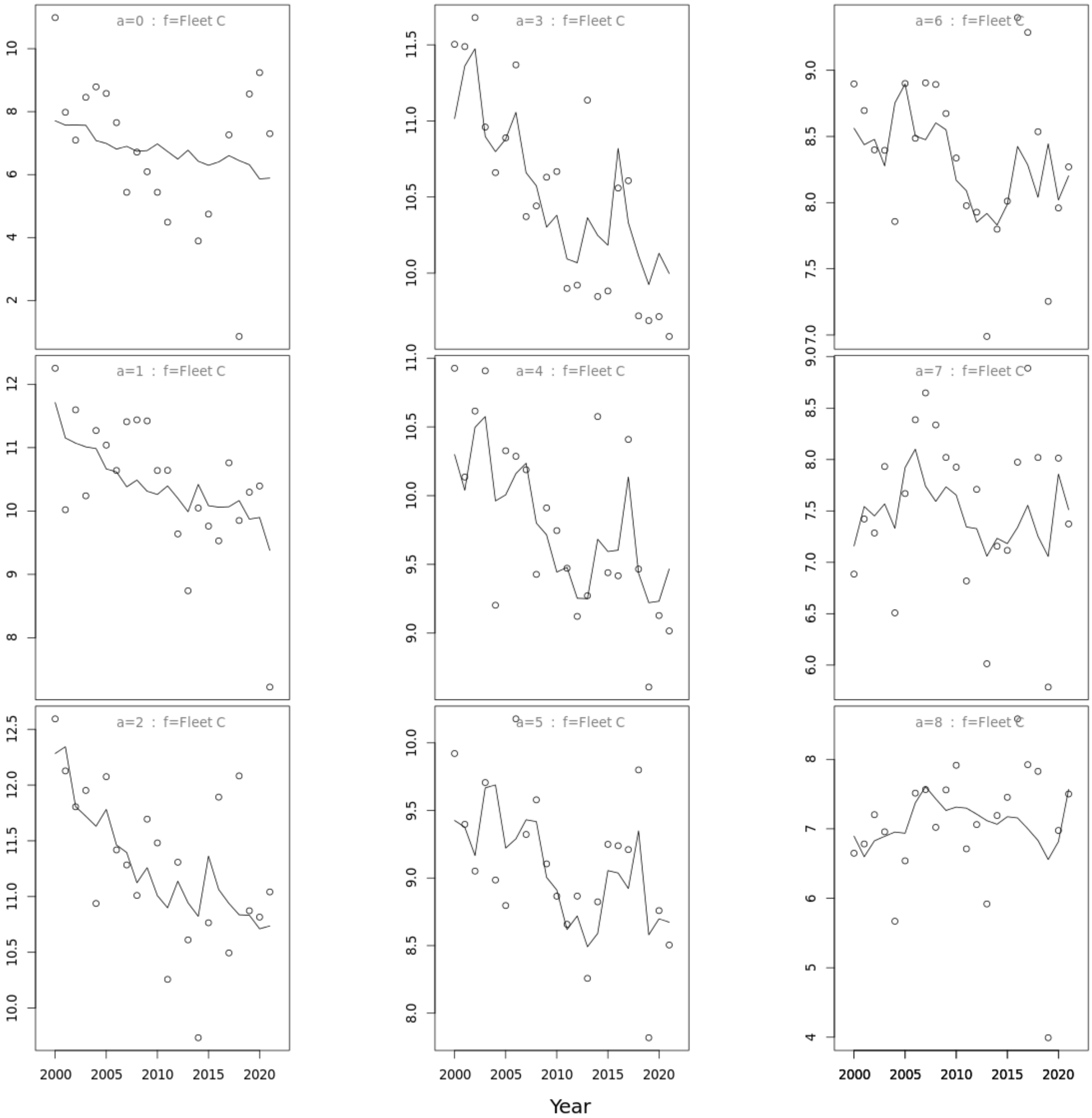


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

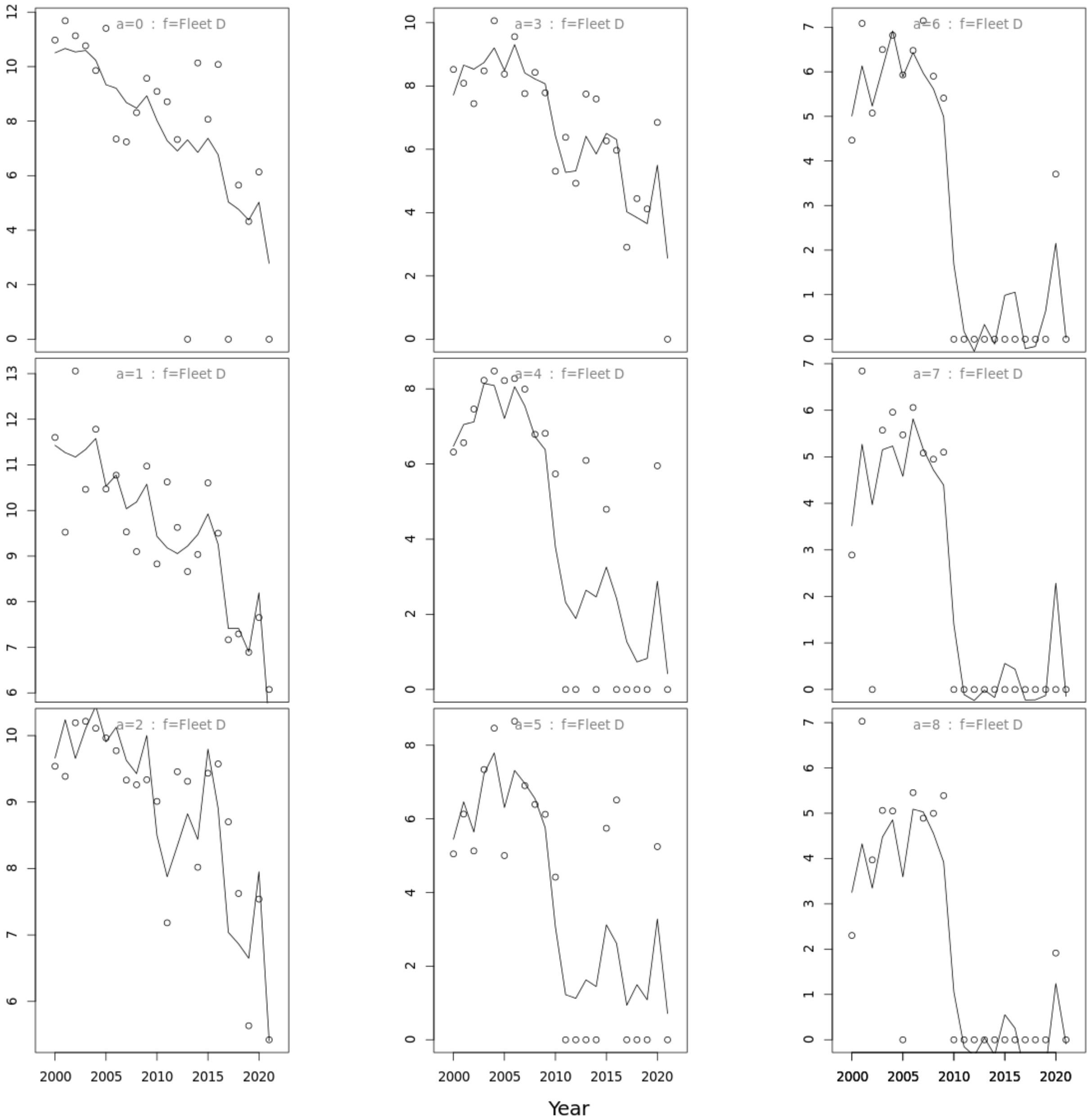


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

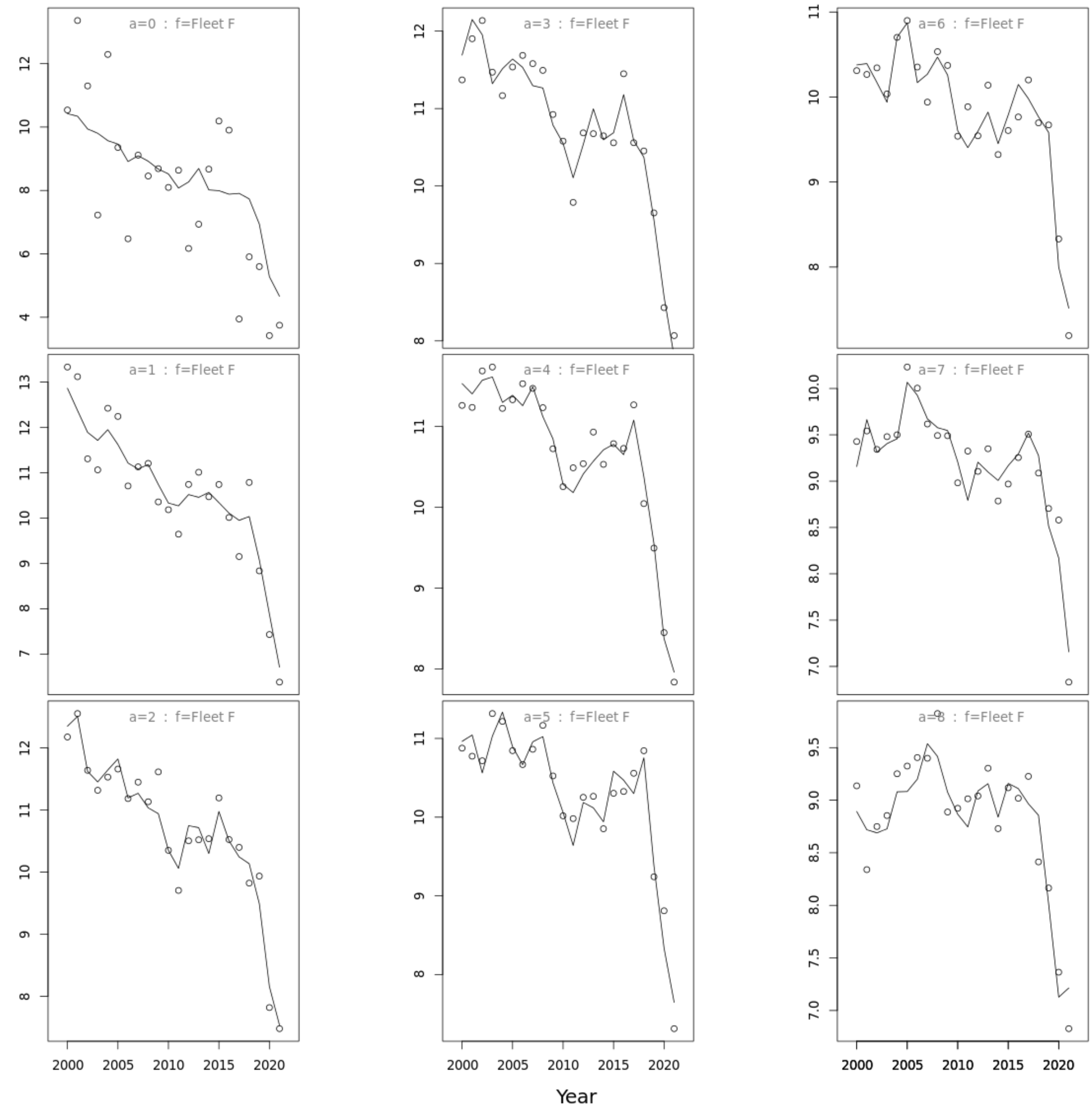


Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet F. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

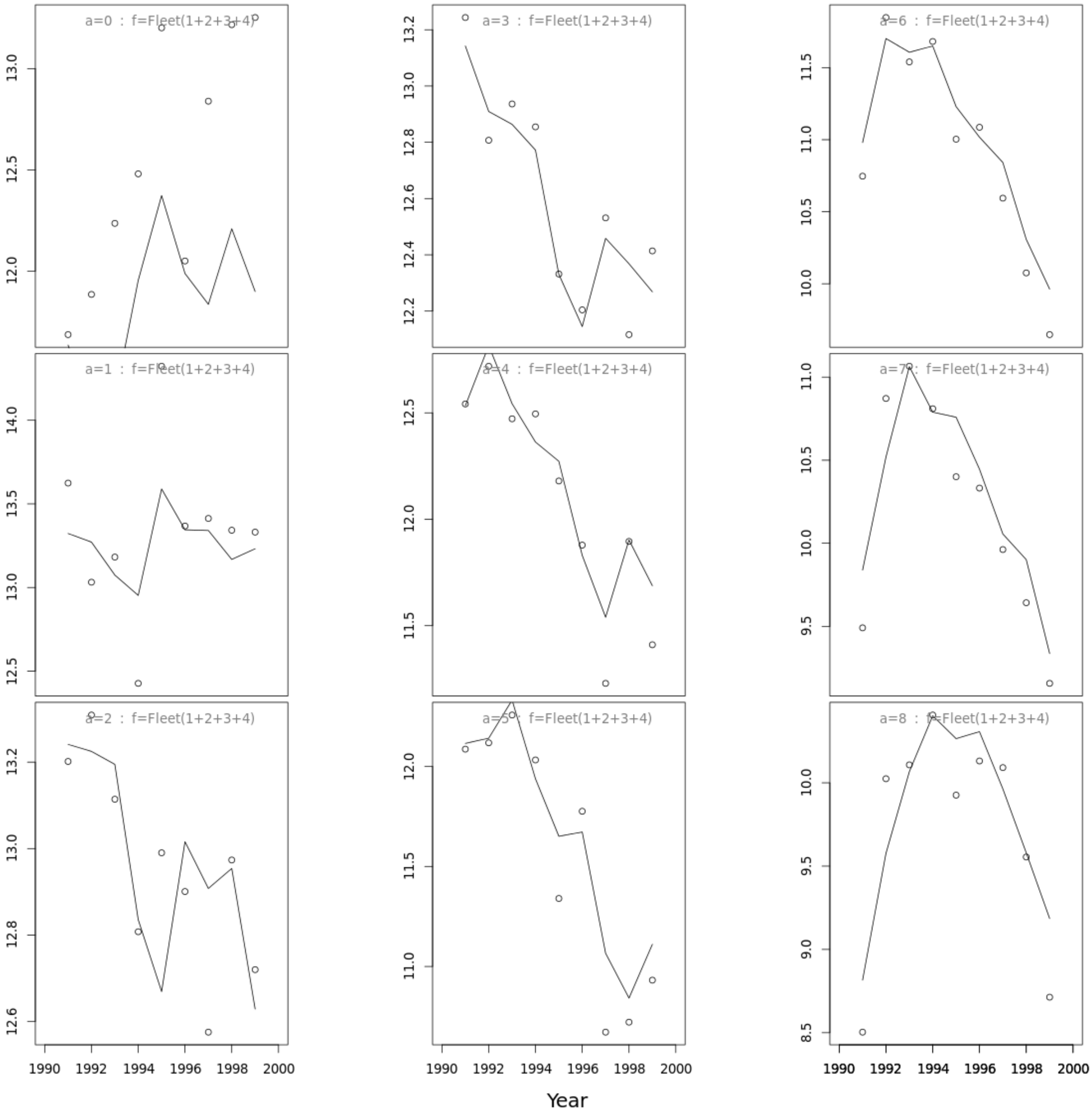


Figure 3.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. sum of fleets Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

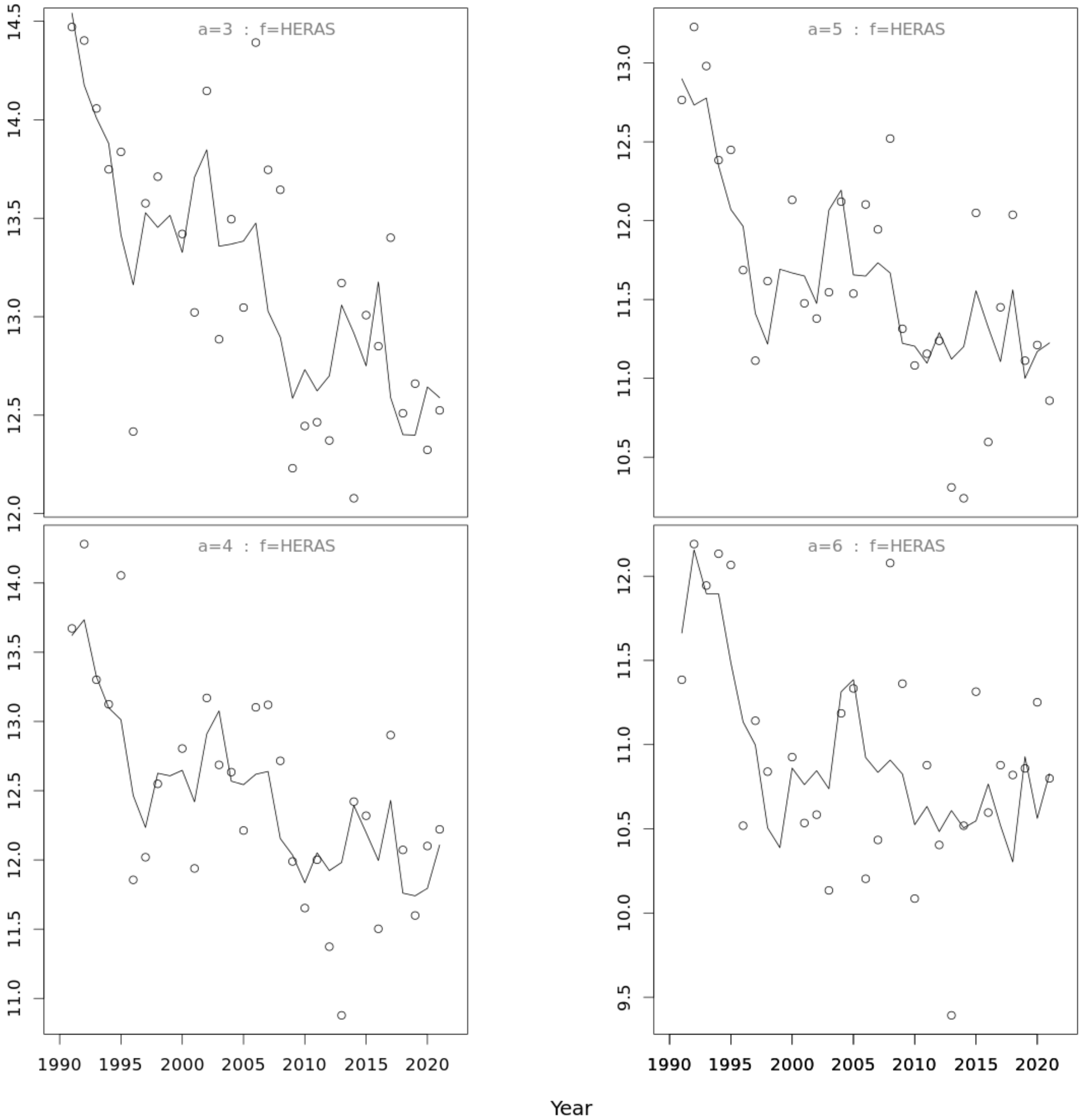


Figure 3.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the HERAS index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

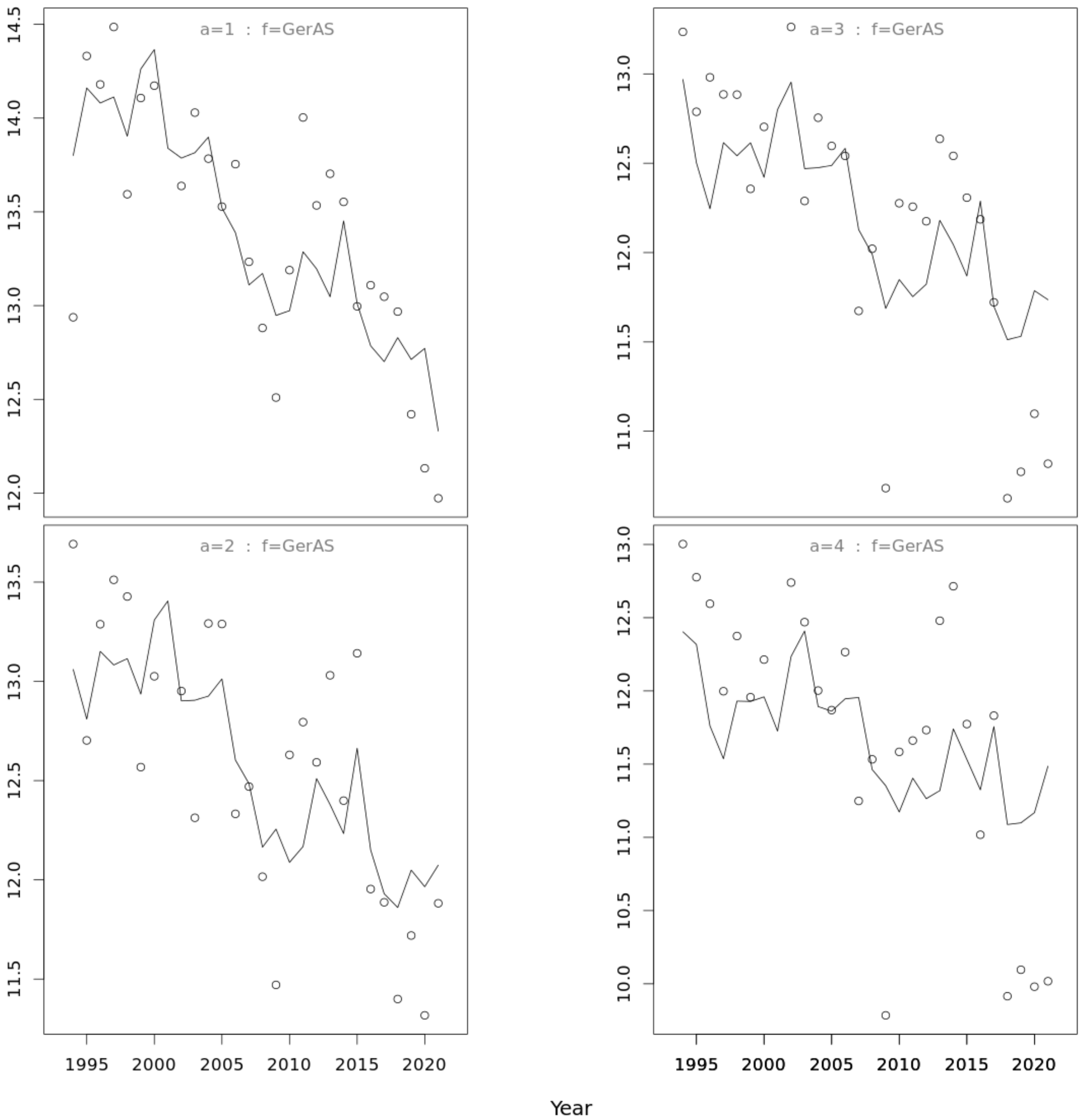


Figure 3.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the GERAS-index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

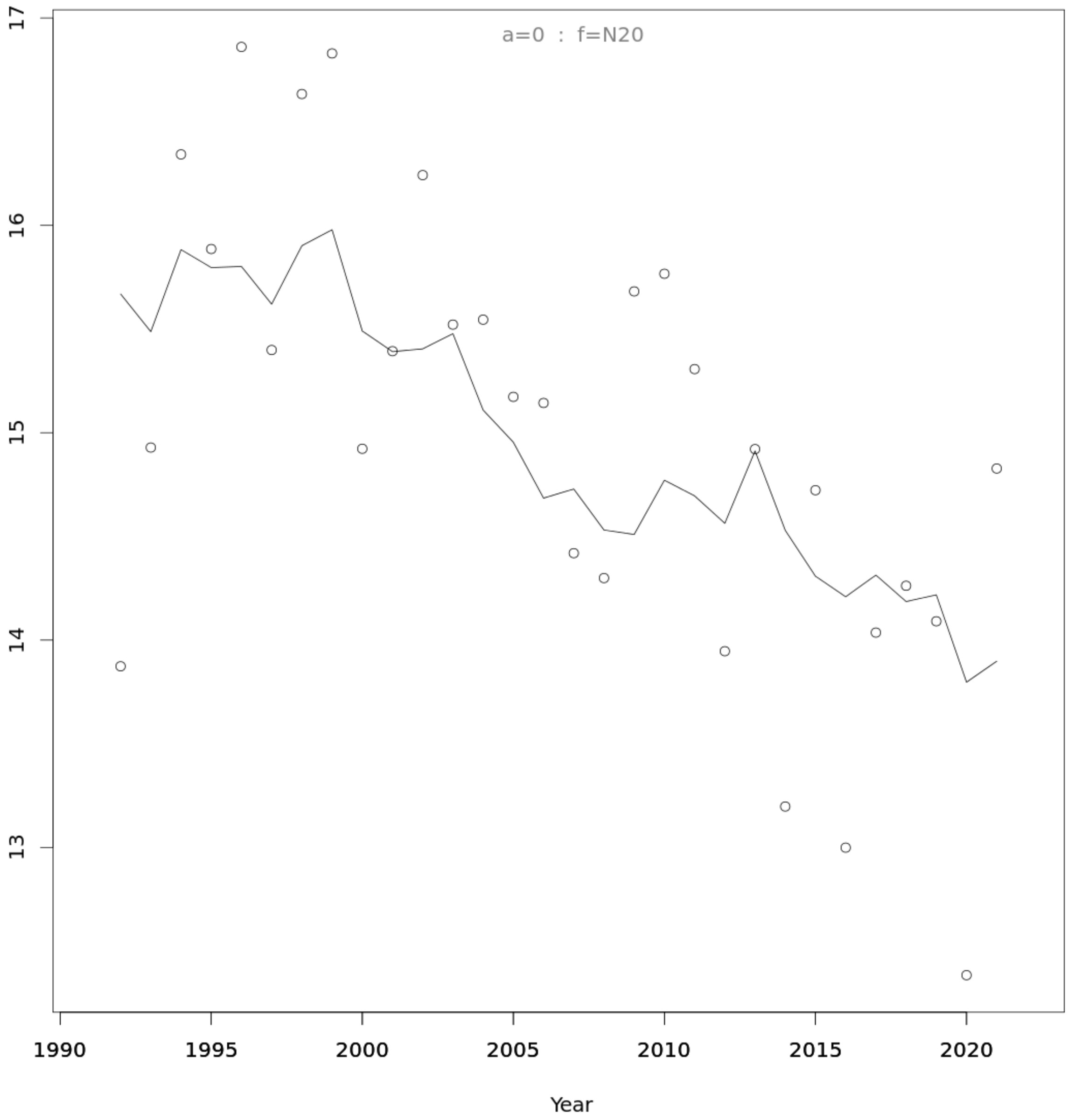


Figure 3.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the N20 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

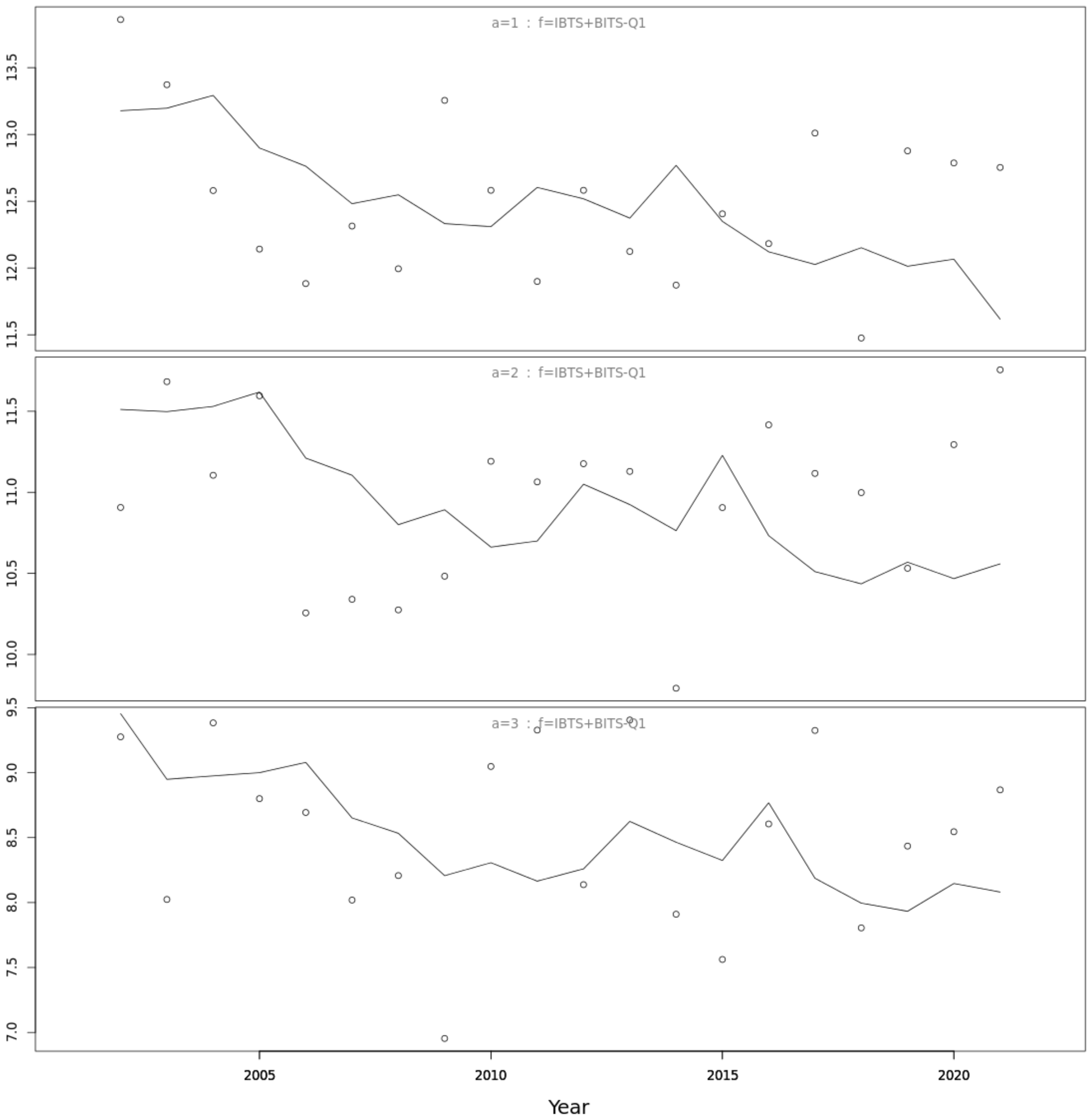


Figure 3.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q1 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

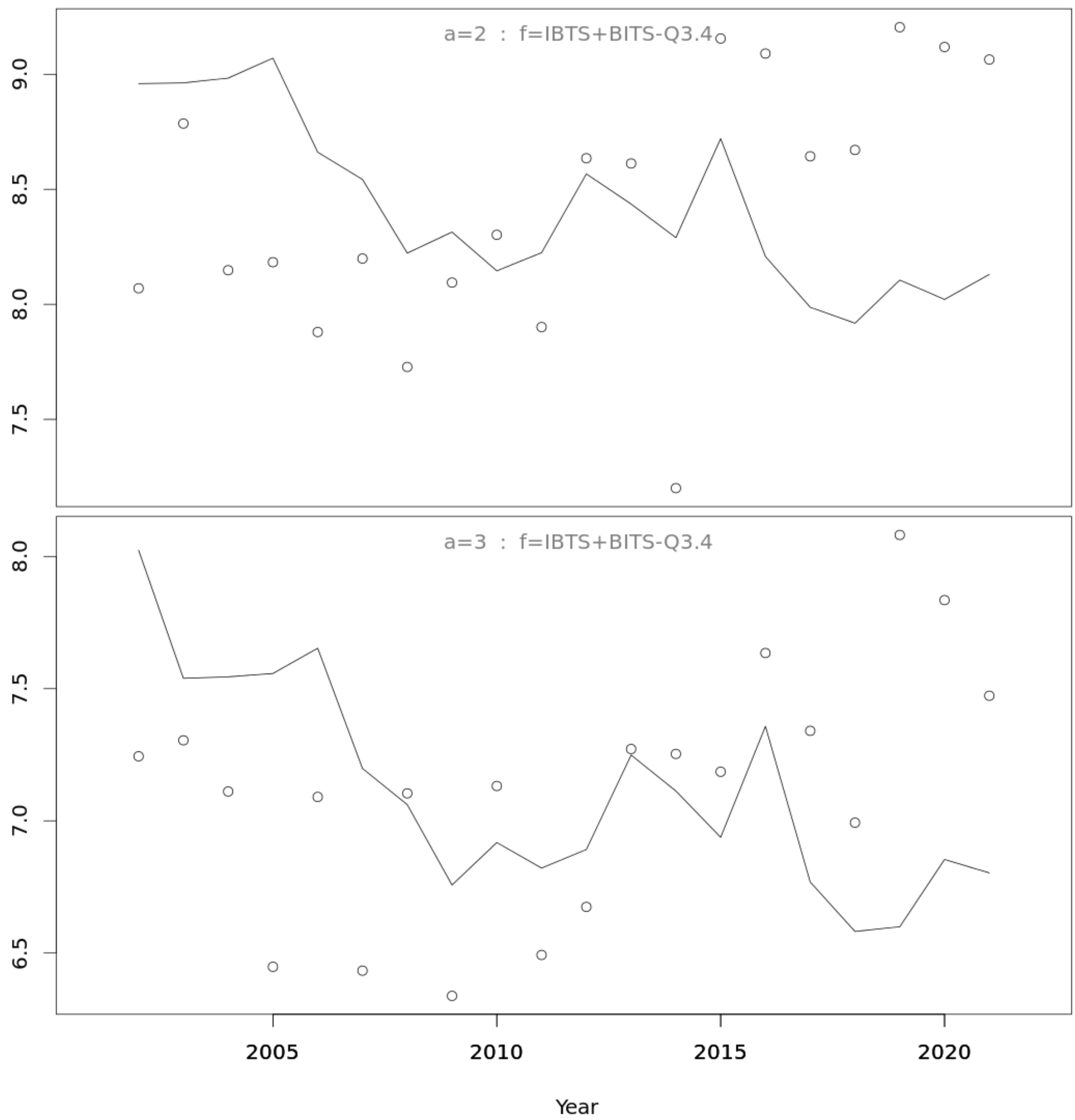


Figure 3.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q3.4 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

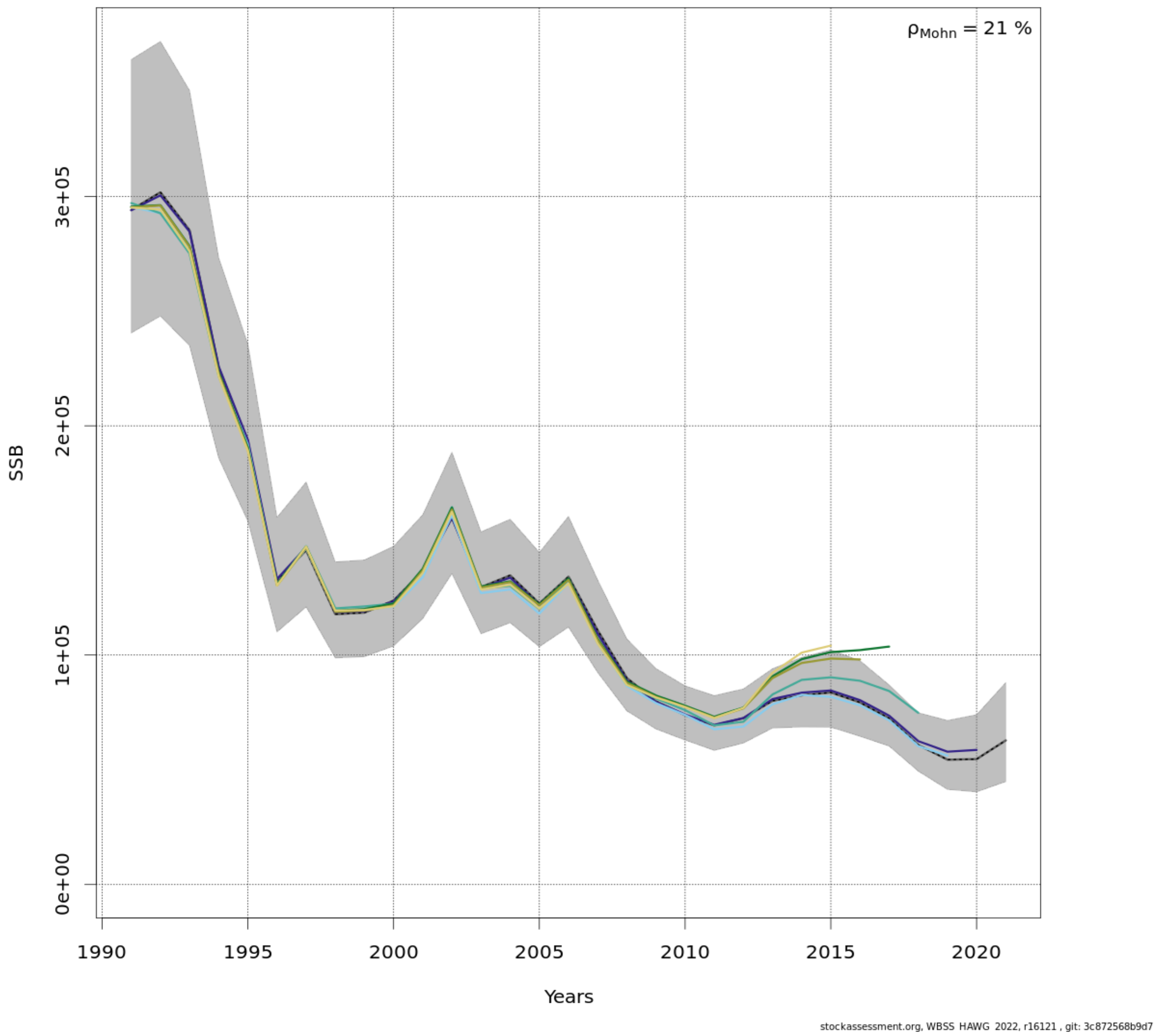


Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Spawning stock biomass.

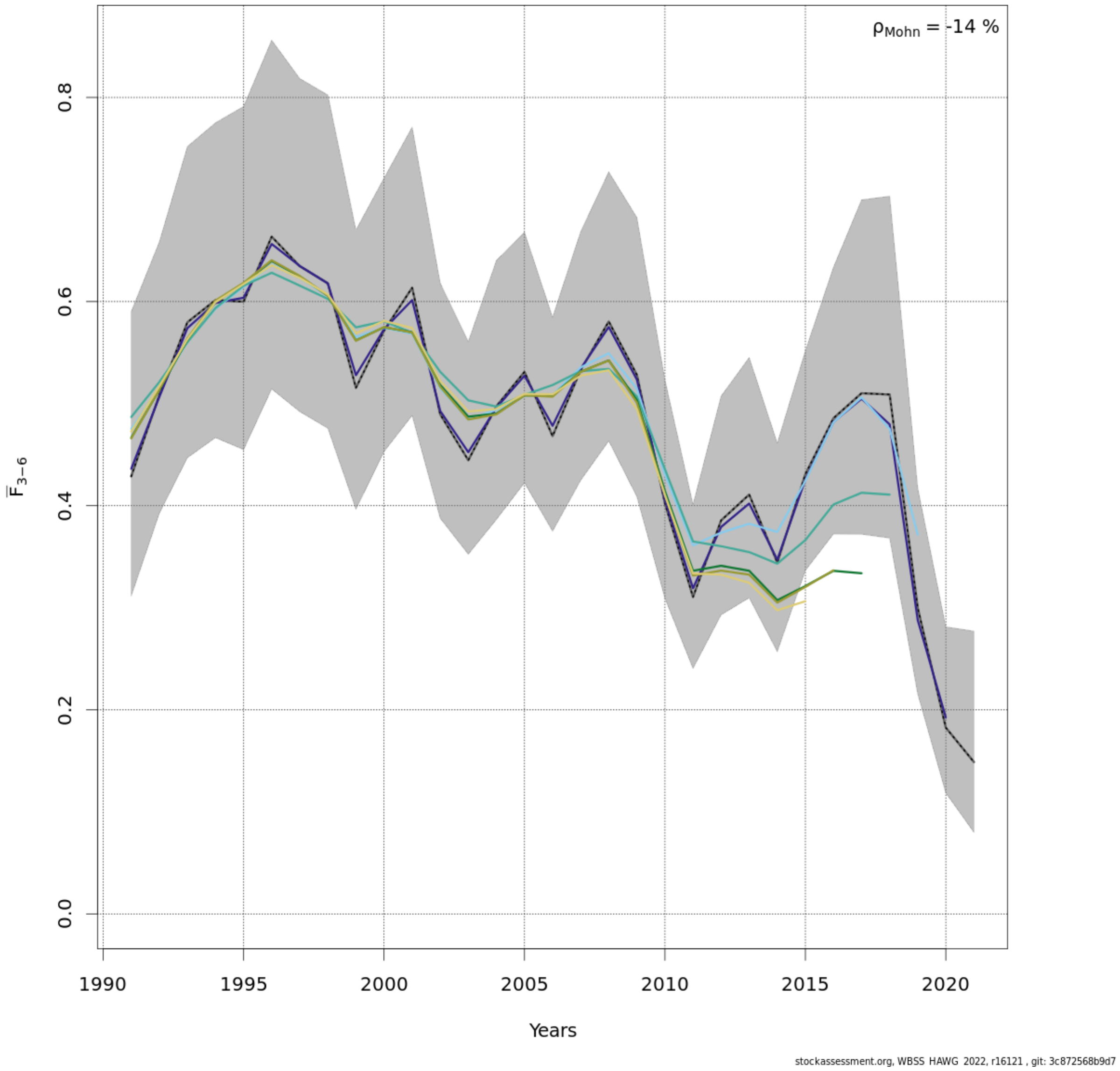


Figure 3.6.4.25 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Average fishing mortality for the shown age range.

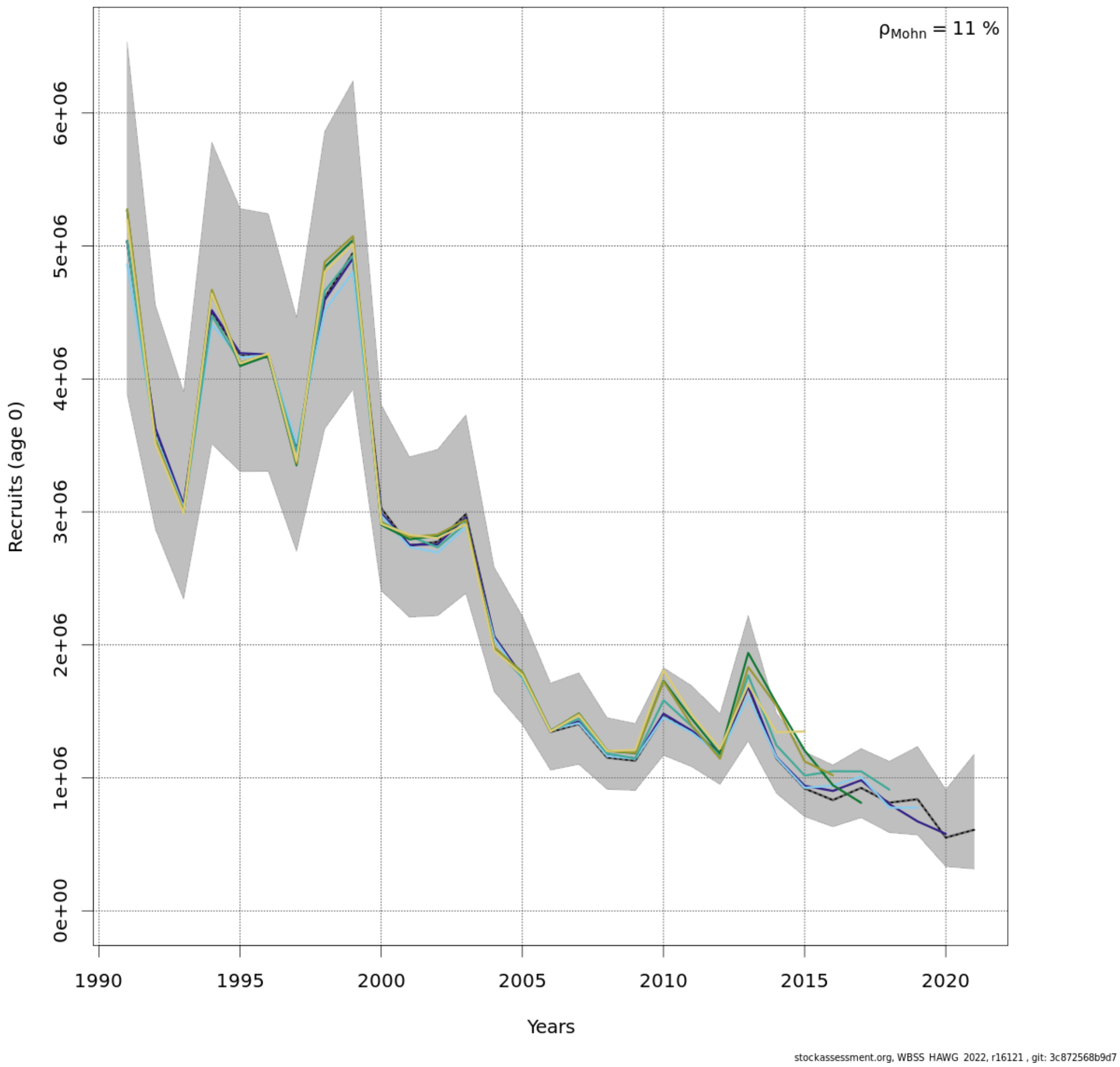


Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

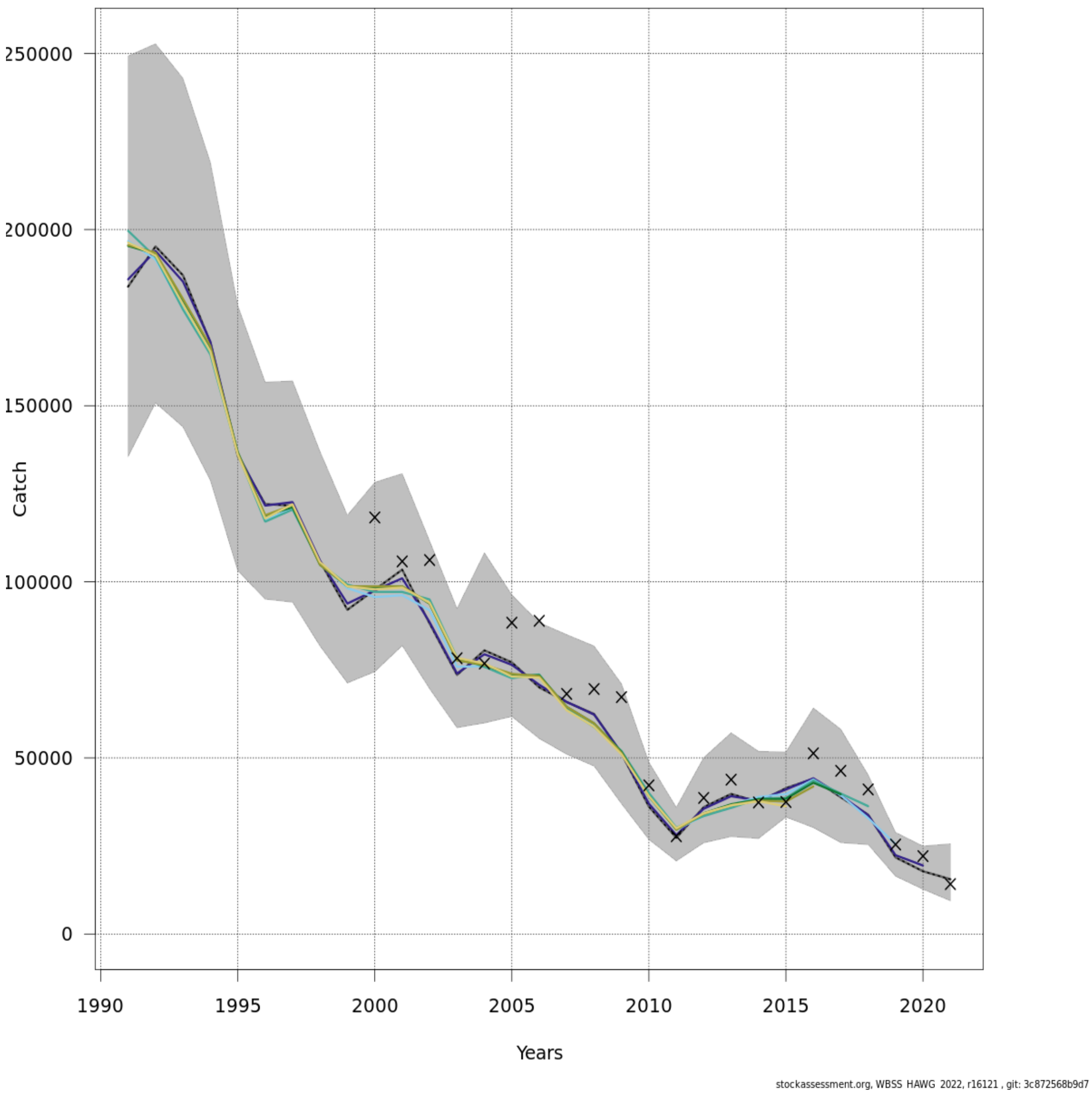


Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Catch.

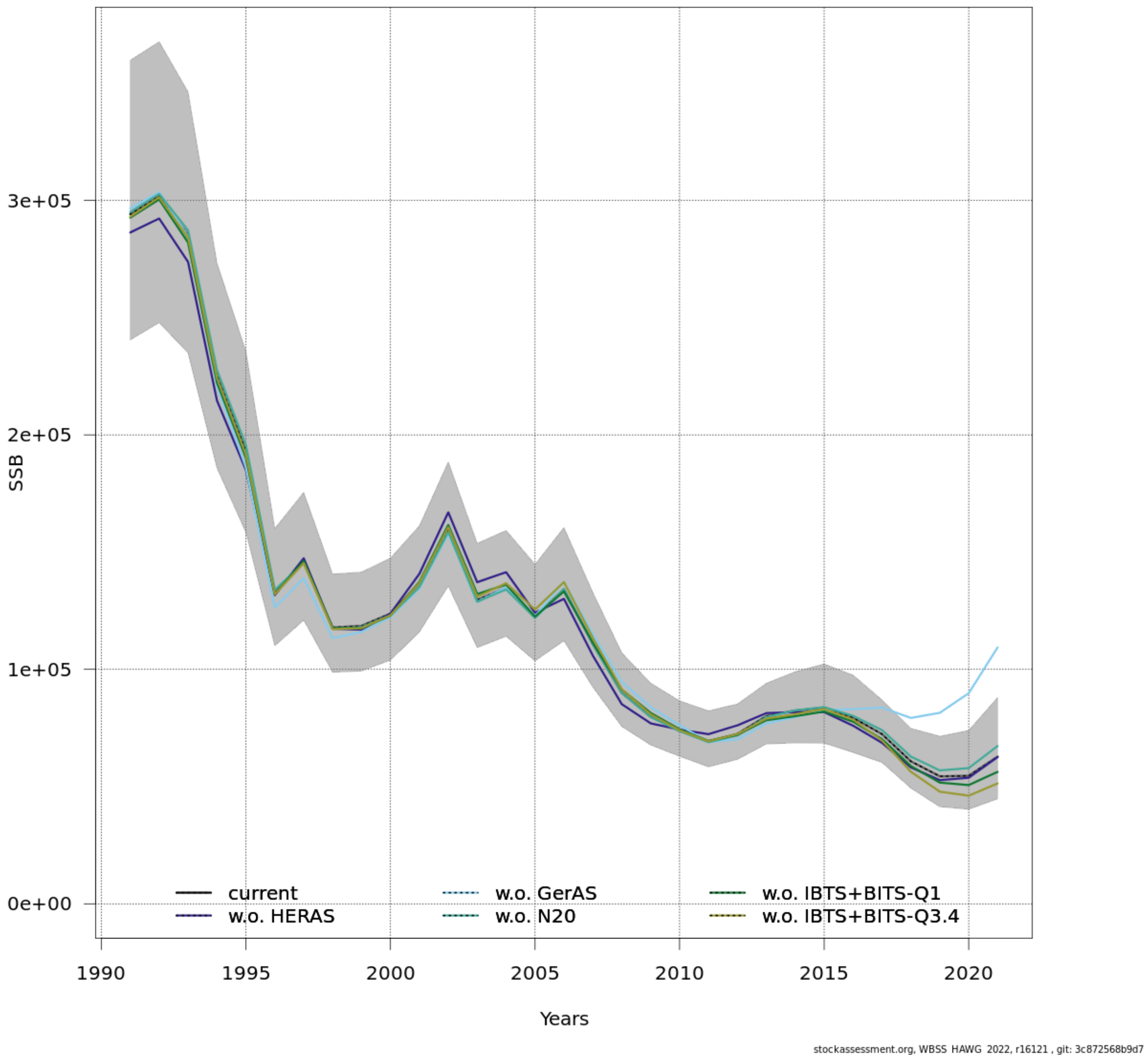


Figure 3.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Spawning stock biomass.

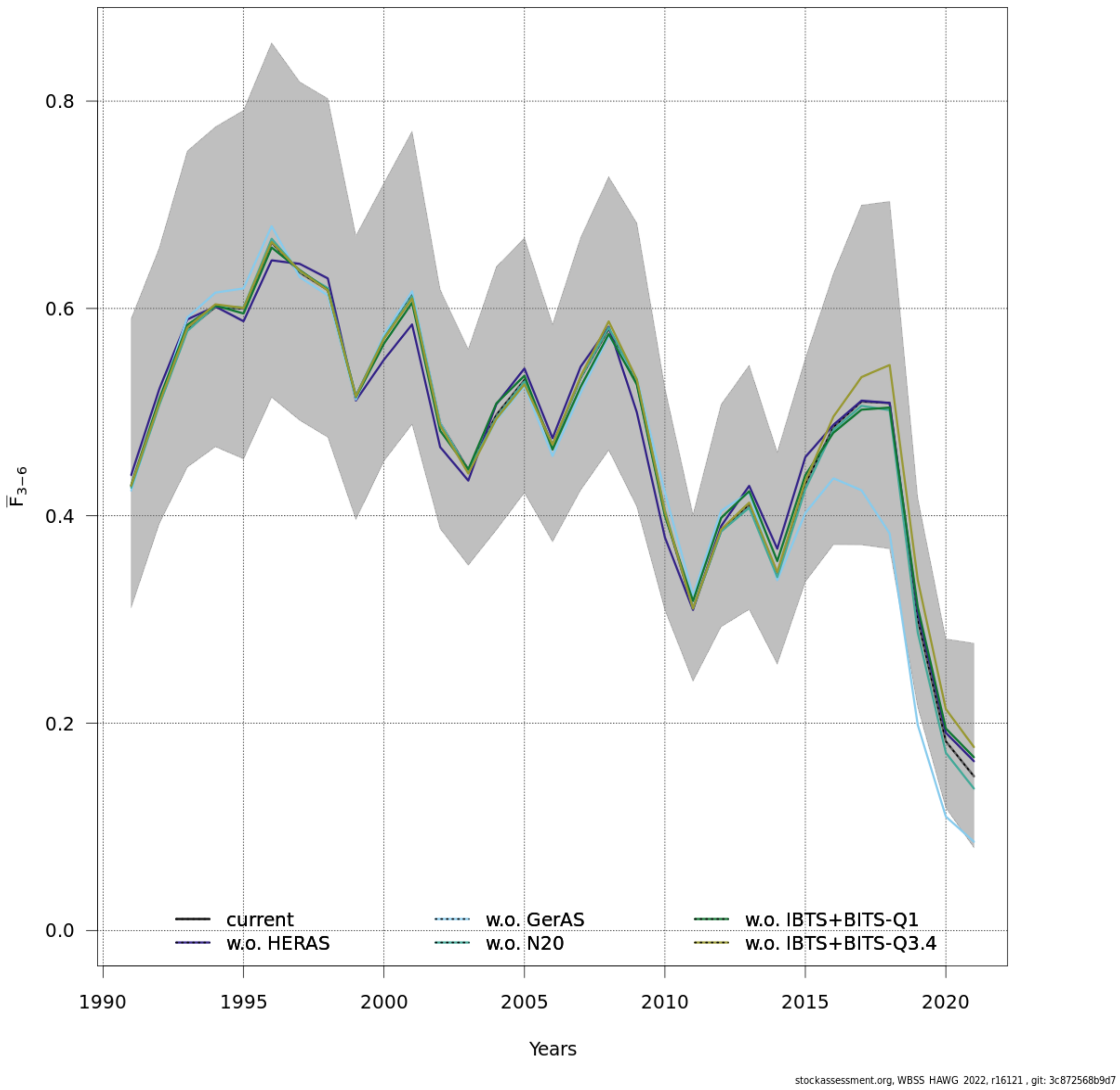


Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

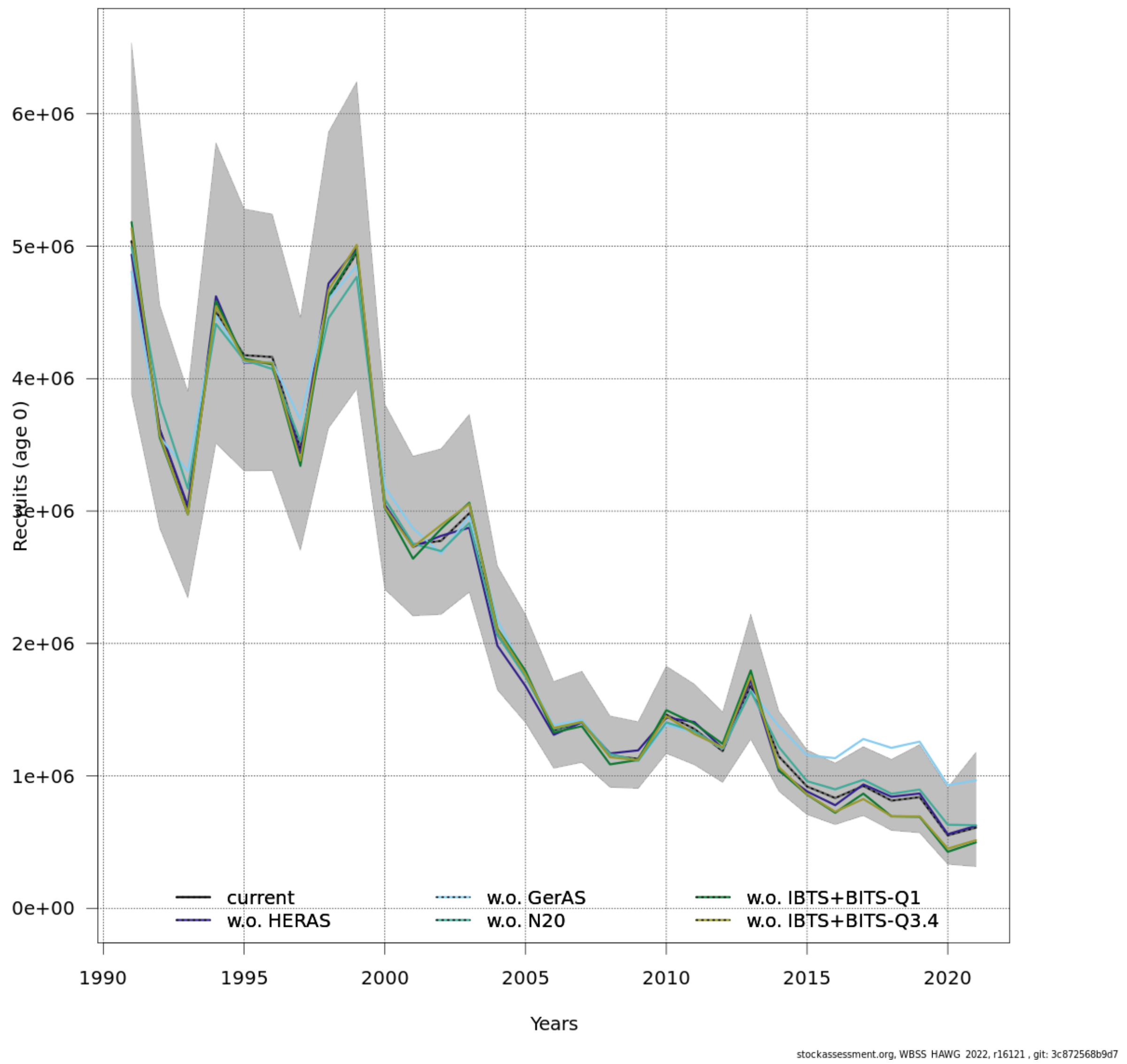


Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Recruitment.

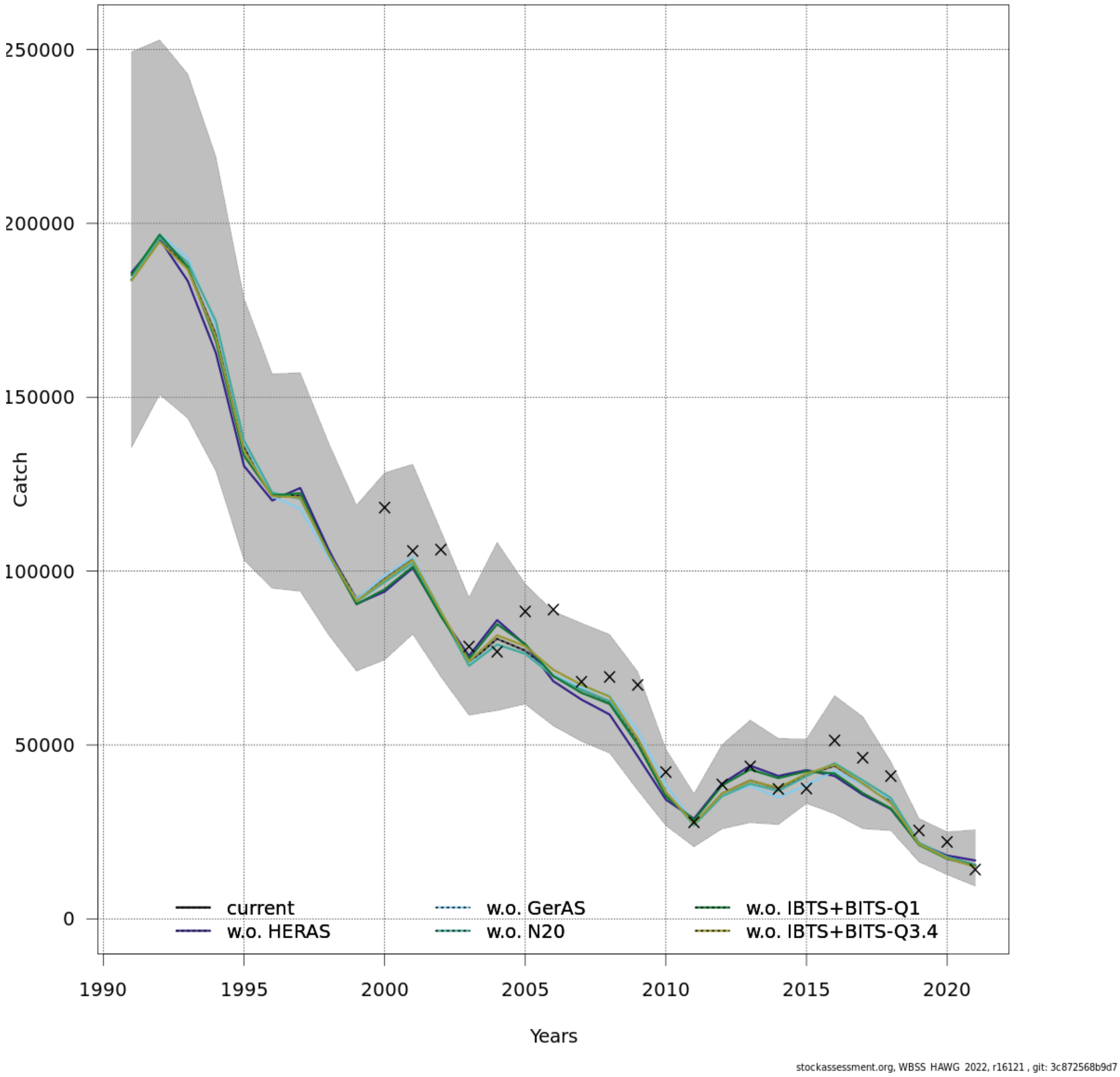


Figure 3.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Catch.

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), the survey indices have been successfully split, and the combined stock was separated back into its components at the WKNSCS benchmark in 2022 (ICES, 2022a).

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 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.

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 the low SSB and low 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 2022a), ICES has returned to providing separate advice for herring in 6.aN, although now this advice only covers the autumn spawning population in 6.aN.

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

The industry–science survey aim is to improve the knowledge base for the spawning components of herring in 6.aN and 6.aS 7.b–c and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan.

Utilizing ICES advice on the monitoring fishery (ICES, 2016g) together with the experience from 2016 a review of spawning areas and timing and discussions with fishing skippers four areas were selected for surveying in 6.aN. Areas 2 and 4 are considered to be active spawning areas and Area 1 a pre-spawning aggregation area that contains an unknown mixture of stocks of Western and potentially North Sea herring where a large proportion of catches has been taken in the years prior to 2016 (ICES 2016g). Area 5 was a new addition for 2018 and 2019 based on evidence from 2017 from local creel fishers catches of herring on the east side of the North Minch.

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 are reduced version of previous area 2 and 3 and correspond to regions that have been covered consistently since 2016. Moreover, refocusing the survey to these new strata means that it is now possible to provide a consistency the survey time-series, which will be necessary for developing time-series indices relevant for assessment purposes.

Following a proposal from 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 acoustic surveys. Details of the survey are reported in WGIPS (ICES 2021b) and 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 acoustic surveys (Mackinson *et al*. 2022). In 2021 1 115 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.

4.1.4 Stock recovery plan

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 benchmark, anticipated for 2021'*. There is no specific stock recovery plan in place for herring 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 evidence suggests 6.aN autumn spawning herring are genetically identical to North Sea autumn spawning herring (NSAS). 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.

4.1.6 Catches in 2021

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.

4.2 Biological Composition of the Catch

Catch and sample data by country and by period (quarter) in 2021 are detailed in Table 4.2.1. 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. Biological data sampled from commercial hauls (n = 2) were used to allocate the age distribution for the 6.aN catches. The allocation of age distributions to un-sampled 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 2021 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 2020 as well as maintaining coverage of the original survey area in 6.aN. Genetic work (Farrell *et al.*, 2021) has allowed estimates from this survey to be split between populations (ICES 2022a), but these only go back to 2014.

The Malin Shelf herring estimate of SSB for autumn spawning herring in 6.aN in 2021 is 43 886 tonnes and 341 million individuals (Table 4.3.1), an increase compared to 2020. 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 2021 is dominated by 2-winter ringers (39.7% of the abundance, 2019 year class). Age disaggregated survey abundance indices for 6.aN autumn spawning herring since 2014 are given in Table 4.3.2 and displayed in Figure 4.3.1.1.

The stock is highly contagious 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

From 2016 to 2021 industry acoustic surveys of herring during the spawning and pre-spawning period were undertaken as part of the monitoring fishery on this stock. The surveys cover known active spawning grounds in both 6.aN and 6.aS,7b at spawning time and aim to provide estimates of minimum spawning stock size in each of the areas. Two industry vessels were used to undertake acoustic surveys on the spawning ground in September to collect acoustic data and information on the size and age of herring required to generate an age-disaggregated acoustic estimate of the biomass of prespawning/ spawning herring in 6.aN.

Full results from the surveys can be found in (ICES 2022b), who conclude that the survey in 2021 provides a reliable estimate of the minimum biomass of mature herring at age and the minimum spawning biomass observed in survey areas during the survey period. The limited sampling by one vessel involved in the survey in 2021 and some uncertainty over the quality of acoustic data recorded using the Furuno FCV-30 on another led to the decision to combine biological samples from both vessels in the acoustic analysis. While this practice is not uncommon, the temporal lag was not optimal.

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 2021 the catch weights have increased across age classes compared to 2020.

4.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 4.4.2.1). The genetically split Malin Shelf Acoustic Survey (MSHAS) provides estimated values for the period 2014 to 2021, but in some years no estimates are available at younger ages. The proportion mature of ages 2 and 4-wr in 2021 were similar to 2020.

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 2015) 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 2021c), and new values for natural mortality became available (Table 4.4.3.1). At the latest benchmark (ICES 2022a) 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 2022a). The tool for the assessment of herring in 6.aN follows the category 3 WKLIFE guidelines (ICES 2021d; ICES 2021e).

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 2021d).

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 2022a). Following the recommendations of WKLIFE, (ICES 2021d), 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 2022a). These fish are unquestionably 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 2021d), and this calculation was updated for HAWG in 2022.

Commercial market sampling data from 2000-2015 and data from commercial hauls under the monitoring TAC were used to recalculate growth parameters. This assessment includes 6.aN autumn spawning herring only, and individuals thought to be from the spring-spawning component should be removed. Therefore samples taken from the South Minch area (Figure 4.6.1) were removed from the market sampling data prior to the calculation of growth parameters.

Von Bertalanffy growth parameters were calculated from the combined commercial data for autumn spawning herring in 6.aN from 2000-2021 (Figure 4.6.2), 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 constant harvest rate (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.

$F_{MSY\ proxy}$ 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. This alternative method for calculating the target reference length was approved at the benchmark meeting in 2022 (ICES 2022a), using the following equation:

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

As per ICES, 2021d, 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 Malin Shelf Herring Acoustic Survey , $\boldsymbol{I_y = 43\ 866.}$
- $F_{MSY\ proxy}$ 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 $\mathbf{0.335}$.
- $b = min\{1, I_y/I_{trigger}\}$. 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:

$C_{y+1} = 43866 \times 0.335 \times 1 \times 0.5 = 7\ 362$ tonnes

Under WKLIFE guidelines (ICES 2021d) a stability clause of +20% and -30% is recommended relative to the previous year's advised catch. Herring in 6.aN is a new stock so the 'previous year's advice' does not apply in this case. Therefore, the stability clause should be applied against a mean of the past three year's catch (1010 tonnes). When the stability clause is applied, the advised catch for herring in 6.aN under the CHR rule is 1 212 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 2022a).

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 now 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 have been under zero advice and a monitoring TAC since 2016 under the combined assessment. Despite and 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

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 Malin Shelf Herring Acoustic Survey has been steadily decreasing since 2008 (ICES 2022b). Although the 2021 estimates for autumn spawning 6.aN herring indicate increases since 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 2020-2022 to allow sampling for each stock separation and maintain the time-series of catch composition.

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.

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 a 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.

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
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

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

***unraised discards**

Table 4.2.1. Herring in division 6.aN. Catch and sampling effort by nation in the fishery in 2021

Country	Quarter	Sampled catch (t)	Official Catch (t)	No. Hauls	No. of samples	No. measured	No.aged	SOP
UK (SCO)	1	0	39	-	-	-	-	0%
	3	671	751	2	2	182	43	112%
UK (NI)	3	0	180	-	-	-	-	0%
UK (ENG)	1	0	5	-	-	-	-	0%
Ireland	1	0	137	-	-	-	-	0%
Netherlands	4	0	5	-	-	-	-	0%
Total		671	1115	2	2	182	43	112%

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

Year	1	2	3	4	5	6	7	8	9+
1977	34836	47739	95834	22117	10083	12211	20992	2758	1486
1978	22525	46284	20587	40692	6879	3833	2100	6278	1544
1979	247	142	77	19	13	8	4	1	0
1980	2692	279	95	51	13	9	8	1	0
1981	36740	77961	105600	61341	21473	12623	11583	1309	1326
1982	13304	250010	72179	93544	58452	23580	11516	13814	4027
1983	81923	77810	92743	29262	42535	27318	14709	8437	8484
1984	2207	188778	49828	35001	14948	11366	9300	4427	1959
1985	40794	68845	148399	17214	15211	6631	6907	3323	2189
1986	33768	154963	86072	118860	18836	18000	2578	1427	1971
1987	19463	65954	45463	32025	50119	8429	7307	3508	5983
1988	1708	119376	41735	28421	19761	28555	3252	2222	2360
1989	6216	36763	109501	18923	18109	7589	15012	1622	3505
1990	14294	40867	40779	74279	26520	13305	9878	21456	5522
1991	26396	23013	25229	28212	37517	13533	7581	6892	4456
1992	5253	24469	24922	23733	21817	33869	6351	4317	5511
1993	17719	95288	18710	10978	13269	14801	19186	4711	3740
1994	1728	36554	40193	6007	7433	8101	10515	12158	10206
1995	266	82176	30398	21272	5376	4205	8805	7971	9787
1996	1952	37854	30899	9219	7508	2501	4700	8458	31108
1997	1193	55810	34966	31657	23118	17500	10331	5213	9883
1998	9092	74167	34571	31905	22872	14372	8641	2825	3327
1999	7635	35252	93910	25078	13364	7529	3251	1257	1089
2000	4511	22960	21825	51420	15504	9002	3897	1835	576
2001	147	83318	15368	9569	25175	9544	6813	4741	1028
2002	992	38481	93975	9014	18113	28016	9040	1547	1422
2003	56	33331	46865	53766	7462	4344	12818	9187	1407
2004	0	7235	23483	29421	48394	4151	8100	9023	4265
2005	182	9632	23236	20602	10237	9783	1014	1194	1430

Year	1	2	3	4	5	6	7	8	9+
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
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

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

Year	1	2	3	4	5	6	7	8	9+
1967	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1968	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1969	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1970	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1971	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1972	0.079	0.104	0.13	0.158	0.164	0.17	0.18	0.183	0.185
1973	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1974	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1975	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1976	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1977	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1978	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1979	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1980	0.09	0.121	0.158	0.175	0.186	0.206	0.218	0.224	0.224
1981	0.08	0.14	0.175	0.205	0.231	0.253	0.270	0.284	0.295
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	0.069	0.103	0.134	0.161	0.182	0.199	0.213	0.223	0.231
1985	0.113	0.103	0.173	0.196	0.215	0.23	0.242	0.251	0.258
1986	0.073	0.143	0.183	0.211	0.22	0.238	0.241	0.253	0.256
1987	0.08	0.112	0.157	0.177	0.203	0.194	0.24	0.213	0.228
1988	0.082	0.142	0.145	0.191	0.19	0.213	0.216	0.204	0.243
1989	0.079	0.129	0.173	0.182	0.209	0.224	0.228	0.237	0.247
1990	0.084	0.118	0.16	0.203	0.211	0.229	0.236	0.261	0.271
1991	0.091	0.119	0.183	0.196	0.227	0.219	0.244	0.256	0.256
1992	0.089	0.128	0.158	0.197	0.206	0.228	0.223	0.262	0.263
1993	0.083	0.142	0.167	0.19	0.195	0.201	0.244	0.234	0.266
1994	0.106	0.142	0.181	0.191	0.198	0.214	0.208	0.277	0.277
1995	0.081	0.134	0.178	0.21	0.23	0.233	0.262	0.247	0.291

Year	1	2	3	4	5	6	7	8	9+
1996	0.089	0.136	0.177	0.205	0.222	0.223	0.219	0.238	0.263
1997	0.097	0.138	0.159	0.182	0.199	0.218	0.227	0.212	0.199
1998	0.076	0.13	0.158	0.175	0.191	0.21	0.225	0.223	0.226
1999	0.1084	0.1327	93910	25078	13364	7529	3251	1257	1089
2000	0.0834	0.1373	0.1637	0.1829	0.2014	0.2147	0.2394	0.2812	0.2526
2001	0.0490	0.1398	0.1628	0.1828	0.1922	0.1959	0.2047	0.2245	0.2716
2002	0.1066	0.1464	0.1625	0.1728	0.1595	0.1780	0.1863	0.2449	0.2802
2003	0.0609	0.1448	0.1593	0.1690	0.1852	0.1997	0.1942	0.1854	0.2938
2004	0	0.1541	0.1732	0.1948	0.2160	0.2197	0.1986	0.1885	0.3030
2005	0.1084	0.1327	0.1632	0.1845	0.2108	0.2258	0.2341	0.2556	0.2496
2006	0.0908	0.158	0.1676	0.1929	0.2076	0.2251	0.2443	0.2615	0.275
2007	0.1152	0.1667	0.1881	0.1968	0.2105	0.2214	0.2161	0.2618	0.303
2008	0	0.1705	0.206	0.231	0.2309	0.2489	0.2529	0.284	0.2877
2009	0.1121	0.1726	0.2141	0.2379	0.2457	0.2535	0.2599	0.2549	0.273
2010	0.0818	0.1549	0.1883	0.2129	0.2337	0.2394	0.2369	0.2400	0.2549
2011	0.0613	0.155	0.1894	0.2178	0.234	0.2388	0.247	0.2463	0.2522
2012	0.0725	0.1469	0.1894	0.2076	0.2161	0.2261	0.2408	0.2817	0.2467
2013	0	0.1441	0.1746	0.1965	0.202	0.2124	0.2304	0.2343	0.2476
2014	0	0.1451	0.1877	0.203	0.2279	0.2449	0.2608	0.2614	0.2835
2015	0.0769	0.1425	0.1795	0.2059	0.2136	0.2307	0.2386	0.2454	0.2685
2016	0.1	0.144	0.178	0.204	0.219	0.229	0.237	0.251	0.257
2017	0	0.137	0.167	0.187	0.204	0.213	0.221	0.233	0.249
2018	0	0.126	0.151	0.174	0.190	0.208	0.218	0.238	0.246
2019	0.089	0.129	0.148	0.182	0.199	0.210	0.220	0.257	0.244
2020	0.074	0.125	0.115	0.147	0.180	0.192	0.210	0.140	0.222
2021	0	0.137	0.158	0.178	0.202	0.201	0.214	0.278	0.238

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 2021. 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	20.5	1.3	0.00	63.1	19.5
2	140.0	15.3	0.45	109.5	23.0
3	57.4	9.2	1.00	160.9	25.8
4	41.9	7.0	1.00	166.1	26.1
5	14.0	2.8	1.00	198.0	27.9
6	14.6	4.0	1.00	272.4	30.9
7	33.7	8.4	1.00	248.8	30.0
8	10.2	2.8	1.00	269.9	31.5
9+	9.1	2.2	1.00	239.5	30.1
Immature	98.0	9.0		91.8	21.8
Mature	243.4	43.9		180.3	26.7
Total	341.4	52.9	0.71	154.9	25.3

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 2021.

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

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 2021.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
2014		0.142	0.179	0.182	0.212	0.216	0.229	0.226	0.255
2015		0.159	0.184	0.198	0.214	0.220	0.219	0.198	0.220
2016		0.147	0.154	0.174	0.195	0.209	0.201	0.219	0.225
2017		0.130	0.175	0.184	0.197	0.207	0.211	0.238	0.221
2018	0.051	0.103	0.164	0.181	0.203	0.206	0.200	0.232	0.217
2019		0.121	0.140	0.175	0.208	0.214	0.204		0.212
2020	0.050	0.112	0.149	0.168	0.198	0.199	0.220		
2021	0.063	0.110	0.161	0.166	0.198	0.272	0.249	0.270	0.239

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 2021.

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

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 landings	Modal Catch	Lc	Mean>Lc	LF=M	f	Cy/Iy	$F_{MSY\ proxy}$
2014	32460	22027	28.5	27.5	29.448	28.801	1.022	0.679	0.335
2015	107113	18801	29	27.5	29.208	28.801	1.014	0.176	0.335
2016	10870	4724	29.5	25.5	28.691	27.666	1.037	0.435	0.335
2017	21863	4200	27	25.5	27.702	27.666	1.001	0.192	0.335
2018	20663	4063	27	25	27.595	27.382	1.008	0.197	0.335
2019	10508	1739	23.5	20	23.982	24.543	0.977	0.165	0.335
2020	26070	177	NA	NA	NA	NA	NA	0.007	0.335
2021	43886	1115	25.5	24	26.084	26.814	0.973	0.025	0.335

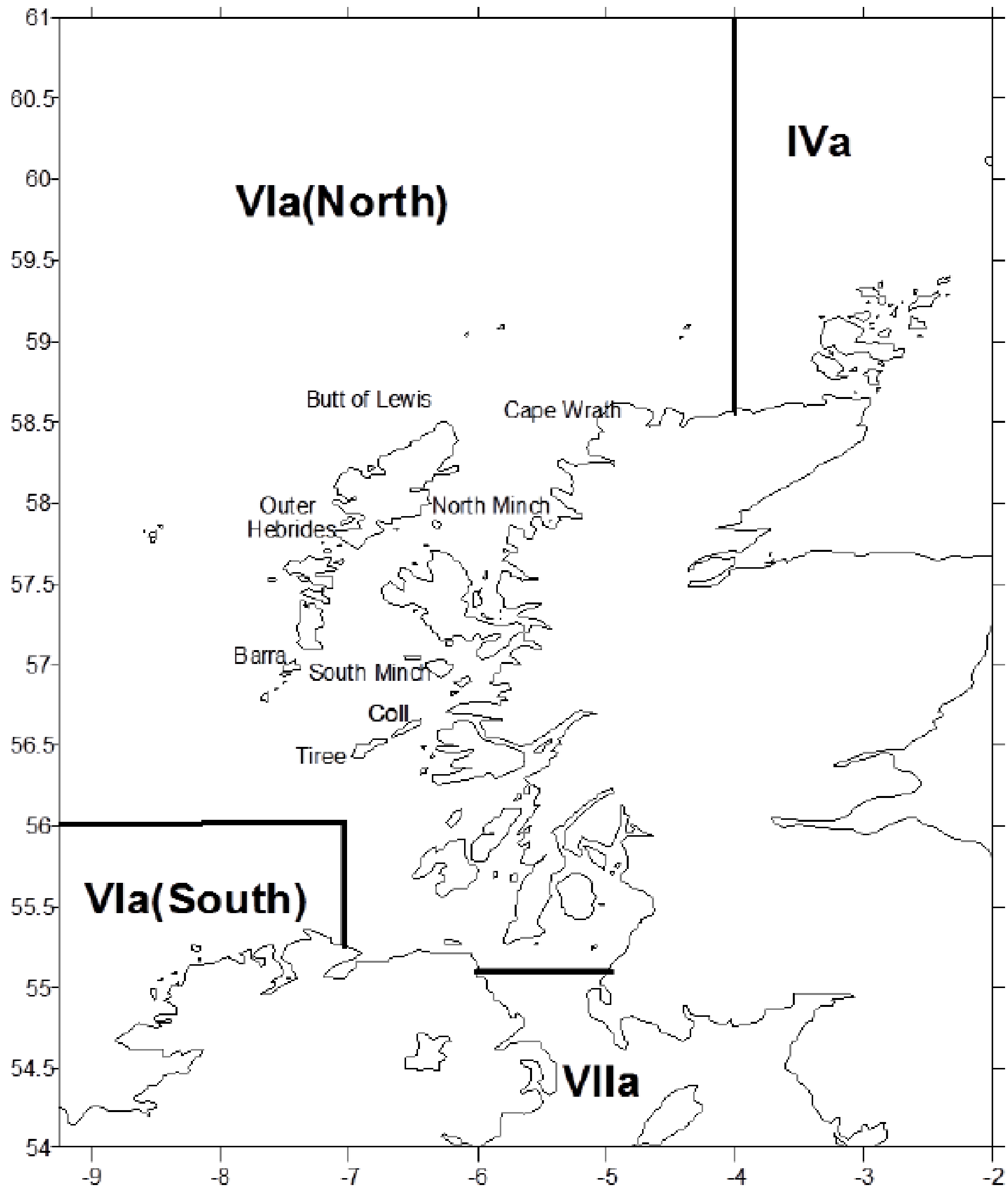


Figure 4.1. Location of ICES area 6.a (North) and adjacent areas with place names.

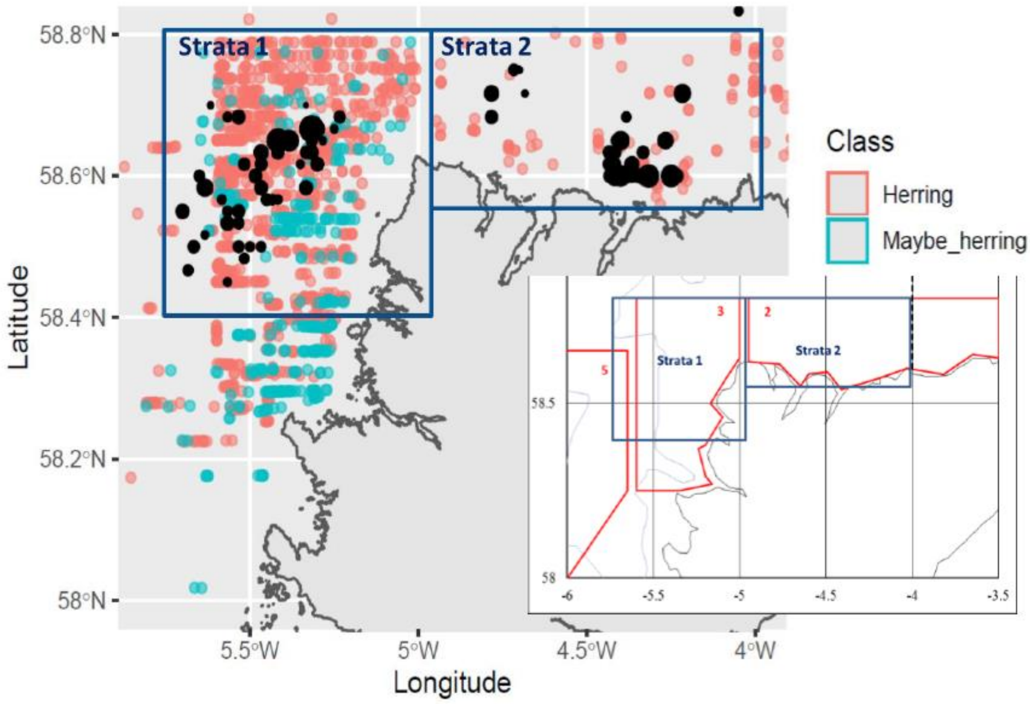


Figure 4.1.3.1. Acoustic survey recordings of herring and 'maybe herring' marks and locations of commercial catches 2016-2019 in defined Strata 1 and 2, showing overlap with previous survey Areas 2,3,5 (inset) and noting that the distribution of catches reflect spawning grounds. Catches (black dots)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

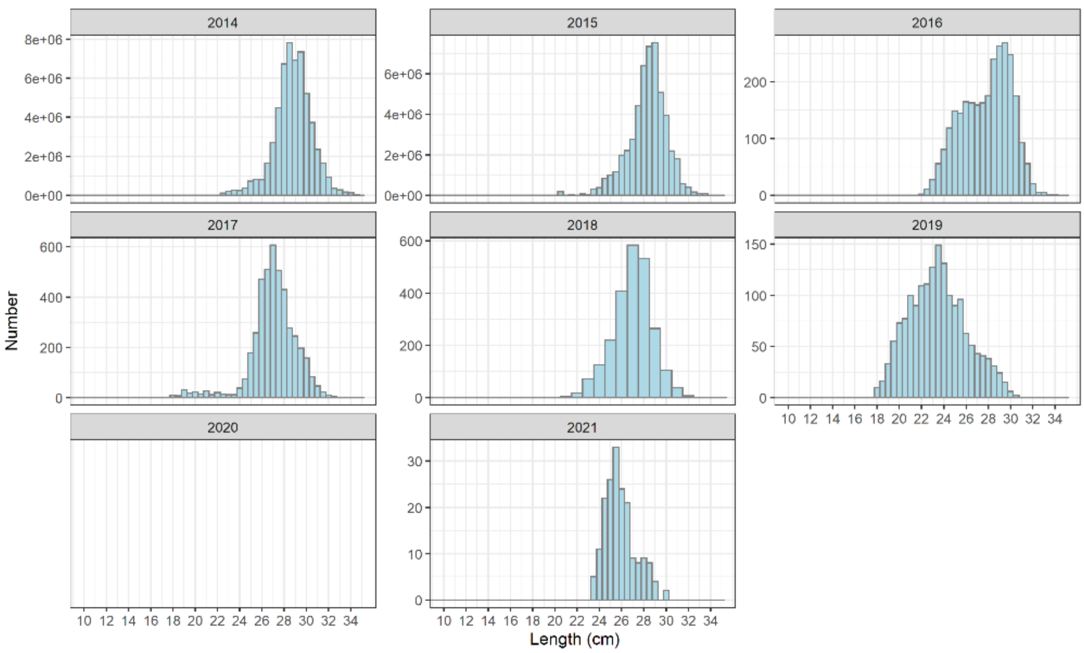


Figure 4.1.7.1. Length-frequency of commercial catches in division 6.aN. Since 2016 a monitoring TAC has been in place for this area. Some data in 2018 were reported to a 1cm resolution, and therefore all data in this year have been binned to this level in this year. No length data from commercial hauls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

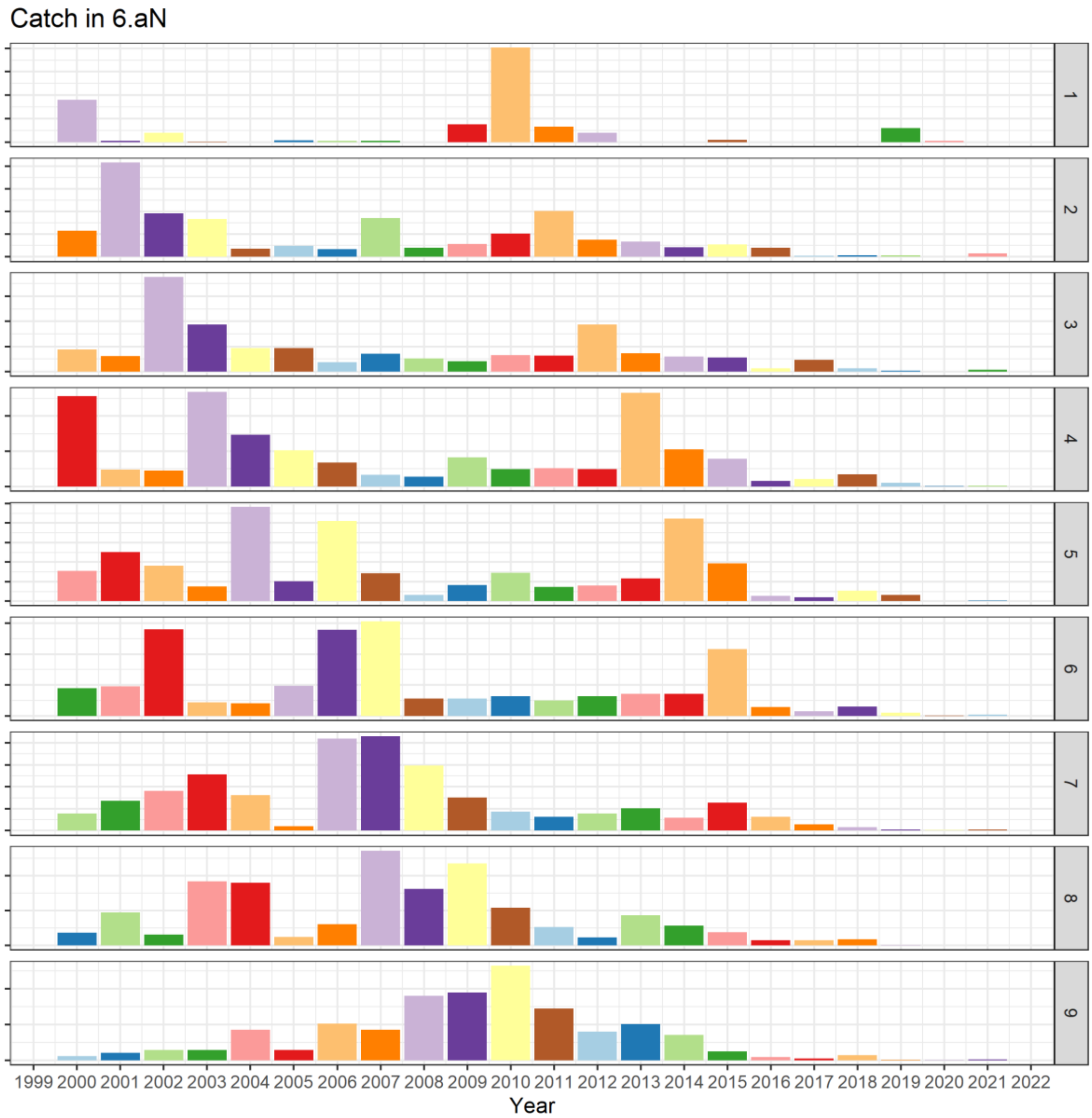


Figure 4.2.1. Catch numbers at age for herring in division 6.aN.

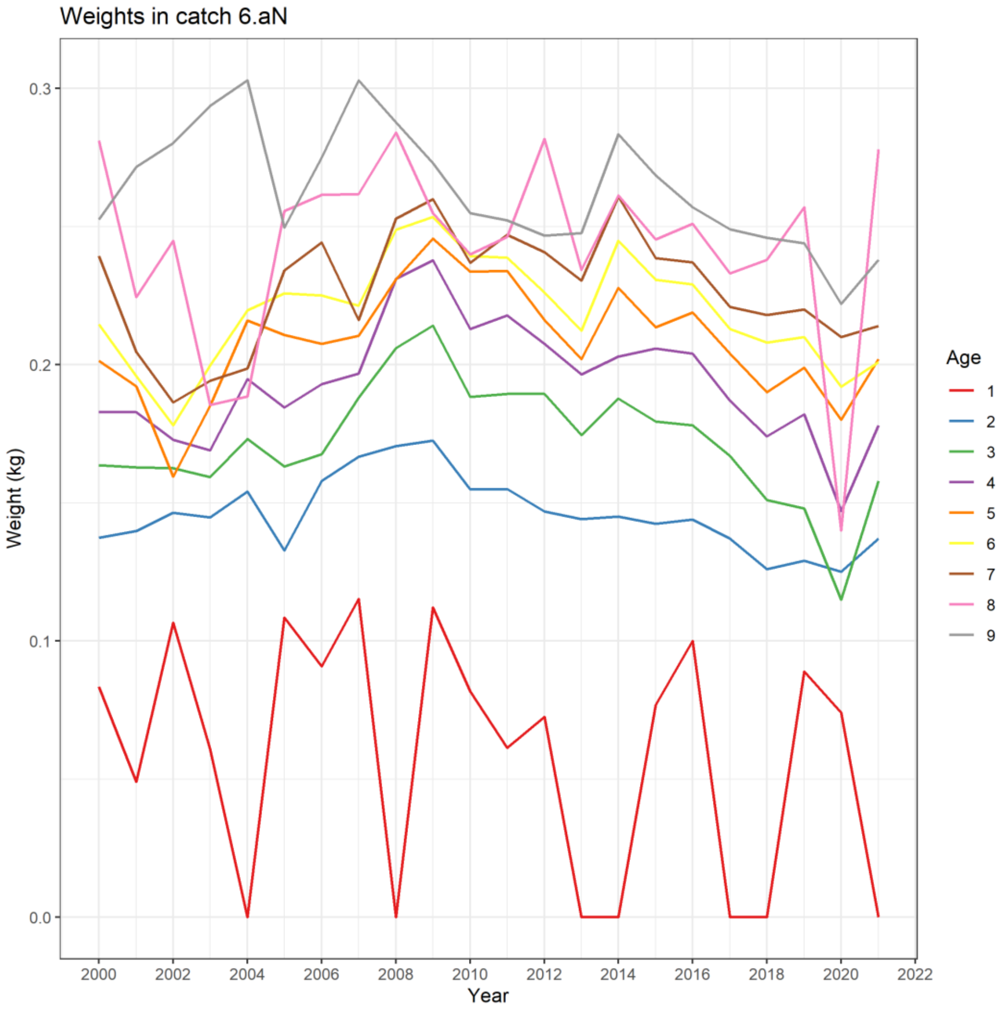


Figure 4.2.2. Weights at age in the catch for herring in 6.aN.

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

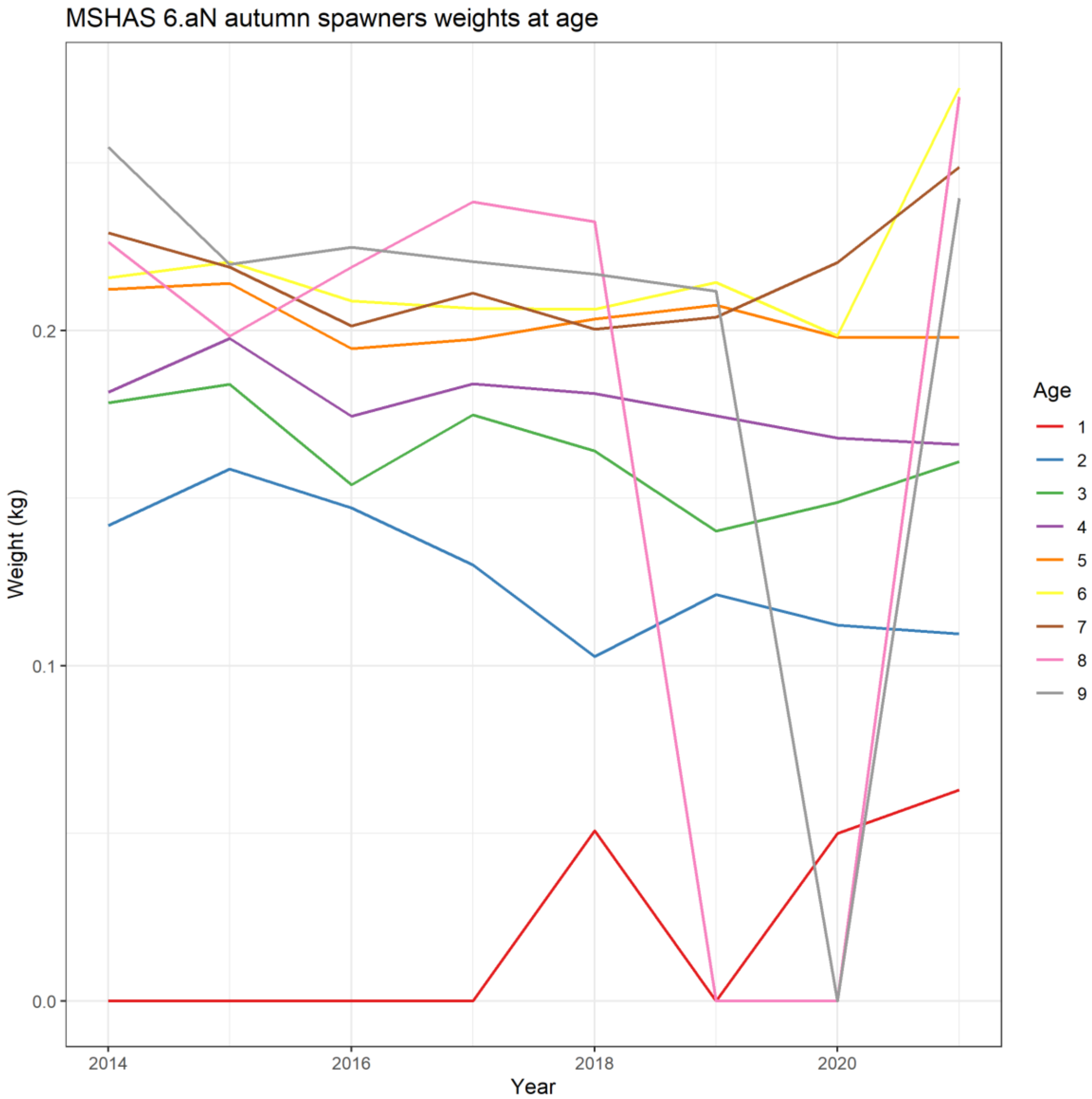


Figure 4.4.1.1. Weights-at-age for 6.aN autumn spawning herring from the genetically split Malin Shelf Herring acoustic survey.

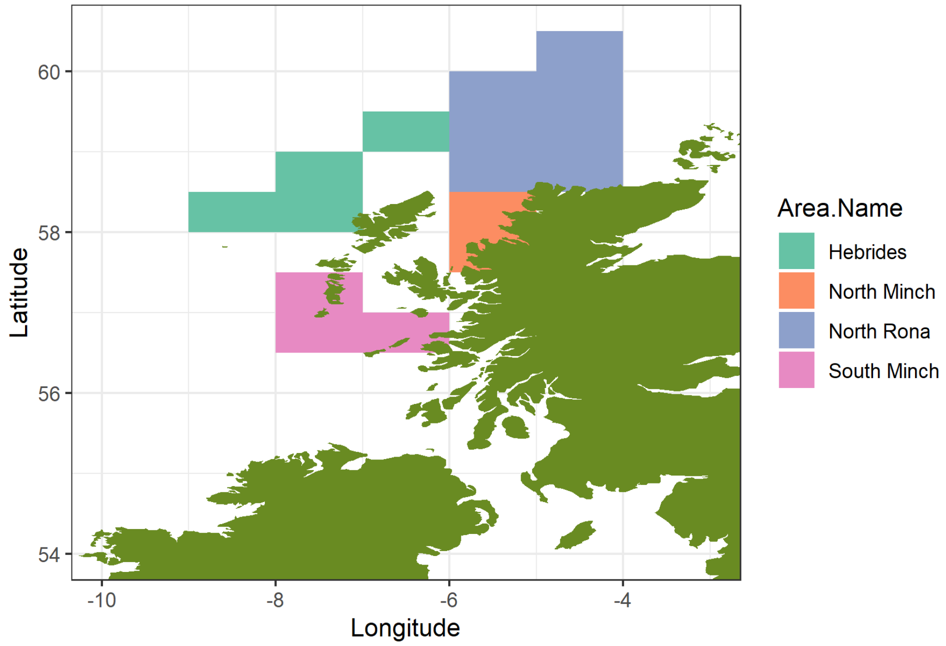


Figure 4.6.1. ICES rectangles where market sample data have been collected from 2000-2015.

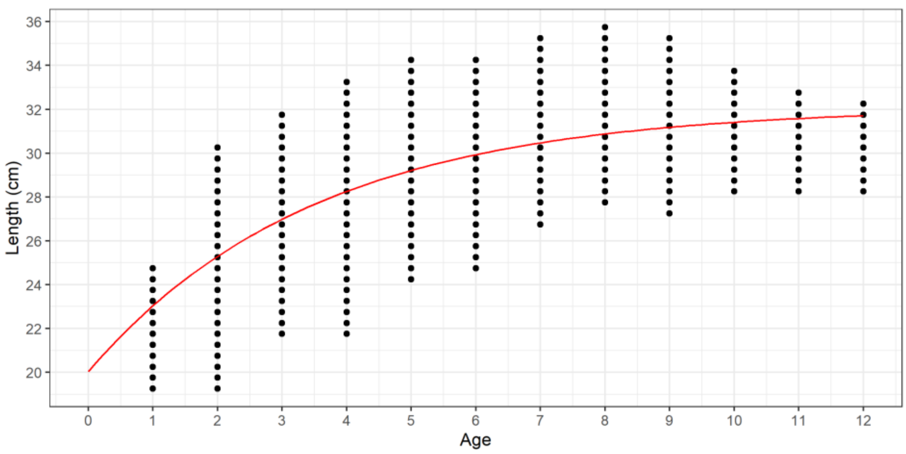


Figure 4.6.2. Growth curve calculated from commercial catches in division 6.aN, and gives an estimated L∞ value of 30.51cm with an associated *k* value of 0.335

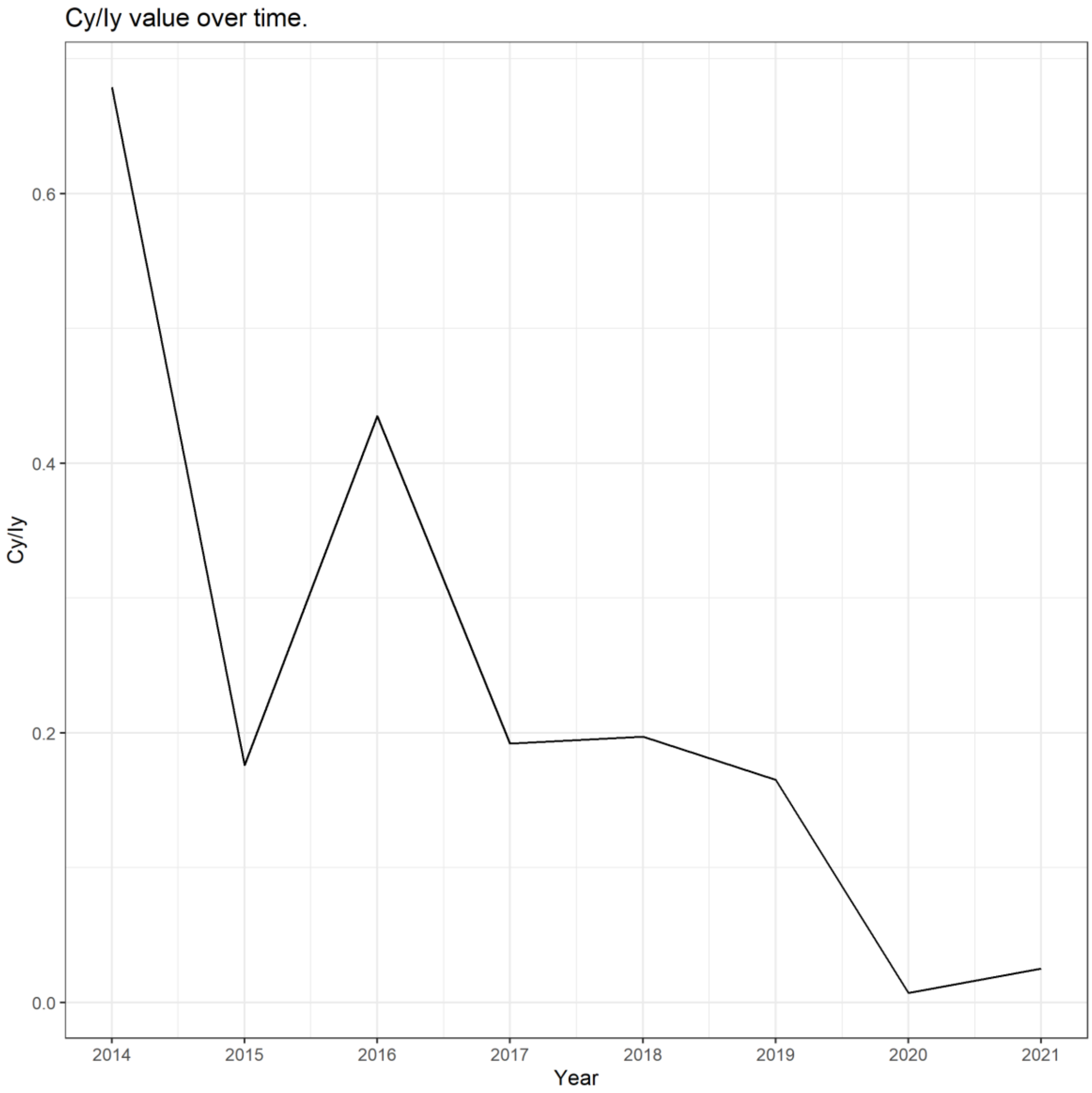


Figure 4.6.3. The ratio C/I for 6.aN herring 2014-2021, from which the $F_{MSY\ proxy}$ value is calculated.

5 Herring (*Clupea harengus*) in divisions 6.aS and 7.b–c

This is the first time since 2015 that the working group presents a separate assessment of herring in Division 6.aS, 7.b-c. This follows from the benchmark workshop, ICES WKNSCS (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 2021–2022

ICES gave separate advice for the stocks in 6aS, 7b,c and 6aN up to 2015 and advice for the combined stocks since 2016. After the benchmarking process in early 2022 (WKNSCS, 2022), 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). Since 2016 the fishery has been restricted to a monitoring fishery with a TAC of 1,630 t between 2016 – 2019, and 1,360 t in 2020 and 2021.

The advice in 2022 is 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 (method 2.2, ICES 2021g) that uses length, survey and catch data from 2014-2021.

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 and 2021. The monitoring TAC, introduced in 2016 and continued up to 2021, 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 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 2021 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 and 2020 fishery. As in 2020, there was also a fishery in January and February to allow for additional data collection.

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 2021

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 1957-2021 is presented in Figure 5.1.4 and the Irish catch map is shown in Figure 5.1.2. In 2021 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 2021, the fishery was dominated by 2- 5-ringers, accounting for 95% of the catch (Table 5.2.1.2). Smaller proportions of 6-9 ringers are evident in the catch data and account for 5% of the total. 3 ringers are the dominant age class (58%) followed by 4 ringers (15%), 2 (13%), 5 (9%). 2019 was the first year since 2012 that 1 ringers are well represented in the catch-at-age data. These have followed through as 2 ringers in 2020 and 3 ringers in 2021.

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. 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 (Figure 5.3.1.3). 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 O'Malley *et al.* 2021 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.

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 a 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 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 2014-2020 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: It was decided by the sub-group that genotyping fails were to be 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: The group decided that using StoX (Johnsen *et al.* 2019) would be the preferred method to split the MSHAS 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 each index from 2014-2021 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 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 in 2016. 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 of 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. It was decided that greater flexibility would allow for a targeted spatial and temporal approach, which avoided the inevitable poor weather that can happen in this area during this time of the year and which lead to reduced survey effort in 2019, but also to some extent in 2017 and 2018. Using smaller vessels allowed surveys to be conducted in shallow inshore areas where herring are known to inhabit during this time of the year.

The 2021 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 polemounted 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 (2016-2021) are included in this table.

5.3.3 Bottom-trawl surveys

As part of the benchmark (WKNSCS, 2022), 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 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 2012 for many age classes. Increases can be seen for many age classes in 2021.

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 a 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. The weights-at-age in the stock have also increased for many age classes in 2021. 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 – 2021. 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 but, with the exception of 2012 (2010 cohort), have been consistently low. In 2019, however 1-ringers represented a significant proportion (15%) of the catch-at-age. In 2020 the number of 1-ringers in the catch was lower than 2019 but higher than 2013-2018. In 2021 the numbers of 1-ringers is lower than 2019 and 2020 and similar to the levels from 2013. 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 recent benchmark (WKNSCS 2022)

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.

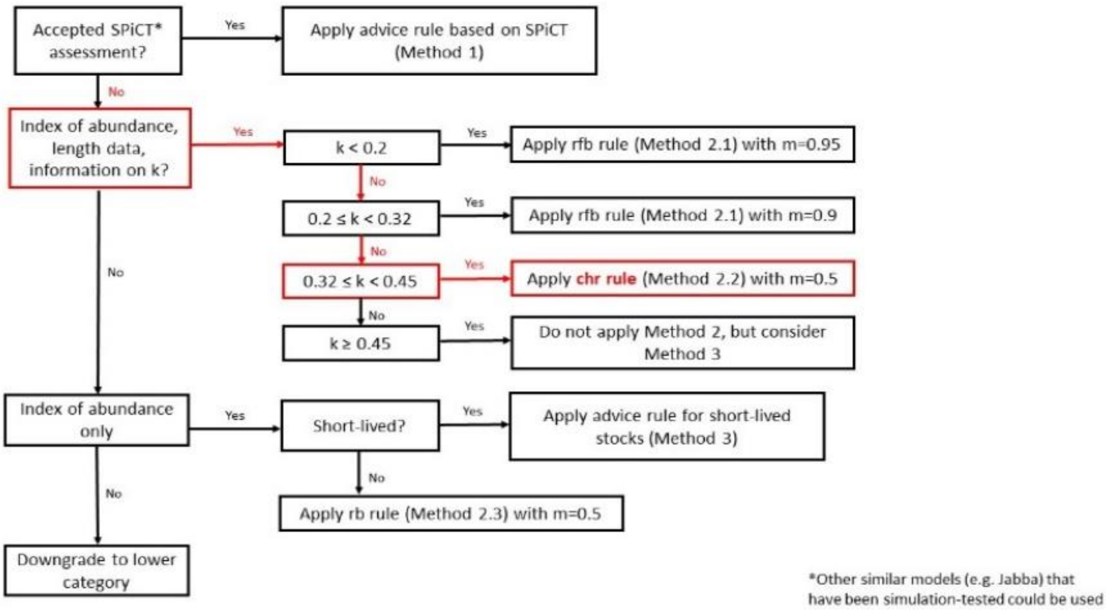
1 ringers in 2019 were not found in a high proportion in the acoustic survey but were found in the catch and contributed to a high proportion of the IBTS data. This 2018 year-class was found by the catch and the survey as 2 ringers in 2020 and 3 ringers in 2021.

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 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 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) was the category three method 2.2 – constant harvest rate (the chr rule).



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 (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 is increasing since 2016 and the latest biomass estimate is 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 values will update for each year of data added to the time series.

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 WKNSCS that the most appropriate starting value would be the average catch in the past three years (ICES, 2021h). Subsequent years will use the previously advised catch as the basis of the stability clause.

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 – 2021 (inclusive). Note that $F_{MSY\ proxy}$, can change with each year of additional data. In conjunction with herring in 6aN, implementation of these calculations in R is being developed and will be uploaded to TAF.

5.7 State of the Stock

The genetically split Malin shelf acoustic survey abundance and biomass estimates for 2014-2021 (incl.) provide the most reliable index for this stock. The biomass has been increasing since 2016 (36,706 t) with the 2021 estimate of 189,856 the second highest since the time series began in 2014 (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 since 2016 and this has 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 3 winter ring and accounted for 58% of the catch numbers at age in 2021.

5.8 Short-term Projections

5.8.1 Short-term projections

No short term forecast was conducted at HAWG 2022.

5.8.2 Yield-per-recruit

No yield-per-recruit analysis was conducted at HAWG 2022.

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. These values will update for each year of data added to the time series.

5.10 Quality of the Assessment

Herring in 6.a South, 7.b-c have been part of a combined assessment with 6.a North since 2015 (ICES, 2015a). Following a benchmark meeting in 2022 (ICES, 2022a), these two stocks are now assessed separately. This was made possible by the development of a genetically split acoustic survey index (MSHAS; ICES, 2022b). 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 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 (2014-2021).This sampling will continue in future years.

The length at first capture (Lc) and the target reference length were calculated independently for every year of data in order to be more responsive to changes in the stock and/or fishery selectivity as the stock rebuilds. As such, the $F_{MSY\ proxy}$ reference point may change in subsequent years.

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 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. 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.

Table 5.1.4 Herring in divisions 6.aS, 7.b–c. Estimated Herring catches in tonnes, 1992–2021. 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	3727	0	0	0	3791	2780	0	6571
2013	0	0	1460	40	0	0	1500	2468	0	3968

Year	France	Germany	Ireland	Netherlands	UK (England & Wales)	UK Scotland	Total landings	Unallocated / area misre-ported	Discards *	ICES estimated catch
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

***Unraised discards**

Table 5.2.1.1. Herring in divisions 6.aS, 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2021.

	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

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%

Table 5.2.2. Herring in divisions 6.aS, 7.b–c. Sampling intensity of catches in 2021.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.aS	1	426	6	382	1841	896
6.aS	4	1395	34	1655	8162	1187
Total	2021	1821	40	2037	10003	1119

Table 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the catches 1970–2021.

	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
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

	1	2	3	4	5	6	7	8	9+
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
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

Table 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2021.

	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
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

	1	2	3	4	5	6	7	8	9+
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
2021	0.070	0.109	0.151	0.171	0.182	0.196	0.203	0.205	0.211

Table 5.3.1.1. Herring in divisions 6.aS, 7.b–c Total numbers (millions) and biomass (tonnes) of herring June–July 2014-2021. 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

Table 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Mean Weights at age of herring June–July 2014-2021. 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

Table 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Maturity at age of herring June–July 2014-2021. 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

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
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 5.6.2.3.1. Herring in divisions 6.aS, 7.b–c. Constants, lengths, survey index and catch data used in the calculation of $F_{MSY\ proxy}$ and target reference lengths.

Year	2014	2015	2016	2017	2018	2019	2020	2021
Catch (t)	5,096	1,078	2,213	2,227	1,495	1,690	1,220	1,821
Biomass estimates (I)	149,270	226,293	36,707	66,342	96,138	92,364	135,335	189,856
modal length in catch L	28.00	27.00	28.00	26.00	27.00	25.50	24.00	25.5
L_c (Length of first capture)	26.00	26.50	25.00	25.00	25.50	23.00	22.50	24.5
Mean length > L_c in catch	27.996	27.68	27.298	27.006	27.184	26.17	25.03	25.99
Target reference length ($L_{F=\gamma M,\ k=\theta M}$)	27.958	28.241	27.393	27.393	27.676	26.264	25.981	27.11
f	1.001	0.98	0.996	0.986	0.982	0.996	0.963	0.959
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 – 2021 (inclusive).

$Catch_{y-1}$ (mean of last 3 years catch)	1,577 t
$Index_{y-1}$ (survey SSB)	189,856 t
$F_{MSY\ proxy}$	0.034
b (biomass safeguard)	1
m (multiplier)	0.5
chr ($C_{y+1} = I_{y-1} \times F_{proxy,MSY} \times b \times m$)	3,241 t
% Change (from previous 3yr catch)	+106%
Stability Clause Applied (-30% or +20%)	1,892 t
Advised Catch $_{y+1}$	1,892 t

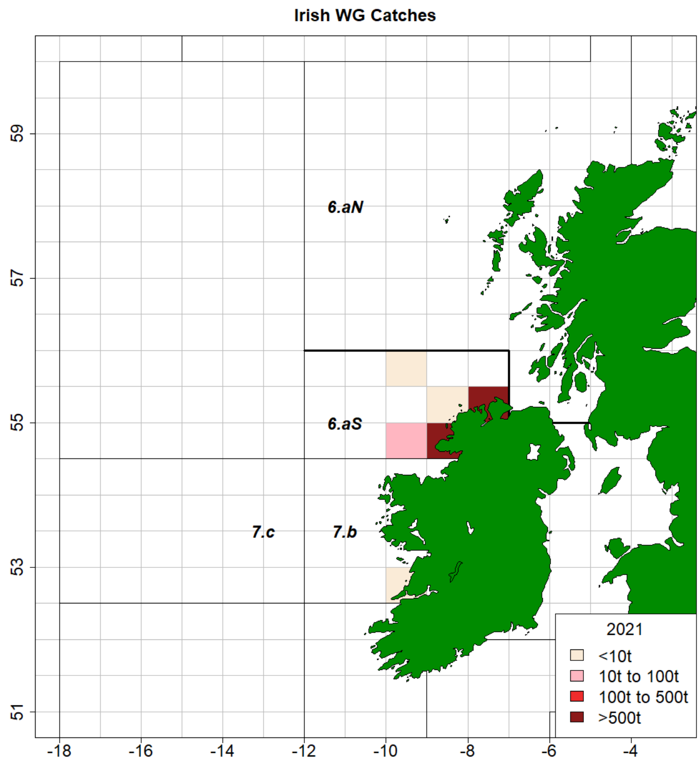


Figure 5.1.2 Herring in divisions 6.aS, 7.b–c. Irish catches in 2021.

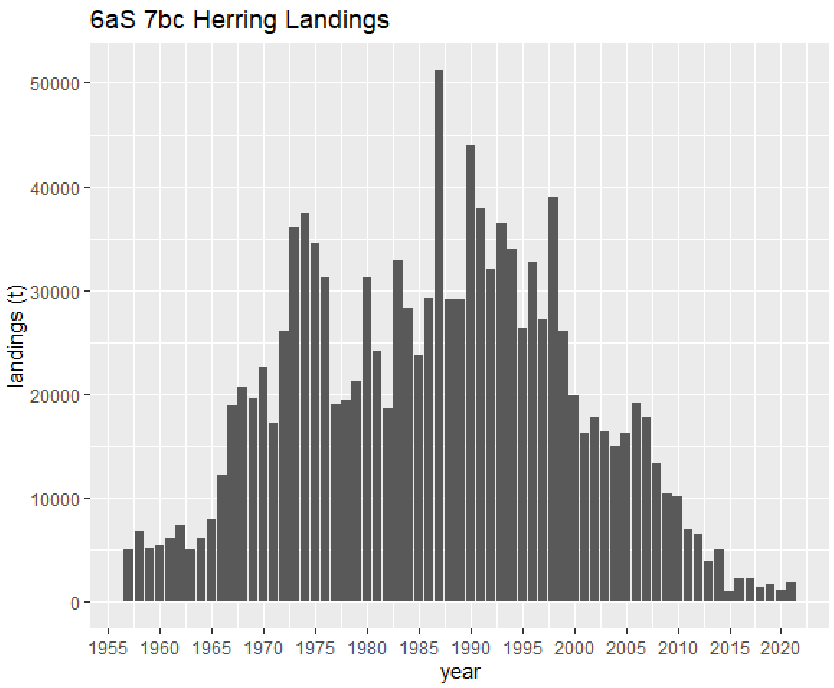


Figure 5.1.4 Herring in divisions 6.aS, 7.b–c. Working group estimate of catches from 1957–2021.

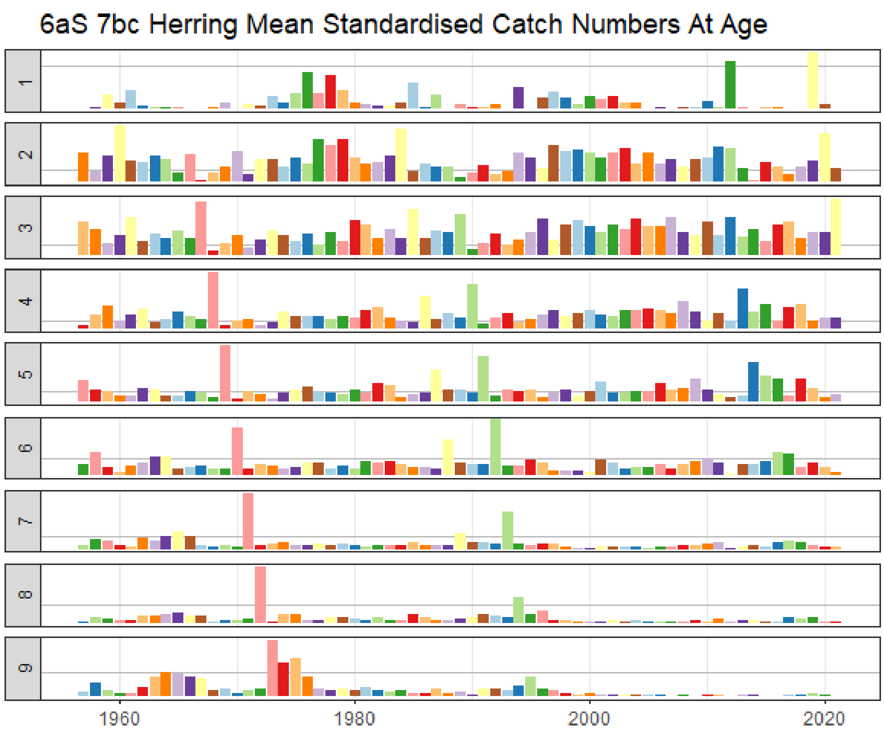


Figure 5.2.1. Herring in divisions 6.aS, 7.b–c. catch numbers-at-age standardized by year for the fishery 1957–2021.

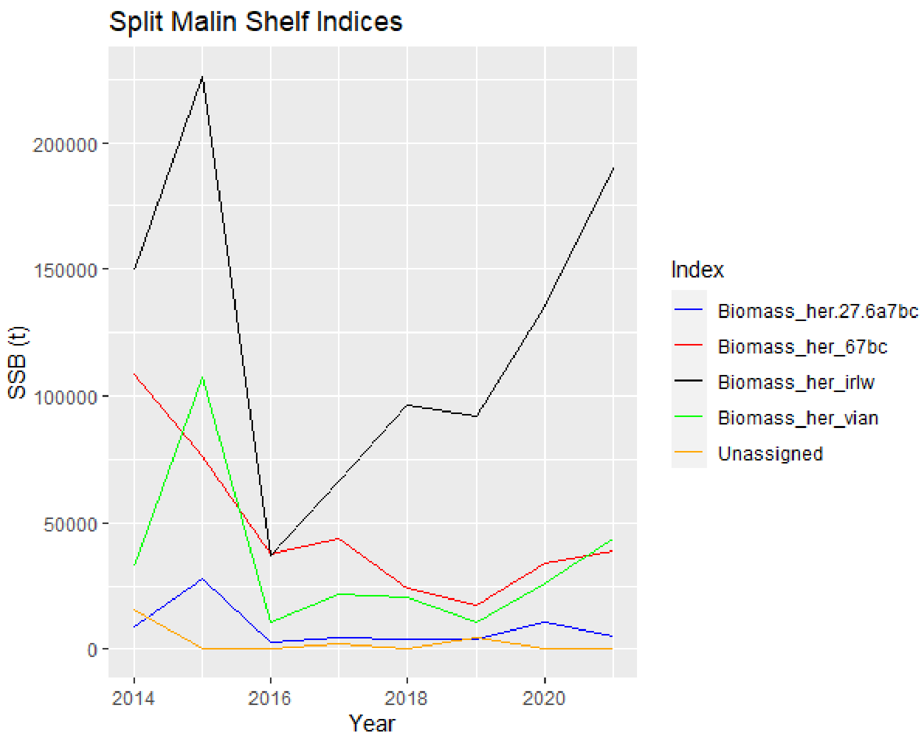


Figure 5.3.1.1. Herring in divisions 6.aS, 7.b–c . SSB (t) time-series for the individual MSHAS split indices (2014 – 2020). her-irlw refers to her.27.6aS,7b,c

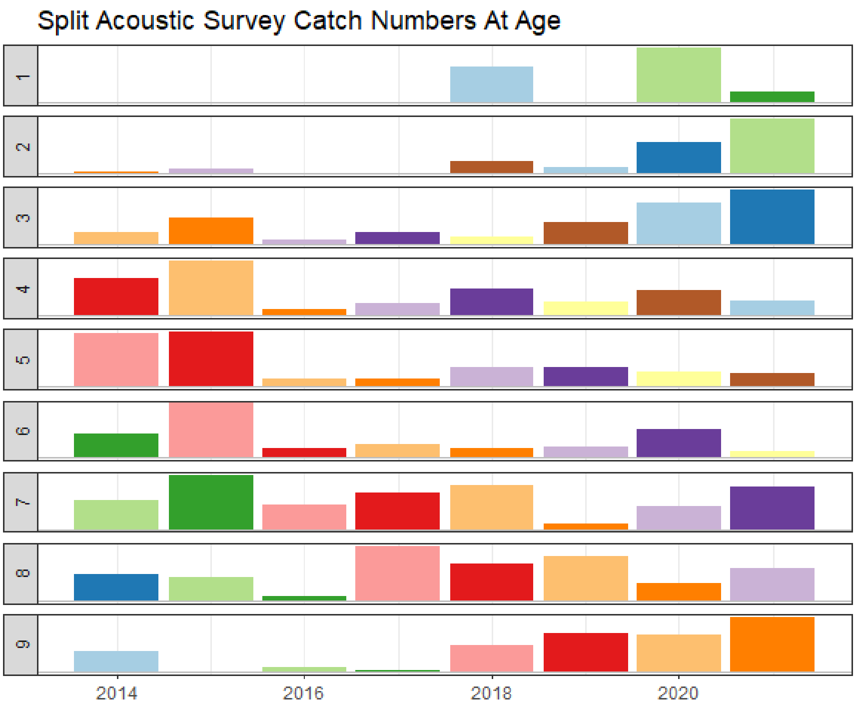


Figure 5.3.1.2. Herring in divisions 6.aS, 7.b–c. Malin Shelf Acoustic Survey - split catch numbers at age.

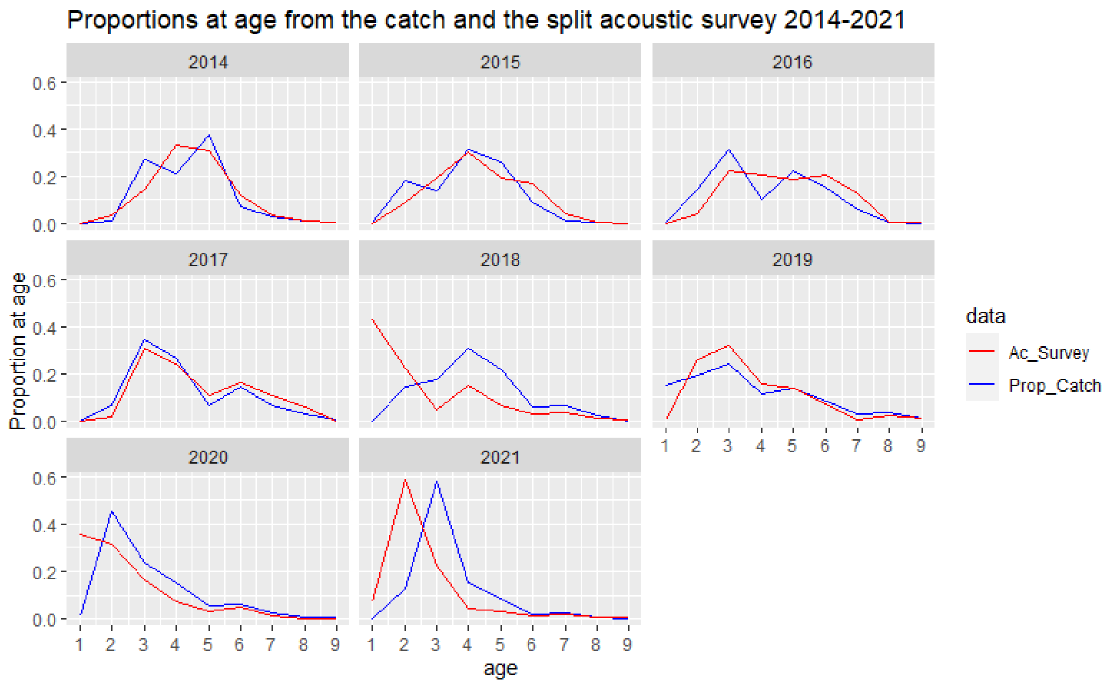


Figure 5.3.1.3. Herring in divisions 6.aS, 7.b–c. Proportions-at-age in the 6aS, 7.b–c catch and 6aS, 7.b–c Split Malin Shelf acoustic survey (MSHAS) 2014–2021.

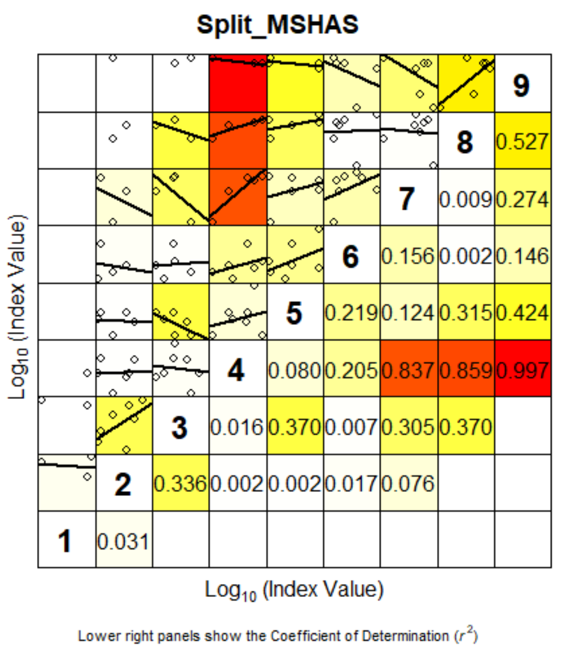


Figure 5.3.1.4 Herring in divisions 6.aS, 7.b–c. Internal consistency between ages (rings) in the Split MSHAS herring acoustic survey time-series (2014–2021).

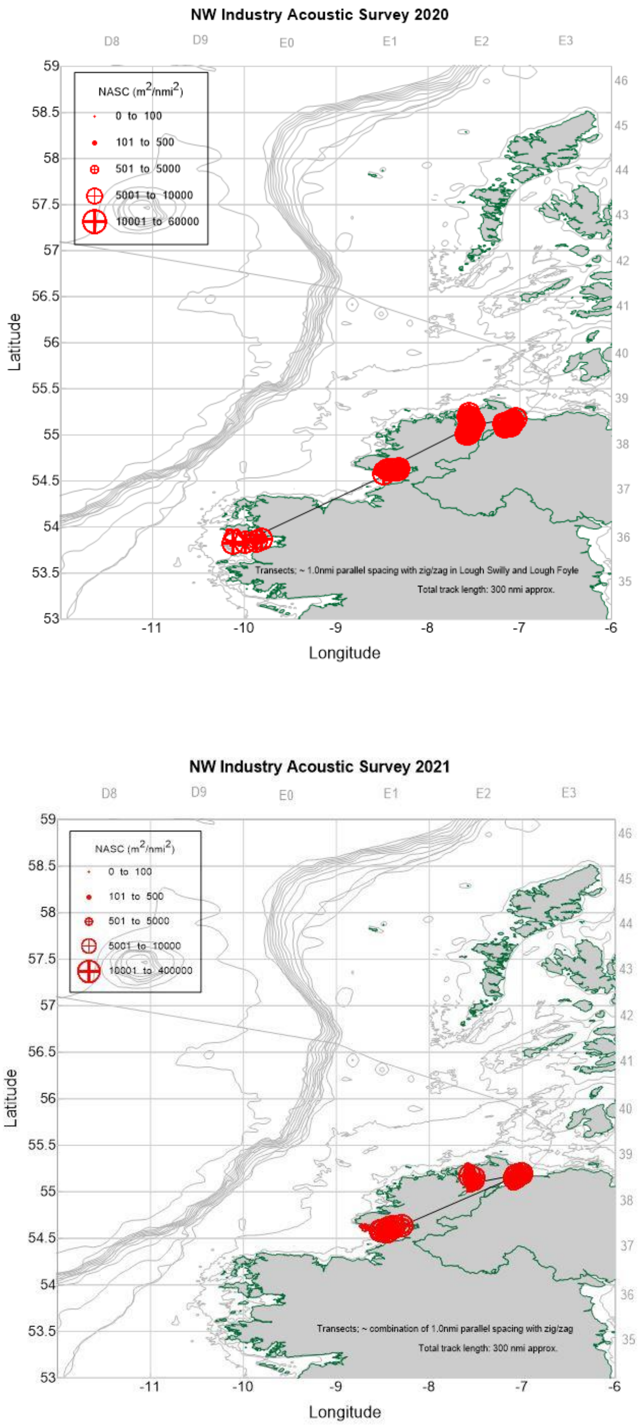


Figure 5.3.2.1. Herring in divisions 6.aS, 7.b–c. NASC distribution in the industry science surveys 2020 and 2021

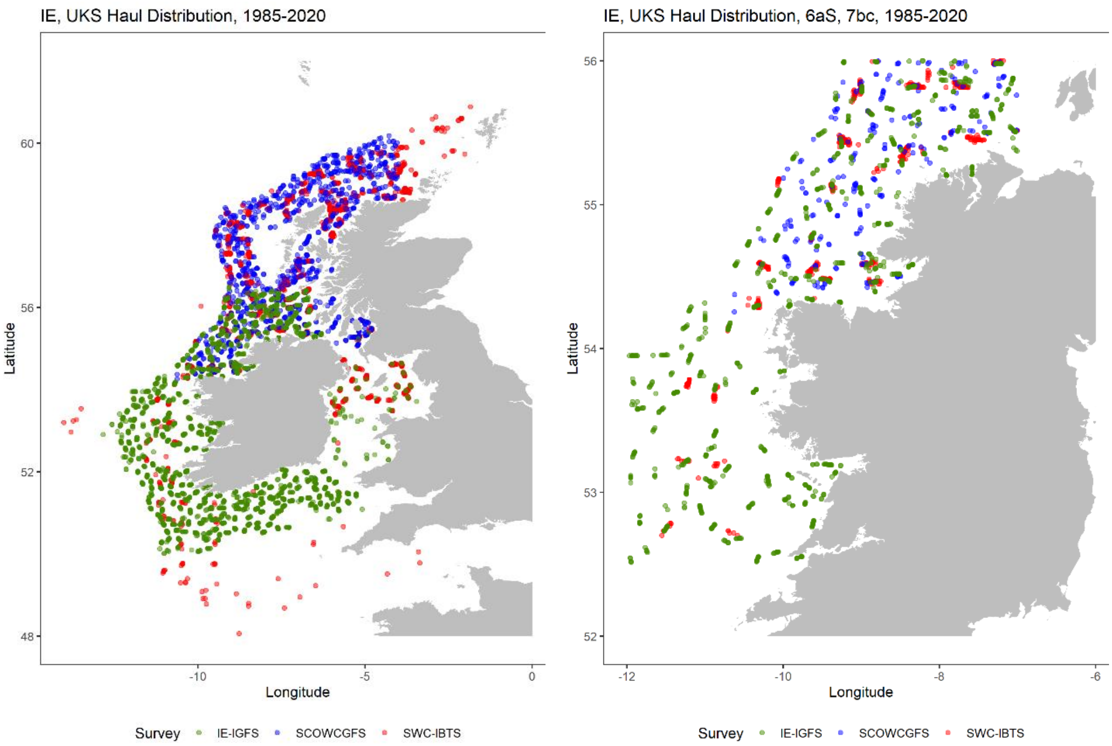


Figure 5.3.3.1 Herring in divisions 6.aS, 7.b–c . IBTS hauls positons from IE-IGFS (green), SWC-IBTS (red) and SCOWCGFS (blue) surveys, left – all hauls, right hauls in div 6a, south of 56˚N and divisions 7b and 7c

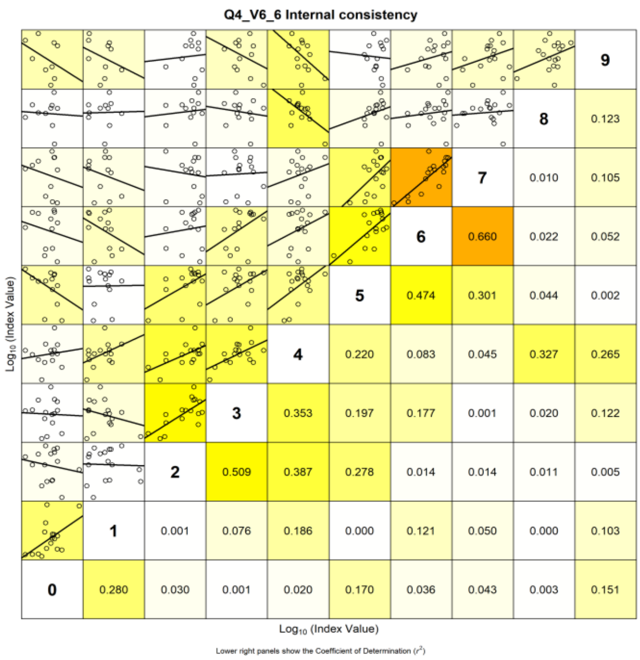


Figure 5.3.3.2. Herring in divisions 6.aS, 7.b–c. Internal consistency plot showing pairwise regressions and associated R^2 values from the IBTS Index.

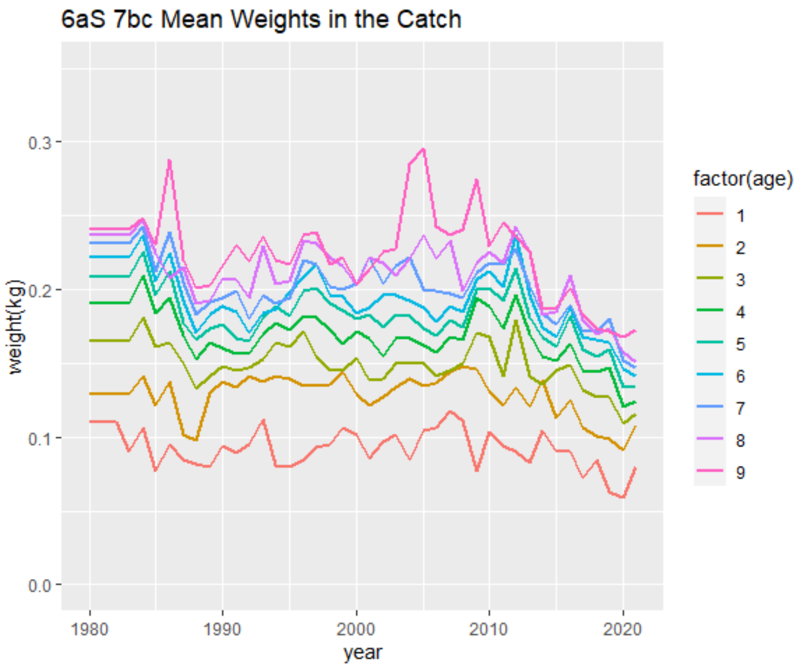


Figure 5.4.1.1. Herring in divisions 6.aS, 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2021). Prior to 1981 weights were fixed.

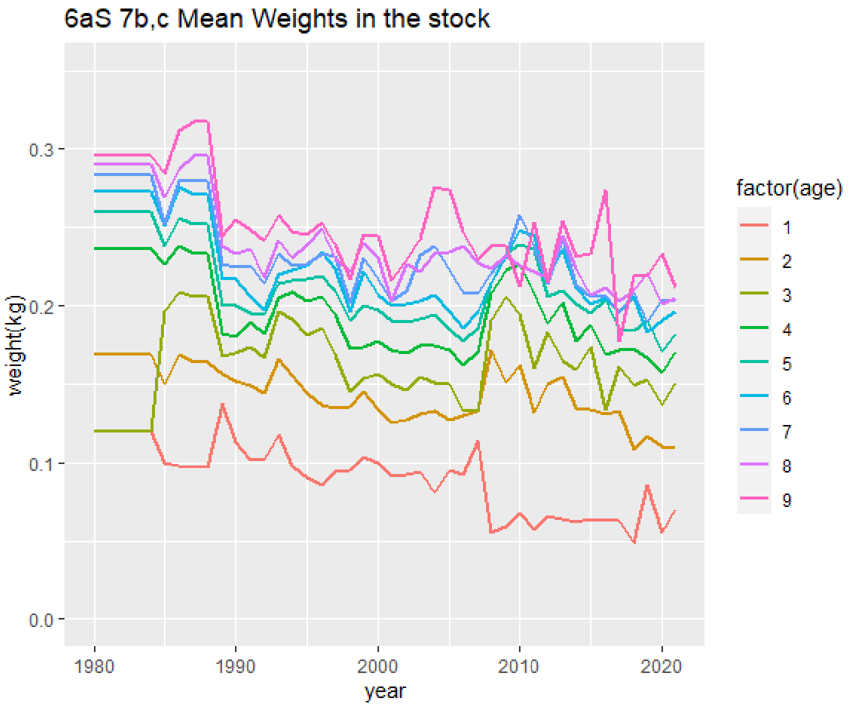


Figure 5.4.1.2. Herring in divisions 6.aS, 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2021). Prior to 1981 weights were fixed.

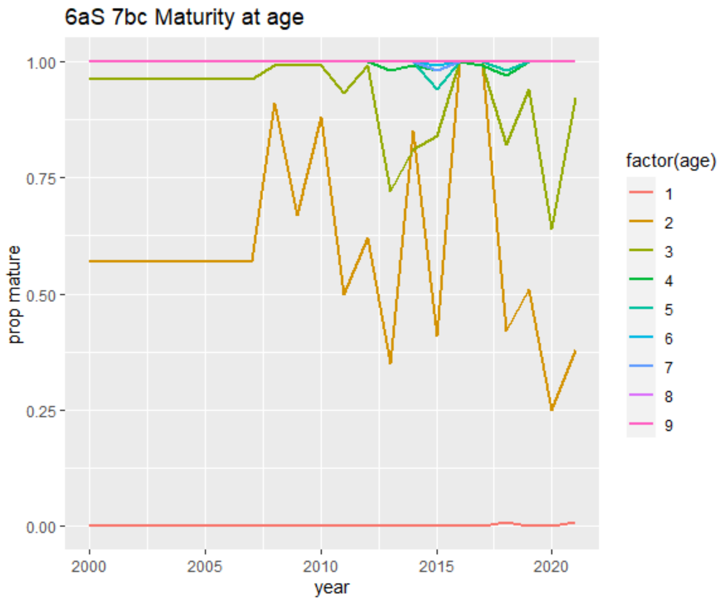


Figure 5.4.2. Herring in divisions 6.aS, 7.b–c. Maturity Ogive.

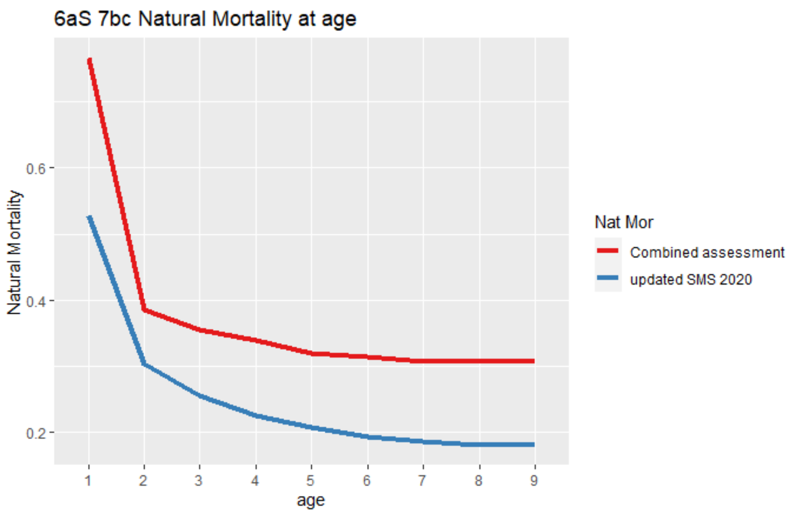


Figure 5.4.3. Herring in divisions 6.aS, 7.b–c. Natural Mortality at age updated at the benchmark in 2022 and the previously used value.

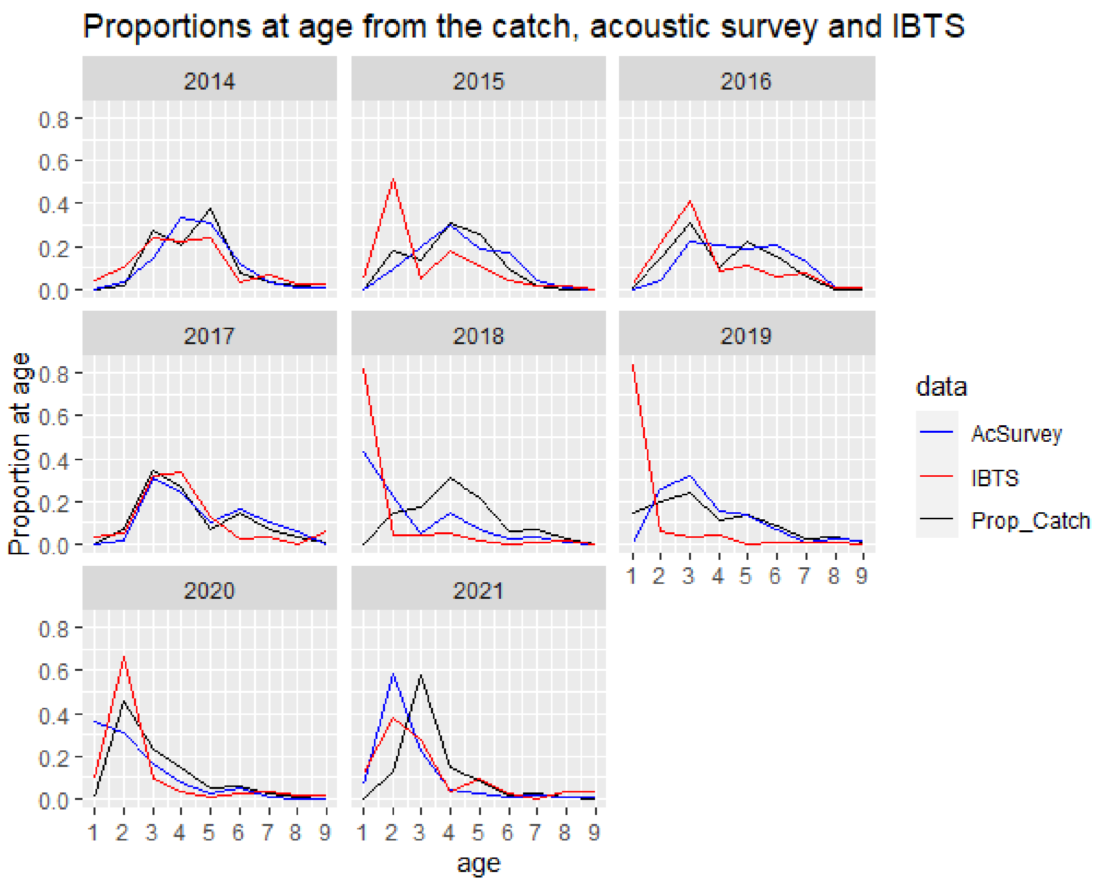


Figure 5.6.1. Herring in divisions 6.aS, 7.b–c. Proportions-at-age in the 6aS, 7.b–c catch and 6aS, 7.b–c Split Malin Shelf acoustic survey (MSHAS) and the IBTS survey 2014-2021.

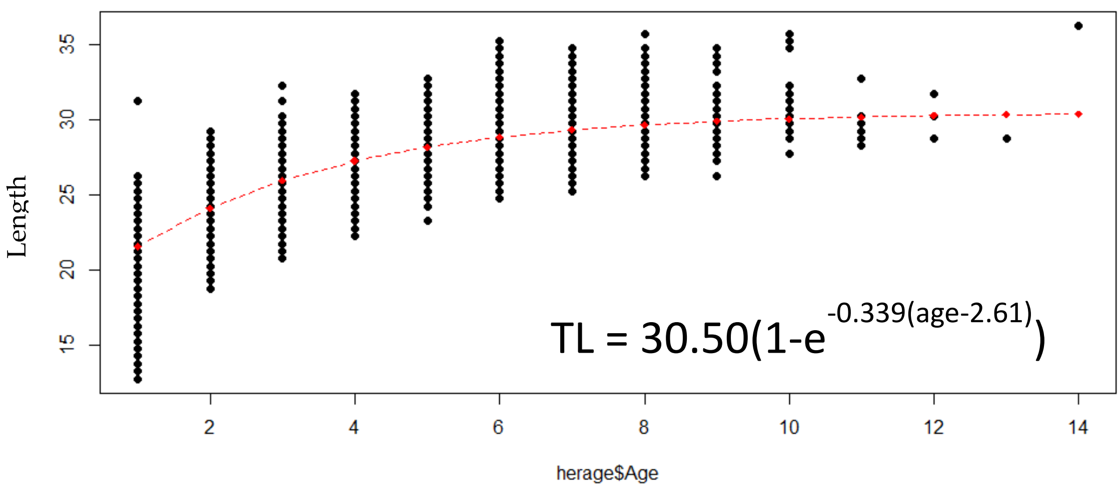


Figure 5.6.2.1. Herring in divisions 6.aS, 7.b–c. Fit of growth curve to length data from commercial catch of herring in 6aS and 7b. n = 594k.

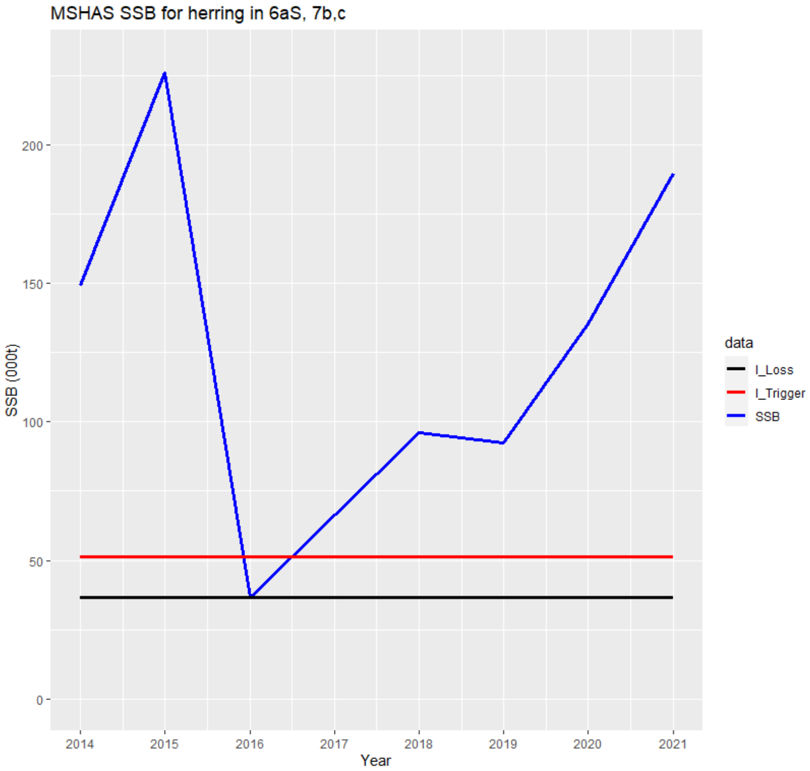


Figure 5.6.2.3.1 Herring in divisions 6.aS, 7.b–c. MSHAS 6aS Split Spawning Stock Biomass (tonnes) by year. Black line shows lowest observed value (I_{loss}); Red line shows 1.4 * I_{loss} ($I_{trigger}$).

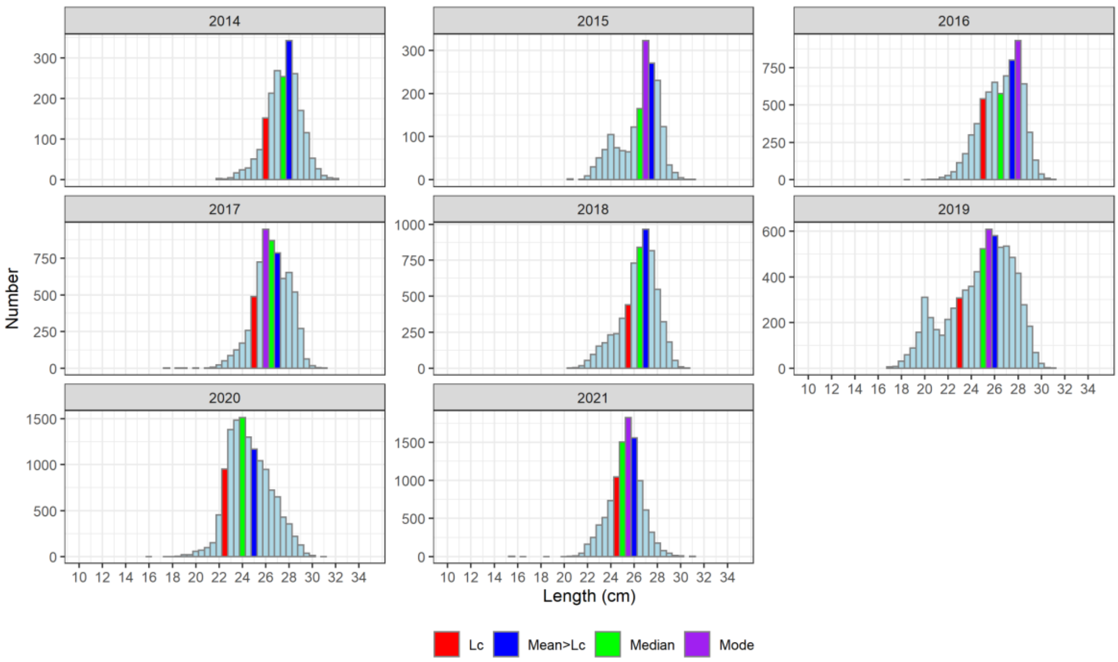


Figure 5.6.2.3.2 Herring in divisions 6.aS, 7.b–c. Length frequency distributions by year showing length at first capture (Lc), Mean length above Lc (Mean>Lc), the median and the mode from catch sampling data.

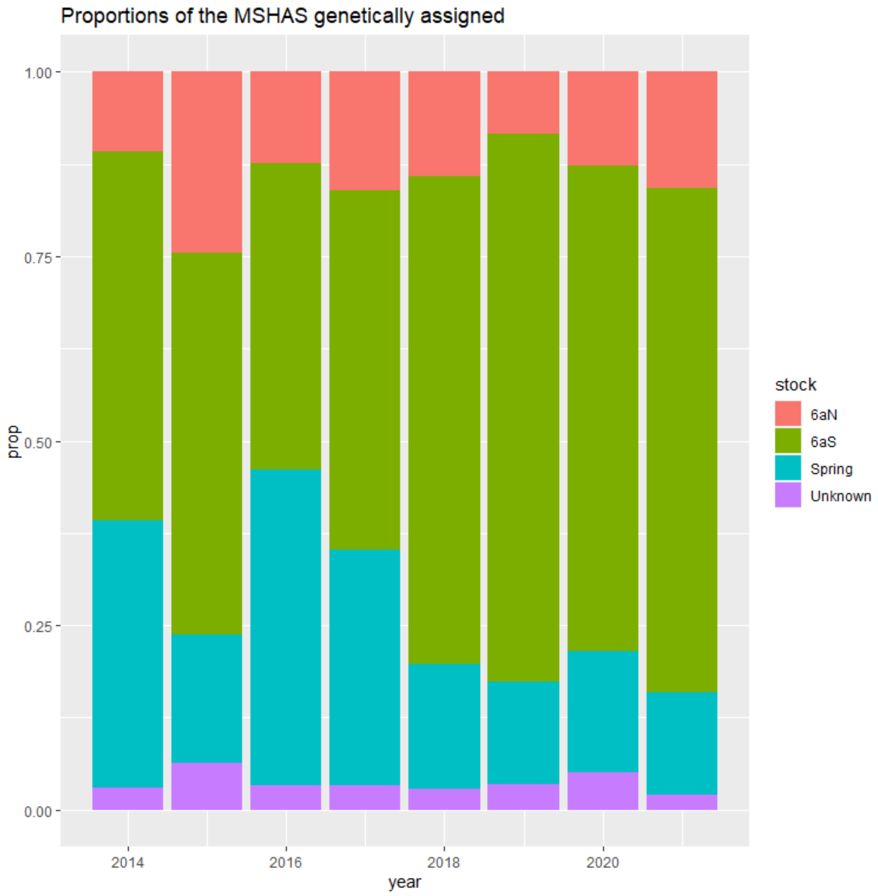


Figure 5.10.1. Herring in divisions 6.aS, 7.b–c. Proportions of the MSHAS genetically assigned.

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. 2021 refers to the 2021–2022 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 2021–2022

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 for 2021 and 2022 was 869 t.

6.1.2 The fishery in 2021–2022

In 2021, the Irish fishery took place in 7.g in Q3 and in 7.g and 7.a.S in Q4 as in previous years. There was also catch taken from 7.j in Q1 2022.

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 September and continued until early November, with over 500 t landed in total. The fishery in 7a.S started in late November and continued until mid-December. In Q1 2022 all of the catch was taken in 7.j.

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 2021 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2021.

The estimated catches from 1988–2021 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 2021–2022 season increased from 132 t in 2020 to 745 t in 2021 (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 <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.

Vessels greater than 50 feet total length are excluded from 7.a.S under local Irish legislation. This has shifted effort onto The Smalls/Celtic Deep ground, south of the 52°N line, in an area which straddles the boundary between the Irish and UK exclusive economic zones (EEZs).

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 2021 two observer trips were carried out during the Celtic Sea herring fishery by the Marine Institute with no discarding observed.

Estimates of discarding from observer trips for the purposes of marine mammal bycatch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014), 1.4% in 2015 in the main fishery and 1.5% in the 7.a.S small boat fishery (Pinfield and Berrow, 2015,), 1.13% in 2016 (O'Dwyer *et al.*, 2016) and 1.19% in 2017 (O'Dwyer and Berrow, 2017). This observer programme was discontinued in 2018; no discard estimates are available for subsequent years.

Since 2015, this stock is covered by the 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 1958-2021. Two winter ringers were the dominant age class in 2020 (61%), and this year class is again dominant in 2021 at 3 ring (61%) (Table 6.2.1.1.). In 2021 the proportion of 2 ringers is 25% followed by 4 ringers at 9%. 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-year 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.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. In 2019 a significant amount of fish less than the MCRS (<20 cm) in the Q3 catches of 7.g led to the early closure of this fishery. Catches in 7.aS Q4 in 2021 did not exhibit a high proportion of below MCRS herring. The length frequencies sampled is very similar between all ICES divisions and quarters.

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 2021. The 23 samples obtained from the monitoring TAC for the main and sentinel fleets in 2021 exceeded the 17 sample minimum advised by ICES in order to provide advice on a similar basis to a commercial fishery.

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 2021, 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 2021–2022 season was carried out from 8 to 28 October 2021, on the Celtic Explorer (O'Donnell *et al*., 2021, https://oar.marine.ie/handle/10793/1732). Geographical coverage was comparable to 2020 (+2%). The herring stock was considered contained within the Celtic Sea survey area with no aggregations observed along the survey periphery, inshore or offshore. The acoustic survey track is shown in Figure 6.3.1.1.

The 2021 survey again consisted of laddered replicate surveys (two broad-scale passes and adaptive mini-surveys) covering the same area. Pass 1, the pass with the largest geographical coverage, provided the biomass and numbers–at–age that were used as input data to tune the assessment model. NASC distribution plots from the broad-scale survey are presented in Figure 6.3.1.2. The herring stock was considered contained within the Celtic Sea survey area with no aggregations observed along the survey periphery, inshore or offshore. Immature herring were observed primarily in coastal waters and were well represented in the survey estimate. Mature herring were observed in two main areas; offshore in a discreet patch and inshore within the confines of Waterford Harbour. In previous years herring were only found inshore.

Herring TSB (total-stock biomass) and abundance (TSN) estimates from the 2021 survey were 9,877 t and 310 million individuals respectively. This is an increase on the low 2020 values of 4,717 t and a total abundance of 67.3 million individuals.

A total of 27 trawl hauls were carried out during the survey in 2021, with twelve containing herring. Herring were observed either within 10 nmi of the coast and made up of immature individuals or as offshore aggregations clustered around one particular area and composed of mature fish. Ten hauls contained immature herring from 1-14% of the catch by weight.

The survey estimate is dominated by 3-wr fish representing over 43% of the total biomass. This 2018 year-class is now considered recruited to the spawning stock and has been successfully tracked across surveys. A significant proportion of 0 wr fish were found in the 2021 survey representing 33% of the total stock biomass and 82% of total stock numbers. The potential of this year class will be monitored through successive summer and autumn surveys.

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 2018 slight increases in mean weights at some ages were observed but subsequent years exhibited further decreases for almost all year classes. In 2021 increases in mean weight can be seen for all 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 increases also seen across all ages in 2021.

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 1.34 over a five–year peel. This is another significant increase compared to the previous update assessments (1.39 in 2021) and it is significantly higher than the 0.2 threshold. Regarding SSB (top panel of Figure 6.6.1.8), 2 of the last 5 peels were out of the 95% CI bounds. This is most likely due to the current low level of the stock, the low level of the survey index (associated with high CV) and the absence of index for the year 2017. 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 2021. 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 2021 and the update assessment in 2022 are presented in Figure 6.6.1.10 and the stock summary in Table 6.6.1.4. The assessment shows SSB is very low and is estimated to be 15 084 t in 2021, still well below B_{lim} (34 000 t). The 2022 assessment shows a similar SSB trajectory to the 2021 assessment but with SSB in 2020 revised downwards. An increase can be seen in 2021. The assessment indicates that the stock has been below B_{lim} since 2016.

The update assessment estimated mean F (2–5 ring) in 2021 to be 0.069, decreasing from the high of 1.2 for 2018 and increasing in from 0.02 in 2020. F was estimated to be above F_{pa} (0.27) and F_{MSY} (0.26) from 2014 until 2019 and above F_{lim} (0.45) from 2015 until 2019. The sharp increase in F in 2016 and 2017 that was seen in the 2021 assessment is again evident in the 2022 assessment.

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 uptick in recruitment for 2020 predicted by the model in the 2021 assessment was revised downwards in 2022. An increase in recruitment can be seen in 2021.

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 (2020). As this SSB value (8 741 t) is below the change-point (16 887 t), the following adjustment is applied.

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

$$Recruitment_{2022} = 380686.6 \times \frac{8740.64}{16886.81} = 197044$$

Interim year catch was taken to be the monitoring TAC (869 t), which has been agreed for 2022. 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 recent 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 2023.

6.7.2 Multiannual short-term forecasts

No multiannual simulations were conducted in 2021.

6.7.3 Yield-per-recruit

No yield-per-recruit analyses were conducted in 2021.

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 2021 are compared with the assessment outputs in 2022 and are shown in the table below. The assessment in 2022 shows SSB revised upward in 2019 but downwards in 2020 and 2021. F is revised down in 2019 and upwards in 2020 and 2021. This can also be seen in the historical retrospective plot in Figure 6.10.1.

	2021 Assessment				2022 Assessment			% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2019	5790	1841	0.77	2019	6168	1841	0.73	7%	-5%
2020	11680	132	0.02	2020	8741	132	0.02	-25%	4%
2021	19278*	869*	0.06*	2021	15084	745	0.07	-22%	11%

*** from intermediate year in STF.**

The 2021 acoustic survey estimate is an increase on the 2020 estimate but is still at a very low level with an SSB estimate of 6,634 t. The survey time-series used in the assessment includes data from 2002 to 2021 (no survey in 2004 and the 2017 survey excluded). The 2018 year class was the strongest encountered in the survey and the catch in 2021. 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 in 2020 and 2021 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. In the Irish Sea, mixing occurs between juvenile winter spawned Celtic Sea fish and autumn spawned Irish Sea fish but the level of mixing is unquantified.

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 2023. F is now below F_{MSY} (0.26) and F_{lim} (0.45). The advice provided for this stock for 2023 is based on the ICES MSY approach, as in recent years. The Council of the European Union set the 2020-2022 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. A maximum catch limitation of 11% of the Irish quota is allocated to this fishery.

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 new ASAP assessment, in terms of recruits per spawner, does not alter this perception (ICES, WKWEST 2015).

Table 6.1.2.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2021. (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

*** 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) 1988/1989–2021/2022. (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
1988/1989	-	-	-	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
2015/2016	-	-	477	16 320	1304	+	-	254	18 355

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
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

*** 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 1970–2021/2022. 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%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%

Year	1	2	3	4	5	6	7	8	9
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%
2018	4%	19%	51%	15%	6%	3%	1%	1%	0%

Year	1	2	3	4	5	6	7	8	9
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%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2021/2022 season.

	7gQ3	7gQ4	7aSQ4	7jQ1 2022
18.5			0.31	
19			0	
19.5			0	
20			0.94	
20.5			0.63	
21		9.98	10.37	
21.5	11.35	19.96	19.49	
22	79.46	72.36	42.44	54.53
22.5	79.46	152.21	77.02	13.63
23	283.79	227.06	100.91	149.95
23.5	289.47	361.80	105.63	149.95
24	368.93	494.04	126.06	218.10
24.5	306.50	441.64	129.83	211.29
25	266.76	281.95	88.65	204.47
25.5	147.57	122.26	46.84	61.34
26	45.41	77.35	17.61	47.71
26.5	34.06	29.94	11.95	34.08
27	5.68	9.98	3.46	20.45
27.5	5.68	7.49	0.95	6.82
28	5.68		0.63	
28.5			0.31	

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2021–2022). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
7.g	2021	3	245	4	194	340	791
7.g	2021	4	273	4	200	925	733
7.aS	2021	4	90	14	600	2494	6654
7.j	2022	1	135	1	100	174	739
Total			**744**	**23**	**1094**	**3933**	**1472**

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
0	0	0	0	0	109	98	1	252.6
1	41	0	125	0	55	22	27.2	
2	117	40	21	6	16	8	32.2	17.2
3	112	48	43	3	27	0.5	5	35.3
4	69	41	40	7	6	0.3	1	3.3
5	20	38	36	5	0	0.1	0	1.2
6	24	7	25	4	0	0	0	0
7	7	6	5	1	-	0	0	0.6
8	17	5	6	1	-	0	0	0.1
9	1	0	0	0		0	0	0
Nos.	408	184	301	27	213	129	67	310

	2014 2015	2015 2016	2016 2017	2017 2018	2018 2019	2019 2020	2020 2021	2021 2022
SSB	48	25	30	4	8	0.3	3.1	6.6
CV	0.59	0.18	0.33	-	0.49	0.55	0.51	0.44

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

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
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298

	1	2	3	4	5	6	7	8	9
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
2006	0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188

	1	2	3	4	5	6	7	8	9
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

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

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
2014	349000	0.5	117300	112100	69400	19800	23600	6800	5

year	value	CV	2	3	4	5	6	7	Sample Size
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

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	206015	279910.7	0.130	408556
1959	15086	197957	324109.2	0.112	1577690
1960	18283	189253	255888.9	0.126	362961
1961	15372	159919	221516.5	0.119	393717
1962	21552	156601	253026.9	0.192	843980
1963	17349	145174	207444.2	0.153	402905
1964	10599	165103	288344.5	0.096	1381900
1965	19126	169927	239714.9	0.139	416515
1966	27030	165194	265757.7	0.199	735267
1967	27658	159041	260064.8	0.225	768497
1968	30236	162296	274660.7	0.243	899711
1969	44389	141929	229285.7	0.362	461941
1970	31727	107098	165717	0.331	248671
1971	31396	97961.8	192767.7	0.453	821309
1972	38203	85876.7	148540.5	0.559	279417
1973	26936	64565.1	118059.3	0.518	325406

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
1974	19940	50061.5	86055.94	0.495	160325
1975	15588	39631.1	73729.2	0.517	202064
1976	9771	36803.9	68499.4	0.388	226223
1977	7833	37415	64383.57	0.291	184803
1978	7559	36168	59015.88	0.268	145587
1979	10321	36021.9	70583.65	0.425	278555
1980	13130	33005.8	59941.31	0.544	166477
1981	17103	36516.9	86692.73	0.837	464972
1982	13000	57440	126449.6	0.458	724433
1983	24981	76388.2	158892.5	0.556	784556
1984	26779	78994.4	148574.7	0.472	666197
1985	20426	85081.3	153927	0.319	642488
1986	25024	93072.5	170578.9	0.366	654169
1987	26200	105472	211262.6	0.389	1200230
1988	20447	108978	170626	0.232	475514
1989	23254	95703.8	164342.7	0.285	575732
1990	18404	89224	147151.9	0.248	503380
1991	25562	71049.2	111654.8	0.381	207415
1992	21127	70955.4	152792.7	0.485	962480
1993	18618	73640.4	119453	0.326	359813
1994	19300	80405.3	151766.9	0.322	768796
1995	23305	81906.9	149916.5	0.388	722078
1996	18816	72427.7	116557.3	0.309	352309
1997	20496	59883.5	104813.8	0.408	372858
1998	18041	47983.6	83141.82	0.446	248780
1999	18485	41993.8	87829.46	0.624	486666
2000	17191	42058.1	87380.49	0.633	477218
2001	15269	41689.8	83394.23	0.534	493295
2002	7465	53818.3	99795.25	0.210	541125

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
2003	11536	42832.6	65097.02	0.307	141584
2004	12743	39041.1	70912.93	0.394	361343
2005	9494	54401.2	116887	0.309	1057130
2006	6944	67023.5	102609.6	0.133	355901
2007	7636	69764.4	116908.3	0.132	723893
2008	5872	82686.6	116763.7	0.079	294385
2009	5745	94170.2	160941.2	0.076	1011860
2010	8370	102117	160671.2	0.101	751592
2011	11470	110331	176543.3	0.130	956829
2012	21820	100126	155754.2	0.253	631242
2013	16247	88219.4	128422.2	0.213	365882
2014	19574	68224.7	105261.3	0.322	304081
2015	18355	44041	70638.95	0.460	175780
2016	16318	25999.6	49273.82	0.766	204642
2017	10767	11791	24166.33	1.176	60833.1
2018	4418	6081.53	13009.89	1.165	51314
2019	1841	6168	14465.95	0.725	180019
2020	132	8740.64	13607.22	0.023	108106
2021	745	15084.2	26967.53	0.069	260375

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

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197044	0.767	0.5	0.5	0.5	0.05	0.02	0.06
2	120316	0.385	1	0.5	0.5	0.09	0.21	0.09
3	32354	0.356	1	0.5	0.5	0.11	0.29	0.11
4	34559	0.339	1	0.5	0.5	0.13	0.29	0.12
5	3844	0.319	1	0.5	0.5	0.13	0.29	0.13
6	1079	0.314	1	0.5	0.5	0.14	0.29	0.15

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
7	774	0.307	1	0.5	0.5	0.16	0.28	0.16
8	196	0.307	1	0.5	0.5	0.17	0.28	0.16
9	2011	0.307	1	0.5	0.5	0.16	0.08	0.17

2023								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197043.9	0.767	0.5	0.5	0.5	0.05	0.02	0.06
2	-	0.385	1	0.5	0.5	0.09	0.21	0.09
3	-	0.356	1	0.5	0.5	0.11	0.29	0.11
4	-	0.339	1	0.5	0.5	0.13	0.29	0.12
5	-	0.319	1	0.5	0.5	0.13	0.29	0.13
6	-	0.314	1	0.5	0.5	0.14	0.29	0.15
7	-	0.307	1	0.5	0.5	0.16	0.28	0.16
8	-	0.307	1	0.5	0.5	0.17	0.28	0.16
9	-	0.307	1	0.5	0.5	0.16	0.08	0.17

2024								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197043.9	0.767	0.5	0.5	0.5	0.052	0.019	0.059
2	-	0.385	1	0.5	0.5	0.088	0.212	0.089
3	-	0.356	1	0.5	0.5	0.108	0.293	0.108
4	-	0.339	1	0.5	0.5	0.126	0.293	0.124
5	-	0.319	1	0.5	0.5	0.132	0.293	0.133
6	-	0.314	1	0.5	0.5	0.144	0.293	0.147
7	-	0.307	1	0.5	0.5	0.157	0.278	0.159
8	-	0.307	1	0.5	0.5	0.170	0.279	0.163
9	-	0.307	1	0.5	0.5	0.162	0.081	0.166

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

Rationale	F_{bar} (2022)	Catch (2022)	SSB (2022)	Fbar (2023)	Catch (2023)	SSB (2023)	SSB (2024)
Catch(2023) = Zero	0.058	869	19348.6	0.00	0.00	22746	25875
Catch(2023) = 2022 TAC	**0.058**	**869**	**19348.6**	**0.046**	**869**	**22319**	**24746**
Fbar(2023) = Fmsy	0.058	869	19348.6	0.260	4475	20454	20049
Fbar(2023) = Fpa	0.058	869	19348.6	0.260	4475	20454	20049
Fbar(2023) = Flim	0.058	869	19348.6	0.450	7150	18953	16914
Fbar(2023) = F2022	0.058	869	19348.6	0.058	1091	22209	24390
Fbar(2023) = Fmsy * SSB2022 /MSY Btrigger	0.058	869	19348.6	0.093	1725	21891	23546

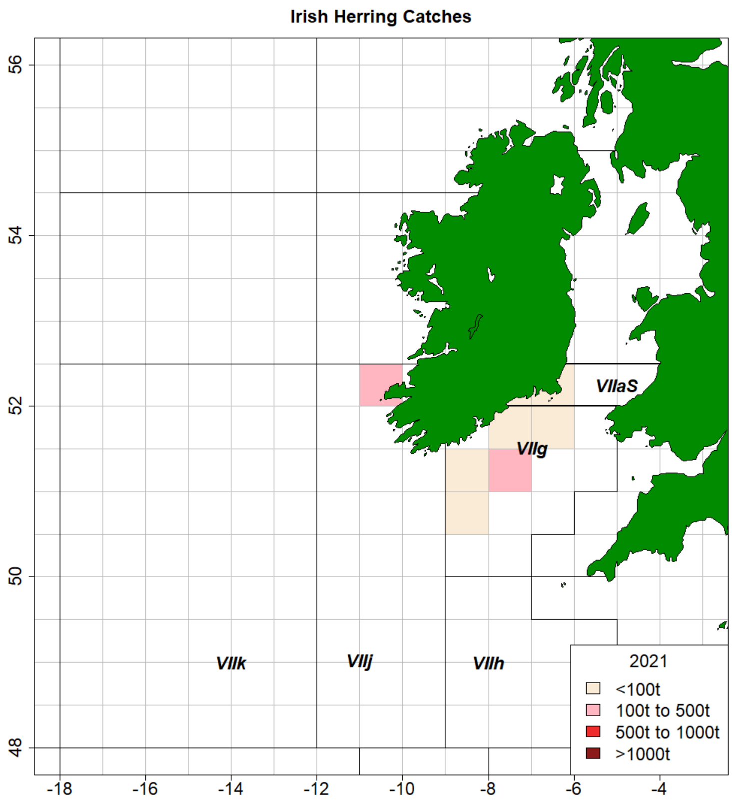


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2021/2022.

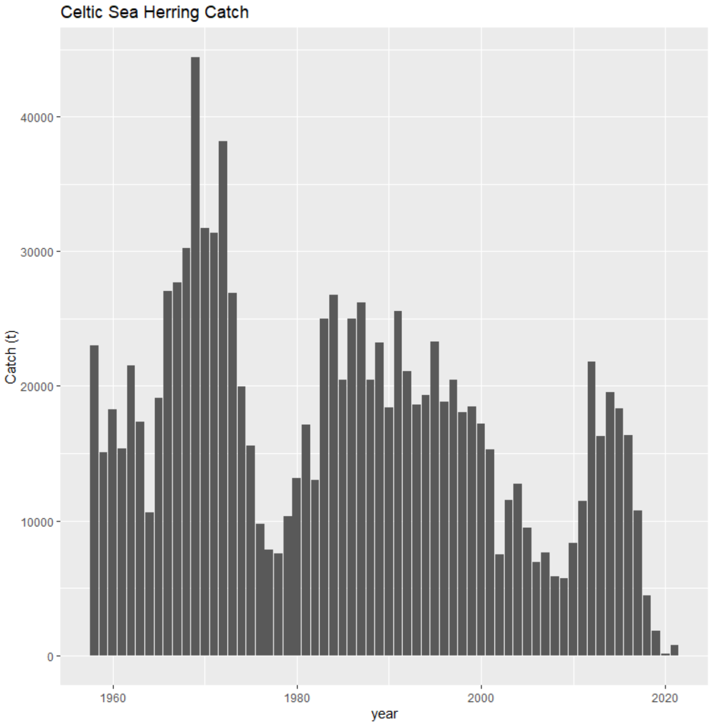


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

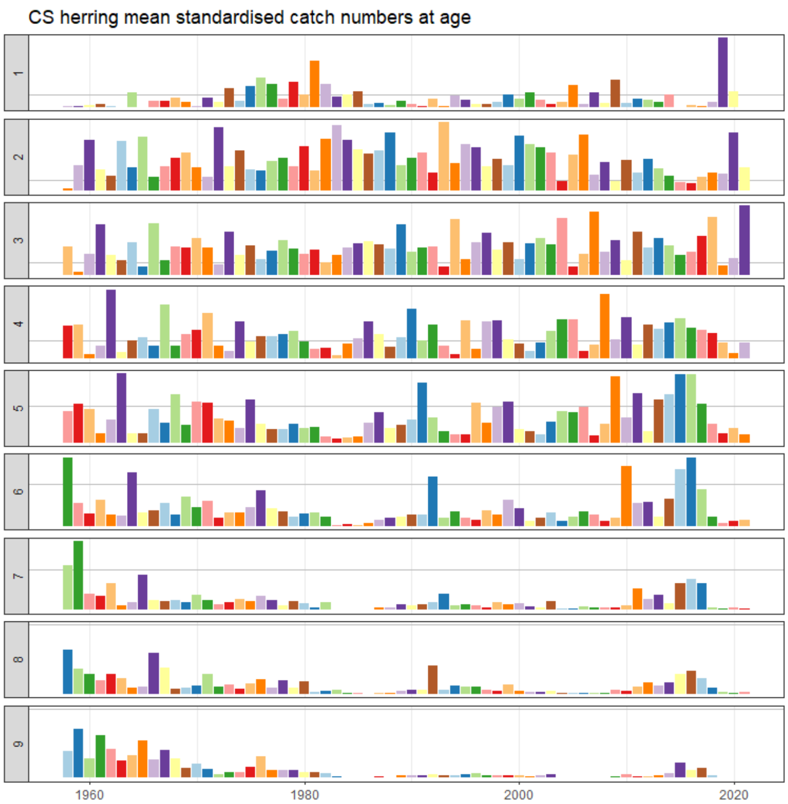


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardized by yearly mean. 9-wr is the plus group. Age in winter rings.

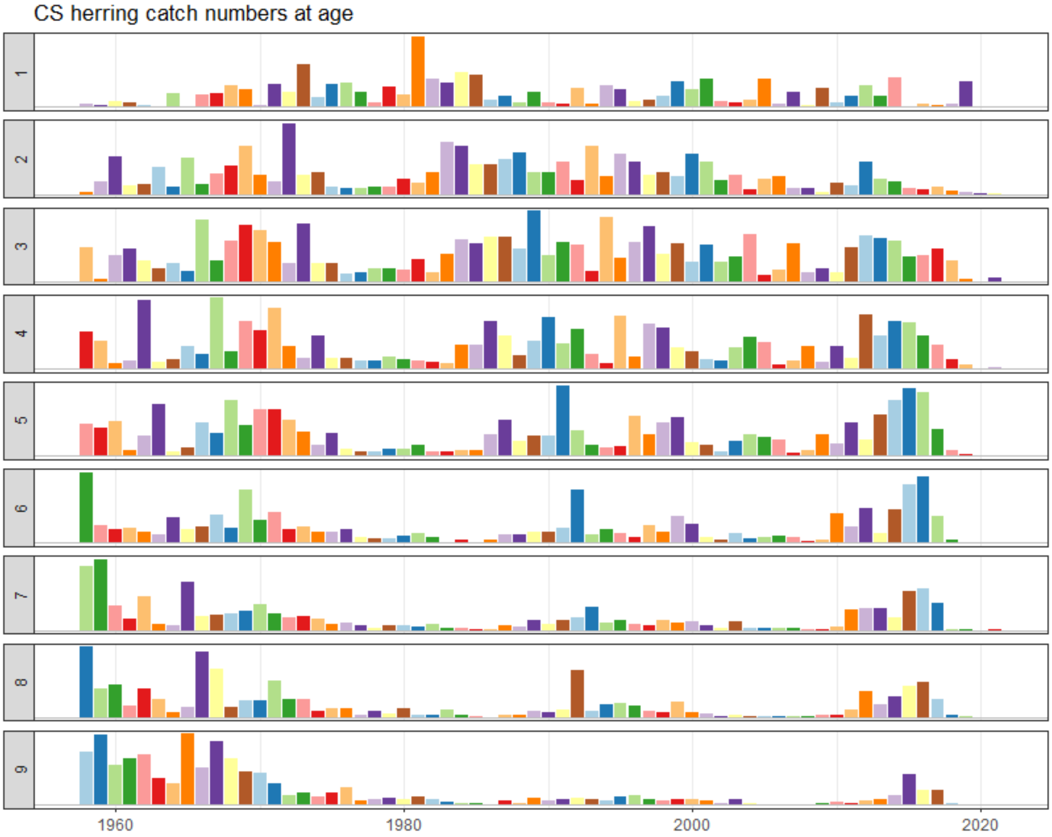


Figure 6.2.1.1 (cont.) Herring in the Celtic Sea. Catch numbers-at-age (unstandardized). 9-wr is the plus group. Age in winter rings.

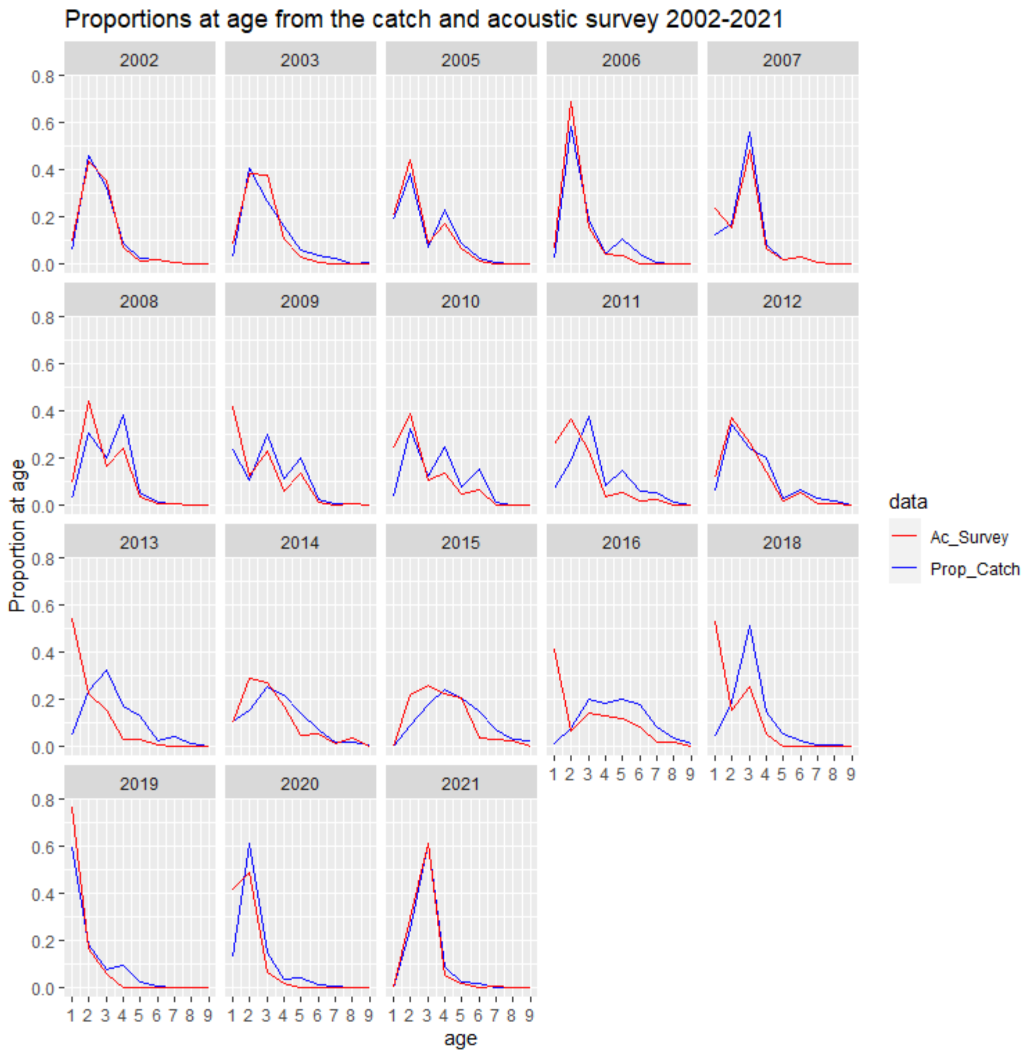


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9 wr) and the commercial fishery (1–9 wr) by year. Age in winter rings.

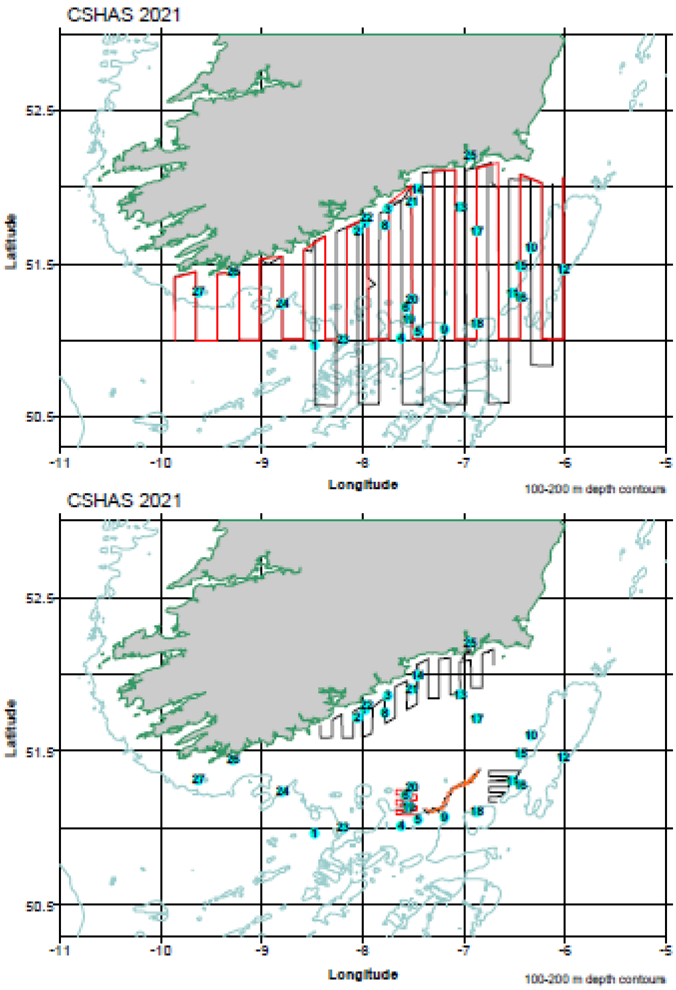


Figure 6.3.1.1. Herring in the Celtic Sea. Top panel: Core replicate acoustic survey effort cruise tracks and numbered haul stations. (Pass 1: black track, Pass 2: orange track). Bottom panel: Adaptive and scouting survey effort mini surveys 1-6. Replicate coverage shown as orange track.

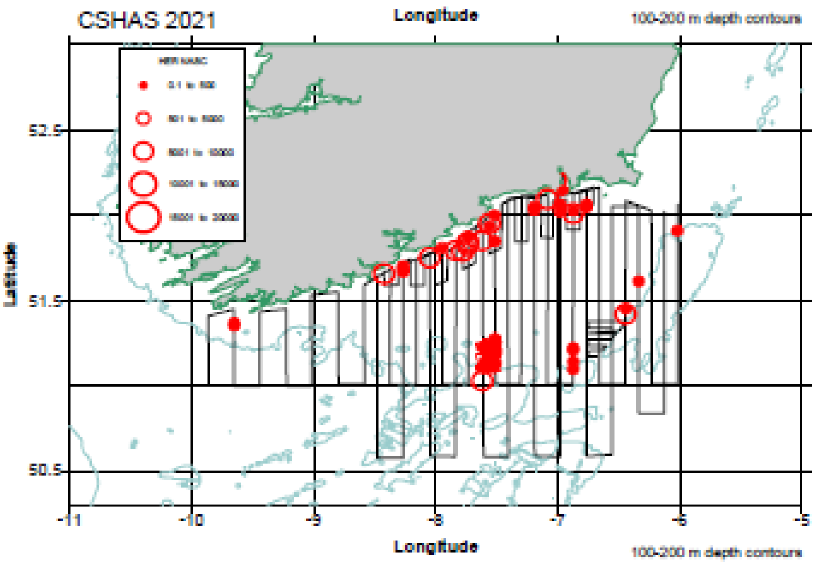


Figure 6.3.1.2. Herring in the Celtic Sea. NASC (Nautical area scattering coefficient) distribution plot of the distribution of herring in 2021 from combined survey effort.

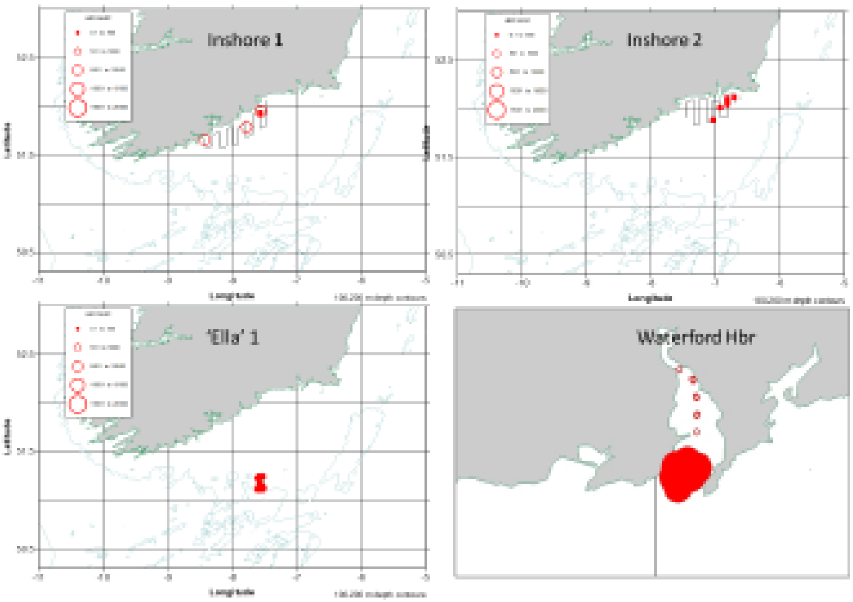


Figure 6.3.1.3. Herring in the Celtic Sea. NASC (nautical area scattering coefficient) plot of the distribution of herring in 2021 in the adaptive mini-surveys.

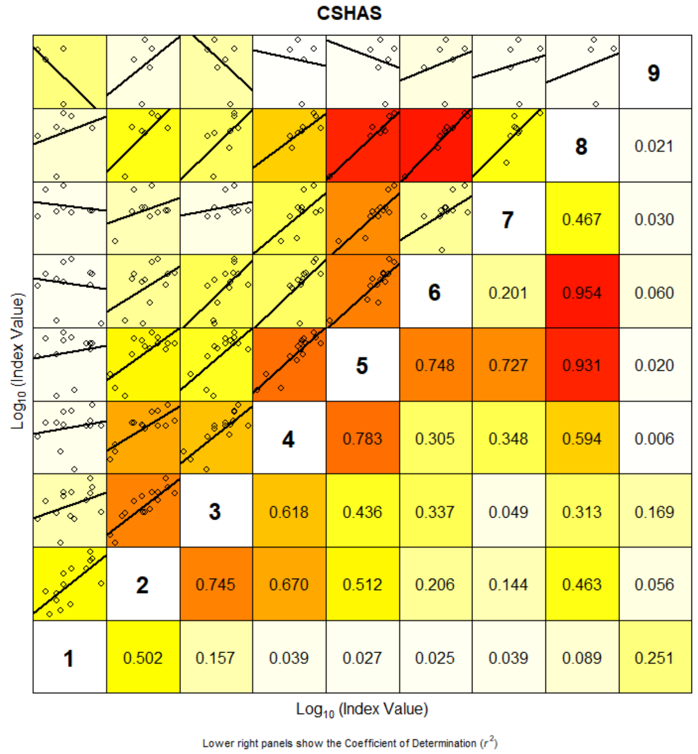


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

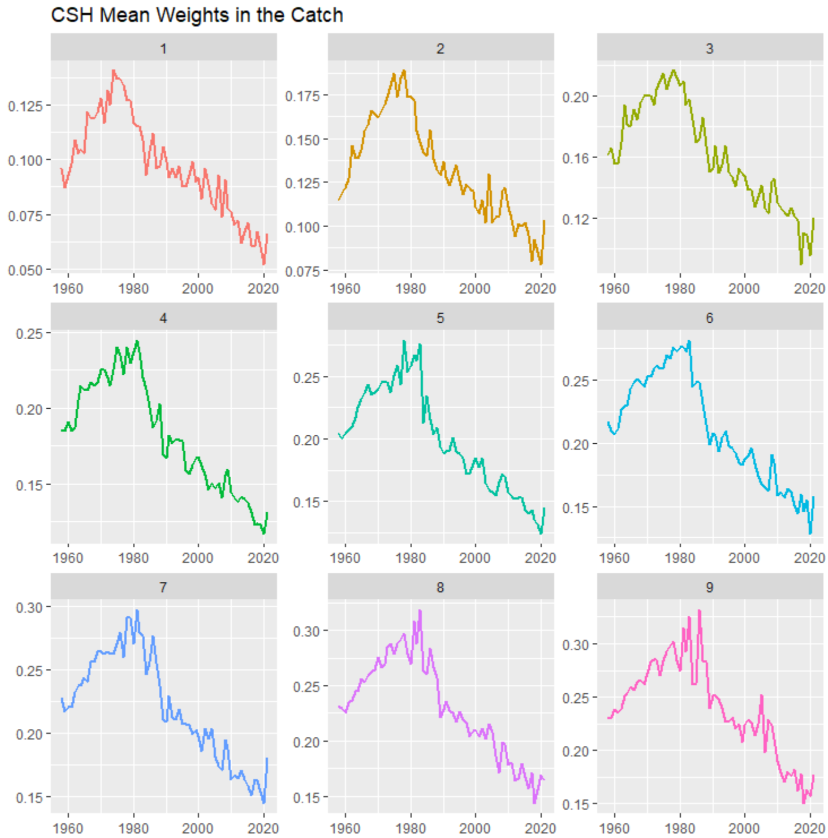


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2021 for 1–9+.

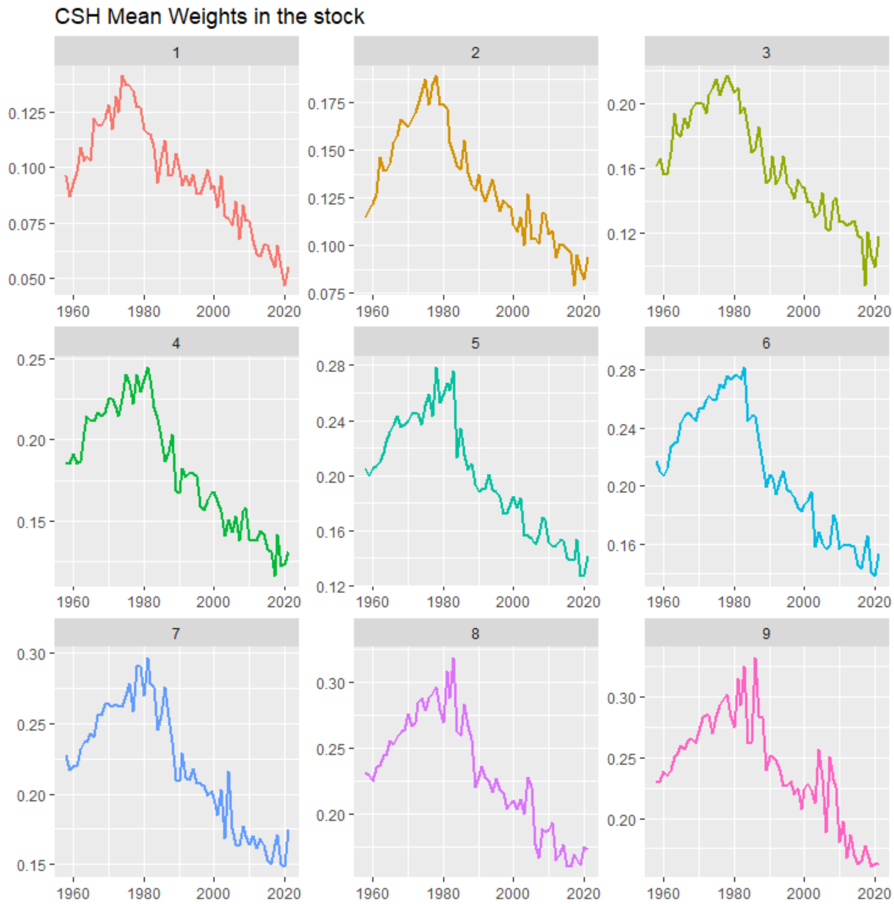


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2021 for 1–9+. Age in winter rings.

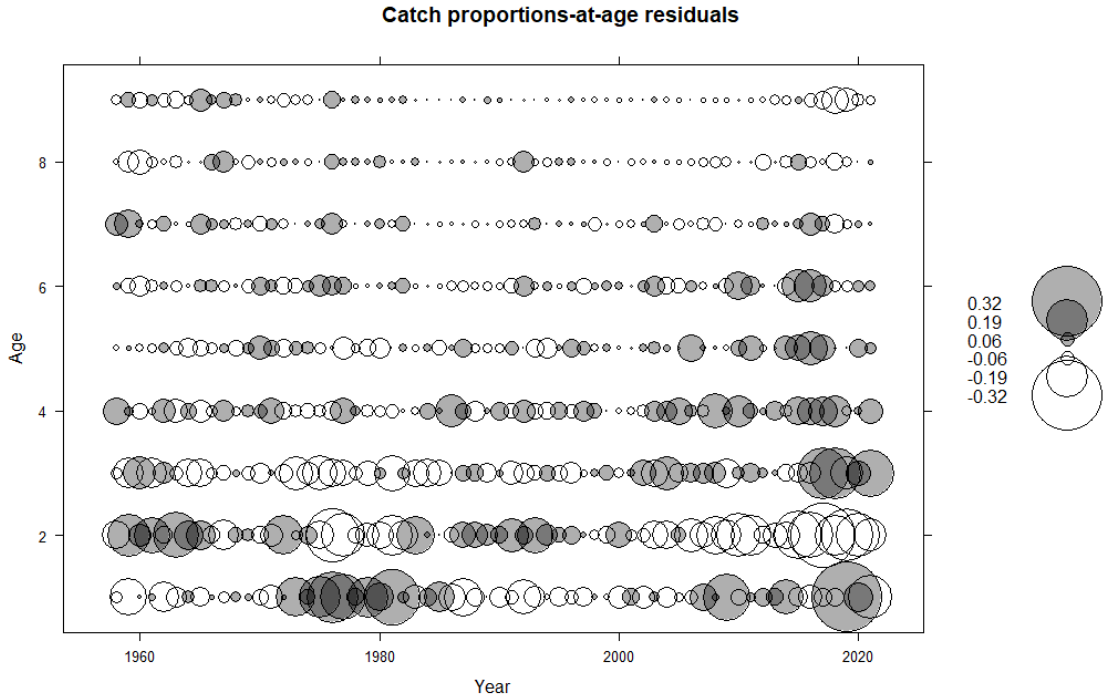


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

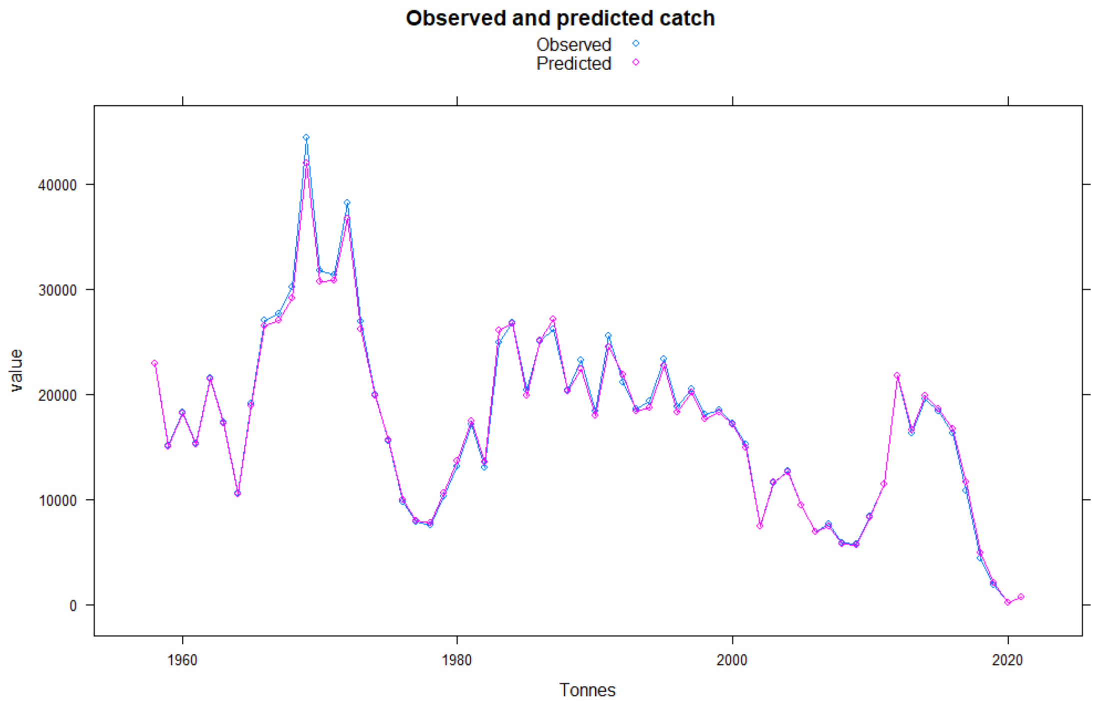


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

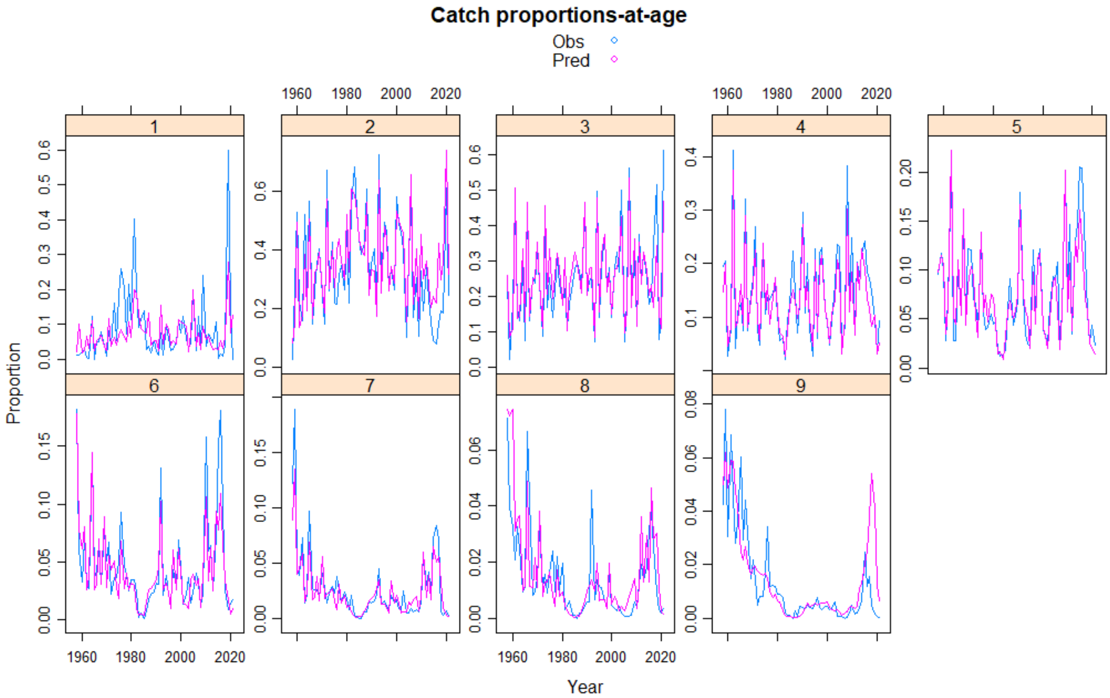


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

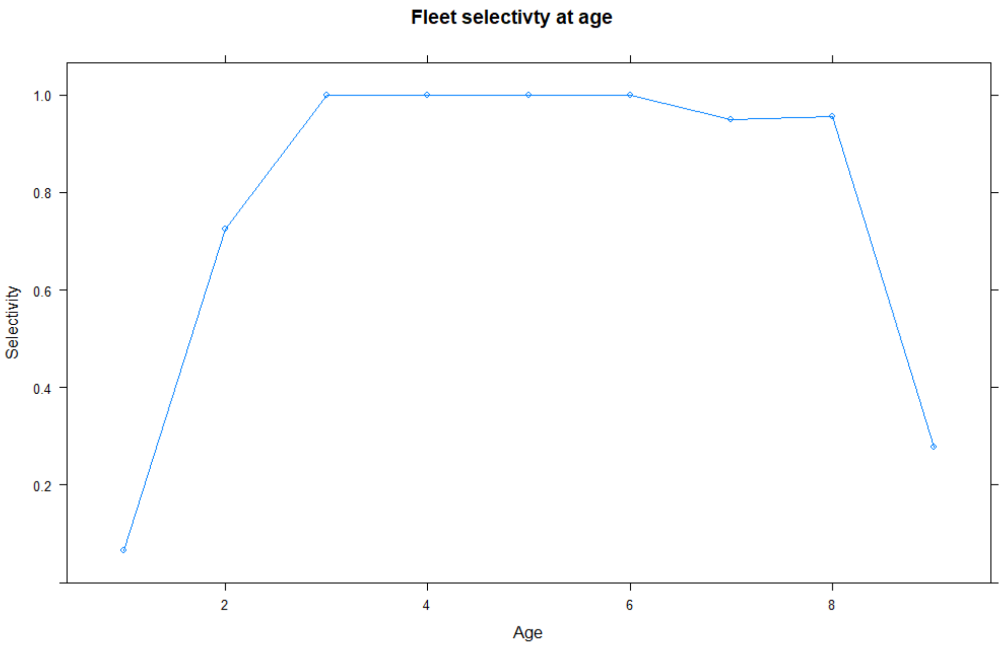


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

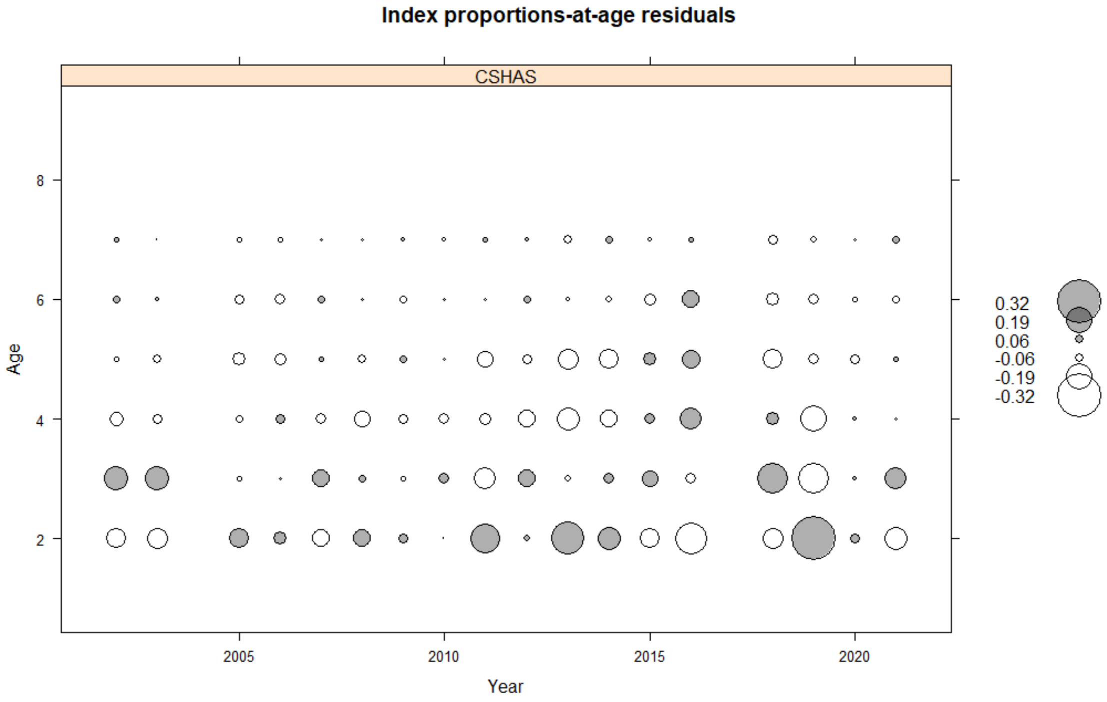


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

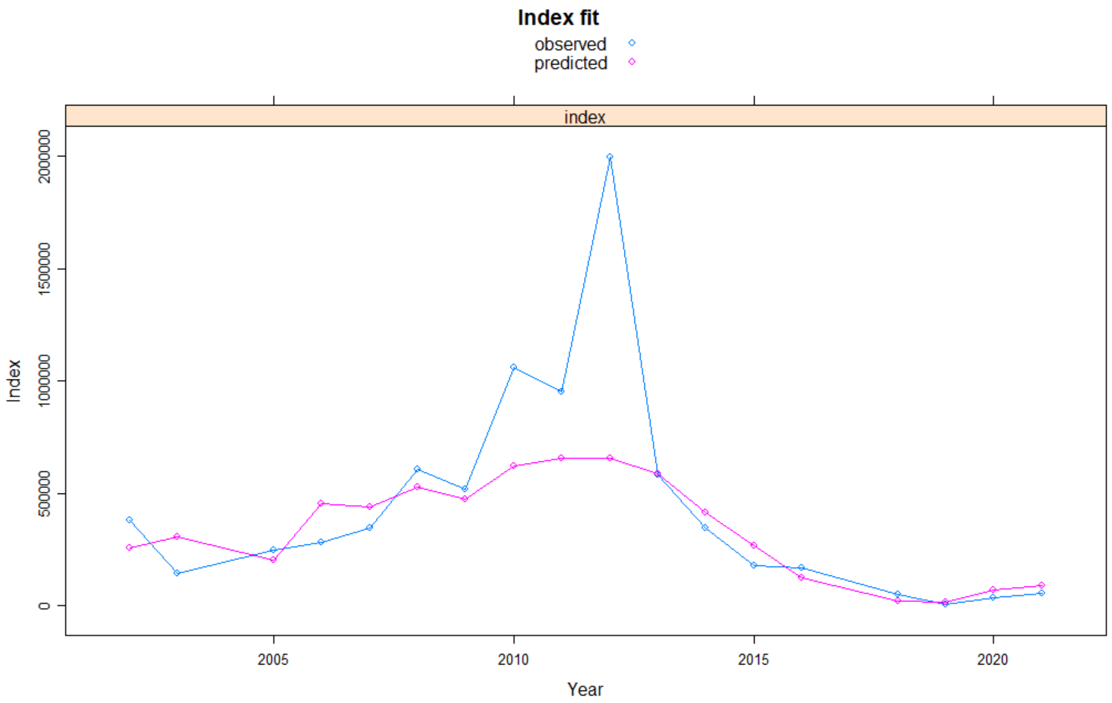


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

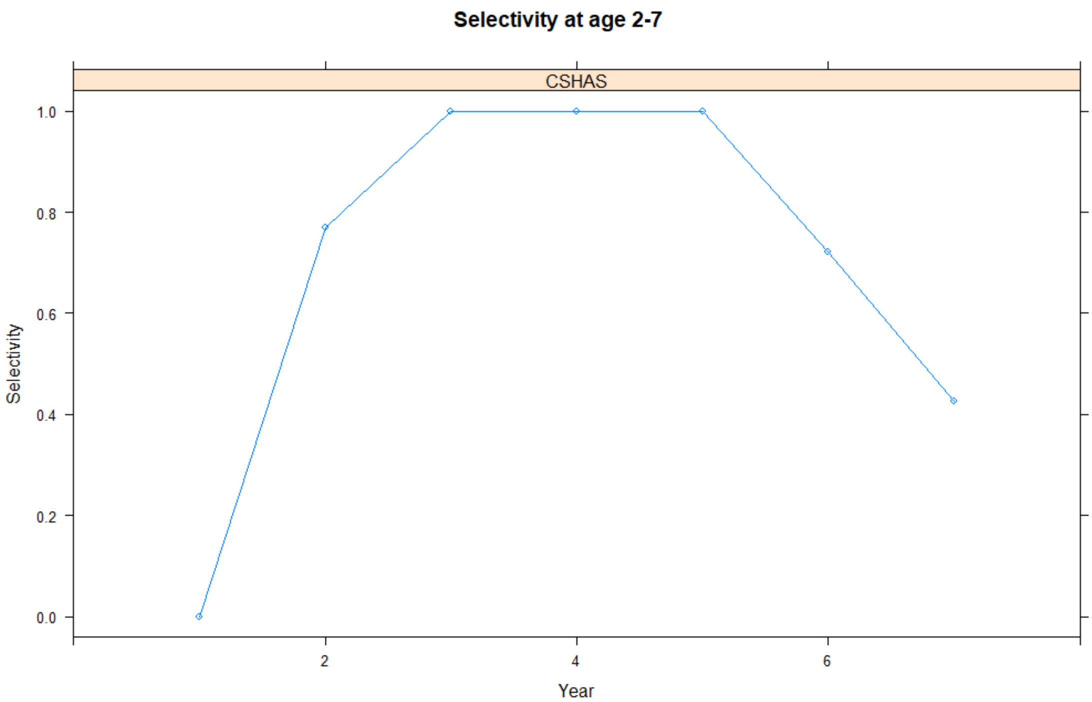


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

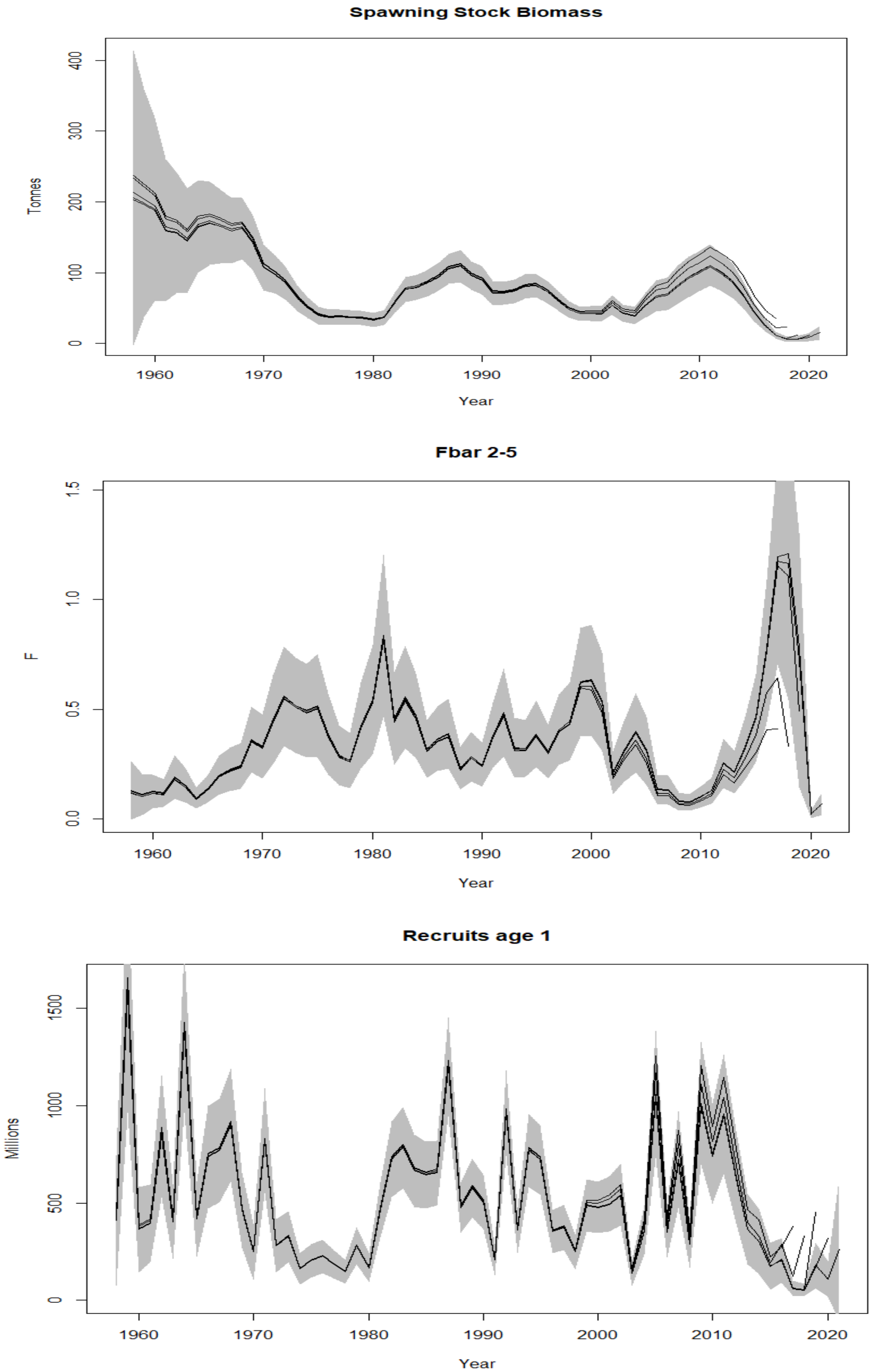


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), and Recruitment (bottom). The shaded area is the 95% confidence interval.

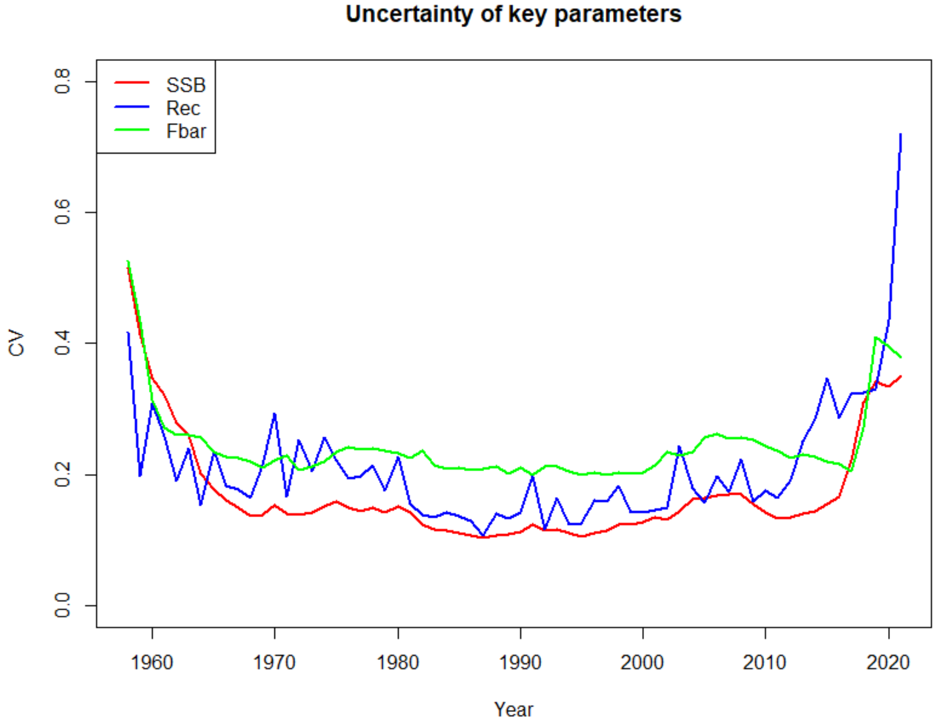


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

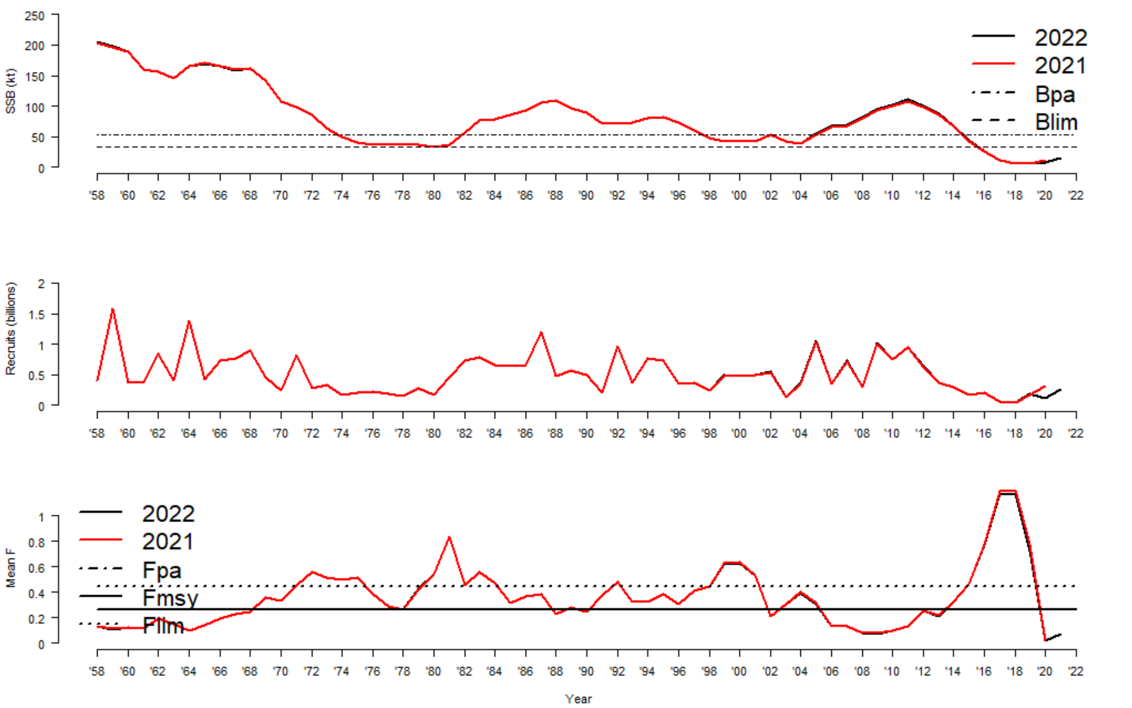


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top), Recruitment (middle) and Mean F2–5 (bottom)

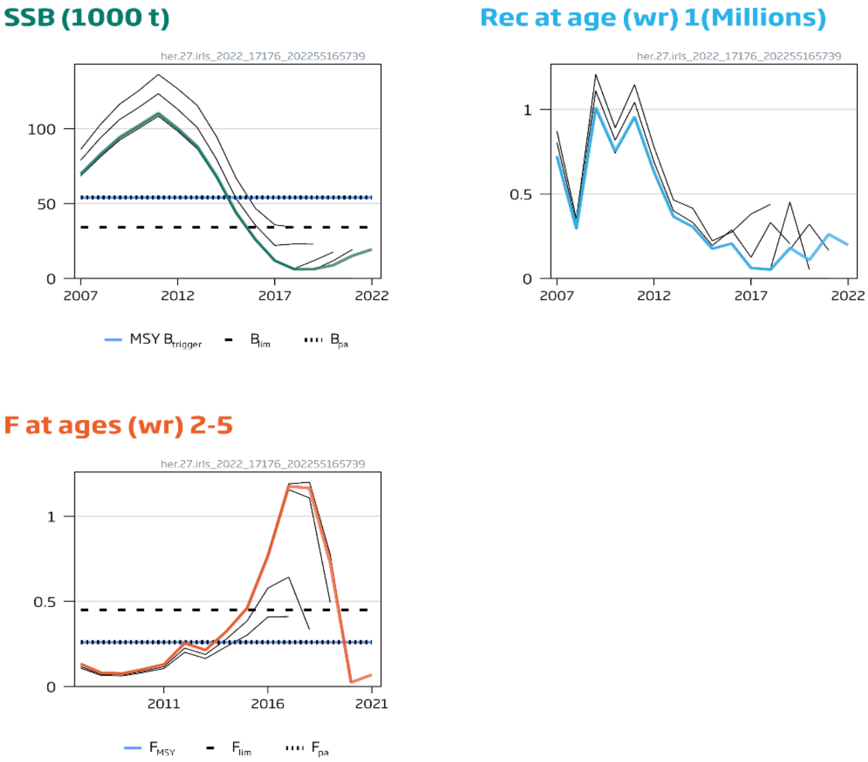


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospectives from the final assessments 2016–2022

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" 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.

7.1 The Fishery

7.1.1 Current advice

ICES advised that when the MSY approach is applied, catches in 2021 should be no more than 7341 tonnes. ICES advised that when the MSY approach is applied, catches in 2022 should be no more than 8455 tonnes.

7.1.2 The fishery in 2021

The catches reported from each country for the period 1987 to 2021 are given in Table 7.1.1, and total catches from 1987 to 2021 in Figure 7.1.1. Reported international landings in 2021 for the Irish Sea amounted to 7208 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2021 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 55 t in 2021.

7.1.3 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.

7.1.4 Changes in fishing technology and fishing patterns

UK Northern Irish and Irish pelagic pair and single trawlers take the majority of catches during the 3rd and 4th quarters. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 3rd or 4th quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, peaking at ~171 t in 2009, there was less than 10 t landings attributed to this fishery in 2018, no catches in 2019, 33 t in 2020 and 55 t in 2021. 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 be 10% 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 2021. Sampling was carried out on landings at fish processing factories for both Irish, Northern Irish vessels and UK English 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 2021 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 2021, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 34 in 2021, 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 2021 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, a larger scale 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 conduct future assessments only 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 2021 was carried out over the period 29th 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). There was an area reduction in the survey due to logistical issues with vessel access to the survey area. 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 2021 were observed on the western sides of the Isle of Man (Figure 7.3.1). Local areas of high abundance of herring were also observed on the known spawning banks toward the county Down coast. The survey followed the methods described in the ICES WGIPS International Pelagic Survey Manual. Sampling intensity was high during the 2021 survey with 31 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 2021 the survey was conducted from the 3rd to 6th of October. The spawning stock biomass was estimated to be 57.1kt, this is a increase from 2020 (47.9kt) but remains 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 2021 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 2016–21 (Figure 7.6.24). The retrospective bias from the model is low.

Comparison with previous assessments

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. The assessed historic SSB appears to be sensitive to addition of a new year of data resulting in revision during the recent time period.

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 (2010–2019) replaced recruitment for 1-ringers in 2021 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 2022–2024, but is predicted to decrease if fishing at F_{MSY}. SSB with zero catch is forecast to increase (+14%). This is largely in response to maturation of the 2022 and 2023 year classes, which will contribute more than 53% of the SSB in 2024.

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 ($\sigma = 0.201$, 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 Fp_{05} 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. 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. Most of the mixing occurs 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 2021 to be the highest in 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.

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
Ireland	119	0	82	200	1299	1317	1957	753
UK	5089	4868	4245	3696	5504	5061	5969	6455
Unallocated		22						
Total	5208	4891	4327	3896	6804	6378	7927	7208

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
14															-					-				16			
14.5															-					-				0	11		
15															-					15				31	50	11	
15.5					10								16		-	93				14				54	74		
16	21	21	17		19	12	9					2			-	107	30		8	0		109		47	233		
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165		84	14		174		176	401	106	
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
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
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
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
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
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
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
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
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

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
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
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
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
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
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
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
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
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
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
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
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
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
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
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			
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
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 2021.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	784	-	-	-
	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	403	7	1840	350
	UK (N. Ireland)	5576	24	2715	1180
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	0	0	0
4	Ireland	350	3	789	150
	UK (N. Ireland)	95	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.3.1. Herring (Clupea harengus) in Division 7.a North of 52°30'N (Irish Sea)Herring in Division 7.a North (Irish Sea).Summary of acoustic survey AC(7.aN) information for the period 1989–2021. 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	-	-	-

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
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 15/09–16/09 28/09–29/09	34 437	0.41	21 593	0.41	281 000	0.07
2005	Area 7.a(N)	29/08–14/09	36 866	0.37	31 445	0.42	141 900	0.10

Year	Area	Dates	herring bio-mass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
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

[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
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

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

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
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
1	7991	12176	15260	5708
2	22903	23112	29059	35337
3	15657	11083	20869	13744
4	12364	6776	4099	3033
5	3240	6661	3355	1163
6	538	1360	3200	976
7	391	182	777	140
8+	50	194	209	26

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

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

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
1	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
3	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
5	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
7	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

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
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
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
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
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
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
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
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
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

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
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
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
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
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
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
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
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
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

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
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
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
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
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
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
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
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
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

TABLE 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	8	8	1980	2020	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	2021-03-18 19:44:30

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. However, reported catches in 2021 were 180 tonnes, and the TAC was 583 t in 2021 (Table 12.1).

8.2 Division 7.e.f

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.

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 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 2021, landings amount to 85 tonnes. (Figure 12.1).

8.3 Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1700 t in 1976, declining gradually to very low levels by the late 1980s. More recently there was a sudden peak pulse of Dutch landings of 8000 t in 2002, declining to low levels since (Figure 12.2, Table 12.3). Data before 2005 were taken from the FISHSTAT database, and data from Spain updated. Data for later years were adjusted, where possible, with data supplied by working group members and from ICES official and preliminary catch statistics.

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.

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**	
Scotland	163	54	266	-	90	119	21	0	0	0	0	0	0	0	180	
Other UK	458	622	488	301	111	184	-	-	-	-	-	-	-	-	-	
Unallo-cated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agreed TAC	800	800	800	720	720	720	648	648	583	583	583	583	583	583	583	
Total	621	676	754	301	201	303	21	0	0	0	0	0	0	0	180	

***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*
UK	377	165	159	193	163	315	199	66	189	106	78	130	185	218	162	274	435	268	204	22	11	8	11	4
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
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
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
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
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
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	5

***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*
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
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
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
UK	14	12	81	0	5	21	47	198	76	115	29	8	23	78	113	136	20	111	227	28	3	4	1	66
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
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
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	85

***Preliminary data**

Table 12.4. Stocks with limited data. Landings of herring in Subarea 8.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020*	2021*
France	50	82	22	7	5	5	4	12	3	1	1	2
Netherlands	502	222	-	-	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-
Spain	38	54	2	-	-	-	-	-	-	-	-	-
UK	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	1	1	-	-	-
Total	590	358	24	7	5	5	4	13	13	1	1	2

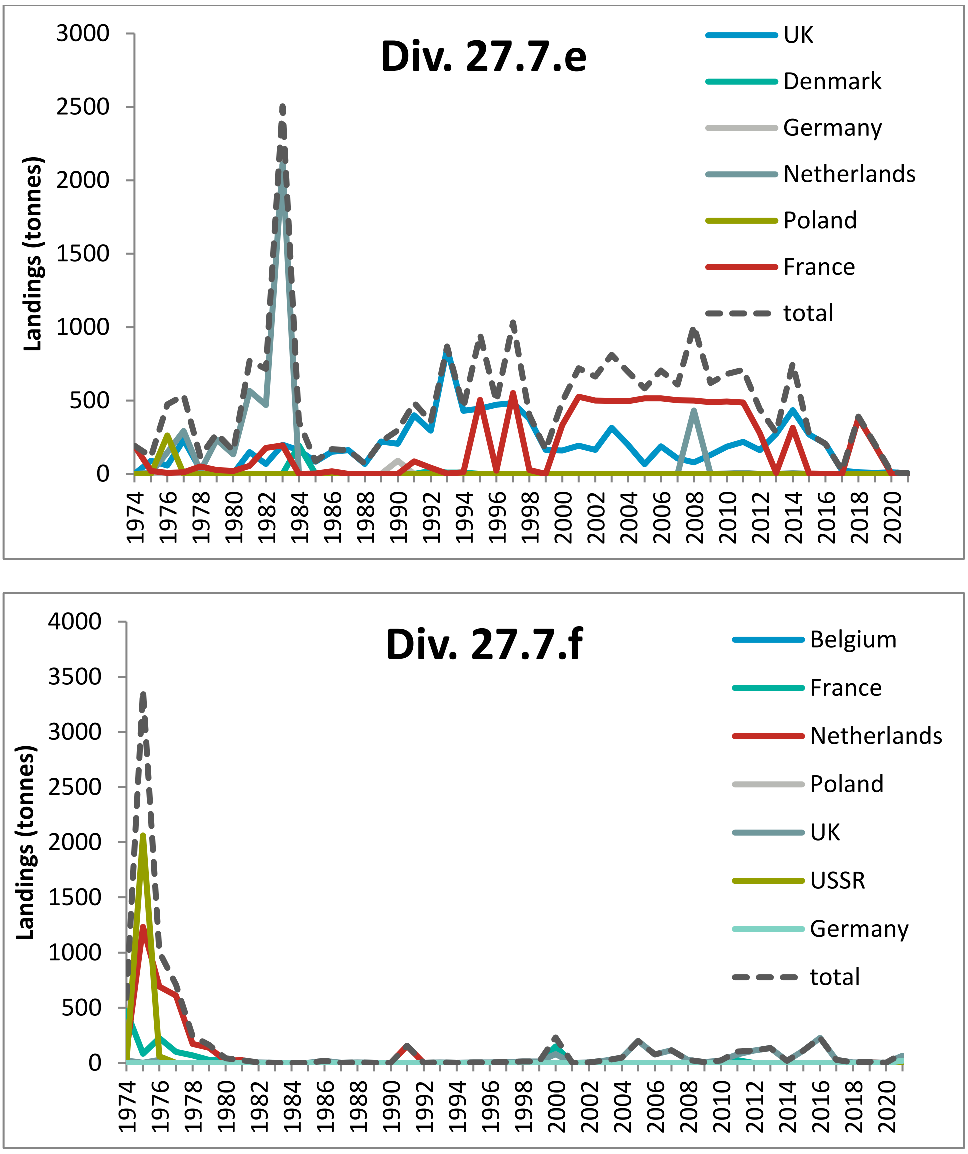


Figure 12.1. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

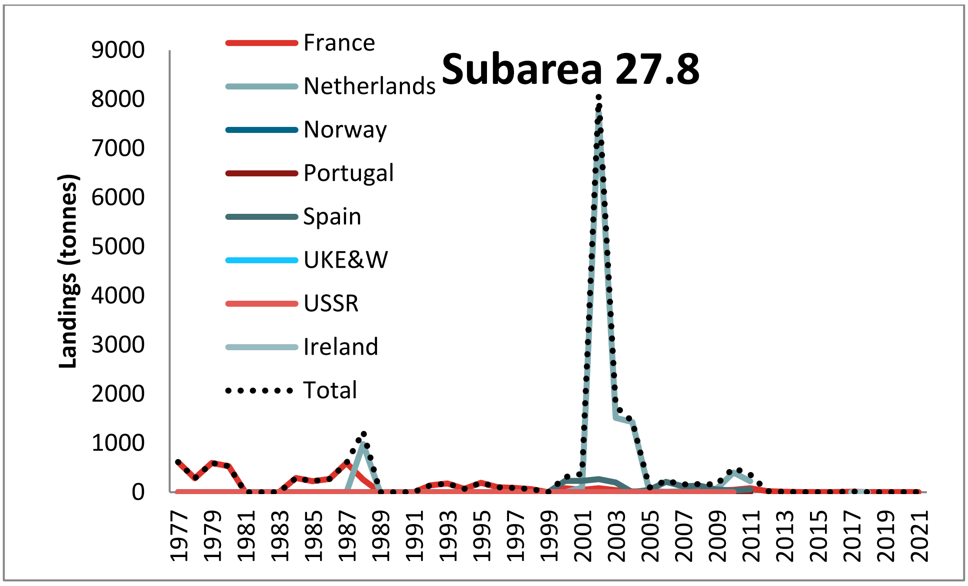


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

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, 2016, 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 Annex and in the benchmark report (ICES, 2016).

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 2016). 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 fifteen years, 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 2020, 27 vessels participated in the fishery. From 2011 to 2020, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1540 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 2020 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 2020 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2021 (Escapement strategy). This approach resulted in an advised TAC for 2020 in SA 1r, SA 2r, SA 3r, and 4 of 113 987t, 62 658 t, 155 072t and 39 611 t, respectively. Advised catches for SA 5, SA 6, and SA 7 for 2019 and 2020 were based on data limited approaches and set at 0 t, 175 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 70 000 tonnes for 2020 was given. As the acoustic survey abundance estimate of age 1 and the total biomass estimate (659 000 tonnes, RSE=0.18%) was the highest observed in the time series the final TAC increased to 250 000 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 2020).

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. 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 HAWG 2017). Because of this, the working in accordance with previous year's reallocated reported catches (14781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1 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 73420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2020 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 with regard to 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 about 6% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively). In 2017 and 2018, the first non-monitoring fishery was advised in the area since 2011 with a total TAC of 54043 t and 59345 t, respectively. In 2019, only a monitoring TAC was advised but in 2020, a TAC of 39 611t 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

In order 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) in November/December. See the Stock Annex for more details. An acoustic survey was carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2010a).

The dredge survey in 2020 was carried out as planned in areas 1r, 2r and 3r and nearly all planned positions were covered in accordance with the survey protocol. However, because of bad weather and a temporary technical obstacle, the survey was extended by 1 week and a few of the low-priority stations were not visited (all high-priority stations were visited).. The survey in area 1r and 2r was expanded to the south in 2017, where new positions were visited south of 54°N. Since 2017 two vessels were used to complete the survey. This was arranged to ensure that all positions can be visited within the 3-week period of the survey (note that new positions have been included gradually over time). All available data were included in the estimated dredge index by area. In area 4, the coverage of the dredge survey was low in 2020, and only 11 stations were sampled and only two out of four main banks (compared to around 50 stations in 2019).

9.2 Sandeel in SA 1r

9.2.1 Catch data

Total catch weight by year for SA 1 is given in tables 9.1.2–9.1.4. Catch numbers-at-age by half-year is given in Table 9.2.1.

In 2021, 1-group and 2-group were equally represented in the catches. The catches contained very few 3-group and older (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 decreased in 2021 and is below the long term mean.

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

In 2020, WGSAM provided updated estimates of natural mortality-at-age from multispecies modelling of southern sandeel (SMS, WGSAM 2020). 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 2016-2017, but have decreased to levels below average in 2018, 2019, 2020, and 2021.

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.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2021 show indices of age 0 and 1 well below the average.

The internal consistency, i.e. the ability of the RTM to follow cohorts, (shows a good consistency correlation between the 1-group and 2-group as well as between 2 and 3-group (i.e. r^2 =0.47 and 0.54, respectively on log scales).

9.2.6 Data analysis

Following the two latest Benchmark assessments (ICES, 2010, 2016) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1983 to 2021. 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 (0.49) for age 0 and high (0.78) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time-series is low to moderate for ages 1, 2, and 3 (0.53, 0.43, and 0.49). 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 (0.35) for age 1 and age 2 in the first half of the year and moderate to high (> 0.5) 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).

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.86), 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. 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 0.43 and 0.87, 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} from 2004 to 2007 and again in 2013-2015. $F_{(1-2)}$ is estimated to have been just below the long-time average since 2010. Recruitment in 2017 was estimated to be the lowest observed in the time-series. 2018 recruitment was also low whereas 2019 shows average recruitment. In 2020 and 2021 the recruitment was below average again.

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 2022 is the geometric mean of the recruitment 1983–2020 (111 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2021. However, as the SMS-model assumes a fixed exploitation pattern since 2010, the choice of years is not critical. Mean weight-at-age in the catch and in the sea is the average value for the years 2017–2021. 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 even a fishing mortality of zero will bring SSB below B_{pa}. However, a monitoring TAC of 5000 t is recommended to ensure the quality of the assessment, consistent with previous year's advice (ICES, 2019).

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 due to the fact that 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 and SSB for the most recent years. 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.

9.2.11.1 Status of the stock

The SSB was below B_{lim} in 2019 and 2020. In 2021, it was estimated to be above B_{lim}, but below B_{pa}. SSB in 2022 is similar to 2021. As noted in last year's report (ICES, 2019), the introduction of a very low recruitment in 2018 combined with a continued decrease in mean weight-at-age led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 2020. The SSB in 2022 is slightly lower than expected from the forecast in 2021. There can be several reasons for that, such as reduced weight-at-age and catches exceeding the TAC advice (due to borrowing and banking).

9.2.12 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, 2014a, 2017) 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, 2017).

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.

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 proportion of the 1-group in the catch was high in both 2020 and 2021, 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 (52%) (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 in 2019 was above the historic average, reaching 108% of the long-term average on average. In 2020, a slight decrease in weights was observed for the 1-group compared to 2019, whereas weight at age of older age-groups increased. In 2021, weights had declined across all age-groups compared to 2020.

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 multispecies modelling of southern and northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 new WGSAM key run (WGSAM 2020) 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 2021 was the second lowest in the time-series, but also the CPUE was the second lowest, coming down from a relatively high CPUE in 2020.

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, 2016). Dredge CPUEs were high in 2021, and in particularly high in the Northern parts, resulting in the second highest age-0 index in the time-series. This year 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. The explorative hauls were uploaded to the database as valid hauls, and were therefore included in the survey index.

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, 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 ro = 0.63) and with density dependent catchability (Mohn’s ro = 0.52). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 decided to include density dependent catchability in the final run. HAWG 2021 re-examined the density dependent parameter and found it still to be significant.

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 low (0.30 for the 0-group) 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 residual plot (Figure 9.3.6) shows no bias for this time-series.

The model CV of catch-at-age 1 and 2 is low (0.40) in the first half of the year and medium or high (> 0.70) 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 (Figure 9.3.7) shows no long-term bias for this time-series for ages 1 and 2 in the first half year.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.02 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.

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 2010–2020, 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 2016).

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 2011 (with few exceptions), some times, 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 (0.55 and 0.37 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. 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 4th 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 2019, the recruitment was average and in 2020 below average. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2012 to 2017 and 2019 to 2022. Since 2004, SSB has been below B_{pa} in all years. $F_{1–2}$ is estimated to have been below the long-time average since 2010 with the exception of 2013, 2017 and 2020.

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 2022 is the geometric mean of the recruitment in 2011–2020. The exploitation pattern and F_{sq} is taken from the assessment values in 2021. 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 2017–2021. 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 0.57 will bring SSB down to B_{pa} in 2023. However, since F_{cap} for this area is 0.44, the TAC should instead be based on a fishing mortality of 0.44, which results in a TAC of 71 859 tonnes in 2022.

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 (WKSAND, 2016).

9.3.10 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessments where the ICES statistical rectangles included in sandeel area 2 changed. The assessment now includes fisheries independent information from a dredge survey representative for the area. The assessment is considered to be of good quality but with some 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 (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 2 is still short (2010–2021) and the quality of the assessment will likely improve once a longer time-series becomes available. Next benchmark will take place in 2022.

9.3.11 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 2020 are estimated below B_{lim} for the second year in a row. In 2021 the stock is expected to be just above B_{lim}. The stock has been below B_{lim} in 17 out of the last 20 years and only at or above B_{pa} in 1 out of 20 years (20 years ago)., 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 is medium. The recruitment in 2021 appears to be high. However, based on the retrospective patterns of this stock, we anticipate some down-scaling in the coming years.

9.3.12 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, 2016) 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 sandeel at 0.44. This means that if the TAC that results from the escapement strategy corresponds to an F_{bar} 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 3 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 2021, the 1-group and 2-group fish dominated the catches, but also a large proportion (second largest in the time-series) of 4-groups was observed. 3-groups were the least frequent.

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 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 provided updated estimates of natural mortality-at-age from multispecies modelling of northern sandeel (SMS, WGSAM 2020).

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 2015 multispecies modelling of southern and northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 since 2003. The last two years, effort has increased, reaching 3492 days in 2020. In 2021, effort is down to the same level as in 2021. CPUE has been increasing for four consecutive years, and in 2021 it was the fourth highest of the time-series.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2021 show average 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. $r^2 = 0.38$ 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, 2016).

The Norwegian acoustic survey (2009–2021) 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. This year a few explorative hauls were taken close to one of the existing stations. However, catch rates in these hauls were not much different from the adjacent fixed station hauls. The explorative hauls were uploaded to the database as valid hauls, and were therefore included in the survey index. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.13.

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. The working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run (see figure below, where I is the survey index of age-0 and N0 the number of recruits) 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 without density dependent catchability (Mohn's rho = 0.57) and with density dependent catchability (Mohn's rho = 0.13). The AIC of the model including density dependent was unchanged. Based on these considerations, HAWG 2020 decided to include density dependent catchability in the final run. This approach was continued in 2021 and 2022.

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 (0.69) and high for age 1 (0.79), 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 (0.60) 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 2020, indicating that the very high acoustic indices were not confirmed by the model.

The model CV of catch-at-age is medium (0.69) 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 high (> 1.00). The catch residual plots for catch-at-age (Figure 9.4.7) confirm that the fits are generally very poor except for age 1 and 2 in the first half year. There is a tendency for clusters of negative or positive residuals for ages 1 and 2 but no trend in recent years.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.07), 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 from a Mohn´s Rho > 0.5 to -0.10 in the present year´s assessment.

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, 2016).

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 9.4.16 and Table 9.4.17). 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.

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 2022 is the geometric mean of the recruitment 1986–2020 (112 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2020. 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 2017–2021. 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 TAC of 85 559 t in 2021 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 151 563 t, well above MSY $B_{trigger}$ of 129 000 t, in 2021. The TAC according to the escapement strategy is therefore 151 563 t in 2021.

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 (WKSAND, 2016).

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. 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 was 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 tables 9.5.2–9.5.4. In 2021, catch numbers were dominated by ages of 1- and 2-groups, whereas older age-groups were not common. This was also the case in 2016 (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 multispecies modelling of northern sandeel (SMS, WGSAM 2015, ICES 2016) 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 key run (WGSAM, 2020) 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

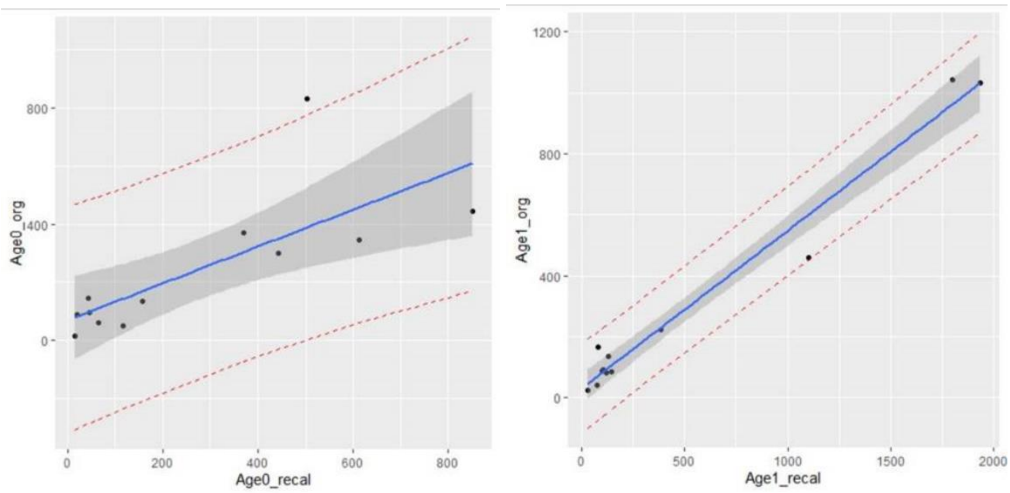
Table 9.5.5–9.5.7 and Figure 9.5.3 show the trends in the international effort over years measured as number of fishing days standardized to a 200 GRT vessel. The standardization includes just the effect of vessel size and does not take changes in efficiency into account. Total international standardized effort peaked in 1994, after which substantial effort reduction has taken place. The effort in 2021 were the third highest in the time-series reflecting the high TAC given. This is in contrast to the most recent decades since 2004 with the effort reflects either a closed or very limited fishery, where only 2018 showed any evident effort that lower than average.

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 2021 around average, whereas for consecutive two years prior (2019 and 2020) strong year-classes have entered.

The ability of the area 4 dredge survey to provide accurate estimates of abundance by age was discussed in detail. All of 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 0.46 (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 5.10 times the index of the cohort at age 0. The 2020 index of the 2018 cohort was 1.87 times the 2019 index 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 of these values are the lowest relative changes observed in the time series. This led to the question of whether the 2020 should be considered a year where the survey for unknown reasons had much higher than usual catchability or the 2020 survey was accurate but a large mortality even had eliminated the sandeel. As the decline was observed in both the fished and closed area, it was considered most likely that the large mortality was caused by factors other than fishing. A possible reason mentioned was harmful algal blooms. A first look at the sandeel dredge data at the station level indicated that internal consistency (abundance of age 0 at t and abundance of age 1 at t+1) was normal between 2019 (age 0) and 2020 (age 1) and followed the general relationship observed at station level between 2008 and 2021. However, between 2020 (age 0) and 2021 (age 1) the relationship showed a clear lack of age 1 fish in 2021. This suggests that catchability was not the issue as values consistent with the time-series were observed for the 2019 cohort and that the issue with the recent indices are likely related to the stratified mean approach in years with reduced sampling at the most productive stations. In addition, the lack of age 1 fish of the 2020 cohort in 2021, also apparent from the station level analysis, is consistent with a large mortality event. In the 2021 assessment, the 2020 index was downscaled to account for changes in sampling distribution as the 2020 index was considered to be likely to be too high due to differences in sampling distribution in this year. The group decided to keep the revised values from 2020 but to run an exploratory assessment excluding this survey year to investigate the impact that the 2020 survey index had on the 2022 assessment.

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 54% of the variation.



Relationship between index estimated for all stations (vertical axis) and index estimated for the 11 stations sampled in 2020 (horizontal axis).

9.5.6 Data analysis

Following the Benchmark assessment (ICES, 2016) the SMS-effort model was used to estimate fishing mortalities and stock numbers-at-age by half year, using data from 1993 to 2021. 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 dredge survey (“sqrt (Survey variance) ~CV” in the table) is low to moderate (<0.60) for all ages. However, the CV have increased for age 0 from 0.3 to 0.55 from the 2021 to the 2022 assessment. The survey residuals in 2020 are large and positive for both ages, indicating that the large observed indices in 2020 are not supported by other information about the abundance of these cohorts.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.74) for age 1 and 2. The catch-at-age residuals (Figure 9.5.6) show no alarming patterns, except for a tendency to positive residuals (observed catch is higher than model catch) for age 1 in the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.50), which is also indicated by the stock recruitment plot (Figure 9.5.7). 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 with the exception of 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 very high retrospective bias in both recruitment and SSB in 2019 and 2020.

As a result of the indications that the 2020 survey may have had an abnormally high catchability, an explorative assessment was conducted removing the 2020 survey index. The results showed an assessment where the 0-group CV of the dredge survey returned to previous levels:

Assessment	CV 0-group in the survey	CV 1-group in the survey	Recruitment 2020 (10^9)	Recruitment 2021 (10^9)	SSB 2022 (10^3 t)
2020	0.30	0.40			
2021	0.30	0.37	303		
2022 all data	0.55	0.30	62.4	46.5	72.8
2022 without 2020 survey	0.30	0.42	36.3	63.5	53.5

The impact on the latest two recruitments and terminal year SSB were substantial (-40 to +37%). Having considered these changes, the group decided that the survey index should be investigated in detail at the upcoming benchmark but that excluding individual years in the survey time series in an update assessment should be avoided. Therefore, the final assessment presented below includes all survey data.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.5.9) 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 72 766 in 2022. $F_{(1\text{–}2)}$ 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. Recruitment has been high in 2014, 2016, 2017 and 2019. 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 2022 is the geometric mean of the recruitment 2011–2020 (55 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2021. 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 2017–2021. 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 9.3.12) shows that a SSB will be below the MSY $B_{trigger}$ of 102 000 t and above B_{lim} of 48.000 t in 2022. Although, even a fishing mortality of zero will bring SSB below Bpa. The TAC is therefore 0 t in 2022. However, a monitoring TAC of 5000 t is recommended to ensure the quality of the assessment, consistent with previous year's advice (ICES, 2019).

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.

9.5.10.1 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 in most years, 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 (0.40).

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016, 2017, 2019, 2020 and 2021 are all above the long-term average, while 2018 is lower. A very restrictive F since 2005 together with the return of recruitment to historic levels has resulted in SSB above B_{pa} in 2016 to 2019 and in 2021. It is between B_{lim} and B_{pa} in 2020 and 2022.

9.5.10.3 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, 2014a, 2017) 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, 2016).

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 2005 on Vikingbanken, which is the main sandeel ground in SA 5. The survey estimates 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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Table 9.1.1 Sandeel. Official catches ('000 t), 1952–2021 for area 27.4 and 27.3.a. Note that catches from 27.3.a are only available from 1973–2021.

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	69.9	1.8223	-	-	-	146.442119	14.977623	-	-	-	233.2

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839
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

	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	16944	4980	157752	53370	0	133	0	233178
arith. mean	284941	99423	151938	30619	5535	1119	940	574516

Table 9.1.3 Sandeel. Total catch (tonnes) by area, first half year as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	314744	92566	21008	2782	0	364	0	431465
1984	419640	86141	43578	2563	5821	735	744	559223
1985	377702	76422	17131	37900	3004	973	0	513132
1986	346053	181733	138020	12539	108	12020	7832	698305
1987	307194	36400	394339	7833	1713	1091	0	748570
1988	395186	107289	288174	1257	0	2114	0	794020
1989	435721	173510	371557	4382	1587	897	450	988104
1990	285321	101899	105554	2926	0	485	0	496185
1991	257591	153869	215770	17140	1168	17	2529	648083
1992	521575	135823	83068	67068	1099	4270	3455	816357
1993	129403	86179	155984	123143	250	4393	3	499354
1994	177685	184792	242027	147019	2754	3222	4	757503
1995	365681	70518	203151	52497	152269	1829	0	845945
1996	257507	63193	110862	48496	14551	1168	0	495777
1997	345199	178735	394181	47668	8615	2194	2448	979040
1998	352275	70075	354639	57373	2907	939	4565	842773
1999	395813	27461	94655	51183	145	0	2152	571409
2000	333044	82405	192474	37792	288	0	3808	649812
2001	368782	49319	59951	47492	1678	26	735	527983
2002	604584	105397	114646	12762	8	493	101	837991
2003	155006	25111	22803	62580	44	111	187	265841
2004	199483	91405	21632	6860	0	571	0	319951
2005	121795	24841	13982	1557	0	259	0	162434
2006	241345	23497	6959	55	0	160	0	272015
2007	110389	44069	75376	11	4	0	0	229849
2008	232249	32602	74943	1168	0	0	0	340963
2009	293529	25399	6024	0	0	0	0	324952
2010	293359	44910	60251	275	0	0	0	398796
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

	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	16481	4978	157627	51075	0	133	0	230293
arith. mean	257473	71690	128242	26057	5077	1021	744	490304

Table 9.1.4 Sandeel. Total catch (tonnes) by area, second half year as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	67885	63641	3820	0	0	0	0	135345
1984	79031	47257	5532	0	0	55	0	131875
1985	82355	35468	3728	222	0	953	0	122726
1986	36791	43848	144314	179	519	1199	2818	229668
1987	65828	12667	959	321	0	72	0	79847
1988	27619	44254	48744	81	0	612	0	121310
1989	10407	53782	2694	2	1316	12	0	68214
1990	20981	31896	57670	388	374	14	0	111323
1991	74613	61697	59069	24232	0	0	0	219611
1992	37027	48418	3954	1837	0	6	0	91243
1993	14986	61785	44138	9993	336	97	78	131414
1994	15557	60152	25254	11671	3	526	0	113163
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

	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	463	3	125	2295	0	0	0	2885
arith. mean	27468	27733	23696	4563	458	98	196	84213

Table 9.1.5 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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

	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	1799	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	418	336	2049	1378	0	4	0	4185
arith. mean	5250	2574	3028	374	81	43	9	11359

Table 9.1.6 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, first half year as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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

	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	389	259	2041	1266	0	4	0	3959
arith. mean	4604	1807	2450	318	76	40	7	9302

Table 9.1.7 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	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

	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	29	76	8	112	0	0	0	225
arith. mean	646	767	578	56	4	3	2	2057

Table 9.1.8 Sandeel. Number of samples from commercial catches by year and area.

	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

	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
Sum	6729	3042	2096	918	39	72	0	12896

Table 9.2.1 Sandeel Area-1r. Catch at age numbers (million) by half 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
1997	19	38667	8899	2332	177	3522	164	713	56

	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	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	4	1069	41	940	25	50	1	31	1
arith. mean	2614	22380	1611	8648	578	2237	184	664	36

Table 9.2.2 Sandeel Area-1r. Individual mean weight (gram) at age in the catch and in the sea.

	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
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

	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	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	3.3	5.9	8.2	9.7	10.6	11.4	13.9	12.8	15.5
arith. mean	3.6	5.8	6.6	9.3	10.4	12.9	14.2	14.8	16.1

Table 9.2.3 Sandeel Area-1r. Proportion mature.

	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

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

```
Date: 01/26/22  Start time:09:46:31 run time:1 seconds

objective function (negative log likelihood):  17.8446
Number of parameters: 80
Maximum gradient: 0.000100632
Akaike information criterion (AIC):   195.689
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             351      75      39       0     465

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
               25.4    -8.2    13.5     0.0     0.0      0.00      31


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.07   -0.11    0.35    0.00


contribution by fleet:
----------------------
Dredge survey 2004-2021     total:   0.941   mean:   0.026
RTM 2007-2021               total:  -9.122   mean:  -0.234
```

```
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
    2010-2021:   0.000 1.000
age: 1 - 4
    1983-1988:   0.457 0.500
    1989-1998:   0.466 0.500
    1999-2004:   0.374 0.500
    2005-2009:   0.254 0.500
    2010-2021:   0.573 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.259  0.959  1.423  1.423
1989-1998:  0.011  0.539  0.722  0.732  0.732
1999-2004:  0.067  1.027  1.142  1.135  1.135
2005-2009:  0.007  1.436  2.177  2.240  2.240
2010-2021:  0.016  0.252  0.596  1.004  1.004


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.320  1.188  1.762  1.762
          season 2:  0.020  0.105  0.388  0.575  0.575

1989-1998 season 1:      0  0.821  1.100  1.116  1.116
          season 2:  0.001  0.033  0.045  0.045  0.045

1999-2004 season 1:      0  0.807  0.897  0.892  0.892
          season 2:  0.018  0.140  0.156  0.155  0.155

2005-2009 season 1:      0  0.740  1.122  1.154  1.154
          season 2:  0.001  0.055  0.083  0.086  0.086

2010-2021 season 1:      0  0.570  1.347  2.269  2.269
          season 2:  0.003  0.025  0.058  0.097  0.097


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.655
 1       0.343   0.581
 2       0.343   0.581
 3       0.657   1.024
 4       0.657   1.024


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3
 Dredge survey 2004-2021       2.646    1.089
 RTM 2007-2021                          0.861    1.820    2.810
```

```
sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3
 Dredge survey 2004-2021        0.49     0.78
 RTM 2007-2021                           0.53     0.43     0.49

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-1r           1017.564   1.100e+005   0.734          0.856
```

Table 9.2.6 Sandeel Area-1r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.012	0.286	1.029	1.511	1.519	0.657
1984	0.013	0.324	1.163	1.706	1.715	0.743
1985	0.014	0.347	1.244	1.833	1.828	0.796
1986	0.005	0.245	0.875	1.277	1.272	0.560
1987	0.008	0.182	0.661	0.970	0.969	0.421
1988	0.005	0.266	0.950	1.376	1.370	0.608
1989	0.001	0.818	1.064	1.068	1.061	0.941
1990	0.002	0.815	1.059	1.062	1.058	0.937
1991	0.005	0.548	0.721	0.730	0.730	0.634
1992	0.003	0.823	1.079	1.084	1.084	0.951
1993	0.001	0.363	0.474	0.481	0.480	0.418
1994	0.001	0.300	0.389	0.392	0.390	0.345
1995	0.002	0.562	0.727	0.732	0.729	0.645
1996	0.003	0.527	0.680	0.683	0.682	0.603
1997	0.005	0.497	0.644	0.649	0.652	0.571
1998	0.002	0.652	0.826	0.828	0.828	0.739
1999	0.017	1.024	1.083	1.064	1.066	1.053
2000	0.016	0.819	0.861	0.852	0.850	0.840
2001	0.049	1.239	1.323	1.315	1.318	1.281
2002	0.004	0.949	1.013	0.975	0.968	0.981
2003	0.015	0.789	0.846	0.819	0.822	0.818
2004	0.007	0.833	0.880	0.848	0.849	0.857
2005	0.000	0.895	1.281	1.308	1.305	1.088
2006	0.001	1.094	1.566	1.590	1.586	1.330
2007	0.000	0.413	0.594	0.604	0.600	0.504
2008	0.000	0.771	1.104	1.114	1.111	0.938
2009	0.001	0.952	1.369	1.391	1.383	1.161
2010	0.002	0.418	0.932	1.496	1.487	0.675
2011	0.001	0.476	1.037	1.674	1.658	0.756
2012	0.000	0.090	0.199	0.324	0.321	0.145
2013	0.000	0.544	1.165	1.913	1.904	0.855
2014	0.001	0.316	0.683	1.133	1.131	0.500

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2015	0.000	0.304	0.652	1.086	1.077	0.478
2016	0.000	0.022	0.047	0.078	0.077	0.034
2017	0.001	0.405	0.896	1.461	1.446	0.650
2018	0.004	0.400	0.906	1.468	1.463	0.653
2019	0.004	0.391	0.885	1.437	1.433	0.638
2020	0.001	0.382	0.860	1.385	1.380	0.621
2021	0.000	0.058	0.133	0.216	0.216	0.096
arith. mean	0.005	0.542	0.869	1.075	1.072	0.706

Table 9.2.7 Sandeel Area-1r. Fishing mortality (F) at age.

	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	0.193	0.063	0.714	0.233	1.059	0.345	1.059	0.345
1984	0.013	0.220	0.069	0.815	0.254	1.209	0.377	1.209	0.377
1985	0.014	0.235	0.074	0.870	0.273	1.290	0.405	1.290	0.405
1986	0.005	0.183	0.024	0.677	0.091	1.004	0.135	1.004	0.135
1987	0.008	0.119	0.042	0.442	0.157	0.655	0.233	0.655	0.233
1988	0.005	0.199	0.025	0.739	0.091	1.096	0.135	1.096	0.135
1989	0.001	0.664	0.027	0.889	0.036	0.902	0.037	0.902	0.037
1990	0.002	0.645	0.045	0.864	0.060	0.876	0.061	0.876	0.061
1991	0.005	0.370	0.121	0.495	0.162	0.502	0.165	0.502	0.165
1992	0.003	0.639	0.076	0.855	0.102	0.868	0.103	0.868	0.103
1993	0.001	0.282	0.034	0.377	0.046	0.383	0.047	0.383	0.047
1994	0.001	0.230	0.026	0.308	0.034	0.312	0.035	0.312	0.035
1995	0.002	0.427	0.052	0.572	0.070	0.580	0.071	0.580	0.071
1996	0.003	0.387	0.060	0.519	0.080	0.526	0.081	0.526	0.081
1997	0.005	0.322	0.118	0.431	0.158	0.437	0.161	0.437	0.161
1998	0.002	0.491	0.049	0.658	0.066	0.667	0.067	0.667	0.067
1999	0.017	0.740	0.129	0.823	0.143	0.818	0.142	0.818	0.142
2000	0.016	0.581	0.121	0.646	0.134	0.642	0.133	0.642	0.133
2001	0.049	0.756	0.374	0.840	0.416	0.836	0.414	0.836	0.414
2002	0.004	0.747	0.028	0.830	0.031	0.826	0.031	0.826	0.031
2003	0.015	0.555	0.113	0.617	0.125	0.614	0.125	0.614	0.125
2004	0.007	0.620	0.057	0.689	0.064	0.686	0.063	0.686	0.063
2005	0.000	0.693	0.052	1.051	0.078	1.081	0.080	1.081	0.080
2006	0.001	0.838	0.074	1.271	0.112	1.308	0.115	1.308	0.115
2007	0.000	0.329	0.000	0.498	0.000	0.513	0.000	0.513	0.000
2008	0.000	0.588	0.035	0.892	0.054	0.918	0.055	0.918	0.055
2009	0.001	0.711	0.072	1.078	0.110	1.109	0.113	1.109	0.113
2010	0.002	0.310	0.013	0.733	0.031	1.234	0.053	1.234	0.053

	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
2011	0.001	0.350	0.009	0.827	0.022	1.392	0.037	1.392	0.037
2012	0.000	0.067	0.000	0.158	0.000	0.266	0.000	0.266	0.000
2013	0.000	0.421	0.000	0.995	0.000	1.675	0.000	1.675	0.000
2014	0.001	0.242	0.008	0.571	0.019	0.961	0.033	0.961	0.033
2015	0.000	0.236	0.000	0.557	0.000	0.938	0.000	0.938	0.000
2016	0.000	0.017	0.000	0.039	0.000	0.066	0.000	0.066	0.000
2017	0.001	0.314	0.005	0.743	0.012	1.251	0.020	1.251	0.020
2018	0.004	0.301	0.029	0.712	0.068	1.198	0.115	1.198	0.115
2019	0.004	0.290	0.034	0.686	0.079	1.156	0.134	1.156	0.134
2020	0.001	0.302	0.004	0.715	0.009	1.203	0.016	1.203	0.016
2021	0.000	0.044	0.003	0.105	0.007	0.176	0.012	0.176	0.012
arith. mean	0.005	0.401	0.053	0.674	0.088	0.852	0.106	0.852	0.106

Table 9.2.8 Sandeel Area-1r. Natural mortality (M) at age.

	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

	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
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
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
arith. mean	0.629	0.457	0.544	0.387	0.420	0.303	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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	299015	13260	52130	2841	242
1984	75976	179350	4339	9694	422
1985	512274	45519	56771	714	1152
1986	77581	300596	14239	8751	186
1987	47398	45284	104383	3122	1514
1988	206586	27125	16027	26651	1015
1989	92629	118264	8995	3220	4263
1990	131123	54377	24694	1653	1563
1991	163993	75981	11376	4692	675
1992	37010	93162	19867	2898	1553
1993	155890	21312	19849	3854	975
1994	223917	91585	6904	6624	1810
1995	56134	131647	30831	2461	3394
1996	403422	33277	34864	7956	1746
1997	63130	231744	9261	9566	2939
1998	121133	35632	61895	2518	3749
1999	159266	65331	7933	14295	1636
2000	252679	84243	9865	1385	3158
2001	418211	135479	15068	2117	1168

	Age 0	Age 1	Age 2	Age 3	Age 4
2002	26725	215558	17118	2064	524
2003	160692	13616	35820	3000	552
2004	67979	79446	2418	6836	800
2005	163089	33196	12486	441	1647
2006	79307	81351	5268	1774	327
2007	194907	38213	10326	560	252
2008	77150	90322	9021	2714	244
2009	560359	37363	15321	1469	566
2010	34547	277020	5933	2103	306
2011	42280	16878	63962	1116	320
2012	103313	19221	3346	11004	158
2013	60111	47021	4888	1056	3760
2014	214166	28923	8874	713	437
2015	36587	103861	7304	2057	216
2016	272957	17842	24718	1819	453
2017	19491	132257	5594	10792	1098
2018	31171	9935	30909	1092	1661
2019	95467	16729	2686	5876	384
2020	52902	51206	4550	518	870
2021	39617	28483	14177	915	213
2022		21333	10218	5259	475

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.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	299013715	625840	460929	378795	0.601
1984	75981466	1165290	196025	498626	0.679
1985	512084393	783157	453160	437114	0.725
1986	77593949	1862800	270493	382844	0.487
1987	47393706	1512290	973838	373021	0.380
1988	206539038	775842	574928	413646	0.527
1989	92618550	747470	154662	446028	0.808
1990	131169377	647380	247707	306240	0.807
1991	163938186	944290	330050	332204	0.574
1992	37021153	1042320	284361	558599	0.836
1993	155942826	459344	260407	132024	0.370
1994	223964922	683504	177726	193241	0.299
1995	56119842	1449690	399113	400588	0.560
1996	403222872	605958	364762	265869	0.523
1997	63148522	1894180	232815	426089	0.515

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1998	121084596	854977	524919	377073	0.632
1999	159252253	577355	222348	422718	0.917
2000	252772391	677968	142059	299167	0.741
2001	418003348	787195	161297	531265	1.193
2002	26722060	1439260	156217	606466	0.818
2003	160691992	343463	243045	148039	0.705
2004	67998758	491587	93246	203646	0.715
2005	163120541	349493	116425	123422	0.937
2006	79319932	554785	75508	240646	1.148
2007	194900553	320875	93620	109624	0.413
2008	77129779	704471	129832	234447	0.784
2009	560309574	399923	145365	290995	0.985
2010	34552829	1852980	129573	300508	0.544
2011	42287412	666689	467895	318840	0.604
2012	103284720	281048	152970	46117	0.112
2013	60128831	305106	83200	214359	0.708
2014	214109902	211344	64861	78830	0.420
2015	36579554	655139	85221	163381	0.396
2016	273004818	372064	231422	14613	0.028
2017	19481970	849954	156530	241916	0.537
2018	31171039	293905	204843	133659	0.555
2019	95439204	153229	71254	66444	0.545
2020	52904555	426837	60901	106100	0.515
2021	39626157	318828	126880	17064	0.079
2022			128284		
arith. mean	149491895	745842	236222	277802	0.608
geo. mean	106856781				

arith. mean for the period 1983–2021

geo. mean for the period 1983–2020

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2022)	106885.513	21333	10218.5	5258.51	474.614
Exploitation pattern 1st half		0.044	0.105	0.176	0.176
Exploitation pattern 2nd half	0.000	0.003	0.007	0.012	0.012
Weight in the stock 1st half		5.544	8.217	10.190	11.888
Weight in the catch 1st half		5.544	8.217	10.190	11.888
weight in the catch 2nd half	3.221	7.739	10.099	13.239	14.905
Proportion mature(2022)	0.000	0.021	0.801	0.988	1.000
Proportion mature(2023)	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(2021)=0.0794; Yield(2021)=17.064; Recruitment(2021)=39.626157; Recruitment(2022)=geometric mean (GM 1983-2020)=106.885513 billion; SSB(2022)=128.284

F multiplier	Basis	F(2022)	Catch(2022)	SSB(2023)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	136.622	7 %	-100 %
0.99	Fsq*0.99	0.079	20.173	123.863	-3 %	18 %
1	Fsq*1	0.079	20.290	123.790	-4 %	19 %
2	Fsq*2	0.159	38.323	112.532	-12 %	125 %
1	Fsq*1	0.079	20.290	123.790	-4 %	19 %
0.08	Fsq*0.08	0.006	1.734	135.520	6 %	-90 %
1.8	Fsq*1.8	0.143	34.856	114.684	-11 %	104 %
2.2	Fsq*2.2	0.175	41.642	110.477	-14 %	144 %
0.11	Fsq*0.11	0.009	2.359	135.123	5 %	-86 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2023 relative to SSB in 2022**

****TAC in 2022 relative to catches in 2021**

Table 9.3.1 Sandeel Area-2r. Catch at age numbers (million) by half 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

	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
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
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	746	0	128	0	2	0	3	0
arith. mean	2707	7004	1427	1650	298	421	107	165	42

Table 9.3.2 Sandeel Area-2r. Individual mean weight (gram) at age in the catch and in the sea.

	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

	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	3.8	5.0	8.2	9.3	13.9	13.0	18.6	16.3	20.7
arith. mean	4.0	6.3	8.2	10.9	13.6	15.0	18.3	17.6	20.4

Table 9.3.3 Sandeel Area-2r. Proportion mature.

	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

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

```
Date: 01/26/22  Start time:09:45:41 run time:0 seconds

objective function (negative log likelihood):  86.0187
Number of parameters: 75
Maximum gradient: 9.66494e-005
Akaike information criterion (AIC):   322.037
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             351      24      39       0     414

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
               90.2    -6.2    20.2     0.0     0.0      0.00     104
```

```
unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.26   -0.26    0.52    0.00


contribution by fleet:
----------------------
Dredge survey 2010-2021     total:  -6.243   mean:  -0.260

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
    2010-2021:   0.000 1.000
age: 1 - 4
    1983-1988:   0.475 0.500
    1989-1998:   0.685 0.500
    1999-2004:   0.421 0.500
    2005-2009:   0.191 0.500
    2010-2021:   0.571 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.041  0.280  0.901  1.490  1.490
1989-1998:  0.099  0.337  0.403  0.476  0.476
1999-2004:  0.041  0.598  0.717  0.721  0.721
2005-2009:  0.001  1.960  1.647  1.731  1.731
2010-2021:  0.001  0.270  0.440  0.555  0.555


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.299  0.962  1.592  1.592
          season 2:  0.051  0.175  0.564  0.932  0.932

1989-1998 season 1:      0  0.725  0.868  1.025  1.025
          season 2:  0.109  0.185  0.222  0.262  0.262

1999-2004 season 1:      0  0.310  0.371  0.373  0.373
          season 2:  0.082  0.600  0.719  0.723  0.723

2005-2009 season 1:      0  0.540  0.454  0.477  0.477
          season 2:  0.001  0.546  0.459  0.482  0.482

2010-2021 season 1:      0  0.638  1.038  1.310  1.310
          season 2:  0.001  0.123  0.201  0.254  0.254


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.641
 1       0.404   0.825
 2       0.404   0.825
 3       0.880   1.082
```

```
 4       0.880   1.082


Survey catchability:
--------------------
                           age 0    age 1
 Dredge survey 2010-2021       0.356   23.650

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1
Dredge survey 2010-2021        1.32     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Dredge survey 2010-2021        0.30     0.76

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-2r            1093.169   5.600e+004   1.038          1.019
```

Table 9.3.6 Sandeel Area-2r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.037	0.369	1.175	1.936	1.935	0.772
1984	0.034	0.310	0.990	1.638	1.637	0.650
1985	0.022	0.290	0.916	1.500	1.497	0.603
1986	0.025	0.416	1.302	2.115	2.111	0.859
1987	0.008	0.092	0.292	0.482	0.481	0.192
1988	0.027	0.309	0.980	1.610	1.608	0.645
1989	0.076	0.728	0.854	0.996	0.994	0.791
1990	0.037	0.489	0.572	0.664	0.662	0.531
1991	0.070	0.552	0.650	0.760	0.759	0.601
1992	0.051	0.561	0.657	0.765	0.763	0.609
1993	0.080	0.442	0.524	0.618	0.617	0.483
1994	0.050	0.470	0.551	0.643	0.642	0.510
1995	0.043	0.255	0.302	0.356	0.355	0.279
1996	0.132	0.379	0.460	0.554	0.555	0.420
1997	0.083	0.555	0.656	0.770	0.768	0.606
1998	0.046	0.286	0.339	0.398	0.397	0.312
1999	0.036	0.370	0.456	0.471	0.472	0.413
2000	0.017	0.550	0.649	0.648	0.647	0.599
2001	0.036	0.479	0.581	0.594	0.595	0.530
2002	0.020	0.665	0.784	0.782	0.780	0.724
2003	0.037	0.441	0.538	0.552	0.552	0.489
2004	0.030	0.897	1.060	1.060	1.059	0.978
2005	0.001	1.177	0.996	1.060	1.060	1.086
2006	0.001	1.229	1.046	1.119	1.119	1.138
2007	0.000	0.752	0.615	0.631	0.628	0.684

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2008	0.000	0.808	0.671	0.700	0.699	0.740
2009	0.000	0.773	0.653	0.695	0.695	0.713
2010	0.000	0.393	0.622	0.773	0.771	0.508
2011	0.000	0.254	0.400	0.495	0.493	0.327
2012	0.000	0.145	0.228	0.282	0.281	0.187
2013	0.000	0.628	0.988	1.221	1.217	0.808
2014	0.000	0.476	0.747	0.920	0.917	0.612
2015	0.000	0.419	0.656	0.806	0.804	0.538
2016	0.000	0.181	0.284	0.350	0.349	0.233
2017	0.001	0.815	1.280	1.581	1.577	1.047
2018	0.000	0.245	0.383	0.471	0.469	0.314
2019	0.000	0.057	0.089	0.110	0.110	0.073
2020	0.000	0.560	0.877	1.080	1.077	0.718
2021	0.000	0.110	0.172	0.211	0.211	0.141
arith. mean	0.026	0.485	0.667	0.831	0.830	0.576

Table 9.3.7 Sandeel Area-2r. Fishing mortality (F) at age.

	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	0.216	0.127	0.696	0.408	1.151	0.674	1.151	0.674
1984	0.034	0.176	0.115	0.567	0.371	0.938	0.614	0.938	0.614
1985	0.022	0.183	0.076	0.590	0.244	0.976	0.404	0.976	0.404
1986	0.025	0.277	0.087	0.891	0.279	1.474	0.461	1.474	0.461
1987	0.008	0.056	0.028	0.179	0.090	0.296	0.150	0.296	0.150
1988	0.027	0.190	0.091	0.610	0.294	1.010	0.486	1.010	0.486
1989	0.076	0.501	0.128	0.600	0.153	0.709	0.181	0.709	0.181
1990	0.037	0.349	0.062	0.418	0.075	0.494	0.088	0.494	0.088
1991	0.070	0.365	0.119	0.438	0.143	0.517	0.168	0.517	0.168
1992	0.051	0.392	0.087	0.469	0.104	0.554	0.123	0.554	0.123
1993	0.080	0.268	0.136	0.321	0.162	0.379	0.192	0.379	0.192
1994	0.050	0.320	0.085	0.383	0.102	0.452	0.121	0.452	0.121
1995	0.043	0.158	0.073	0.189	0.088	0.223	0.103	0.223	0.103
1996	0.132	0.168	0.225	0.201	0.269	0.238	0.318	0.238	0.318
1997	0.083	0.355	0.141	0.425	0.169	0.502	0.199	0.502	0.199
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	0.165	0.320	0.166	0.322	0.166	0.322
2000	0.017	0.359	0.127	0.430	0.152	0.433	0.153	0.433	0.153
2001	0.036	0.222	0.267	0.266	0.321	0.268	0.322	0.268	0.322
2002	0.020	0.441	0.144	0.529	0.172	0.532	0.173	0.532	0.173
2003	0.037	0.192	0.269	0.230	0.322	0.231	0.324	0.231	0.324

	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	0.030	0.580	0.222	0.695	0.267	0.699	0.268	0.699	0.268
2005	0.001	0.583	0.590	0.490	0.495	0.515	0.521	0.515	0.521
2006	0.001	0.558	0.704	0.469	0.592	0.493	0.622	0.493	0.622
2007	0.000	0.600	0.000	0.505	0.000	0.530	0.000	0.530	0.000
2008	0.000	0.529	0.189	0.444	0.159	0.467	0.167	0.467	0.167
2009	0.000	0.390	0.375	0.328	0.315	0.344	0.331	0.344	0.331
2010	0.000	0.278	0.054	0.452	0.087	0.570	0.110	0.570	0.110
2011	0.000	0.187	0.020	0.305	0.032	0.385	0.040	0.385	0.040
2012	0.000	0.109	0.007	0.178	0.012	0.224	0.015	0.224	0.015
2013	0.000	0.465	0.056	0.756	0.090	0.955	0.114	0.955	0.114
2014	0.000	0.364	0.021	0.592	0.034	0.748	0.043	0.748	0.043
2015	0.000	0.327	0.006	0.533	0.009	0.673	0.011	0.673	0.011
2016	0.000	0.139	0.004	0.226	0.007	0.285	0.009	0.285	0.009
2017	0.001	0.605	0.073	0.985	0.120	1.244	0.151	1.244	0.151
2018	0.000	0.191	0.002	0.310	0.003	0.392	0.003	0.392	0.003
2019	0.000	0.044	0.000	0.072	0.000	0.091	0.000	0.091	0.000
2020	0.000	0.430	0.023	0.699	0.038	0.883	0.048	0.883	0.048
2021	0.000	0.085	0.000	0.139	0.000	0.176	0.000	0.176	0.000
arith. mean	0.026	0.307	0.130	0.436	0.169	0.550	0.209	0.550	0.209

Table 9.3.8 Sandeel Area-2r. Natural mortality (M) at age.

	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

	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	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
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
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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1983	158917	16431	14521	729	27
1984	47208	61033	3656	1901	58
1985	280397	18190	14296	564	198
1986	60449	109293	4400	2449	92
1987	35468	23489	23822	539	175
1988	174767	14019	6773	7181	219
1989	87304	67817	3319	1082	792
1990	158712	32262	11328	616	370
1991	113021	60965	6701	2730	265
1992	117418	41991	11773	1480	722
1993	231610	44462	8156	2619	538
1994	108224	85213	9306	1984	854

	Age 0	Age 1	Age 2	Age 3	Age 4
1995	77846	41013	17812	2260	768
1996	418473	29716	10206	5331	1048
1997	16077	146094	6290	2516	1752
1998	26957	5897	27887	1370	1018
1999	75193	10260	1429	8087	799
2000	43989	28897	2146	347	2607
2001	133274	17230	5572	473	798
2002	10281	51217	3312	1223	340
2003	47588	4018	8950	648	370
2004	19118	18285	795	2033	281
2005	19287	7392	2570	120	421
2006	27034	7681	717	378	93
2007	40603	10764	681	98	74
2008	25407	16181	1851	162	49
2009	78639	10123	2475	400	54
2010	8418	31324	1476	513	110
2011	11325	3353	7051	340	151
2012	45359	4513	855	1986	154
2013	25698	18075	1259	279	805
2014	17956	10236	3368	213	180
2015	4966	7154	2185	711	86
2016	122957	1979	1608	501	192
2017	3783	48999	538	502	248
2018	9563	1507	7791	70	89
2019	45903	3811	390	2248	52
2020	26409	18293	1143	143	1002
2021	100926	10522	3647	216	219
2022		40221	3028	1252	176

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.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean $F_{1\text{-}2}$
1983	158934067	251523	141775	155664	0.723
1984	47204510	410875	71396	133343	0.615
1985	280476360	277668	134592	110546	0.547
1986	60430228	718573	83200	225470	0.767
1987	35462984	413235	233748	49070	0.176
1988	174773254	273465	184795	149466	0.593
1989	87312134	439951	53316	223507	0.692
1990	158775212	353697	111190	133874	0.452

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1991	113011484	652157	180052	215508	0.532
1992	117388558	441433	135944	184033	0.526
1993	231710661	521263	165215	139826	0.444
1994	108254988	603092	137173	244939	0.445
1995	77827080	584986	240386	113899	0.254
1996	418421560	454272	228891	182562	0.431
1997	16078604	882459	117948	242094	0.545
1998	26963644	392074	302247	99814	0.282
1999	75225438	240168	155749	69427	0.445
2000	43969202	270755	74013	92908	0.534
2001	133284967	198800	85905	90200	0.538
2002	10282973	335242	46444	117388	0.643
2003	47583661	141597	100912	53710	0.506
2004	19115307	154485	37459	110546	0.882
2005	19288122	93467	34269	34396	1.079
2006	27044656	72874	14644	37860	1.162
2007	40588689	77448	11142	43090	0.552
2008	25418810	116369	24441	35604	0.660
2009	78609255	90010	26265	35687	0.704
2010	8418986	201457	23576	51670	0.435
2011	11330401	108620	72475	24896	0.272
2012	45353595	80403	42319	10594	0.153
2013	25699960	131764	25745	47814	0.683
2014	17948193	93429	34787	48033	0.505
2015	4965378	88355	35846	37902	0.437
2016	122914555	36435	26796	5230	0.188
2017	3782894	286154	19141	141314	0.892
2018	9559060	84166	64602	20307	0.253
2019	45901117	69640	40175	5091	0.058
2020	26403312	157776	37235	68932	0.595
2021	100936282	92452	35490	4979	0.112
2022			51277		
arith. mean	78372459	279297	91067	97210	0.521
geo. mean	44633712				

arith. mean for the period 1983–2021

geo. mean for the period 1983–2020

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2022)	19066.388	40221.1	3028.4	1251.88	175.923

Exploitation pattern 1st half		0.085	0.139	0.176	0.176
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.873	10.367	13.999	16.826
Weight in the catch 1st half		5.873	10.367	13.999	16.826
weight in the catch 2nd half	3.621	8.133	13.271	17.076	19.689
Proportion mature(2022)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2023)	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(2021)=0.1123; Yield(2021)=4.979; Recruitment(2021)=100.936282; Recruitment(2022)=geometric mean (GM 2011-2020)=19.066388 billion; SSB(2022)=51.277

F multiplier	Basis	F(2022)	Catch(2022)	SSB(2023)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	137.618	168 %	-100 %
3.920	Fsq*3.92	0.440	71.859	93.977	83 %	1343 %
1.000	Fsq*1	0.112	20.970	124.704	143 %	321 %
3.040	Fsq*3.04	0.341	57.941	102.283	99 %	1064 %
0.080	Fsq*0.08	0.009	1.700	136.567	166 %	-66 %
7.000	Fsq*7	0.786	112.558	70.216	37 %	2161 %
9.000	Fsq*9	1.011	133.602	58.313	14 %	2583 %
11.000	Fsq*11	1.235	151.324	48.551	-5 %	2939 %
13.000	Fsq*13	1.460	166.321	40.520	-21 %	3241 %
5.097	MSY	0.572	88.771	84.000	64 %	1683 %

***SSB in 2023 relative to SSB in 2022**

****TAC in 2022 relative to catches in 2021**

Table 9.4.1 Sandeel Area-3r. Catch at age numbers (million) by half 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

	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	2975	66856	10388	2912	134	607	13	194	9
1998	30136	3954	992	28137	740	2553	192	290	32
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	11	3211	6	2768	1	530	0	1378	0
arith. mean	3341	11204	972	3396	90	699	28	272	15

Table 9.4.2 Sandeel Area-3r. Individual mean weight (gram) at age in the catch and in the sea.

	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

	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
1995	4.7	5.6	8.2	9.7	10.2	13.8	13.7	16.5	16.1
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	3.8	12.8	8.4	19.8	15.4	27.8	20.2	34.0	21.9
arith. mean	4.6	7.2	9.4	12.6	16.2	18.4	21.5	23.3	23.3

Table 9.4.3 Sandeel Area-3r. Proportion mature.

	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

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

```
Date: 01/26/22  Start time:09:44:46 run time:1 seconds

objective function (negative log likelihood):  124.547
Number of parameters: 61
Maximum gradient: 4.83144e-005
Akaike information criterion (AIC):   371.094
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                              324      85      36       0     445

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
              102.4    22.0    17.9     0.0     0.0      0.00     142


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.32    0.26    0.50    0.00


contribution by fleet:
----------------------
Dredge survey 2004-2021     total:   4.217   mean:   0.128
Acoustic survey             total:  17.760   mean:   0.342

F, season effect:
```

```
-----------------
age: 0
    1986-1998:   0.000 1.000
    1999-2021:   0.000 1.000
age: 1 - 4
    1986-1998:   0.883 0.500
    1999-2021:   1.021 0.500

F, age effect:
--------------
                0      1      2      3      4
1986-1998:  0.103  0.372  0.413  0.333  0.333
1999-2021:  0.056  0.169  0.254  0.243  0.243


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1986-1998 season 1:      0  0.640  0.710  0.574  0.574
          season 2:  0.170  0.308  0.342  0.276  0.276

1999-2021 season 1:      0  0.551  0.827  0.790  0.790
          season 2:  0.164  0.249  0.373  0.357  0.357


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.132
 1      0.673   1.038
 2      0.673   1.038
 3      1.021   1.232
 4      1.021   1.232


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2021       0.509    0.509
 Acoustic survey                        3.011    4.839    4.611    4.611

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1    age 2    age 3
age 4
Dredge survey 2004-2021        1.03     1.00
Acoustic survey                            1.00     1.00     1.00     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2021        0.61     0.79
 Acoustic survey                         0.69     0.69     1.06     1.06

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-3r            1481.927   8.000e+004   0.994          0.997
```

Table 9.4.6 Sandeel Area-3r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1986	0.076	0.453	0.495	0.399	0.401	0.474
1987	0.001	0.713	0.758	0.598	0.596	0.736
1988	0.051	0.915	0.975	0.778	0.778	0.945
1989	0.003	1.033	1.097	0.885	0.882	1.065
1990	0.050	0.580	0.623	0.502	0.502	0.602
1991	0.040	0.701	0.753	0.603	0.602	0.727
1992	0.003	0.326	0.346	0.270	0.270	0.336
1993	0.042	0.604	0.651	0.519	0.518	0.628
1994	0.016	0.646	0.692	0.540	0.537	0.669
1995	0.007	0.514	0.553	0.434	0.433	0.534
1996	0.043	0.504	0.547	0.432	0.431	0.525
1997	0.066	0.906	0.982	0.790	0.786	0.944
1998	0.140	1.149	1.255	1.014	1.007	1.202
1999	0.140	0.733	1.091	1.028	1.023	0.912
2000	0.004	0.754	1.089	0.993	0.987	0.922
2001	0.145	0.473	0.714	0.682	0.685	0.594
2002	0.000	0.496	0.709	0.673	0.670	0.602
2003	0.019	0.265	0.383	0.368	0.367	0.324
2004	0.019	0.184	0.268	0.259	0.258	0.226
2005	0.000	0.089	0.128	0.120	0.119	0.108
2006	0.000	0.038	0.054	0.051	0.051	0.046
2007	0.000	0.224	0.323	0.302	0.301	0.274
2008	0.000	0.242	0.349	0.332	0.331	0.295
2009	0.000	0.020	0.030	0.028	0.028	0.025
2010	0.000	0.262	0.382	0.359	0.356	0.322
2011	0.000	0.170	0.246	0.233	0.230	0.208
2012	0.000	0.103	0.149	0.143	0.142	0.126
2013	0.000	0.050	0.073	0.070	0.069	0.061
2014	0.000	0.200	0.290	0.277	0.275	0.245
2015	0.000	0.262	0.381	0.364	0.362	0.322
2016	0.000	0.103	0.149	0.143	0.142	0.126
2017	0.000	0.227	0.330	0.316	0.313	0.279
2018	0.000	0.243	0.352	0.337	0.335	0.297
2019	0.000	0.364	0.528	0.506	0.502	0.446
2020	0.000	0.610	0.883	0.846	0.840	0.747
2021	0.000	0.370	0.537	0.514	0.510	0.453
arith. mean	0.024	0.431	0.532	0.464	0.462	0.482

Table 9.4.7 Sandeel Area-3r. Fishing mortality (F) at age.

	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	0.076	0.285	0.137	0.317	0.152	0.256	0.123	0.256	0.123
1987	0.001	0.576	0.002	0.639	0.002	0.516	0.002	0.516	0.002
1988	0.051	0.686	0.093	0.761	0.103	0.615	0.083	0.615	0.083
1989	0.003	0.863	0.006	0.957	0.007	0.774	0.005	0.774	0.005
1990	0.050	0.425	0.090	0.472	0.100	0.381	0.081	0.381	0.081
1991	0.040	0.540	0.072	0.600	0.080	0.484	0.064	0.484	0.064
1992	0.003	0.261	0.006	0.289	0.007	0.234	0.005	0.234	0.005
1993	0.042	0.449	0.076	0.498	0.084	0.403	0.068	0.403	0.068
1994	0.016	0.502	0.029	0.557	0.032	0.450	0.026	0.450	0.026
1995	0.007	0.408	0.013	0.453	0.014	0.366	0.012	0.366	0.012
1996	0.043	0.358	0.078	0.397	0.086	0.321	0.070	0.321	0.070
1997	0.066	0.670	0.119	0.744	0.133	0.601	0.107	0.601	0.107
1998	0.140	0.794	0.254	0.881	0.282	0.712	0.228	0.712	0.228
1999	0.140	0.470	0.212	0.705	0.318	0.674	0.304	0.674	0.304
2000	0.004	0.592	0.006	0.889	0.008	0.850	0.008	0.850	0.008
2001	0.145	0.247	0.220	0.371	0.330	0.354	0.315	0.354	0.315
2002	0.000	0.368	0.000	0.553	0.000	0.528	0.000	0.528	0.000
2003	0.019	0.183	0.029	0.274	0.044	0.262	0.042	0.262	0.042
2004	0.019	0.126	0.029	0.190	0.043	0.181	0.041	0.181	0.041
2005	0.000	0.069	0.000	0.103	0.000	0.098	0.000	0.098	0.000
2006	0.000	0.029	0.000	0.044	0.001	0.042	0.001	0.042	0.001
2007	0.000	0.178	0.000	0.267	0.000	0.255	0.000	0.255	0.000
2008	0.000	0.197	0.000	0.295	0.000	0.282	0.000	0.282	0.000
2009	0.000	0.017	0.000	0.025	0.000	0.024	0.000	0.024	0.000
2010	0.000	0.213	0.001	0.319	0.001	0.305	0.001	0.305	0.001
2011	0.000	0.135	0.000	0.203	0.000	0.194	0.000	0.194	0.000
2012	0.000	0.082	0.000	0.123	0.000	0.118	0.000	0.118	0.000
2013	0.000	0.040	0.000	0.060	0.000	0.057	0.000	0.057	0.000
2014	0.000	0.160	0.000	0.240	0.000	0.230	0.000	0.230	0.000
2015	0.000	0.211	0.000	0.316	0.000	0.303	0.000	0.303	0.000
2016	0.000	0.082	0.000	0.123	0.000	0.118	0.000	0.118	0.000
2017	0.000	0.183	0.000	0.274	0.000	0.262	0.000	0.262	0.000
2018	0.000	0.195	0.000	0.292	0.000	0.280	0.000	0.280	0.000
2019	0.000	0.294	0.000	0.441	0.000	0.422	0.000	0.422	0.000
2020	0.000	0.497	0.000	0.745	0.000	0.712	0.000	0.712	0.000
2021	0.000	0.299	0.000	0.448	0.000	0.428	0.000	0.428	0.000
arith. mean	0.024	0.325	0.041	0.413	0.051	0.364	0.044	0.364	0.044

Table 9.4.8 Sandeel Area-3r. Natural mortality (M) at age.

	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	0.60	0.600	0.470	0.420	0.370	0.360	0.350
1987	1.430	0.750	0.57	0.600	0.440	0.420	0.350	0.360	0.340
1988	1.540	0.710	0.58	0.570	0.430	0.390	0.350	0.350	0.340
1989	1.330	0.680	0.49	0.550	0.360	0.390	0.330	0.360	0.320
1990	1.280	0.630	0.48	0.490	0.350	0.340	0.300	0.310	0.290
1991	1.220	0.630	0.47	0.490	0.350	0.330	0.290	0.300	0.280
1992	1.190	0.650	0.52	0.490	0.390	0.330	0.290	0.300	0.290
1993	1.140	0.670	0.52	0.510	0.400	0.350	0.320	0.330	0.310
1994	1.110	0.690	0.58	0.530	0.460	0.360	0.340	0.340	0.320
1995	1.010	0.710	0.55	0.560	0.450	0.410	0.350	0.380	0.340
1996	0.990	0.660	0.57	0.530	0.470	0.390	0.360	0.360	0.350
1997	0.900	0.640	0.53	0.520	0.430	0.400	0.380	0.380	0.360
1998	0.970	0.630	0.51	0.490	0.410	0.380	0.360	0.350	0.330
1999	1.040	0.730	0.58	0.540	0.470	0.360	0.330	0.330	0.300
2000	1.120	0.800	0.65	0.610	0.550	0.420	0.390	0.390	0.370
2001	1.190	0.820	0.78	0.660	0.670	0.490	0.510	0.450	0.490
2002	1.220	0.840	0.80	0.720	0.670	0.580	0.630	0.540	0.610
2003	1.220	0.830	0.77	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.70	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.65	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.61	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.58	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.50	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.47	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.50	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.55	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2017	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2018	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2019	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2020	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
2021	1.190	0.700	0.54	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.166	0.712	0.57	0.565	0.462	0.419	0.406	0.386	0.389

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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1986	510341	81391	5618	276	690
1987	116127	123867	13687	1206	318
1988	360728	27760	18563	2547	426
1989	107678	73467	3507	2877	711
1990	198082	28385	9565	538	808
1991	124100	52392	5586	2330	458
1992	257964	35216	9456	1223	872
1993	190940	78219	8373	2918	899
1994	180436	58569	14079	1883	1229
1995	153307	58535	9679	2905	976
1996	742461	55439	10896	2209	1257
1997	63923	264307	10483	2472	1124
1998	93207	24330	37233	1688	822
1999	121485	30713	2729	4733	478
2000	133994	37321	4190	357	988
2001	127087	43558	4814	536	264
2002	31976	33433	5513	632	154
2003	72768	9440	4487	790	140
2004	47107	21074	1542	838	209
2005	80268	13782	3830	340	280
2006	114995	25416	2900	1020	218
2007	58672	37512	5905	878	487
2008	89724	20532	8141	1536	459
2009	137164	33339	5181	2343	675
2010	15674	50962	11359	2117	1462
2011	11102	5163	13841	3455	1297
2012	84278	3310	1345	4283	1775
2013	207141	25639	882	437	2313
2014	223070	63017	7129	306	1146
2015	8121	67853	15536	2062	508
2016	705102	2471	15900	4165	812
2017	32491	214507	659	5171	1888
2018	223823	9884	51718	184	2331
2019	303286	68092	2354	14201	843
2020	160646	92266	14685	557	4188
2021	77181	48872	16249	2565	1030
2022		23480	10490	3818	1005

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.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1986	510550442	567338	74236	282315	0.446
1987	116104360	987817	182773	395296	0.610
1988	360859773	458951	265136	330358	0.822
1989	107715064	541626	98913	350409	0.916
1990	198044042	330066	104089	163224	0.544
1991	124149867	544535	159692	274839	0.646
1992	257878732	350577	120451	86788	0.281
1993	190850317	662154	194464	175786	0.554
1994	180456444	625916	234685	267281	0.559
1995	153314205	476147	140225	173607	0.444
1996	742104035	738395	234451	159024	0.459
1997	63910869	1541930	185350	470670	0.833
1998	93175931	535338	331373	462081	1.105
1999	121448395	332708	108662	191253	0.852
2000	133953060	326032	68665	186837	0.748
2001	127038405	378300	76726	193684	0.584
2002	31960138	352699	75660	116298	0.461
2003	72783512	135401	71754	34673	0.265
2004	47110195	183270	32048	31285	0.194
2005	80277505	183214	65382	13991	0.086
2006	114949102	252982	60114	7094	0.037
2007	58644245	395299	104402	74972	0.222
2008	89701675	332573	145365	74933	0.246
2009	137206823	319880	103570	6261	0.021
2010	15665948	662839	247459	61241	0.267
2011	11106044	327267	248451	92452	0.169
2012	84309069	203662	167376	40116	0.103
2013	207159586	287986	59934	9844	0.050
2014	223070852	654582	113777	90876	0.200
2015	8121294	815063	226160	104631	0.264
2016	705205636	315656	260146	42845	0.103
2017	32475613	1791780	202400	115642	0.228
2018	223741069	617770	442856	75388	0.244
2019	303229348	838505	275130	135899	0.368
2020	160691992	1118810	284077	246139	0.621

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2021	77206947	1051620	375120	157472	0.373
2022			210029		
arith. mean	171290233	562186	171661	158208	0.415
geo. mean	112898529				

arith. mean for the period 1986–2021

geo. mean for the period 1986–2020

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2022)	112945.768	23480.1	10489.9	3818.36	1005.44
Exploitation pattern 1st half		0.299	0.448	0.428	0.428
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		8.716	13.566	18.282	23.645
Weight in the catch 1st half		8.716	13.566	18.282	23.645
weight in the catch 2nd half	3.782	8.413	15.411	20.172	21.859
Proportion mature(2022)	0.000	0.036	0.766	1.000	1.000
Proportion mature(2023)	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(2021)=0.3735; Yield(2021)=157.472; Recruitment(2021)=77.206947; Recruitment(2022)=geometric mean (GM 1986-2020)=112.945768 billion; SSB(2022)=210.029

F multiplier	Basis	F(2022)	Catch(2022)	SSB(2023)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	200.747	-4 %	-100 %
0.780	Fsq*0.78	0.290	85.559	151.563	-28 %	-46 %
1.000	Fsq*1	0.373	106.151	140.019	-33 %	-33 %
0.400	Fsq*0.4	0.149	46.963	173.527	-17 %	-70 %
0.600	Fsq*0.6	0.224	68.080	161.460	-23 %	-57 %
0.800	Fsq*0.8	0.299	87.775	150.315	-28 %	-44 %
0.100	Fsq*0.1	0.037	12.371	193.529	-8 %	-92 %
0.120	Fsq*0.12	0.045	14.793	192.120	-9 %	-91 %
0.140	Fsq*0.14	0.052	17.198	190.722	-9 %	-89 %
1.233	MSY	0.461	126.038	129.000	-39 %	-20 %

***SSB in 2023 relative to SSB in 2022**

****TAC in 2022 relative to catches in 2021**

Table 9.4.13. Sandeel Area-3r. Acoustic survey indices (millions of individuals).

Year	Age 1	Age 2	Age 3	Age 4
2009	7709.06 (CV=0.29)	4923.33 (CV=0.34)	945.29 (CV=0.3)	64.03 (CV=0.47)
2010	16852.06 (CV=0.19)	6133.6 (CV=0.18)	1123.19 (CV=0.38)	608.57 (CV=0.4)
2011	816.16 (CV=0.73)	8622.2 (CV=0.19)	855.81 (CV=0.33)	192.37 (CV=0.49)
2012	846.68 (CV=0.81)	211.31 (CV=0.67)	3226.29 (CV=0.25)	368.16 (CV=0.24)
2013	2154.47 (CV=0.2)	258.25 (CV=0.36)	72.62 (CV=0.41)	554.48 (CV=0.43)
2014	21889.62 (CV=0.23)	1711.1 (CV=0.36)	170.41 (CV=0.64)	80.34 (CV=0.85)
2015	9466.6 (CV=0.12)	2254.92 (CV=0.27)	686.55 (CV=0.29)	7.03 (CV=1.18)
2016	79.55 (CV=1)	6317.38 (CV=0.29)	679.13 (CV=0.25)	259.1 (CV=0.37)
2017	35267.58 (CV=0.16)	131.65 (CV=0.77)	3465.88 (CV=0.27)	631.09 (CV=0.27)
2018	1544.39 (CV=0.31)	16989.62 (CV=0.1)	79.82 (CV=0.34)	440.33 (CV=0.31)
2019	9564.52 (CV=0.16)	464.24 (CV=0.25)	15573.73 (CV=0.12)	214.53 (CV=0.33)
2020	42141.65 (CV=0.27)	10064.47 (CV=0.27)	535.24 (CV=0.42)	9944.09 (CV=0.2)
2021	14564.25 (CV=0.19)	12971.11 (CV=0.17)	2770.14 (CV=0.2)	285.07 (CV=0.33)

Table 9.5.1 Sandeel Area-4. Catch at age numbers (million) by half 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
2014	0	346	0	54	0	15	0	47	0

	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
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	2	3323	16	2196	83	354	11	383	42
arith. mean	122	1232	164	1010	145	604	25	263	47

Table 9.5.2 Sandeel Area-4. Individual mean weight (gram) at age in the catch and in the sea.

	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
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

	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
2020	4.4	6.7	7.7	8.6	10.7	11.9	14.6	12.4	17.6
2021	4.4	5.6	7.7	9.2	10.7	11.9	14.6	17.8	17.6
arith. mean	3.9	5.6	7.9	9.4	13.2	13.2	16.0	17.1	21.1

Table 9.5.3 Sandeel Area-4. Proportion mature.

	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	585	1010
2021	160	194

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

```
Date: 01/26/22  Start time:09:43:34 run time:1 seconds

objective function (negative log likelihood):  14.7669
Number of parameters: 48
Maximum gradient: 2.44224e-005
Akaike information criterion (AIC):   125.534
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             261      37      29       0     327

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
               36.9   -23.1    20.4     0.0     0.0      0.00      34


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.14   -0.63    0.70    0.00


contribution by fleet:
----------------------
New Dredge survey 2008-2021     total: -13.592   mean:  -0.485
Old Dredge survey 1999-2003     total:  -9.555   mean:  -1.062

F, season effect:
-----------------
age: 0
    1993-2021:   0.000 1.000
age: 1 - 4
    1993-2021:   0.724 0.500

F, age effect:
--------------
                0      1      2      3      4
1993-2021:  0.002  0.097  0.194  0.274  0.274


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1993-2021 season 1:      0  0.601  1.205  1.704  1.704
          season 2:  0.003  0.065  0.129  0.183  0.183


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               2.102
 1       0.736   0.587
 2       0.736   0.587
 3       0.679   1.240
 4       0.679   1.240
```

```
Survey catchability:
--------------------
                           age 0    age 1
 New Dredge survey 2008-2021       0.790    4.221
 Old Dredge survey 1999-2003       0.784   18.050

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 New Dredge survey 2008-2021        0.55     0.30
 Old Dredge survey 1999-2003        0.30     0.30

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-4             1250.432   4.800e+004   1.500          1.225
```

Table 9.5.6 Sandeel Area-4. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0.001	0.346	0.671	0.923	0.921	0.509
1994	0.001	0.402	0.778	1.067	1.064	0.590
1995	0.000	0.120	0.232	0.316	0.315	0.176
1996	0.006	0.234	0.479	0.696	0.700	0.357
1997	0.001	0.148	0.289	0.400	0.399	0.218
1998	0.000	0.161	0.312	0.427	0.426	0.237
1999	0.000	0.234	0.450	0.613	0.610	0.342
2000	0.000	0.116	0.224	0.306	0.304	0.170
2001	0.000	0.182	0.351	0.479	0.477	0.266
2002	0.000	0.039	0.075	0.102	0.102	0.057
2003	0.000	0.289	0.558	0.763	0.760	0.423
2004	0.000	0.056	0.108	0.147	0.147	0.082
2005	0.000	0.024	0.047	0.065	0.064	0.036
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	0.004	0.005	0.005	0.003
2012	0.000	0.019	0.036	0.049	0.049	0.027
2013	0.000	0.010	0.020	0.027	0.027	0.015
2014	0.000	0.014	0.027	0.036	0.036	0.020
2015	0.000	0.011	0.021	0.029	0.029	0.016
2016	0.000	0.022	0.042	0.057	0.057	0.032
2017	0.000	0.047	0.092	0.125	0.125	0.070
2018	0.000	0.135	0.261	0.356	0.354	0.198
2019	0.000	0.058	0.111	0.152	0.151	0.084
2020	0.000	0.046	0.088	0.120	0.120	0.067

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2021	0.001	0.357	0.689	0.943	0.940	0.523
arith. mean	0.000	0.106	0.206	0.283	0.282	0.156

Table 9.5.7 Sandeel Area-4. Fishing mortality (F) at age.

	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	0.260	0.028	0.521	0.056	0.736	0.079	0.736	0.079
1994	0.001	0.305	0.027	0.612	0.053	0.865	0.075	0.865	0.075
1995	0.000	0.094	0.000	0.189	0.000	0.267	0.001	0.267	0.001
1996	0.006	0.112	0.141	0.225	0.283	0.318	0.401	0.318	0.401
1997	0.001	0.106	0.020	0.212	0.039	0.300	0.056	0.300	0.056
1998	0.000	0.124	0.005	0.249	0.010	0.352	0.015	0.352	0.015
1999	0.000	0.185	0.000	0.370	0.000	0.523	0.000	0.523	0.000
2000	0.000	0.091	0.000	0.183	0.000	0.259	0.000	0.259	0.000
2001	0.000	0.142	0.002	0.285	0.004	0.403	0.006	0.403	0.006
2002	0.000	0.030	0.000	0.061	0.000	0.086	0.000	0.086	0.000
2003	0.000	0.223	0.011	0.447	0.021	0.632	0.030	0.632	0.030
2004	0.000	0.044	0.000	0.087	0.001	0.124	0.001	0.124	0.001
2005	0.000	0.019	0.000	0.038	0.000	0.054	0.000	0.054	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	0.029	0.000	0.041	0.000	0.041	0.000
2013	0.000	0.008	0.000	0.016	0.000	0.023	0.000	0.023	0.000
2014	0.000	0.011	0.000	0.022	0.000	0.030	0.000	0.030	0.000
2015	0.000	0.009	0.000	0.017	0.000	0.025	0.000	0.025	0.000
2016	0.000	0.017	0.000	0.034	0.000	0.048	0.000	0.048	0.000
2017	0.000	0.037	0.000	0.075	0.000	0.105	0.000	0.105	0.000
2018	0.000	0.106	0.000	0.213	0.000	0.302	0.000	0.302	0.000
2019	0.000	0.045	0.000	0.090	0.000	0.128	0.000	0.128	0.000
2020	0.000	0.036	0.000	0.072	0.000	0.101	0.000	0.101	0.000
2021	0.001	0.274	0.017	0.549	0.034	0.777	0.047	0.777	0.047
arith. mean	0.000	0.079	0.009	0.159	0.017	0.225	0.024	0.225	0.024

Table 9.5.8 Sandeel Area-4. Natural mortality (M) at age.

	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
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.

	Age 0	Age 1	Age 2	Age 3	Age 4
1993	118989	25765	23897	7791	1483
1994	233754	38010	4965	4515	1816
1995	62359	74674	7008	858	1100
1996	329020	19943	17455	1950	676
1997	93616	104596	3976	3531	569

	Age 0	Age 1	Age 2	Age 3	Age 4
1998	42109	29915	23698	1039	1269
1999	225520	13464	6752	6146	721
2000	182791	72126	2876	1568	1796
2001	23268	58460	16913	805	1170
2002	79947	7441	13001	4259	593
2003	154617	25568	1854	4113	1966
2004	11572	49427	5200	390	1398
2005	6949	3701	12154	1601	720
2006	4248	2222	933	3932	980
2007	6307	1359	571	313	2176
2008	19031	2017	349	192	1138
2009	276709	6086	517	117	605
2010	47595	88497	1564	174	330
2011	35026	15222	22718	525	228
2012	27988	11202	3905	7616	334
2013	18201	8951	2836	1275	3357
2014	254612	5821	2281	938	2057
2015	34055	81430	1479	751	1318
2016	73102	10892	20740	489	913
2017	90992	23379	2751	6741	605
2018	23107	29101	5787	859	2915
2019	200668	7390	6722	1572	1271
2020	62418	64177	1815	2064	1122
2021	46546	19962	15909	568	1286
2022		14876	3834	2987	369

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.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1993	119043556	618393	366957	132599	0.432
1994	233805469	571687	145801	158690	0.498
1995	62332904	772094	120090	52591	0.142
1996	329142057	382202	228662	158490	0.381
1997	93642978	779492	72330	58446	0.189
1998	42118600	459550	226387	58746	0.195
1999	225538177	268367	169397	53334	0.277
2000	182817693	354099	69564	37714	0.137
2001	23277552	323825	103881	47902	0.217
2002	79957036	156276	111302	12736	0.046
2003	154545638	184694	63831	63731	0.351

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2004	11570855	259656	53210	6882	0.066
2005	6948247	111495	79937	1557	0.029
2006	4248175	95431	80178	0	0.000
2007	6305924	50393	42702	0	0.000
2008	19038999	32923	22652	0	0.002
2009	276577049	54412	17771	0	0.000
2010	47583661	475943	19456	0	0.001
2011	35039971	286284	169736	0	0.002
2012	27979985	154307	101114	2585	0.022
2013	18201235	149987	96761	5225	0.012
2014	254548005	126895	79301	4314	0.016
2015	34038405	399110	40905	4392	0.013
2016	73075229	291562	193881	6188	0.025
2017	90966330	305129	121905	18474	0.056
2018	23115178	285935	107474	42296	0.160
2019	200635422	159464	100811	6651	0.068
2020	62395268	481854	50312	20101	0.054
2021	46548252	288685	145656	51882	0.437
2022			72766		
arith. mean	96038438	306212	109151	34673	0.132
geo. mean	54570282				

arith. mean for the period 1993–2021

geo. mean for the period 1993–2020

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2022)	55898.143	14875.6	3834.27	2986.51	368.905
Exploitation pattern 1st half		0.274	0.549	0.777	0.777
Exploitation pattern 2nd half	0.001	0.017	0.034	0.047	0.047
Weight in the stock 1st half		6.292	9.522	12.802	17.445
Weight in the catch 1st half		6.292	9.522	12.802	17.445
weight in the catch 2nd half	4.408	7.693	10.738	14.556	17.601
Proportion mature(2022)	0.000	0.000	0.790	0.980	1.000
Proportion mature(2023)	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(2021)=0.4368; Yield(2021)=51.883; Recruitment(2021)=46.548252; Recruitment(2022)=geometric mean (GM 2011-2020)=55.898143 billion; SSB(2022)=72.766

F multiplier	Basis	F(2022)	Catch(2022)	SSB(2023)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	70.783	-3 %	-100 %
3.25	Fsq*3.25	1.418	103.545	15.406	-79 %	100 %
1	Fsq*1	0.437	49.577	41.872	-42 %	-4 %
2	Fsq*2	0.874	79.937	26.093	-64 %	54 %
3	Fsq*3	1.310	99.723	17.017	-77 %	92 %
4	Fsq*4	1.747	113.364	11.516	-84 %	119 %
5	Fsq*5	2.184	123.223	8.016	-89 %	138 %
6	Fsq*6	2.621	130.628	5.697	-92 %	152 %
7	Fsq*7	3.058	136.362	4.110	-94 %	163 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2023 relative to SSB in 2022**

****TAC in 2022 relative to catches in 2021**

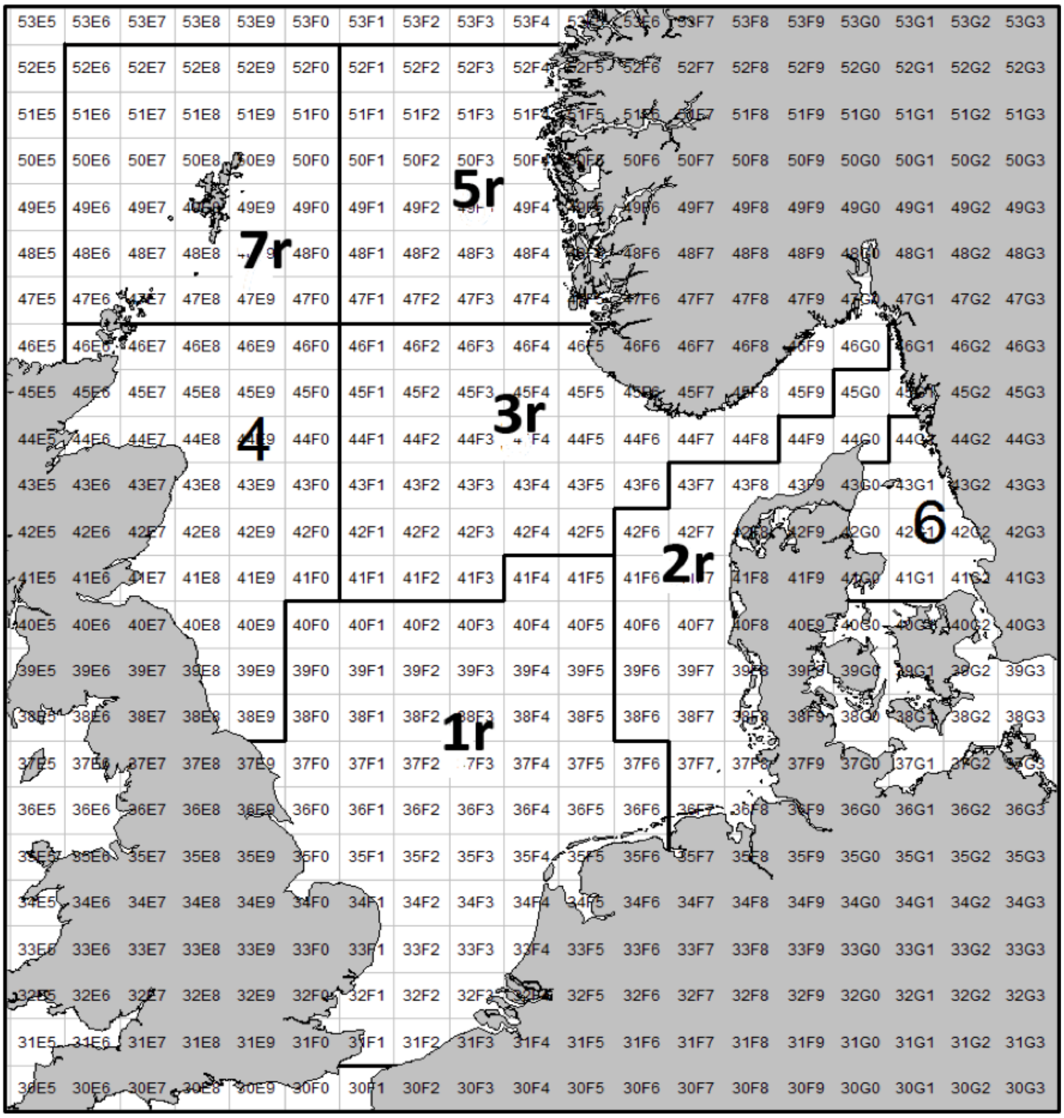


Figure 9.1.1 Sandeel in ICES Subarea 4 and Div. 3.a. Sandeel management areas.


2021
2020
2019
2018
2017
2016
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006

Figure 9.1.2 Sandeel in ICES Subarea 4 and Div. 3.a. Catch by ICES rectangles 2006–2021 (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.

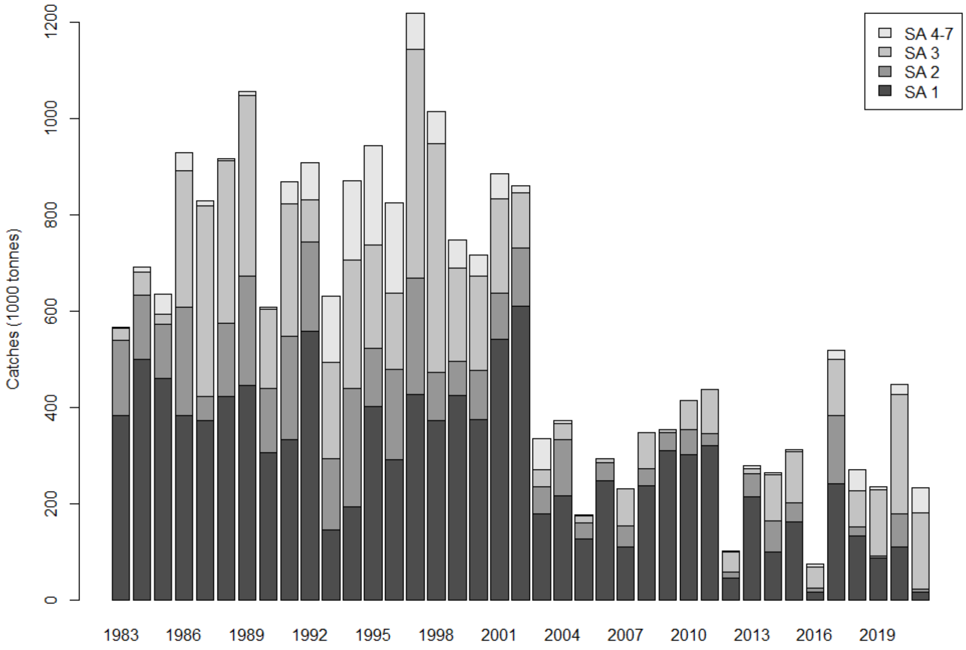


Figure 9.1.3 Sandeel in ICES Subarea 4 and Div. 3.a. Total catches by year and area.

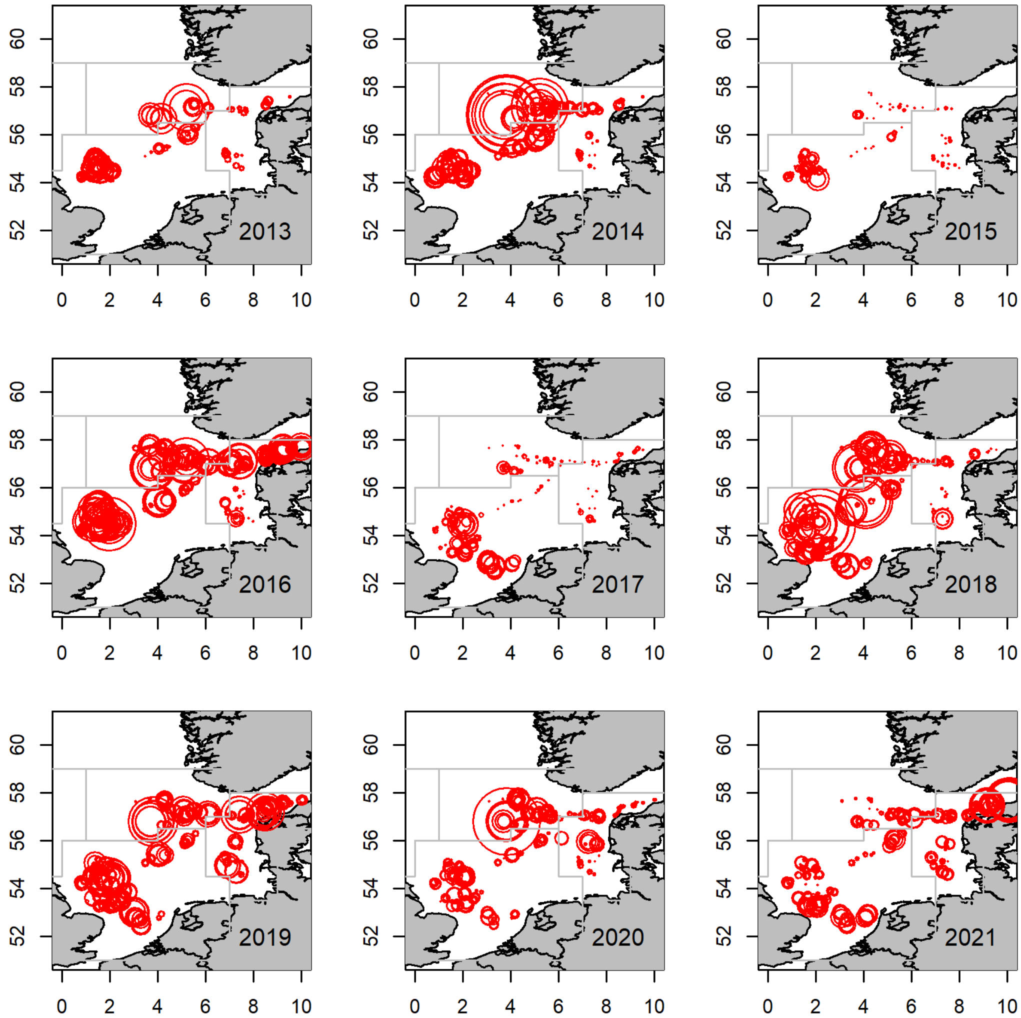


Figure 9.1.4 Sandeel in ICES Subarea 4 and Div. 3.a. Danish survey catches by haul for 0-group. Area of the circles is proportional to catch number.

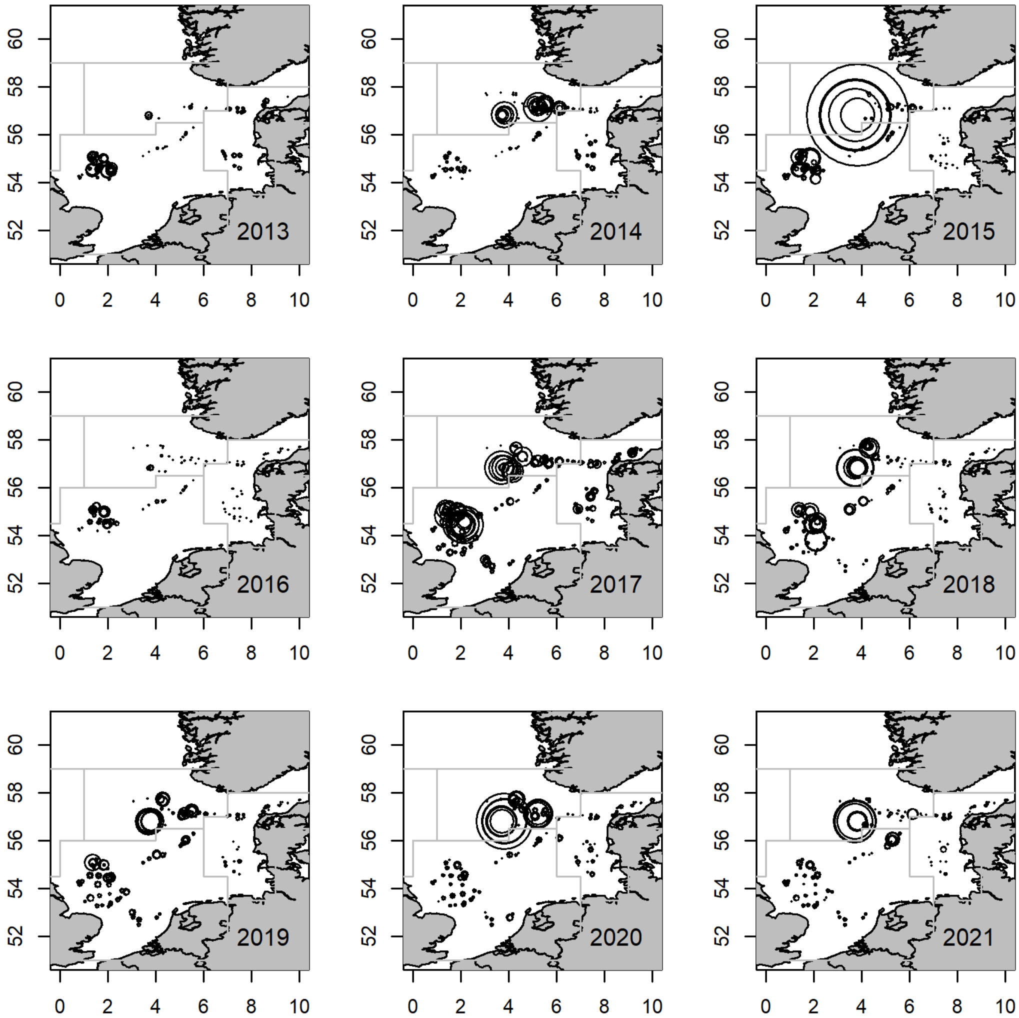


Figure 9.1.5 Sandeel in ICES Subarea 4 and Div. 3.a. Danish survey catches by haul for 1-group. Area of the circles is proportional to catch number.

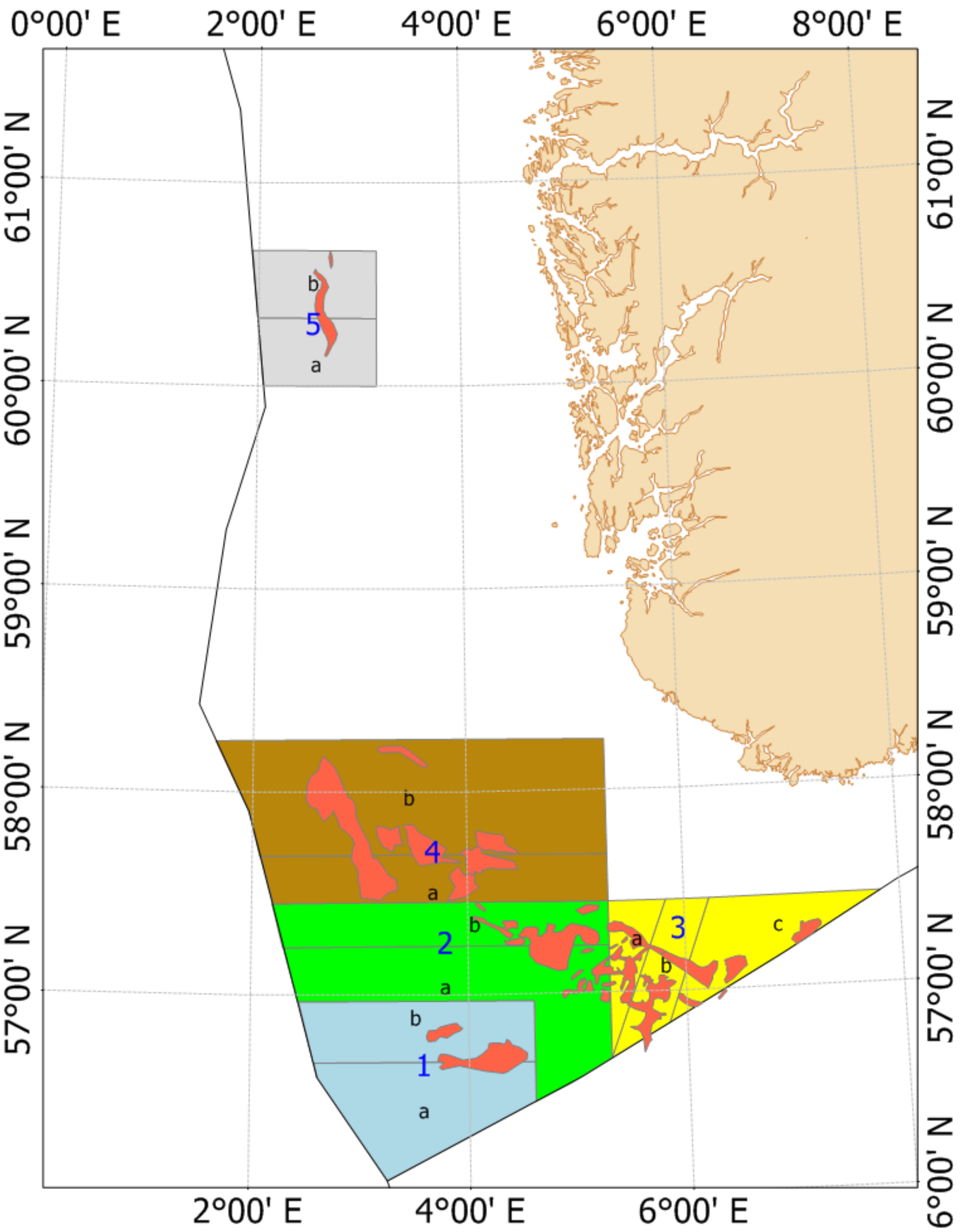


Figure 9.1.6 Sandeel in ICES Subarea 4 and Div. 3.a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.

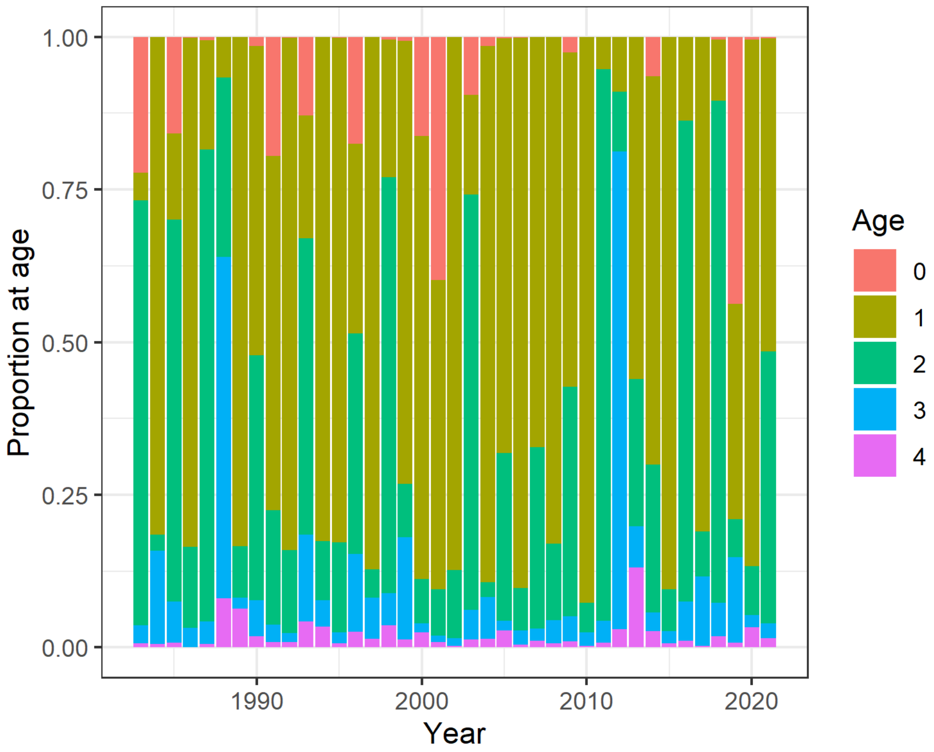


Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

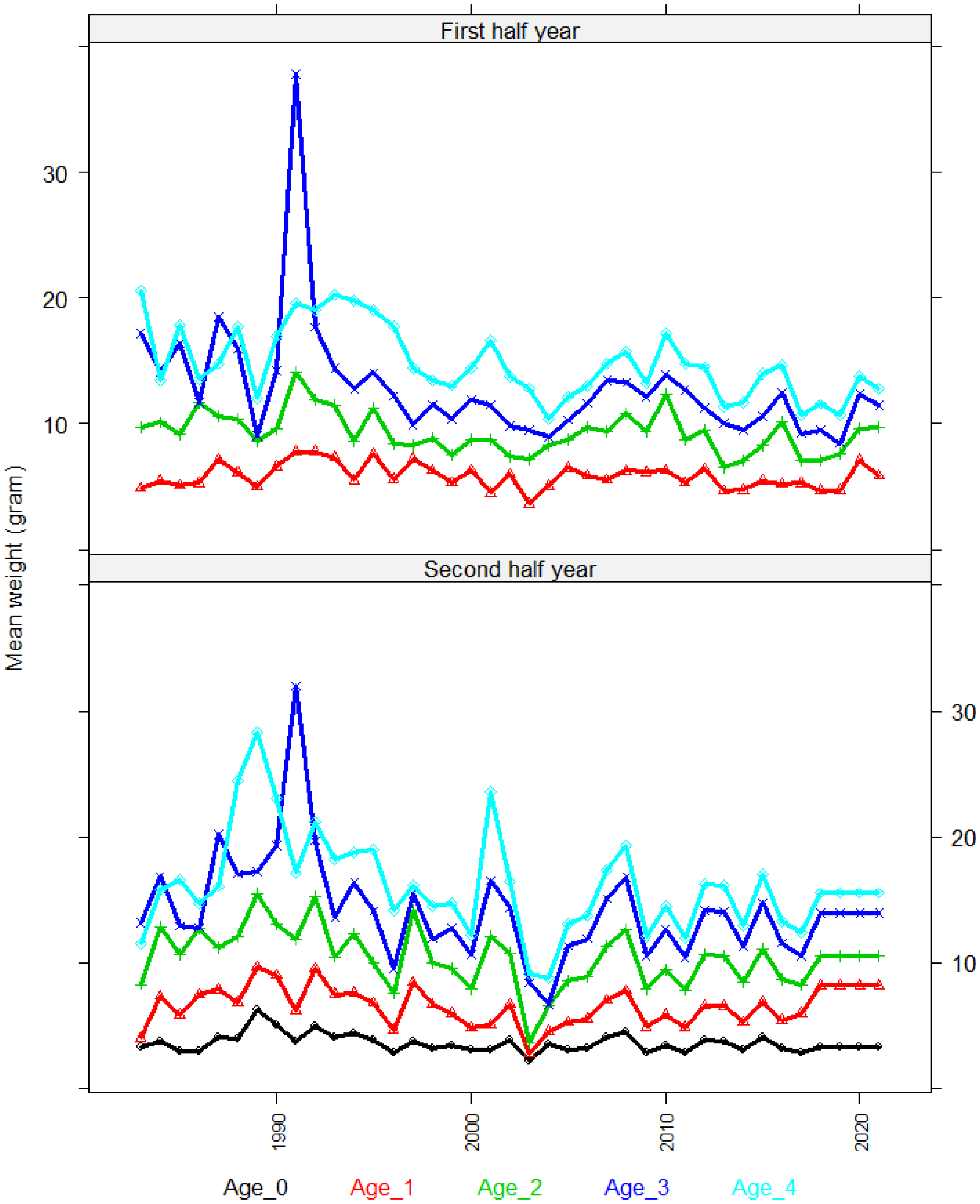


Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

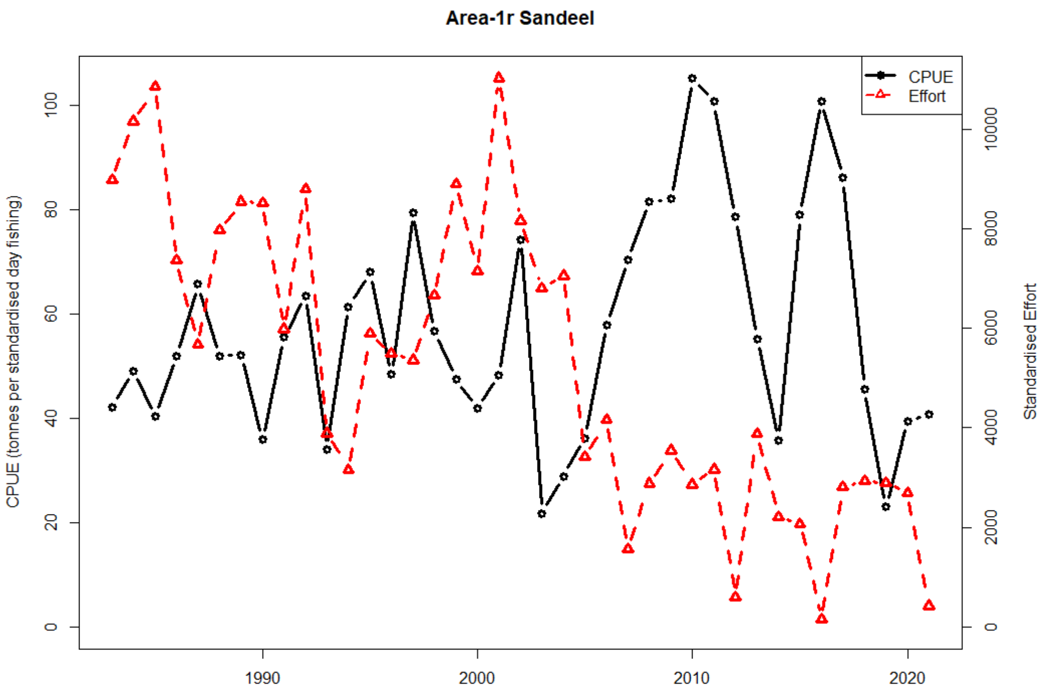


Figure 9.2.3 Sandeel Area-1r. CPUE and effort.

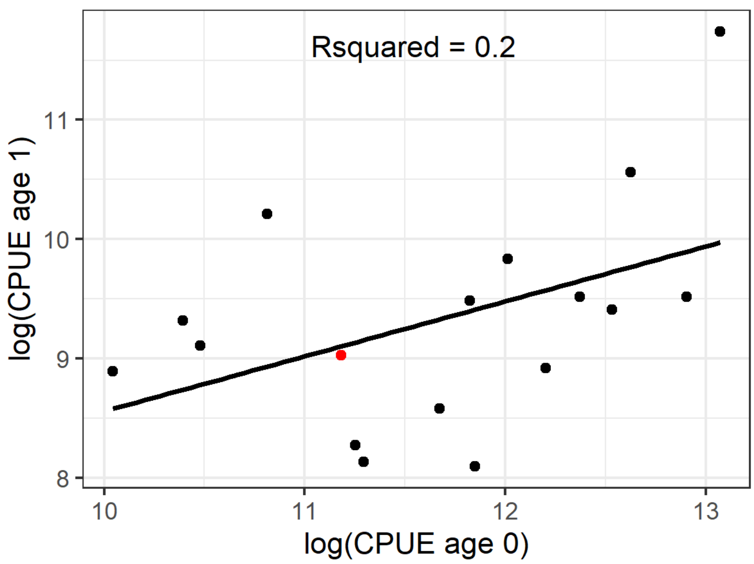


Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

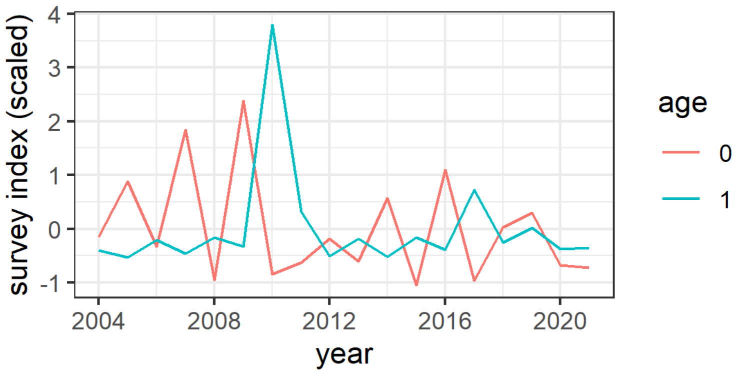


Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.

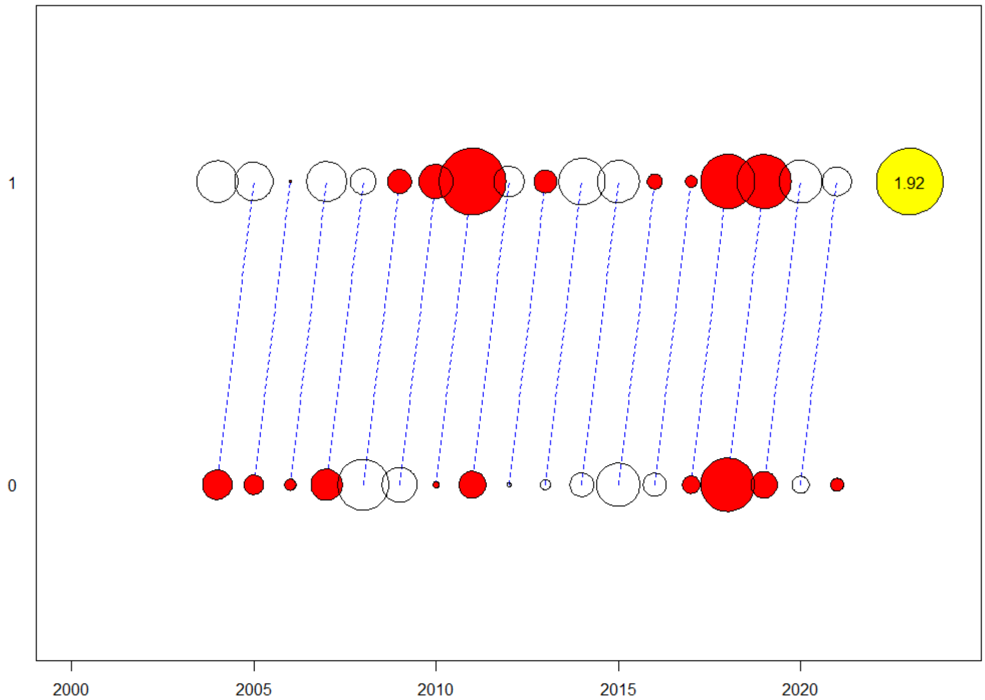


Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

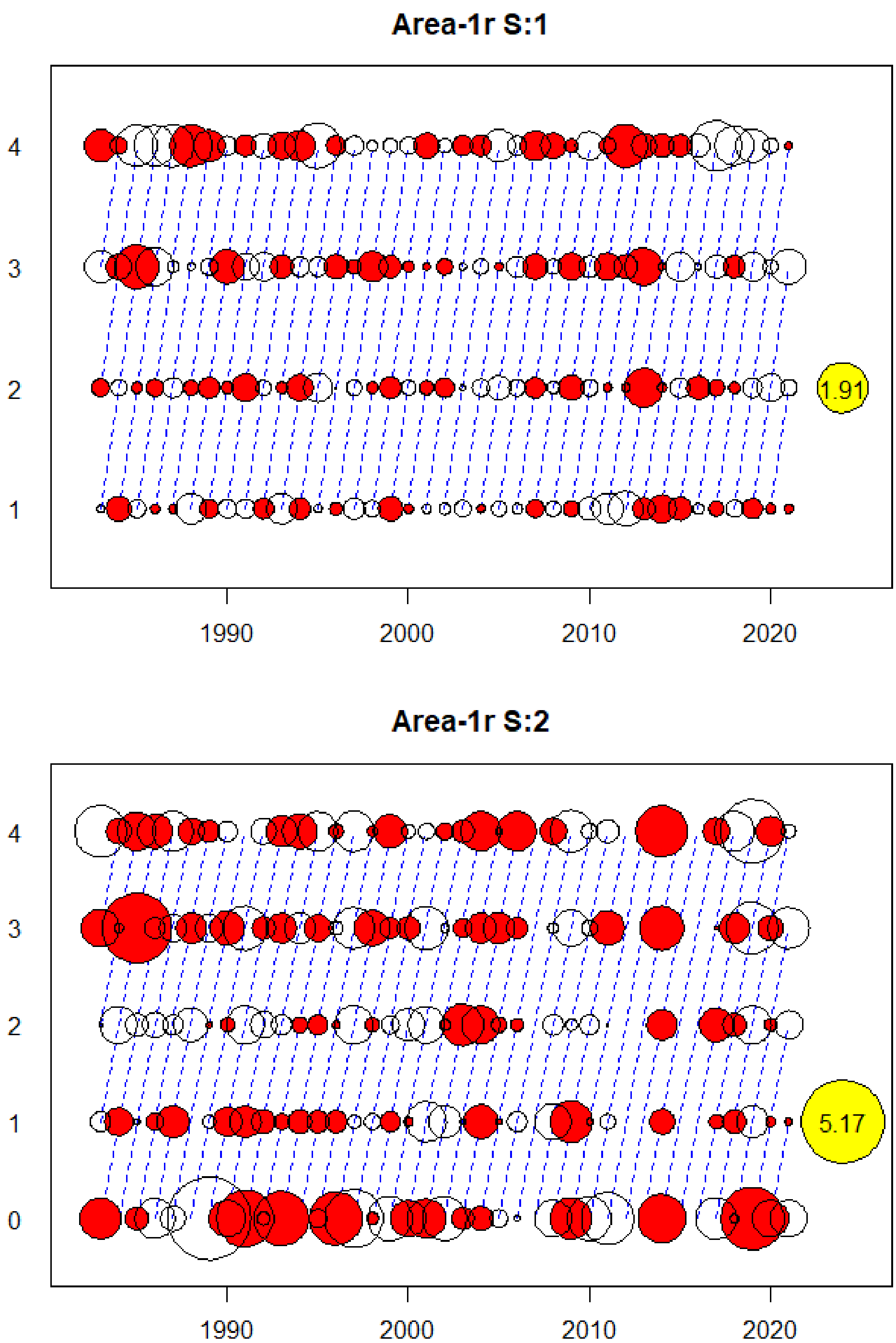


Figure 9.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

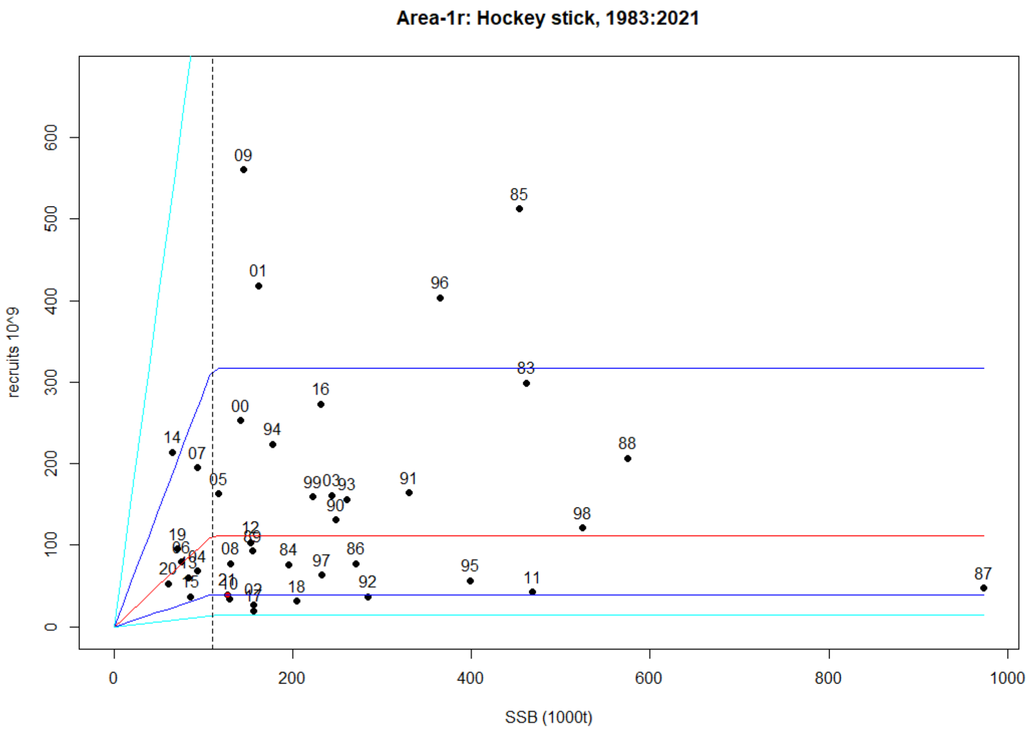


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

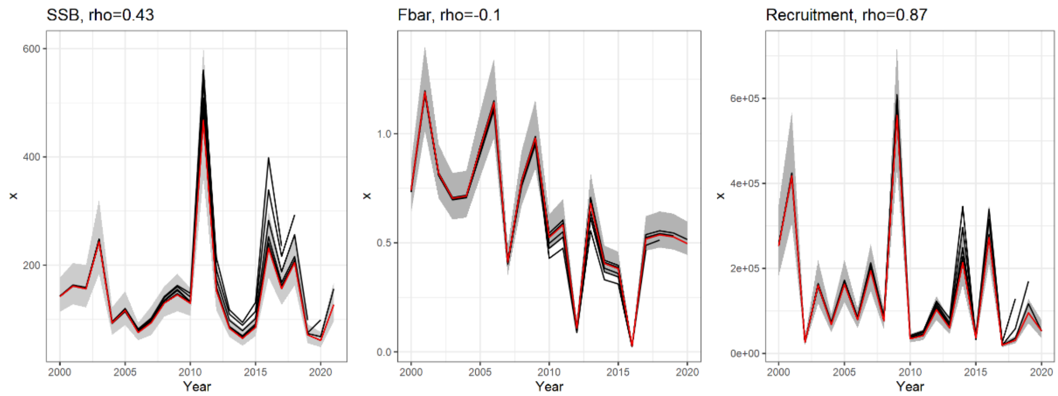


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

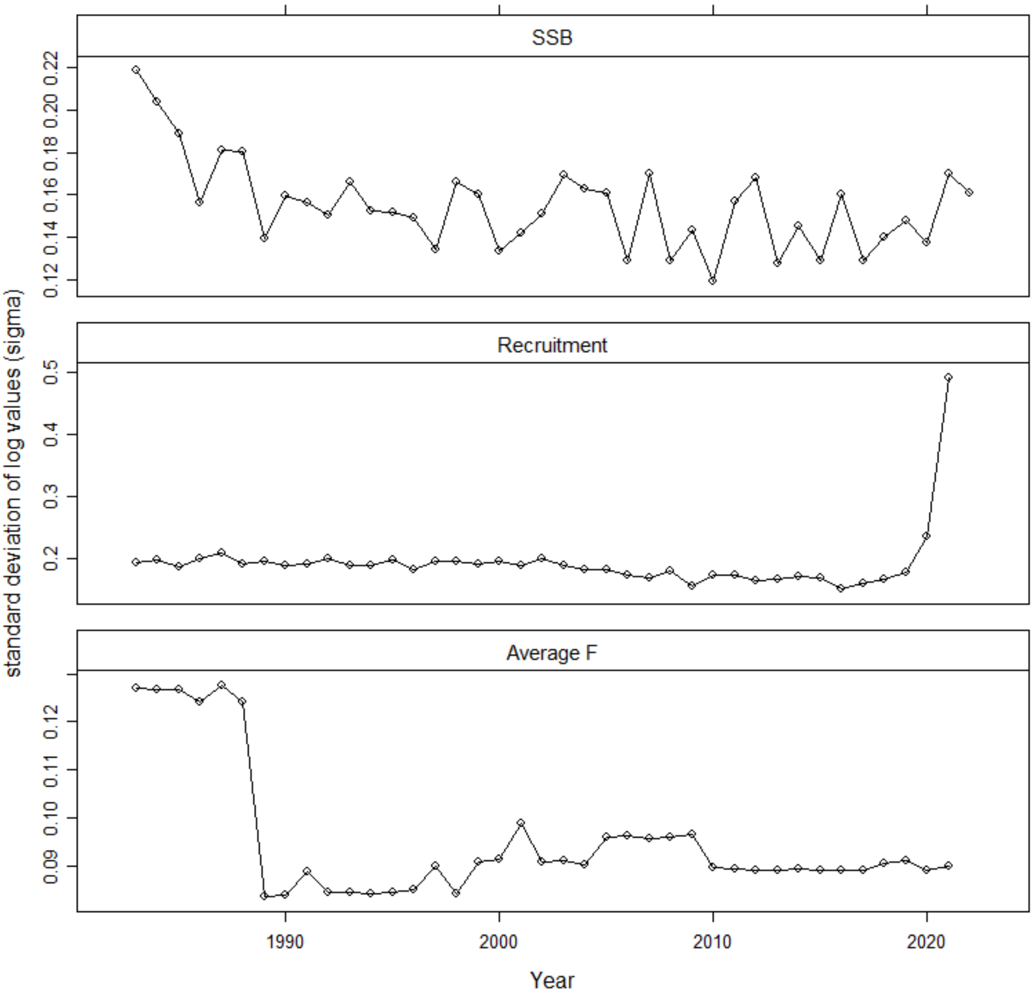


Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

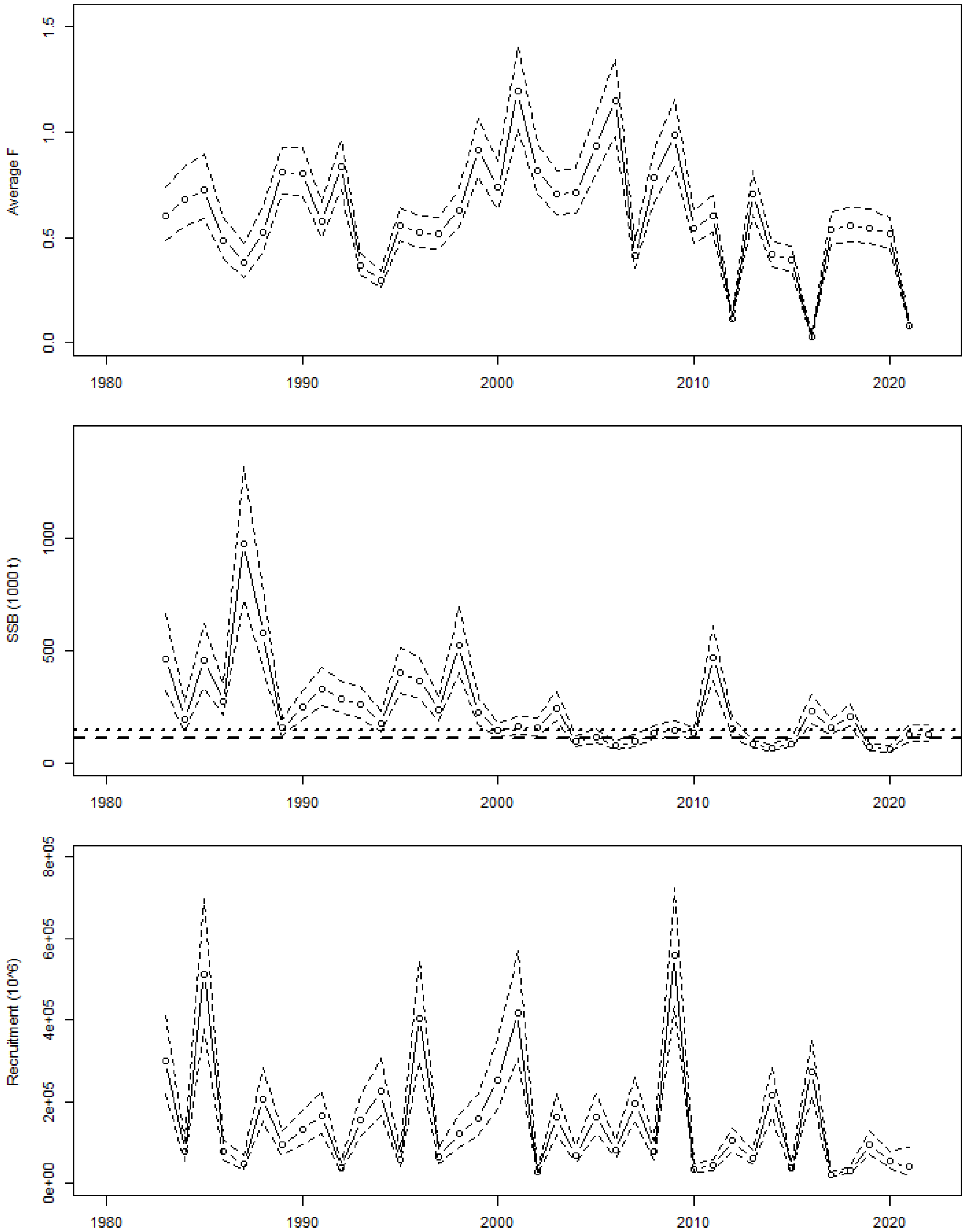


Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

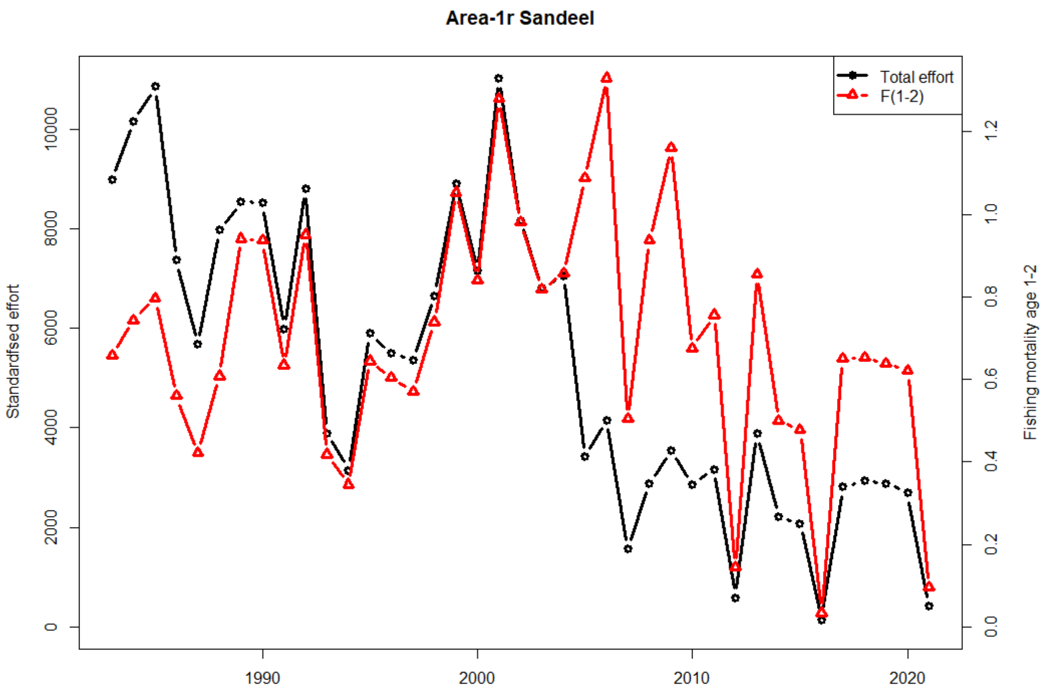


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

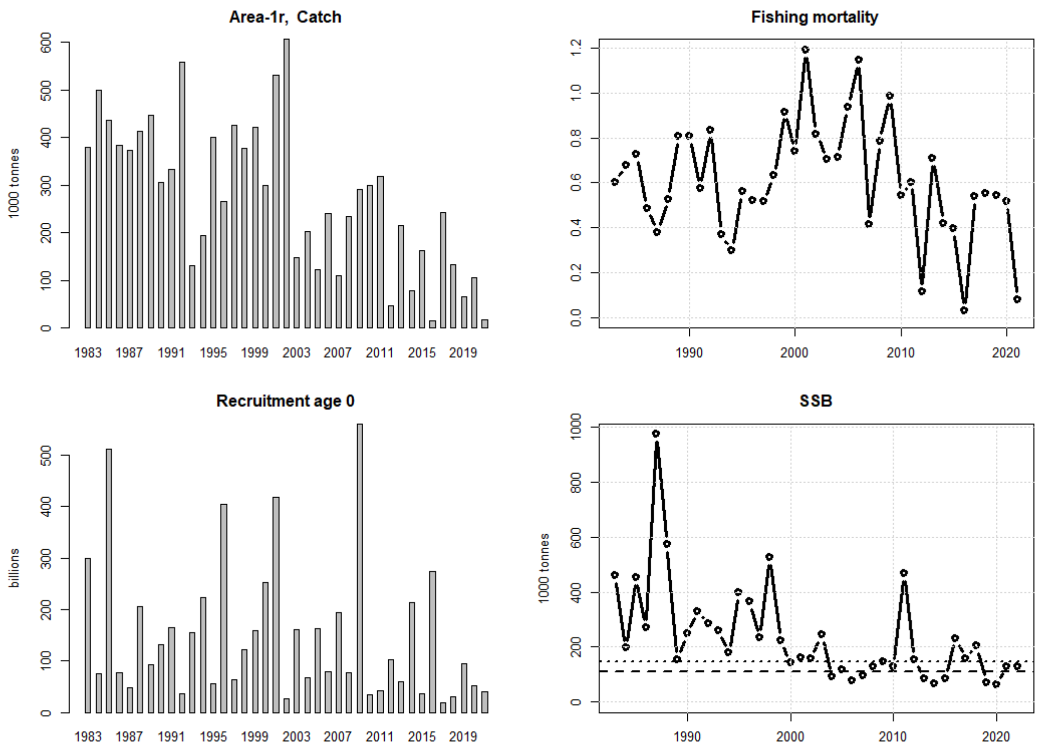


Figure 9.2.13 Sandeel Area-1r. Stock summary.

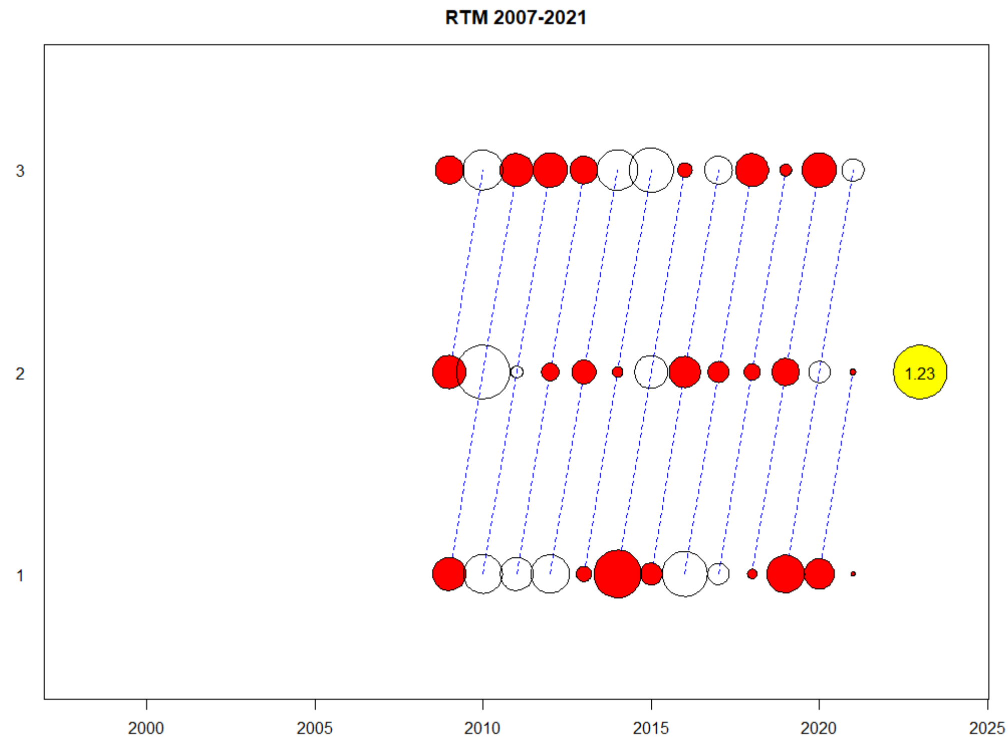


Figure 9.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

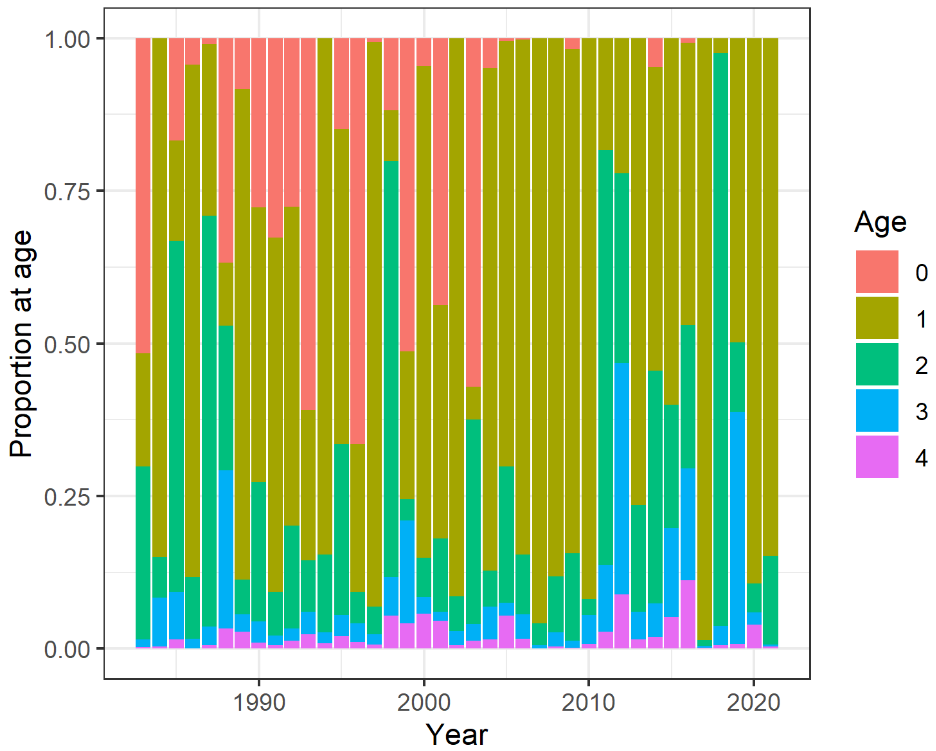


Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

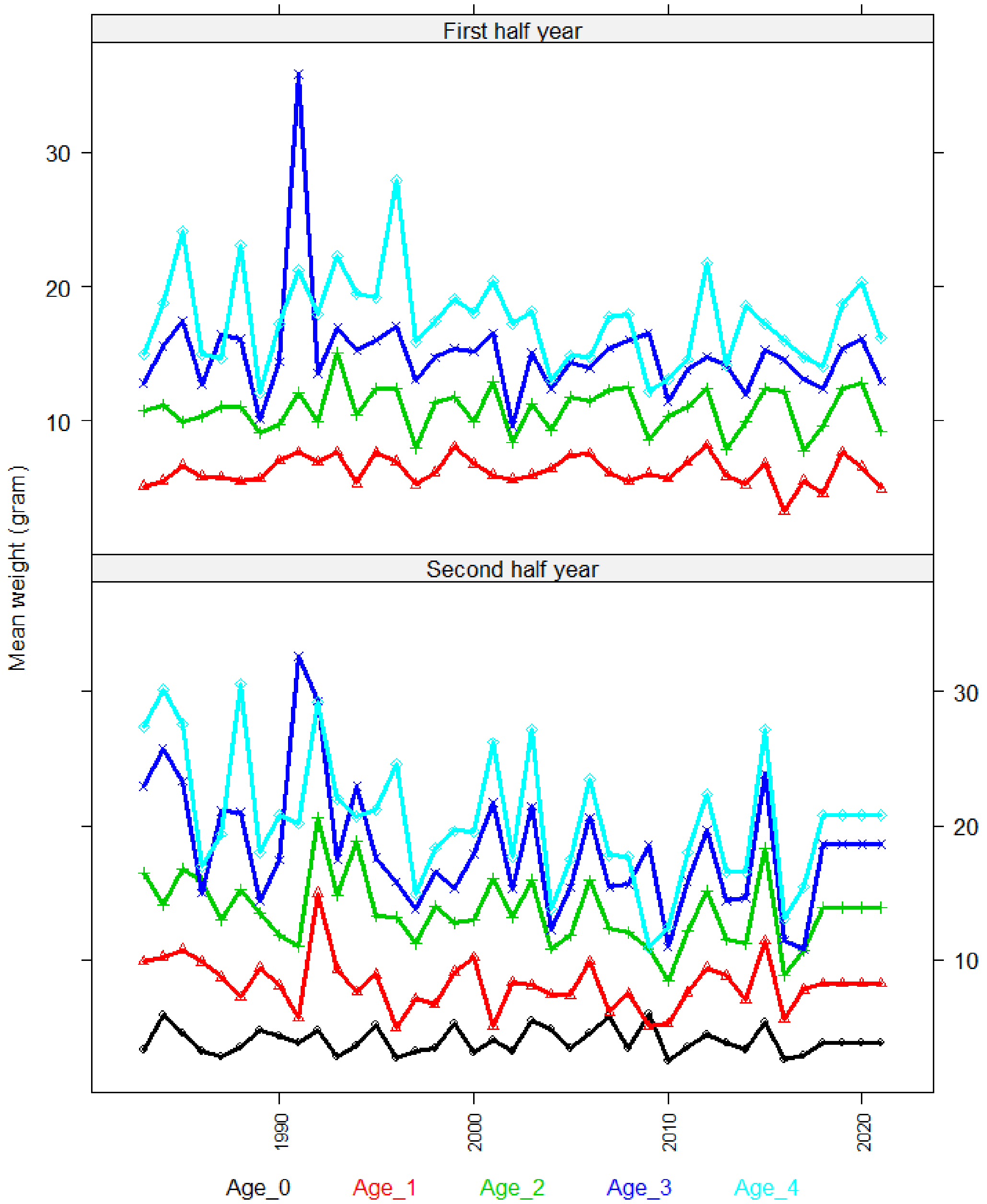


Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

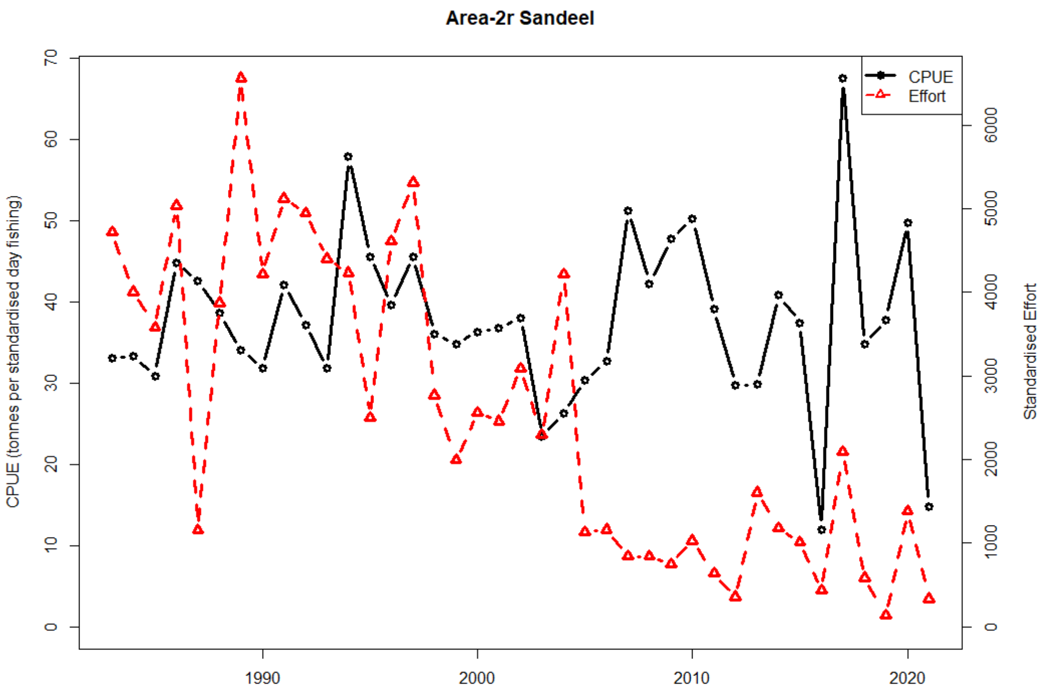


Figure 9.3.3 Sandeel Area-2r. CPUE and effort.

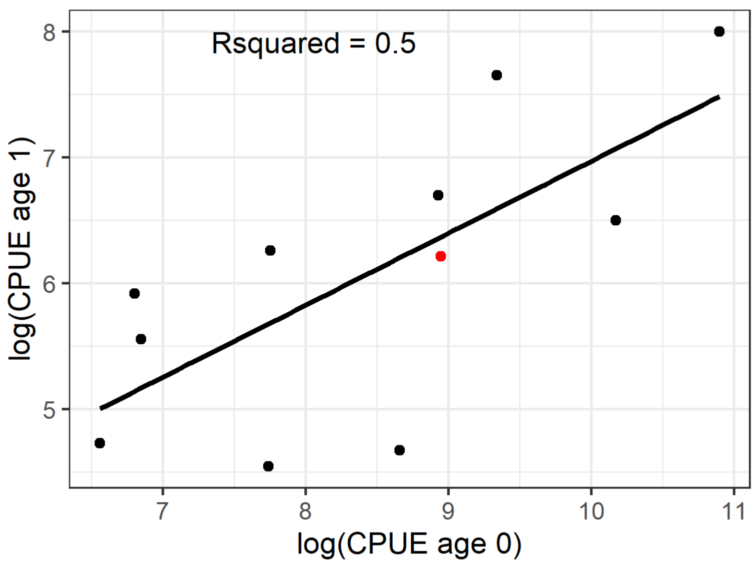


Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

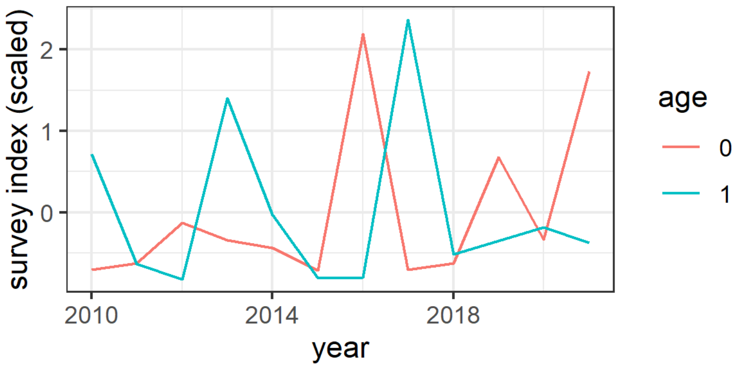


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

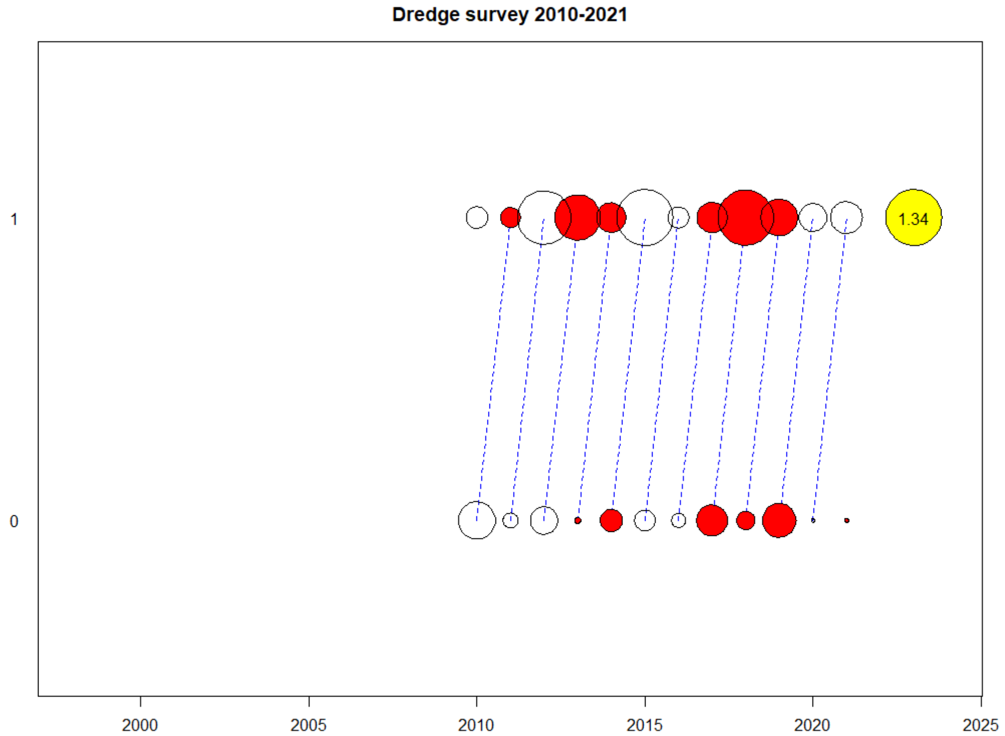


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

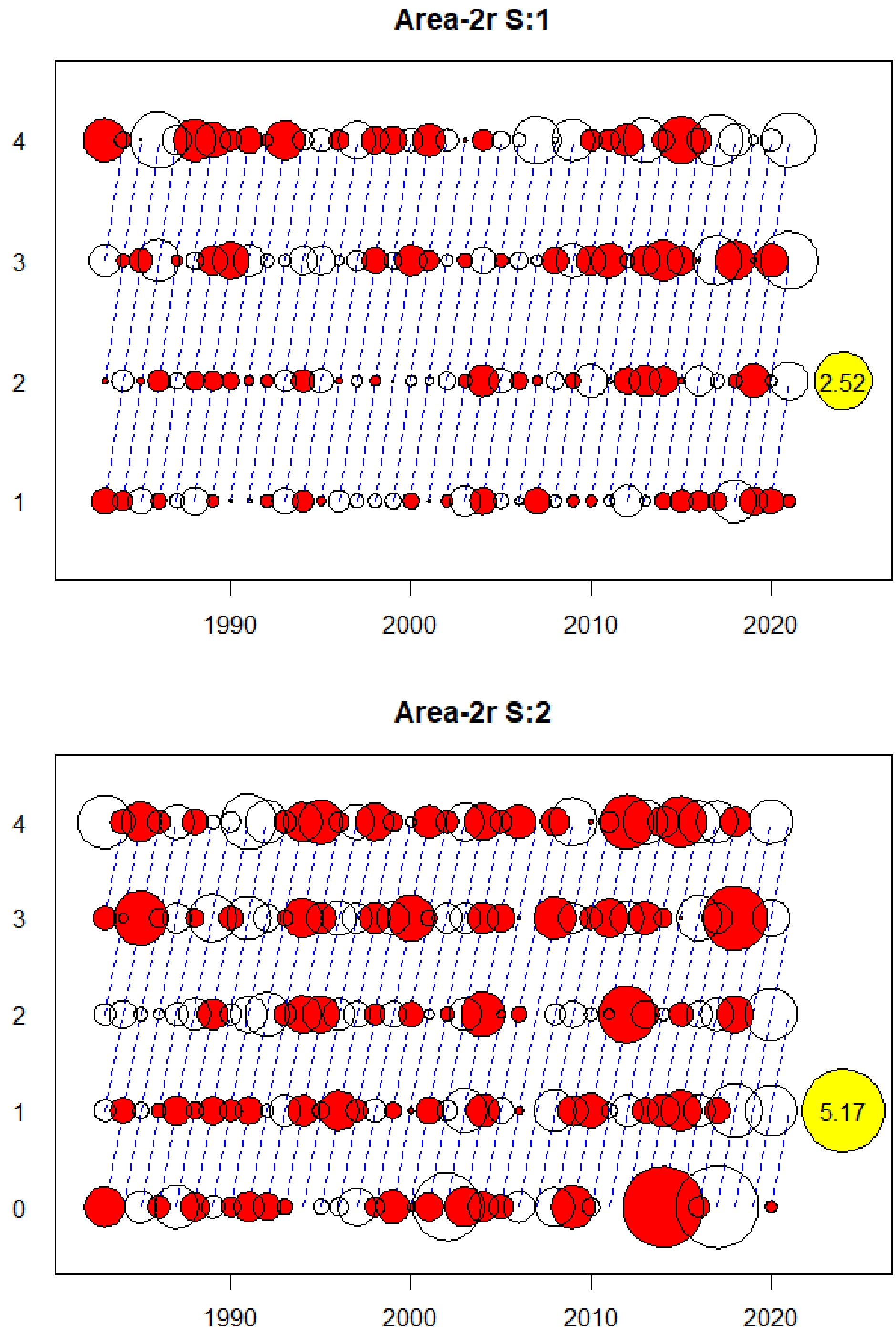


Figure 9.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

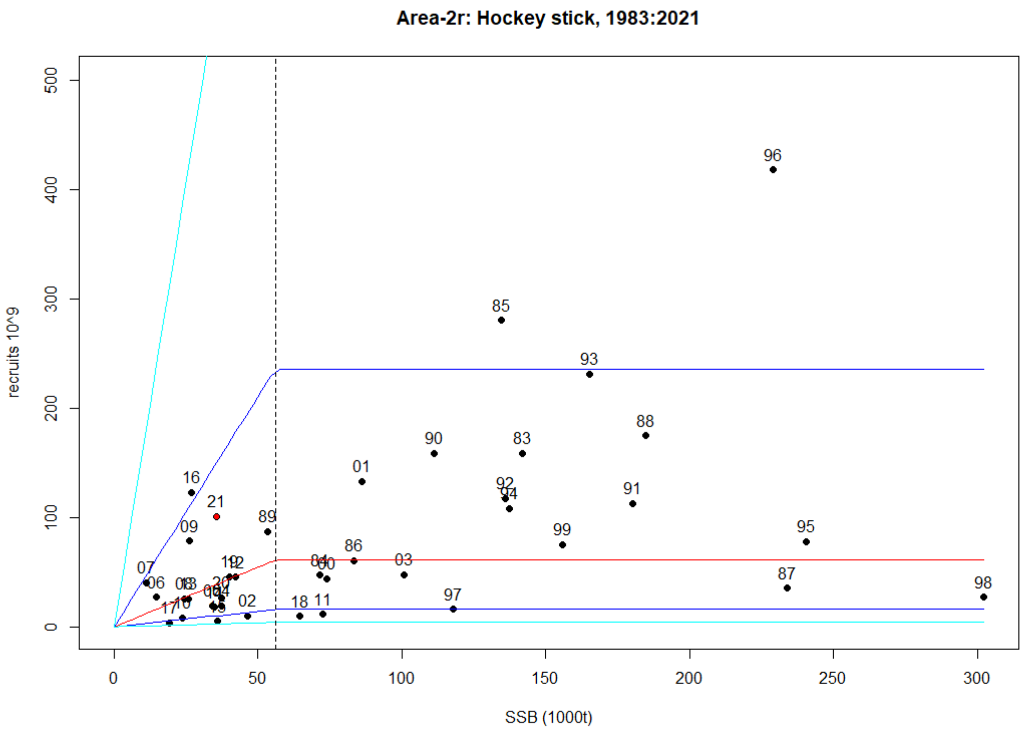


Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

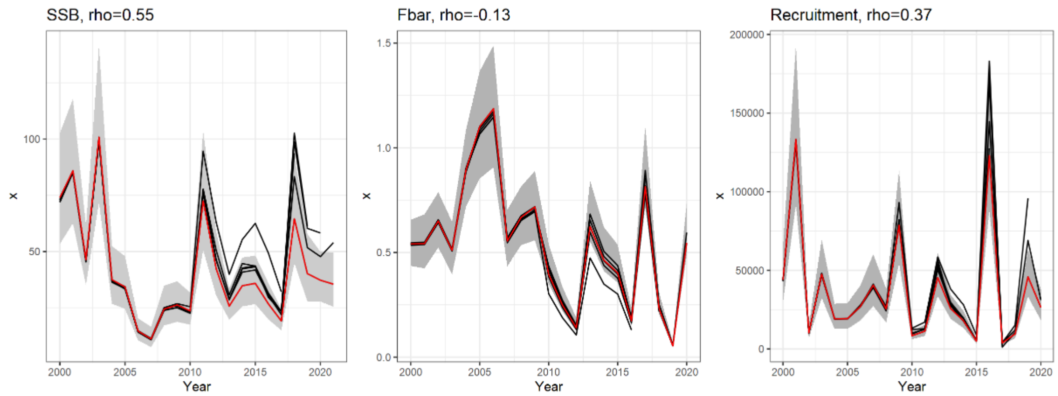


Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.

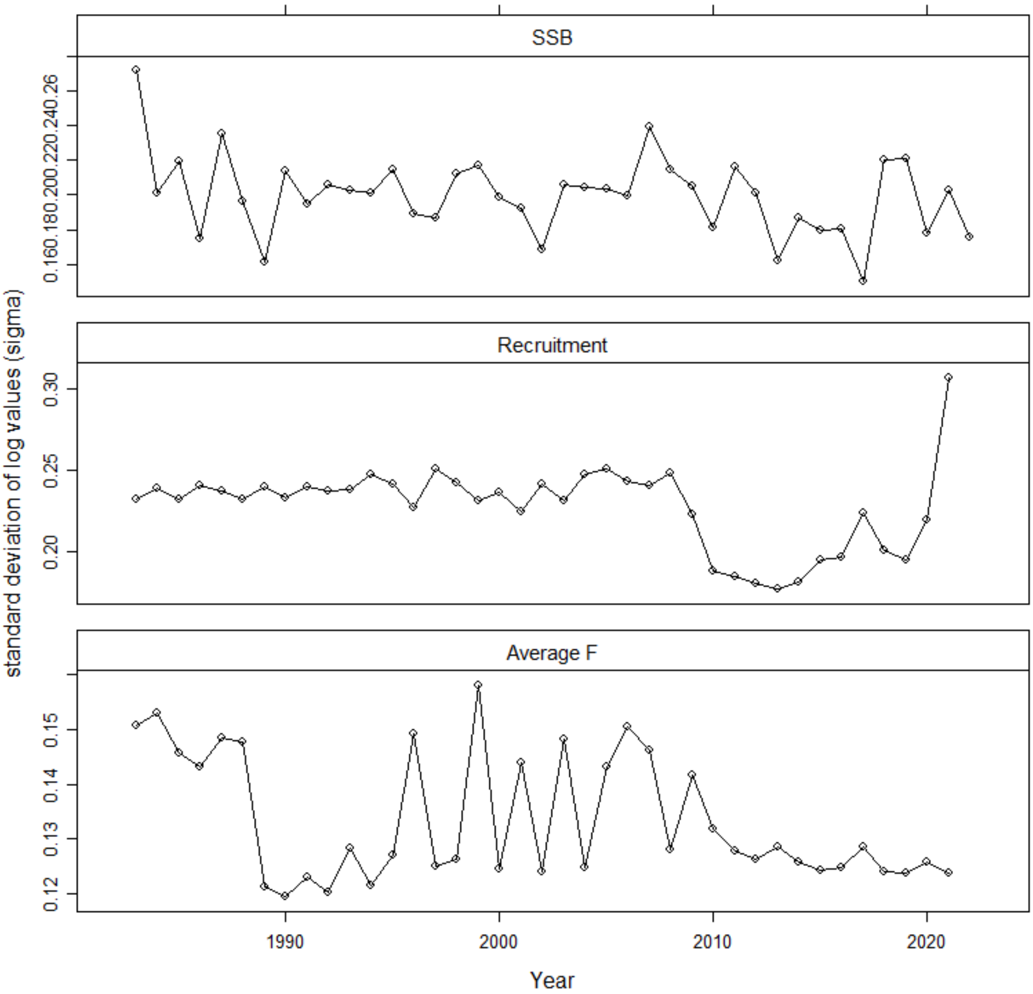


Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

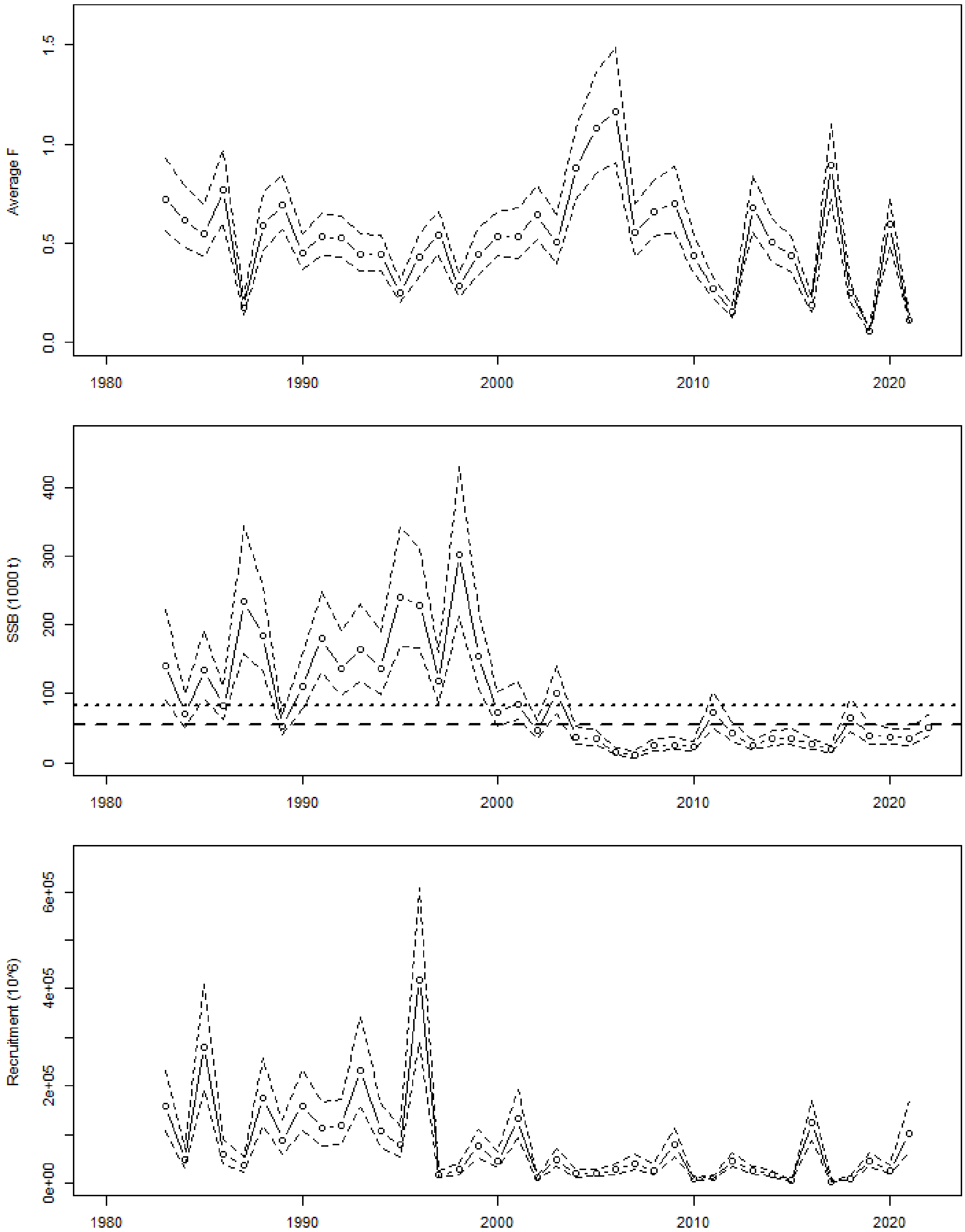


Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

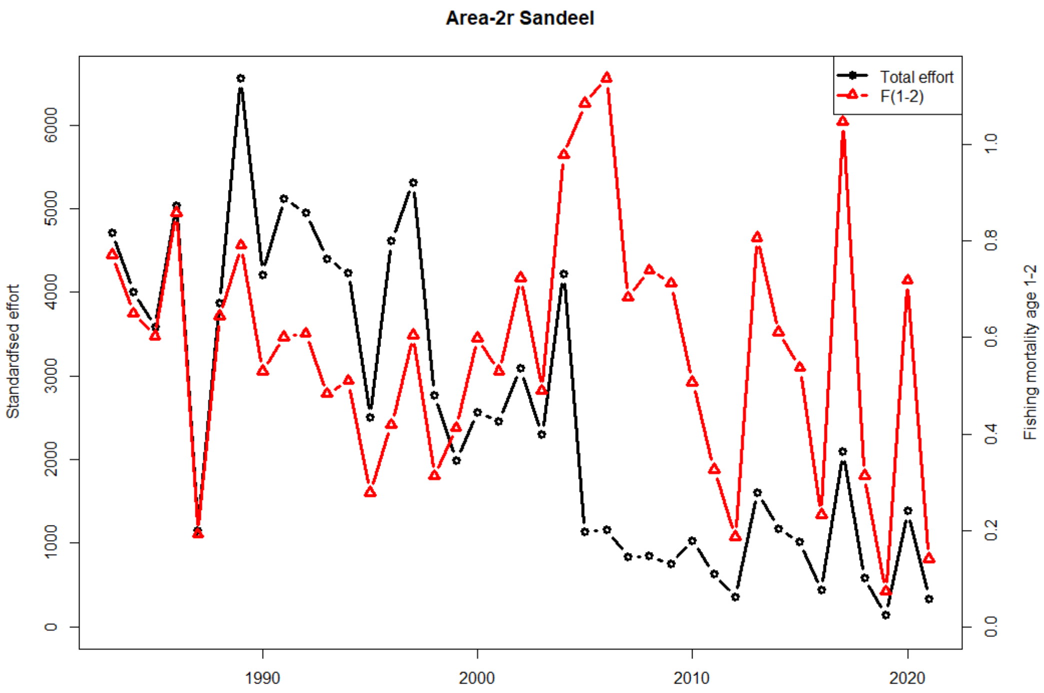


Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

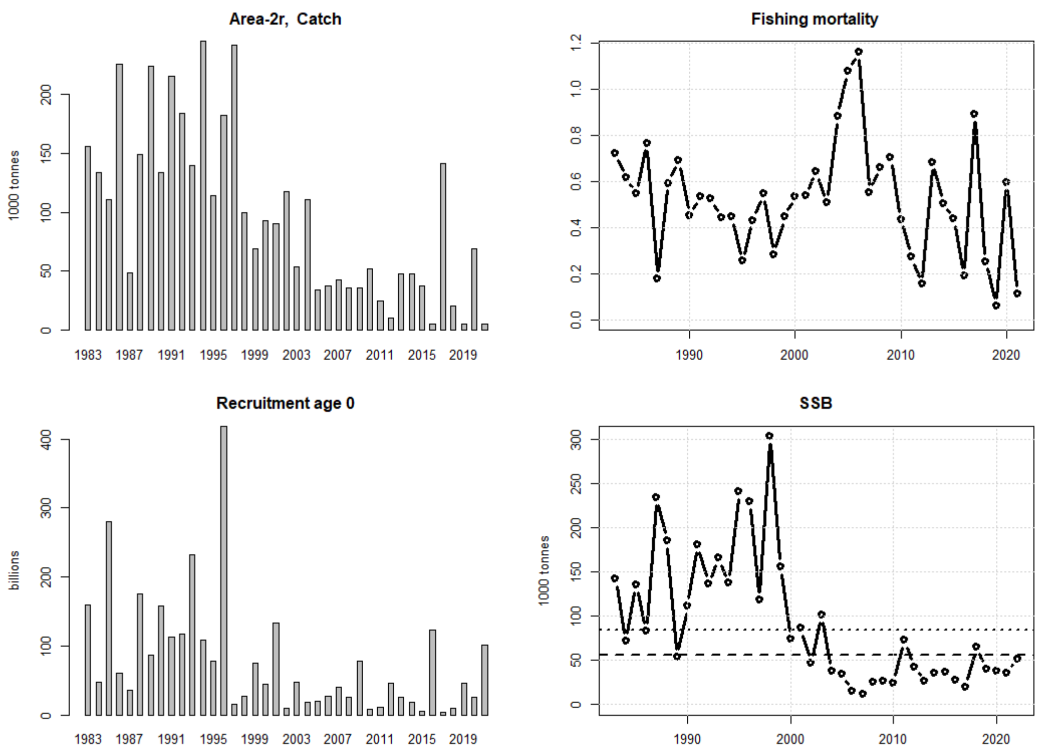


Figure 9.3.13 Sandeel Area-2r. Stock summary.

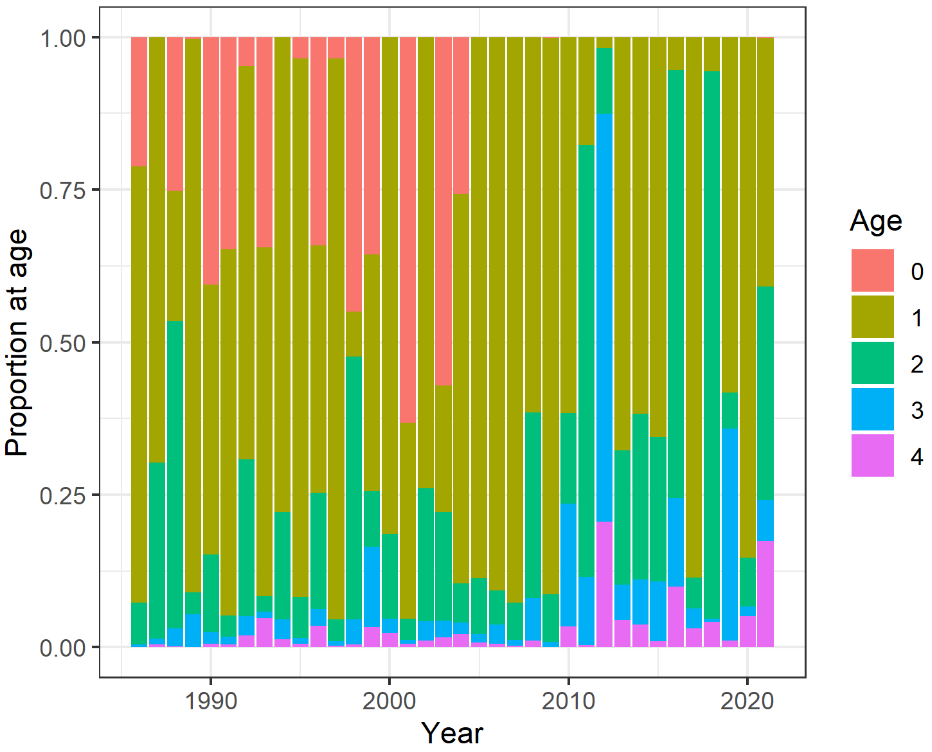


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

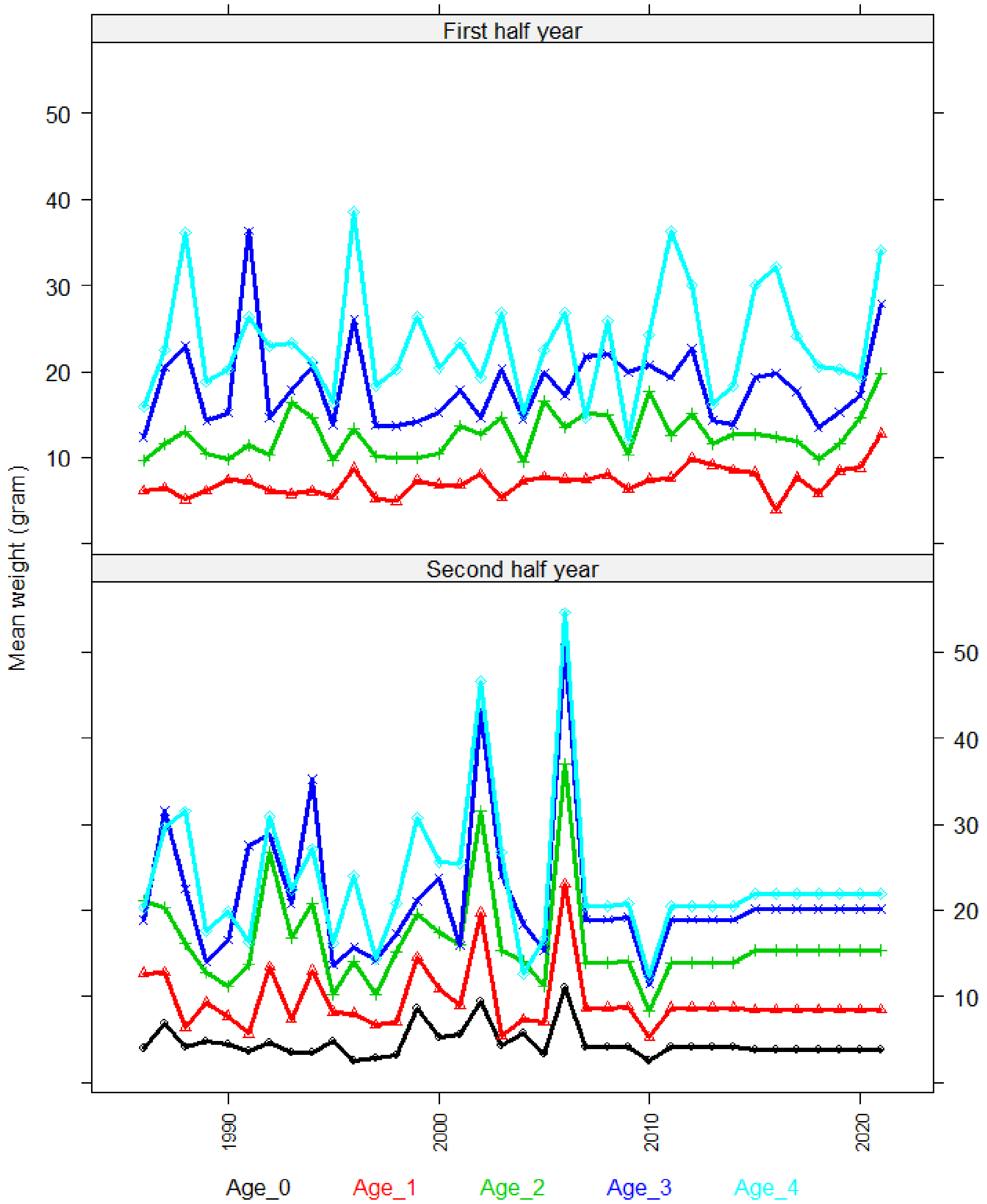


Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

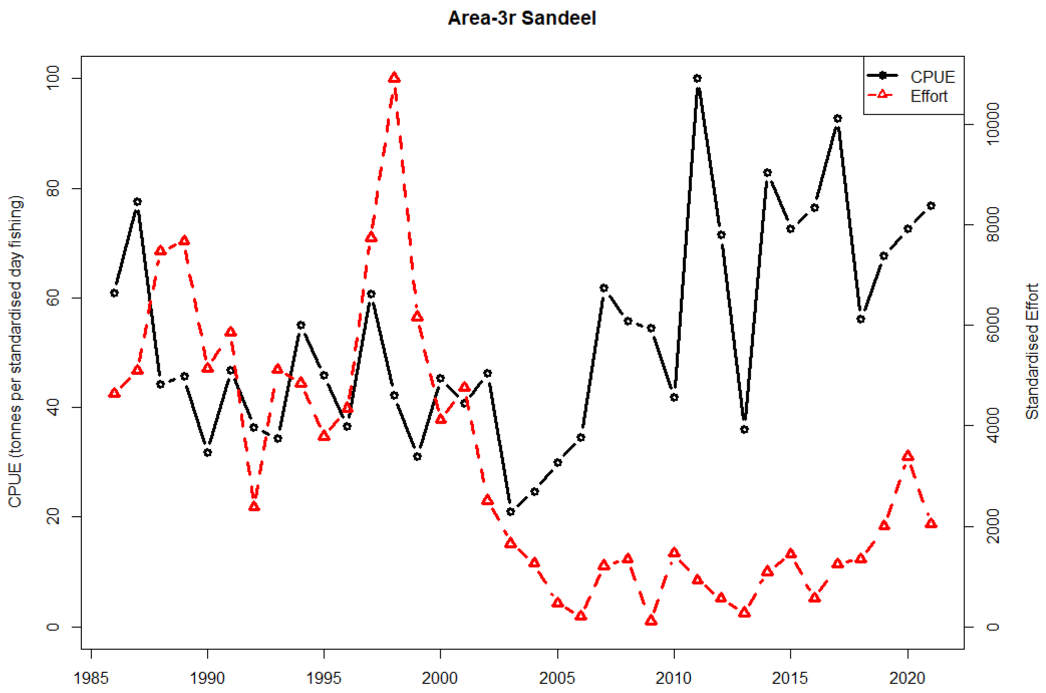


Figure 9.4.3 Sandeel Area-3r. CPUE and effort.

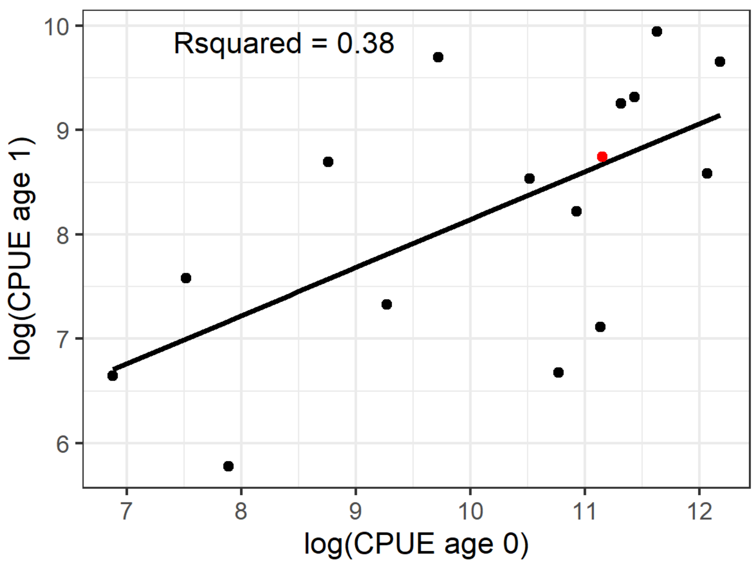


Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

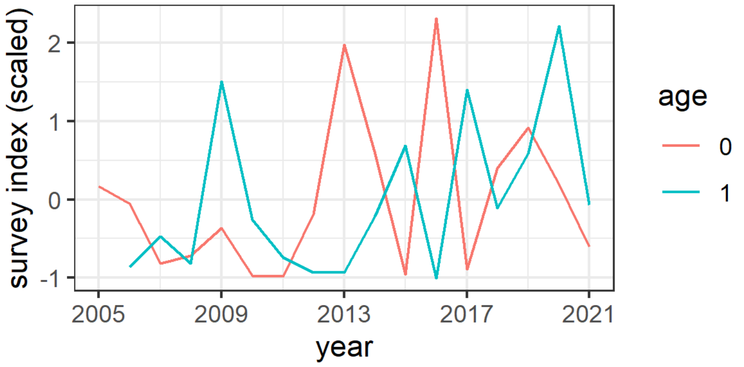


Figure 9.4.5 Sandeel Area-3r. Dredge survey index timeline.

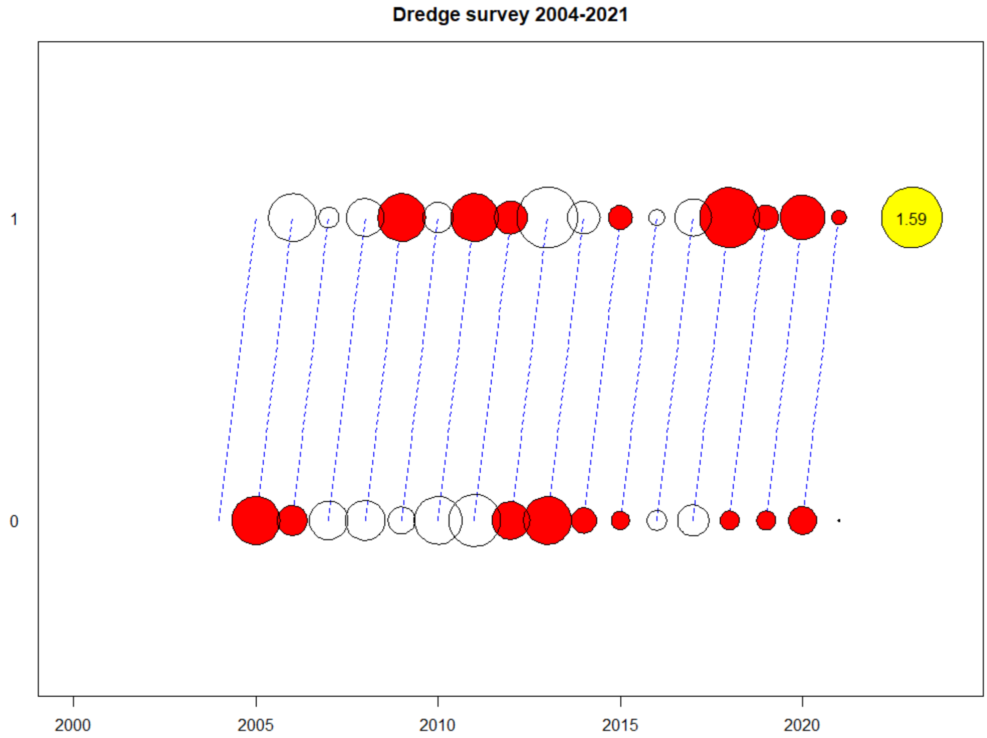


Figure 9.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

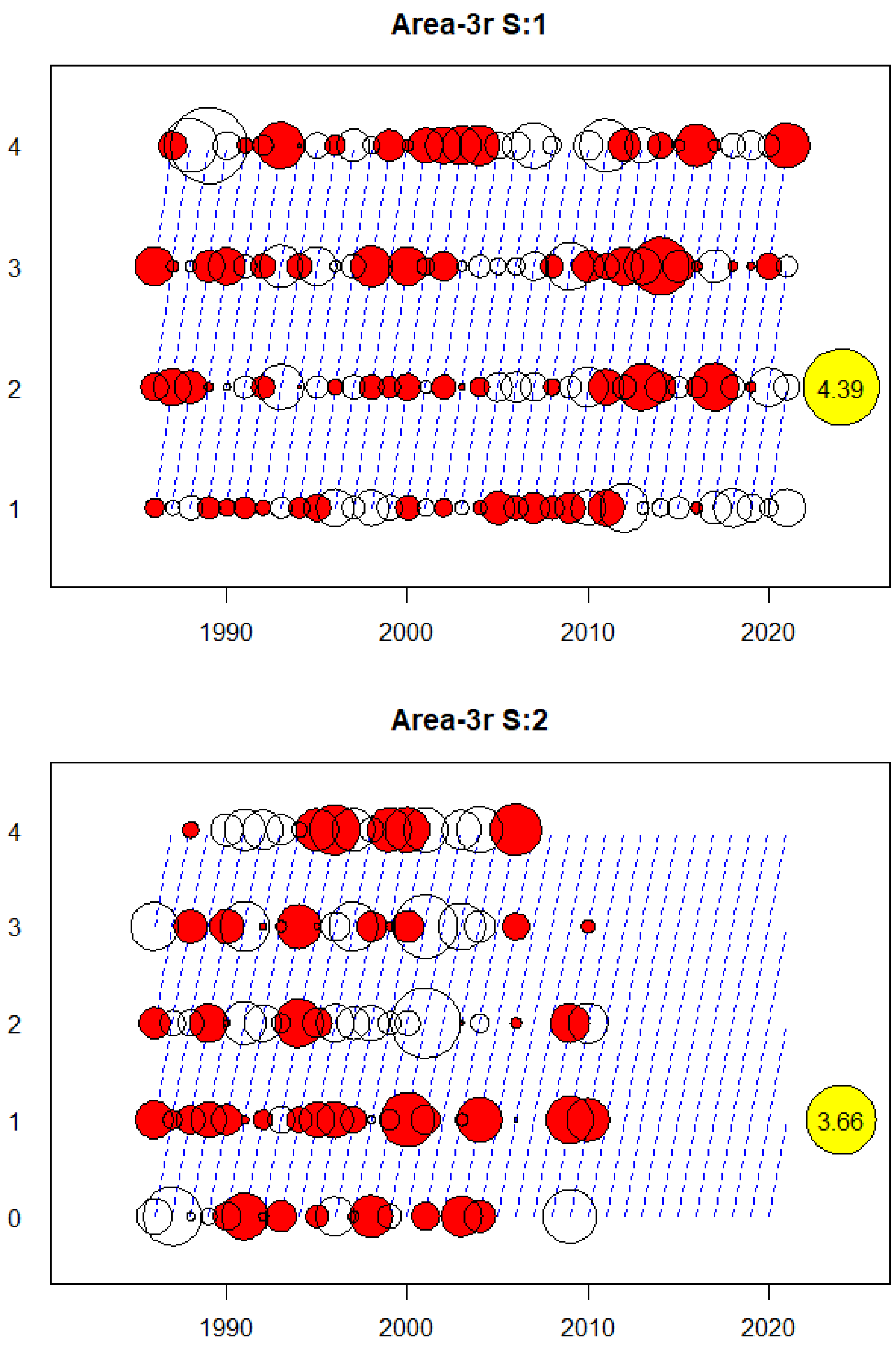


Figure 9.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

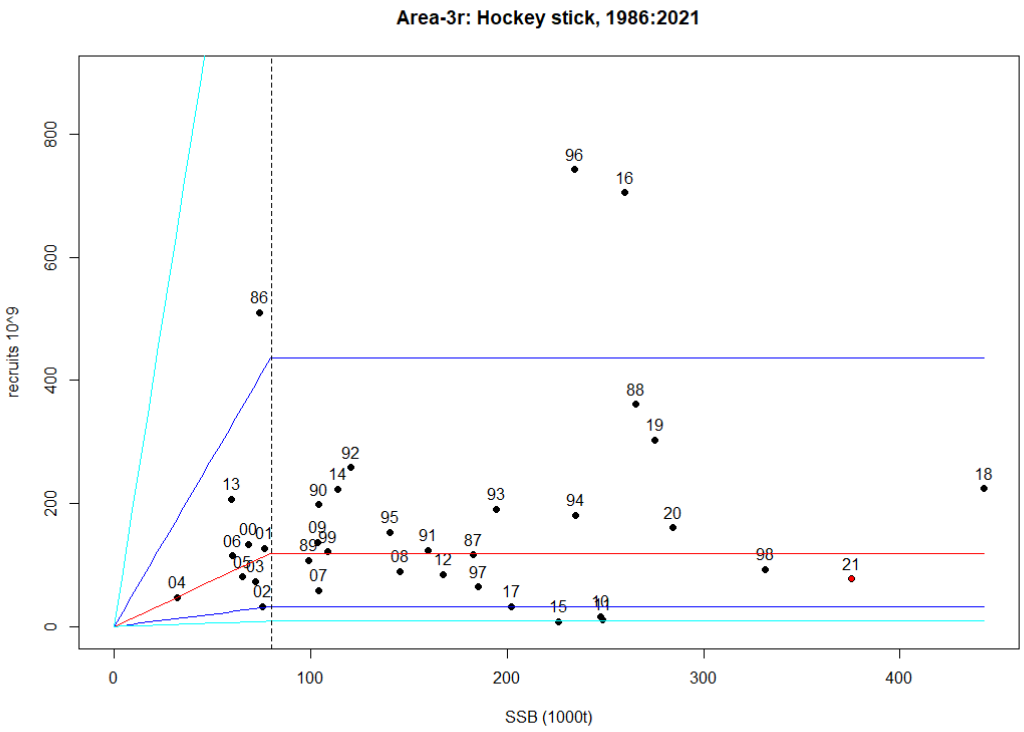


Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

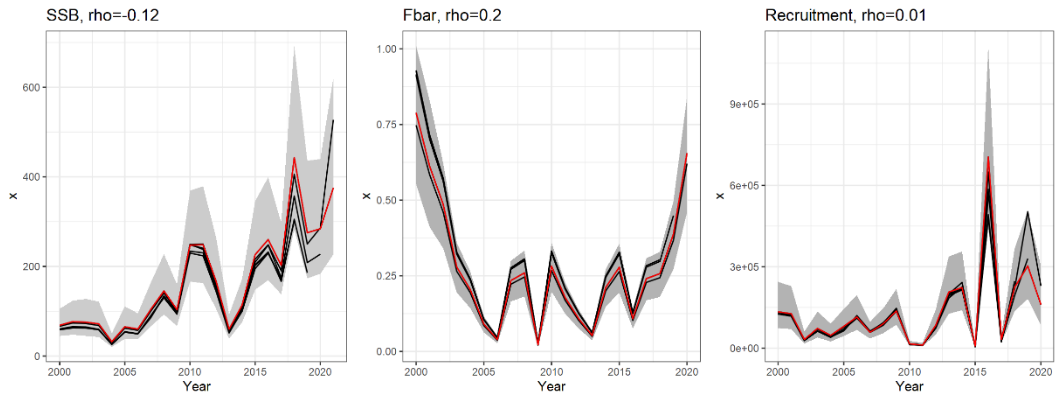


Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.

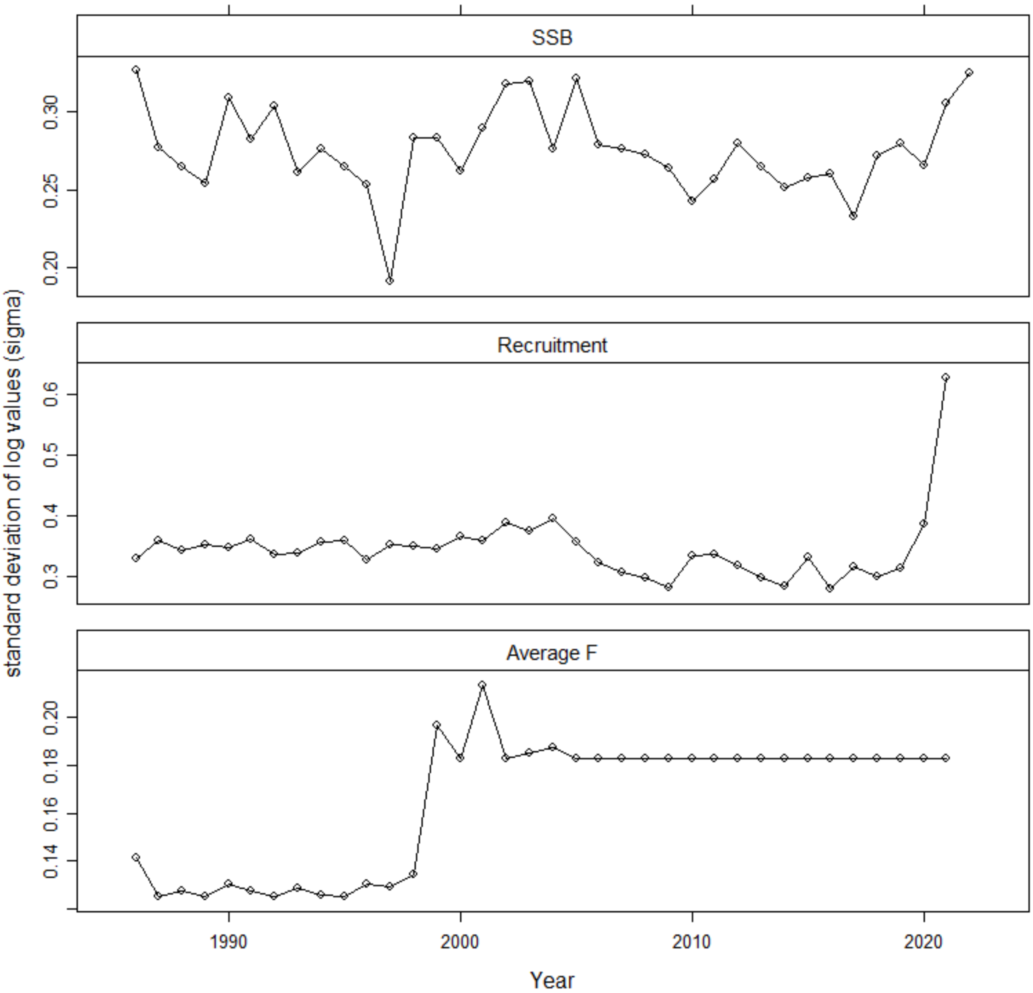


Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

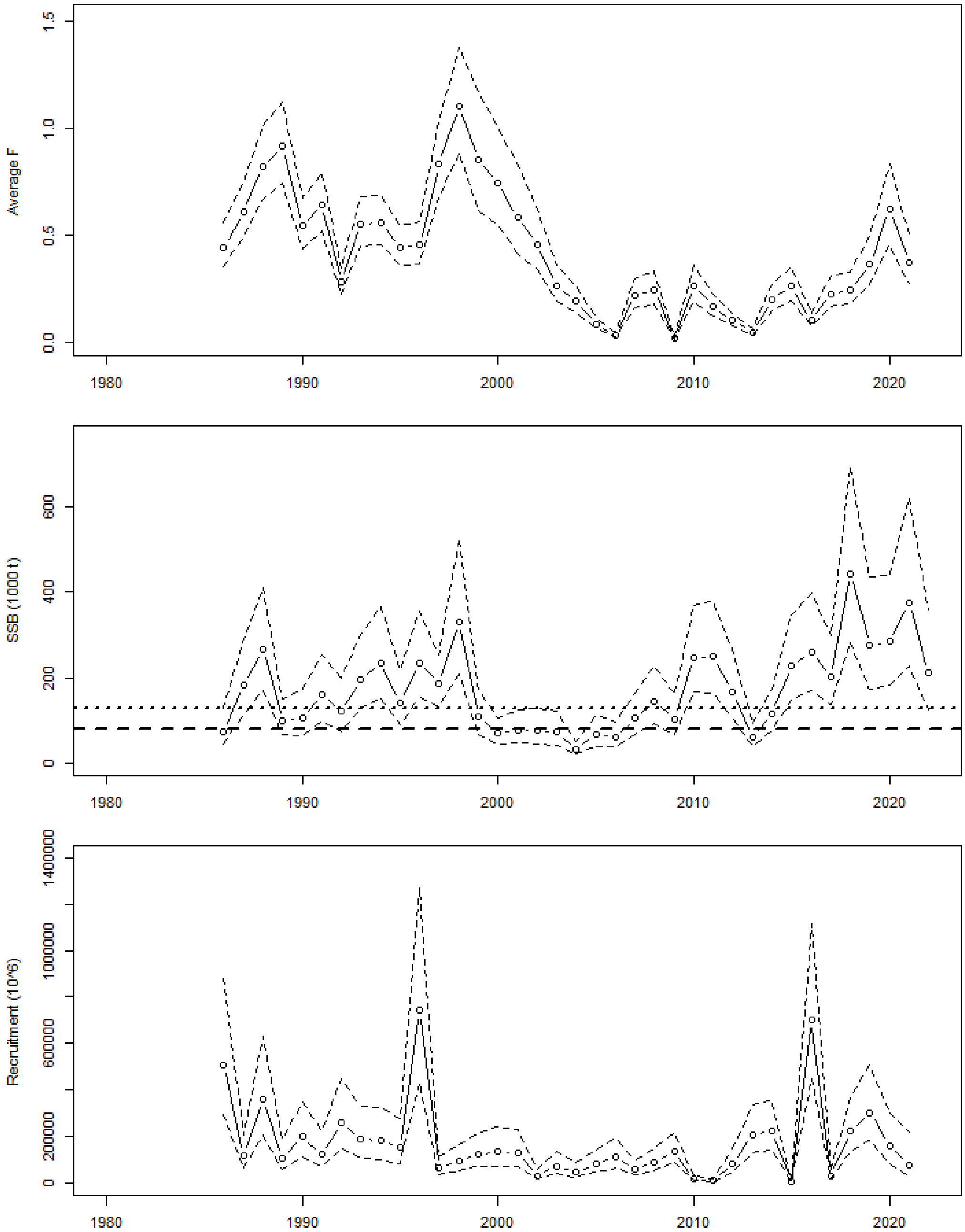


Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

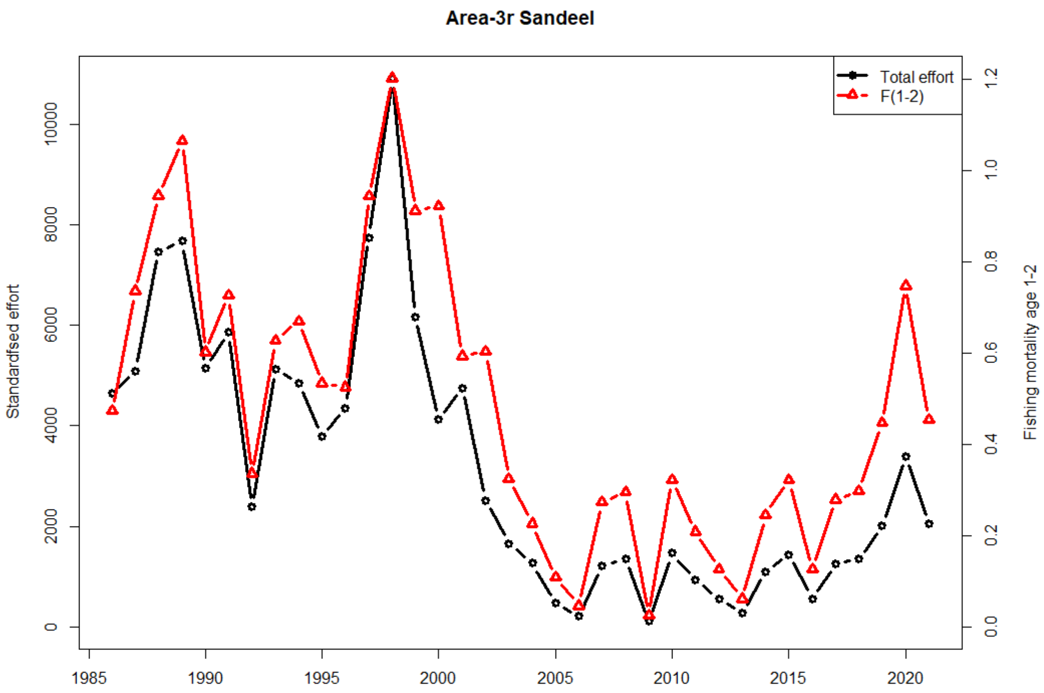


Figure 9.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

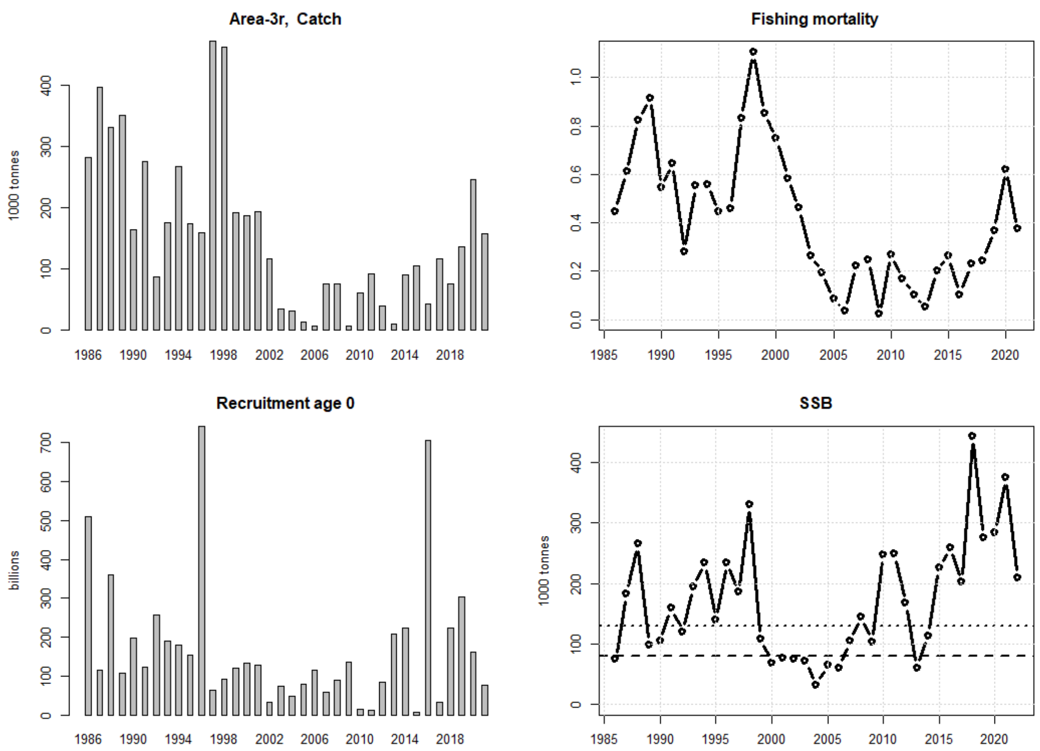


Figure 9.4.13 Sandeel Area-3r. Stock summary.

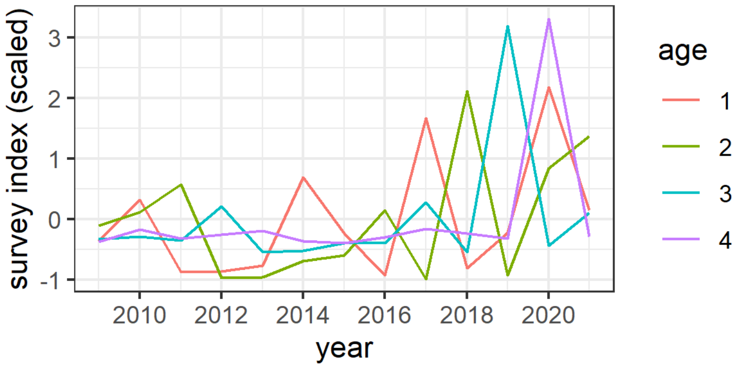


Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.

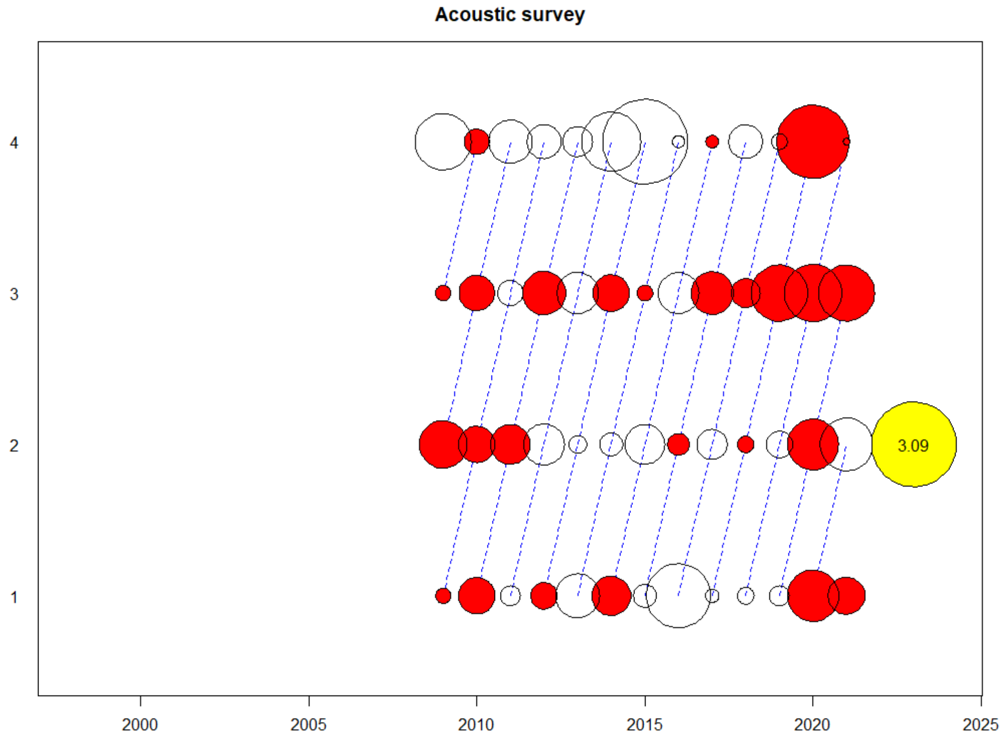


Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

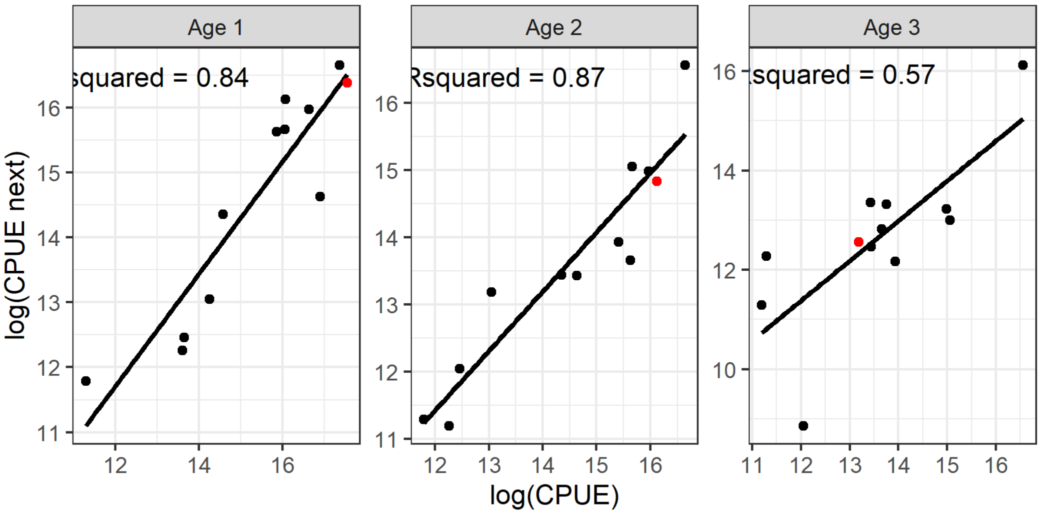


Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

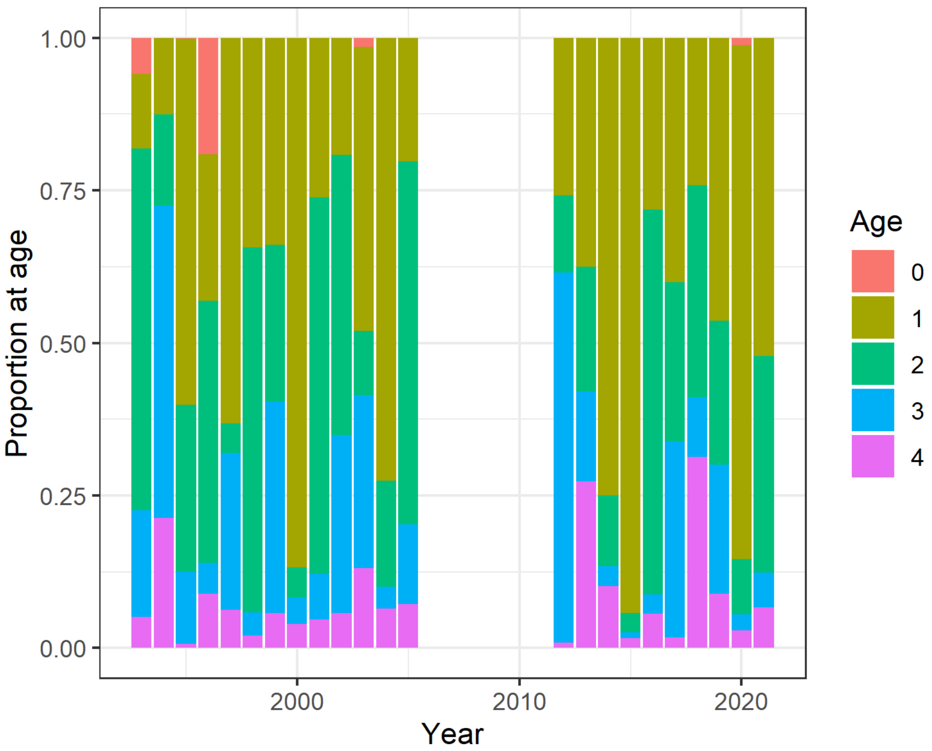


Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.

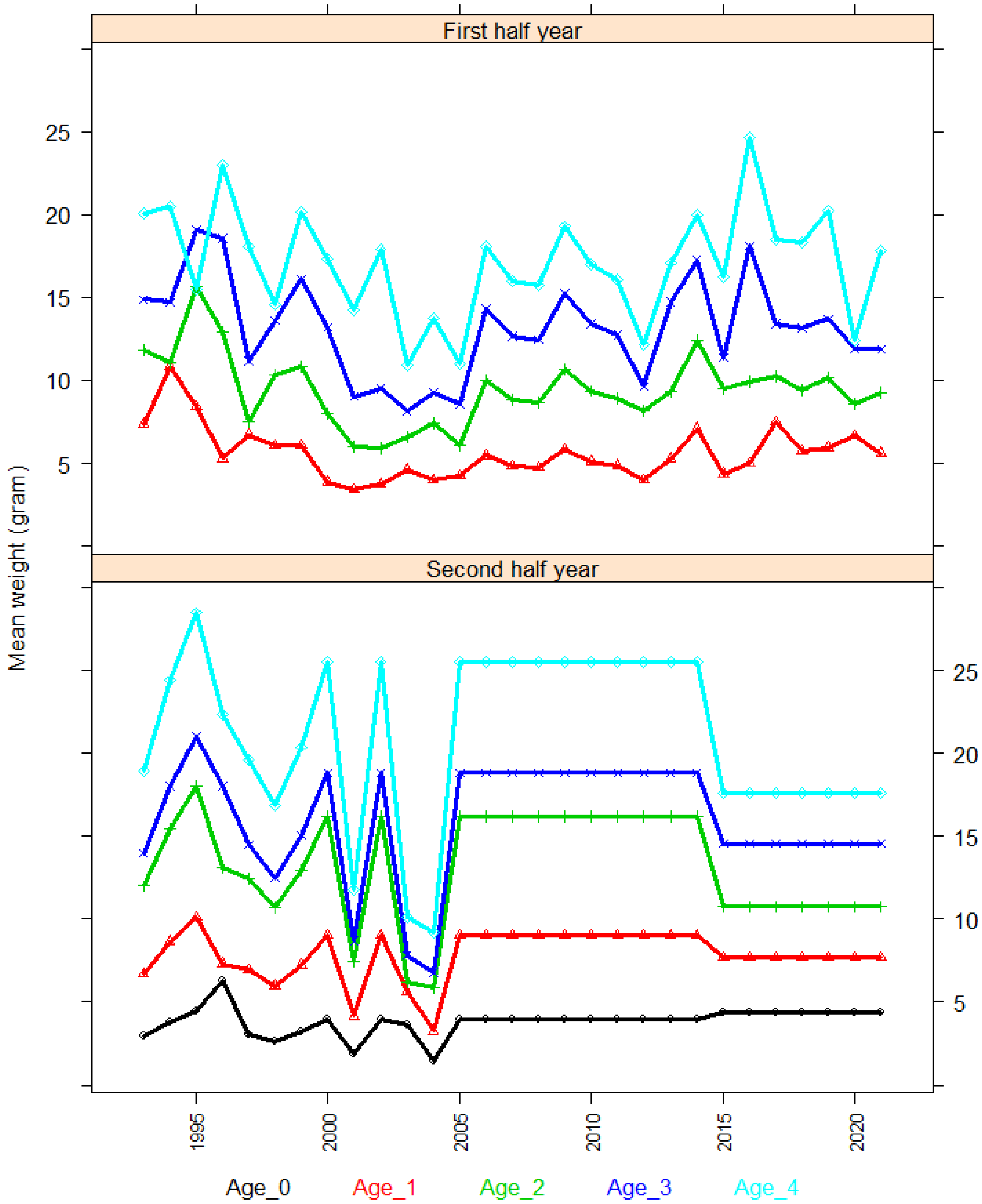


Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

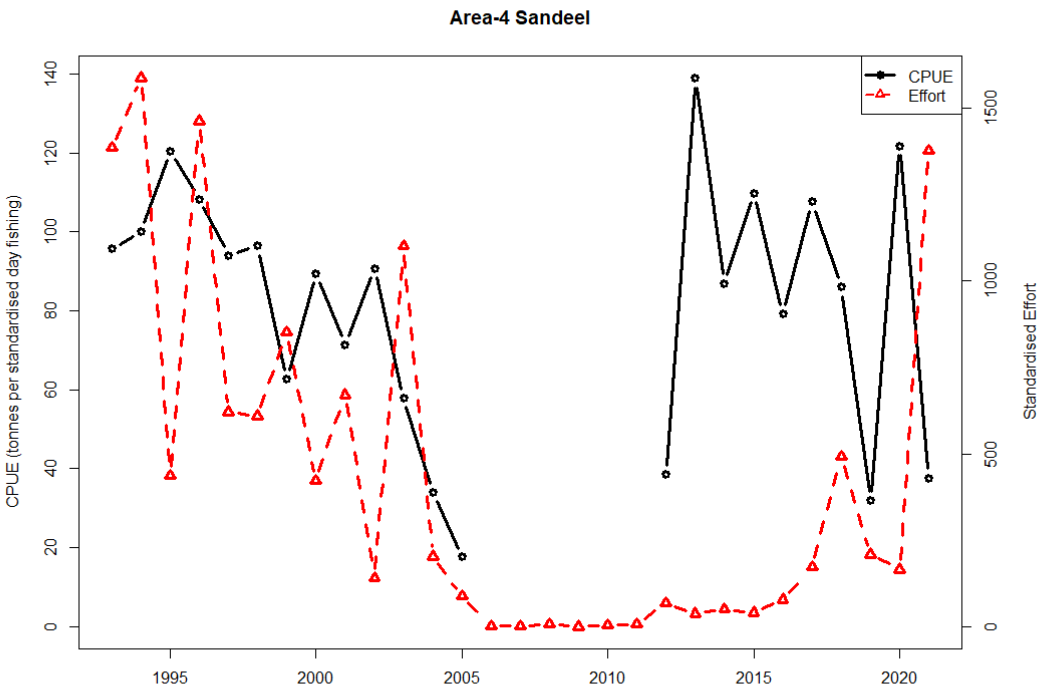


Figure 9.5.3 Sandeel Area-4. CPUE and effort.

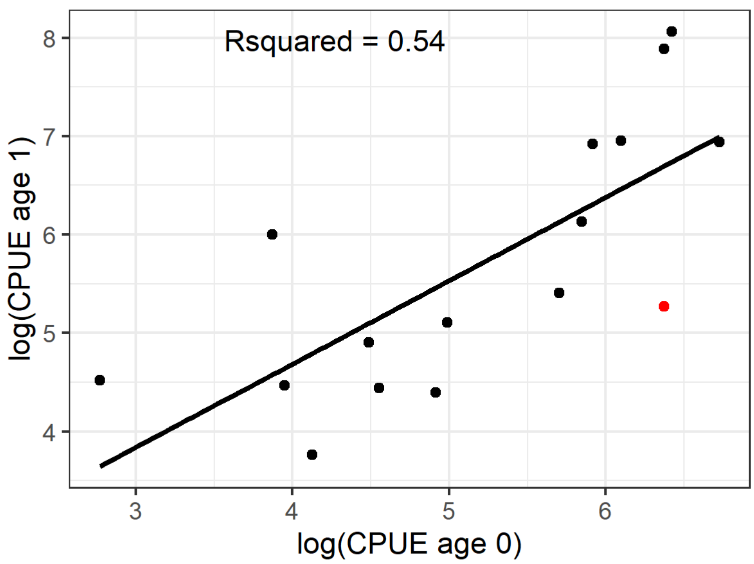


Figure 9.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

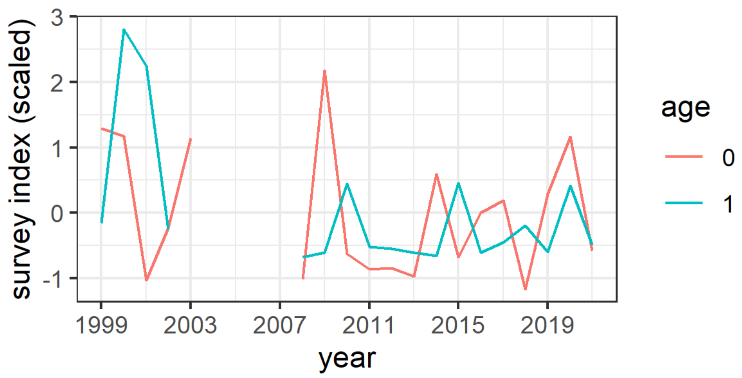


Figure 9.5.5 Sandeel Area-4. Dredge survey index timeline.

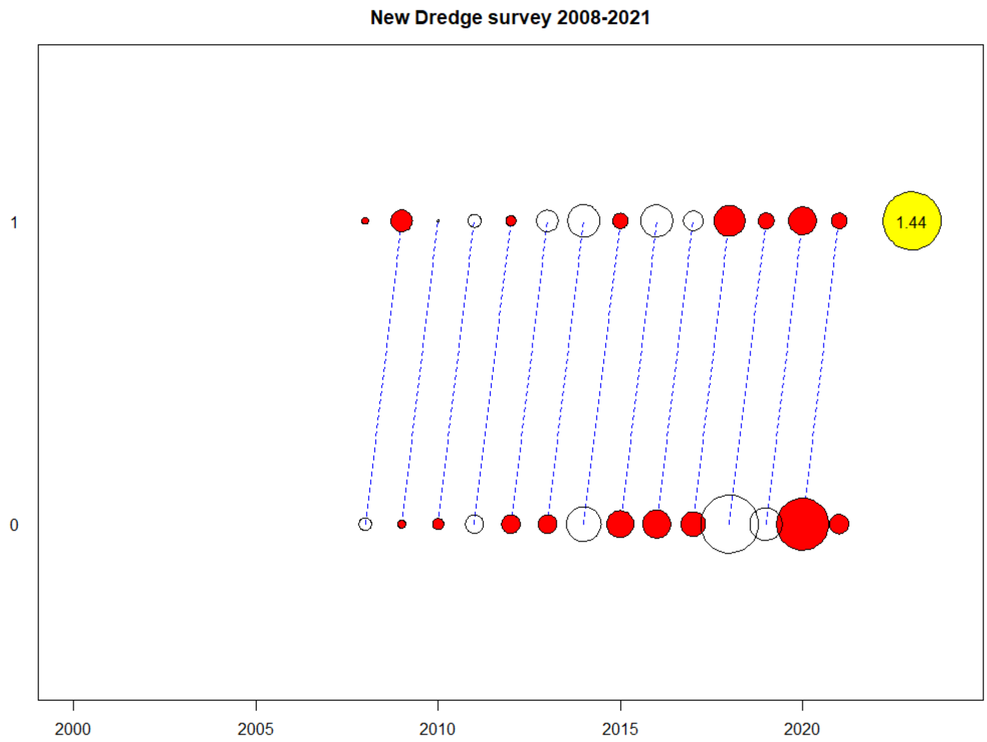


Figure 9.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

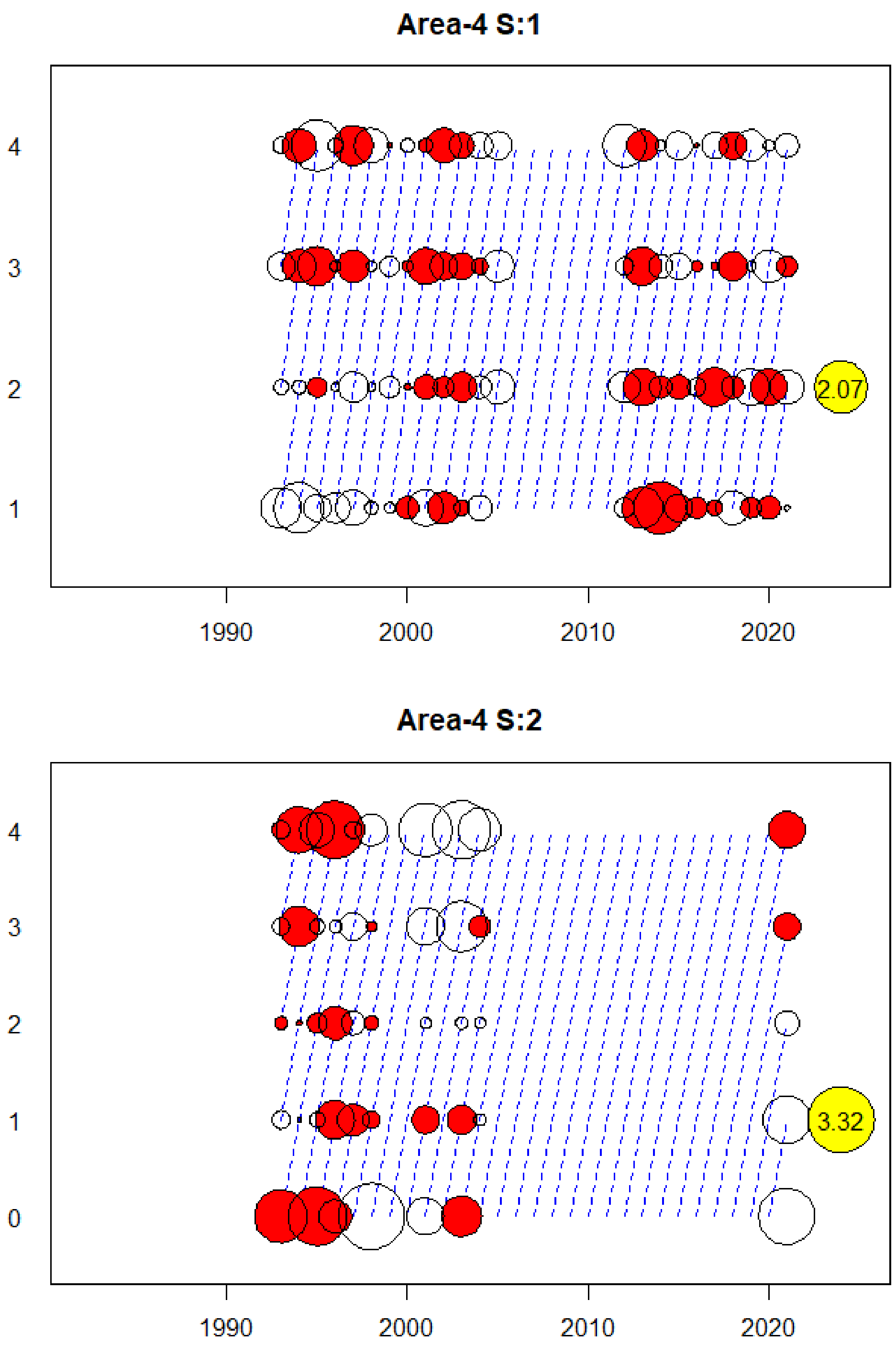


Figure 9.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE)). "Red" dots show a positive residual.

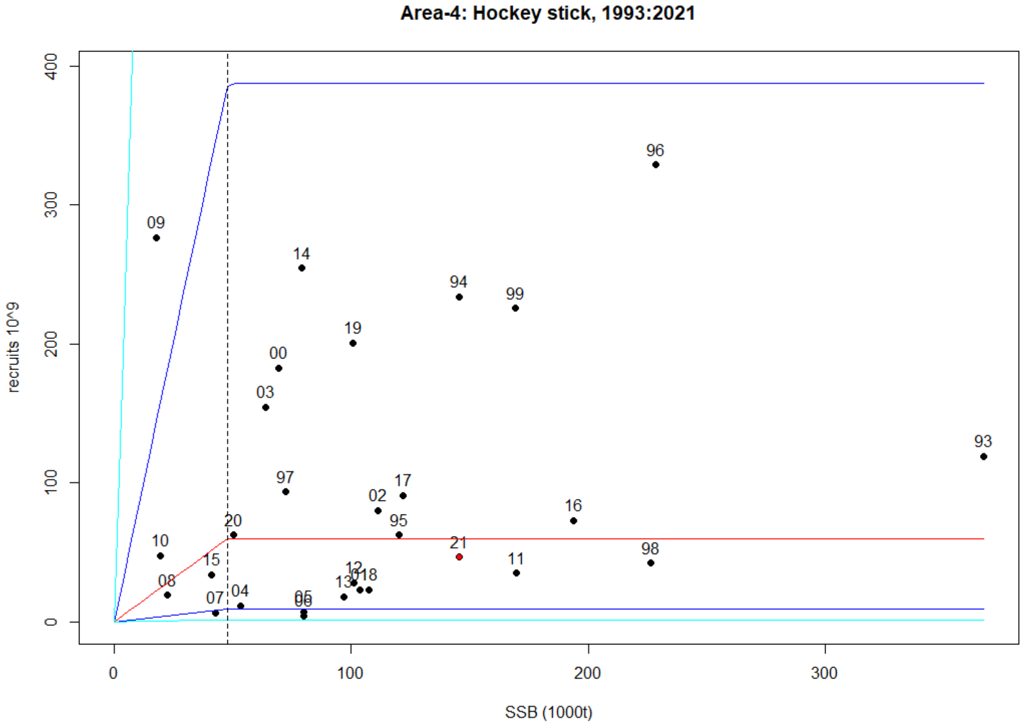


Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

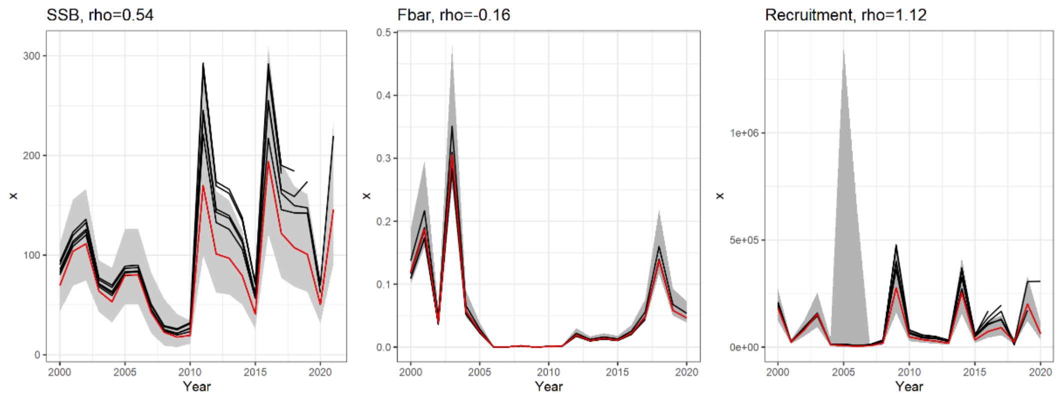


Figure 9.5.9 Sandeel Area-4. Retrospective analysis.

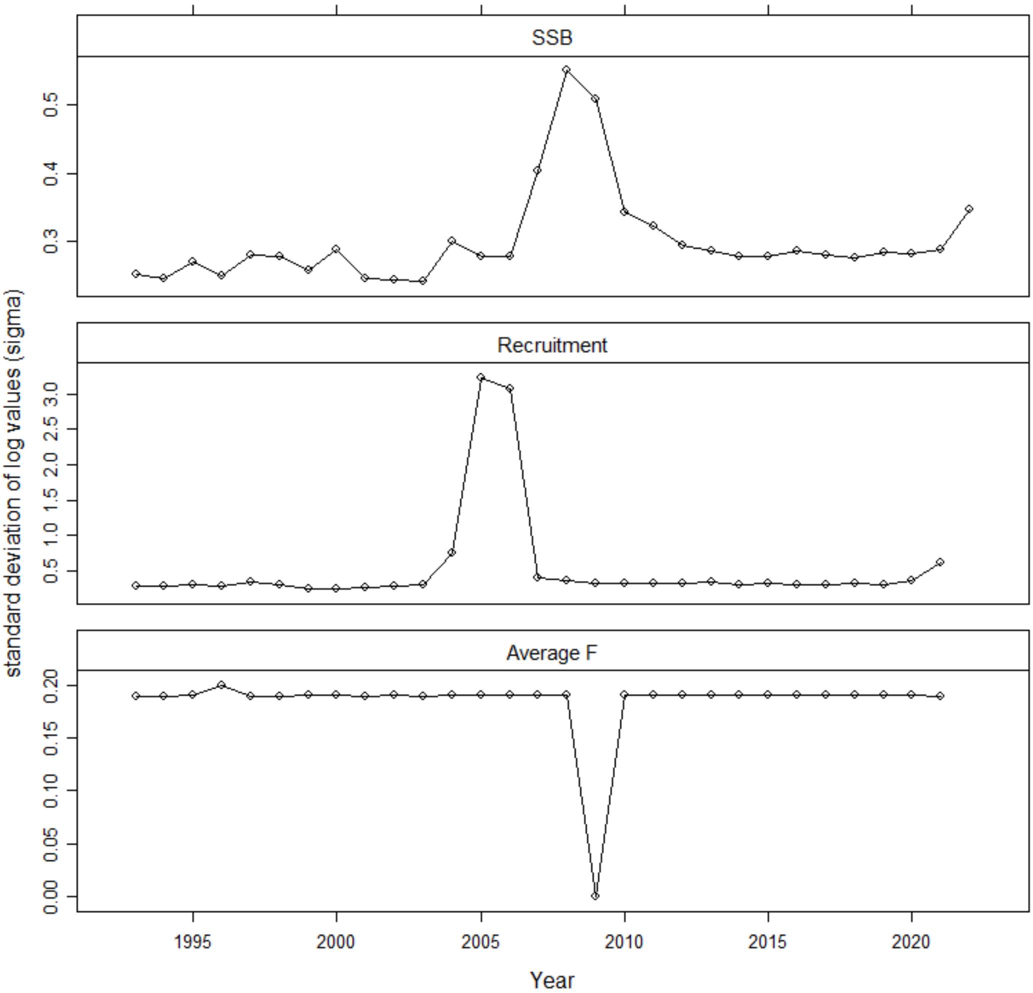


Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

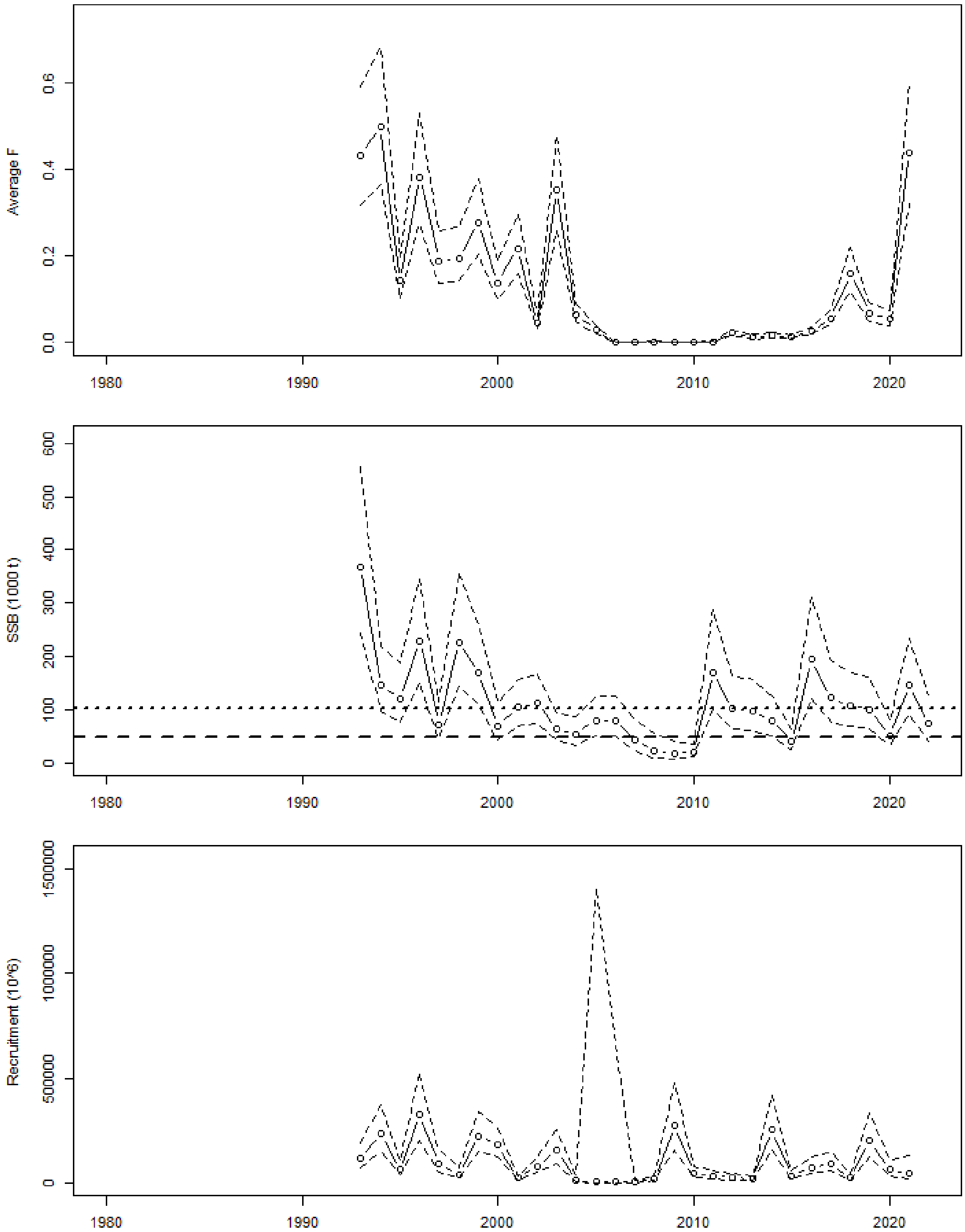


Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

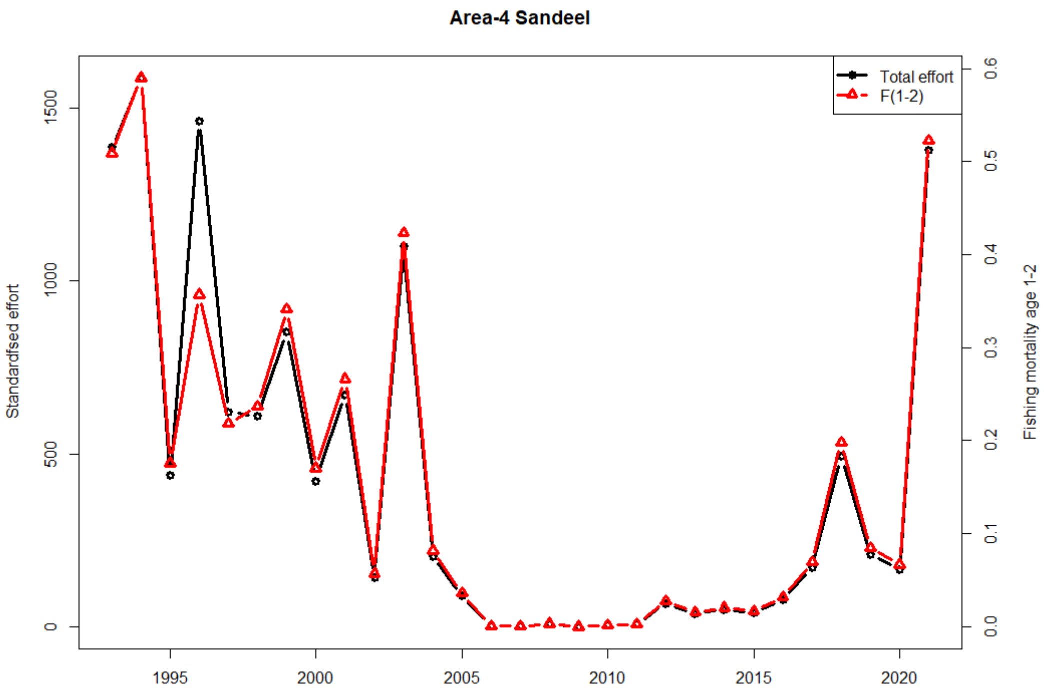


Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

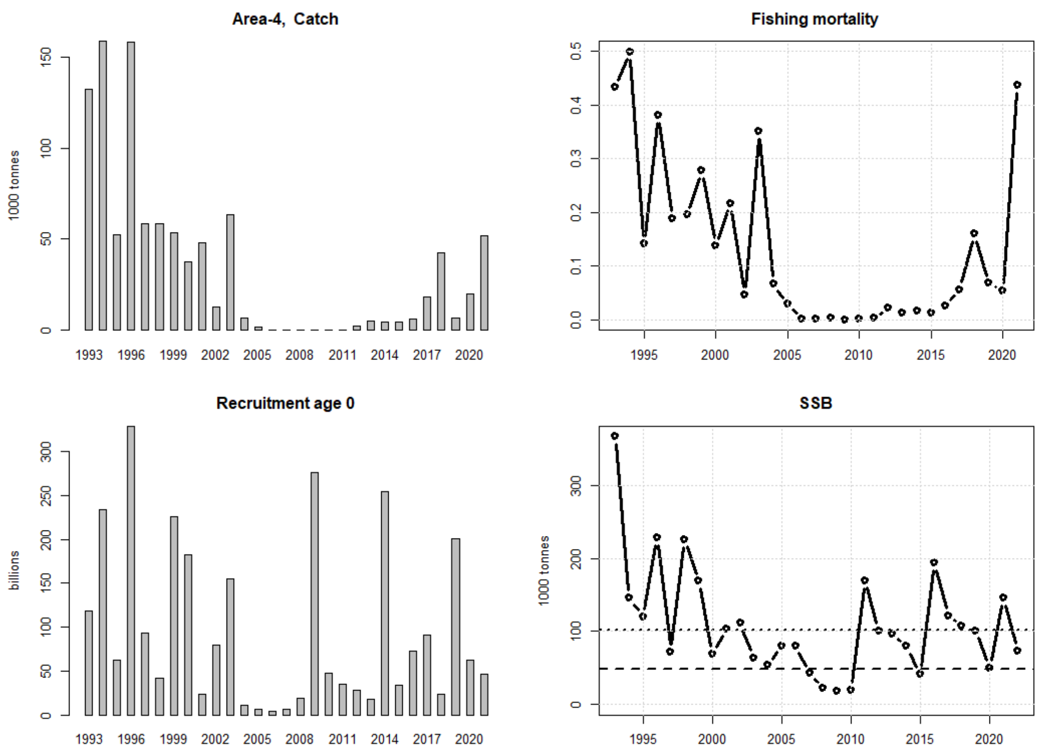


Figure 9.5.13 Sandeel Area-4. Stock summary.

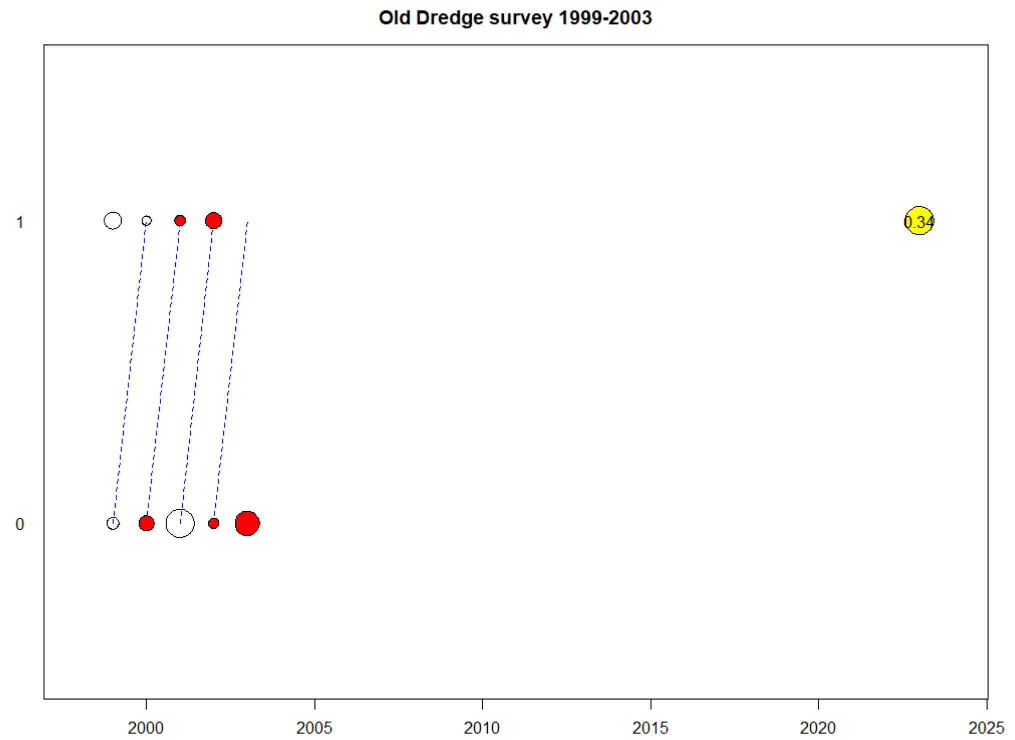


Figure 9.5.1 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE)). “Red” dots show a positive residual.

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 2020 and 2021

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2021 to June 2022) was set to 106 715 t for sprat in Subarea 4 and Division 3.a. The 2021 herring bycatch quotas were 7 750 t for the North Sea and 6 659 t for Division 3.a. 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, 2018) for further details).

10.1.2 Catches in 2021

Catch statistics for 1997–2021 for sprat in the North Sea 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 not included in the catch tables (Table 10.1.1–10.1.2). The WG estimate of total catches for the North Sea and Division 3.a in 2021 were 80 761t (total official catches amounted to 81 807 t). This is a 56% decrease compared to 2020. The Danish catches represent 86% of the total catches.

The spatial distribution of landings was similar to 2020, although smaller catches were seen (Figure 10.1.1). A very low percentage (~1% in 2021) of the catches were landed in the first and second quarter of 2021 (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 7.2% and 10.7% bycatch of herring in 2021 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 1974–2021 are presented in Table 10.2.2. In the model year 2021 (1 July 2021–30 June 2022), one-year old sprat contributed 68% of the total landings, which is close to the 1990–2020 average (66%). 2-year-olds contributed 20% in 2021 (model year), which is above the 1990–2020 average (15%). 0-year-olds contributed 8% of the total landings, which is lower than the 1990–2020 average (16%).

Denmark and Sweden provided age data of commercial landings in 2021 (Table 10.2.4). Quarter 1, 3 and 4 were covered. Quarter 1 in 2021 had very low catches and low number of samples. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by Germany (3 572 t), the Netherlands (139 t), UK-Scotland (105 t), UK-England and Wales (33 t) and Belgium (<1 t) were unsampled and Norway didn't catch the stock in 2021. 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 2021.

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

Table 10.3.1 and Figure 10.3.1 and 10.3.2 give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report (2018) for further details). The data source is the IBTS Q1 data from 1983–2022. The index for IBTS Q1 1-year old in 2021 (age-0 in the model and the table, serving as a recruitment index) was 35% below average and 45% lower than last year's index. There has been a tendency for an increase in the IBTS age 0 in the time-series since 1990. Furthermore, older age-groups (i.e. age-1 and age-2) decreased by >45% compared to the year before. Note that due to both rough weather and outbreaks of Covid-19, IBTS Q1 survey was limited, which affected the sampling coverage. Thus, the coverage was reduced drastically for some parts of the North Sea. Although, it is not expected to have any significant effect for the sprat assessment, a 15% increase in CV for the index is reported compared to last year. Spatial pattern in residuals was checked and did not raise any concerns. Furthermore, the model is designed to handle such issues to some extent. IBTS Q3 survey indices were also used in the assessment for older age-groups, and the 2021 values for all age-groups (i.e. age-1, age-2 and age-3+) were more than 50% lower compared to 2020.

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 2021 values were 22% higher, 61% lower, and 27% lower (age-1, age-2, and age-3, respectively) compared to the 2020-values.

10.4 Mean weights-at-age 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, show 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. Weights were almost identical for all age-groups S1 compared to 2020. In contrast weights for all age-groups declined 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, 2013).

10.5 Recruitment

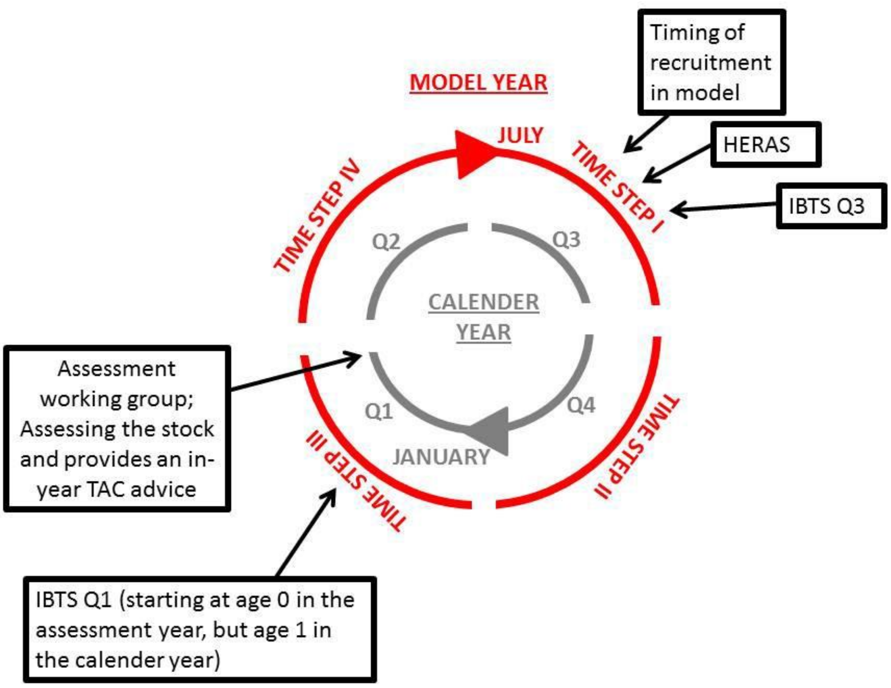
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1) is used as a recruitment index for this stock. The 2022 value, indicative of the 2021 recruitment, was 35% below average, corresponding to a 45% decrease of the recruitment index in the previous year. The recruitment estimated by the model for 2021 is 19% lower than the recruitment in 2020 and 43% below the 2011-2020 geometric mean (Table 10.6.4). 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 2018 for further details).

10.6 Stock Assessment

The stock assessment was benchmarked in November 2018 (WKSPRAT: ICES, 2018). 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 configuration of the assessment model (see WKSPRAT report (ICES, 2018) 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 was estimated at 1 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 apply (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 1 July 2000 to 30 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



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 10.6.1. 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 2022, only 478 t were taken in quarter 1 and no age samples taken. To avoid the resulting high uncertainty in the age distribution of these catches, they were transferred to 2021 quarter 4, leading to a total catch of 15 617 t in this quarter.

10.6.1.2 Weight-at-age

The mean weights at age observed in the catch are given in Table 10.2.3 and Figure 10.4.1 by season. It is assumed that the mean weights in the stock are the same as in the catch. The mean weight at age of S1 that is used to calculated SSB.

10.6.1.3 Surveys

Three surveys were included (Tables 10.3.1–3), IBTS Q1 (1975–present), IBTS Q3 (1991–present) and HERAS (Q3) (2003–present). 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, 2017). The major changes were changes to mean weight of whiting leading to lower mortalities particularly in the early part of the time series. HAWG 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 M's 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 old mortalities were used in the assessments from 2021 and 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+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2013).

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 were included, IBTS Q1 ages 1–4+, 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, 2018).

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). All surveys had low CVs (Table 10.6.2). There were no patterns in the residuals raising concern. Although, there appears to be a periodic cycling (on a decadal time-scale) between positive and negative residuals in the IBTS Q3 survey and the catches (Figures 10.6.2–3). Common CVs were estimated for the groups: 1 to 3-year olds in IBTS Q1 and 2 and 3-year olds in IBTS Q3 and HERAS.

The retrospective analyses showed a tendency to overestimate recruitment (5 years Mohn´s rho = 0.27) (Figure 10.6.5). As 41% (see 10.6.1.5) 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.

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 sprat stock has a decreasing trend during the last couple of years judging by all the surveys and by the assessment output. The stock has been well above B_{pa} since 2013 and above B_{lim} since 1991 but is now estimated to be below B_{pa} for the first time in nine years. The current SSB is 20% below 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 F_{cap} is seen in simulations applying the escapement strategy on very large incoming year classes, and this is the rationale for implementing an F_{cap} as otherwise, the escapement strategy is not precautionary at large stock sizes.

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, 2018). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). During the WKSPRATMSE (ICES, 2018) 0.69 was found to be the optimal F_{cap} value (from both a full MSE and a shortcut MSE, see the WKSPRATMSE report (WKSPRATMSE: ICES, 2018) 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.

SSB in 2023 is expected to be higher than in 2022 and above the long-term average, and well above B_{pa} (+45%). Using the input and assumptions detailed above, the projection for an F = 0 is an SSB in July 2023 of 222 210 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 TAC advice of 69 690 t (July 2022–June 2023), which is expected to result in an SSB of 181 215 t in July 2023, 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 benchmark (ICES, 2018). A complete overview of the choices made during the benchmark can be found in the WKSPRAT report (ICES, 2018) 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 0.25 and 0.27, respectively) is below the advised limit of 0.3 discussed in WKFORBIAS (2019).

There appears to be a systematic pattern in the catch residuals of model season 1 (quarter 3), which remains unexplained.

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 8174 t and 6659 t of juvenile herring in 2022 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, 2018). 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 sprats 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 WKSPRAT2018: ICES, 2018).

Table 10.1.1. North Sea & 3.a sprat. Landings (' 000 t) 1998–2021. See ICES CM 2006/ACFM:20 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	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Division 27.4.a																								
Denmark		0.7		0.1	1.1		*		*	0.8	*	*					*	*	0.1	0.1		*	0.5	*
Norway												*		*								0.1	*	
Sweden				0.1																				
UK (Scotland)														0.5						*	*			
Germany																		*	*					
Netherlands																		*						
Total		0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1	0.5	*
Division 27.4.b																								
Denmark	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	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	66.0
Norway	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0	8.0	0.1	6.2	*	8.9	0.3	19.6	9.7	9.3	10.0	9.3	
Sweden	1.7	2.1		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
UK (Scotland)		1.4								0.1		2.5	1.1	1.9	0.7						*	1.3	1.7	*
UK (Engl. & Wales)												*								*	*		0.1	
Germany														3.3	0.5	0.6	1.5	3.1	5.4	6.0	3.7	3.4	10	3.6
Netherlands														1.1	2.7	0.4	2.4	1.2	1.0	1.6	1.6		0.5	
Faroe Islands																			4.7	1.0	1.0		1	
Total	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7	122.4	90.4	98.4	77.5	45.8	138.0	244.6	220.0	127.0	179.7	132.6	164.7	75.5
Division 27.4.c																								
Denmark	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6	8.1	8.2	48.5	20.0	3.2	15.4	2.2	34.0	18.7	1.5	6.2	8.9	2.4	2.7
Norway	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9	3.0	1.7	0.1	8.8	0.6		0.5	0.6	0.7	

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
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)	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	0.1	0.2	0.1	*
Germany														*	*	1.0		0.6	0.2				0.1	
Netherlands		0.2												4.2	1.0	0.7	*	1.2	0.8	*	0.7		1.6	0.1
Belgium														*		*	*	*	*	*		*	*	*
France																		*		*				
Total	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6	53.0	35.2	8.0	20.1	2.3	45.8	20.6	1.6	7.5	9.6	5.6	4.0
Division 27.3.a																								
Denmark	11.2	17.2	12.8	20.2	13.4	10.2	14.4	31.9	7.8	9.9	5.8	6.9	8.4	8.0	8.4	1.9	16.7	11.7	6.7	1.0	2.9	3.9	9.5	0.6
Sweden	6.2	9.3	6.4	7.6	4.3	5.5	6.5	7.7	4.4	4.2	2.4	1.6	1.4	2.0	1.5	1.1	1.5	1.3	1.1	0.2	1.1	1.7	2.4	0.7
Germany																	*				*			
Faroe Islands																			*					
Total	17.4	26.5	19.2	27.7	17.7	15.7	20.9	39.6	12.2	14.1	8.2	8.5	9.8	10.0	9.9	3.0	18.3	13.0	7.9	1.2	4.0	5.6	11.9	1.3
Total North Sea and Skagerrak-Kattegat																								
Denmark	142.3	181.5	203.9	177.3	155.4	185.4	207.1	237.9	111.2	86.7	65.4	130.7	137.7	119.0	77.4	62.1	140.2	280.1	203.1	103.3	165.6	123.1	150.9	69.3
Norway	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8	11.1	10.0	9.1	1.7	9.0	9.1	20.2	9.7	9.8	10.6	10	
Sweden	7.9	11.4	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
UK (Scotland)		1.4								0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3	2.5	0.1
UK (Engl. & Wales)	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	*	0.2	0.2	*
Germany														3.3	0.5	1.6	1.6	3.7	5.6	6.0	3.7	3.4	10.1	3.6
Netherlands		0.2												5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3		2.1	0.1

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
Faroe Islands																			4.7	1.0	1.0		1	
Belgium														*		*	*	*	*	*		*	*	*
France																		*		*				
Total	181.7	214.9	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

* < 50 t

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 CM 2007/ACFM:11.

Year	Quarter	Division 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
	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

Year	Quarter	Division 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
	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

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
	3		56 207	165	1720	58 092
	4		84 629	15 651	7349	107 629
	Total		152 919	23 570	15 683	192 172
2004	1		827	1831	4456	7113
	2	7	260	16	1510	1793
	3		54 161	496	4138	58 794
	4		120 685	15 937	10 775	147 397
	Total	7	175 932	18 280	20 879	215 097
2005	1		11 538	2457	8148	22 143
	2		2515	123	4722	7360
	3		107 530		19 418	126 948
	4		82 474	1033	7296	90 803
	Total		204 057	3613	39 584	247 254
2006	1	47	13 713	33 534	8105	55 399
	2		190	8	324	522
	3		40 051	8	1440	41 499
	4	2	26 579	77	2335	28 993
	Total	49	80 533	33 627	12 204	126 413
2007	1		582	247	2646	3475
	2		241	3	1291	1535
	3		16 603		5357	21 960
	4	769	41 850	23 531	4761	70 911
	Total	769	59 276	23 781	14 055	97 881
2008	1		2872	43	2890	5805
	2		52	*	1017	1069
	3		21 787		636	22 423

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
	3		124 512	335	6528	131 375
	4	25	88 395	28 375	4389	121 184
	Total	25	244 566	45 789	12 978	303 358
2016	1	68	18 487	5969	746	25 250
	2		8927	51	669	9 647
	3	*	158 522	111	4664	163 297
	4	2	34 070	14 466	1764	50 301
	Total	70	220 007	20 596	7843	248 516
2017	1	1	3432	1220	92	4 745
	2		1327	0	33	1 360
	3	*	92 885	217	227	93 329
	4	94	29 310	174	849	30 426
	Total	95	126 954	1611	1200	129 860
2018	1	*	8994	1628	168	10 790
	2		11 898	0	224	12 122
	3		112 361	1	1328	113 690
	4		46 411	5922	2249	54 582
	Total	*	179 664	7551	3969	191 184
2019	1		389	9 592	627	10 609
	2	2	3 606	11	379	3 999
	3	2	95 829	7	2 249	98 087
	4	49	32 750	3	2 296	35 098
	Total	53	132 574	9 614	5 551	147 793
2020	1	3	298	1 076	378	1 746
	2		19 430	*	173	19 603
	3	2	120 890	*	4 268	125 160

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
	4		27 994	8334	3672	40 001
	Total		52 706	8377	8215	69 298
2009	1		36	1268	2600	3904
	2		2526	1	300	2827
	3	22	41 513		3300	44 835
	4		78 373	9336	2400	90 109
	Total	22	122 448	10 604	8600	141 675
2010	1		10 976	17 072	1462	29 510
	2		3235	3	648	3886
	3		14 220		3405	17 625
	4		62 006	35 973	4278	102 257
	Total		90 437	53 048	9793	153 278
2011	1		3747	21 039	3216	28 002
	2		2067	3	617	2687
	3		22 309	451	2311	25 072
	4	8	70 256	13 759	3887	87 910
	Total	8	98 380	35 252	10 031	143 671

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
	4	520	24 049	4 489	7 087	36 145
	Total	526	164 667	5 566	11 896	182 654
2021	1	0	137	236	445	818
	2	*	326	1	11	338
	3	1	63 401	902	57	64 361
	4	1	11 601	2 850	791	15 244
	Total	2	75 464	3 989	1 305	80 761
2022	1**		81		330	412

* < 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.

	Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total		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	1998	9 143	3 385	230	467	54	0	49	7	2 866	16 202
t	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757	t	1999	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
t	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641	t	2000	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
t	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862	t	2001	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
t	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471	t	2002	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
t	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210	t	2003	8 182	4 928	340	252	4	4	4	1	567 14	14 282
t	2004	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906	t	2004	13 374	4 620	97	976	18	24	27	116	2 155	21 408
t	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251	t	2005	30 157	6 171	244	871	63	18	20	746	1 758	40 047
t	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033	t	2006	6 814	2 852	215	276	13	3	45	1	232 10	10 451
t	2007	74 734	6 596	168	900	6	126	18	6	253	82 807	t	2007	7 116	2 043	34	190	31	8	4	1	469 9	9 896
t	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563	t	2008	4 805	1 948	14	285	0	0	11	462	39 7	7 563
t	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345	t	2009	4 839	3 016	37	169	15	0	1	53	47 8	8 177
t	2010	112 395	4 410	11	119	2	18	0	1 236	577	118 769	t	2010	2 851	2 134	25	142	6	1	2	135	171 5	5 466
t	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026	t	2011	4 754	2 461	0	43	0	7	1	141	40 7	7 447
t	2012	67 263	8 573	2	354	0	246	0	93	411	76 943	t	2012	5 707	5 495	9	149	7	10	5	0	228 11	11 610
t	2013	55 792	5 176	47	445	0	277	2	1	369	62 109	t	2013	1 143	1 751	2	46	0	0	1	1	27 2	2 971
t	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280	t	2014	16 751	3 777	5	343	1	20	5	12	888 21	21 801
t	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723	t	2015	11 448	5 831	0	565	0	29	8	1	154 18	18 036
t	2016	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643	t	2016	7 001	2 140	0	335	1	19	3	0	78 9	9 579
t	2017	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394	t	2017	963	328	0	172	0	19	1	0	32 1	1 515
t	2018	161 536	7 528	174	716	0	366	0	24	344	170 687	t	2018	2 872	257	2	150	1	11	0	0	12 3	3 304
t	2019	118 302	2 757	1	897	1	176	0	3	503	122 639	t	2019	3 429	351	0	59	0	2	0	0	8 3	3 850
t	2020	140 954	6 227	19	898	93	1 188	0	11	724	150 114	t	2020	9 494	551	4	249	5	41	1	0	27 10	10 372
t	2021	68 492	5 518	39	1 064	345	747	0	3	602	76 809	t	2021	638	82	0	13	1	1	0	0	32	767
%	1998	88.6	8.1	0.4	0.5	0	0.2	0	1.5	0.8	100	%	1998	56.4	20.9	1.4	2.9	0.3	0	0.3	0	17.7	100
%	1999	91.4	4.2	0.2	0.6	0	0.2	0	2.9	0.4	100	%	1999	50.7	25.9	0.4	3.1	0.6	0	0.2	10.2	8.8	100
%	2000	90.3	5.6	1.6	1	0	0.4	0	0.2	0.9	100	%	2000	49.1	31.4	0	4.1	1.2	0	0.2	0.1	13.9	100
%	2001	79.9	8.2	0	1	0.1	0.2	0	10	0.7	100	%	2001	54.6	24.5	0.2	3.8	0.2	0	0.1	12.8	3.8	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
%	2002	83.9	9.9	1.2	1.5	0	0.4	0	2.4	0.5	100	%	2002	40.1	45.5	0.1	4.1	0	0	0.1	2.1	8	100
%	2003	88.8	5.3	0.4	0.6	0	0.4	0	2.8	1.8	100	%	2003	57.3	34.5	2.4	1.8	0	0	0	0	4	100
%	2004	89.6	5	0.2	0.2	0	2.2	0	1.9	0.9	100	%	2004	62.5	21.6	0.5	4.6	0.1	0.1	0.1	0.5	10.1	100
%	2005	85.9	9	1.1	0.2	0	0.4	0	2.9	0.4	100	%	2005	75.3	15.4	0.6	2.2	0.2	0	0	1.9	4.4	100
%	2006	86	7.5	0.5	0.3	0	0.8	0	4.5	0.5	100	%	2006	65.2	27.3	2.1	2.6	0.1	0	0.4	0	2.2	100
%	2007	90.3	8	0.2	1.1	0	0.2	0	0	0.3	100	%	2007	71.9	20.6	0.3	1.9	0.3	0.1	0	0	4.7	100
%	2008	85.4	11.1	0	0.5	0	0.5	0	0	2.4	100	%	2008	63.5	25.8	0.2	3.8	0	0	0.1	6.1	0.5	100
%	2009	92.1	5.9	0	0.3	0	0.1	0	1.2	0.3	100	%	2009	59.2	36.9	0.5	2.1	0.2	0	0	0.6	0.6	100
%	2010	94.6	3.7	0	0.1	0	0	0	1	0.5	100	%	2010	52.2	39	0.5	2.6	0.1	0	0	2.5	3.1	100
%	2011	91.1	6.7	0	0.2	0	0.1	0	1.6	0.3	100	%	2011	63.8	33	0	0.6	0	0.1	0	1.9	0.5	100
%	2012	87.4	11.1	0	0.5	0	0.3	0	0.1	0.5	100	%	2012	49.2	47.3	0.1	1.3	0.1	0.1	0	0	2	100
%	2013	89.8	8.3	0.1	0.7	0	0.4	0	0	0.6	100	%	2013	38.5	58.9	0.1	1.6	0	0	0	0	0.9	100
%	2014	89.7	8.3	0	0.7	0	0.1	0	0	1.2	100	%	2014	76.8	17.3	0	1.6	0	0.1	0	0.1	4.1	100
%	2015	96.2	1.7	0	0.7	0	0.2	0	0.1	1.2	100	%	2015	63.5	32.3	0	3.1	0	0.2	0	0	0.9	100
%	2016	91.5	5.3	0	2	0	0.2	0	0	1	100	%	2016	73.1	22.3	0	3.5	0	0.2	0	0	0.8	100
%	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	89.2	7.2	0.1	1.4	0.4	1.0	0.0	0.0	0.8	100.0	%	2021	83.1	10.7	0.0	1.6	0.2	0.1	0.0	0.0	4.2	100.0

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
1982	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
1992	2	222991	1185132	132166	16491

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	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
2001	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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
2011	2	420004	4234059	2917969	999295

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	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
2020	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 have been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2021	1	539434	5840604	1505982	255540
2021	2	254055	814057	395606	139605
2021	3	0	0	0	0
2021	4	0	0	0	0

Table 10.2.3. North Sea & 3.a sprat. Mean weight at age (kg) in catches by season and year. (Model year, e.g., 2021 = July 2021–June 2022)

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there are no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1974	1	0.0063	0.0083	0.0135	0.0184
1974	2	0.0058	0.0089	0.0150	0.0197
1974	3	0.0050	0.0077	0.0150	0.0197
1974	4	0.0066	0.0107	0.0183	0.0163
1975	1	0.0048	0.0086	0.0129	0.0172
1975	2	0.0075	0.0111	0.0168	0.0216
1975	3	0.0048	0.0106	0.0154	0.0192
1975	4	0.0062	0.0116	0.0170	0.0171
1976	1	0.0049	0.0070	0.0113	0.0134
1976	2	0.0043	0.0090	0.0153	0.0190
1976	3	0.0022	0.0059	0.0104	0.0126
1976	4	0.0034	0.0057	0.0085	0.0106
1977	1	0.0054	0.0082	0.0126	0.0180
1977	2	0.0059	0.0110	0.0146	0.0196
1977	3	0.0023	0.0080	0.0106	0.0138
1977	4	0.0025	0.0063	0.0083	0.0122
1978	1	0.0038	0.0069	0.0122	0.0146
1978	2	0.0044	0.0103	0.0155	0.0196
1978	3	0.0031	0.0089	0.0123	0.0166
1978	4	0.0020	0.0052	0.0087	0.0094
1979	1	0.0050	0.0058	0.0087	0.0113
1979	2	0.0057	0.0105	0.0150	0.0173
1979	3	0.0032	0.0077	0.0129	0.0165
1979	4	0.0029	0.0106	0.0121	0.0153
1980	1	0.0063	0.0052	0.0068	0.0083
1980	2	0.0051	0.0052	0.0069	0.0083
1980	3	0.0032	0.0086	0.0131	0.0168
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156

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**
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
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

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**
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
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

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**
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
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

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**
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
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

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**
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	0.0101	0.0132	0.0170	0.0197
2021	4	0.0064	0.0102	0.0133	0.0160

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2021. 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	2	202	99
	2	0.2	0	0	0
	3	59.1	84	9086	3979
	4	9.6	14	1350	594
	Total	69.3	100	10638	4672
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	0.4	9	237	236
	2	0.0	0	0	0
	3	3.6	0	0	0
	4	3.6	8	489	489
	Total	7.6	17	726	725
All countries	1	0.8	11	439	335
	2	0.2	0	0	0
	3	62.7	84	9086	3979
	4	13.2	22	1839	1083
Total		76.9	117	11364	5397

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	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
2007	1917763	1035569	162880	12506

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**
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

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
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

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

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, 2017) 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

Table 10.6.2. North Sea sprat. Assessment diagnostics.

ate: 03/23/22 Start time:17:06:28 run time:1 seconds

objective function (negative log likelihood): 299.074
Number of parameters: 143
Maximum gradient: 0.239804
Akaike information criterion (AIC): 884.147
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
768	298	48	0	1114

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
412.8	-114.9	11.8	0.0	0.0	0.00	310

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.54	-0.39	0.25	0.00

contribution by fleet:

IBTS Q1 total: -74.980 mean: -0.469
IBTS Q3 total: -31.619 mean: -0.351
Acoustic total: -8.283 mean: -0.173

F, Year effect:

1974: 1.000
1975: 1.802
1976: 1.884
1977: 1.624
1978: 1.073
1979: 0.684
1980: 2.495
1981: 1.247
1982: 1.080
1983: 1.772
1984: 1.057
1985: 1.458
1986: 1.248
1987: 0.397
1988: 1.388
1989: 0.448
1990: 1.602
1991: 0.876
1992: 0.941
1993: 1.726
1994: 0.871
1995: 1.495

```
1996:   1.539
1997:   1.112
1998:   1.885
1999:   0.964
2000:   1.605
2001:   1.740
2002:   1.776
2003:   1.387
2004:   2.176
2005:   1.423
2006:   1.766
2007:   1.853
2008:   1.678
2009:   0.948
2010:   1.178
2011:   1.067
2012:   1.500
2013:   1.569
2014:   0.680
2015:   1.428
2016:   2.494
2017:   1.595
2018:   1.583
2019:   1.325
2020:   2.010
2021:   2.730

F, season effect:
-----------------
age: 0
   1974-2021:   0.037 0.201 0.362 0.250
age: 1
   1974-2021:   0.541 0.527 0.196 0.250
age: 2
   1974-2021:   0.240 0.474 0.114 0.250
age: 3
   1974-2021:   0.219 0.549 0.351 0.250

F, age effect:
--------------
              0      1      2      3
1974-2021:  0.037  0.399  1.520  1.520


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                    0      1      2      3
1974-2021 season 1:  0.001  0.192  0.326  0.297
          season 2:  0.007  0.188  0.642  0.744
          season 3:  0.012  0.070  0.154  0.476
          season 4:  0.008  0.089  0.339  0.339


sqrt(catch variance) ~ CV:
--------------------------

             season
```

----

age	1	2	3	4
0	1.414	1.414	1.271	0.100
1	0.853	0.763	1.414	0.100
2	1.012	1.084	1.414	0.100
3	1.012	1.084	1.414	0.100

Survey catchability:
----

	age 0	age 1	age 2	age 3
IBTS Q1	0.000	1.590	3.153	6.540
IBTS Q3		0.870	1.126	1.140
Acoustic		1.172	2.362	6.561

Stock size dependent catchability (power model)
----

	age 0	age 1	age 2	age 3
IBTS Q1	1.65	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	0.43	0.37	0.37	0.37
IBTS Q3		0.48	0.40	0.40
Acoustic		0.44	0.55	0.55

Average F:
----

	sp. 1
1974:	1.109
1975:	1.705
1976:	1.802
1977:	1.602
1978:	1.049
1979:	0.676
1980:	2.299
1981:	1.152
1982:	0.986
1983:	1.589
1984:	0.987
1985:	1.308
1986:	1.117
1987:	0.361
1988:	1.259
1989:	0.423
1990:	1.494
1991:	0.848
1992:	0.916
1993:	1.587
1994:	0.804
1995:	1.342
1996:	1.395
1997:	1.049
1998:	1.765

1999: 0.936
2000: 1.485
2001: 1.644
2002: 1.676
2003: 1.372
2004: 2.085
2005: 1.356
2006: 1.659
2007: 1.722
2008: 1.578
2009: 0.886
2010: 1.072
2011: 0.969
2012: 1.336
2013: 1.422
2014: 0.638
2015: 1.314
2016: 2.253
2017: 1.459
2018: 1.448
2019: 1.217
2020: 1.827
2021: 2.169

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1316.549	9.000e+04	0.601	0.776

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	543036000	334604000	239556000	175705000	139916000	71456700	45757200	32147400	10206300	4740150	1856610	1311090	564485	306102	110129	54212
1975	709595000	421523000	311385000	218722000	111574000	46246900	25400300	16362000	19327000	6562280	1467900	864143	679416	294583	55264	16978
1976	327714000	200305000	143739000	97395300	136215000	56933800	30088300	18618100	10520700	3492490	718691	408031	577268	230920	39462	11353
1977	630579000	405010000	275610000	184507000	59943200	28014100	15589700	9660700	11954300	4571630	1131060	666272	275344	117455	24819	8136
1978	1071680000	709383000	497293000	334648000	113084000	60277900	38202800	24590400	6223900	2862460	1062380	717015	437888	220394	74254	34022
1979	539449000	348437000	228676000	152913000	214500000	121129000	81524400	53582800	16543100	8477520	4053540	2856720	516645	274597	123664	68080
1980	334838000	208560000	130888000	85906800	98051400	36021800	16412600	9464200	36302200	9368020	1201790	618695	2006250	577864	57232	11974
1981	87282900	52813800	34749200	23829500	56502300	26570100	15585600	10329200	6522900	2644320	824742	532257	450514	207577	58145	23924
1982	45555800	27300800	19447700	14127300	16355000	8419360	5327480	3884760	7423910	3432010	1269890	878234	425886	232756	79136	37065
1983	58821600	34454900	24295000	17645200	10279300	4569930	2488660	1761840	2945250	1088410	244596	151429	745375	330588	62084	20282
1984	31588200	18407300	12284500	8893450	12912600	6719240	4250850	3082660	1359230	693448	262874	183354	145108	85103	29152	13886
1985	23019800	13264800	8102330	5754980	6448840	2852700	1591720	1107200	2343350	947696	258165	168002	161927	81829	19657	7560
1986	70963900	39277900	24758600	17228700	4186070	1876160	1055200	739060	845766	351832	107452	71770	148853	76240	21440	9129
1987	38488000	21196500	13203800	9196920	12322200	6971920	4678720	3652010	556102	308891	172070	132845	68300	46320	26377	17645
1988	55817100	29924200	18094000	12251500	6559980	2945170	1562910	1104490	2757330	1053900	283000	178650	125118	60921	14603	5587
1989	48771900	26657400	15711900	10939400	8536000	4657730	3040950	2336520	817077	449786	242811	180096	146005	101554	53824	33961
1990	67307700	40016200	24089900	16834900	7524810	3267040	1675650	1139490	1710590	637302	151469	89498	161558	74287	15031	4981
1991	103265000	64967900	43460400	31493600	11432900	6200460	3939730	2825750	828606	436979	184461	126784	70924	40750	15885	7960
1992	98542600	65307900	47469400	34938400	21346600	12158200	7950910	5609240	2051690	1098170	454928	312678	101110	57313	21822	10679
1993	129113000	81680600	63540700	47296400	24116200	10990800	6205100	4208490	4159450	1576050	376218	230322	246785	102653	20436	6710
1994	113155000	68384200	50722500	38749000	33413800	17722600	11803700	8852710	3198710	1643500	721318	513028	185724	99320	40055	20808
1995	35487900	21223000	15701900	12328100	28200700	12905300	7538890	5541070	6909940	2854090	800120	517089	427172	191081	45770	17247
1996	59588600	35915800	24695800	19517200	9461590	4574380	2637400	1969810	4487250	1966670	530904	349843	442030	213995	49667	18785
1997	46909200	29830500	21972400	17247600	15384400	9032030	5829660	4405610	1621100	875433	326079	226809	315342	186651	63298	29481

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
1998	105848000	68705600	47185300	35779000	13178700	6617570	3655170	2559150	3555840	1424570	307293	186608	216003	95415	17109	5262
1999	75667400	49581800	36815200	27619900	26037400	15871400	10710000	7806430	2002530	1116250	470693	329117	157605	92331	35463	17511
2000	72250500	48034400	33277400	25274800	19765200	9939310	5813380	4142640	5976400	2582580	679193	439846	272028	128241	28364	10294
2001	58320100	38658700	28297200	21180500	19128800	9471370	5307730	3696480	3272880	1373460	320622	195989	371477	172239	33179	10824
2002	77193400	49869200	35902200	27255600	15592300	7710180	4248190	3007840	2854650	1173930	263910	159833	167104	78070	14439	4607
2003	98936600	64923600	47852100	36257500	19739000	11186500	6648750	4742960	2315440	1125270	336658	211375	132257	70488	18072	6880
2004	166990000	107622000	80201400	61834900	24730700	11740100	5984970	4083420	3485160	1250330	215256	120043	163976	65654	8877	2257
2005	63546300	40780100	29619800	23312100	42466000	22680000	13511500	9887520	3017980	1430700	428579	280082	92584	46486	11917	4660
2006	80677800	48624200	36830800	28953900	16154400	8061150	4500040	3218460	7388710	3094690	730428	452924	227374	102001	19789	6488
2007	56916600	35127100	25990800	20548200	20114100	9873790	5357310	3890690	2439230	1011160	224692	140075	375259	168619	30422	9719
2008	124143000	76807100	57979500	46400900	15035700	7707420	4419340	3259170	3068290	1378780	352157	223023	125743	60963	12924	4468
2009	104609000	67004900	47975700	39157400	34238000	19432600	13031200	10210100	2601340	1457570	629108	453453	186832	115897	45212	23146
2010	109958000	64799600	43261800	34634500	29225800	15010200	9430000	7166920	8232240	3919490	1402810	975767	394248	224740	71364	32451
2011	89088900	53381500	36186600	28382500	25428900	13053500	8216910	6175170	5714940	2632520	1006520	699597	828122	484339	166193	78607
2012	67893400	40718700	27860800	21938900	20241300	9515820	5469660	4079530	4791890	1964890	551427	367917	621832	316709	75810	29442
2013	151849000	101659000	76624500	61038400	16386900	8094030	4723490	3506530	3257200	1380800	378710	248903	332029	169702	39123	14596
2014	171345000	118599000	91223000	73167400	46597100	28788900	20463600	16192200	2811660	1716910	890556	679152	220470	152916	74360	44370
2015	95014500	65823400	51382800	40770100	55746600	29190300	17814700	13342900	12902800	5972630	1814030	1220960	602108	325834	85265	34283
2016	136982000	93631400	71213800	55706300	30878400	12747800	6175880	4254930	10661400	3307910	465689	260642	1047910	396437	42419	9652
2017	168157000	115082000	88114100	69758900	42190700	21142500	12375000	9147960	3399830	1464670	393931	257575	225649	115102	26081	9591
2018	163028000	111574000	85435800	67649600	52833800	26546400	15578300	11527100	7309530	3163210	858347	562436	223037	114237	26153	9680
2019	139860000	95751900	73460700	58368200	51236300	27215200	16861000	12730800	9210530	4379360	1430820	980317	477617	266526	75670	32143
2020	85515000	58490800	44646600	35150700	44206700	20256400	10864900	7774630	10172300	3765950	751141	457106	845227	375561	60179	17729
2021	69413200	47430600	36011600	29123700	26622400	10446200	4816020	4033920	6212200	1768500	210101	181019	396405	138661	12187	10500
2022	0				22057600				3223240				159885			

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., 2021 = July 2021–June 2022.

Year	Recruitment	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
1974	543036000	974148742	302713625	607031	989431	372423	463344	1.109	1.745	0.705
1975	709595000	1246579022	403925507	622040	1003062	385752	732312	1.705	2.538	1.145
1976	327714000	568380217	188951801	501939	813172	309827	628598	1.802	2.602	1.247
1977	630579000	1072938408	370598976	338439	521324	219712	385257	1.602	2.337	1.098
1978	1071680000	2020964214	568292112	389956	614573	247433	458804	1.049	1.768	0.623
1979	539449000	951361745	305882831	641332	1100917	373604	463638	0.676	1.302	0.351
1980	334838000	523306464	214246324	440425	747259	259581	387434	2.299	3.174	1.666
1981	87282900	128749607	59171479	307740	455678	207831	280582	1.152	1.754	0.757
1982	45555800	66143585	31376148	176147	263737	117646	162357	0.986	1.419	0.685
1983	58821600	79197337	43688093	82240	111675	60563	115440	1.589	1.941	1.300
1984	31588200	46065568	21660742	59357	76799	45877	113444	0.987	1.369	0.712
1985	23019800	31533307	16804808	55195	72629	41947	62514	1.308	1.657	1.033
1986	70963900	98483537	51134182	22058	29283	16616	27520	1.117	1.486	0.839
1987	38488000	52243884	28354059	50112	67314	37307	53942	0.361	0.549	0.238
1988	55817100	81761291	38105424	52957	67389	41616	103652	1.259	1.572	1.008
1989	48771900	67851635	35057346	39506	53836	28990	58420	0.423	0.804	0.222
1990	67307700	92743440	48847946	36902	50947	26728	78180	1.494	1.890	1.181
1991	103265000	134841771	79082766	79217	105401	59537	125815	0.848	1.175	0.613
1992	98542600	132518416	73277694	110149	138739	87450	156471	0.916	1.229	0.682
1993	129113000	203275378	82007801	155391	200600	120370	208848	1.587	1.894	1.330
1994	113155000	150994478	84798161	120194	177863	81223	424206	0.804	1.085	0.596
1995	35487900	47272692	26640984	169861	229949	125474	446555	1.342	1.679	1.072
1996	59588600	78950898	44974805	104983	130860	84223	95496	1.395	1.705	1.141
1997	46909200	62490879	35212707	106236	134353	84003	125174	1.049	1.354	0.813
1998	105848000	142504252	78620805	130525	162642	104750	188907	1.765	2.072	1.504
1999	75667400	98896332	57894517	125568	164272	95983	243158	0.936	1.248	0.702
2000	72250500	94446022	55271092	180665	227382	143546	222027	1.485	1.826	1.208
2001	58320100	75670180	44948143	124318	156010	99064	153321	1.644	1.981	1.364
2002	77193400	102094534	58365720	106899	133428	85644	174713	1.676	1.992	1.411
2003	98936600	131377949	74506041	132982	168882	104713	174988	1.372	1.700	1.108
2004	166990000	218038501	127893285	161765	206207	126901	231352	2.085	2.414	1.801
2005	63546300	81669576	49444756	203907	260209	159787	280275	1.356	1.666	1.104
2006	80677800	103508005	62883131	160733	200768	128681	78028	1.659	1.987	1.384
2007	56916600	74132739	43698633	130934	162701	105369	99902	1.722	2.046	1.449
2008	124143000	158849105	97019649	95608	119311	76613	69892	1.578	1.913	1.301
2009	104609000	134930708	81101204	164733	205575	132005	170934	0.886	1.182	0.664
2010	109958000	153382153	78827696	170207	211284	137116	145415	1.072	1.377	0.835

Year	Recruitment (thousands)	High	Low	SSB (tonnes)	High	Low	Catches (tonnes)	F ages 1-2 (per year)	High	Low
2011	89088900	115680121	68610164	149422	192407	116040	122472	0.969	1.296	0.724
2012	67893400	86480522	53301179	124904	153810	101430	96030	1.336	1.634	1.093
2013	151849000	206375367	111729027	103116	127342	83499	60207	1.422	1.808	1.119
2014	171345000	232252288	126410419	192302	251584	146989	190268	0.638	0.883	0.461
2015	95014500	126602235	71308024	311969	410654	236999	298227	1.314	1.629	1.059
2016	136982000	176588472	106258739	216052	278800	167426	227169	2.253	2.561	1.982
2017	168157000	216616887	130538192	176752	221935	140768	135824	1.459	1.774	1.199
2018	163028000	217041203	122456605	200339	249556	160828	190779	1.448	1.749	1.199
2019	139860000	183850729	106395116	209892	267130	164919	137489	1.217	1.558	0.951
2020	85515000	115933635	63077598	288838	368367	226479	181990	1.827	2.159	1.546
2021	69413200	106348965	45305493	141574	178714	112152	80032	2.169	2.567	1.832
2022	120979028			100495	138634	72848				

* Geometric mean recruitment (2011–2020)

Table 10.9.1. North Sea and Division 3.a Sprat. Input to forecast (years and age refer to the model year, e.g., 2021 = July 2021–June 2022).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2022) (millions)	120979	22058	3223	160
Exploitation pattern S1	0.003	0.433	0.734	0.668
Exploitation pattern S2	0.015	0.423	1.447	1.678
Exploitation pattern S3	0.027	0.157	0.348	1.073
Exploitation pattern S4	0.000	0.000	0.000	0.000
Weight in the stock S1 (gram)	4.800	7.593	10.633	13.621
Weight in the catch S1 (gram)	4.80	7.59	10.63	13.62
Weight in the catch S2 (gram)	5.78	9.00	11.84	15.58
Weight in the catch S3 (gram)	5.81	9.34	12.21	15.19
Weight in the catch S4 (gram)	6.44	9.42	12.36	15.93
Proportion mature(2020)	0.00	0.41	0.87	0.95
Proportion mature(2021)	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., 2021 = July 2021–June 2022.

Catch options. Catches and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2021) = geometric average 2011–2020.					
Basis	**Catches(2022)**	**F(2022)**	**SSB(2023)**	**%SSB change***	**%TAC change****
F_{cap}	68.690	0.69	181215	80%	-36%
F=0	0	0	222210	121%	-100%
F=0.1	12.231	0.1	214704	114%	-89%
F=0.2	23.557	0.2	207825	107%	-78%
F=0.3	34.071	0.3	201505	101%	-68%
F=0.4	43.852	0.4	195688	95%	-59%
F=0.5	52.971	0.5	190322	89%	-50%
F=0.6	61.490	0.6	185363	84%	-42%
F=0.7	69.465	0.7	180772	80%	-35%
F=0.8	76.944	0.8	176512	76%	-28%
F=0.9	83.971	0.9	172554	72%	-21%
F=1.0	90.586	1	168869	68%	-15%
$B_{escapement}$ without F_{cap}	178.672	3.28	125000	24%	-67%

* SSB in July 2023 relative to SSB in July 2022

** catch (July 2022-June 2023) relative to the sum of the TACs (106715 tonnes) for July 2021–June 2022 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.

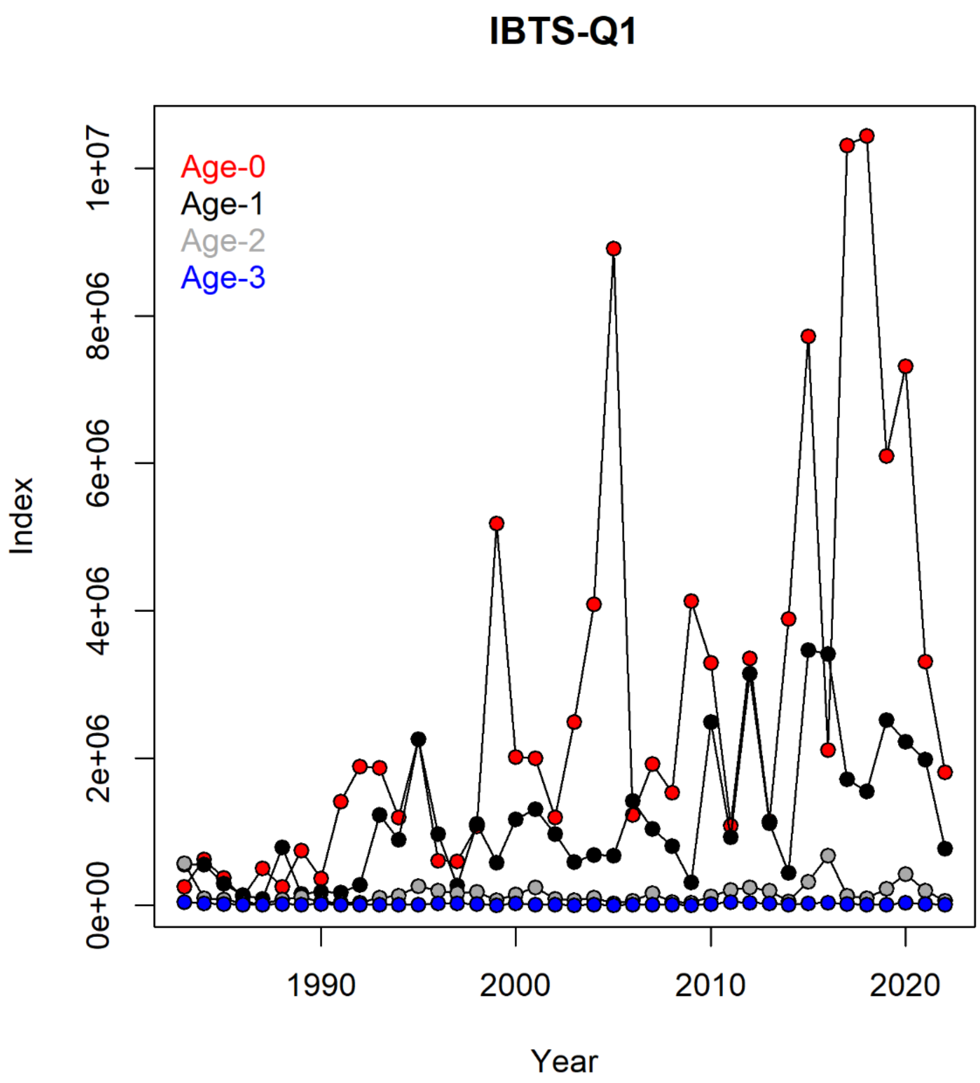


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

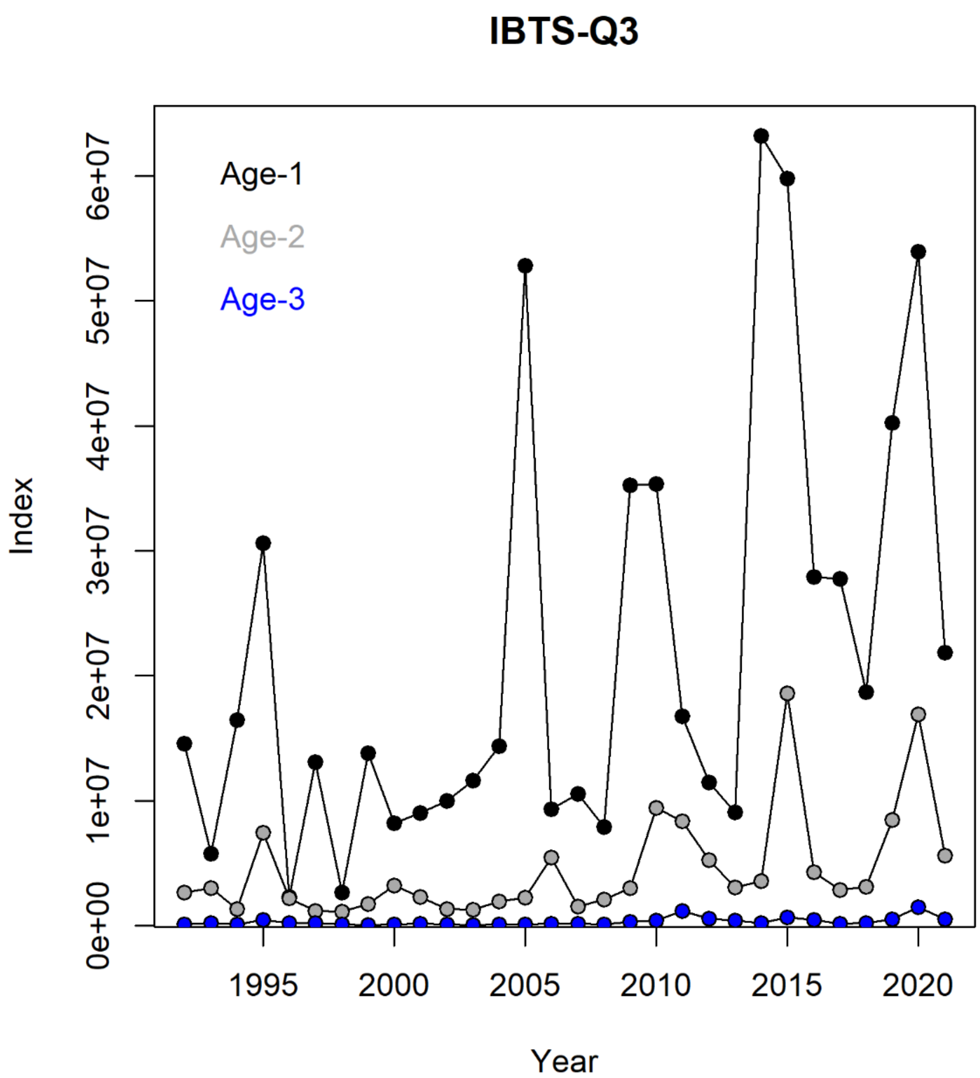


Figure 10.3.2a. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

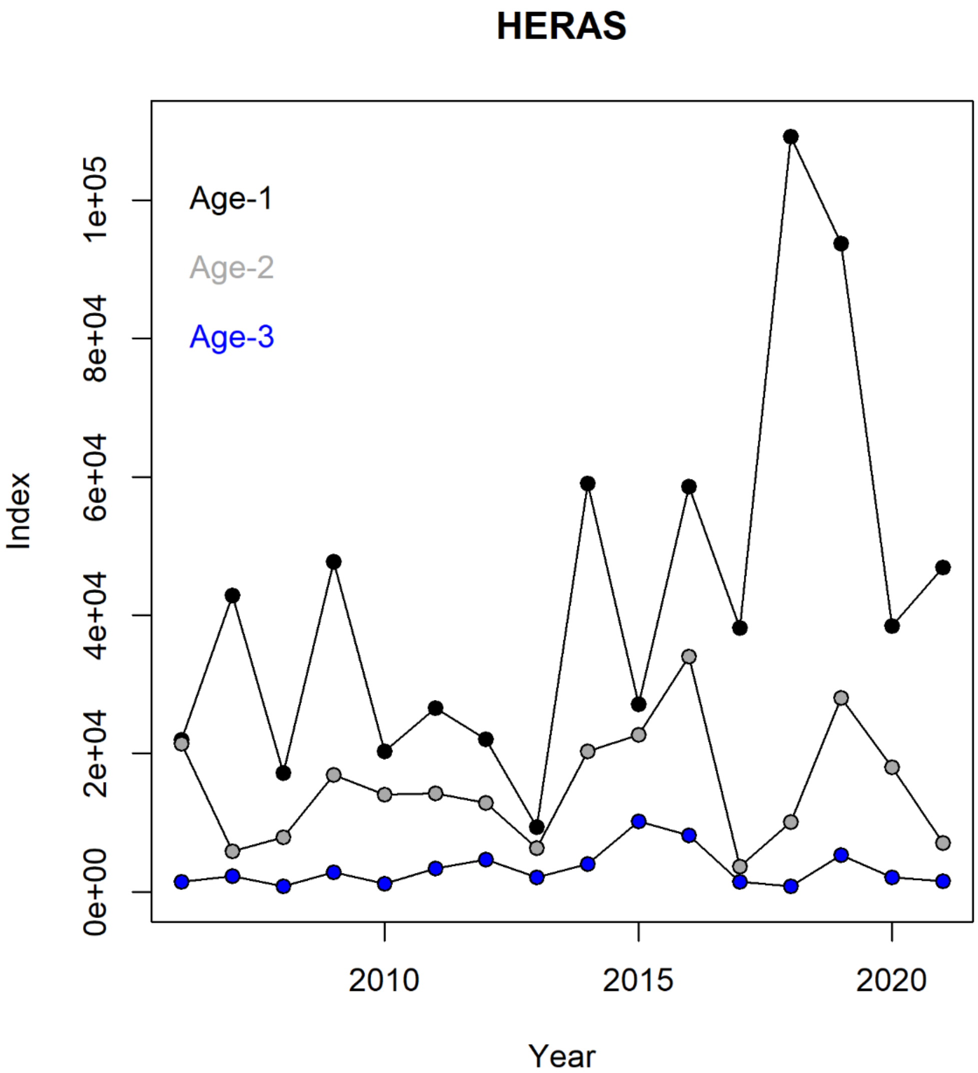
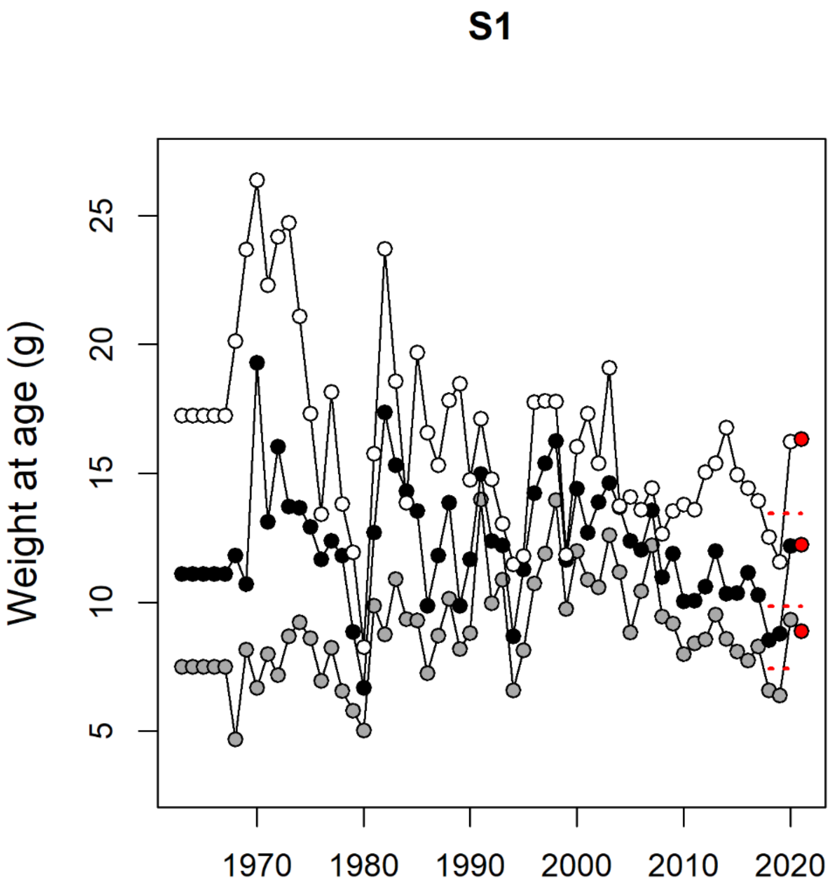
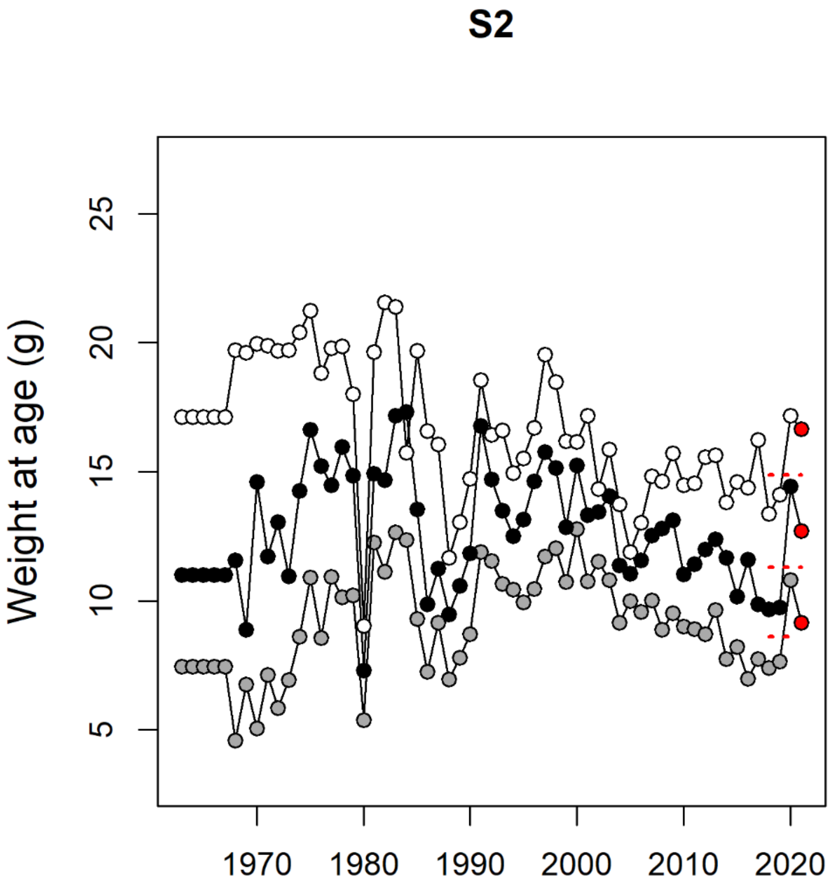


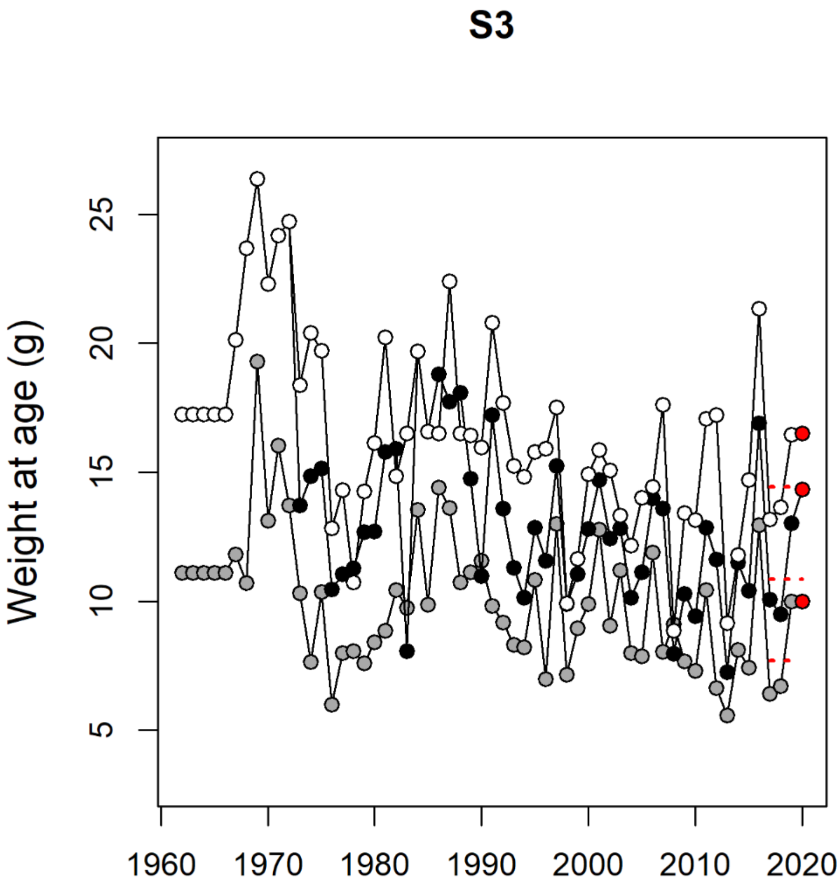
Figure 10.3.2b. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS). Years refer to the calendar year.



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

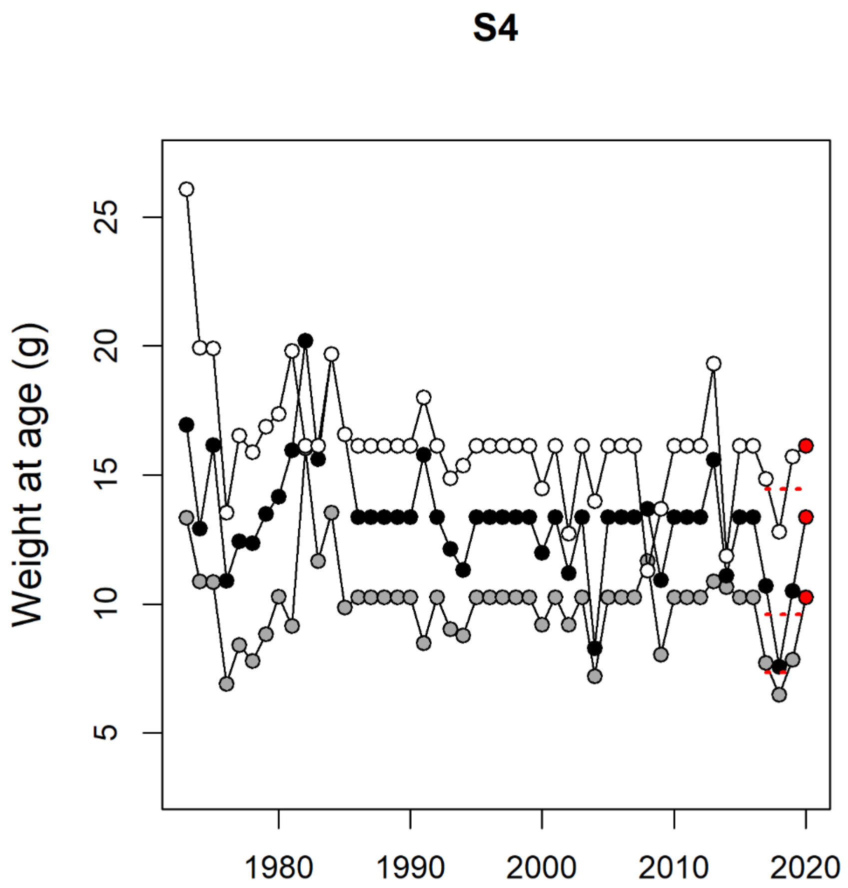


Figure 10.4.1. North Sea & 3.a sprat. Mean weight at age in season 1–4 (S1–S4) (years refer to the model year, e.g., 2021 = July 2021–June 2022). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year.

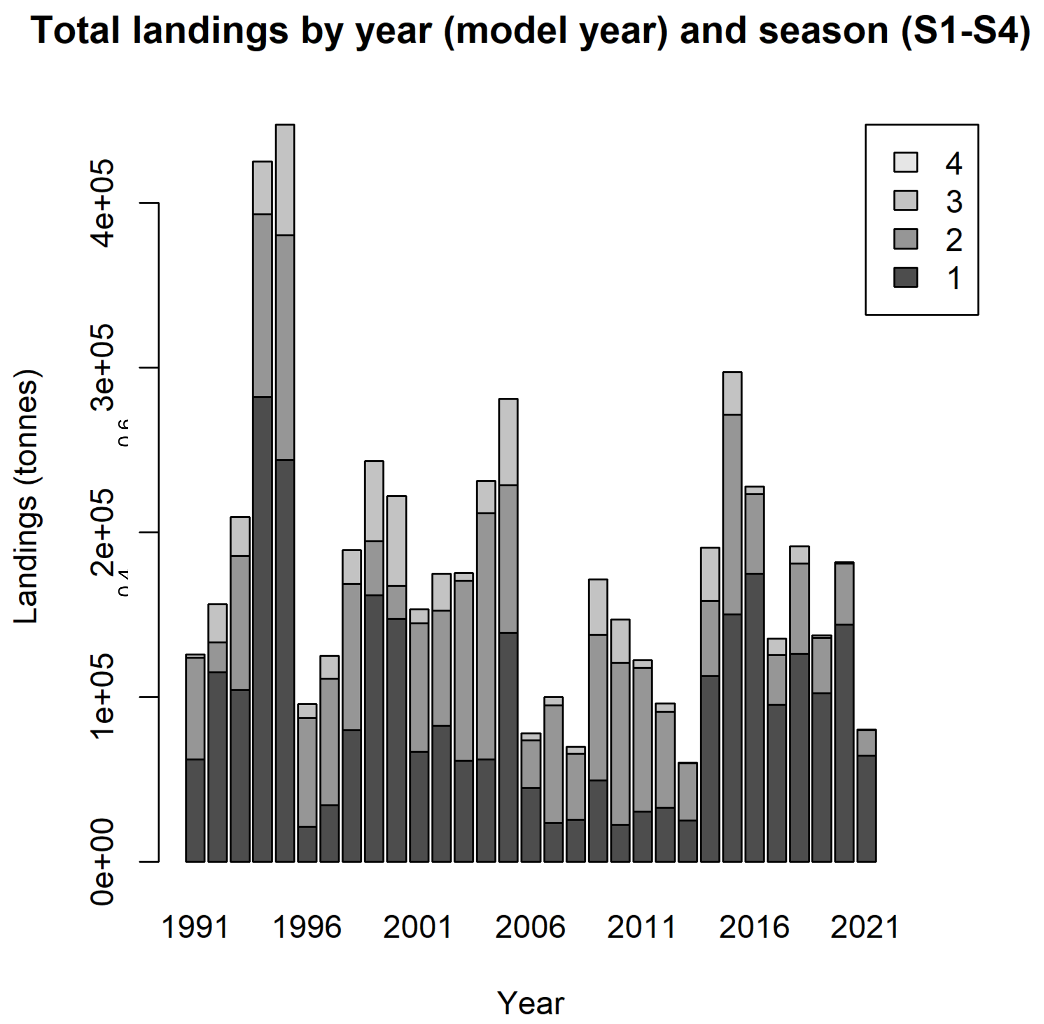


Figure 10.6.1a. North Sea & 3.a sprat. Seasonal distribution of catches. Year and season 1-4 refer to the time-steps of the model (e.g., 2021 = July 2021–June 2022). Note that since the model year of 2021 is not yet finished, the 2021 column will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT 2018 report (ICES, 2018) for details).

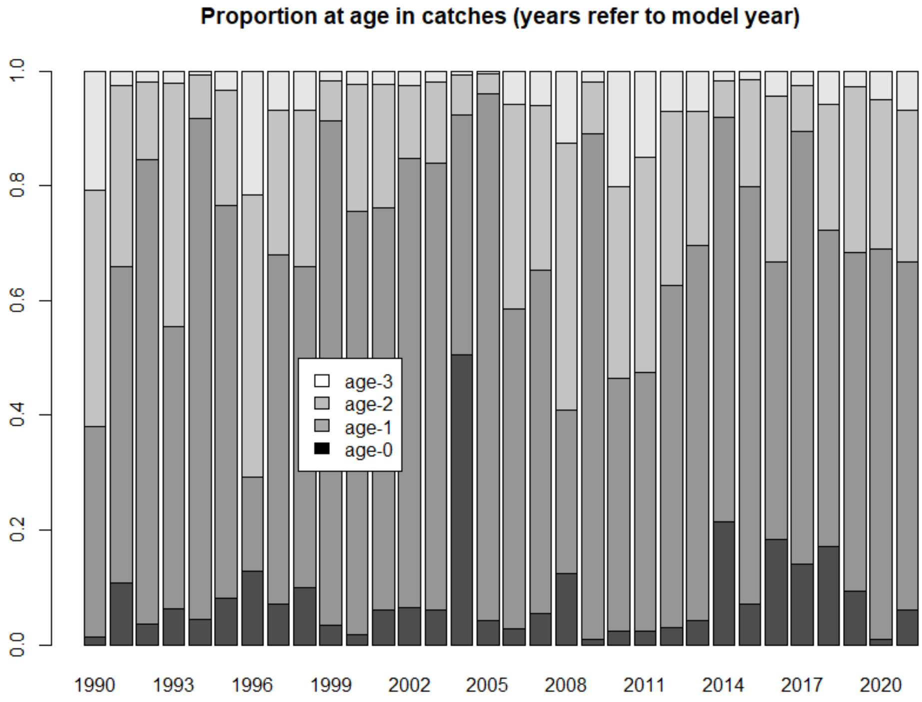


Figure 10.6.1b. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year (e.g., 2021 = July 2021–June 2022).

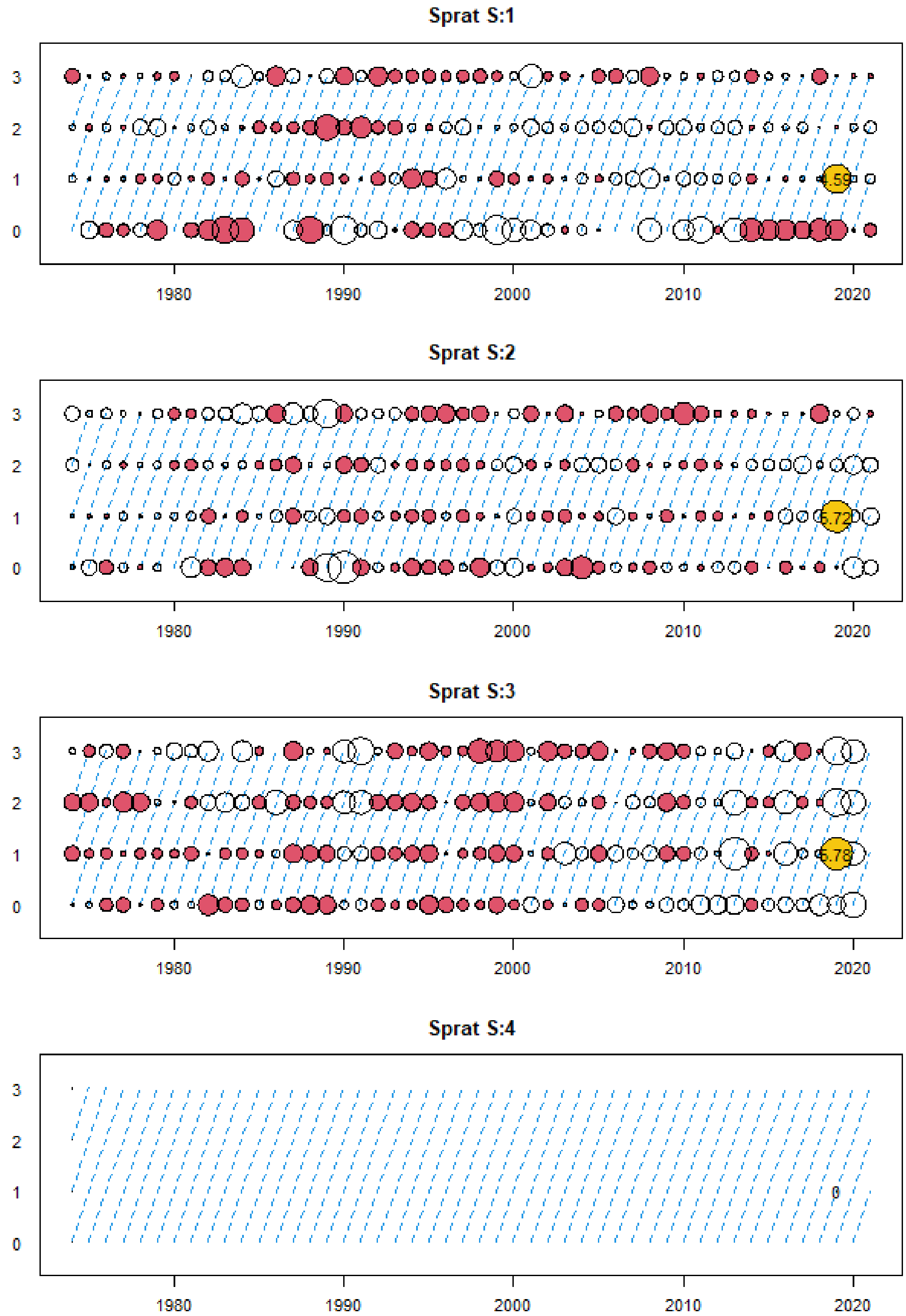


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

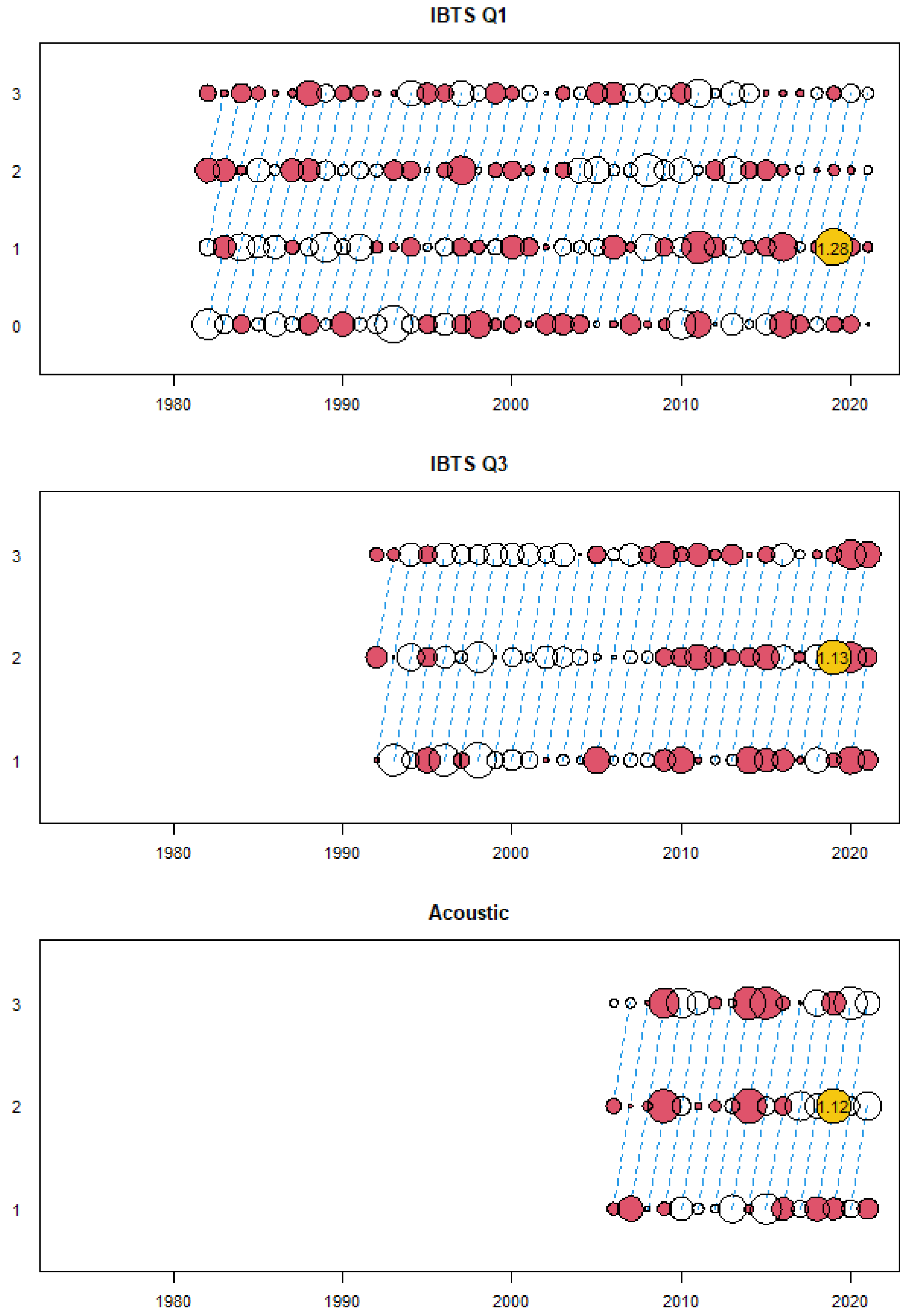


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year, e.g., 2021 = July 2021–June 2022)

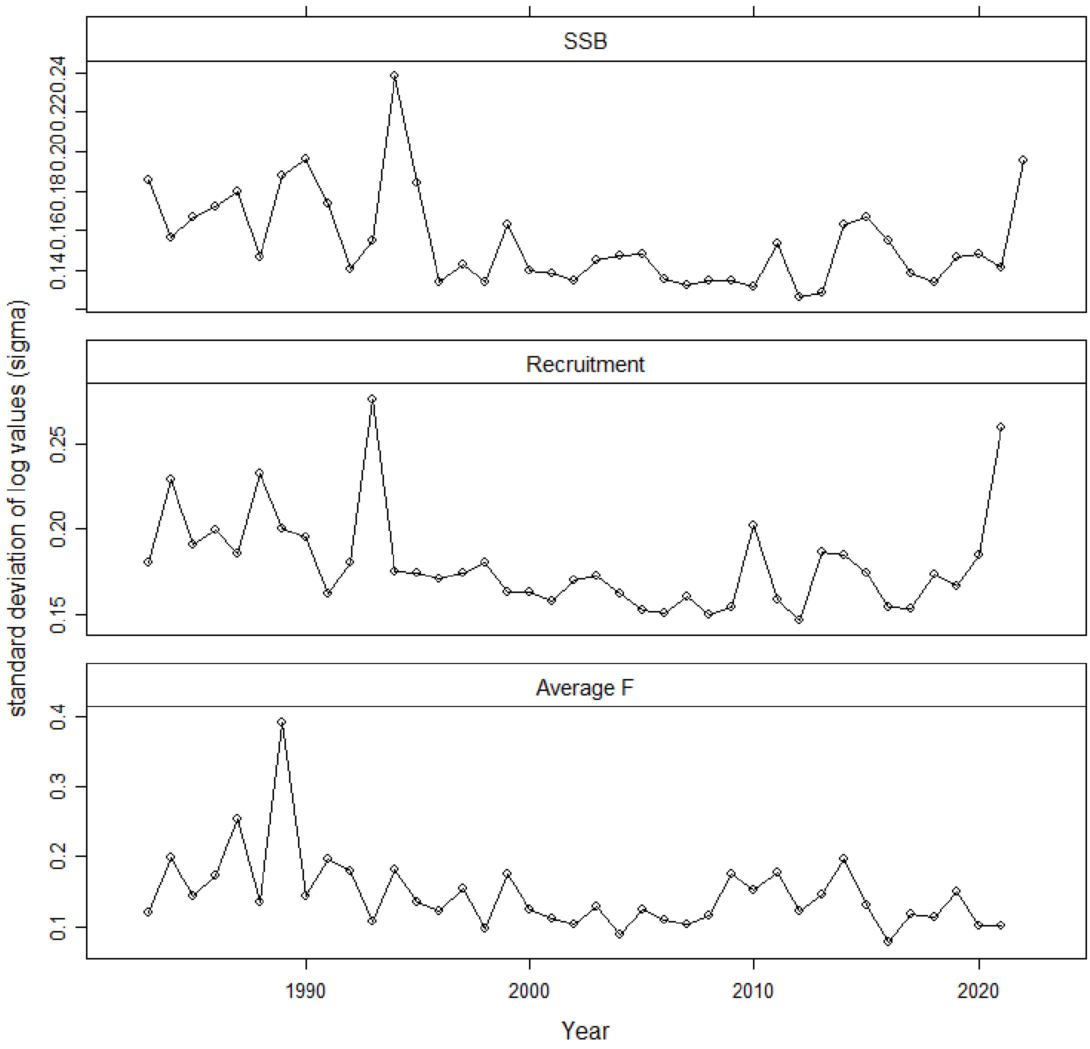


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year, e.g., 2021 = July 2021–June 2022).

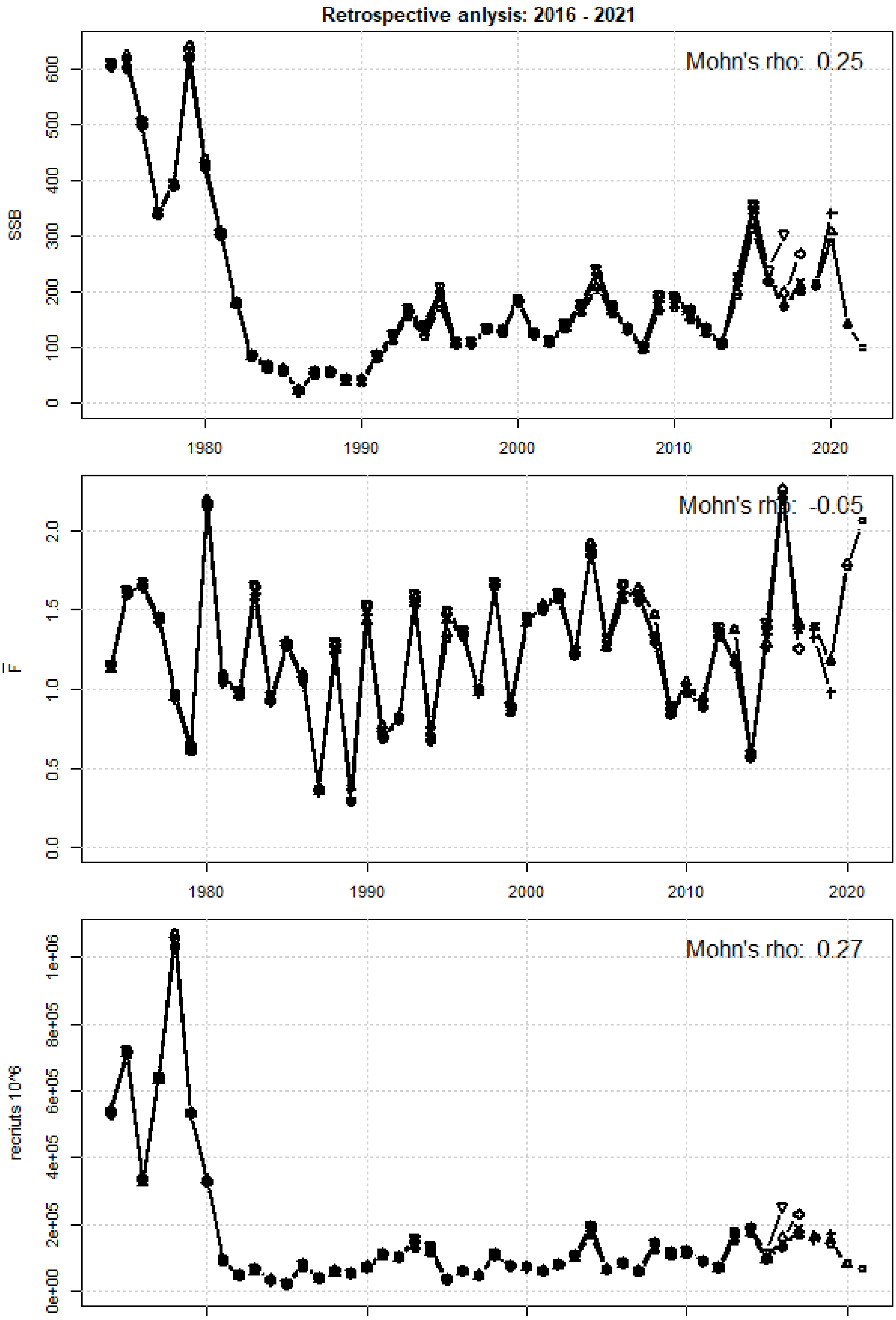


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year, e.g., 2021 = July 2021–June 2022)

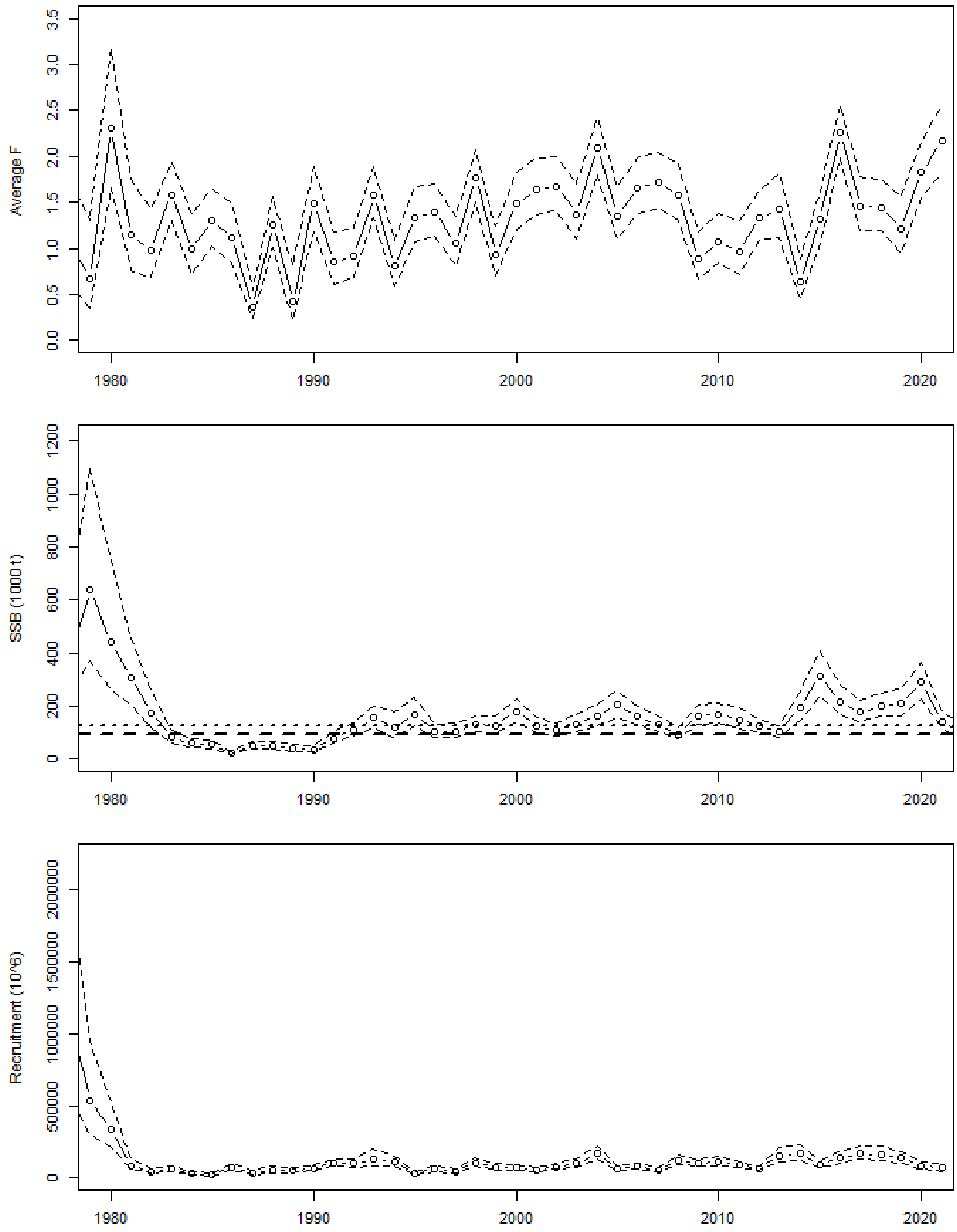


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year, e.g., 2021 = July 2021–June 2022).

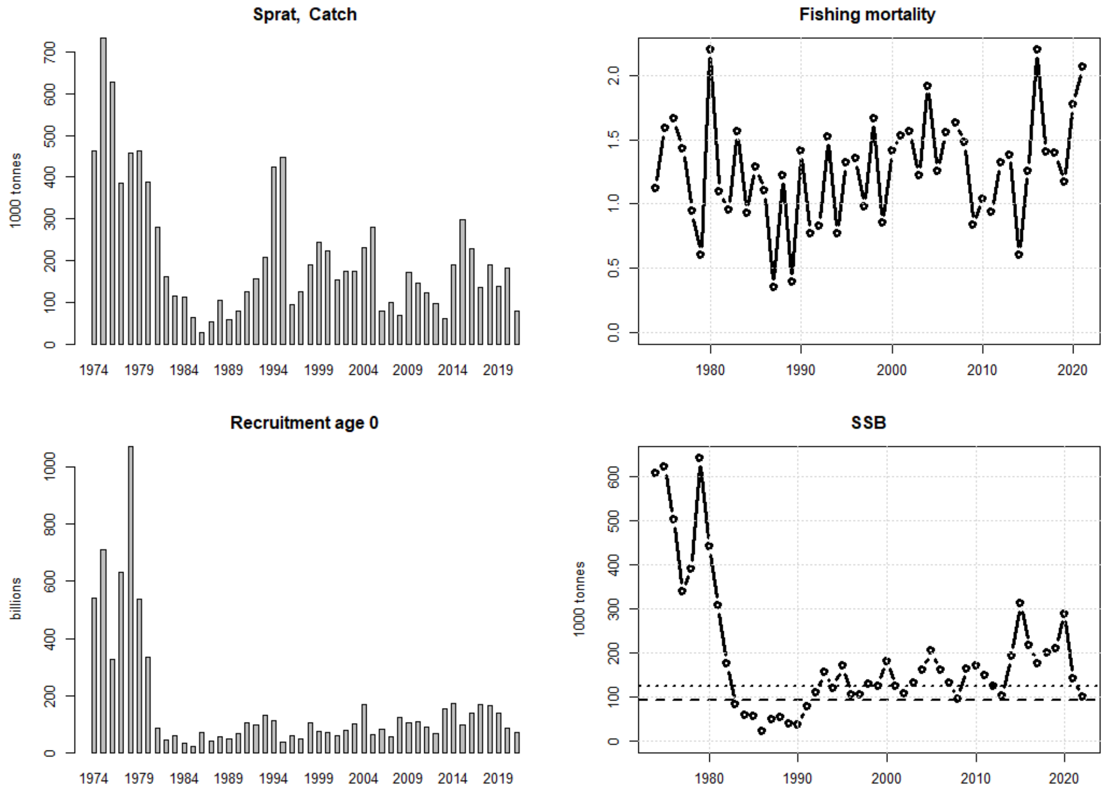


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year, e.g., 2021 = July 2021–June 2022).

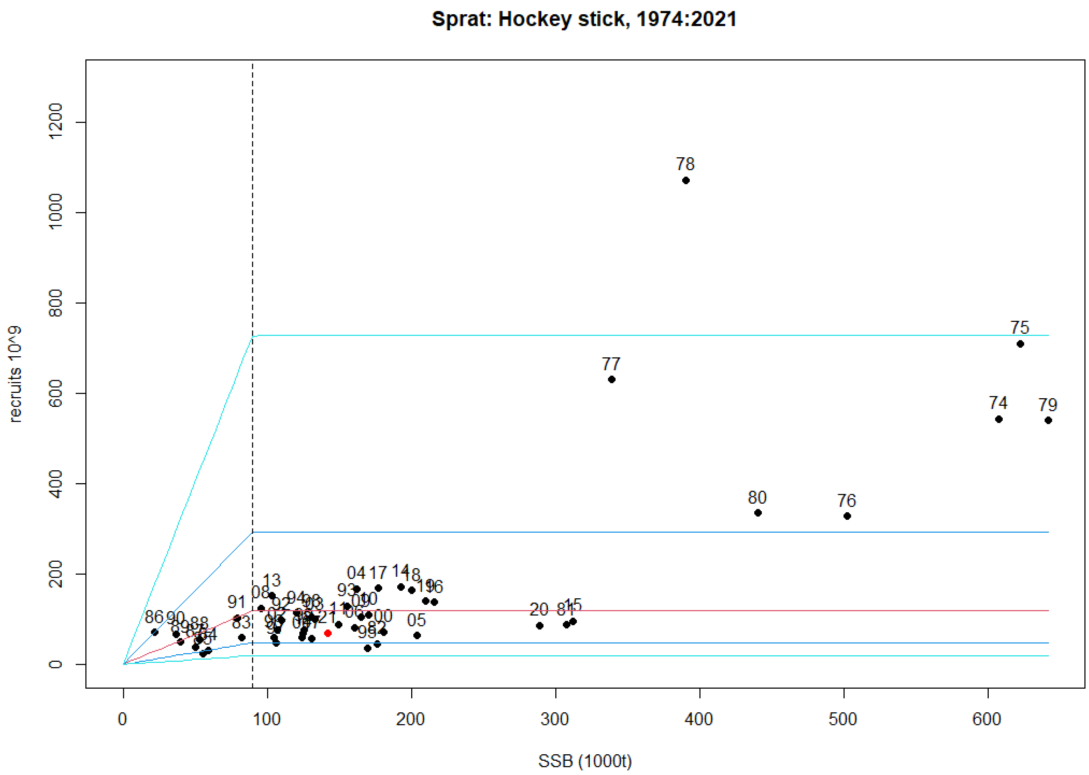


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year, e.g., 2021 = July 2021–June 2022).

10.14 References

WKSPRAT 2013. Report of the Benchmark Workshop on Sprat Stocks. ICES CM 2013/ACOM:48

WGSAM 2017. Interim Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2017/SSGEPI:20

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ICES. 2022. ICES Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. *In prep*.

ICES. 2020. Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; outputs from 2019 meeting). ICES Scientific Reports. 2:28. 38 pp. http://doi.org/10.17895/ices.pub.5997

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 2022

The advised catch for the English Channel (7.d and e) was set equal to 9200 tonnes.

11.1.2 Landings

The total sprat landings by country from 1986-2021 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 2021 99.5% of the catches were taken by UK vessels. Landings were very low in 2021, 49 tonnes in total (Figure 11.1.1), which has been attributed to a large number of small sprat in the catch, leading to a short season for the UK fleet and a switch to beaming and scalloping.

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 they 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 2000-2022 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 in 2021 however due to low uptake in the fishery only 1 vessel submitted data. 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. Figure 11.3.3 supports this and shows the large increase in 0 age fish in 2022 compared to 2021.

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.

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.

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 notes that the current advice is given annually, however it is recommended to move to an annual- seasonal calendar. This will reduce 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, 2021b).

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.

Sprat was in general the dominant small pelagic species in the trawl samples, with highest densities in the eastern parts of the western Channel and the Bristol Channel, with the bulk of the biomass centred in Lyme bay. As in previous years, large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. 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 2021b.

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) show a three fold 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 has increased substantially from 36 798 tonnes in 2020 to 107355 tonnes in 2021. The harvest rate has dropped from 3% to 0.05%. This is due low catches in 2021 which has been attributed to a large number small sprat mixed in with the catch. The fleet is thought to have switched to beam trawling and scalloping because of this but should be expected to return when these small sprats mature.

11.8 Catch Advice

Applying the constant harvest rate of 8.57% to the current estimate of PELTIC biomass gives an advised catch of 9200 tonnes.

11.9 Short-term projections

No projections are presented for this stock.

11.10 Reference Points

The IBP suggested the use of the Istat value developed as part of WKDSLLS2 (ICES, 2021) 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 very little extend outside. In fact, the transects carried out off the French coast found very little sprat, mostly of ages 0 and 1. This pattern may have changed somewhat in recent years as sprat have been recorded off the coast of France and around the channel island in 2018 and 2019. 2021 also saw sprat present off the coast of France, in line with a general increase in biomass across the area and consisted primarily of small age 0 fish. They 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 suggesting no movements of sprat between the two areas 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.

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 2532 tonnes on average. The average harvest rate for the 9-year time-series is 8%, however if the 2016 value of 34% is removed, this drops to 5%. The average harvest rate is 2 % over the last 3 years. In general, however, it seems that Lyme Bay, where most of the fishery occurs, consistently hosts quite a substantial part of the sprat stock: this is confirmed by the fact that even in 2016, when the estimated biomass was overall very low, Lyme Bay still contributed 50% of the total sprat population in the Western English Channel.

The strong biomass fluctuations observed in the acoustic index and the relatively strong increase in biomass observed in 2017, suggests that the low level of catch is not impairing the stock. 2021 has seen another large increase in biomass. Due to the low fishing pressure and reports of average oceanographic condition from the survey, it is likely the increase is driven by environmental conditions or interactions with other stocks.

The timing of the advice relative to the PELTIC survey has been considered, previously the advice has been issued on an annual basis. This led to a lag between survey, advice and uptake, which was identified as problematic in a short-lived species. 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.

Table 11.1.1 Sprat in 7.d-e. Landings of sprat, 1986–2021.

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1986	15	0	0	1163	0	0	1178
1987	250	23	0	2441	0	0	2714
1988	2529	2	1	2944	0	0	5476
1989	2092	10	0	1520	0	0	3622
1990	608	79	0	1562	0	0	2249
1991	0	0	0	2567	0	0	2567
1992	5389	35	0	1791	0	0	7215
1993	0	3	0	1798	0	0	1801
1994	3572	1	0	3176	40	0	6789
1995	2084	0	0	1516	0	0	3600
1996	0	2	0	1789	0	0	1791
1997	1245	1	0	1621	0	0	2867
1998	3741	0	0	1973	0	0	5714
1999	3064	0	1	3558	0	0	6623
2000	0	1	1	1693	0	0	1695
2001	0	0	0	1349	0	0	1349
2002	0	0	0	1196	0	0	1196
2003	0	2	72	1368	0	0	1442
2004	0	6	0	836	0	0	842
2005	0	0	0	1635	0	0	1635
2006	0	7	0	1969	0	0	1976
2007	0	0	0	2706	0	0	2706
2008	0	0	0	3367	0	0	3367
2009	0	2	0	2773	0	0	2775
2010	0	2	0	4408	0	0	4410
2011	0	1	37	3138	0	0	3176
2012	6	2	8	4458	0	0	4474

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	0	3793	0	0	3793
2014	45	0	275	3338	0	0	3658
2015	0	1	352	2659	0	0	3012
2016	185	7	231	2867	0	49	3339
2017	0	0	235	2498	0	0	2733
2018	474	1	0	1776	0	0	2252
2019	0	0.67	0	1544	0	28	1573
2020	0	0	0	873	0	0	873
2021	0	0.25	0	48.75	0	0	49

Table 11.6.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas annual pelagic acoustic survey)

Survey	Area	Season	2013	2014	2015	2016	2017	2018	2019	2020	2021
PELTIC	W Eng Ch	Oct	70 680	85 184	65 219	9826	32 751	21 772	36 789	33 798	107 355

*** ICES rectangles 29E6, 30E6**

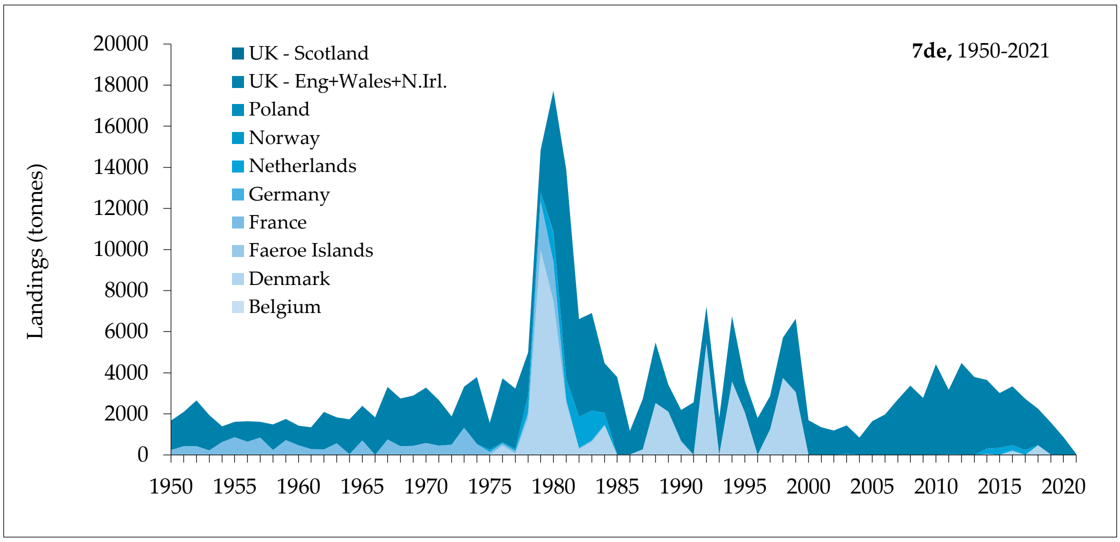

Figure 11.1.1. Sprat in 7.d-e. Landings of sprat 1950–2021.

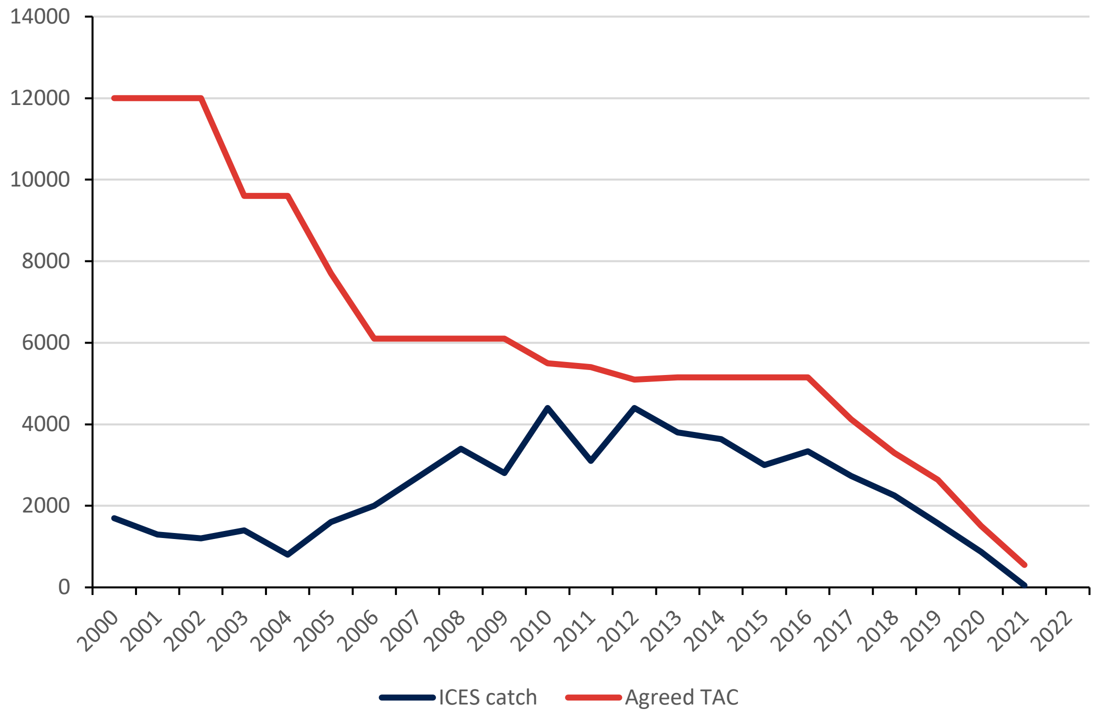

Figure 11.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2022.

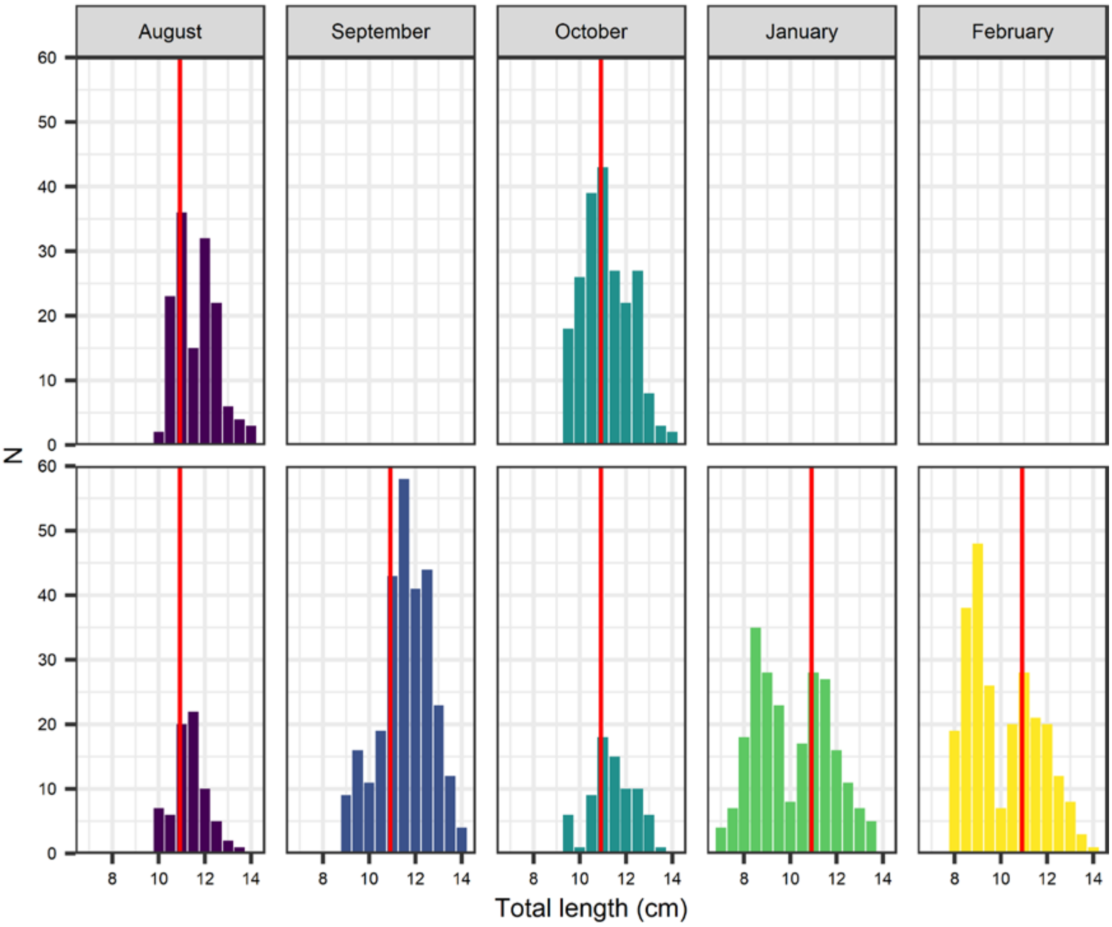

Figure 11.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month 2019, For the two boats supplying the FSP program.

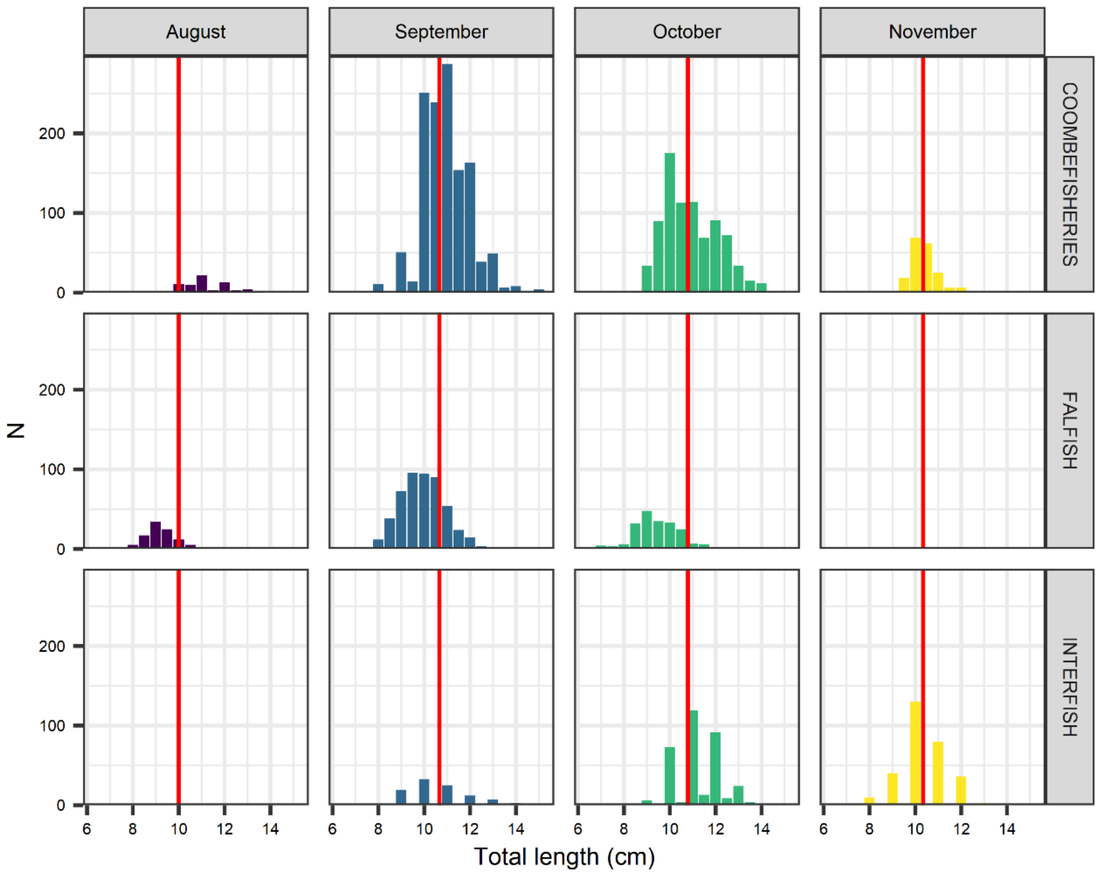

Figure 11.2.2. Monthly sprat total length distribution collected by the three processors in the 2020 season. Red line indicates weighted mean length at each month.

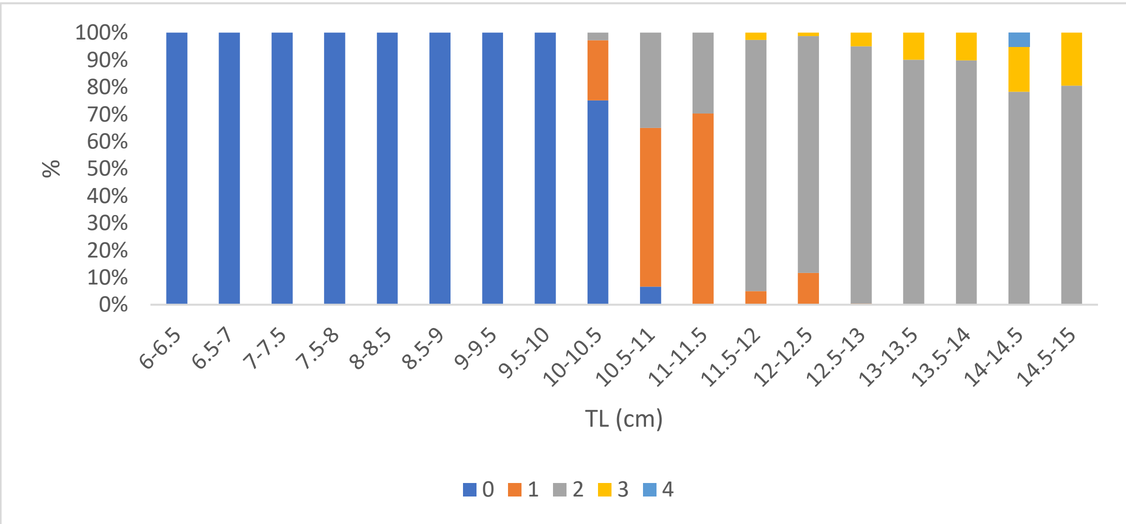

Figure 11.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2021 PELTIC acoustic survey.

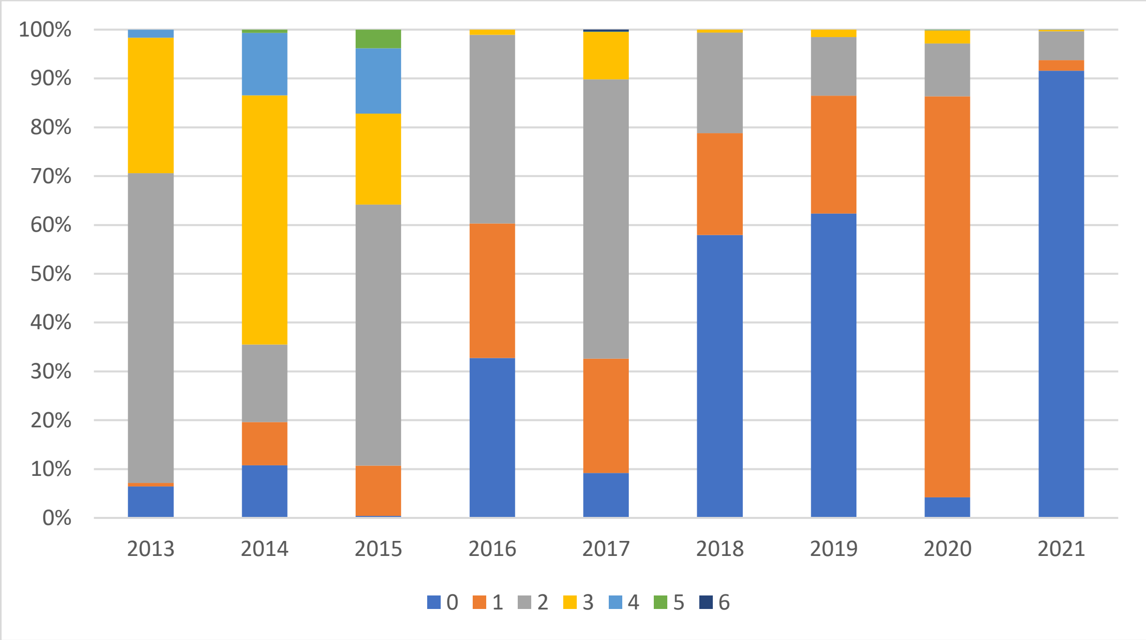

Figure 11.3.3. Sprat in 7.d-e. Proportion of numbers-at-age in the biological samples collected during the 2013–2021 PELTIC acoustic surveys.

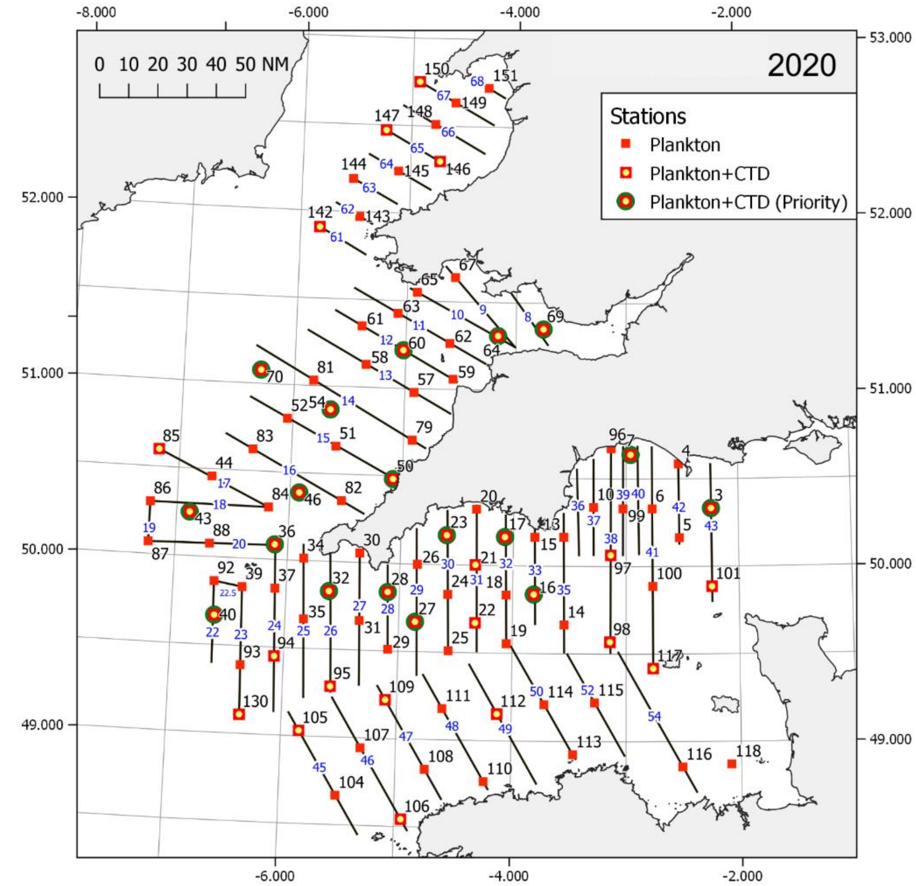

Figure 11.3.1. Sprat in 7.d–e. Survey design (2021) with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

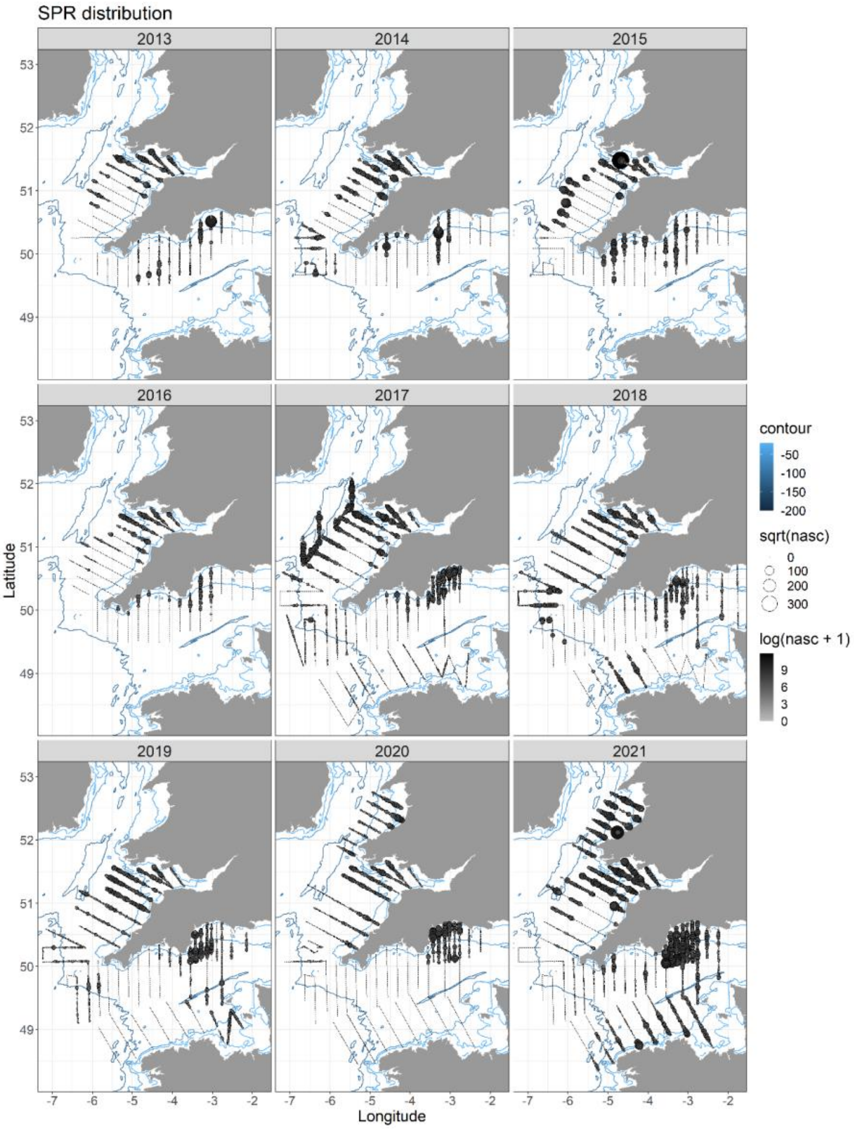

Figure 11.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2013–2021 PELTIC surveys.

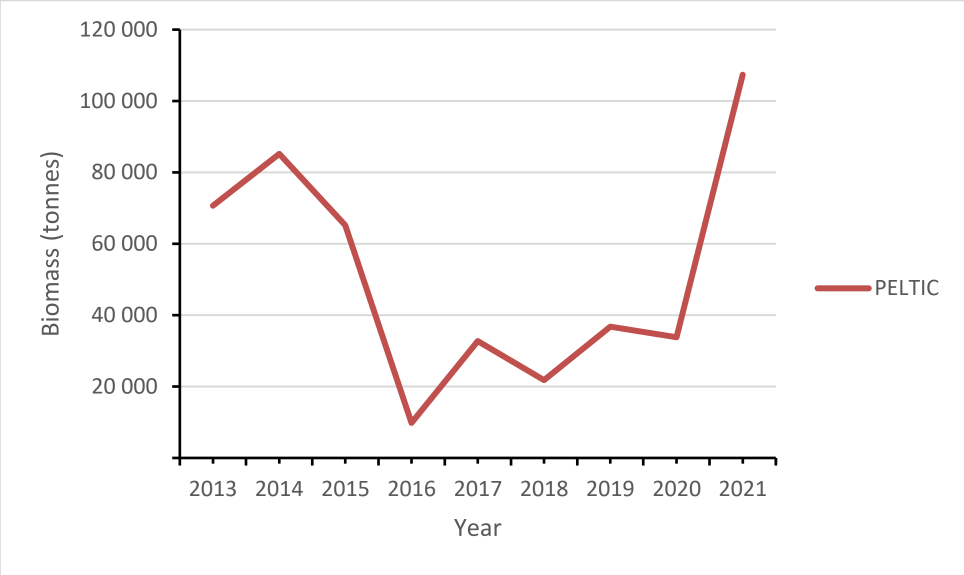

Figure 11.6.2. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2021 for Division 7.e (red line) and the Lyme Bay area (blue line). The Partial survey has not been run since 2019.

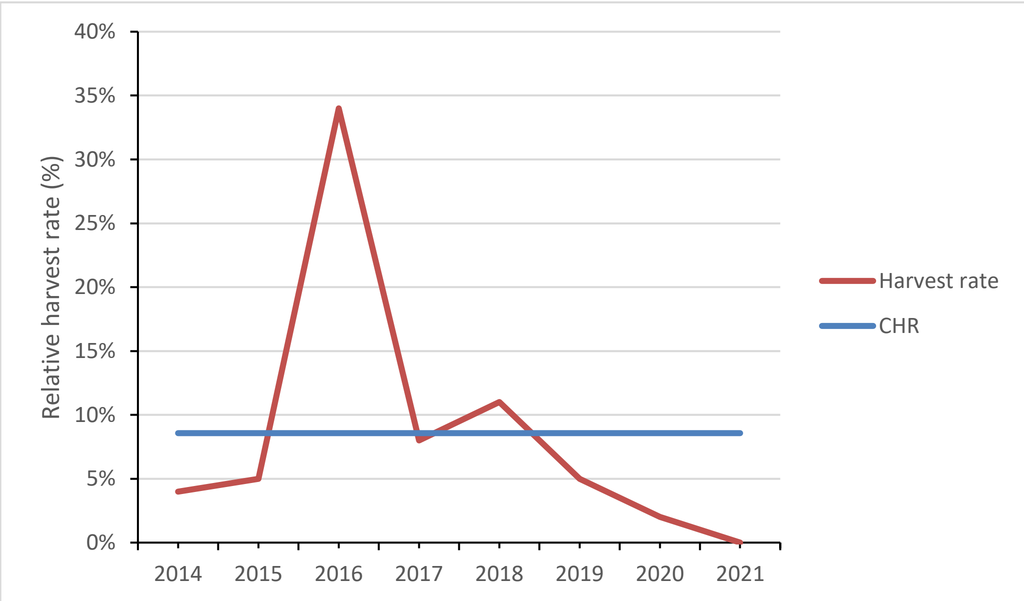

Figure 11.7.1. Sprat in 7.d-e. Constant Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

11.14 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 2022 and 2023

ICES analysed data for sprat in the Celtic Sea and West of Scotland. Currently there is no TAC for sprat in this area, 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. Therefore, when the precautionary approach is applied, ICES advises that catches should be no more than 2240 t in 2022 and 2023. The TAC for the English Channel (7.d and e) is the only one in place for sprat in this area.

12.1.2 Landings

The total sprat landings, by ICES Subdivision (where available) are provided in tables 12.1.1–12.1.7, with the total landings in Table 12.1.8, and in figures 12.2.1–12.2.8. Only Ireland and the United Kingdom landed from the stock in 2022, with Ireland taking the majority of the landings (Table 12.1.8).

12.1.3 Division 6.a (West of Scotland and Northwest of Ireland)

Landings 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 landings between the two countries are similar, though the UK data have been higher. Irish data may be underestimated, due to difficulties in quantifying the landings 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. Landings were high in the early part of the time-series peaking with average annual landings of ~7000 t in the period 1972 to 1978 (Figure 12.2.1). Landings were low for a period after this until a second peak in the period 1995 to 2000 where landings averaged just around 4600 tonnes annually. In 2005 to 2009 the fishery was virtually absent but has slowly picked up again since 2010. In 2013 landings reached 968 tonnes, lower than in 2012, but then increased again in the last 3 years, until 2176 t in 2016. In 2015 Irish landings were higher than the Scottish ones, with 1300 t, but decreased again to low values in 2016. 2018 landing were only recorded for Ireland and were much lower in 2017, 1 tonne in total. Irish landings in 2019 increased substantially to 3423 tonnes. This has been attributed to a low herring quota in the Celtic sea for the Irish fishery. Landings dropped to 736 tonnes in 2020 and anecdotal reports suggest the fleet may have moved to 7.aS to target abundant sprat in the area. Limitations to the licensing of large vessels (>18 m) in Irish inshore waters that were due to come into effect in 2020 have been delayed due to an ongoing legal case. A total of 245.7 tonnes was taken in 2021, 160.7 by Scotland and the remainder (85 tonnes) by Ireland.

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 landings 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. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion.

Irish Landings 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 raised again 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 landings from 7.aS increased to 6888 tonnes up from 2785 tonnes in 2019. Irish landings from 7.aS are predominantly from Waterford Harbour (Table 12.1.3)

No landings from 7.aN were reported by Ireland in 2009–2013 or 2018 (Table 12.1.2), however there have been reported landings of 522 t in 2014, 771 t in 2015 and 150 t in 2016 and 2017. Irish landings in 2020 were 2521 tonnes up from 9 tonnes in 7.aN in 2019. Scotland reported landings in 2021 of less than a tonne while Ireland took 381 tonnes

12.1.4 Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landings were in 1980 and 1981 during winter of 1980-1981, when over 5000 t were landed by Irish boats (Table 12.1.4, Figure 12.2.4). This fishery took place in Galway Bay in winter 1980-1981 (Department of Fisheries and Forestry, 1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year in 2000. Zero catches were reported for 2016, increasing to above 500 tonnes in the two subsequent years. Irish landings in 2020 were 1308 tonnes and 295 tonnes in 2021. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

12.1.5 Divisions 7.g–k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated landings. Patterns of Irish landings in divisions 7.g and 7.j are similar, though the 7.j landings have been higher. Landings for 7.g and 7.j were aggregated in this report. Landings 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 2452 t. Irish landings increased significantly in 2019 to 6148 tonnes, this has dropped to 2933 tonnes in 2020. Irish landings in 2021 increased to 5524 tonnes. Irish data may be underestimated, due to difficulties in quantifying the landings 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.

Recently the Irish government changed the regulation relating to the access of the inshore fishing grounds. Vessels >18 m LOA will not have access to the 6nm inshore zone from 1 January 2020. For vessels targeting sprat, an exemption from this regulation is in place that allows a total sprat catch of up to 2000 t in 2020, up to 1000 t in 2021 and these vessels will not have access to the inshore zone from 2022. However, the policy directive is subject to an ongoing legal case and is not yet fully implemented.

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 in 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 landings 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 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.

Sprat biomass in the survey has decreased substantially from 60 608 tonnes in 2019 to 4523 tonnes in 2020 and is the lowest since 2003. The distribution of sprat was notably different in 2020 with the distribution concentrated along the shore in the east and a lack of fish in the southwest. Anecdotal evidence suggests that prior to the survey a high abundance of sprat was observed in the southwest and was the focus of prolonged and persistent marine mammal feeding activity. Given the inshore distribution observed this year it is possible that the sprat stock was not fully contained within the survey area and so the estimate is low. The size profile of sprat was dominated by larger fish overall and lacked the spread of cohorts normally observed. This is not considered reflective of the state of the stock but rather a year effect which has been observed previously (O'Donnell *et al*, 2020).

The biomass of sprat in 2021 was higher than observed in 2020 (2021: 12 376 t and 2020: 4523 t). As in 2020, the distribution of sprat was concentrated in inshore waters. Given the inshore distribution this year it is possible that the sprat stock was not fully contained within the survey area and so an unknown proportion of the stock remains unaccounted for. The size profile of sprat was dominated by smaller fish compared to 2020 and lacked the larger length cohorts that dominated catches.

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 12.3.3. In 2013 the survey was cancelled due to technical problems but has been continued up to 2018.

12.3.3 Scottish IBTS surveys (G1179)

The Scottish West Coast IBTS has been carried out in Q1 since 1981 to the present and in Q4 from 1991 onwards (Figure 12.3.2). Although the survey is a groundfish bottom trawl survey it does catch sprat throughout the survey area. The survey provides numbers at length per haul and aggregated age-length keys on a subarea basis. In the period 1981 to 2012 a total of 1434 hauls were completed and approximately half of these caught sprat. Although the survey is still carried out the figure has not been updated in the last five years (2013 to 2018).

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). While targeting herring, a sprat biomass is also calculated. The annual calculated biomass from 1998–2014 is shown in Figure 12.3.4 and Table 12.3.2. The biomass is estimated to have peaked in 2002 with 405 000 t and it has declined since then to just under 95 000 t in 2010. Recent estimates suggest an increase with 2014 being the second highest estimate in the time-series, followed by a decline in the final year of the survey. Spatial distribution of sprat at the time of the survey is shown in Figure 12.3.5. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

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

Currently, the only assessment carried out in the Celtic 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. The only assessment available in the area for this species is for sprat in the English Channel (for that, please refer to Section 12 of this report).

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.

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.

The sprat has mainly been fished together with herring. The human consumption fishery only takes 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.

Table 12.1.1 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2021, Division 6.a. Irish data may be underestimated, due to difficulties in quantifying the landings 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

Table 12.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2021 from Division 7.aN. Irish data may be underestimated, due to difficulties in quantifying the landings 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
2000	0	0	371	0	371

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
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

Table 12.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2021 from Division 7.aS. Irish data may be underestimated, due to difficulties in quantifying the landings 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

Table 12.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2021, from divisions 7.b–c. Irish data may be underestimated, due to difficulties in quantifying the landings 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
2001	138

Country	Ireland
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

Table 12.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2021, 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	0
2021	0	0.35	0.35

Table 12.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2021, divisions 7.g–k. Irish data may be underestimated due to difficulties in quantifying the landings 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
2000	0	0	1764	0	0	0	1764

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
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
013	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

Table 12.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2021 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	4916	0	0	0	0	2	968	5887
2014	0	0	0	2852	0	0	0	0	1	1540	4392
2015	0	0	0	9328	0	0	0	0	0	1060	10389
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					0.35	0.078	14146

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
2011	31593

Year	Biomass (t)
2012	35114
2013	44685
2014	54826
2015	83779
2016	42694
2017	70745
2018	47806
2019	60608
2020	4523
2021	12376

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
2007	204 700	0.09	91	187 200
2008	252 300	0.12	83	209 800

Year	Sprat & 0-group herring			Sprat
	Biomass (t)	CV	% sprat	Biomass (t)
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

Figure 12.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

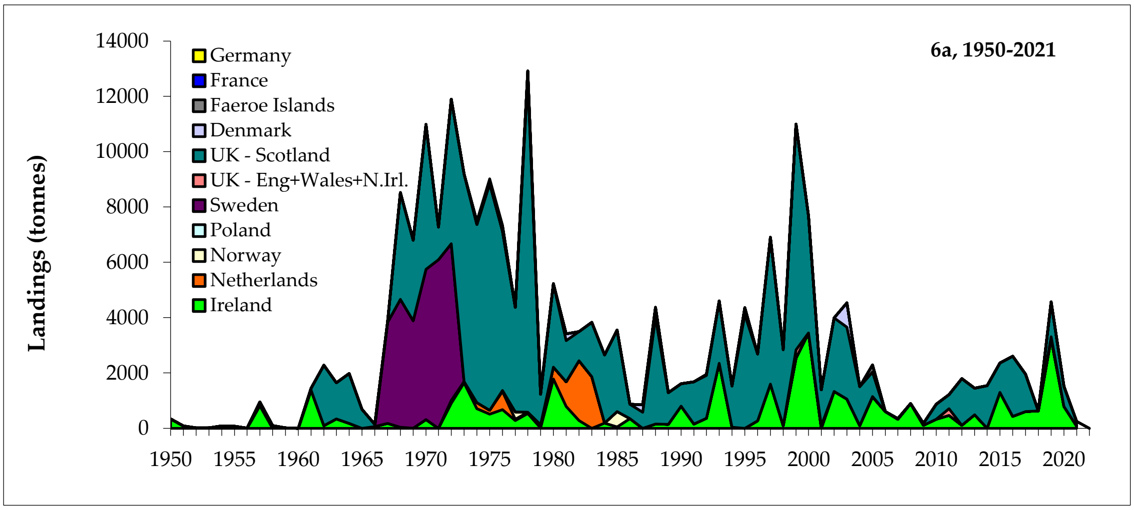

Figure 12.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES Division 6.a.

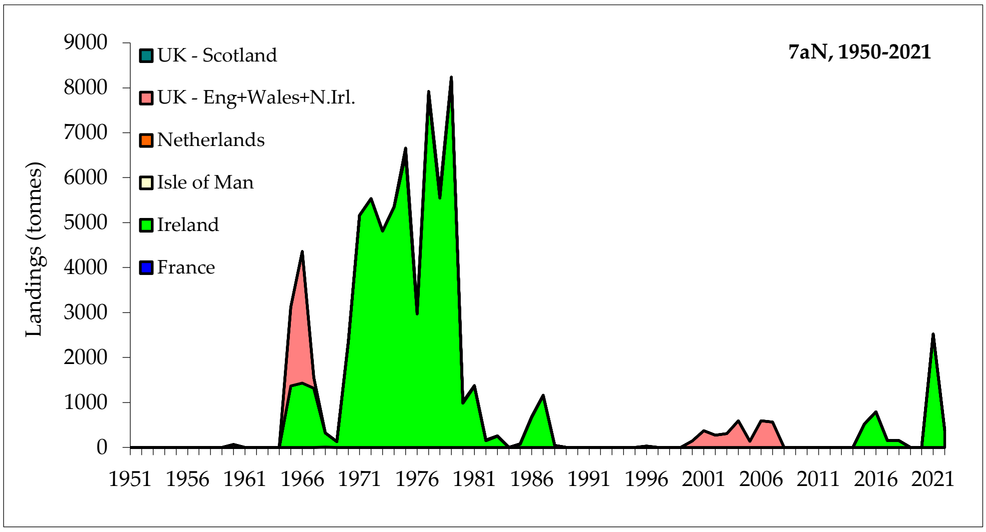

Figure 12.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES Division 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

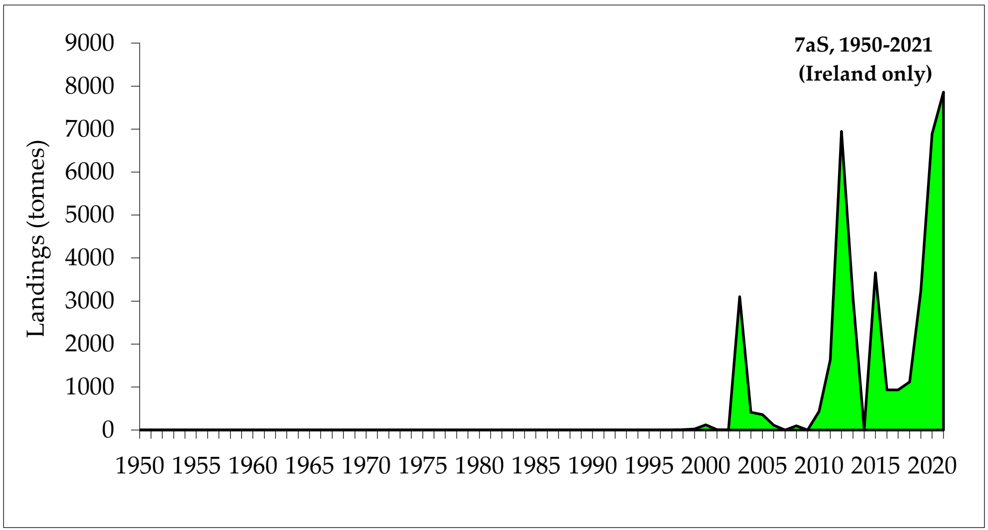

Figure 12.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES Division 7.aS.

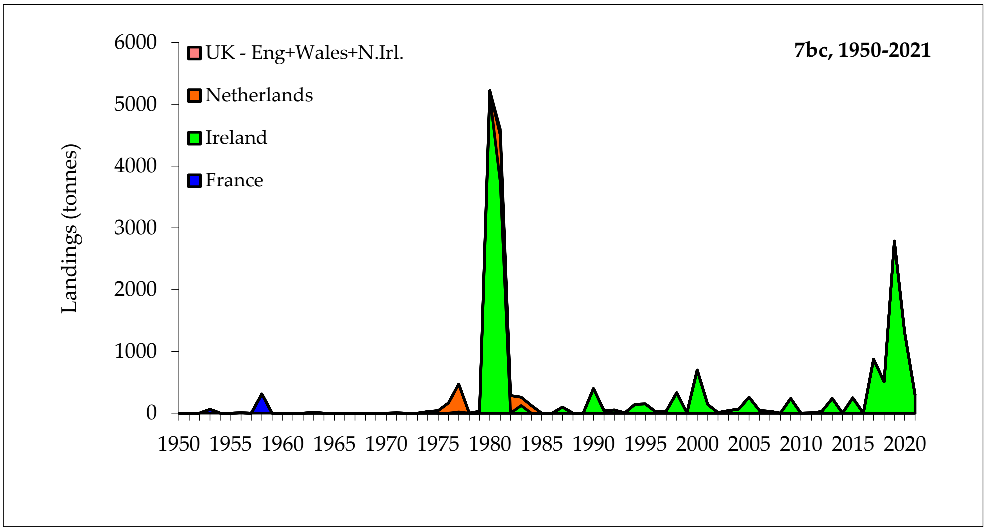

Figure 12.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES divisions 7.b–c.

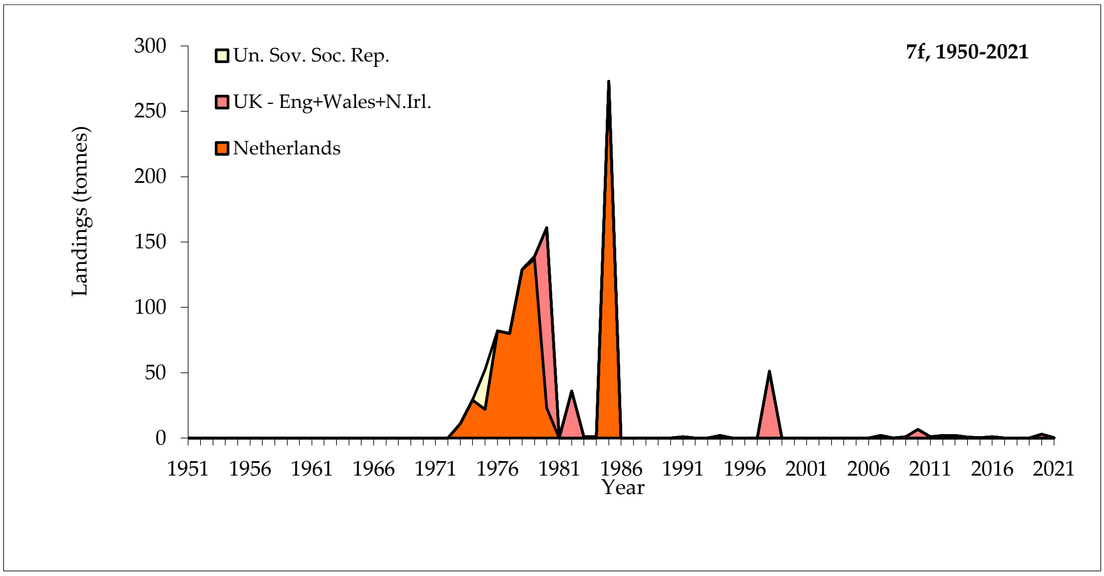

Figure 12.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES Division 7.f.

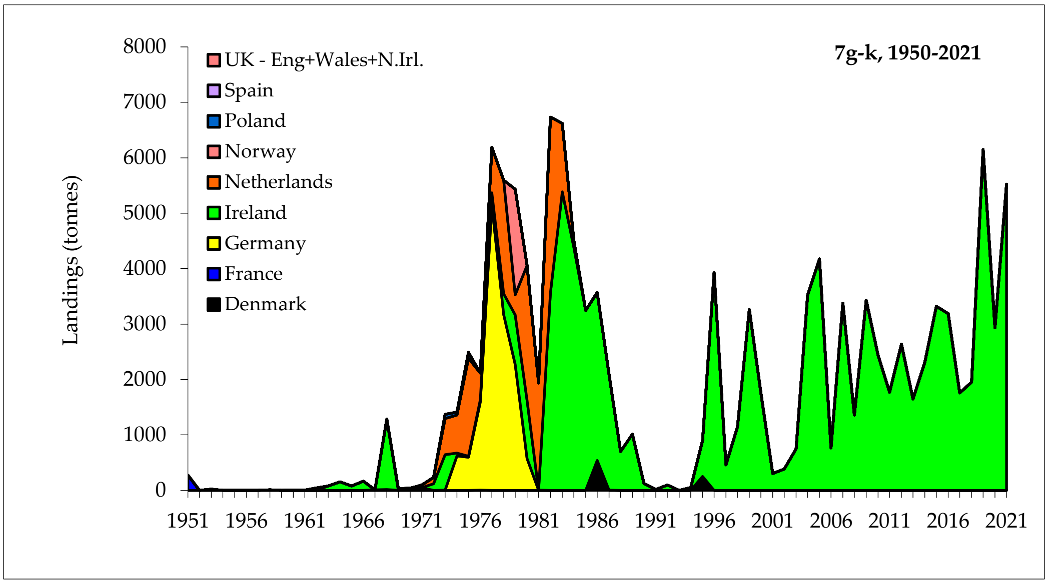

Figure 12.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES divisions 7.g–k.

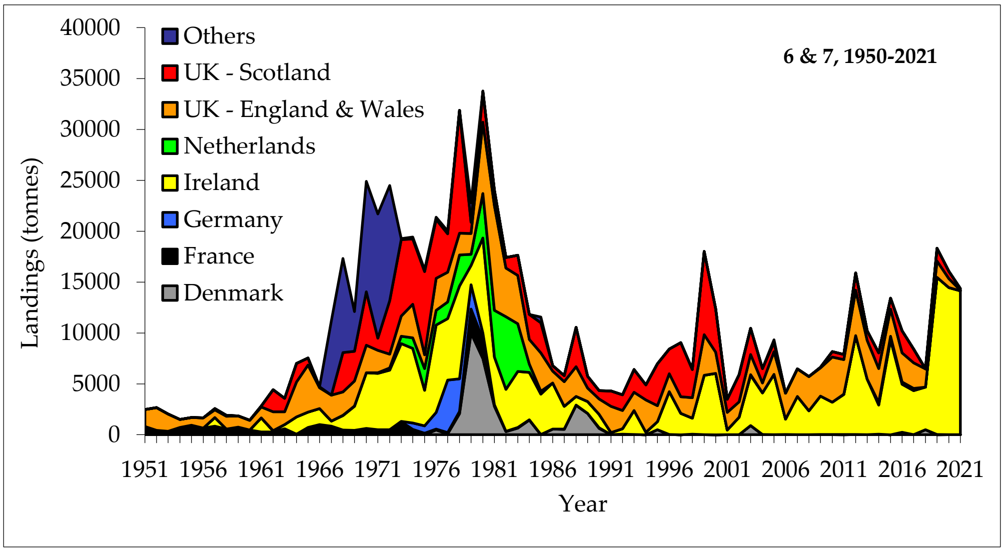

Figure 12.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2021 ICES subareas 6 and 7 (Celtic Seas Ecoregion).

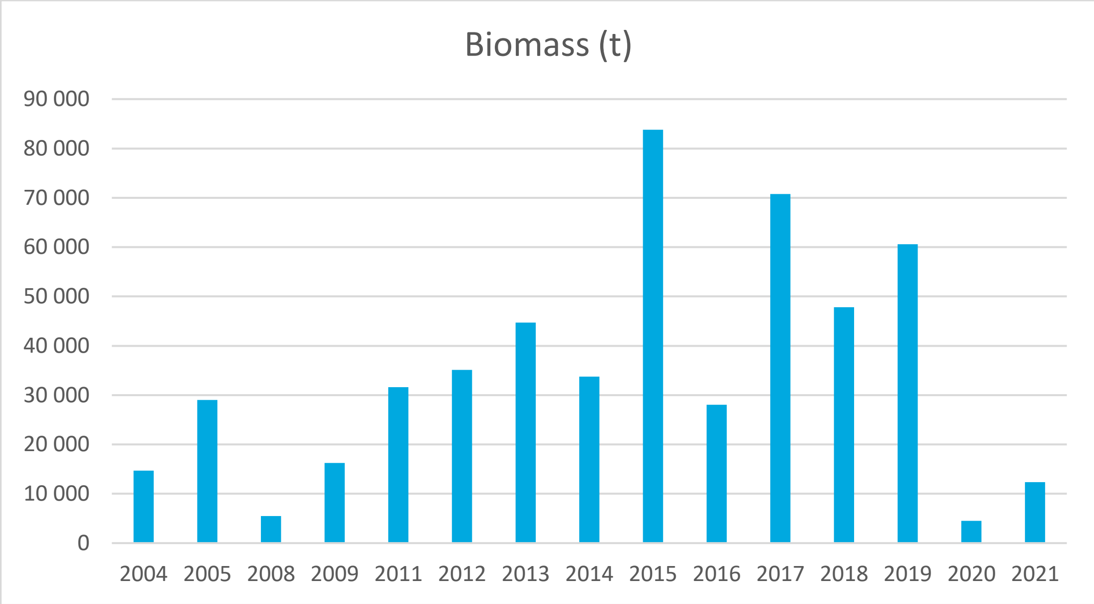

Figure 12.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass from the MI Celtic Sea Herring Acoustic Survey 2004–2021 (A4705).

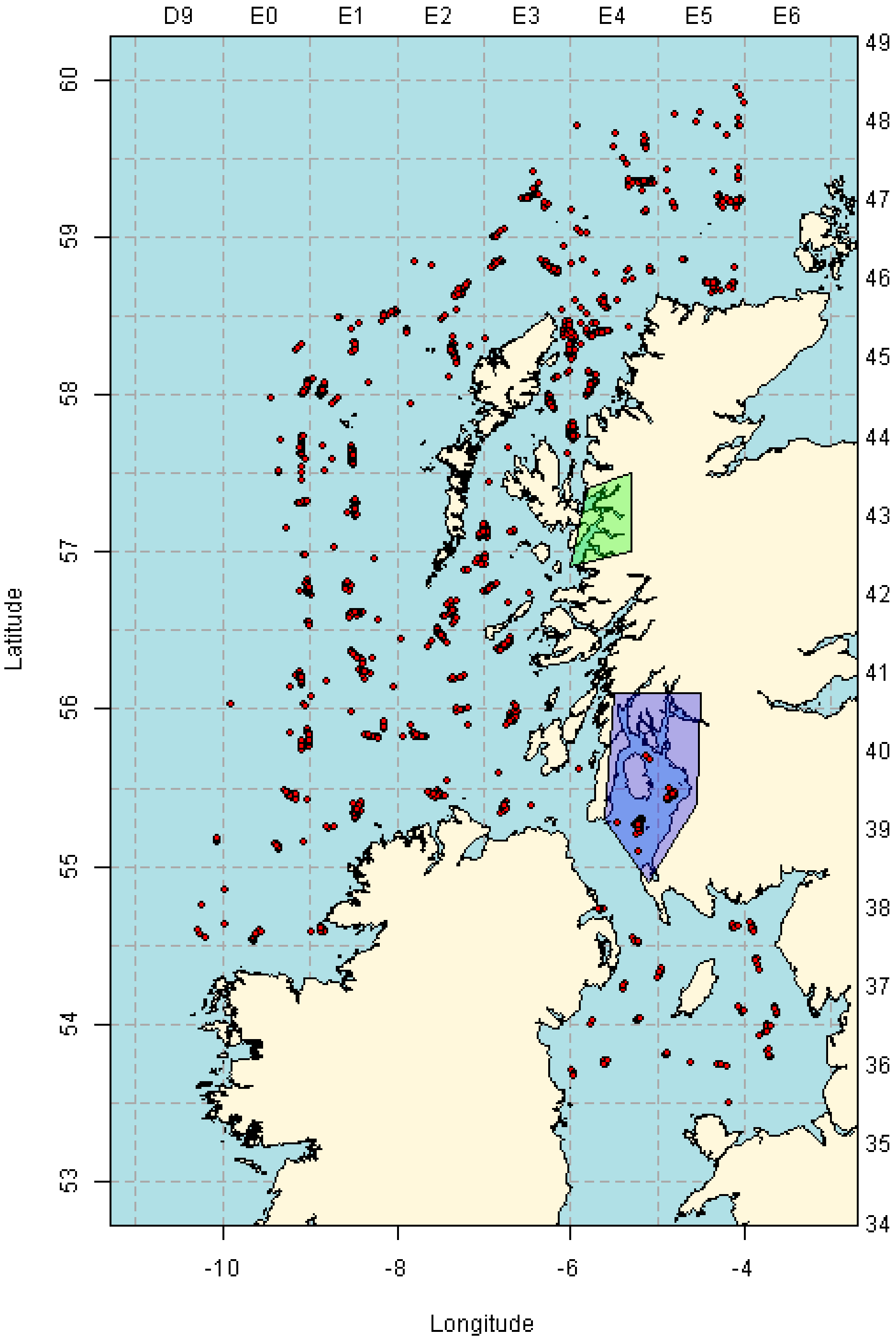

Figure 12.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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).

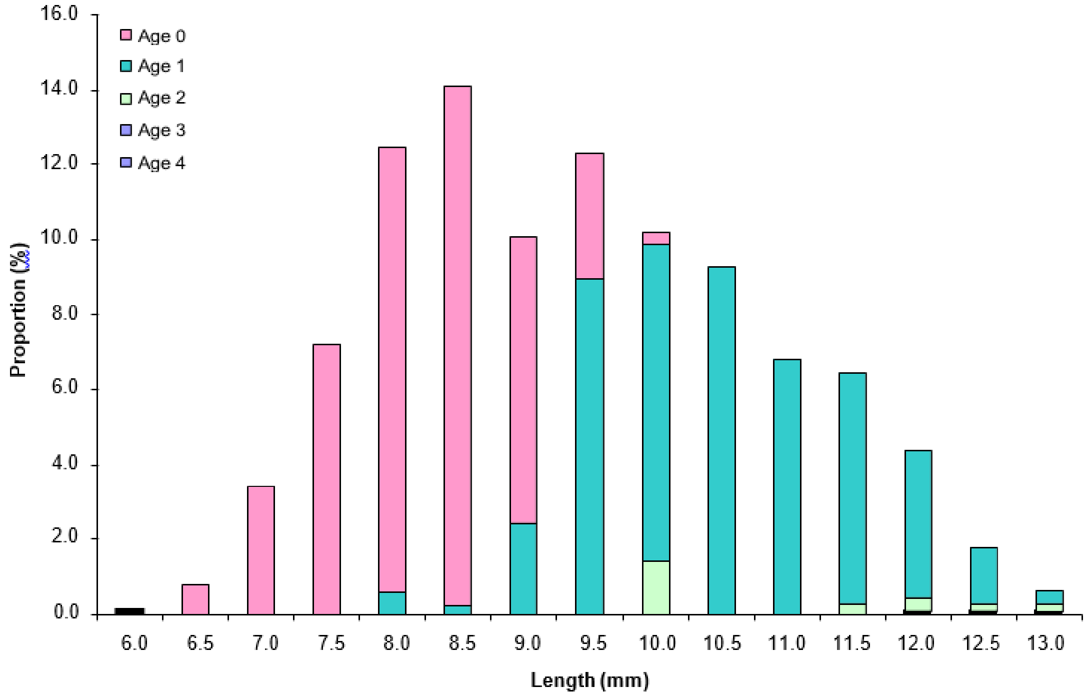

Figure 12.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged (G7144).

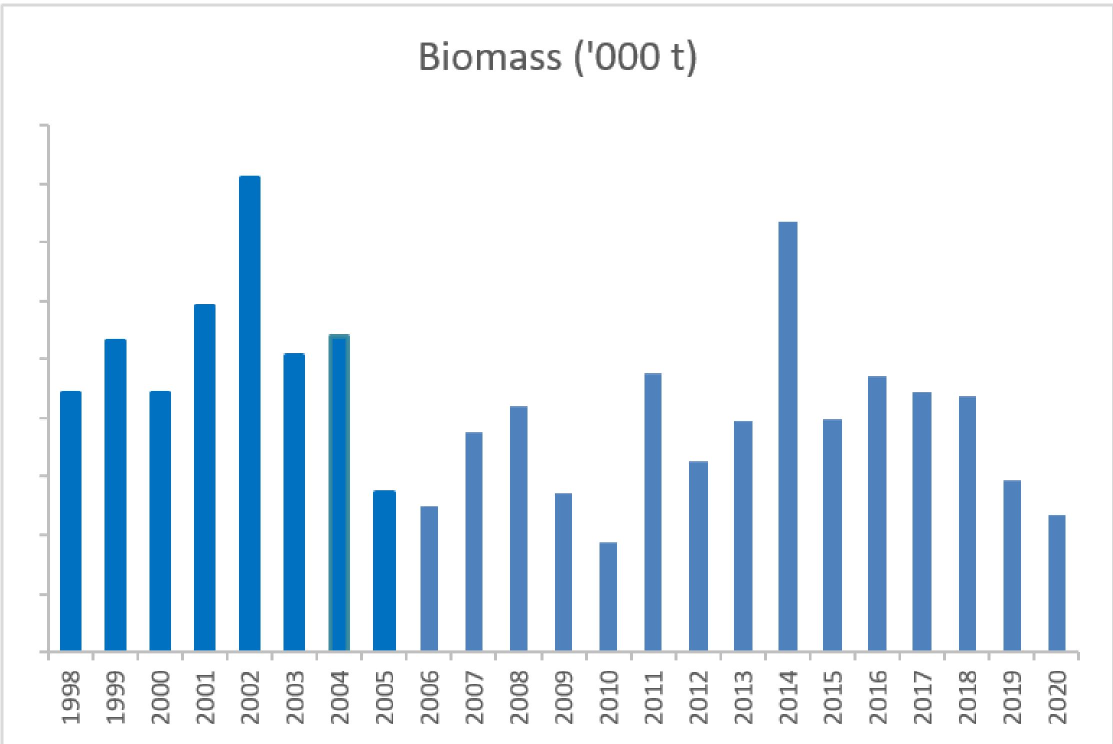

Figure 12.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN from the AFBI Acoustic Survey (A4075)

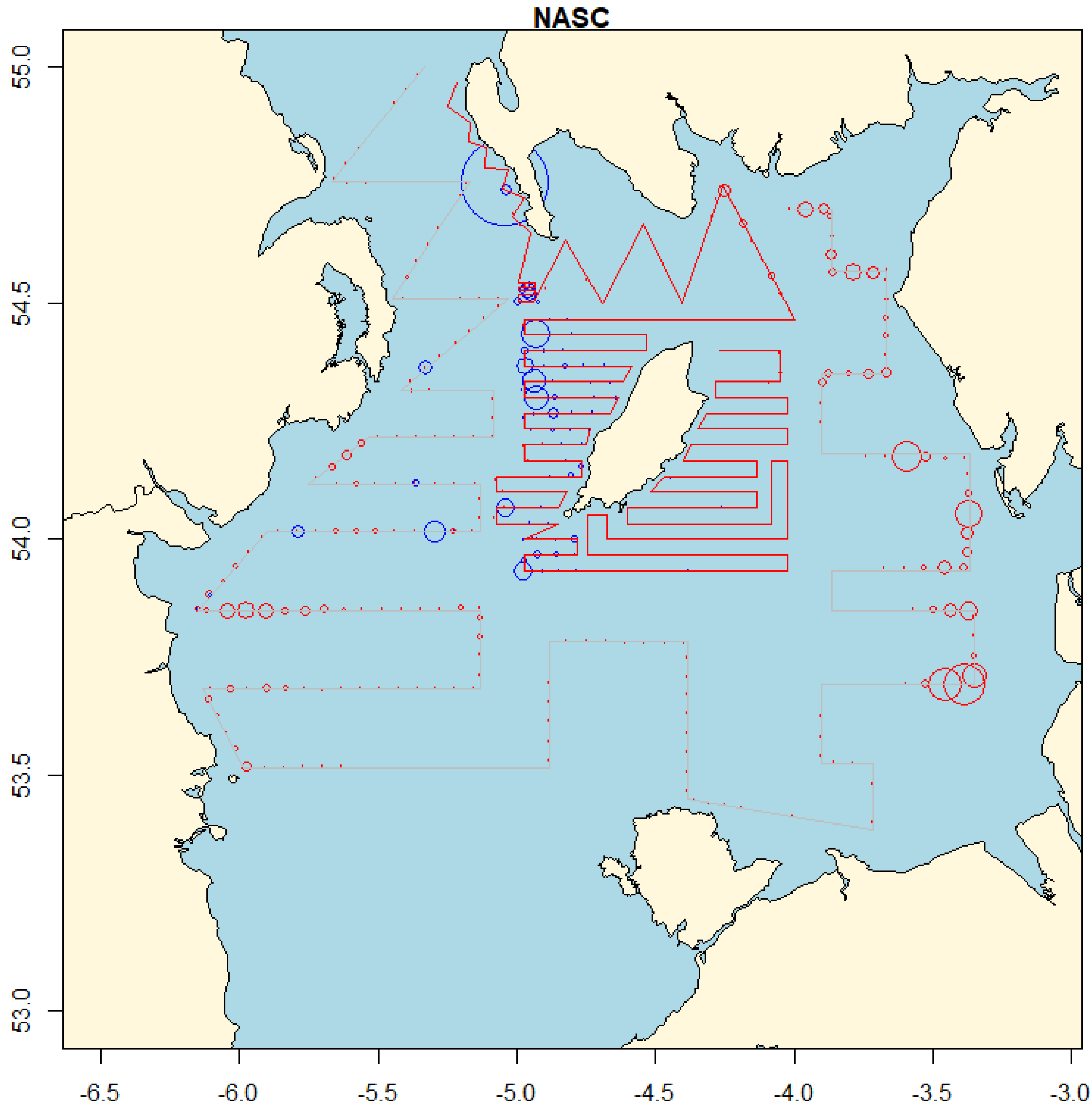

Figure 12.3.5. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2020 acoustic survey on RV "Corystes". (a) Open blue circles are for herring NASC values (maximum value was 18895 and (b) open red circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 2714) from the AFBI acoustic survey (A4705).

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Annex 1: List of participants

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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:

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.

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 Afra Egan, Ireland, and Cecilie Kvamme, Norway will meet:

Online/hybrid meeting 25–27 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 Copenhagen, Denmark (***dates tbc)*** to:

b) compile the catch data of North Sea and Western Baltic herring on (***dates tbc***);

c) address generic ToRs for Regional and Species Working Groups on (***dates tbc)*** 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 11 February (sandeel), (***dates tbc)*** (sprat) and (***dates tbc)*** (herring) 2022 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 2021	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)	2013	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: List of Working Documents

Working documents HAWG 2022	
WD 01	Polte, P and Gröhsler, T. 2021 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey
WD 02	Gröhsler, T. German Herring Fisheries and Stock Assessment data in the Western Baltic in 2021.
WD 03	Régnier, T. and Boulcott, P. Marine Scotland Science sandeel dredge survey indices for SA4
WD 04	Cruise report sandeel survey 2021. Arctic Hunter and M/S Reykjanes
WD 05	Pastoors, M.A. and Quirijns, F.A. PFA Self sampling report for North Sea herring Fisheries, Including sprat and plichard, 2016-2021
WD 06	Berg, F., Trijoulet, V., Moesgaard Albertsen, C., Birch Håkansson, K., Bekkevold, D., Mosegaard, H., Gröhsler, T., Bartolino, V., Kvamme, C., Rohlf, N., Pastoors, M. and Bergès, B. Stock splitting of North Sea autumn spawners (NSAS) and western Baltic spring spawners (WBSS) for their 2022 assessments.
WD 07	Trijoulet, V. et al. Roadmap for WBSS herring benchmark

Annex 5: Audit reports

Audit of her.27.20-24

Review of ICES Scientific Report, (HAWG) *(2022)* (20.05.2022)
Reviewers: Norbert Rohlf, Martin Pastoors

Expert group Chair: Cecilie Kvamme, Afra Egan

Secretariat representative: Sarah 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 and strong decline in fishing mortalilty in recent years

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. Assumptions on age structure in catches taken in the transfer area differ somewhat from preceding years, but conclusions were analyses, presented and explained at HAWG.
6) Stock status: SSB is below Blim. Recruitment continues to be very low.
7) Management plan: There is no agreed management plan for this stock.

General comments
In 2022, 100% of herring quotas can be transferred from 3.a into 4.a., compared to 50% in recent years. This results in important changes of the proportions of WBSS caught in the different fleets, and predicted catches of WBSS highly depend on the area where the catches will be taken.
The stock is caught in different management unit. Recovery will be impaired if catches are not minimized in all units.

Fleet definitions used in the assessment and forecast have been updated to respond to the recent requenst for explanation for several stakeholders. These definitions have also been used for the North Sea herring advice.

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.

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.

☒ 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.

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

Audit of Her.6aS7bc

Working Group: HAWG Stock Name: her.27.6aS7bc

Review of ICES Scientific Report, HAWG 2022

Reviewers: Paul Marchal, Kirsten Birch Håkansson

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Assessment and forecasts up to date with 2022 procedure for Category 3 stocks (constant harvest rate, method 2.2)
- The reasons why MSHAS survey lacks of consistency for a number of age pairs should be further investigated

For single-stock summary sheet advice

Stock : Herring in 6a South and 7b,c

Short description of the assessment as follows:

1) Assessment type: benchmark (carried out in 2022; Category 3 stock)
2) Assessment: accepted
3) Forecast: NA
4) Assessment model: Category 3, Constant harvest rule (CHR, WKLIFE method 2.2), based on a survey-based biomass index (Split Malin Shelf Acoustic Surveyand harvest rates. Advised catches building on the MSHAS biomass index, commercial catch length frequencies and relative von Bertalanffy parameters estimates, a biomass safeguard cap and a life-history-based multiplier. A stability clause bound by -30% and +20% of 1999-2021 catch applies.
5) Consistency: the most reliable survey index (MSHAS) has been used.
6) Stock status: Increasing biomass from low level in 2006, but no recent recruitment indices in recent years. Harvest rate < $F_{proxyMSY}$ and SSB > MSY $B_{trigger}$. No recent recruitment indices. Advised catch increased by 20% compared to 2019-2021 catch average, which is entirely driven by the stability clause in the CHR;
7) Management plan: NA

Conclusions

Assessment performed correctly and according to procedure, except the value for the index trigger value seems a bit of in the advice table 1 and 3. The value is set to 51,340 t, but table 8 (advice) shows that the lowest value is 36,707 t, which should give a value of 51,390 t. Further, it is not clear from the report if this index trigger value will be updated if a lower survey biomass is observed in the future.

The reasons why the MSHAS survey lacks of consistency for a number of age pairs should be further investigated.

Audit of Her.6aN

Review of ICES Scientific Report, (*HAWG*) *(2022*) (*9-12/06/2022*)
Reviewers: Vanessa Trijoulet

Expert group Chair: Cecilie Kvamme and Afra Egan

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: Autumn-spawners herring in Division 6.a North

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update following benchmark in 2022, Category 3
2) Assessment: accepted
3) Forecast: Not relevant
4) 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)
5) Consistency: Method used as agreed at the benchmark
6) 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.
7) Management plan: Not relevant

General comments

The assessment and advice was performed in adequacy with what was decided at the 2022 benchmark. The 2023 advice of 1 212 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 (8 119 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. The advice catch for 2023 is below the monitoring TAC that was used to date.

Technical comments

The following comments were sent to the stock assessors and edited accordingly:
Advice sheet:

Stock development over time: SSB plot the $I_{trigger}$ line is full in the plot but described as dashed in the caption. Catches plot, is the value of 177 t in 2020 missing or it is due to the scale of the plot?

Catch scenarios: Table 1 add "tonnes" after 8 119 (CHR calculation) or eventually remove the unit everywhere and add it to the caption. Second footnote (**) should maybe be Cy+1 = Iy-1 × FMSY proxy × b × m? C because it is not last year advice but 3 year average catch and index of year for I.

Issues relevant for the advice: 4th paragraph "remains"?

History of commercial landings table: should the double asterisk be removed for 2020?

Summary assessment: Table 8, typo in caption: "L_{mean} refers"

References: References identified by Ellie should be removed if not added somewhere in the sheet.

Stock annex: Reference to multifleet SAM model should be replaced by Nielsen et al. 2021 (https:doi.org/10.1093/icesjms/fsab078)

Report: Add value of $I_{trigger}$ in the section 4.6. Some problems with values when comparing tables in report and advice sheet (explained in a excel document to stock assessors). This needs to be checked to see which are correct. Also 2 columns for UK in Table 4.1.6 in report.

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 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.

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 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

Audit of Her.27.irls

Working Group: HAWG Stock Name: her.27.irls

Date: May 2022

Review of ICES Scientific Report, Herring Assessment Working Group (HAWG) 2022, 9-12/05/2022
Reviewers: Neil Campbell

Expert group Chair: Cecilie Kvamme (Norway), Afra Egan (Ireland)

Secretariat representative: Sarah Millar

Stock **Celtic Seas Herring**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Update
2) Assessment: Accepted
3) Forecast: Accepted
4) Assessment model: ASAP – as defined at WKWEST (2015) and WKPELA (2018), tuned by the Celtic Sea herring acoustic survey
5) Consistency: the assessment has developed a strong retrospective pattern on SSB (Mohn's rho = 1.34). Because the stock is below Blim, the assessment is still used to provide advice.
6) Stock status: $B < B_{lim}$ with no catch options in 2023 consistent with rebuilding the stock above this level; F under the monitoring TAC below both F_{pa}; uncertainty on R is high in the most recent year
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 advises 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.

General comments

The spawning-stock biomass (SSB) has decreased significantly in the last decade and has been below B_{lim} since 2016. The fishing mortality (F) was above Fmsy since 2014, and above F_{lim} between 2016 and 2019, but in 2020 F fell below F_{msy} and remained there in 2021. Recruitment has been below average since 2013 and is uncertain. The assessment had a substantial historical retrospective bias in recent years. Applying the ICES MSY approach results in zero catch for 2023, however, in order to continue to monitor the stock development ICES provides a technical service assuming a continued monitoring TAC of 869 tonnes, the same as last year.

The assessment is well presented and carried out in line with the process described in the stock annex.

Technical comments

Table 8 (advice sheet) and Table 6.1.1.2 (report) Totals column do not correspond to sum of catches in country & discard columns, differing by up to 30%.

Conclusions

The assessment has been performed correctly in line with the stock annex, and appropriate procedures followed to provide advice and technical services.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice? **Yes**

Is the assessment according to the stock annex description? **Yes**

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Management plan not used.**

Have the data been used as specified in the stock annex? **Yes**

Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes**

Is there any **major** reason to deviate from the standard procedure for this stock? **No**

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies. **Done**

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables. **Done**

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG. **OK**

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.

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 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

Her27.irls

Review of ICES Scientific Report, (HAWG) *(2022)* (24.05.2022)
Reviewers: Johnathan Ball

Expert group Chair: Cecilie Kvamme, Afra Egan

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.irls

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: ASAP Analytical assessment, using a single acoustic survey ages 2-7 (2002-2021) and catch data (1958-2021)
5) Consistency: The assessment has been accepted last year and this year, but has suffered from retrospective revisions for both SSB and F.
6) Stock status: Biomass remains below $B_{lim,}$ but has seen a slight increase, F at age was above F_{pa} between 2016 and 2019, but in 2020 was brought under F_{msy} and remains there in 2021. Recruitment is up from 2020 but remains low and a downwards revision is

seen in the retrospectives. The uncertainty in recruitment has been attributed to a lack of fisheries independent information.

7) Management plan: The long-term management strategy for the stock was evaluated by ICES in 2018 and the harvest control rule was found to be no longer consistent with the precautionary approach. The current TAC (869t) has been agreed following the special request to ICES and the advisement of a monitoring TAC to allow for continued stock assessment in the face of a zero catch advice.

General comments

Well written

Technical comments

No comments

Conclusions

The assessment has been performed correctly

Audit of Her.27.nirs

Review of ICES Scientific Report, (*expert group/workshop title*) *(year*) (*dates*)

Reviewers: *Campbell Pert and Ed Farrell*

Expert group Chair: *Afra Egan, & Cecile Kvamme*

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: *Herring in Division 7.a North of 52°30'N (Irish 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 (FLSAM; ICES, 2022) that uses catches in the model and in the forecast.*
5) Consistency: *The advice is consistent with last year's assessment although the historic SSB appears to be sensitive to addition of a new year's data resulting in revision during the recent time period.*
6) Stock status: *The assessment is performed on a mixed stock (including juveniles from the Celtic Sea), which affects the estimates of the younger ages. Due to the presence of herring from other stocks, the assessment may overestimate*

the Irish Sea stock. However, fishing pressure on the stock is below FMSY and spawning-stock size is above MSY Btrigger, Bpa, and Blim.

7) Management plan: *There is no agreed management plan for this stock*.

General comments

This has previously been raised but it seems unusual to be calculating F on ages 4-6, when from the data it's clear that the majority of the catches comprise of 2-3wr and therefore this appears to differ from how we deal with other stocks.

A wider issue with this and other adjacent stocks is that trying to forecast the SSB to 2024 given all the uncertainties and also the partial data for 2022 seems like a bit of a stretch and perhaps not very useful for the advice. This is a wider issue than just this stock though it may be worth discussing at the ADG.

The assessment outputs (recruitment, F at age and SSB) seem to have a high level of uncertainty, which has increased annually over the past number of years.

Technical comments

Figure 1 SSB, Table 1, Table 9: The SSB for 2022 in Fig 1 and Table 9 is indicated as 27504t but in Table 1 it is 24716t. The 2022 SSB in the presentation was the same as Table 1. Also applies to Figure 2 SSB.

Table 2. Can you check the percentage SSB change and advice change values in this table.

Table 4. There is only one 2021 reference so you don't need 2021a

Table 8. The UK catch in 2021 doesn't tally with the catch in slide 23 of the presentation. Was there other UK catch (apart from NI) that wasn't sampled?

On the references 'Groot' is cited in the text but it should be 'de Groot'

Conclusions

As an update assessment the assessment appears to have been performed correctly for the purposes of providing updated advice. However given the issues mentioned above in general comments and the pattern on increasing uncertainty it may be time to look at the assessment data and model in more detail.

Audit of san.sa.1r

Reviewers: Espen Johnsen

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

For single-stock summary sheet advice

Stock: san.sa.1r

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Analytical assessment based on SMS 2 season (Jan-Jun and Jul-Dec) model. Age based assuming a relationship between F and fishing effort. 1 fleet and 1 dredge survey,

5) Consistency: Consistent assessment, but with some retrospective pattern in the recruitment and SBB
6) Stock status: spawning-stock size is above below MSY Bescapement and Bpa, but above Blim 1st January 2022. R 2021 is far below average.
7) Management plan: No MP for SA1r

General comments

Technical comments

Audit of san.sa.1r

Review of ICES Scientific Report, HAWG 2022
Reviewers: Claus R. Sparrevohn

Expert group Chair: Cecilie Kvamme

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

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS with dredge survey index and commercial effort
5) Consistency: Accepted. Model is consistent with to last year
6) Stock status: SSB > B_{lim} but fluctuates somewhat between years due to the nature of shortlived species. No fishery reference point is defined for this stock
7) Management plan: No agreed management plan

General comments
Due to a low recruitment index (dredge survey), the combination of the incoming 2021 yearclass and the estimated 2022 SSB is not big enough to support any fishery. Because of that, the group support setting a monitoring TAC on 5000 t combined with a sampling procedure ensuring data for next years assessment.

Technical comments

There is retrospecitive bias in the assessment, especially in the SSB and recruitment,

Conclusions
An assessment appropriate basis for advice.

Audit of san.sa.2r

Review of ICES Scientific Report, HAWG 2022, 3 February
Reviewers: Valerio Bartolino and Christopher Griffiths

Expert group Chair: Cecilie Kvamme and Afra Egan

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 procedures
- The retrospective patterns in both R and SSB are known to be problematic for the stock and the Mohn's rho has deteriorated further compared to the last year's assessment (ρ.SSB from 0.49 to 0.55 and ρ.R from 0.29 to 0.37). When compared to last year's assessment, SSB has been revised downwards for several years back in time. The reasons for this are not clear from the text in the advice sheet but it must be related to the revision in R.
- The dredge survey found high densities of age 0 in 2021 throughout both the northern and southern grounds. This builds confidence in the good 2021 age 0 survey index
- The estimate of survey catchability (especially for age 0) is highly variable among years which is problematic to the assessment of the stock. However, the net effect given by the combination of the catchability parameter and the parameter used in the power model is consistent with last year's assessment.
- The increase in the advice seems in line with the predicted 2021 year class

For single-stock summary sheet advice

Stock: san.sa.2r

Short description of the assessment as follows (examples in grey text):

8) Assessment type: update
9) Assessment: accepted
10) Forecast: accepted
11) Assessment model: analytical assessment based on SMS assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey, two timesteps per year (Jan-Jun and Jul-Dec).
12) Consistency:
    - The assessment has a strong retrospective pattern. The downward revision of recruitment and SSB is not limited to last year estimates and goes several years back in time. Reasons for this are only partially understood by the group
    - There is an important change in the survey catchability especially for age0 (from 0.616 to 0.356) but ultimately not in the net effect

once the density-dependent catchability parameter (DD-parameter) of the power model is taken into account. The DD-parameter is estimated to be 1.32 in the 2022 assessment compared to 1.27 from the 2021 assessment

- An increased variance in catchability for all ages in the fishery suggests some deterioration of model fitting to the catch.
- The survey residuals for age 0 are larger in the years 2015, 2016, 2018, 2019 compared to the last year's assessment (see bubble plot residuals for age 0).

13) Stock status: SSB in 2022 is estimated below Blim but the good year class estimated for 2021 results in relatively high advice. This might not the best situation given the tendency to overestimate recruitment in this assessment. Increases in the DD-parameter should help but uncertainty around this advice remain high. The overall perception is that the stock has had low productivity for >20 years and it continues to stay low despite signals of occasionally good incoming year classes (only informed by the survey). The good incoming year class for 2021 has produced a considerable increase in the advice for 2022. The Fcap drives the advice for 2022.
14) Management plan: No MP for SA2r.

Conclusions

The assessment has been performed correctly and according to procedure. The retrospective pattern is problematic, especially on SSB.

Audit of San.sa.3r

Working Group: HAWG Stock Name: san.sa.3r

Review of ICES Scientific Report, (HAWG) *(2022)* (02.02.2021)

Reviewers: Johnathan Ball

Expert group Chair: Cecilie Kvamme

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.3r

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 (Inter-benchmark in 2020). Sandeel area 3r mainly consists of fishing grounds in Norwegian EEZ.

15) Assessment type: update
16) Assessment: accepted
17) Forecast: accepted
18) Assessment model: SA3r uses a seasonal SMS-effort model, tuned by dredge and acoustic survey index. The recruitment index of the dredge survey includes a density-dependency, to account for overestimation of large incoming year classes. An update to natural mortality's is available but has not been implemented.
19) Consistency: The advice is consistent with last year's assessment.
20) Stock status: SSB has been above B_{pa} since 2015. F is lower than last year, however confidence around F has increased compared to recent pre 2020 values and remains above averages. Recruitment is noted to be lower than average for the stock.
21) Management plan: There is no agreed management plan for this stock.

General comments.
This has probably been discussed but should a note be added to the management plan section of the advice mentioning the existence of a Norwegian management plan. I realise this is not universally agreed, but it does affect the stock. It's a bit jarring to find it buried in the report with no mention in the advice.

Will the new natural moralities be looked at the benchmark?

Advice sheet

- SSB legend and lines are different from last year
- blim and bpa values swapped in legend MSYbescape also appears to be 80,000 not 129,000 as in table 4
- same issue in figure 2
- History of catch (table 8) does not match the table 9 provided during advice meeting.

Report

- Report table 9.4.10 is this model values vs actual values as they do not match advice table 9. I also checked the report table also does not match the sag graph data
  from the sag excel. Is this just because the tables are showing different things? I do note that the report labels table 9.4.10 as report model estimates

Technical comments

Conclusion

The report is well written, however given the discussion around the power model should a detailed explanation of how it functions and is applied be added?

Audit of San.sa.3r

Review of ICES Scientific Report, (HAWG) *(2022)* (03.02.2022)
Reviewers: Norbert Rohlf

Expert group Chair: Cecilie Kvamme, Afra Egan

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.3r

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 (Inter-benchmark in 2020). Sandeel area 3r mainly consists of fishing grounds in Norwegian EEZ.

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Seasonal SMS-effort model, tuned by dredge and acoustic survey index. Density-dependency in the recruitment index of the dredge survey was included to account for overestimation of large incoming year classes. Natural mortalities not updated with latest SMS runs; this would have led to substantial changes of stock's historic perception. HAWG to consider if new reference points should be estimated.
5) Consistency: consistent with last year's assessment. Model was applied as per stock annex. Implementing density dependence on the relationship between recruitment and the dredge survey reduced the retrospective bias in the recruitment and the Mohn's Rho in the current assessment.
6) Stock status: SSB has been above B_{pa} since 2015, combined with low F. Above recruitment in period 2018 to 2020. F is actually increasing and peaked in 2020. Thus, SSB has decreased considerably, but is still well above B_{pa}.
7) Management plan: There is no agreed management plan for this stock. Since 2011, the Norwegian sandeel fishery in SA3r has been managed according to an area-based management plan for the Norwegian EEZ.

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. Most of the fishing grounds are in Norwegian EEZ and managed according to a Norwegian area based management plan. However, this management plan has not been evaluated by ICES.

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 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

Audit of San.sa.4

Review of ICES Scientific Report, HAWG 2022, 4 February
Reviewers: Espen Johnsen

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

Audience to write for: advice drafting group, ACOM, and next year's expert group

General
The is a concern that TAC is given for an area that includes a closed area without any commercial sandeel fishing. The advice does not consider the potential consequences of this spatial distribution of effort, which may lead to a high catches in the open areas.

For single-stock summary sheet advice

Stock: san.sa.4

22) Assessment type: update
23) Assessment: accepted
24) Forecast: accepted
25) Assessment model: Analytical assessment based on SMS 2 season (Jan-Jun and Jul-Dec) model. Age based assuming a relationship between F and fishing effort. 1 fleet and 1 dredge survey,
26) Consistency: The 2022 assessment resulted in a marked reduction and downshift in SBB for the full time series (see attached Figure). The reason for this change is not clear, but it may be related to an increase in the assessment CV of the dredge survey that has destabilize the assessment.
27) Stock status: spawning-stock size is above below MSY Bescapement and Bpa, but above Blim 1st January 2022. R 2021 is below average.
28) Management plan: No MP for SA4, but the area off the east coast of Scotland, from Rattray Head to St Abbs have been closed for industrial fishery for sandeel since 2000.

General comments
The dredge survey covers the closed area off the coast of Scottland, and does not overlap with the open area with commercial catches. Any spatial structure of recruitment and survival may affect the two time series and lead to some extra uncertainty in the assessment.

Technical comments

Conclusions
The assessment has been performed correctly and according to procedure. The retrospective downscaling of the SSB is of concern.

Audit of San.sa.4

Review of ICES Scientific Report, (*expert group/workshop title*) *(year*) (*dates*)
Reviewers: Claus R. Sparrevohn

Expert group Chair: Cecilie Kvamme

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 **SA4**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS with dredge survey index
5) Consistency: Accepted. Model is consistent with to last year
6) Stock status: SSB > B_{lim} but fluctuates somewhat between years due to the nature of shortlived species. No fishery reference point is defined for this stock
7) Management plan: No agreed management plan

General comments
Due to a low recruitment index (dredge survey), the combination of the incoming 2021 yearclass and the estimated 2022 SSB is not big enough to support any fishery. Because of that, the group support setting a monitoring TAC on 5000 t combined with a sampling procedure ensuring data for next years assessment.

Technical comments

There is a pronounced retrospective bias in the assessment, especially in the SSB and recruitment. The 2020 recruitment has been downward revised with 79% and a downward revision is seen for most of the timeseries. This is related to changes in catchability in the dredge survey, which also had a higher CV this year.

Conclusions

An assessment appropriate basis for advice, but there is some issues that should be looked at during he upcoming benchmark.

Audit of Spr.27.7de

Working Group: HAWG Stock Name: spr.27.7.de

Review of ICES Scientific Report, *HAWG 2022, 5th April 2022*

Reviewers: *Eleanor MacLeod, Kristen Birch Hakånsson*

Expert group Chair: *Afra Egan, Cecile Kvamme*

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**: Sprat in the English Channel (spr.27.7de)**

Short description of the assessment as follows (examples in grey text):

8) Assessment type: *update*
9) Assessment: *accepted, based on PELTIC survey biomass trends*
10) Forecast: *NA*
11) Assessment model: *There is no assessment model for this stock*
12) Consistency: *This advice is consistent with last year's assessment, following ICES category 3 rules using an adjusted CHR (8.57%)*
13) Stock status: *No reference points for this stock, but large increase in stock biomass. Drop in harvest rate attributed to large abundances of juvenile sprat mixed into the stock hampering fishing.*
14) Management plan: *There is no agreed management plan for this stock*

General comments

Assessment has been conducted correctly according to the guidelines set out at the last interbenchmark. Both the draft report and the catch advice are clear and well explained.

There are three matters awaiting secretariat support:

1. SAG graphs in the advice sheet have not yet been completed. Updated plots should replace ones currently there.
2. Two references in the advice sheet need to be updated
3. Secretariat support required to decide whether the Istat value gets updated this year or stays at the level set at the interbenchmark. Will need to be updated in the advice sheet and draft report section.

Drop in harvest rate – second year in a row that this has substantially dropped – concerning that in both years there seems to be an extenuating circumstance to explain the drop. Last year the drop at least resulted in a small decrease in advice due to a lower index, now due to the index there is a substantial increase in advice. This is not an issue with the way the assessment has been performed this year, but should be kept in mind going forward.

Technical comments

The assessment appears to be done according to the stock annex.

Conclusions

The assessment seems to have been conducted correctly according to the Stock Annex and the advice was given following the new rules agreed at the 2021 interbenchmark for this category 3 stock

Audit of Spr.27.3a4

Working Group: HAWG Stock Name: spr.27.3a4

Review of ICES Scientific Report, HAWG 2022

Reviewers: Paul Marchal

Expert group Chair: Cecilie Kvamme and Afra Egan

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 procedures
- Retrospective patterns in both R and SSB persist but have reduced to acceptable levels
- Trends in catch and IBTS-Q3 residuals to be investigated
- All catch options lead to an increase in forecast SSB. This may be driven by the GM-estimated 2022 recruitment value used in short-term forecast (120 billion), which is much higher than the 2021 (69 billion) and the 2020 (85 billion) values

For single-stock summary sheet advice

Stock **:** Sprat in 3a and 4

Short description of the assessment as follows (examples in grey text):

15) Assessment type: update (last benchmark in November 2018)
16) Assessment: accepted
17) Forecast: accepted
18) Assessment model: SMS-based analytical model with quarterly time steps, and tuned by three surveys
19) Consistency:
    a. Medium-high CV for catch residuals; small CV for survey residuals;
    b. Negative trend in catch residuals since late 1990s and positive trend in IBTS-Q3 residuals since late 2000s;
    c. Tendency to overestimate R and SSB (although reduced compared to previous assessment);
20) Stock status: B_{lim} < B(2022) < B_{pa} ; 2022 recruitment below average; F(2021)=2.17 well above F_{cap}=0.69 used in the advice
21) Management plan: NA

Conclusions

Assessment performed correctly and according to procedure. The reasons for trends in catch and IBTS-Q3 residuals should be investigated.