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

Please note: Annex 4 was updated in August 2021; Section 2 was added to this report in November 2021

VOLUME 3 | ISSUE 12

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

ICES Scientific Reports

Volume 3 | Issue 12

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

Recommended format for purpose of citation:

ICES. 2021. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 3:12. 917 pp. https://doi.org/10.17895/ices.pub.8214

Editors

Afra Egan • Cecilie Kvamme

Authors

Johnathan Ball • Valerio Bartolino • Florian Berg • Benoit Berges • Kirsten Birch Håkansson • Neil Campbell • Afra Egan • Tomas Gröhsler • Ole Henriksen • Bastian Huwer • Espen Johnsen • Matthias Kloppmann • Cecilie Kvamme • Christophe Loots • Mathieu Lundy • Steve Mackinson • Susan Mærsk Lusseau • Eleanor McLeod • Henrik Mosegaard • Richard Nash • Cormac Nolan • Martin Pastoors • Mark Payne • Campbell Pert • Claus Reedtz • Thomas Regnier • Anna Rindorf • Norbert Rohlf • Vanessa Trijoulet • Cindy van Damme • Mikael van Deurs

ICES CIEM International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

The ICES herring assessment working group (HAWG) met on an interactive virtual platform for nine days in March 2021 to assess the state of five herring stocks and three sprat stocks. HAWG also provided advice for eight sandeel stocks but reported on those, prior to this meeting, in February. The working group conducted update assessments for four of the five herring stocks. The assessment of the North Sea autumn spawning herring was postponed to an interbenchmark 8–10 June 2021 (IBPNSHerring 2021). An analytical assessment was performed for the combined North Sea and Division 3.a sprat, and data limited assessment (ICES category 3 and 5) were conducted for English Channel sprat (spr.27.7de) and sprat in the Celtic Sea (spr.27.67a-cf-k).

The North Sea autumn spawning herring (her.27.3a47d) assessment is postponed to the interbenchmark in June 2021 and advice will follow in September 2021.

The **Western Baltic spring-spawning herring (her.27.20-24)** assessment was updated. The SSB and recruitment in 2020 are at record low levels. SSB is estimated to be around 58 400 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 has decreased in 2018 to 0.19 and is now below F_{MSY} (0.31). 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.

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 at 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 0.023 in 2020, having decreased from the peak of 1.2 in 2018. Recruitment has been consistently below average since 2013.

The assessment of the combined stocks of herring in **6.aN and 6.aS/7.b, c (her.27.6a7bc)** went through an interbenchmark procedure in 2019 and the advice is based on trends from an analytical assessment. SSB has decreased since 2003. SSB in 2020 is estimated to have increased from the 2019 level but remains at a very low level relative to the long term mean. Recruitment has been low with no strong cohorts in recent years. Fishing mortality has reduced since 2016 when catches have been limited to a scientific monitoring TAC but recovery of the stock is hampered by the very low recruitment.

Irish Sea autumn spawning herring (her.27.nirs) assessment shows an increase in SSB in 2020 to 27 500 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 at 0.2 since 2013 and is below F_{MSY} (0.266). Catches increased in 2020 in line with the increased TAC.

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. Despite the fact that fishing mortality in the last years has fluctuated at high levels between 0.6–2.2, recruitments slightly but consistently above the average during recent years have contributed to an increase in SSB well above MSY $B_{escapement}$. The estimates for 2021 show an SSB of 162 000 t which is above 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.

Advice is now provided using a constant harvest rate of 8.57% of the acoustic survey biomass. The new advice basis has led to a 100% increase in catch advice for 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, estimating the amounts of discarded fish, 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	2021
Reporting year in cycle	1/1
Chairs	Afra Egan, Ireland
	Cecilie Kvamme, Norway
Meeting venues and dates	HAWG sandeel: 20–22 January 2021, virtual meeting (9 participants)
	HAWG: 16–24 March 2021, virtual meeting (31 participants)

1 Introduction

1.1 HAWG 2021 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 20th –22nd January 2021 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 16th –24th March 2021 to:

b) compile the catch data of North Sea and Western Baltic herring on 16th–17th March;
c) address generic ToRs for Regional and Species Working Groups 18th –24th March for all other stocks assessed by HAWG.

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

Material and data relevant for the meeting must be available to the group on the dates specified in the 2021 ICES data call. HAWG will report by 12th February (sandeel), 29th March (sprat) and 7th April (herring) 2021 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
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

Stock Name	Stock Coord.	Assesss. Coord.	Assessment Method
Herring in Divisions 6.a and 7.b and 7.c	UK (Scotland) / Ireland	UK (Scotland)	SAM
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

2020/2/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 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex 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 2020.
   iv. Estimate 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/WKF ORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

2) b. 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) 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) 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) 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 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) eReview progress on benchmark issues and processes of relevance to the Expert Group.

i. update the benchmark issues lists for the individual stocks;

ii. review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;

iii. determine the prioritization score for benchmarks proposed for 2022–2023;

iv. as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

f) 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.

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

h) 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.

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 2021 in preparation for the new year of advice and science working group activities. This was the first 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. A separate FRSG meeting was held on the 11th February to discuss the changes to the advice sheets for 2021, the RDBES and any data issues assessment groups may encounter related to the COVID disruption.

A number of presentations were given which were relevant to HAWG. The revamped 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) has been formed to provide 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 principles of reference points and how they are applied in the advice rules were presented. Also the decision by ACOM that the basis for F_{pa} should be $F_{p0.5}$ was communicated across the assessment groups. Work is ongoing on reference points in relation to MSE work. WKGMSE3 developed guidelines for when and how reference points should be extracted when an MSE is conducted. WKRPCHANGE highlighted that there is increasing awareness that reference points will vary with demographic parameters, species interactions and other environmental changes. Density dependence is important and should be included in EQSIM.

The new guide to ICES advice was presented and the ten principles for ICES advice highlighted. The guide explains how these ten principles are applied to recurrent advice, special requests, overviews and viewpoints. The basis and rationale for advice for fishing opportunities and for ecosystem services and impacts are provided in subsections of the guide. The different roles of expert groups in producing the ecosystem overviews was also discussed.

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 18th–22nd January 2021. 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 2021 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2021 pelagic acoustic surveys are available from the WGIPS report (ICES 2021, WGIPS). The following text refers only to the surveys of relevance to HAWG.

North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys (HERAS) in 2020: 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 previous year at 1.7 million tonnes (2019: 1.9 million tonnes) due to a decrease in the number of fish (2019: 10 295 million fish, 2020: 8 915 million fish).

The 2020 estimate of **Western Baltic Spring Spawning herring** 3+ group is 103 000 tonnes and 667 million. This is an increase of 39% and 16%, respectively, compared to the 2019 estimates of 74 000 tonnes and 574 million fish.

The **West of Scotland herring** estimate (6.a.N) of SSB is 158 000 tonnes and 943 million individuals, a large increase compared to the 76 000 tonnes and 406 million herring estimate in 2019.

The 2020 SSB estimate for **the Malin Shelf area (6.a and 7.b, c combined)** is 226 000 tonnes and 1 435 million individuals. This is higher than the 2019 estimates (128 000 tonnes and 740 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 2020, which is similar to 2019. There were significant numbers of herring distributed south of 56°N again in 2020, dominated by 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 2020 was estimated at 67 055 million individuals and the biomass at 531 000 tonnes. This is a decrease from last year, but slightly above the long-term average of the time series, in terms of both abundance and biomass. The stock is dominated by 1- and 2-year-old sprat (92% in biomass). The estimate includes 0-group sprat (19% in numbers, and 2% in biomass), which only occasionally is observed in the HERAS survey.

For **Div. 3.a,** the sprat abundance in 2020 is estimated at 4 282 million individuals and the biomass at 39 900 tonnes. This is the second highest estimate of the time series in terms of biomass, and well above the long-term average both in terms of abundance (107%) and biomass (52%). The stock is dominated by 1-year-old sprat.

Irish Sea Acoustic Survey: The herring abundance for the Irish Sea and North Channel (7.a.N) during 25th August–11th September 2020 was reported by Northern Ireland. The herring stock estimate in the Irish Sea/North Channel area was estimated to be 101,253t. 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 Mull of Galloway on the Scottish coast with scattered lower abundance observed throughout the Irish Sea. The estimate of herring SSB of 40,076t is within the observed range for the time series and the biomass estimate of 59,645t for 1+ ringers for 2020 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 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 a SSB index. The major contribution of ages to the total estimates is from ages 1 fish by number and 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 47,933t for the 2020 acoustic survey is an increase from 44,184 t in 2019. 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 2020 was reported by the Marine Institute, Ireland. Geographical coverage was lower than in 2019 and can be accounted for by the lack of herring in offshore waters. The core distribution areas were however comprehensively covered and the stock was considered contained within the Celtic Sea survey area. Herring were observed exclusively within coastal waters (10 nmi) and were composed of mixed age classes.

The 2020 total standing stock estimate is 4,717 t and 67,368,000 individuals (CV 0.51) is an increase on the 2019 estimate (2,245 t and a total abundance of 106,900,000 individuals). The standing stock biomass however still remains in a low state. The stock is dominated by 2-wr fish representing over 57% of the total biomass and 48% of total abundance. This cohort is now considered recruited to the spawning stock.

The low abundance of sprat observed is the lowest in the recent time series but is considered a year effect of the survey rather than a change in stock state. The nearshore distribution of sprat likely led to the stock not being fully contained within the survey area.

Pelagic ecosystem survey in Western Channel and eastern Celtic Sea (PELTIC): This survey was conducted by Cefas, UK, in the Western Channel and eastern Celtic Sea in October 2020. For the fourth year, the survey was extended beyond the area covered between 2012 and 2016. The 2020 survey coverage included the French waters of western English Channel and for the first time Cardigan Bay in the southern Irish Sea. The pelagic fish objectives of the survey were successfully completed. In total 2019 nautical miles of acoustic sampling units were collected and supplemented with 36 valid trawls. Sprat were very localised in Lyme Bay and sizes were smaller than in previous years. 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 33,798 t which was slightly lower than the 2019 estimate of 36,789t.

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 2020 also in SD 21. The GERAS-index is routinely adjusted to account for the mixing of the two stocks. The adjustment is based on growth parameters.

The 2020 GERAS-index was estimated to be 1.4 x 10^9 fish or about 37.0 x 10^3 tonnes in subdivisions 21–24. The biomass index in 2020 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-November 2020) reviewed the following activities falling within its remit and of interest for HAWG:

- One workshop was planned during the previous year for herring (*Clupea harengus*) and sprat (*Sprattus sprattus)* stocks assessed by HAWG. There was no workshop or exchange planned for Sandeel (*Ammodytes*).
- A workshop on the identification of clupeid larvae (WKIDCLUP2) was scheduled on 31 August – 4 September 2020 to be held in Bremerhaven, Germany. Due to COVID-19 measures this workshop could not take place. Instead an online short workshop was held as a starter 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. The full workshop is postponed to 30th August – 3rd September 2021.

Other clupeid stocks

- An otolith exchange was held for sprat in the Baltic Sea. Results were not available for the WGBIOP 2020 meeting.

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 NSH 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 2020 was focused 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 and started up the process of creating practical, updated and accessible guidelines for sampling. In respect to the small-scale fisheries, WGCATCH 2020 updated and refined the risk assessment for transversal data quality methodology and started 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. This year, a new key run of the North Sea SMS model is available (ICES 2021, WGSAM) with updated estimates of predation mortalities (available by age and quarter for the period 1974-2019 as direct output of SMS) for the stocks mentioned above. 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 and 2019. 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 survey is planned to continue in April 2021.

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 are planned for 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. Currently 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) are routinely quantified and accounted for in the assessments. 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. During HAWG 2019 a mini symposium was arranged to facilitate exchange of ideas and foster collaboration of researchers working on different aspects and methods. 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 6a/7b,c Herring

Atlantic herring west of Scotland and northwest of Ireland comprise at least two reproductively isolated biological populations. The 6aN herring spawn off Cape Wrath in northwest Scotland in Autumn (September/October) and the 6aS/7bc herring spawn off Donegal in northwest Ireland in winter (November to January). 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 provides combined advice for the two areas and stocks, and has recommended a zero TAC for the last six years. Scientific samples are obtained during the scientific monitoring fisheries in 6aS/7bc and industry surveys in 6aN.

The EASME herring project

In December 2020 University College Dublin (UCD), the Marine Institute (MI) and Marine Scotland Science (MSS) completed the European Commission's Executive Agency for Small and Medium-sized Enterprises (EASME) funded, 36-month, project 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 built on industry and Institute funded studies on the same subject which were initiated in UCD in 2015 and ran until commencement of the EASME project in December 2017.

The primary objective of this study was to assess the identity of herring stocks in ICES Divisions 6a, 7b and 7c, through genetic analysis, in order to develop genetic profiles of the northern (ICES Division 6a North) and southern (ICES Divisions 6a South, 7b and 7c) stocks, which could be used to discriminate the two stocks during times of mixing, such as, in the summer acoustic surveys. In addition, body and otolith morphometric methods were developed to test if the variation in body and otolith shape could also be used to discriminate the stocks in these areas. The study comprised an extensive review of the history of the existing stock delineations, comprehensive sampling for both the genetic and morphometric components of the project, 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.

Genetic analyses

Genetic baseline spawning samples were collected over five spawning seasons (2014-2019) and archive samples from the WESTHER project (2003-2004) were also reanalysed. In total c.4,900 individuals from Divisions 6.a, 7.b and 7.c, 1,860 individuals from outgroup populations, 650 individuals from the WESTHER samples and 3,665 individuals from the MSHAS (2014-2019) samples were analysed as part of the genetic analysis tasks.

The genetic analyses indicated that herring in ICES Division 6a comprise at least three distinct populations; 6aS herring, 6aN autumn spawning herring and 6aN spring spawning herring. The 6aS 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 6aS herring. No baseline spawning samples could be collected in Divisions 7b or 7c therefore the relationship between the herring that spawn in this area and those that spawn in 6aS is unknown. Non-spawning herring caught in Division 7b assigned genetically to the 6aS population. Samples of herring from Lough Foyle were shown to be genetically and biologically 6aS herring, though they are currently defined as 6aN autumn spawning herring according to the ICES stock delineation.

Across the six years of MSHAS samples that were genetically assigned (2014-2019), there was a consistent pattern of a higher proportion of 6aS herring in the samples than 6aN autumn spawning herring. The 6aS 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 6aS fish were observed in the hauls closest to the Irish coast. The highest proportions of 6aN autumn spawning fish were observed in the most northerly hauls adjacent to the 4°W stock delineator. Generally, the proportion of 6aN autumn spawning herring in the hauls was less than 20%. Potential 6aN spring spawning herring comprised a significant proportion of the MSHAS hauls west of the Hebrides in the 2014-2019 MSHAS samples.

There is no historical or contemporary evidence to support the differentiation of 6aN autumn spawning herring and North Sea autumn spawning herring. The term 'west of Scotland herring' originally referred to populations of spring spawning herring that spawned in the Minch area. It now refers to autumn spawning herring that occur west of the 4°W boundary during the period of the MSHAS. The Celtic Sea herring and Irish Sea herring are distinct from each other and from the populations in ICES Divisions 6a 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. Historical evidence does suggest that they may be found in the Clyde area at this time before returning to spawn in the Irish Sea in autumn.

Morphometric analyses

Morphometric (body and otolith shape) data from spawning samples of 6aN autumn spawning herring and 6aS winter spawning herring were collected to develop a morphometric baseline profile of the spawning stocks. This baseline was then used to determine the stock composition of mixed samples collected during the MSHAS. The baseline data consisted of morphometric measurements taken from 1429 spawning herring, collected between 2014 and 2019. In 2020, the model chosen to differentiate between the 6aN and 6aS stocks was finalised and trained using the baseline data. The model demonstrated a significant difference between the two stocks and resulted in classification rates of >75%. The 6aS stock showed a higher misclassification rate than 6aN, which may be attributed to the possible presence of a later spawning cohort that was detected by the genetic analysis. Three samples of known origin were input blindly to the model to see how well they could be assigned back to their stock of origin. Two of the samples that were tested resulted in the majority of individuals assigning back to the correct stock of origin (<70%). This does create uncertainty around the assignments, with ~30% of the individuals being misassigned. Most of the individuals from the third sample were assigned back to the wrong stock and demonstrated a possible inter-annual variability issue. Although the self-assignments looked promising initially, a significant amount of uncertainty in the assignments was observed when the model was tested with 'known-unknown' samples.

During the MSHAS, morphometric data was collected from herring of unknown stock of origin between 2010 and 2019. Over 10,000 mixed herring were sampled during this 10-year period and processed for input to the model. The classification model was initially tested using the 2015 MSHAS samples. They were collected over a wide distribution throughout ICES Division 6a, including samples south of the 56° line of latitude. The assumption would be that the more northern hauls will contain a larger proportion of 6aN herring and the southern hauls, closer to Ireland, would contain more 6aS herring. These samples of unknown origin were input to the model which provides a predicted stock of origin for each individual herring. The results of the MSHAS sample assignments were inconclusive because the majority of herring were classified as unknown. The herring that were assigned to a stock, did not conform with what would be expected biologically. The results were then compared with the results from the genetic assignments and there was very little agreement between the two stock discriminations methods at an individual herring level.

One of the main conclusions of the EASME project was that morphometrics is not suitable to discriminate between mixed herring along the Malin Shelf. Although the use of body and otolith shape showed potential in discriminating between 6aN and 6aS 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 presented in the final EASME report (Farrell et al, 2020) constitute a tool that can be used for the assignment of herring caught in mixed survey and commercial catches in Division 6a into their population of origin with a high level of accuracy (>90%). This approach should be used for regular monitoring of MSHAS and commercial catches of herring in this area.

2021 6.a herring genetic analyses

Prior to the commencement of the benchmark process, it is possible to undertake additional analyses in order to fill any potential data gaps identified during the EASME project. It was agreed to undertake the following additional analyses in preparation for the benchmark.

Resolve the maturity staging issue.

A potential maturity staging issue concerning some of the 6aN autumn spawning baseline samples was discussed in detail in Section 4.9 of the EASME report (Farrell et al., 2020). In brief, the samples concerned were collected in 2018 and 2019 by PFA vessels, were processed by WUR and were considered to be stage 3 spawning fish (6-point scale). Genetic analyses indicated that a significant proportion of the samples assigned to the 6aS/6aN_Sp baseline. Additional samples collected by SPFA vessels in the same area at the same time and processed by MSS with the 9-point maturity scale indicated a wide range of maturity stages present in the same area at the same time as the genetically analysed samples. This indicates a potentially large degree of mixing of autumn and later spawning populations close to the 6aN spawning area during the autumn spawning period. Genetic analysis of the MSS samples will help to determine if there was a maturity staging issue with the IMARES samples and if this is the case then it will provide justification for removing them from the baseline dataset and will thus increase the resolution of the assignment model. This is considered to be an important issue to resolve prior to the benchmark.

Additional samples to analyse

1. MSHAS 2020 samples
2. The 2020 industry survey and fishery samples
3. 6aS Q1 monitoring fishery and additional 6aN_Sp samples
4. MSHAS 2021

Further information on the results presented here are available in the final EASME project report (Farrell et al., 2020) or from Edward Farrell (edward.d.farrell@gmail.com) and Emma White (emma.white@marine.ie).

Updates on tools to split herring populations

Discrimination and splitting of mixed stocks are essential to stock assessment and advice. Herring stocks assessed by HAWG are mainly separated based on a priori assumptions that fish stocks rigidly follow artificial geographical boundaries. Currently, splitting methods are only applied for the separation of North Sea autumn spawning herring (NSASH, her.27.3a47d) and western Baltic spring spawning herring (WBSSH, her.27.20-24). Splitting is limited to Danish, Swedish and Norwegian samples from commercial catches and scientific surveys in Skagerrak-Kattegat and the north-eastern North Sea. Further, applied splitting methods are not consistent between labs and countries.

Otolith shape analysis is one of the splitting methods used to separate NSASH and WBSSH. In recent years, the use of otolith shape analysis to discriminate fish stocks has increased rapidly. Open-access packages like shapeR (Libungan and Pálsson, 2015) allow scientists to easily extract otolith outlines for further analysis. Otolith shape analysis of Atlantic herring reveals clear differences between populations in the north-eastern Atlantic (Libungan *et al*., 2015). Further, there is a clear genetic effect on herring otolith shape (Berg *et al*., 2018). Smoliński et al. (2020) have compared the assignment performance of different statistical classifiers, including traditional and machine learning classifiers. Their study provides a solid reference guideline for otolith shape analysis.

In previous years, results of preliminary otolith shape analysis and other splitting methods have been reported in HAWG reports (ICES, 2019, 2020). The results of Berg et al. (2019) are shortly summarized again, since they have been reused for updated studies using genetics. A baseline of spawning individuals from three herring stocks (NSASH, WBSSH, and Norwegian spring spawning herring = NSSH) was established. The otolith shape of herring was transformed into 64 wavelet coefficients for further testing. Cross-validation was performed following the guidelines of Smoliński et al. (2020). In general, the overall assignment accuracy was relatively high (>80%), indicating that our baseline is suitable for assignment of individuals from unknown catches. The aim was to assign unknown herring from mixed catches to their original stock. Herring samples of unknown origin were collected during several scientific surveys in the North Sea and adjacent areas (Figure 1.2.7.1), and otoliths as well as genetics were sampled for further analysis. Several classifiers were applied to assign unknown otoliths and the results were compared. Otoliths were not assigned if the difference in assignment probability between the two most likely stocks was <20%. The results demonstrated that otolith shape analysis can, combined with machine learning techniques, be used to assign individuals of unknown origin to one of these three stocks (~82.5% assigned, ~17.5% not assigned).

A recent study (Berg et al. 2020) combined different discrimination methods to assign autumn and spring spawning herring. The results suggest gene flow between autumn and spring spawning herring and are thus highly relevant to the HAWG assessments. In addition to the traditional splitting method using otolith microstructure, newly developed genetic markers as well as their maturity development were used to discriminate autumn and spring spawning herring. Herring were only sampled during the spawning seasons in spring and autumn. Most herring (~77%) had an otolith microstructure and genetic assignment coinciding with the phenotypically assigned spawning season (based on maturity stages). Non-spawning herring (<5%) classified as belonging to the current spawning season using genotyping and otolith-typing were assigned as skipped spawners. For ~8% of spawning herring, the genetic and otolith assignment contradicted the phenotypically assigned spawning season, characteristic of straying individuals. Otolith-typing contradicted the genetic and phenotypical assignment in ~7% of the cases, potentially representing individuals reuniting back to the spawning season favored by their genotype. The disagreement of ~23% could have potential influence on splitting of herring solely based on otolith microstructure, as applied in the assessment of NSAS and WBSS.

In the most recent study, Berg et al. (2021) applied both genetic and otolith shape analysis on the same individuals. The objective was to apply a new diagnostic panel of SNPs to assign individual herring from trawl samples in the HERAS survey to their stock(s) of origin. The SNP panel was established based on Han et al. (2020). 950 individuals from the Norwegian part of the HERAS survey were genotyped. In total, 809 (85%) individuals were successfully assigned to their stock of origin. It was demonstrated that the stock's spatial distribution and phenotypic characteristics agreed with expectations. However, some individuals were assigned as NSSH in the survey area. This will have a bias on the survey estimates because NSSH are usually bigger than other herring. The benefit of using genetic methods to identify stock components in the study region, in comparison with traditionally implemented phenotyping methods, was demonstrated. A disadvantage for all methods, is that fish from stocks not included in the baseline, that appear in mixed catches, cannot be properly assigned.

All in all, discrimination methods used for assignment of unknown individuals need to be further developed and adjusted. Preliminary analyses comparing genetic and otolith shape assignments showed relatively low overall agreement (71%, excluding not assigned individuals). The results further indicate that the geographical boundaries, not only for stocks, but also for the so-called "transfer area" (Figure 1.7.1), should be discussed. Boundary adjustments and including more stocks for the assignment and splitting might improve the assessment and advice of herring stocks in the greater North Sea ecoregion. Further information on this work is available from florian.berg@hi.no.

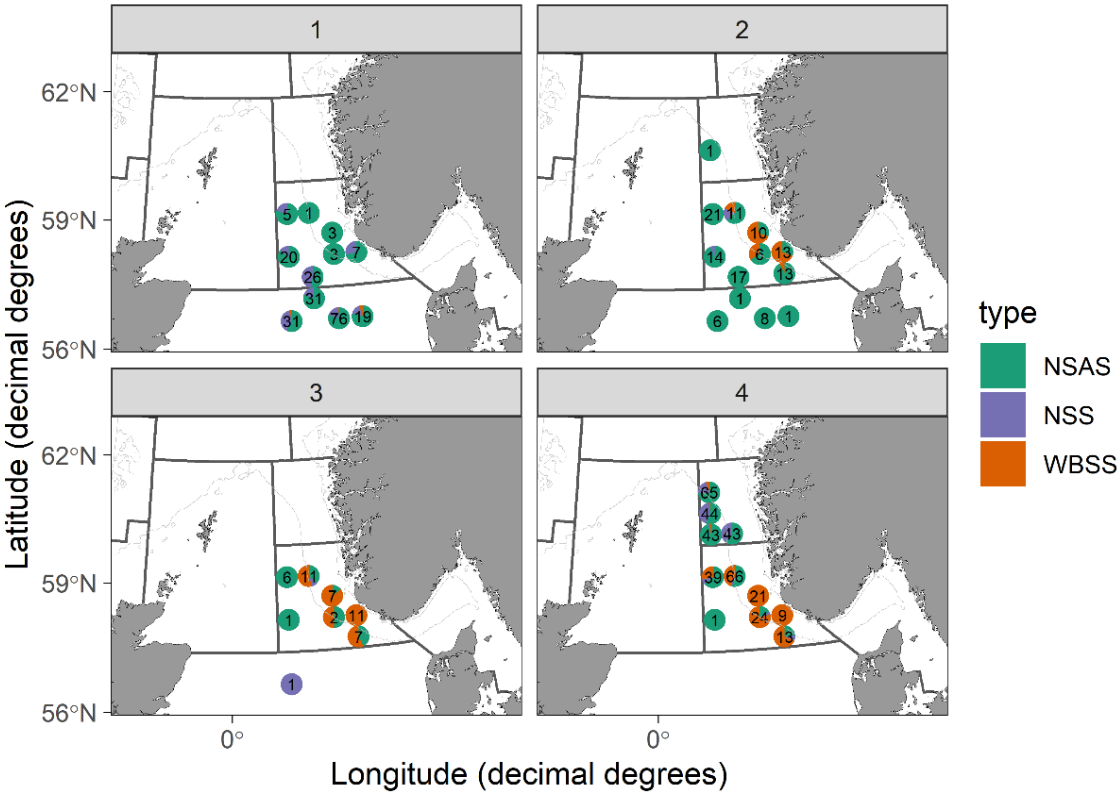


Figure 1.2.7.1: Genetic assignment of individual herring to their original stock. Norwegian part of HERAS 2020 separated by age 1-3 and 4+ winter ringer. Numbers indicate the numbers of analyzed herring.

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).

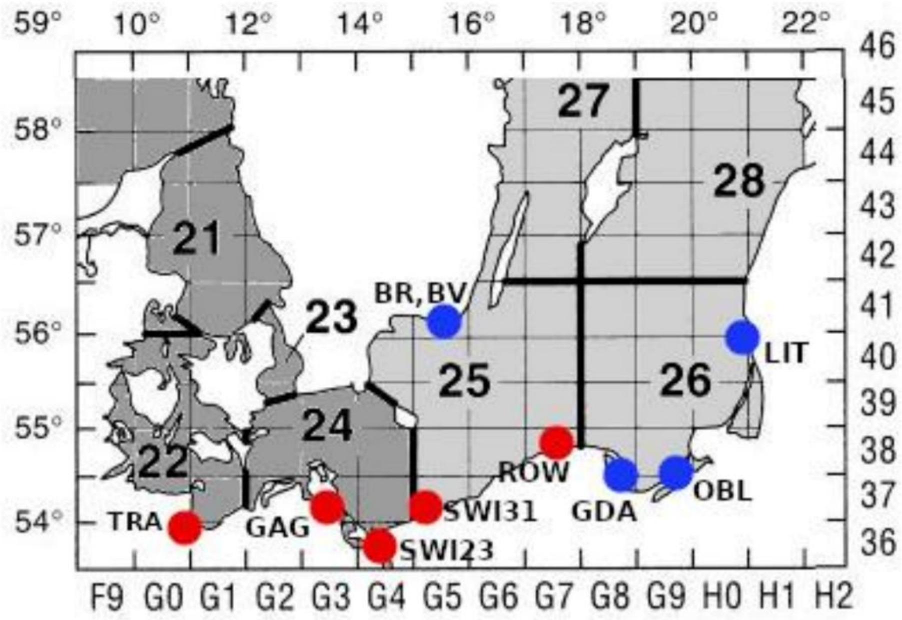


Figure 1.2.7.2. Map with sampling locations of spawning herring during spring 2019-2020. Colors correspond to the two clusters identifies in the Canonical Analysis of Principal Coordinates (See Figure 1.2.7.3).

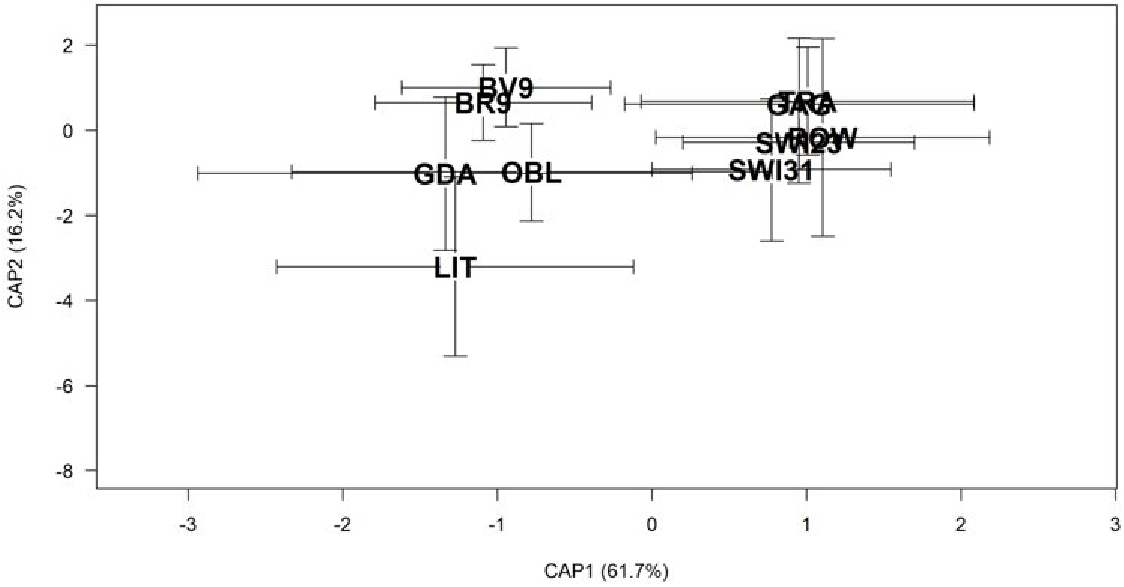


Figure 1.2.7.3. Plot of the first and second Principal Components from the analysis of standardized Wavelet coefficients. The black labels show the centroid for each spawning location. TRA: Bay of Lübeck (GER), GAG: Bay of Greifswald (GER), SWI23: Pomeranian Bay (POL), SWI31: Kolobrzeg (POL), ROW: Rowy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

1.3.7 WKFORBIAS

The workshop on catch forecasts from biased assessments, WKFORBIAS, met on 11-15 November 2019 to address and develop general guidelines for dealing with the issue of retrospective patterns in stock assessments. WKFORBIAS reaffirmed previous recommendations that retrospective analysis should always be conducted as a diagnostic to examine the internal consistency of analytical stock assessments. Across the wide range of ICES stocks examined, no obvious explanatory variables, such as model type, location, fishery type, or biological trait, separate stocks with and without strong retrospective patterns. A decision tree was developed to help expert groups to determine the severity of retrospective patterns and a course of action.

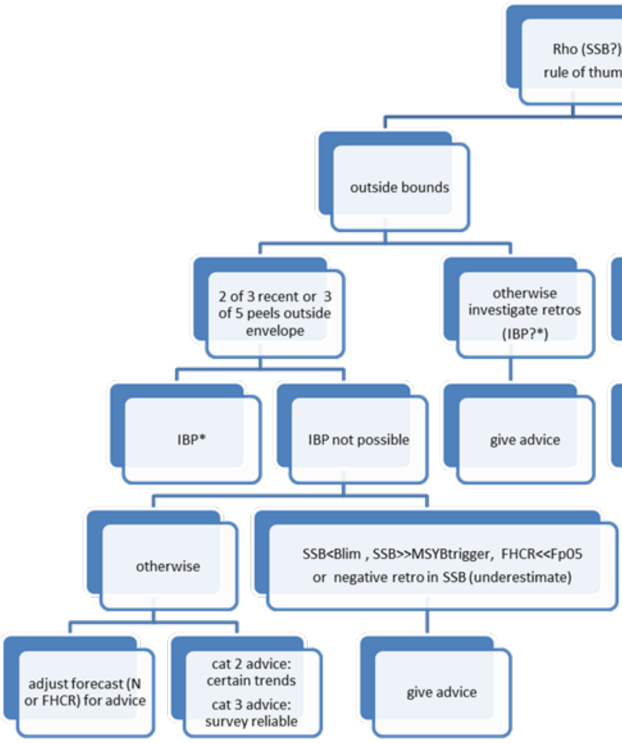


Figure 1.2.8.1: Decision tree for handling assessments with retrospective patterns produced by WKFORBIAS.

General recommendations from WKFORBIAS include:

- when evaluating a retrospective pattern, the consistency of the pattern is of primary importance;
- a large Mohn's rho statistic driven by one outlier should not be treated in the same manner as a consistent directional retrospective pattern;
- retrospective patterns should be viewed as one of many diagnostics to be used in determining whether to use an assessment for management advice or not;
- Management Strategy Evaluation can potentially be a useful tool for examining the robustness of harvest control rules to different magnitudes of retrospective pattern

Two presentations directly linked to HAWG were presented at WKFORBIAS and contributed to the workshop:

- Retrospective Bias in Some Short-lived North Sea Stocks (Van Deurs M.)
- Successes and Failures in the Daily Fight to Stock Assessment biases: Experience from an ICES assessment Working Group (Bartolino V.)

1.3.8 WKDLSSLS

The Workshop on Data Limited Stocks of Short-Lived Species 2 (WKDLSSLS2) built on the work of the previous workshop in 2019 (WKDLSSLS) to further develop methods for stock assessment and catch advice for category 3–4 short-lived species. Work was also carried out to evaluate the management procedures currently in use and their appropriateness for short- lived species by means of Long-Term Management Strategy Evaluations (LT-MSE). A number of stocks were examined including Sprat in 7d, e. WKDLSSLS 2020 tested seasonal Surplus Production in Continuous Time (SPiCT) models and variations and refined the application of harvest rates and tend based assessments, including the 1o2 rule with 80% uncertainty cap (UC). SPiCT was found to have comparable estimates compared to data rich models (specifically tested against Gadget model output) and emerged as the preferential choices for data limited stocks. The working group also noted that seasonal fishing mortality was a key factor when modelling such species and assessments should aim for bellow MSY as a precaution. MSE testing of HCR and trend-based rules, conditioned on 7d, e sprat, confirmed a constant harvest rate is more precautionary than a trend-based rule. The 1o2 with a 20% UC was determined to be not precautionary and may result in stock collapse while accepting it is an improvement on the 2o3 rule, the 1o2 rule with 80% UC in combination with a biomass safeguard is preferred. Although the working group notes this is a provisional rule and may lead to decreasing catches and may not be precautionary for depleted stocks. The work of WKDLSSLS is not considered finished and will look into optimizing the application of harvest control rules including the CHR and 1o2 rule. Refinement to the current guidelines may be expected in 2021.

1.3.9 IBSPRAT

An Interbenchmark for 7.de Sprat was carried out in February 2021 to revise the advice framework based on the most recent changes to data limited short lived species assessments. The advice was previously based on a 2 over 3 rule following the ICES framework for data limited category 3 stocks. This was deemed to be unsuitable for short lived species by WKDLSSLS1 and 2 (ICES 2019b, ICES 2020). A 1 over 2 rule was implemented at HAWG 2020, along with a request for an interbenchmark (IBP) in 2021.

The inter-benchmark was tasked with clarifying the application of the latest advice for category 3 short-lived species following the conclusion of WKDLSSLS 2020 (working group for data-limited stocks of short-lived species) to the Sprat 27.7de stock.

a) a) Review the conclusions of WKDLSSLS for implementation in ICES advice for short-lived category 3 stocks.

b) b) Review and calculate the options for providing advice, using the conclusions from WKDLSSLS 2020 for sprat 27.7de.

Three advice approaches for short lived data limited species were explored, namely Surplus Production in Continuous Time (SPiCT), Management Strategy Evaluation (MSE) determined constant harvest rate (CHR) and a 1o2 rule with an 80% uncertainty cap (UC). The IBP determined that SPiCT was not currently viable for the stock and that a CHR as determined by management strategy evaluation was the most appropriate assessment and advice framework. The 1o2 rule with an 80%UC was also examined, but it has been determined by both WKDLSSLS 1&2 that a properly determined CHR is more precautionary. The 1o2 rule with an 80% UC is a default option when no other approach can be applied. The final harvest rate was determined to be 12 %, which was then adjusted down to 8.57% to account for a timing differential between the MSE and the actual survey. The CHR is directly applied to the last year of survey biomass from the PELITC. The IBP considered the proposed CHR to be heavily precautionary. Full details and justification for the MSE parameters can be found in the IBP report (ICES 2021, IBPSprat) along with a detailed explanation of the correction factor.

1.3.10 Other activities relevant to HAWG

Industry-Science survey of herring in 6.a, 7b–c. in 2020

(see Section 05 for additional details).

In 2020, industry and scientific institutions from Scotland, Netherlands and Ireland successfully carried out scientific surveys with the aim to improve the knowledge base for the herring spawning components 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.

Following agreement on a monitoring fishery TAC of 4 840 t (3480 t in 6aN and 1360 t in 6aS/7bc) the scientific survey was designed using ICES advice on sampling required to collect assessment-relevant data, a review of spawning areas and timing and discussions with fishing skippers following the experiences from the 2016-2019 surveys.

The survey provides a fifth data point in a new survey series, the details of and utility of which will be explored during the benchmark in 2022. Genetic data from spawning fish will continue to contribute to the new baseline data required to assess separately the stocks in 6.aN and 6.aS, 7.b–c, during the 2022 benchmark.

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 which is carried on in the North Sea (Figure 1.2.14.2). 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% and 0.6%, 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 this confirmed also in 2019 and 2020. The level of infection is lower in 2020 than in 2019 and shifted more towards younger ages. After an unusual complete lack of infection in the Swedish commercial samples from 2019, the 2020 commercial samples confirm very low infection levels (<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.

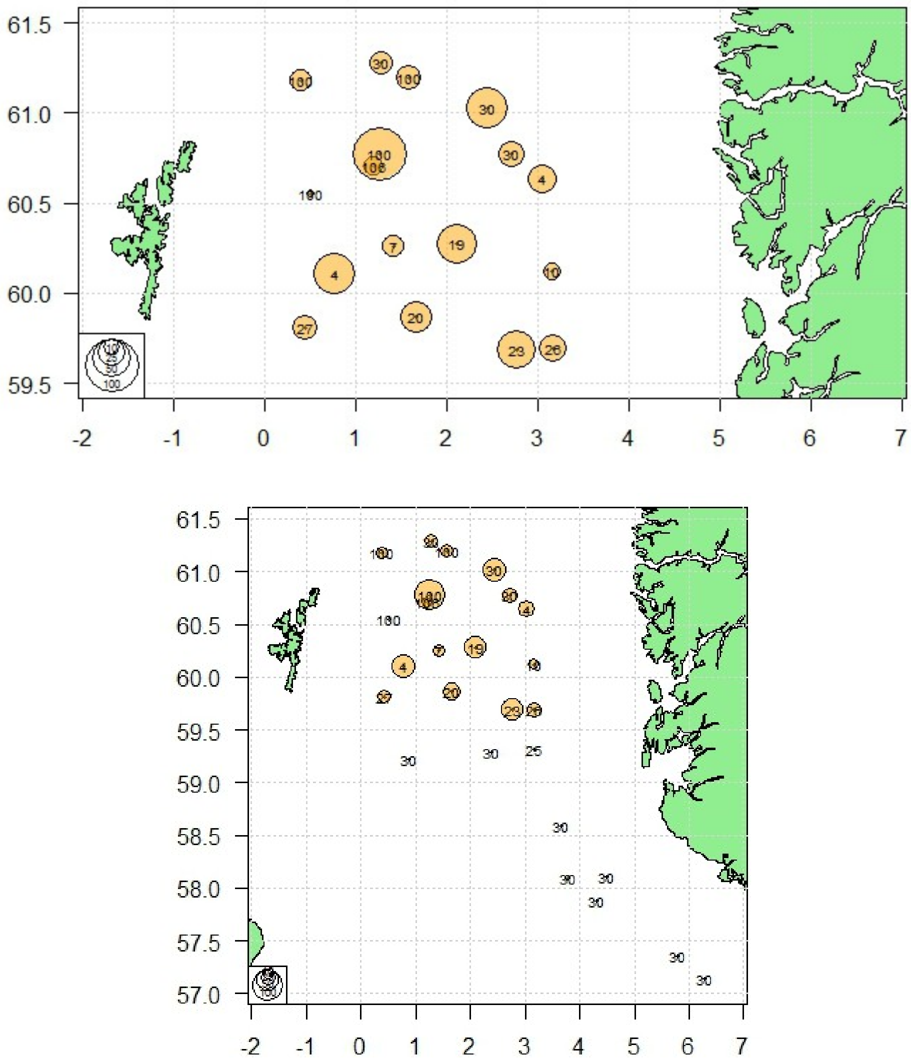


Figure 1.2.14.2 Occurrence of *Ichthyophonus hoferi* in the Norwegian part of the IBTSQ1 2017, the last year with high prevalence. Bubble sizes show the percentage of diseased herring, whereas the numbers show the number of herring examined. The upper figure shows the details of the area with infection.

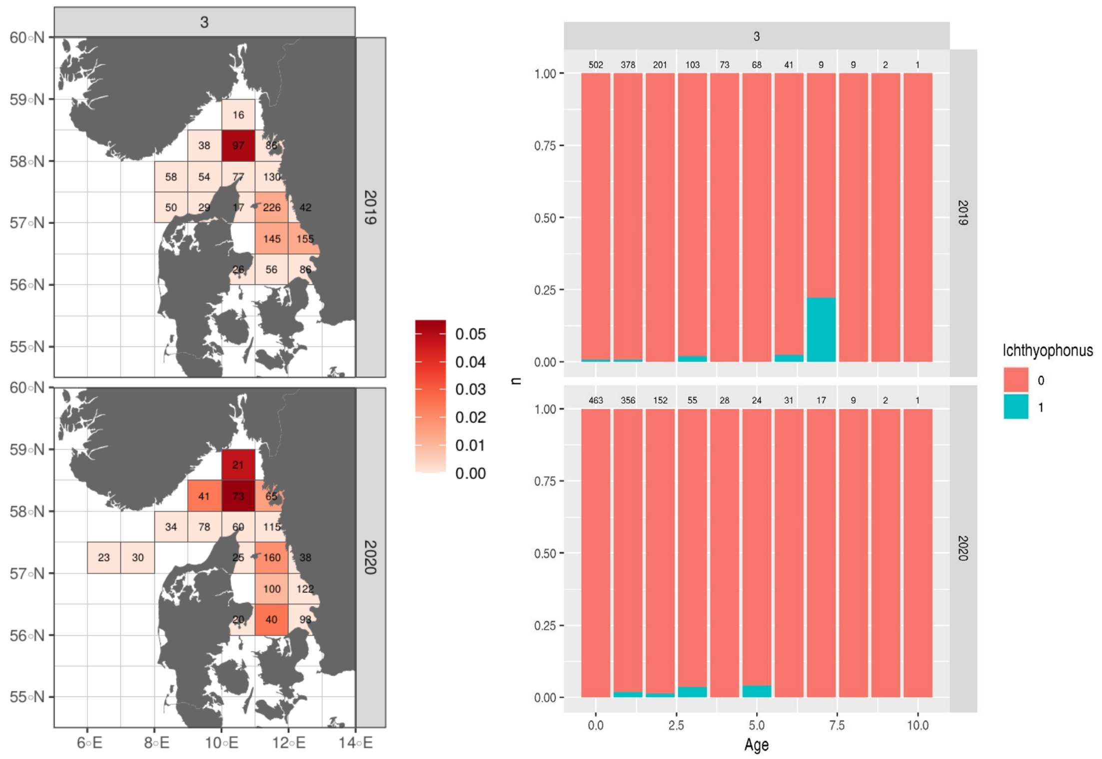


Figure 1.2.14.3 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ3 2019-2020. Left map with distribution of the proportion of infested herring and number of samples in each rectangle; right distribution of infestation among ages.

Regional Database and Estimation System (RDBES)

The RDBES is still under development, and in 2020 had its first major upload of data, from sampling schemes covering a small group of stocks, spr.27.22-32, cod.27.21, whb.27.1-91214, YFT (Yellowfin tuna (tropical)), sol.27.7fg, mur.27.67a-ce-k89a, mon.27.78abd, mon.27.8c9a, ank.27.78abd, ank.27.8c9a, mac.27.nea. The stocks were chosen to ensure that most countries were involved in this first major test of the system. This data call did not include any stocks covered by HAWG, but all counties were encouraged to submit more stocks.

The 2021 data call will be similar to the data call in 2020. However, landing and effort data will be requested for all species, while last year landing and effort data were requested for only 11 selected stocks. Detailed sample data should be uploaded to the RDBES for the 11 stocks requested in 2020 and potentially a few extra stocks which may include stocks from HAWG.

In 2021, three further workshops will be held in relation to the RDBES, WKRDB-POP Workshop on Populating the RDBES data model (June 14th-18th), WKRDB-EST –Workshop on Estimation with the RDBES data model (September 20th-24th) and WKRDB-RAISE&TAF - support migrating of present estimation routines to TAF. In 2021, a data call requesting upload of all stock will be launched.

Further information about the RDBES status and roadmap can be found in ICES (2020).

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

Since 2015, ICES requested relevant countries within a data call to submit the national catches into InterCatch or to accessions@ices (via the standard exchange files). National catch data submission was due by 1st March 2021. 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	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
4.a(E)	58597	58326	704	12
4.a(W)	235613	195184	5152	22
4.b	95422	71901	1926	20
4.c	4922	1464	50	10
7.d	32768	22915	394	12
7.a(N)	7927	7927	1226	155
6.a(N)	177	64	50	282
3.a	17779	15085	3100	174
SD22-24	3966	3306	4041	1019
Celtic, 7.j	132	40	150	1136
6.a(S), 7.b and 7.c	1220	1212	2610	2129

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 most recent 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 time 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.

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.

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 dis-tribution	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.27.6a7bc	3	2	3	2	0	1	2	2	2	2
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

Stock code	MSE (management/rebuilding plans). Uncertainty or differing operating models					Advice	Distribution & habitats			Mixed fisheries			Climate
	environ. driven recruitment	truncating recruitment time-series	variable weight@a (env or density)	recent or trend mat@a (envir or density)	dynamic nat mort	escapement or other productivity rule	influence of population state	habitat suitability/ quality	within species stock mixing	Catch and bycatch of target species	bycatch of non-target species	consideration in mixed fisheries advice	consideration of changes from climate
her.27.20-24						0	2	2	3	3	3	0	1
her.27.3a47d	0	3	2	2	2	0	2	1	3	3	1	0	1
her.27.6a7bc						0	2	2	1	3	3	0	0
her.27.irls	0	3	0	0	0	0	1	1	1	0	1	0	0
her.27.nirs						0	1	1	1	0	0	0	0
san.sa.1r	0	3	0	0	0	3	0	1	0	0	0	0	1
san.sa.2r	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.3r	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.4	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.5r						0	0	0	0	0	0	0	0
san.sa.6						0	0	0	0	0	0	0	0
san.sa.7r						0	0	0	0	0	0	0	0
san.27.6a													
spr.27.3a4	0	3	0	0	0	3	0	0	0	0	1	0	0
spr.27.67a-cf-k						0	0	0	0	0	0	0	0
spr.27.7de	0	2	2	0	2	0	0	1	0	0	0	0	1

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

Another potential impact of the North Sea herring fishery is the removal of fish that could provide other "ecosystem services". The North Sea ecosystem needs a biomass of herring to graze the plankton and act as prey for other organisms. If herring biomass is very low other species, such as sandeel, 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 impact on 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 (part of her-6.a):

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 (part of her-6.a):

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 sprats (*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. 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 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 seabird 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 10 of the 16 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.

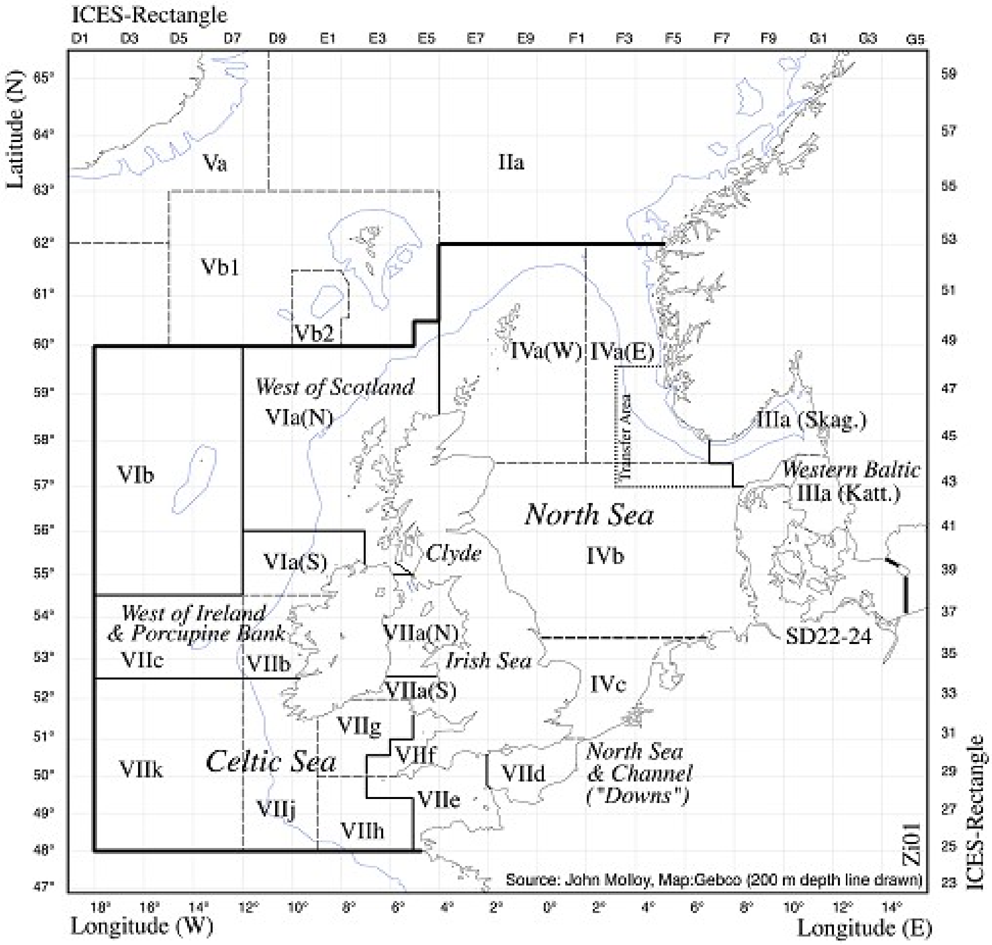


Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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.

The 2021 assessment has been postponed and an interbenchmark will take place in June 2021 and the advice will follow in September 2021.

Western Baltic Spring Spawners (her.27.20-24) is the only spring-spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners, and recently mixing with Central Baltic herring stock has been reported in the western Baltic area. The stock has decreased consistently during the second half of the 2000s. The 2019 SSB (57 841 t) and 2020 recruitment (582 158 thousand) are record low. The estimate of SSB in 2020 (58 434 t) is considered low, below both B_{pa} and B_{lim}. Fishing mortality ($F_{3\text{-}6}$) was reduced from 0.58 in 2008 to 0.32 in 2011. It had then remained above F_{MSY} (0.31) until 2014 (0.35-0.38) but showed an increase in 2015-2018 with an estimated $F_{3\text{-}6}$ above 0.43. The 2019 $F_{3\text{-}6}$ has decreased

(0.288) below F_{MSY} and the 2020 $F_{3–6}$ decreased even further to 0.19. The 2022 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 65 046 t in 2021 to 68 903 t in 2022. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2023 (83 794 t). A medium-term forecast to 2024 showed that SSB can increased to 102 194 t if F=0 in 2022-2023 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 2020 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. This year assessment estimates a fishing mortality, $F_{2–5}$, of 0.023 in 2020 which is the lowest in the time series and below all reference points (F_{MSY} is 0.26 and F_{lim} is 0.45). Short-term projections predict SSB to increase to 19 278 t in 2021.

Herring in 6.a: The stock was much larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-1970s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid-1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved; in recent years misreporting has remained relatively low. The assessment is a combination of two herring stocks, one residing in 6.aS, 7.b and 7.c, and one in 6.aN. It is currently not possible to separate the two stocks for assessment purposes and therefore stock size is a combined estimate. SSB and recruitment have been declining since around 2000 and are currently predicted to be at the lowest level in the time-series. Fishing mortality has reduced since 2016 when catches have been limited to a scientific monitoring TAC.

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 2020, SSB and recruitment have been estimated at 23 435 t and 470 241 thousand respectively, estimates of SSB in recent years appear to be relatively stable. $F_{4–6}$ is estimated at 0.20 in 2020. Under the MSY approach the stock is expected to show an increase to 25 394 t in 2022.

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. Even though fishing mortality in the last years has fluctuated at high levels between 0.6–2.2, recruitments slightly above the average during recent years have contributed to an increase in SSB well above MSY $B_{escapement}$. The estimates for 2021 show an SSB of 162 000 t which is above B_{pa} (125 000 t). The ICES advise for the period 1 July 2021–30 June 2022 indicates that catches of sprat should not exceed 106 715 t which represents a 49% decrease on the last year advice.

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 2020 survey also extended into Cardigan Bay. The advice provided is based on the application of a constant harvest rate of 8.57% to the 2020 acoustic survey biomass estimate. The advised catch of 2897 t for 2022 is 100% higher compared to last year (applying the 1 over 2 rule with the uncertainty cap and the precautionary buffer).

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 74 000 t in 2019 and 69 000 t in 2020. The forecasting indicates that SSB will increase to a level above B_{lim} (110 000 t), but below B_{pa}, in 2021. Recruitment in 2020 was below the geometric mean of the time-series, and lower than in 2019. 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 has remained relatively stable for the last four years (c. 0.5).

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 and further in 2020 to set at 47 000 t. There is indications that recruitment will be just above B_{lim} in 2021, with the exception of the 2016 year class. The 2019-year class is estimated to be below the long-term average. Fishing mortality was relatively high in 2020 due to monitoring large TAC for 2020.

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 360 000 t in 2018 and is estimated to 318 000 t in 2020. The recruitments in 2016 and 2019 were among the five highest on record. Fishing mortality. Forecast indicate an SSB in 2021 similar to 2020. Fishing mortality (F) declined in the early 2000s and has been low until2018. F has been increasing in the last couple of years and is now above the long-term average

A4: Fishing mortality (F) has been low since 2005 but increased in 2018 before decreasing again in 2019. SSB has fluctuated above precautionary reference points (B_{pa} = MSY $B_{escapement}$) since 2011 with the exception of 2015 and 2020. Recruitment was low in 2018 but the 2019-year class is estimated to be above the long-term average which drives a large increase in the advised catch. Recruitment in 2020 is expected to be similar to 2019.

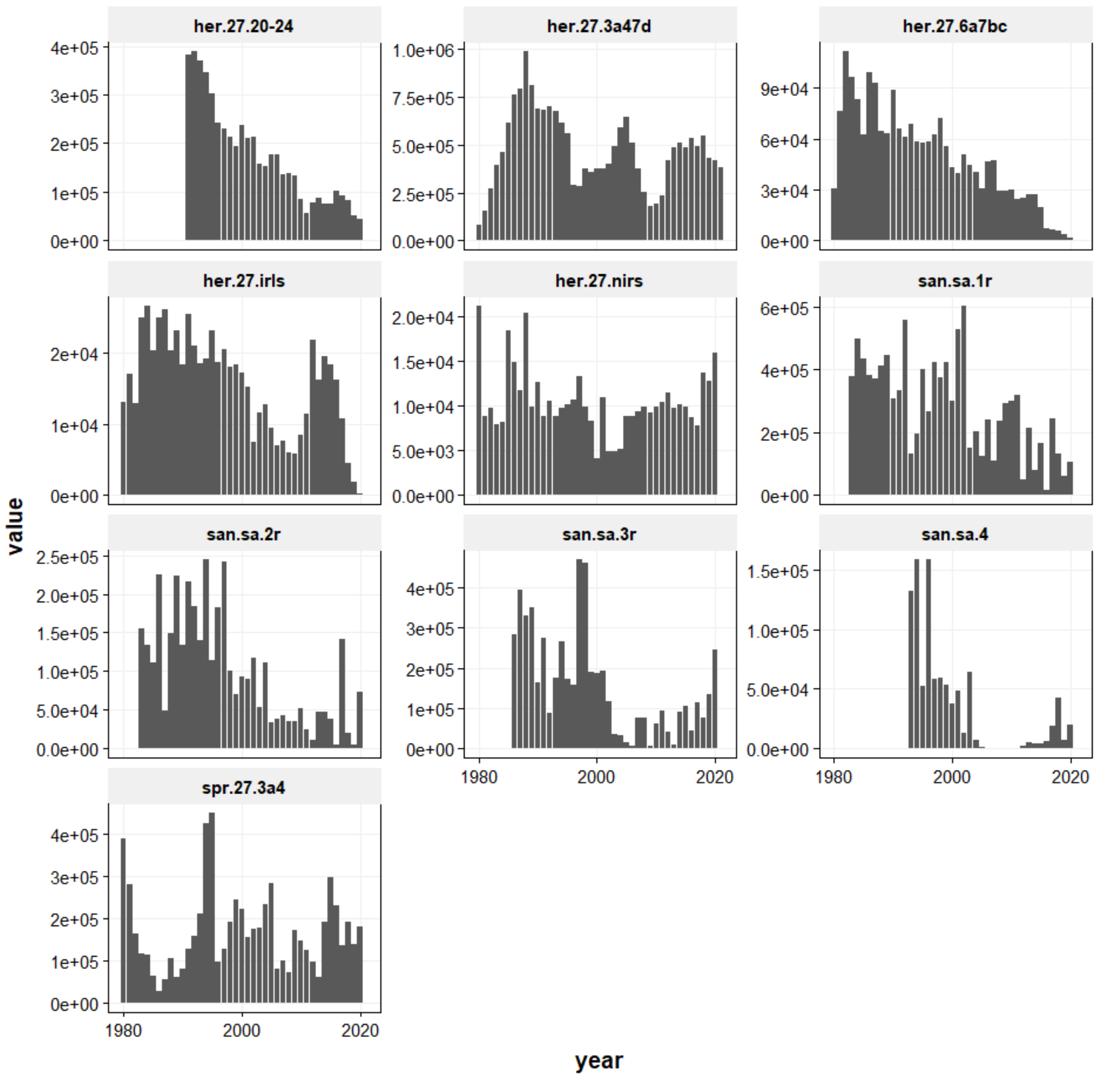


Figure 1.7.2 WG estimates of catch/landings (yield) of the herring, sprat and sandeel stocks presented in HAWG 2021

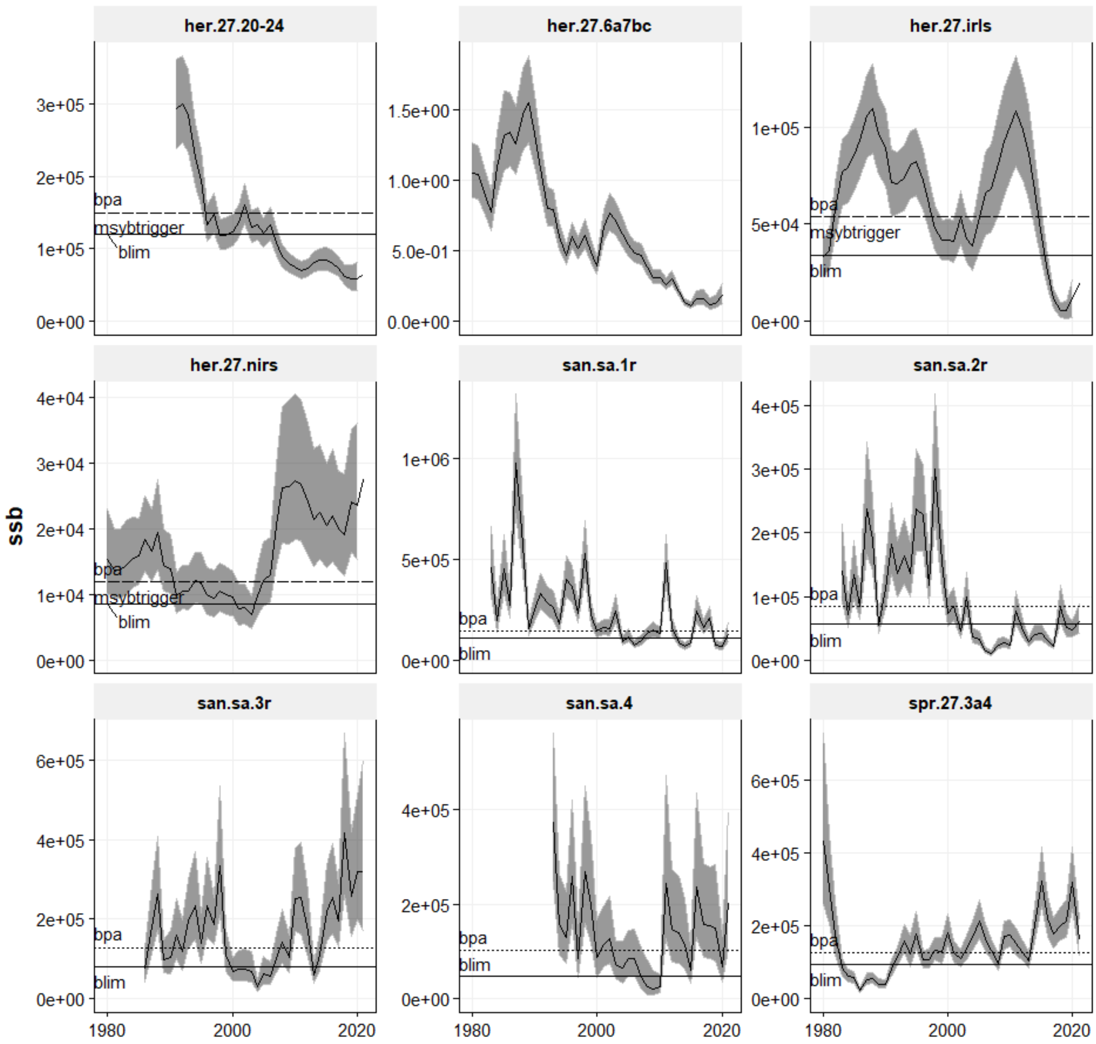


Figure 1.7.3 Spawning-stock biomass estimates for the sprat, herring and sandeel stocks assessed at HAWG 2021.

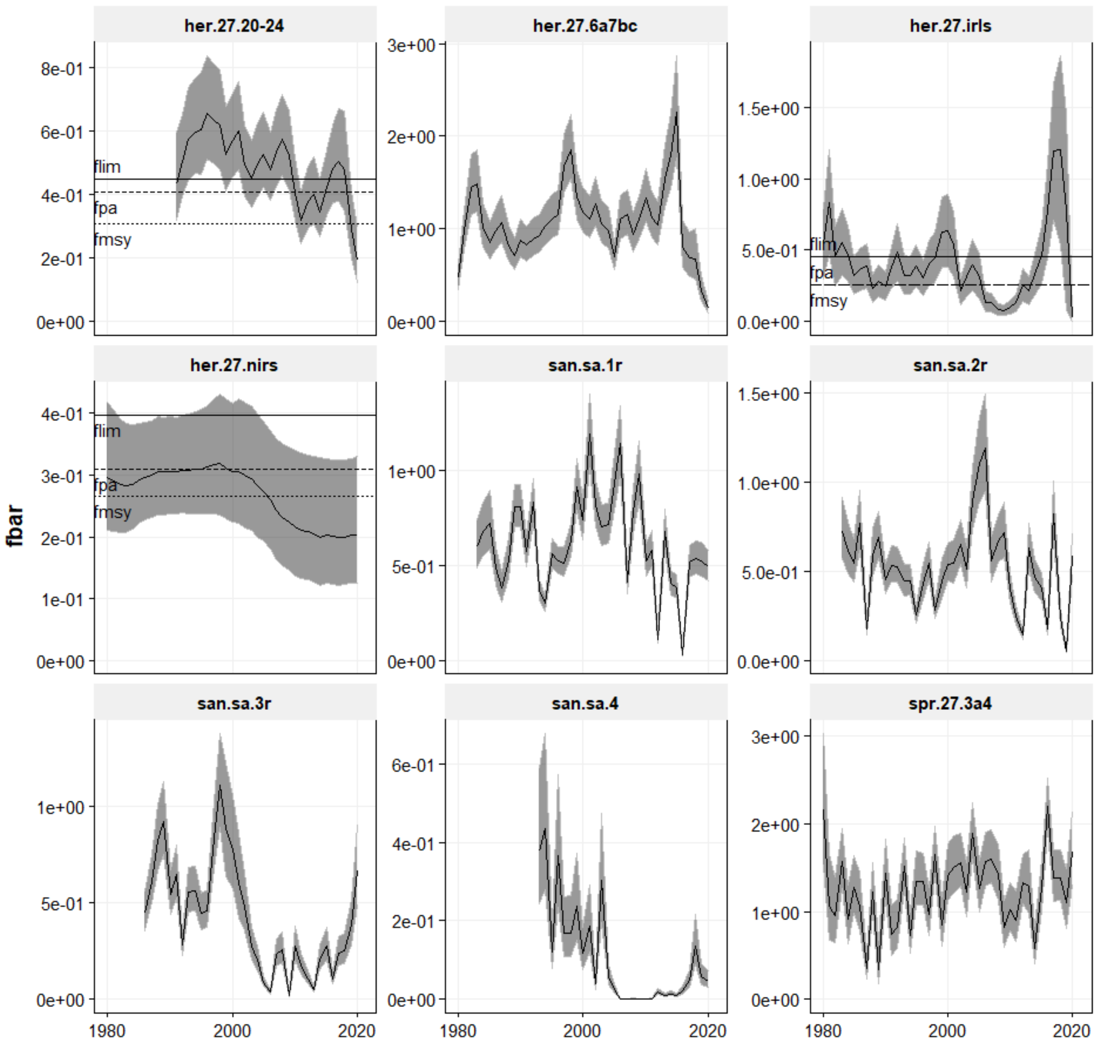


Figure 1.7.4 Estimates of mean F for the sprat, herring and sandeel stocks assessed at HAWG 2021.

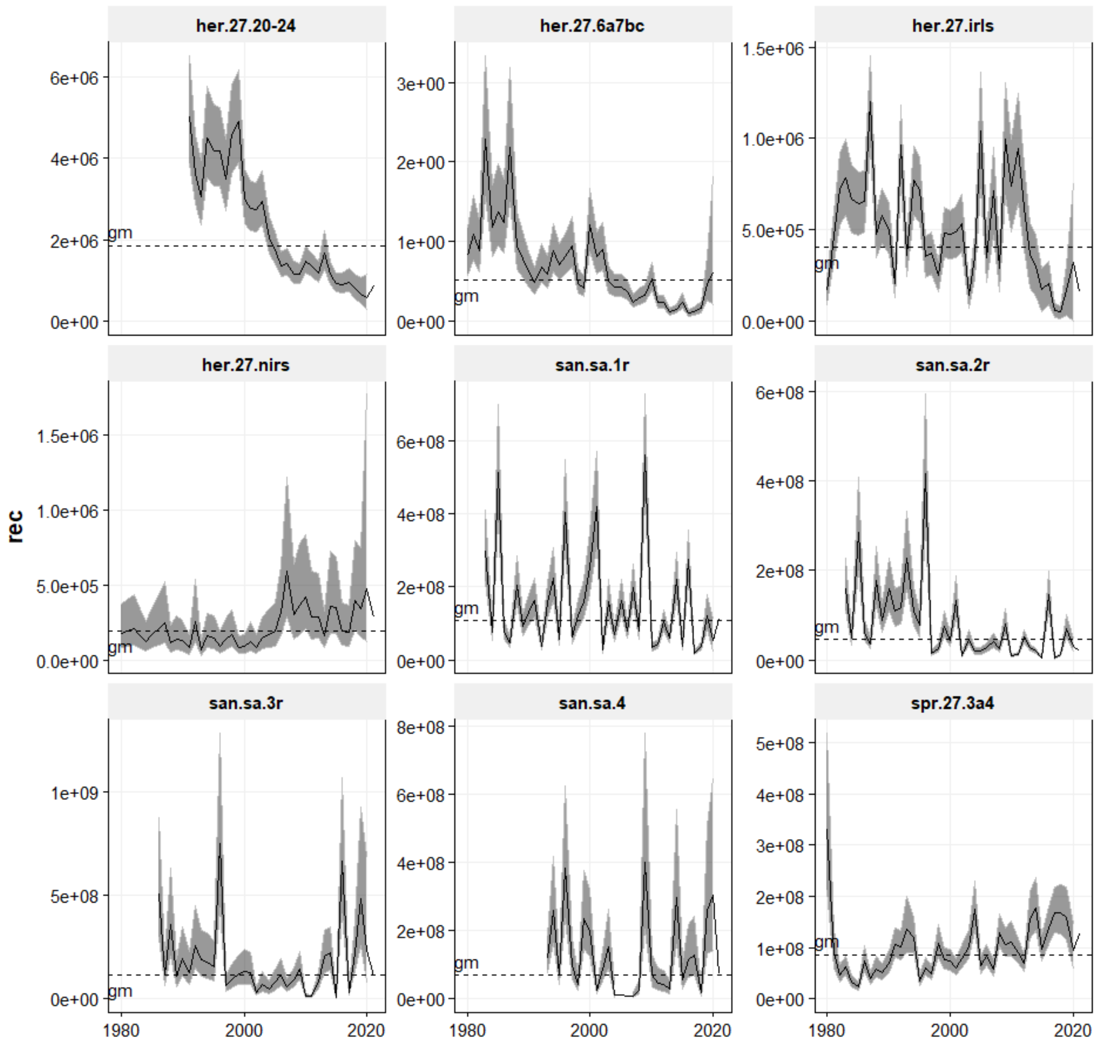


Figure 1.7.5 Estimates of recruitment for the sprat, herring and sandeel stocks assessed at HAWG 2021.

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[*]:

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

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/Expert-Groups/Lists/Retrobias2020/Allitems.aspx and they are included in this report in Table 1.8.1.

---

[*] 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	2020	5	-0.134	No	0.196	No	0.073
her.27.3a47d*	2020	5		No		No	
her.27.6a7bc	2020	5	0.177	No	-0.123	No	0.221
her.27.irls	2020	5	-0.435	No	1.397	No	2.956
her.27.nirs	2020	5	-0.162	No	0.076	No	-0.384
san.sa.1r	2020	5	-0.110	No	0.450	No	0.590
san.sa.2r	2020	5	-0.120	No	0.490	No	0.290
san.sa.3r	2020	5	0.190	No	-0.230	No	-0.100
san.sa.4	2020	5	-0.040	No	0.140	No	0.110
spr.27.3a4	2020	5	-0.070	Yes	0.280	No	0.250

1.10 Transparent Assessment Framework (TAF)

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

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

1. North Sea herring (her.27.3a47d) update single-fleet SAM assessment, multi-fleet model run required for the forecast, and the forecast analysis (Update in progress 2021)
2. Herring west of Scotland and Ireland (her.27.6a7bc) SAM assessment (Last updated 2019, will be updated after the benchmark in 2022)
3. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment (Update in progress 2021)
4. Sprat in 7d, e Category 3, biomass trends (Last updated 2018)
5. Sandeel in area 1r (san.sa.1r) SMS assessment (Last updated 2019)
6. Sandeel in area 5r (san.sa.5r) category 5.4 analysis (Last updated 2019)
7. Sandeel in area 6 (san.sa.6) category 5.2 analysis (Last updated 2019)
8. Sandeel in area 7r (san.sa.7r) category 5.3 analysis (Last updated 2019)

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. An Interbenchmark will be held in June 2021 for North Sea herring. Herring in 6.a, 7.b,c will be benchmarked in early 2022.

Stock	Assessment category	Latest benchmark	Benchmark or Interbechmark in the next 12 months	Further planning	Comments
NSAS herring	1	2018 Interbenchmark 2021	Yes	Exploration of M scaling methodologies, model configuration, new M values	Issue list available
WBSS herring	1	2018	No	Split mixed catches with central Baltic herring. Compile catch matrix by fleet from data in the Regional Database and move to RDBES when non-EU countries on-board	Issue list available, likely need for an interbenchmark to revisit reference points
6.a, 7.bc herring	3	2015 Interbenchmark 2019 Benchmark 2022	Yes	Splitting of survey and new assessment, explore new indices, reference points, MSE	Issue list available
Celtic Sea herring	1	2015 Interbenchmark 2018	No	Mixing with Irish Sea herring, recruitment signal	Issue list available
7.aN herring	1	2017	No	Explore stock mixing, recruitment signal and F in the assessment	Issue list available
Sprat NS.3a	1	2018	No	Consider stock component, local components in 3a, boundary with the Baltic	Issue list available
Sprat 7.de	3	2018 Interbenchmark 2021	No	Consider stock components, review advice guidance for short lived species	Issue list available
Sprat Celtic	5	2013	No	Research roadmap to review and plan sprat work	Issue list available
Sandeel areas 1r–4	1	2016	No	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

This section was added to the report in November 2021

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 2020 and 2021

Norway and the European Union had submitted a joint request to ICES in 2018 to evaluate possible elements for long-term management strategies for several fish stocks, including North Sea autumn spawning herring (Anon, 2017). The management strategy evaluations were finalized in April 2019 and resulted in an ICES advice of 17 April 2019 (ICES, 2019). On North Sea autumn spawning herring, ICES concluded that *"Optimum values of F_{target} were found to be between 0.22 and 0.23 and $B_{trigger}$ at 1 400 000 t across management strategies. Not all management strategies are considered precautionary in the long term. The median long-term yield differs by less than 2% across the management strategies. The ICES MSY advice rule with current FMSY and MSY $B_{trigger}$ was found not to be precautionary (probability of SSB < B_{lim} higher than 5%) under the assumptions of the present simulations."*

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 2020 was 393 962 tonnes for Area 4 and Division 7.d, where no more than 42 351 t should be caught in Division 4.c and 7.d. For 2021, the total TAC is 364 107 t (356 357 t for the A-Fleet), including a TAC of 34 793 t for Division 4.c and 7.d.

The bycatch TAC for the B-Fleet in the North Sea (and Division 2.a) was 8954 t in 2020 and has decreased by 13% to 7750 t in 2021. As North Sea autumn spawners are also caught in Division 3.a, regulations for the fleets operating in this area have to be taken into account 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 2020

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 (either official landings or Working Group catch) by statistical rectangle. The catch figures in tables 2.1.1–2.1.5 are mostly 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 427 321 t in 2020. Official catches by the human consumption fishery were 414 935 t, corresponding to an overshoot of 8% of the TAC for the human consumption fishery (385 008 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 37 689 t. The separate TAC for this area was 42 351 t, so 11% of the TAC remains in Division 4.c and 7.d (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 9864 tonnes in 2020. The bycatch ceiling for the B-Fleet was 8954 t. Since the introduction of yearly bycatch ceilings in 1996, these ceilings have fully been taken in 2014, 2016 and 2020.

The total North Sea TAC and catch estimates for the years 2015 to 2020 are shown in the table below (adapted from Table 2.1.6).

Year	2015	2016	2017	2018	2019	2020
TAC HC (‘000 t)	445	518	482	601	385	385
“Official” landings HC (‘000 t) *	472	545	485	594	439	415
Working Group catch HC (‘000 t)	474	545	485	594	440	417
Excess of landings over TAC HC (‘000 t)	28	27	3	-7	55	32
Bycatch ceiling (‘000 t) **	16	13	11	10	13	9
Reported bycatches (‘000 t) ***	8	15	7	8	5	10
Working Group catch North Sea (‘000 t)	482	560	492	602	446	427

HC = human consumption fishery

*** Landings might be provided by WG members to HAWG before the official landings become available; they may then 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 2021, half of the EU quota for Division 3a (HER/03A.) can be taken in the North Sea (HER/*04C.). Based on correspondence with the Pelagic AC, the expected transfer of this quota in 2021 is uncertain, depending on the outcome of ongoing trilateral EU, UK and Norway negotiations. Norway can take up to 50% of its quota for Division 3.a in the North Sea (Subarea 4).

In the North Sea, Norway can take up to 3000 tonnes of its quota in UK and EU waters in divisions 4.a and 4.b (HER/*4AB-C). 3000 tonnes of the EU quota can be taken within Norwegian waters south of 62°N (HER/*04N-S62).

Half of the EU quota 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 UK and EU waters in 4 (HER/*04-C-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.

At HAWG 2020, the effect of quota swaps and banking and borrowing could not be assessed by the WG. Unfortunately, there is still no complete coverage of whether countries have applied the annual quota flexibility.

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.

As usual, the herring fishery concentrated in the Northwestern 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 55% of the total. Subdivision 4.aE provided 14% of the catches in 2020 and catches in Division 4.b contributed 22%.

The utilization of catches in divisions 4.c and 7.d has decreased since 2010. Since 2014, catches in the southern North Sea contributed less than 10% to the total catch, while they were in the range of 15% for the period before 2010. The TAC in this Division is not fully taken since 2012. Catches in Division 4.c were only 4920 t in 2020 (1.2%).

The bycatch ceiling for the small-meshed fishery (B-Fleet) has fully been taken in 2020. Amount of catches have almost doubled compared to 2019, and catches were more equally distributed in 4.aW (45%) and 4.b (55%). 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 2005–2020 (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 2010–2020.

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 4.36 billion fish and NSAS amounts to 4.48 billion fish in 2020. The proportion of 0- and 1-ringers of herring taken in the North Sea has increased considerably. It is 49% of the total catch in numbers in 2020 (Table 2.2.5), compared to 21% in 2019. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0-ringers amount to 78% of the total catch in numbers.

The proportion of 3+ winter ring herring is down to 39% of the total catch in numbers taken in the North Sea (compared to 76% in 2019).

In terms of biomass, the 6 and 7 winter ring herring contributed most to the catches in 2020.

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 2005–2020. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 426 928 tonnes.

Area	Allocated	Unallocated	BMS/Discard	Total
4.a West	235 330		284	235 613
4.a East	58 597			58 597
4.b	95 422			95 422
4.c/7.d	35 451		2238	37 689
	Total catch in the North Sea			427 321
	Autumn spawners caught in Division 3.a (SOP)			6409
	Baltic spring spawners caught in the North Sea (SOP)			-6802
	Total catch NSAS used for the assessment			426 928

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 and amount to only 88 t in 2020.

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. At the time of HAWG, no catch figure for 2020 was available.

In recent years, no larger quantities of spring spawners were reported from routine sampling of commercial catch taken in the west.

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 2020, 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 284 tonnes in 2020. 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 2020 North Sea herring fishery. However, discards occurred in demersal fisheries not targeting on herring. These discards sum to 2283 tonnes in 2020.

The sampling of commercial landings covers 82% 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 115 different reported métiers, 28 were sampled in 2020. The sampling level of more than 1 sample per 1000 t catch has been met for only 17 métiers. With regards to age readings, 15 métiers appear to be sampled sufficiently (>25 fish aged per 1000 t catch).

However, some of the métiers yielded very little catch. In 71 métiers, the catch is below 1000 t. The total catch in these métiers sums to 10 582 t, so the remaining 45 métiers represent 416 739 t of the working group catch (98%). Of these 45 métiers, 24 were sampled. 11 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 of UK (England and Wales) 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 2020

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 2021a). 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 2020 estimate of North Sea autumn spawning herring SSB (spawning-stock biomass) is lower than previous year at 1.7 million tonnes (2019: 1.9 million tonnes) due to a decrease in the number of fish (2019: 10 295 million fish, 2020: 8 915 million fish). The mean weight of mature fish is similar to last year at 192.6g and the decrease in biomass follows directly from a decrease in numbers. The spawning stock is dominated by fish of age 2, 5 and 6 wr. In the 2019 survey 3 and 5 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 decreased by 3% since last year from 15 265 million in 2019 to 14 851 million this year. This is influenced by the small number of immature 2 wr fish.

Maturity of 2 winter ringers was at an all-time low at 37% in 2018. This year the maturity level was high for this age group (75% mature in 2020; 59% mature in 2019) and although the abundance of 2 winter ringers was twice the abundance in 2019, the high maturity level meant this age group contribute mainly to the mature fish abundance this year. Maturities for ages 3 and above were comparable to the long-term average, with 98% of 3 winter ringers and 99% or higher maturity for all ages 4 and above. Since 2015, observed maturities are reported for all age groups, previously maturity was 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 2020–2021. 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 2020 and January 2021 (Figures 2.3.2.1–2.3.2.4).

The survey around the Orkneys revealed relatively low numbers of newly hatched larvae, in line with the estimate last year. In the Buchan and the central North Sea, larvae hatched in larger quantities, but concentrated in only two dense areas, while the remaining stations contributed only low numbers of larvae (Figure 2.3.2.2).

The two surveys in the southern North Sea showed a peak in abundance in January. In recent years, this peak was most often observed in December. However, the overall distribution of larvae and thus the main spawning area used by herring is not obviously different from preceding 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 2021. Instead, an additional MIK sampling is scheduled for March–April 2021 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)

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

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as a recruitment index for the stock. This year, 683 depth-integrated hauls were completed with the MIK-net, which is 117 MIK hauls more than in 2020. For the index, all hauls north of 51° N were used, in total 663 hauls, 111 more than in 2020. Due to bad weather during the second week of February, some participants could not take their stations, but these gaps could be successfully filled by other participants. Coverage of the survey area was good, mostly achieving the desired 4 hauls per ICES rectangle. Index values are calculated as described in detail in the Stock Annex.

Larvae measured between 7 and 41 mm standard length (SL, Figure 2.3.3.1.1). Again, and as in most years, the smallest larvae <10 mm were the most numerous. Larger larvae >18 mm SL were rarer and were caught in higher densities than last year (Figure 2.3.3.1.2). 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 south-eastern and eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was lower than last year.

The newly proposed rule was applied to the MIK herring larvae data time series from 1992 onwards, where because of data quality issues all French data before 2008 are excluded. The results of the calculation can be found in Table 2.3.3.1.1. The 2021 index is 95.2.

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 2019 is shown in Table 2.3.3.2.1 The index from the 2021 survey is 3128 which is well above the long-term average of the time series. Figure 2.3.3.2.1 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2019, 2020 and 2021. For the 2019 year class, the vast majority of the 1-ringers were found in the Kattegat/Skagerrak area, while in the North Sea, the 1-ringer abundance was low. Just 4 rectangles in the Kattegat/Skagerrak area contributed to more than 75 % of the index for this year. After 6 years in a row, where the trajectories for six recent 1-ringer abundances (year classes 2013–2018) correspond very well to the trajectories of their 6 respective 0-ringer indices (Figure 2.3.3.2.2), this correspondence has weakened again for the 2019 year class. While the index for the 0-ringers only showed a slight increase in the 2020 MIK survey, the 2021 IBTS revealed a much stronger increase for the same year class.

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 most fish are approaching their peak weights just prior to spawning.

The mean weights in the acoustic survey in 2020 were lighter for groups 1 to 3-wr and 9+ wr compared to those in the catch (Table 2.4.1.1).

However, 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 in 2020. 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.

The signal of the 2007-year class (part of the plus group) is meanwhile blurred and not to be seen any longer. This year class have been growing slower throughout the years and was also the year class exhibiting greatly reduced maturity as 2-wr in 2010 and 3-wr in 2011.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2020 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, 2 winter ringers were to 75% mature, much more in line with previous years. Maturities for winter ringers 3 (98%) 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 WKPELA 2018, a benchmark interim model specification was used. In practice, the assessment profiling should have been performed using the WKPELA 2018 final model configuration to ensure consistency in the derivation of additive rescaling. This discrepancy was only discovered at HAWG 2021 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, 2021b).

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 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 2002–2012), 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 the 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 27 % 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 2014 it 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 class until the 2019 year class (Figure 2.3.3.2.2). For the 2020 year class, the relationship between the MIK 0-ringer and the IBTS 1-ringer index decreased again.

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 75%, 98%, 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 has substantially increased 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. One strong feature in 2020 is the large proportion of young fish caught (age 0) which is due to the large update of the B fleet.

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 2020 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 2020 is estimated at approximately 1.5 million tonnes, similar to 2019 (1.55 million tonnes), suggesting a stall in the decrease of the stock observed since 2012. As for recruitment, the 2021 estimates are the highest since 2013, in line with survey observations. Mean F_{2-6} in 2019 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 new assessment model from the latest inter-benchmark (ICES, 2021b), the catchability of the HERAS survey is 1.11, 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. Overall, the assessment is informed best by catch data and HERAS over the core ages of the stock (ages 2–6).

Estimated survey catchabilities for the HERAS and IBTSQ surveys are given in Table 2.6.2.2 and plotted in Figures 2.6.2.8. With the new assessment model from the latest inter-benchmark (ICES, 2021b), the catchability of the HERAS survey is 1.11, in line with the expectation for this survey that covers the stock in its entirety.

The analytical retrospective pattern is lower than for the 2020 assessment, partly due to the change in model settings as a result of the latest inter benchmark (ICES, 2021b). With the current model, the analytical retrospective is limited until 2018 (Table 2.6.2.5, Figure 2.6.2.9). The mean mohn's rho with a 5-year period for the peel is of: -5.1% (F_{bar}), -9.5% (rec), and 8% (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 is 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 is 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 2020 was estimated at 1.51 million tonnes, which is above B_{pa} (0.96 million t) and MSY $B_{trigger}$(1.23 million t).

Since 2013, stock recruitment has been low but a large recruitment was observed in 2021 (highest level since 2013). In 2021, recruitment is estimated at 30 billion, 28% higher than the 10-years weighted mean. This is expected to benefit the stock in the coming years.

Similarl to recent years' assessments, fishing mortality on older ages remains high in recent years. As for the 2020 assessment, the fishing mortality-at-age 7 and 8 is estimated at 0.51 in 2020, which is substantially higher than $F_{bar2–6}$ (0.20). In the 2017 assessment (ICES HAWG, 2017), comparison of the only acoustic survey and catch data gave the same impression that the catches at the older ages are relatively high compared to the estimated number of fish in those ages.

2.7 Short-term predictions

Short-term predictions for the years 2020, 2021, and 2022 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 2023 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 2020 year class, obtained from the assessment (informed by the 2021 IBTS0 survey) served as the estimate for 2021.

For the intermediate year (2021), no overshoot for the A fleet was assumed. Previous negotiations between the EU and Norway resulted in the allowance of 50% of the C-fleet TAC in the Kattegat-

Skagerrak area to be taken in the North Sea. Because a TAC for the C-fleet had been agreed for 2021 despite the zero advice for WBSS herring, the pelagic AC was requested to estimate the percentage of the 3.a herring TAC that would be taken in the North Sea. The pelagic AC estimated it at 48% in 2021. The same proportion has been used in this projection for the scenarios where the C-fleet catch was not set to zero.

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 2022, 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 2022. The catch scenarios with a 0 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 IBPNSherring2021 (ICES, 2021b) 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 2022, the SSB is calculated above MSY $B_{trigger}$ which results in a target $F_{(WR)\ 2–6} = F_{MSY}$ (Figure 2.7.1.1).

There is no specific allowance in the ICES MSY AR for multiple fishing mortality targets, such as the F 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. In addition, three scenarios are presented in which 1) a fixed target fishing mortality for the B-fleet is used and 2) and 3) the TACs of the C and D fleet are the same as in 2020 (with and without transfer of the C fleet to the North Sea).

All predictions are for North Sea autumn spawning herring only.

2.7.1 Comments on the short-term projections

The new assessment model from IBPNSherring2021 (ICES, 2021b) resulted in a lower estimated stock size and higher fishing mortality than in the previous assessment. The interbenchmark process also led to an update of the reference points for the stock. The new biomass limit reference point B_{lim} has increased to 874 198 tonnes. MSY reference points have been updated with a lower MSY $B_{trigger}$ (1 232 828 tonnes) and a higher F_{MSY} (0.31). The increase in F_{MSY} in particular is mainly the result of changing selection patterns in the fishery and the stock–recruitment model used in the estimation process. The 2021 data suggest that the steep decline of the stock observed since 2016 has stalled, and the spawning stock biomass is now above MSY $B_{trigger}$. The decrease in the rate of stock decline and the higher F_{MSY} lead to higher catch advice for 2022 compared to 2021, more specifically an increase of 45%.

2.7.2 Exploratory short-term projections

The 2021 assessment predicted a stall in the decline of the stock. This contrasts with the projections made in 2020, based on the sharp decline of the stock observed since 2017 (Figure 2.7.2.1).

As a result, the SSB in the intermediate year is calculated as much higher which contributes to an increase in catch opportunity, alongside the use of newly derived reference points.

A direct comparison of the forecast results with the last two assessments (2020 and 2019) 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 2022 relative to 2021 where the proportion of age 7–8 is substantial.

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 2023–2027 (Figure 2.7.2.4). This is using the new model and reference points derived during IBPNSherring 2021 (ICES, 2021b). This projection resulted catch of ~420 tonnes by 2026. SSB would decline steadily from 1.6 million tonnes to 1.1 million tonnes. 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.

2.9 Precautionary and Limit Reference Points and F_{MSY} 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 B_{lim} and MSY $B_{trigger}$ and an upward 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. 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, 2021b). These are described in the North Sea Herring Stock Annex (a list of links to the Stock Annexes can be found in Annex 4). The changes made during the 2021 inter-benchmark overall improved the assessment model. Sensitivity testing revealed that the derivation of reference points for herring in the North Sea is very sensitive to the choice of time periods and stock–recruitment models used.

2.11 North Sea herring spawning components

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

2.11.1 International Herring Larval Survey

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

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

Prior to 2002 there were large differences in the contributions of each of the components to the total SSB with northern components (Orkney/Shetland and Buchan) being the major contributors. Since 2002 there has been a more even contribution from each of the four components with some interannual variability. However, the Downs component may be underrepresented in some years due late spawning and Orkney-Shetland due to a lack of sampling due to vessel constraints in 2016–2019.

2.11.2 IBTS0 Larval Index

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

2.11.3 Component considerations

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

2.12 Ecosystem considerations

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

2.13 Changes in the environment

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

Spring-spawning herring and an increase in mean weight is seen in the combined Malin Shelf herring.

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

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

2.14 References

A. Nielsen and C. W. Berg, "Estimation of time-varying selectivity in stock assessments using state-space models," *Fish. Res.*, vol. 158, pp. 96–101, Oct. 2014.

ICES. 2019. EU and Norway request concerning the long-term management strategy of cod, saithe, and whiting, and of North Sea autumn-spawning herring. *In* Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.06, https://doi.org/10.17895/ices.advice.4895

ICES. 2020. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 2:60. 1151 pp. http://doi.org/10.17895/ices.pub.6105

ICES. 2021a. Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 3:40. 481pp. https://doi.org/10.17895/ices.pub.8055

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

Table 2.1.1. Herring caught in the North Sea. Total catch (tonnes) by country, 2016–2020. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2016	2017	2018	2019	2020
Belgium	26	13	32	60	119
Denmark *	133 962	110 318	132 231	91 680	95 615
Faroe Islands	833	442	497	614	804
France	35 177	28 801	31 505	25 288	19 768
Germany	44 231	43 707	51 636	37 699	29 439
Netherlands	98 859	84 914	111 302	79 465	75 036
Norway	150 183	134 132	162 594	128 614	115 879
Sweden *	16 625	18 518	19 408	13 184	13 149
Ireland	127	868	515	3	235
UK (England)	20 485	16 997	19 591	12 685	16 241
UK (Scotland)	59 240	49 514	66 005	50 771	49 692
UK (N.Ireland)	-	3 469	6 916	3 938	2 681
Unallocated landings	8	0	0	0	0
Total landings	559 756	491 693	602 232	444 001	424 800
Discards/BMS	170	-	96	1 630	2 522
Total catch	559 926	491 693	602 328	445 631	427 321
Estimates of the parts of the catches which have been allocated to spring-spawning stocks					
WBSS	1 839	632	2 164	8 832	6 802
Thames estuary **	1	0	0	-	-
Norw. Spring Spawners ***	216	83	310	5	88

*** 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	2016	2017	2018	2019	2020
Denmark *	81080	76277	90763	54820	56676
Faroe Islands	811	405	496	611	794
France	15073	11064	14745	13344	7688
Germany	27926	32736	35884	19851	16694
Lithuania	-	-	-	-	2789
Netherlands	66740	55832	56990	44071	50363
Norway	57056	57744	78647	53254	35674
Sweden	9933	12447	14132	8557	7718
Ireland	127	868	515	3	235
UK (England)	13010	12072	12313	5640	11439
UK (Scotland)	58557	49012	64424	50771	42581
UK (N. Ireland)	-	3469	5582	3938	2681
Total Landings	330313	311926	374491	254860	235330
Discards/BMS	100	-	-	-	284
Total catch	330413	311926	374491	254860	235613

*** 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	2016	2017	2018	2019	2020
Denmark *	16305	3928	751	-	62
Netherlands	-	-	-	100	-
Norway	78125	74216	73452	64592	58535
Sweden	3985	705	377	-	-
Total landings	98415	78849	74580	64692	58597
Discards/BMS	-	-	-	-	-
Total catch	98415	78849	74580	64692	58597
Norw. Spring Spawners **	216	85	310	5	88

*** 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	2016	2017	2018	2019	2020
Belgium	-	-	-	-	11
Denmark*	36149	30045	4067	36750	38842
Faroe Islands	22	37	1	3	10
France	6225	7423	6090	1359	5092
Germany	3419	2048	4964	8568	4197
Netherlands	17233	15739	34491	20700	8814
UK (N. Ireland)	-	-	1334	-	-
Norway	15002	2172	10495	10768	21671
Sweden*	2705	5366	4899	4627	5431
UK (England)	3820	2435	3262	2750	919
UK (Scotland)	683	502	1581	-	7082
Unallocated landings	0	0	0	0	0
Total landings	85258	65767	107794	85525	95422
Discards	-	-	1	800	-
Total catch	85258	65767	107795	86325	95422

*** 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	2016	2017	2018	2019	2020
Belgium	26	13	32	60	108
Denmark*	428	68	40	110	36
France	13879	10314	10670	10585	6988
Germany	12886	8923	10788	9280	8548
Netherlands	14886	13343	19821	14594	15859
Sweden	2	-	-	-	
UK (England)	3655	2490	4016	4295	3883
UK (Scotland)	-	-	-	-	30
Unallocated landings	8	0	0	0	0
Total landings	45770	35151	45367	38924	35451
Discards/BMS	70	-	95	830	2238
Total catch	45840	35151	45462	39754	37689
Coastal spring spawners included above**	1	-	10	-	-

*** 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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Subarea 4 and Division 7.d: TAC (4 and 7.d)													
Agreed Divisions 4.a,b	147.4	149.0	173.5	360.4	427.7	418.3	396.3	461.2	428.7	534.5	342.7	342.7	317.2
Agreed Div. 4.c, 7.d	23.6	15.3	26.5	44.6	50.3	51.7	49.0	57.0	53.0	66.0	42.4	42.4	34.8
Bycatch ceiling in the small mesh fishery *	16.0	13.6	16.5	17.9	14.4	13.1	15.7	13.4	11.4	9.7	13.2	9.0	7.8
CATCH (4 and 7.d)													
National catch Divisions 4.a,b **	145.0	148.1	191.7	387.2	453.8	465.9	439	514.0	456.5	556.9	405.1	389.3	
Unallocated catch Divisions 4.a,b	-1.1	0.0	0.0	-3.0	0.0	3.3	1.5	0.0	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.a,b ***	0.1	0.0	-	-	-	0.0	-	0.1	-	0.0	0.8	0.3	
Total catch Divisions 4.a,b #	143.9	148.1	191.7	384.2	453.9	469.2	440.5	514.1	456.5	556.9	405.9	389.6	
National catch Divisions 4.c, 7.d **	21.5	26.5	26.7	37.1	44.7	38.2	41.1	45.8	35.2	45.4	38.9	35.5	
Unallocated catch Divisions 4.c,7.d	0.4	0.0	0.0	3.3	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	
Total catch Divisions 4.c, 7.d	21.9	26.5	26.7	40.4	44.7	38.2	41.1	45.8	35.2	45.5	39.8	37.7	
Total catch 4 and 7.d as used by ICES #	165.8	174.6	218.4	424.6	498.5	507.5	481.6	559.9	491.7	602.3	445.6	427.3	
CATCH BY FLEET/STOCK (4 and 7.d) ##													
North Sea autumn spawners directed fisheries (Fleet A)	152.1	164.8	209.2	411.8	489.9	490.5	471.5	543.6	484.1	591.7	440.5	417.5	
North Sea autumn spawners industrial (Fleet B)	9.8	9.1	8.9	10.6	8.1	14.0	7.9	14.5	7.0	8.5	5.2	9.9	
North Sea autumn spawners in 4 and 7.d total	161.9	173.9	218.1	422.5	498.1	504.5	479.4	558.1	491.1	600.2	436.8	420.5	
Baltic-3.a-type spring spawners in 4	3.9	0.8	0.3	2.1	0.5	3.0	2.2	1.8	0.6	2.2	8.8	6.8	
Coastal-type spring spawners	0.0	0.1	0.0	0.1	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 ###	44.6	56.9	12.2	9.6	3.2	2.3	2.2	0.2	0.1	0.3	0.0	0.1	
Division 3.a: TAC (3.a)													
Agreed herring TAC	37.7	33.9	30.0	45.0	55.0	46.8	43.6	51.1	50.7	48.4	29.3	24.5	21.6
Bycatch ceiling in the small mesh fishery	8.4	7.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CATCH (3.a)													
National catch	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	
Catch as used by ICES	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	17.8	
CATCH BY FLEET/STOCK (3.a) ##													
Autumn spawners human consumption (Fleet C)	5.1	12.0	6.6	7.8	11.8	9.5	10.2	4.1	7.4	3.2	5.8	6.0	
Autumn spawners mixed clupeoid (Fleet D)	1.5	1.8	1.8	4.4	1.6	3.3	4.4	1.4	0.2	0.2	0.3	0.4	
Autumn spawners in 3.a total	6.5	13.8	8.4	12.2	13.4	12.8	14.7	5.5	7.6	3.4	6.1	6.4	
Spring spawners human consumption (Fleet C)	29.4	23.0	10.8	14.5	16.6	15.4	11.3	23.3	19.0	19.7	8.8	10.9	
Spring spawners mixed clupeoid (Fleet D)	2.9	0.5	0.8	1.0	1.3	0.6	1.8	1.1	0.2	0.2	0.0	0.5	
Spring spawners in 3.a total	32.3	23.5	11.6	15.5	17.9	16.1	13.1	24.4	19.2	19.9	8.8	11.4	
North Sea autumn spawners Total as used by ICES	168.4	187.6	226.5	434.6	511.4	517.3	494.1	563.6	498.7	603.5	442.9	426.9	

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 2020. Catch in numbers (millions) at age (CANUM), 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	79.4	0.0	0.0	0.0	562.2	1476.1	9.6	0.0	2038.3	9.6	2127.4	2047.9
1	26.6	21.7	1.8	19.9	54.9	10.7	0.1	0.0	85.5	0.1	112.1	87.3
2	44.2	147.1	3.2	143.	271.0	77.8	1.6	10.	492.7	12.	549.	508.3
3	5.3	44.4	5.8	38.5	108.3	39.9	4.1	19.2	186.7	23.3	215.2	215.8
4	2.2	38.8	7.5	31.3	186.4	33.6	4.5	33.9	251.3	38.4	291.9	297.2
5	0.3	18.1	1.2	16.9	85.6	7.8	1.2	34.0	110.3	35.2	145.8	146.7
6	0.6	57.4	10.7	46.7	313.2	105.4	5.5	44.1	465.2	49.6	515.4	525.5
7	0.8	39.5	5.3	34.2	186.4	88.9	6.9	32.	309.5	39.	349.4	354.0
8	0.0	8.8	1.8	7.0	31.2	23.8	1.8	5.1	61.9	6.9	68.8	70.6
9+	0.0	12.7	2.8	10.0	45.9	41.4	2.2	8.4	97.3	10.6	107.8	110.6
Sum	159.3	388.5	40.2	348.2	1845.2	1905.3	37.4	187.7	4098.7	225.1	4483.2	4364.1
Quarter: 1												
0	0.0	0.0	0.0	0.0	11.7	1.9	2.3	0.0	13.6	2.3	15.9	15.9
1	14.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	15.0	0.1
2	32.5	0.1	0.2	0.0	2.6	0.8	1.5	0.1	3.4	1.6	37.4	5.1
3	1.0	0.0	0.1	0.0	1.5	0.5	2.8	0.8	2.0	3.6	6.6	5.6
4	0.1	0.0	0.1	0.0	3.6	1.0	1.1	0.9	4.6	2.1	6.7	6.7
5	0.0	0.0	0.2	0.0	3.0	0.3	0.5	1.5	3.3	2.0	5.4	5.3
6	0.0	0.0	0.3	0.0	11.0	0.9	3.6	1.6	11.9	5.1	17.0	17.1
7	0.0	0.0	0.0	0.0	14.7	0.8	3.6	1.2	15.5	4.8	20.3	20.3
8	0.0	0.0	0.1	0.0	1.2	0.1	0.6	0.3	1.2	0.8	2.0	2.0
9+	0.0	0.0	0.1	0.0	10.7	0.3	2.0	0.3	11.0	2.2	13.2	13.2
Sum	48.5	0.3	1.1	0.0	60.0	6.4	18.0	6.7	66.5	24.7	139.6	91.4
Quarter: 2												
0	0.8	0.0	0.0	0.0	40.3	346.9	0.0	0.0	0.2	0.1	388.0	387.2
1	1.1	18.6	1.6	17.0	0.5	2.4	0.0	0.0	19.9	0.0	21.0	21.5
2	1.6	130.7	2.2	128.	63.7	0.5	0.0	0.0	192.8	0.0	194.	194.9
3	0.0	37.6	3.7	33.9	35.7	0.2	0.0	0.0	69.8	0.0	69.9	73.5
4	0.0	33.1	4.9	28.2	66.0	0.1	0.0	0.0	94.4	0.0	94.4	99.3
5	0.0	15.7	0.7	15.0	17.7	0.0	0.0	0.0	32.7	0.0	32.7	33.4
6	0.0	46.6	6.1	40.5	54.0	0.5	0.0	0.0	95.0	0.0	95.1	101.2
7	0.0	31.1	2.9	28.2	38.3	0.5	0.0	0.0	67.0	0.0	67.0	70.0
8	0.0	7.5	1.1	6.3	4.2	0.1	0.0	0.0	10.7	0.0	10.7	11.8
9+	0.0	10.5	1.6	8.9	6.3	0.3	0.0	0.0	15.5	0.0	15.5	17.0
Sum	3.5	331.4	24.9	306.5	326.7	351.7	0.0	0.1	597.8	0.3	988.5	1009.9
Quarter: 3												
0	8.3	0.0	0.0	0.0	56.8	831.3	0.0	0.0	888.0	0.0	896.4	888.0
1	7.0	3.0	0.2	2.8	10.4	6.4	0.0	0.0	19.6	0.0	26.6	19.8
2	9.8	15.9	0.8	15.1	140.3	68.4	0.0	0.0	223.8	0.0	233.	224.6
3	4.3	6.6	2.0	4.6	56.5	32.5	0.0	0.0	93.6	0.0	97.8	95.6
4	2.1	5.5	2.5	3.0	91.6	19.7	0.0	0.0	114.3	0.0	116.4	116.8
5	0.2	2.4	0.3	2.0	54.2	4.3	0.0	0.0	60.6	0.0	60.8	60.9
6	0.6	10.5	4.3	6.3	221.4	84.9	0.0	0.0	312.6	0.0	313.2	316.9
7	0.8	8.3	2.4	5.9	111.8	71.7	0.0	0.0	189.3	0.0	190.	191.7
8	0.0	1.3	0.6	0.7	23.3	18.7	0.0	0.0	42.6	0.0	42.6	43.2
9+	0.0	2.2	1.0	1.2	27.7	33.2	0.0	0.0	62.2	0.0	62.2	63.2
Sum	33.0	55.7	14.1	41.6	794.0	1171.1	0.0	0.0	2006.7	0.0	2039.7	2020.8
Quarter: 4												
0	70.3	0.0	0.0	0.0	453.5	296.0	7.3	0.0	749.5	7.3	827.1	756.8
1	3.6	0.1	0.0	0.1	43.9	1.9	0.0	0.0	45.8	0.0	49.5	45.8
2	0.4	0.3	0.0	0.3	64.4	8.1	0.0	10.	72.8	10.	84.0	83.7
3	0.0	0.1	0.0	0.1	14.6	6.7	1.2	18.4	21.5	19.6	41.1	41.1
4	0.0	0.1	0.0	0.1	25.3	12.8	3.3	33.0	38.1	36.3	74.5	74.5
5	0.0	0.0	0.0	0.0	10.7	3.2	0.7	32.5	13.9	33.2	47.1	47.1
6	0.0	0.2	0.0	0.1	26.7	19.1	1.9	42.5	45.9	44.4	90.3	90.4
7	0.0	0.1	0.0	0.1	21.6	15.9	3.4	30.	37.7	34.	72.0	72.0
8	0.0	0.0	0.0	0.0	2.6	4.9	1.2	4.8	7.5	6.0	13.5	13.6
9+	0.0	0.0	0.0	0.0	1.2	7.6	0.3	8.1	8.7	8.3	17.1	17.1
Sum	74.3	1.0	0.1	0.9	664.5	376.1	19.4	180.9	1041.5	200.3	1316.2	1241.9

Table 2.2.2. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2020. 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	0.014	0.000	0.000	0.004	0.004	0.004	0.000	0.004	0.004	0.004	0.004
1	0.037	0.105	0.105	0.079	0.048	0.021	0.000	0.082	0.021	0.071	0.082
2	0.066	0.126	0.128	0.138	0.150	0.112	0.117	0.136	0.116	0.130	0.136
3	0.139	0.144	0.146	0.160	0.174	0.138	0.125	0.159	0.127	0.155	0.155
4	0.168	0.158	0.160	0.174	0.186	0.153	0.153	0.173	0.153	0.171	0.170
5	0.175	0.169	0.170	0.195	0.212	0.154	0.178	0.192	0.177	0.189	0.189
6	0.199	0.180	0.183	0.216	0.234	0.199	0.187	0.215	0.188	0.214	0.213
7	0.216	0.191	0.193	0.218	0.241	0.201	0.198	0.221	0.199	0.219	0.219
8	0.000	0.197	0.199	0.239	0.252	0.221	0.232	0.238	0.229	0.238	0.237
9+	0.000	0.210	0.000	0.246	0.265	0.188	0.223	0.249	0.216	0.247	0.246
Quarter: 1											
0	0.000	0.000	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002
1	0.025	0.104	0.104	0.016	0.024	0.015	0.000	0.031	0.015	0.025	0.029
2	0.048	0.125	0.125	0.080	0.138	0.112	0.131	0.095	0.000	0.055	0.100
3	0.074	0.142	0.142	0.117	0.158	0.138	0.124	0.127	0.000	0.123	0.132
4	0.089	0.155	0.155	0.116	0.171	0.154	0.140	0.128	0.148	0.133	0.134
5	0.122	0.165	0.165	0.106	0.170	0.106	0.180	0.112	0.161	0.130	0.131
6	0.130	0.177	0.177	0.142	0.186	0.204	0.192	0.145	0.200	0.162	0.162
7	0.121	0.185	0.185	0.149	0.188	0.198	0.201	0.151	0.000	0.162	0.162
8	0.000	0.194	0.194	0.160	0.201	0.228	0.235	0.162	0.000	0.189	0.189
9+	0.000	0.204	0.204	0.180	0.194	0.183	0.221	0.181	0.188	0.182	0.182
Quarter: 2											
0	0.009	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.002	0.002
1	0.035	0.104	0.104	0.044	0.016	0.000	0.000	0.093	0.000	0.089	0.093
2	0.050	0.125	0.125	0.140	0.149	0.150	0.116	0.130	0.000	0.129	0.130
3	0.080	0.142	0.142	0.151	0.174	0.170	0.121	0.146	0.138	0.147	0.146
4	0.000	0.156	0.156	0.167	0.188	0.187	0.139	0.163	0.149	0.164	0.163
5	0.000	0.167	0.167	0.176	0.209	0.221	0.180	0.172	0.181	0.172	0.172
6	0.127	0.178	0.178	0.191	0.230	0.260	0.191	0.185	0.216	0.186	0.185
7	0.148	0.188	0.188	0.206	0.242	0.259	0.200	0.198	0.000	0.199	0.198
8	0.000	0.195	0.195	0.215	0.250	0.265	0.234	0.203	0.000	0.204	0.203
9+	0.000	0.208	0.208	0.230	0.269	0.273	0.221	0.217	0.238	0.218	0.217
Quarter: 3											
0	0.011	0.000	0.000	0.004	0.004	0.000	0.000	0.004	0.000	0.004	0.004
1	0.058	0.114	0.114	0.075	0.061	0.000	0.000	0.076	0.000	0.071	0.076
2	0.127	0.135	0.135	0.145	0.150	0.150	0.000	0.146	0.000	0.145	0.146
3	0.154	0.153	0.153	0.168	0.176	0.154	0.000	0.170	0.000	0.169	0.170
4	0.171	0.167	0.167	0.184	0.190	0.173	0.000	0.184	0.000	0.184	0.184
5	0.187	0.178	0.178	0.213	0.217	0.212	0.000	0.211	0.000	0.212	0.212
6	0.201	0.190	0.190	0.229	0.237	0.226	0.000	0.230	0.000	0.231	0.230
7	0.220	0.200	0.200	0.237	0.245	0.234	0.000	0.238	0.000	0.239	0.238
8	0.000	0.207	0.207	0.251	0.255	0.243	0.000	0.251	0.000	0.252	0.251
9+	0.000	0.220	0.220	0.275	0.269	0.249	0.000	0.270	0.000	0.271	0.270
Quarter: 4											
0	0.014	0.000	0.020	0.004	0.004	0.004	0.000	0.004	0.000	0.005	0.004
1	0.045	0.108	0.108	0.080	0.042	0.024	0.000	0.079	0.000	0.076	0.079
2	0.078	0.134	0.134	0.123	0.148	0.139	0.117	0.126	0.117	0.124	0.125
3	0.000	0.153	0.153	0.154	0.163	0.137	0.125	0.157	0.126	0.142	0.142
4	0.116	0.166	0.166	0.163	0.182	0.153	0.153	0.169	0.153	0.162	0.162
5	0.117	0.177	0.177	0.167	0.209	0.189	0.178	0.176	0.178	0.178	0.178
6	0.116	0.189	0.189	0.182	0.221	0.191	0.187	0.198	0.187	0.193	0.193
7	0.000	0.199	0.199	0.188	0.227	0.204	0.198	0.204	0.199	0.202	0.202
8	0.000	0.207	0.207	0.203	0.242	0.218	0.232	0.228	0.229	0.229	0.229
9+	0.000	0.220	0.220	0.252	0.249	0.225	0.223	0.249	0.223	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 2020. 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**	**7.6**	**7.6**	**0.0**	**7.6**	**7.6**	**7.6**
1	**n.d.**	**21.7**	**n.d.**	**20.5**	**15.9**	**13.6**	**0.0**	**20.2**	**13.6**	**20.2**
2	**n.d.**	**23.2**	**n.d.**	**24.8**	**25.1**	**23.9**	**24.0**	**24.4**	**24.0**	**24.4**
3	**n.d.**	**24.3**	**n.d.**	**25.5**	**26.4**	**25.5**	**24.5**	**25.4**	**24.7**	**25.4**
4	**n.d.**	**25.2**	**n.d.**	**26.2**	**26.9**	**26.0**	**26.1**	**26.1**	**26.1**	**26.1**
5	**n.d.**	**25.7**	**n.d.**	**27.6**	**27.7**	**26.2**	**27.0**	**27.3**	**27.0**	**27.2**
6	**n.d.**	**26.3**	**n.d.**	**28.4**	**28.8**	**28.2**	**27.4**	**28.3**	**27.5**	**28.2**
7	**n.d.**	**26.9**	**n.d.**	**28.4**	**29.2**	**28.2**	**27.9**	**28.4**	**27.9**	**28.4**
8	**n.d.**	**27.2**	**n.d.**	**29.5**	**30.0**	**29.0**	**29.1**	**29.3**	**29.1**	**29.3**
9+	**n.d.**	**27.7**	**n.d.**	**30.1**	**30.2**	**29.3**	**29.3**	**29.8**	**29.3**	**29.8**
Quarter: 1										
0	n.d.	0.0	n.d.	6.9	6.9	6.9	0.0	6.9	6.9	**6.9**
1	n.d.	21.6	n.d.	12.0	12.4	12.0	0.0	13.6	12.0	**13.4**
2	n.d.	23.1	n.d.	21.7	23.7	23.9	24.6	22.2	23.9	**22.7**
3	n.d.	24.2	n.d.	25.0	24.8	25.7	24.4	24.9	25.4	**25.3**
4	n.d.	25.1	n.d.	25.1	25.6	26.4	25.5	25.2	26.0	**25.4**
5	n.d.	25.6	n.d.	24.9	26.0	24.9	27.1	25.0	26.5	**25.6**
6	n.d.	26.2	n.d.	27.0	26.8	28.5	27.6	27.0	28.2	**27.3**
7	n.d.	26.8	n.d.	27.4	27.3	28.5	27.9	27.4	28.3	**27.6**
8	n.d.	27.1	n.d.	28.0	27.8	29.6	29.1	28.0	29.4	**28.6**
9+	n.d.	27.8	n.d.	29.2	28.9	29.3	29.4	29.2	29.3	**29.2**
Quarter: 2										
0	n.d.	0.0	n.d.	6.9	6.9	0.0	0.0	6.9	0.0	**6.9**
1	n.d.	21.6	n.d.	14.8	12.1	0.0	0.0	20.4	0.0	**20.4**
2	n.d.	23.1	n.d.	24.2	24.9	25.6	23.3	23.5	25.4	**23.5**
3	n.d.	24.2	n.d.	24.8	26.2	26.4	24.3	24.5	25.1	**24.5**
4	n.d.	25.1	n.d.	25.6	26.9	27.5	25.5	25.4	25.9	**25.4**
5	n.d.	25.6	n.d.	26.1	27.5	27.9	27.1	25.9	27.1	**25.9**
6	n.d.	26.2	n.d.	26.9	28.6	29.7	27.5	26.6	28.3	**26.6**
7	n.d.	26.8	n.d.	27.6	29.1	30.0	27.9	27.2	0.0	**27.2**
8	n.d.	27.1	n.d.	28.0	29.6	30.9	29.1	27.5	0.0	**27.5**
9+	n.d.	27.6	n.d.	28.8	30.4	31.4	29.4	28.1	30.0	**28.1**
Quarter: 3										
0	n.d.	0.0	n.d.	7.8	7.8	0.0	0.0	7.8	0.0	**7.8**
1	n.d.	22.2	n.d.	19.9	17.4	0.0	0.0	19.4	0.0	**19.4**
2	n.d.	23.7	n.d.	25.4	25.1	25.6	0.0	25.2	25.6	**25.2**
3	n.d.	24.8	n.d.	26.0	26.5	25.7	0.0	26.1	25.7	**26.1**
4	n.d.	25.7	n.d.	26.7	27.2	26.8	0.0	26.7	26.8	**26.7**
5	n.d.	26.2	n.d.	28.4	28.0	27.7	0.0	28.3	27.7	**28.3**
6	n.d.	26.9	n.d.	29.0	29.0	28.6	0.0	28.9	28.6	**28.9**
7	n.d.	27.5	n.d.	28.8	29.4	29.0	0.0	29.0	29.0	**29.0**
8	n.d.	27.6	n.d.	29.8	30.1	29.9	0.0	29.9	29.9	**29.9**
9+	n.d.	28.1	n.d.	30.7	30.4	30.3	0.0	30.5	30.3	**30.5**
Quarter: 4										
0	n.d.	0.0	n.d.	7.8	7.8	7.8	0.0	7.8	7.8	**7.8**
1	n.d.	22.0	n.d.	20.8	15.8	14.3	0.0	20.6	14.3	**20.6**
2	n.d.	23.7	n.d.	24.3	24.9	25.5	24.0	24.3	24.0	**24.3**
3	n.d.	24.8	n.d.	25.7	25.8	24.9	24.5	25.8	24.5	**25.2**
4	n.d.	25.7	n.d.	26.1	26.6	25.9	26.1	26.3	26.1	**26.2**
5	n.d.	26.2	n.d.	26.7	27.6	27.1	27.0	26.9	27.0	**27.0**
6	n.d.	26.9	n.d.	27.7	28.1	27.5	27.4	27.8	27.4	**27.6**
7	n.d.	27.5	n.d.	28.1	28.5	27.9	27.9	28.2	27.9	**28.1**
8	n.d.	27.7	n.d.	29.7	29.4	28.8	29.1	29.5	29.0	**29.3**
9+	n.d.	28.1	n.d.	29.1	29.3	29.3	29.3	29.3	29.3	**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 2020. 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	1.1	0.0	0.0	0.0	2.1	5.2	0.0	0.0	7.3	0.0	8.4	7.3
1	1.0	2.3	0.2	2.1	4.3	0.5	0.0	0.0	6.9	0.0	7.9	7.1
2	2.9	18.5	0.4	18.1	37.4	11.7	0.2	1.3	67.2	1.4	71.6	69.1
3	0.7	6.4	0.9	5.5	17.3	6.9	0.6	2.4	29.7	3.0	33.4	33.5
4	0.4	6.1	1.2	4.9	32.4	6.3	0.7	5.2	43.6	5.9	49.8	50.7
5	0.1	3.1	0.2	2.8	16.7	1.7	0.2	6.1	21.2	6.2	27.5	27.7
6	0.1	10.4	2.0	8.4	67.6	24.6	1.1	8.2	100.6	9.3	110.0	111.9
7	0.2	7.5	1.0	6.5	40.7	21.4	1.4	6.4	68.6	7.8	76.5	77.4
8	0.0	1.7	0.4	1.4	7.5	6.0	0.4	1.2	14.8	1.6	16.4	16.7
9+	0.0	2.7	0.0	2.7	11.3	11.0	0.4	1.9	24.9	2.3	27.2	27.2
Sum	6.4	58.7	6.2	52.4	237.3	95.2	4.9	32.6	384.9	37.5	428.8	428.6
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	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
2	1.6	0.0	0.0	0.0	0.2	0.1	0.2	0.0	0.3	0.2	0.0	0.5
3	0.1	0.0	0.0	0.0	0.2	0.1	0.4	0.1	0.2	0.5	0.8	0.7
4	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.1	0.6	0.3	0.9	0.9
5	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.3	0.3	0.3	0.7	0.7
6	0.0	0.0	0.0	0.0	1.6	0.2	0.7	0.3	1.7	1.0	2.7	2.8
7	0.0	0.0	0.0	0.0	2.2	0.1	0.7	0.2	2.3	1.0	3.3	3.3
8	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.2	0.2	0.4	0.4
9+	0.0	0.0	0.0	0.0	1.9	0.1	0.4	0.1	2.0	0.4	2.4	2.4
Sum	2.0	0.0	0.2	-0.1	7.0	0.8	2.7	1.2	7.7	3.9	11.5	11.7
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.8	0.0	0.8	0.8
1	0.0	1.9	0.2	1.8	0.0	0.0	0.0	0.0	1.8	0.0	1.9	2.0
2	0.1	16.3	0.3	16.1	8.9	0.1	0.0	0.0	25.0	0.0	25.1	25.3
3	0.0	5.3	0.5	4.8	5.4	0.0	0.0	0.0	10.2	0.0	10.2	10.8
4	0.0	5.2	0.8	4.4	11.0	0.0	0.0	0.0	15.4	0.0	15.4	16.2
5	0.0	2.6	0.1	2.5	3.1	0.0	0.0	0.0	5.6	0.0	5.6	5.7
6	0.0	8.3	1.1	7.2	10.3	0.1	0.0	0.0	17.6	0.0	17.7	18.7
7	0.0	5.8	0.6	5.3	7.9	0.1	0.0	0.0	13.3	0.0	13.3	13.9
8	0.0	1.5	0.2	1.2	0.9	0.0	0.0	0.0	2.2	0.0	2.2	2.4
9+	0.0	2.2	0.3	1.8	1.4	0.1	0.0	0.0	3.4	0.0	3.4	3.7
Sum	0.1	49.2	4.0	45.1	49.1	1.2	0.0	0.0	95.4	0.0	95.6	99.5
Quarter: 3												
0	0.1	0.0	0.0	0.0	0.2	3.3	0.0	0.0	3.6	0.0	3.6	3.6
1	0.4	0.3	0.0	0.0	0.8	0.4	0.0	0.0	1.2	0.0	1.9	1.5
2	1.2	2.2	0.1	0.0	20.4	10.3	0.0	0.0	30.7	0.0	33.9	32.8
3	0.7	1.0	0.3	0.0	9.5	5.7	0.0	0.0	15.2	0.0	16.6	16.2
4	0.4	0.9	0.4	0.0	16.9	3.7	0.0	0.0	20.6	0.0	21.5	21.5
5	0.0	0.4	0.1	0.4	11.5	0.9	0.0	0.0	12.8	0.0	12.9	12.9
6	0.1	2.0	0.8	0.0	50.8	20.2	0.0	0.0	70.9	0.0	72.3	73.0
7	0.2	1.7	0.5	1.2	26.5	17.5	0.0	0.0	45.2	0.0	45.4	45.7
8	0.0	0.3	0.1	0.1	5.8	4.8	0.0	0.0	10.7	0.0	10.7	10.9
9+	0.0	0.5	0.2	0.3	7.6	8.9	0.0	0.0	16.8	0.0	16.8	17.1
Sum	3.1	9.3	2.6	1.9	150.0	75.8	0.0	0.0	227.7	0.0	235.6	235.1
Quarter: 4												
0	1.0	0.0	0.0	0.0	1.8	1.2	0.0	0.0	3.0	0.0	4.0	3.0
1	0.2	0.0	0.0	0.0	3.5	0.1	0.0	0.0	3.6	0.0	3.8	3.6
2	0.0	0.0	0.0	0.0	7.9	1.2	0.0	1.3	9.1	1.3	10.4	10.4
3	0.0	0.0	0.0	0.0	2.2	1.1	0.2	2.3	3.3	2.5	5.8	5.8
4	0.0	0.0	0.0	0.0	4.1	2.3	0.5	5.1	6.5	5.6	12.0	12.0
5	0.0	0.0	0.0	0.0	1.8	0.7	0.1	5.8	2.5	5.9	8.4	8.4
6	0.0	0.0	0.0	0.0	4.9	4.2	0.4	7.9	9.1	8.3	17.4	17.4
7	0.0	0.0	0.0	0.0	4.1	3.6	0.7	6.1	7.7	6.8	14.5	14.5
8	0.0	0.0	0.0	0.0	0.5	1.2	0.3	1.1	1.7	1.4	3.1	3.1
9+	0.0	0.0	0.0	0.0	0.3	1.9	0.1	1.8	2.2	1.9	4.0	4.0
Sum	1.2	0.2	0.0	0.1	31.1	17.4	2.2	31.4	48.7	33.6	83.5	82.4

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	49.9%	0.0%	0.0%	0.0%	30.5%	77.5%	25.7%	0.0%	49.7%	4.3%	47.5%	46.9%
1	16.7%	5.6%	4.5%	5.7%	3.0%	0.6%	0.1%	0.0%	2.1%	0.0%	2.5%	2.0%
2	27.7%	37.9%	8.0%	41.3%	14.7%	4.1%	4.2%	5.8%	12.0%	5.5%	12.3	11.6
3	3.3%	11.4%	14.5%	11.1%	5.9%	2.1%	10.9%	10.2%	4.6%	10.3%	4.8%	4.9%
4	1.4%	10.0%	18.7%	9.0%	10.1%	1.8%	12.0%	18.1%	6.1%	17.1%	6.5%	6.8%
5	0.2%	4.7%	3.0%	4.9%	4.6%	0.4%	3.3%	18.1%	2.7%	15.6%	3.3%	3.4%
6	0.4%	14.8%	26.6%	13.4%	17.0%	5.5%	14.6%	23.5%	11.4%	22.0%	11.5%	12.0%
7	0.5%	10.2%	13.2%	9.8%	10.1%	4.7%	18.5%	17.2	7.6%	17.4	7.8%	8.1%
8	0.0%	2.3%	4.5%	2.0%	1.7%	1.2%	4.8%	2.7%	1.5%	3.0%	1.5%	1.6%
9+	0.0%	3.3%	6.9%	2.9%	2.5%	2.2%	5.9%	4.5%	2.4%	4.7%	2.4%	2.5%
Sum 3+	5.7%	56.6%	87.5%	53.0%	51.9%	17.9%	70.0%	94.2%	36.2%	90.2%	37.8%	39.4%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	19.5%	29.2%	13.0%	0.0%	20.4%	9.5%	11.4%	17.4%
1	30.7%	5.5%	0.5%	100.0	0.1%	0.2%	0.1%	0.0%	0.2%	0.1%	10.8%	0.1%
2	67.0%	38.7%	20.5%	0.0%	4.3%	12.5%	8.5%	0.8%	5.1%	6.4%	26.8%	5.6%
3	2.0%	11.2%	11.3%	0.0%	2.5%	7.5%	15.8%	12.1%	3.0%	14.8%	4.7%	6.2%
4	0.1%	9.9%	11.6%	0.0%	6.0%	15.8%	6.3%	14.0%	6.9%	8.4%	4.8%	7.3%
5	0.1%	4.8%	14.4%	0.0%	5.0%	4.1%	2.9%	22.9%	4.9%	8.3%	3.8%	5.8%
6	0.0%	14.3%	24.0%	0.0%	18.4%	13.3%	19.8%	23.5	17.9%	20.8	12.2%	18.7%
7	0.1%	9.8%	0.0%	0.0%	24.5%	11.9%	19.7%	18.6	23.3%	19.4	14.5	22.2
8	0.0%	2.3%	6.8%	0.0%	1.9%	1.1%	3.1%	3.8%	1.8%	3.3%	1.5%	2.2%
9+	0.0%	3.6%	10.8%	0.0%	17.8%	4.3%	10.9%	4.1%	16.5%	9.1%	9.5%	14.5
Sum 3+	2.3%	55.8%	79.0%	0.0%	76.1%	58.0%	78.4%	99.2%	74.3%	84.0%	51.0%	76.9%
Quarter: 2												
0	23.7%	0.0%	0.0%	0.0%	12.3%	98.7%	0.0%	0.0%	0.0%	51.3%	39.3%	38.3%
1	30.2%	5.6%	6.5%	5.5%	0.2%	0.7%	0.0%	0.0%	3.3%	0.0%	2.1%	2.1%
2	45.0%	39.4%	8.7%	41.9%	19.5%	0.2%	12.7%	0.4%	32.2%	2.0%	19.7	19.3
3	0.9%	11.4%	15.0%	11.1%	10.9%	0.0%	14.6%	11.5%	11.7%	6.1%	7.1%	7.3%
4	0.0%	10.0%	19.6%	9.2%	20.2%	0.0%	9.1%	14.2%	15.8%	6.2%	9.5%	9.8%
5	0.0%	4.7%	2.9%	4.9%	5.4%	0.0%	1.0%	23.5%	5.5%	8.1%	3.3%	3.3%
6	0.0%	14.1%	24.7%	13.2%	16.5%	0.1%	31.0%	23.6	15.9%	12.6	9.6%	10.0%
7	0.1%	9.4%	11.8%	9.2%	11.7%	0.1%	19.0%	18.7	11.2%	9.2%	6.8%	6.9%
8	0.0%	2.2%	4.5%	2.1%	1.3%	0.0%	7.9%	3.8%	1.8%	2.5%	1.1%	1.2%
9+	0.0%	3.2%	6.3%	2.9%	1.9%	0.1%	4.7%	4.2%	2.6%	2.1%	1.6%	1.7%
Sum 3+	1.0%	54.9%	84.8%	52.5%	68.0%	0.5%	87.3%	99.6%	64.4%	46.7%	39.0%	40.2%
Quarter: 3												
0	25.2%	0.0%	0.0%	0.0%	7.2%	71.0%	0.0%	0.0%	44.3%	0.0%	43.9%	43.9%
1	21.2%	5.3%	1.2%	0.0%	1.3%	0.5%	0.0%	0.0%	1.0%	0.0%	1.3%	1.0%
2	29.6%	28.6%	5.7%	0.0%	17.7%	5.8%	5.9%	0.0%	11.2	5.9%	11.5	11.1
3	12.9%	11.8%	14.1%	0.0%	7.1%	2.8%	12.1%	0.0%	4.7%	12.1%	4.8%	4.7%
4	6.4%	9.9%	17.8%	0.0%	11.5%	1.7%	19.2%	0.0%	5.7%	19.2%	5.7%	5.8%
5	0.7%	4.3%	2.4%	0.0%	6.8%	0.4%	3.6%	0.0%	3.0%	3.6%	3.0%	3.0%
6	1.8%	18.9%	30.2%	0.0%	27.9%	7.2%	22.9%	0.0%	15.6%	22.9%	15.4%	15.7%
7	2.3%	14.8%	17.0%	0.0%	14.1%	6.1%	23.9%	0.0%	9.4%	23.9%	9.3%	9.5%
8	0.0%	2.3%	4.3%	0.0%	2.9%	1.6%	9.1%	0.0%	2.1%	9.1%	2.1%	2.1%
9+	0.0%	4.0%	7.4%	0.0%	3.5%	2.8%	3.2%	0.0%	3.1%	3.2%	3.0%	3.1%
Sum 3+	24.1%	66.1%	93.0%	0.0%	73.9%	22.6%	94.1%	0.0%	43.6%	94.1%	43.3%	44.0%
Quarter: 4												
0	94.6%	0.0%	0.0%	0.0%	68.2%	78.7%	37.5%	0.0%	72.0%	3.6%	62.8%	60.9%
1	4.9%	6.4%	0.0%	7.2%	6.6%	0.5%	0.2%	0.0%	4.4%	0.0%	3.8%	3.7%
2	0.5%	29.0%	0.0%	32.5%	9.7%	2.2%	0.1%	6.0%	7.0%	5.4%	6.4%	6.7%
3	0.0%	11.4%	0.0%	12.8%	2.2%	1.8%	6.3%	10.2%	2.1%	9.8%	3.1%	3.3%
4	0.0%	9.8%	5.7%	10.3%	3.8%	3.4%	17.3%	18.2%	3.7%	18.1%	5.7%	6.0%
5	0.0%	4.2%	0.0%	4.8%	1.6%	0.8%	3.6%	17.9%	1.3%	16.6%	3.6%	3.8%
6	0.0%	18.4%	45.3%	15.2%	4.0%	5.1%	9.8%	23.5%	4.4%	22.2%	6.9%	7.3%
7	0.0%	14.6%	0.0%	16.3%	3.3%	4.2%	17.4%	17.1	3.6%	17.1	5.5%	5.8%
8	0.0%	2.3%	18.3%	0.3%	0.4%	1.3%	6.4%	2.7%	0.7%	3.0%	1.0%	1.1%
9+	0.0%	3.8%	30.7%	0.6%	0.2%	2.0%	1.3%	4.5%	0.8%	4.2%	1.3%	1.4%
Sum 3+	0.1%	64.6%	100.0%	60.3%	15.5%	18.6%	62.1%	94.0%	16.6%	90.9%	27.0%	28.6%

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	2047.9	0.004	68.3	0.014	11.2	0.009	2'127.4	0.004
1	69.8	0.107	15.7	0.036	22.9	0.034	3.7	0.053	112.1	0.081
2	499.7	0.139	5.4	0.117	43.2	0.065	1.0	0.098	549.3	0.133
3	209.4	0.157	0.6	0.156	5.1	0.140	0.2	0.115	215.2	0.156
4	288.2	0.172	1.5	0.149	2.1	0.171	0.1	0.116	291.9	0.172
5	144.8	0.191	0.7	0.150	0.3	0.178	0.0	0.117	145.8	0.190
6	512.7	0.215	2.0	0.169	0.6	0.200	0.0	0.116	515.4	0.215
7	346.6	0.221	2.0	0.175	0.8	0.218	0.0	0.000	349.4	0.221
8	68.5	0.240	0.3	0.195	0.0	0.000	0.0	0.000	68.8	0.240
9+	107.6	0.248	0.3	0.203	0.0	0.000	0.0	0.000	107.8	0.248
TOTAL	2'247.3		2'076.5		143.2		16.2		4'483.2	
SOP catch		416.9		9.8		6.0		0.4		433.2

Table 2.2.7. Catch-at-age (numbers in millions) of North Sea herring, 2005–2020.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2005	919	408	203	487	1326	480	577	116	108	39	4664
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
2019	513	35	34	292	197	740	542	140	85	138	2717
2020	2048	86	505	210	290	146	515	349	69	108	4324

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, 2005–2020.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
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

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

Table 2.2.9. Catch-at-age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2005–2020.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2005	96.4	307.5	159.2	16.2	5.4	2.4	2.3	0.5	0.2	589.9
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

Table 2.2.10. Catch-at-age (numbers in millions) of the total NSAS stock 2005–2020.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2005	1016	716	355	486	1318	480	576	115	108	39	5209
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
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

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	2010	0.077	0.122	0.149	0.191	0.221	0.216	0.205	-
	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
	2012	0.067	0.124	0.169	0.175	0.2	0.221	0.216	-
	2013	0.075	0.134	0.16	0.201	0	0	0	-
	2014	0.074	0.109	0.162	0.191	0.209	0.221	0.228	-
	2015	0.068	0.133	0.157	0.18	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	0.19	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	-	-
4.a(E)	2010	0.131	0.154	0.201	0.201	0.21	0.223	0.248	0.235
	2011	0.142	0.162	0.18	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	0.2	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	0.17	0.182	0.193	0.198	0.203	0.209
	2018	0.125	0.152	0.173	0.188	0.201	0.212	0.219	0.23
	2019	0.134	0.155	0.173	0.212	0.204	0.209	0.22	0.25
	2020	0.126	0.144	0.158	0.169	0.18	0.191	0.197	0.21
4.a(W)	2010	0.137	0.166	0.195	0.223	0.22	0.216	0.236	0.252
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.22	0.243
	2012	0.132	0.184	0.186	0.206	0.226	0.24	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	0.25
	2017	0.12	0.16	0.177	0.192	0.218	0.226	0.236	0.236
	2018	0.114	0.156	0.188	0.193	0.22	0.241	0.25	0.258
	2019	0.134	0.154	0.174	0.205	0.206	0.22	0.246	0.248
	2020	0.138	0.16	0.174	0.195	0.216	0.218	0.239	0.246
4.b	2010	0.134	0.176	0.182	0.229	0.237	0.235	0.232	0.265
	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.24	0.268
	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.25	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	0.24	0.249	0.256	0.277
	2015	0.14	0.162	0.189	0.203	0.208	0.216	0.227	0.25

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	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	0.23	0.24	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	0.21	0.229	0.251	0.244	0.253
	2020	0.15	0.174	0.186	0.212	0.234	0.241	0.252	0.265

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 2010–2020.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
4.a & 4.b	2010	0.136	0.167	0.192	0.224	0.222	0.22	0.236	0.25
	2011	0.142	0.161	0.184	0.198	0.22	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	0.19	0.203	0.223	0.219	0.228	0.245
	2016	0.134	0.159	0.185	0.21	0.218	0.235	0.226	0.242
	2017	0.116	0.159	0.176	0.19	0.217	0.223	0.231	0.23
	2018	0.117	0.152	0.187	0.195	0.22	0.238	0.245	0.254
	2019	0.136	0.153	0.173	0.208	0.21	0.22	0.239	0.251
	2020	0.136	0.159	0.173	0.192	0.215	0.221	0.238	0.249
4.c & 7.d	2010	0.145	0.167	0.187	0.204	0.207	0.207	0.223	0.216
	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	0.18	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	0.21
	2016	0.114	0.127	0.137	0.166	0.177	0.199	0.193	0.216
	2017	0.1	0.122	0.146	0.165	0.186	0.193	0.22	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
Total North Sea Catch	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
	2011	0.141	0.16	0.183	0.197	0.217	0.221	0.223	0.24
	2012	0.13	0.171	0.185	0.206	0.222	0.239	0.239	0.247
	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	0.2	0.221	0.217	0.226	0.243
	2016	0.132	0.155	0.18	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	0.22	0.23	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	0.17	0.189	0.213	0.219	0.237	0.246

Table 2.2.12. Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2020 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	2	0	0%	26	0	0	0	n
	2	4	0	0%	13	0	0	0	n
	3	1	0	0%	0	0	0	0	n
	4	2	0	0%	80	0	0	0	n
total		9	0	0%	119	0	0	0	n
Denmark (A)	1	2	1	98%	6697	2	67	133	n
	2	2	0	0%	2380	0	0	0	n
	3	3	2	100%	53112	73	1904	5465	y
	4	2	2	100%	23623	14	350	1165	n
total		9	5	97%	85812	89	2321	6763	y
Denmark (B)	1	4	0	0%	61	0	0	0	n
	2	3	1	81%	910	11	102	546	y
	3	2	1	88%	3837	16	215	571	y
	4	4	0	0%	4995	0	0	0	n
total		13	2	42%	9803	27	317	1117	y
UK(E&W)	1	3	0	0%	2346	9	0	1150	n
	2	3	0	0%	6	0	0	0	n
	3	4	2	100%	11930	30	624	2778	y
	4	4	0	0%	4198	7	0	960	n
total		14	2	65%	18479	46	624	4888	y
France	1	2	0	0%	1468	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
	2	3	0	0%	1440	0	0	0	n
	3	3	0	0%	10964	0	0	0	n
	4	4	0	0%	5897	0	0	0	n
total		12	0	0%	19768	0	0	0	n
Germany	2	2	1	100%	5268	25	216	10192	y
	3	2	1	90%	10733	17	238	6885	n
	4	4	1	64%	13438	5	194	689	n
total		8	3	80%	29439	47	648	17766	n
Ireland	1	1	0	0%	8	0	0	0	n
	4	1	0	0%	226	0	0	0	n
total		2	0	0%	235	0	0	0	n
Nether-lands	1	2	0	0%	27	0	0	0	n
	2	1	0	0%	8991	0	0	0	n
	3	3	2	100%	46375	76	1888	9579	y
	4	4	3	85%	19643	11	275	2014	n
total		10	5	84%	75036	87	2163	11593	y
Norway	1	3	0	0%	728	0	0	0	n
	2	3	2	100%	74652	20	873	1423	n
	3	3	3	100%	32820	6	200	372	n
	4	3	2	98%	7679	2	69	196	n
total		12	7	99%	115879	28	1142	1991	n
UK (Scotl.)	1	2	0	0%	6	0	0	0	n
	2	1	1	100%	2850	5	152	655	y
	3	2	2	100%	46016	17	823	21891	n
	4	3	0	0%	820	0	0	0	n
total		8	3	98%	49692	22	975	22546	n
Sweden	1	1	0	0%	297	0	0	0	n
	2	1	0	0%	2761	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	2	0	0%	8882	0	0	0	n
	4	2	0	0%	1148	0	0	0	n
total		6	0	0%	13088	0	0	0	n
Sweden (B)	2	1	0	0%	4	0	0	0	n
	3	1	0	0%	57	0	0	0	n
total		2	0	0%	61	0	0	0	n
Faroese	1	1	0	0%	36	0	0	0	n
	3	2	0	0%	260	0	0	0	n
	4	1	0	0%	508	0	0	0	n
total		4	0	0%	804	0	0	0	n
UK(NI)	1	1	0	0%	18	0	0	0	n
	3	1	0	0%	2555	0	0	0	n
	4	1	0	0%	108	0	0	0	n
total		3	0	0%	2681	0	0	0	n
Lithuania	3	2	0	0%	6120	0	0	0	n
	4	1	0	0%	22	0	0	0	n
total		3	0	0%	6142	0	0	0	n
Period total	1	24	1	56%	11716	11	67	1283	y
Period total	2	24	5	84%	99276	61	1343	12816	y
Period total	3	32	14	87%	233945	236	5928	47577	y
Period total	4	36	8	68%	82385	39	888	5024	y
Total 2020		117	28	82%	427321	347	8226	66700	n
Human Cons. only		101	26	83%	417457	320	7909	65583	n
Total 2018		103	33	83%	602328	394	8868	63991	n
Total 2019		104	29	83%	445633	376	7781	57198	n
Human Cons. Only 2019		92	28	83%	440471	315	7284	56254	n

2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2020. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IRL) EIGB	22 June – 12 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	3 Juny – 25 July	MSHAS,WoS, NSAS, Sprat NS	1, 91 (north of 58°30'N), 111, 121
Johan Hjort (NOR) LDGJ	27 June – 14 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NED) PBVO	25 June – 12 July	NSAS, Sprat NS	81, 91 (south of 58°30'N), 101
Solea (GER) DBFH	29 June – 19 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	25 June – 09 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 2020. 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	7178	27	0.00	3.8	8.3
1	7130	315	0.03	44.1	17.5
2	2736	340	0.75	124.3	23.9
3	1156	183	0.98	158.7	26.0
4	1371	261	1.00	190.7	27.4
5	1674	371	1.00	221.9	28.8
6	1666	389	1.00	233.4	29.1
7	504	124	0.99	246.8	29.7
8	164	42	0.99	255.6	30.2
9+	188	50	1.00	268.3	30.7
Immature	14851	387		26.0	13.4
Mature	8915	1717		192.6	27.1
Total	23766	2104	0.38	88.5	18.5

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2020. 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

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1995	4202	3799	2056	656	272	175	135	110	84	11220	1082
1996	6198	4557	2824	1087	311	99	83	133	206	18786	1446
1997	9416	6363	3287	1696	692	259	79	78	158	22028	1780
1998	4449	5747	2520	1625	982	445	170	45	121	16104	1792
1999	5087	3078	4725	1116	506	314	139	54	87	15107	1534
2000	24735	2922	2156	3139	1006	483	266	120	97	34928	1833
2001	6837	12290	3083	1462	1676	450	170	98	59	26124	2622
2002	23055	4875	8220	1390	795	1031	244	121	150	39881	2948
2003	9829	18949	3081	4189	675	495	568	146	178	38110	2999
2004	5183	3415	9191	2167	2590	317	328	342	186	23722	2584
2005	3113	1890	3436	5609	1211	1172	140	127	107	16805	1868
2006	6823	3772	1997	2098	4175	618	562	84	70	20199	2130
2007	6261	2750	1848	898	806	1323	243	152	65	14346	1203
2008	3714	2853	1709	1485	809	712	1749	185	270	20355	1784
2009	4655	5632	2553	1023	1077	674	638	1142	578	31526	2591
2010	14577	4237	4216	2453	1246	1332	688	1110	1619	43705	3027
2011	10119	4166	2534	2173	1016	651	688	440	1207	25524	2431
2012	7437	4718	4067	1738	1209	593	247	218	478	23641	2269
2013	6388	2683	3031	2895	1546	849	464	250	592	36484	2261
2014	11634	4918	2827	2939	1791	1236	669	211	250	61339	2610
2015	6714	9495	2831	1591	1549	926	520	275	221	24508	2280
2016	9034	12011	5832	1273	822	909	395	220	146	51686	2648
2017	3054	1761	6095	3142	787	365	298	153	140	30055	1943
2018	9938	4254	1692	5150	2440	719	529	293	111	32606	2337
2019	10146	1303	2345	1212	3506	1657	395	252	172	25560	1919
2020	7130	2736	1156	1371	1674	1666	504	164	188	23766	1717

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 number of larvae are expressed as mean number per ICES rectangle * 10^9.

Period/ Year	Orkney/Shetland		Buchan		Central North Sea			Southern North Sea		
	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.
1972	1133	4583	30		165	88	134	2	46	
1973	2029	822	3	4	492	830	1213			1
1974	758	421	101	284	81		1184		10	
1975	371	50	312			90	77	1	2	
1976	545	81		1	64	108			3	
1977	1133	221	124	32	520	262	89	1		
1978	3047	50		162	1406	81	269	33	3	
1979	2882	2362	197	10	662	131	507		111	89
1980	3534	720	21	1	317	188	9	247	129	40
1981	3667	277	3	12	903	235	119	1456		70
1982	2353	1116	340	257	86	64	1077	710	275	54
1983	2579	812	3647	768	1459	281	63	71	243	58
1984	1795	1912	2327	1853	688	2404	824	523	185	39
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38
1986	3529	1842	3278	341	1611	6112	188	780	123	18
1987	7409	1848	2551	670	799	4927	1992	934	297	146
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512
1990		10144	4590	2045	19955	1239	975	2552	1204	
1991	1021	2397		2032	4823	2110	1249	4400	873	
1992	189	4917		822	10	165	163	176	1616	
1993		66		174		685	85	1358	1103	
1994	26	1179				1464	44	537	595	
1995		8688					43	74	230	164
1996		809		184		564		337	675	691
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

Period/ Year	Orkney/Shetland		Buchan		Central North Sea			Southern North Sea		
	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.**
2009		7543		4629		4219		15295	14712	1689
2010		2362		1493		2317		7493	13230	8073
2011		3831		2839		17766		5461	6160	1215
2012		19552		5856		517		22768	11103	3285
2013		21282		8618		7354		5	9314	2957
2014		6604		5033		1149				1851
2015		9631		3496		3424		2011	1200	645
2016				3872		3288		20710	1442	1545
2017				5833		3965		10553	5880	
2018		102		1740		1509		1140		
2019	2488		5654	3794		10605		14082	5258	
2020		3208		3418		7663		4077	9704	

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 2020 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 recorded in the stock annex.

Area	Northwest	Northeast	Central west	Central east	Southwest	Southeast	Division 3.a	South'Bigh t	IBTS-0 in-dex
Area m² x 10^9	83	34	86	102	37	93	31	31	no. in 109
Year class									
1991	0.227	0.074	0.364	0.444	0.466	0.329	0.33	0.259	164
1992	0.191	0.037	0.576	0.387	0.638	0.3	0.359	0.871	195.8
1993	0.574	0.231	0.545	0.178	0.117	0.14	0.223	0.322	155.1
1994	0.131	0.023	0.438	0.359	0.36	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
1996	0.026	0.003	0.878	0.099	0.443	0.298	0.04	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	0.79	0.065	4.354	342
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	0.03	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	0.02	0.065	0.698	52.9
2007	0.013	0.009	0.185	0.031	0.084	0.058	0.019	0.32	39.5
2008	0.145	0.138	0.281	0.253	0.158	0.139	0.16	0.279	99.2
2009	0.073	0.074	0.194	0.052	0.39	0.291	0	0.042	73.5
2010	0.025	0.004	0.595	0.063	0.188	0.082	NA	0.096	77.6
2011	0.008	0.001	0.312	0.132	0.214	0.129	0.076	0.059	65.1
2012	0.022	0.003	0.193	0.072	0.144	0.257	0.005	0.195	61.2
2013	0.132	0.151	0.24	0.253	0.389	0.313	0.037	0.213	113.8
2014	0.009	0.006	0.15	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	0.02	0.082	0.035	0.02	0.196	27.8
2017	0.111	0.001	0.395	0.181	0.397	0.26	0.031	0.019	102.1
2018	0.017	0.023	0.29	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

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2019 year classes (the data for the 1977 to 1994 year classes can be found in the stock annex). Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus 3.a.

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs.small in total area
1995	1997	4403	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.20	0.09
1998	2000	3304	1068	0.32	939	0.28	0.18
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	3881	1520	0.39	1436	0.37	0.12
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1015	341	0.34	357	0.35	0.02
2004	2006	900	115	0.13	121	0.13	0.02
2005	2007	1322	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.01
2007	2009	2339	734	0.31	623	0.27	0.21
2008	2010	1206	279	0.23	286	0.24	0.05
2009	2011	2939	1331	0.45	1407	0.48	0.02
2010	2012	1353	279	0.21	288	0.21	0.04
2011	2013	1665	747	0.45	796	0.48	0.01
2012	2014	2615	1297	0.5	1245	0.48	0.11
2013	2015	3918	1808	0.46	1105	0.28	0.43
2014	2016	783	368	0.47	364	0.47	0.08
2015	2017	2396	1306	0.54	1008	0.42	0.28
2016	2018	778	406	0.52	424	0.55	0.03
2017	2019	1543	432	0.28	397	0.26	0.15
2018	2020	1021	168	0.16	150	0.15	0.17
2019	2021	3128	487	0.16	256	0.08	0.51

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.

W. rings	1		2		3		4		5		6		7		8		9+	
Year	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q	AS	3Q
1996	45	75	119	135	196	186	253	224	262	229	299	253	306	292	325	300	335	302
1997	45	43	120	129	168	175	233	220	256	247	245	255	265	278	269	295	329	295
1998	52	54	109	131	198	172	238	209	275	237	307	263	289	269	308	313	363	298
1999	52	62	118	128	171	163	207	193	236	228	267	252	272	263	230	275	260	306
2000	46	54	118	123	180	172	218	201	232	228	261	241	295	266	300	286	280	271
2001	50	69	127	136	162	167	204	199	228	218	237	237	255	262	286	288	294	298
2002	45	50	138	140	172	177	194	200	224	224	247	244	261	252	280	281	249	298
2003	46	65	104	119	185	177	209	198	214	210	243	236	281	247	290	272	307	282
2004	35	45	116	125	139	159	206	203	231	234	253	250	262	264	279	262	270	299
2005	43	53	135	124	171	177	181	201	229	234	248	249	253	261	274	287	295	270
2006	45	61	127	139	158	163	188	192	188	205	225	242	243	257	244	260	265	285
2007	66	75	123	153	155	171	171	183	204	215	198	211	218	252	247	263	233	273
2008	62	67	141	151	180	192	183	207	194	211	230	240	217	243	268	276	282	312
2009	56	56	148	166	208	217	236	242	232	259	240	261	266	274	249	274	263	292
2010	38	74	138	150	183	190	229	222	245	245	233	239	237	248	252	265	251	271
2011	35	86	151	155	171	176	210	201	242	227	258	244	249	246	252	253	275	267
2012	48	61	125	142	192	198	194	205	212	223	232	223	242	251	239	256	243	268
2013	38	48	131	149	161	170	221	217	210	207	236	222	257	252	249	254	252	265
2014	44	49	130	142	177	191	195	208	225	239	218	233	225	243	250	264	246	266
2015	49	33	121	134	146	168	183	212	200	226	220	253	205	243	210	255	229	276
2016	37	31	112	141	158	169	187	200	223	227	235	241	243	259	232	244	236	263
2017	43	47	100	109	156	167	178	187	198	207	225	235	233	242	237	254	230	252
2018	40	45	92	126	145	163	192	202	224	211	228	235	240	254	272	262	273	270
2019	38	51	105	137	145	158	162	179	205	218	226	219	240	235	258	255	256	263
2020	44	71	124	145	159	169	191	184	222	211	233	230	247	238	256	251	268	270

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 2020. In the period 1988–2014, maturity of age 5+ were set to 100%.

Year \ Ring	2	3	4	5	6	7+
1988	65.6	87.7	100	100	100	100
1989	78.7	93.9	100	100	100	100
1990	72.6	97.0	100	100	100	100
1991	63.8	98.0	100	100	100	100
1992	51.3	100	100	100	100	100
1993	47.1	62.9	100	100	100	100
1994	72.1	85.8	100	100	100	100
1995	72.6	95.4	100	100	100	100
1996	60.5	97.5	100	100	100	100
1997	64.0	94.2	100	100	100	100
1998	64.0	89.0	100	100	100	100
1999	81.0	91.0	100	100	100	100
2000	66.0	96.0	100	100	100	100
2001	77.0	92.0	100	100	100	100
2002	86.0	97.0	100	100	100	100
2003	43.0	93.0	100	100	100	100
2004	69.8	64.9	100	100	100	100
2005	76.0	97.0	96.0	100	100	100
2006	66.0	88.0	98.0	100	100	100
2007	71.0	92.0	93.0	100	100	100
2008	86.0	98.0	99.0	100	100	100
2009	89.0	100	100	100	100	100
2010	45.0	90.0	100	100	100	100
2011	87.0	84.0	99.0	100	100	100
2012	91.0	99.0	100	100	100	100
2013	83.0	96.0	98.0	100	100	100
2014	85.0	100	100	100	100	100
2015	70.0	90.0	96.0	98.0	99.0	100

Year \ Ring	2	3	4	5	6	7+
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

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	1972–2020	1973–2020
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2021	1984–2021
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2020	1998–2020
Acoustic (+trawl)	1 wr 2-9+ wr	1995–2020 1984–2020	1997–2020 1989–2020
IBTS0	0wr	1977–2021	1992–2021

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

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

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

2003	0.846	0.5848	0.3318	0.2699	0.2338	0.2048	0.1884	0.1765	0.1704
2004	0.8616	0.594	0.3383	0.2786	0.2455	0.216	0.1993	0.1863	0.1783
2005	0.8745	0.598	0.3419	0.2839	0.253	0.2239	0.2071	0.1937	0.1844
2006	0.887	0.5914	0.3407	0.2838	0.2547	0.2275	0.2113	0.1987	0.1888
2007	0.9004	0.5777	0.3368	0.2814	0.2542	0.2299	0.2147	0.2036	0.1931
2008	0.9082	0.5656	0.3327	0.2788	0.2531	0.2313	0.217	0.2073	0.1966
2009	0.9104	0.5549	0.3273	0.2747	0.25	0.2305	0.217	0.2087	0.1983
2010	0.9099	0.542	0.3203	0.2687	0.2448	0.2279	0.2154	0.2087	0.1991
2011	0.9046	0.5311	0.3147	0.2647	0.2415	0.2266	0.2147	0.2093	0.2003
2012	0.8947	0.5218	0.3105	0.2623	0.2397	0.2262	0.2147	0.2102	0.2017
2013	0.8812	0.512	0.3058	0.2597	0.2375	0.2253	0.2141	0.2106	0.2026
2014	0.863	0.5031	0.3017	0.2578	0.2358	0.2246	0.2136	0.2108	0.2034
2015	0.84	0.4952	0.298	0.2566	0.2347	0.2242	0.2131	0.2109	0.204
2016	0.8128	0.4876	0.2945	0.2558	0.2337	0.2237	0.2123	0.2106	0.2043
2017	0.7812	0.4806	0.2912	0.2555	0.2332	0.2233	0.2116	0.2101	0.2045
2018	0.745	0.4746	0.2886	0.2563	0.2336	0.2235	0.2112	0.2098	0.2047
2019	0.7043	0.4691	0.2864	0.2578	0.2346	0.224	0.2109	0.2093	0.2049
2020	0.7767	0.4814	0.2918	0.2564	0.234	0.2237	0.2118	0.2101	0.2045

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	0.003733	0.04073	0.1072	0.1495	0.1816	0.2168	0.2291	0.2424	0.2642

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

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

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

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

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	1057817
1985	1446897
1986	1661096
1987	3137067
1988	1482843

1989	1591869
1990	744095
1991	1071987
1992	1114619
1993	1819697
1994	2689360
1995	2098605
1996	1232897
1997	807578
1998	1449610
1999	700200
2000	2040323
2001	1561990
2002	1727130
2003	1331163
2004	761958
2005	902034
2006	725301
2007	859058
2008	711772
2009	702501
2010	857704
2011	1496233
2012	782949
2013	486052
2014	1615026
2015	1887540
2016	546220
2017	1339906
2018	664630
2019	962149
2020	1123548
2021	1213197

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	719773	455714	316775	93361	24297	11505
1999	4541143	295220	213730	124536	50986	18432
2000	1737104	773325	266121	118352	69886	17892
2001	1845109	321669	227932	96962	42963	26429
2002	2201182	1961996	455396	352498	82049	32678
2003	883932	473736	575503	152070	113444	19400
2004	2102067	391439	294586	426275	97329	51332
2005	1074321	386041	116365	84271	99832	31922
2006	1015001	290901	197834	80049	46619	53582
2007	2201537	135003	97101	102389	50900	31186
2008	565133	153916	117814	61448	36091	19461
2009	2794963	202906	98021	65138	27721	12481
2010	1310958	510778	180637	83358	37295	15758
2011	816825	320129	180333	101912	50637	21915
2012	769491	208984	93256	68896	38859	22368
2013	1798965	264571	146546	126210	86043	40312
2014	7253797	442997	198984	90513	80426	45453
2015	518307	723028	360968	128454	67567	46000
2016	1693195	175029	375536	213840	68403	43301
2017	848528	279280	79209	200643	128757	41359
2018	1882241	328189	117615	49491	86881	39764
2019	1484308	137972	72442	41243	26007	36248
2020	761929	312232	269581	75962	66438	26408

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 corresponds 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

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 corresponds 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

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

Table 2.6.1.14 North Sea herring input data. LAI index from the IHLS larvae survey for the Orkney/Shetland component. The columns corresponds 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

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	0.42	0.1295	0.3258	0.5414
catch unique	1	0.42	0.1295	0.3258	0.5414
catch unique	2	0.1203	0.1797	0.08459	0.1711
catch unique	3	0.1203	0.1797	0.08459	0.1711
catch unique	4	0.1203	0.1797	0.08459	0.1711
catch unique	5	0.1203	0.1797	0.08459	0.1711
catch unique	6	0.1203	0.1797	0.08459	0.1711
catch unique	7	0.188	0.1969	0.1278	0.2765
catch unique	8	0.188	0.1969	0.1278	0.2765
HERAS	1	0.4677	0.1549	0.3452	0.6336
HERAS	2	0.277	0.1495	0.2066	0.3713
HERAS	3	0.1503	0.192	0.1032	0.219
HERAS	4	0.2146	0.1028	0.1754	0.2625
HERAS	5	0.2146	0.1028	0.1754	0.2625
HERAS	6	0.2146	0.1028	0.1754	0.2625
HERAS	7	0.2948	0.1273	0.2297	0.3783
HERAS	8	0.2948	0.1273	0.2297	0.3783
IBTS-Q1	1	0.2801	0.1515	0.2082	0.377
IBTS0	0	0.3311	0.1717	0.2365	0.4635
IBTS-Q3	0	0.4962	0.1345	0.3812	0.6459
IBTS-Q3	1	0.4962	0.1345	0.3812	0.6459
IBTS-Q3	2	0.3198	0.09693	0.2645	0.3867
IBTS-Q3	3	0.3198	0.09693	0.2645	0.3867
IBTS-Q3	4	0.3198	0.09693	0.2645	0.3867
IBTS-Q3	5	0.3198	0.09693	0.2645	0.3867
LAI-ORSH	0	1.186	0.04378	1.089	1.293
LAI-BUN	0	1.186	0.04378	1.089	1.293
LAI-CNS	0	1.186	0.04378	1.089	1.293
LAI-SNS	0	1.186	0.04378	1.089	1.293

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.9736	0.06892	0.8506	1.114
HERAS	2	0.9736	0.06892	0.8506	1.114
HERAS	3	1.111	0.05787	0.9921	1.245
HERAS	4	1.111	0.05787	0.9921	1.245
HERAS	5	1.111	0.05787	0.9921	1.245
HERAS	6	1.111	0.05787	0.9921	1.245
HERAS	7	1.111	0.05787	0.9921	1.245
HERAS	8	1.111	0.05787	0.9921	1.245
IBTS-Q1	1	0.1046	0.06874	0.09144	0.1197
IBTS0	0	3.256e-06	0.08747	2.743e-06	3.865e-06
IBTS-Q3	0	0.09443	0.1243	0.07402	0.1205
IBTS-Q3	1	0.04673	0.1201	0.03693	0.05914
IBTS-Q3	2	0.04292	0.08835	0.0361	0.05104

IBTS-Q3	3	0.03882	0.08741	0.03271	0.04607
IBTS-Q3	4	0.03249	0.08886	0.0273	0.03868
IBTS-Q3	5	0.02543	0.0899	0.02132	0.03033
LAI-ORSH	0	0.01634	0.1084	0.01322	0.02021
LAI-BUN	0	0.01634	0.1084	0.01322	0.02021
LAI-CNS	0	0.01634	0.1084	0.01322	0.02021
LAI-SNS	0	0.01634	0.1084	0.01322	0.02021

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	34857881	16680211	14660510	5425498	7277607	4449931	3924311	2074043	6325976
1948	33168667	16187259	9543339	8681479	3657537	5098815	2949151	2232636	4890220
1949	27738944	15537033	11577103	7236067	4193053	2291596	3253556	1876381	4271621
1950	39631096	12084218	9003995	9355772	5179172	2342726	1452529	1816396	3243745
1951	38360314	19088869	6487739	6041255	6836818	3625286	1474115	842354	2795739
1952	38129475	17636661	10465234	3853368	3573078	3786985	2164242	939014	2272124
1953	43298993	17305639	9202520	5719870	2628711	2112546	2221294	1230766	1766283
1954	40509210	20067363	8842474	5245050	3098707	1712297	1242620	1281490	1707087
1955	34330892	18209442	10518999	5103956	2663062	1787491	1056176	664209	1408756
1956	25331383	16054303	8628867	6053882	2883634	1462171	1043436	582614	1387132
1957	57963495	10812125	8069740	3749229	3535432	1680721	930477	649597	1173520
1958	24750757	32719724	4741248	4547890	1881058	2251610	924820	543666	1009764
1959	28494509	11012382	19162399	2162398	2339013	1102672	1161482	565241	1192216
1960	12367216	14423512	4966163	10522033	1057661	1141799	605727	616521	1089061
1961	53361602	4138894	7300411	2358295	7110642	669132	791812	344387	870537
1962	28315663	27303876	1582948	3197868	1370387	4379456	425932	513021	709262
1963	34500367	13017996	16027038	1006587	1247776	674159	2245959	203487	694291
1964	34525401	14923259	6519608	9343192	663285	733233	506575	1536287	545429
1965	17044568	16549405	6223506	3394630	5410037	389402	424945	320077	1376011
1966	18512296	7870349	7515213	2139546	1362624	2331009	167865	188111	843336
1967	25695882	7857955	3576051	3135318	848526	651482	865371	101042	465422
1968	22010621	11650464	3122995	1881190	1146857	290548	245781	277496	164772
1969	12613954	9881122	4268170	656699	301304	350062	78421	65458	95289
1970	22028340	5778197	4123154	1523208	210230	99161	108060	16313	42985
1971	17203786	10136867	2325572	1205937	371550	50929	31733	30017	17499
1972	12689647	7686035	3289672	756597	313779	95230	13979	1050	6516
1973	6837978	5415084	2652965	1130932	291865	120700	47504	7462	4447
1974	10910155	2757854	1558627	728578	262988	97774	40071	11366	5278
1975	2523737	5374724	926433	432972	232235	81126	26821	11722	5882
1976	3316846	823949	1814023	210166	93143	61564	13545	6305	2464
1977	4408473	1395086	279817	614578	49371	24709	18595	4556	2120
1978	4284612	1873406	704192	219598	248557	30461	11451	10094	3164
1979	7817493	1689144	909159	407271	175764	121744	20564	7019	7297
1980	12579125	3211513	752052	476612	228267	155953	62300	16908	8080
1981	27479729	4657428	1599985	322459	218736	138200	120509	54266	20189
1982	46668043	8062729	1841134	1035370	199014	119523	76757	70873	39184
1983	46332060	14935007	3220681	1051336	502265	125254	102656	52268	82683
1984	46430895	13363932	6133080	1792274	671652	272551	79210	67102	80892
1985	54857205	14879024	5711834	3584437	995104	358122	123896	46884	74951
1986	66589031	19868171	5448494	2982583	1543296	426092	169011	54204	61010
1987	57753733	26261354	8693814	2593006	1541899	774858	222020	76439	50328
1988	37584120	18965563	9960509	4557099	1326761	803112	387644	111535	66689
1989	29601203	12878841	6888564	5477231	2639122	689988	398854	192021	89387
1990	27314412	9856830	4447087	3904302	3607786	1547698	370521	215721	161202
1991	29768324	10495112	4143256	2311420	2293798	2138016	875406	212058	195856
1992	52687967	10251094	4465858	1770582	1321879	1330987	1291741	519107	242211
1993	55478713	16789015	3709483	1997534	935276	729725	738683	634231	402580
1994	42818450	16891069	5843508	1421385	858324	400336	343160	336688	464138
1995	44509451	13850076	6023246	2593486	719137	369200	197793	171229	371868
1996	35721124	14046247	5131069	3052111	1084083	339765	150869	96276	262705
1997	29399447	13515440	6353427	2957339	1656944	661134	209031	88297	221301
1998	18671594	12044905	8851140	3158182	1468259	888050	434125	129117	172623
1999	57118961	8161444	5503217	5398176	1658768	745983	430706	224751	148320
2000	39913773	22592181	5403398	2873619	3161767	1027590	469949	267389	192499
2001	69493485	15798562	11134746	3503680	1684905	1763461	549118	277565	221530
2002	36544676	29090250	7874546	8080049	1896410	912324	1076200	319658	306603

2003	20448136	14030920	17030853	4411714	4906427	1062319	562983	649505	333484
2004	23148557	7688985	6201456	10804646	2945095	2964686	544446	363524	491119
2005	20618261	9632810	3816209	3819177	6431627	1743669	1594204	268014	401314
2006	21102267	7181087	4894101	2427044	2373262	4071355	850498	714648	279865
2007	24216457	7568169	3147984	2848749	1524446	1348256	2266159	440109	459004
2008	21414758	8611089	4308626	2066651	1678380	978784	854478	1446952	560066
2009	35173993	8532231	5284804	2562902	1397486	1114075	665705	622011	1594208
2010	27075893	12737198	5441542	3860553	1895774	1040715	986899	511842	1728964
2011	24662241	11175270	6590373	3479572	2424209	1218597	711217	641481	1464792
2012	22821042	9010834	5783853	4928300	2573030	1685121	789097	463816	1170997
2013	30576450	8410358	4510187	4009966	3385734	1935187	1174750	496635	1015130
2014	47591435	13669299	5272924	3113374	3292025	2267687	1226766	689046	744763
2015	13105001	18853171	9531387	2921972	1918310	2042486	1358805	709002	800657
2016	23845023	5088352	11564153	6805937	1800290	1212702	1150899	685728	707570
2017	14290297	8800444	2498258	8220706	4728236	1194975	619655	541186	584752
2018	25779018	5865147	4223435	1886892	5867194	3351792	785001	415514	680883
2019	22973841	10313476	2552430	2651584	1422376	3665829	1969431	417338	555067
2020	24676160	9830005	6762472	1592844	1778346	1025975	2153938	961056	472236
2021	30422344	10430934	5562841	4371804	978694	1081013	626713	1195599	651684

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	0.0001157	0.001001	0.03874	0.09546	0.1107	0.148	0.2434	0.27	0.27
1948	9.34e-05	0.000785	0.03304	0.08732	0.1057	0.1398	0.2101	0.2394	0.2394
1949	0.0002352	0.002242	0.04986	0.1096	0.1253	0.1587	0.2559	0.3049	0.3049
1950	0.0005803	0.006255	0.07411	0.1364	0.1484	0.1639	0.2183	0.2371	0.2371
1951	0.001799	0.02262	0.1306	0.2025	0.2141	0.2098	0.2351	0.2269	0.2269
1952	0.003094	0.04189	0.1609	0.2107	0.2197	0.2254	0.2822	0.3074	0.3074
1953	0.00464	0.0664	0.1906	0.233	0.2283	0.2339	0.2824	0.2986	0.2986
1954	0.006564	0.1014	0.2338	0.2751	0.2577	0.2722	0.3645	0.3796	0.3796
1955	0.007037	0.121	0.2509	0.2666	0.2354	0.2405	0.2706	0.2344	0.2344
1956	0.007211	0.136	0.2756	0.2687	0.2289	0.2311	0.2456	0.2389	0.2389
1957	0.007962	0.1487	0.2854	0.2756	0.2413	0.2613	0.2864	0.273	0.273
1958	0.008671	0.1508	0.295	0.277	0.2309	0.2377	0.204	0.1728	0.1728
1959	0.01478	0.2138	0.3508	0.3148	0.2707	0.2709	0.2906	0.2882	0.2882
1960	0.01688	0.1918	0.3093	0.2567	0.2143	0.2109	0.2381	0.2689	0.2689
1961	0.01932	0.1967	0.3273	0.2935	0.2548	0.2404	0.2535	0.2374	0.2374
1962	0.01229	0.13	0.2739	0.3162	0.3024	0.3072	0.3796	0.3506	0.3506
1963	0.01236	0.1167	0.2352	0.2254	0.1796	0.1682	0.1305	0.1437	0.1437
1964	0.01855	0.1946	0.3406	0.3399	0.2879	0.2733	0.2262	0.2173	0.2173
1965	0.02421	0.2894	0.5231	0.5835	0.525	0.5226	0.5059	0.5132	0.5132
1966	0.02449	0.2534	0.4913	0.5597	0.496	0.513	0.4109	0.5118	0.5118
1967	0.02906	0.2872	0.5654	0.7341	0.6703	0.7105	0.763	0.9549	0.9549
1968	0.04956	0.5381	0.9943	1.298	1.004	0.9679	1.149	1.216	1.216
1969	0.0276	0.2961	0.6919	0.8796	0.8017	0.8537	1.191	1.069	1.069
1970	0.04675	0.4239	0.8172	1.023	0.9372	0.8549	1.174	0.9097	0.9097
1971	0.06861	0.5661	0.885	1.085	1.073	1.129	2.923	1.726	1.726
1972	0.06893	0.46	0.6992	0.729	0.6019	0.5294	0.539	0.3173	0.3173
1973	0.1016	0.6356	0.91	1.021	0.8642	0.8639	1.08	0.7063	0.7063
1974	0.1143	0.5424	0.8407	0.938	0.8404	0.9414	0.957	0.8424	0.8424
1975	0.1763	0.6803	1.011	1.242	1.117	1.294	1.285	1.619	1.619
1976	0.1491	0.4459	0.7307	1.014	0.88	0.9515	0.8044	1.151	1.151
1977	0.06785	0.1265	0.2632	0.3893	0.3317	0.4024	0.2731	0.4595	0.4595
1978	0.07722	0.112	0.2153	0.2811	0.2351	0.2652	0.1396	0.2527	0.2527
1979	0.1098	0.1291	0.2111	0.2496	0.1945	0.2004	0.08247	0.1525	0.1525
1980	0.1636	0.1566	0.216	0.2356	0.1736	0.1568	0.05054	0.09119	0.09119
1981	0.331	0.2668	0.2505	0.2799	0.2501	0.2647	0.213	0.3801	0.3801
1982	0.302	0.2375	0.2215	0.2521	0.2056	0.1747	0.107	0.1537	0.1537
1983	0.306	0.2709	0.2426	0.29	0.2863	0.2775	0.2585	0.3394	0.3394
1984	0.2201	0.2611	0.2608	0.3443	0.3891	0.3872	0.3917	0.4952	0.4952
1985	0.1888	0.3275	0.324	0.438	0.5006	0.4813	0.5229	0.5885	0.5885
1986	0.1459	0.3039	0.3101	0.3817	0.4372	0.4437	0.5182	0.5839	0.5839
1987	0.1808	0.3864	0.3281	0.3605	0.4175	0.429	0.4581	0.4595	0.4595
1988	0.1675	0.3919	0.3151	0.3302	0.3992	0.4254	0.4587	0.4728	0.4728
1989	0.1638	0.3907	0.3238	0.3286	0.3959	0.4099	0.4221	0.4296	0.4296
1990	0.1183	0.2817	0.2815	0.2678	0.3084	0.3159	0.2889	0.308	0.308

1991	0.1595	0.3418	0.3484	0.3125	0.3252	0.3111	0.2884	0.2626	0.2626
1992	0.2305	0.4171	0.3991	0.363	0.3811	0.3595	0.3801	0.3609	0.3609
1993	0.2669	0.4557	0.45	0.4488	0.4697	0.4062	0.4266	0.412	0.412
1994	0.2161	0.3603	0.4197	0.4861	0.5134	0.4038	0.3738	0.3279	0.3279
1995	0.1892	0.2925	0.3443	0.434	0.4534	0.4078	0.3976	0.3213	0.3213
1996	0.0701	0.1068	0.1738	0.2199	0.2214	0.2148	0.171	0.1169	0.1169
1997	0.03331	0.05968	0.1386	0.1938	0.2105	0.2126	0.188	0.1373	0.1373
1998	0.03779	0.07588	0.163	0.2321	0.2487	0.2542	0.245	0.1507	0.1507
1999	0.03777	0.06593	0.1461	0.2254	0.2363	0.2355	0.2012	0.1244	0.1244
2000	0.04309	0.06897	0.1394	0.2176	0.2519	0.2569	0.22	0.1369	0.1369
2001	0.03485	0.0486	0.1033	0.1704	0.2111	0.2293	0.2022	0.1418	0.1418
2002	0.0316	0.0413	0.09124	0.1487	0.1934	0.2183	0.2021	0.1718	0.1718
2003	0.03575	0.04474	0.09226	0.1523	0.2171	0.2717	0.2556	0.2131	0.2131
2004	0.04368	0.04813	0.09552	0.1582	0.2419	0.3306	0.4059	0.346	0.346
2005	0.06805	0.07025	0.1157	0.1768	0.2731	0.3734	0.5312	0.5731	0.5731
2006	0.0574	0.05444	0.1042	0.1646	0.2498	0.3245	0.4234	0.5099	0.5099
2007	0.05112	0.04771	0.09997	0.1622	0.2355	0.2949	0.3702	0.4524	0.4524
2008	0.04976	0.04189	0.08907	0.1121	0.1485	0.1772	0.1702	0.2159	0.2159
2009	0.02916	0.02209	0.05689	0.06111	0.07915	0.09585	0.06983	0.09698	0.09698
2010	0.03413	0.02548	0.06377	0.07314	0.08519	0.09988	0.07151	0.08083	0.08083
2011	0.03778	0.02727	0.06997	0.09432	0.112	0.1312	0.1043	0.1068	0.1068
2012	0.05491	0.04466	0.09909	0.1556	0.1949	0.2307	0.2496	0.2599	0.2599
2013	0.04571	0.03861	0.09097	0.1536	0.2162	0.2774	0.3563	0.4014	0.4014
2014	0.05265	0.03647	0.08629	0.1504	0.2195	0.2755	0.3228	0.3915	0.3915
2015	0.05422	0.02808	0.06814	0.1229	0.1953	0.2838	0.4179	0.5698	0.5698
2016	0.06981	0.02995	0.06864	0.1447	0.2197	0.3009	0.4533	0.6859	0.6859
2017	0.05842	0.02284	0.05936	0.1429	0.213	0.2563	0.3197	0.4824	0.4824
2018	0.06088	0.02082	0.06022	0.1459	0.2338	0.2938	0.3962	0.5639	0.5639
2019	0.05309	0.01717	0.05705	0.1356	0.1904	0.2371	0.346	0.5062	0.5062
2020	0.09221	0.02791	0.08446	0.1706	0.2038	0.2092	0.3168	0.5199	0.5199
2021	0.09187	0.0278	0.08431	0.1704	0.2035	0.2089	0.3162	0.5191	0.5191

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

year	ssb	fbar	rec
2010	7.661	-7.753	9.465
2011	11.56	-12.53	15.54
2012	21.39	-26.88	27.13
2013	19.46	-24.83	17.64
2014	12.04	-14.21	3.966
2015	10.54	-11.21	3.418
2016	8.704	-8.299	-18.75
2017	16.73	-22.57	-3.747
2018	9.615	-10.59	-5.563
2019	2.642	-4.247	-5.887
2020	0	0	0
av_5y	8.037	-9.486	-5.089

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	34857881	19566759	62098781	8596428	6509047	11353209	5304809	3812859	7380551	851385	733005	988884	0.1273	0.08904	0.1819	581760	1.461
1948	33168667	19643157	56007315	7398166	5643991	9697544	4507224	3269228	6214025	661466	578381	756488	0.1152	0.0818	0.1622	502100	1.333
1949	27738944	16603093	46343714	6812224	5270800	8804431	4073143	2988470	5551502	724464	634002	827834	0.1399	0.1005	0.1947	508500	1.45
1950	39631096	24197834	64907620	6433639	5058209	8183076	3817484	2856938	5100980	648198	579018	725645	0.1482	0.1092	0.2011	491700	1.307
1951	38360314	23614595	62313739	6293017	5032127	7869846	3376403	2559170	4454607	778325	700391	864930	0.1984	0.1501	0.2624	600400	1.324
1952	38129475	23644950	61486990	6039356	4865442	7496507	3192340	2438907	4178525	834725	754075	924000	0.2198	0.167	0.2892	664400	1.272
1953	43298993	27707974	67662933	5811393	4703122	7180824	2959020	2265210	3865337	835824	754960	925350	0.2336	0.1783	0.3061	698500	1.198
1954	40509210	26015170	63078430	5667463	4601866	6979808	2702263	2056007	3551653	948533	851296	1056877	0.2807	0.2129	0.3701	762900	1.251
1955	34330892	22185594	53125021	5413699	4391804	6673371	2711088	2073292	3545086	844385	751597	948629	0.2528	0.1923	0.3324	806400	1.06
1956	25331383	16360988	39220062	5057134	4114586	6215596	2625707	2012275	3426140	834166	743053	936451	0.25	0.1912	0.3268	675200	1.271
1957	57963495	37135278	90473720	4946212	4037420	6059566	2376135	1820665	3101074	784036	703013	874397	0.27	0.2062	0.3536	682900	1.158
1958	24750757	16120130	3.8e+07	4956761	4029065	6098059	2019640	1548848	2633536	735801	627696	862524	0.2489	0.1918	0.323	670500	1.167
1959	28494509	18051180	44979723	5527220	4545199	6721414	2921352	2257045	3781181	1169672	1012979	1350603	0.2996	0.2313	0.3879	784500	1.519
1960	12367216	7921912	19306960	4627866	3804361	5629630	2512220	1946027	3243147	806359	705369	921808	0.2458	0.1914	0.3158	696200	1.183
1961	53361602	34292842	83033672	4800640	3982820	5786387	2537990	1994375	3229781	769317	684101	865148	0.2739	0.2168	0.346	696700	1.135
1962	28315663	18555381	43209934	4475692	3713501	5394322	1770623	1373269	2282950	729991	635062	839109	0.3158	0.249	0.4007	627800	1.171
1963	34500367	22737402	52348782	5175671	4328076	6189255	2790589	2234463	3485127	595946	513649	691430	0.1878	0.1517	0.2324	716000	0.8602
1964	34525401	22910327	52029083	5113229	4421466	5913223	2514252	2079298	3040190	902274	787863	1033300	0.2936	0.2445	0.3526	871200	1.066
1965	17044568	11298604	25712670	4617448	4077916	5228362	1993503	1678142	2368128	1306082	1151653	1481218	0.532	0.4503	0.6286	1168800	1.15
1966	18512296	12357458	27732653	3461372	3071396	3900863	1595712	1354624	1879707	933917	833911	1045917	0.4942	0.4218	0.579	895500	1.071
1967	25695882	17067719	38685800	2677224	2387640	3001930	957124	821887	1114612	833276	743404	934012	0.6887	0.5966	0.795	695500	1.176
1968	22010621	14742297	32862413	2275807	1999454	2590355	524139	448778	612154	914094	783434	1066546	1.083	0.9548	1.227	717800	1.255
1969	12613954	8330232	19100529	1689138	1460128	1954066	479677	394011	583968	502642	428863	589113	0.8835	0.7721	1.011	546700	0.9674
1970	22028340	14562338	33322106	1661830	1443715	1912898	455651	374003	555124	549385	473129	637931	0.9612	0.8452	1.093	563100	0.9657
1971	17203786	11504088	25727398	1469094	1250025	1726555	285726	236130	345738	525013	425292	648116	1.419	1.257	1.602	520100	1.075
1972	12689647	8425304	19112326	1324939	1138786	1541521	329391	272004	398884	394104	320627	484421	0.6197	0.5367	0.7156	497500	0.9197
1973	6837978	4553638	10268262	1106662	969162	1263670	278904	232982	333878	444968	374574	528592	0.9478	0.8332	1.078	484000	0.9575
1974	10910155	7148470	16651325	777475	676502	893519	191534	160941	227942	270959	233064	315015	0.9035	0.7917	1.031	275100	0.968
1975	2523737	1641013	3881290	615050	514217	735656	105793	87481	127939	270875	215506	340468	1.19	1.026	1.379	312800	0.9343
1976	3316846	2086489	5272720	453291	379076	542036	145064	110119	191098	159746	135463	188383	0.876	0.6861	1.119	174800	0.953
1977	4408473	2705689	7182878	318237	250457	404361	109640	79690	150847	52020	44214	61204	0.3319	0.242	0.4553	46000	1.198
1978	4284612	2600765	7058655	378021	288753	494886	136400	99908	186220	45455	26090	79192	0.2273	0.1421	0.3634	11000	.
1979	7817493	4920897	12419116	497105	394024	627153	186512	142851	243517	59261	33417	105092	0.1876	0.116	0.3033	25100	.
1980	12579125	8414357	18805284	667866	547932	814052	210081	167595	263337	80479	63254	102394	0.1665	0.132	0.21	70764	1.094
1981	27479729	18469675	40885155	1090857	890505	1336285	269723	215918	336935	147016	113201	190933	0.2516	0.2008	0.3153	174879	1.008
1982	46668043	31440694	69270296	1709514	1386183	2108264	383532	311037	472923	240514	175414	329775	0.1921	0.156	0.2366	275079	0.9786
1983	46332060	31905307	67282218	2349000	1948754	2831450	547127	447195	669392	384092	286229	515414	0.271	0.2235	0.3285	387202	1.077
1984	46430895	32037057	67291699	3116775	2649209	3666864	901451	736525	1103309	476438	387542	585725	0.3546	0.2956	0.4255	428631	1.054
1985	54857205	37752875	79710828	3551311	3049640	4135508	989707	816985	1198946	638933	546279	747303	0.4534	0.3787	0.5427	613780	1.042
1986	66589031	45655076	97121708	3949550	3370944	4627472	1026633	852629	1236147	717723	579583	888788	0.4182	0.349	0.5011	671488	1.137
1987	57753733	39661767	84098463	3935883	3387080	4573607	1202006	999625	1445361	767766	631803	932989	0.3986	0.3344	0.4752	792058	1.017
1988	37584120	25872048	54598154	3804949	3314623	4367809	1526300	1274147	1828354	880877	726450	1068130	0.3857	0.3255	0.4571	887686	1.164
1989	29601203	20385974	42982062	3441500	3053242	3879130	1575946	1352002	1836983	810108	701556	935457	0.376	0.3212	0.4403	787899	1.034
1990	27314412	18745128	39801121	3440816	3050789	3880706	1727079	1485408	2008069	632116	552214	723580	0.2925	0.2486	0.3441	645229	1.052
1991	29768324	20468236	43294065	3305793	2935077	3723332	1531311	1322180	1773521	685358	590845	794991	0.3171	0.2702	0.3723	658008	1.02
1992	52687967	37928528	73190868	3285883	2909769	3710613	1164571	1002480	1352872	708253	606169	827529	0.3765	0.3204	0.4425	716799	0.995
1993	55478713	39723675	77482447	3064196	2678580	3505326	828950	706094	973180	710257	598953	842246	0.4403	0.3732	0.5194	671397	1.023
1994	42818450	30532864	60047418	2959153	2553989	3428592	881872	749630	1037441	716297	578074	887570	0.4394	0.3725	0.5182	568234	1.05

1995	44509451	31612411	62668149	2780497	2406022	3213256	914363	771554	1083605	613167	521566	720854	0.4074	0.3422	0.4851	579371	1.008
1996	35721124	25470068	50097970	2728764	2344717	3175714	1072305	906626	1268260	266844	233359	305134	0.2002	0.1667	0.2404	275098	0.9987
1997	29399447	20852487	41449611	2816091	2437221	3253858	1239664	1052633	1459925	275177	243957	310392	0.1887	0.1575	0.226	264313	1.001
1998	18671594	13526686	25773379	3096764	2700347	3551377	1417070	1213544	1654729	377596	335404	425096	0.2286	0.1914	0.273	391628	1.002
1999	57118961	41264064	79065787	3150087	2762064	3592621	1513149	1297362	1764826	354680	315688	398488	0.2089	0.1759	0.2482	363163	1
2000	39913773	29077194	54788963	3755815	3266497	4318433	1532129	1314553	1785716	382515	340382	429864	0.2172	0.1826	0.2582	388157	1
2001	69493485	49864872	96848626	4214997	3666979	4844915	1920016	1647772	2237239	371748	332093	416139	0.1833	0.1539	0.2182	374065	0.9901
2002	36544676	26433923	50522707	5042634	4373540	5814091	2384603	2046244	2778911	395321	352979	442741	0.1708	0.1435	0.2032	394709	0.9974
2003	20448136	14871253	28116411	5286370	4604284	6069503	2330323	2012177	2698770	484912	436651	538508	0.1978	0.1668	0.2345	482281	1.015
2004	23148557	16788901	31917259	4631565	4083650	5252996	2303309	1994338	2660148	588693	531397	652165	0.2464	0.2075	0.2927	587698	0.9985
2005	20618261	15067739	28213438	3838831	3403381	4329996	2083193	1793322	2419918	662297	597533	734080	0.294	0.2482	0.3483	663813	1.003
2006	21102267	15375183	28962627	3221594	2854360	3636076	1695789	1462083	1966853	512080	461799	567835	0.2533	0.2135	0.3005	514597	0.995
2007	24216457	17496090	33518163	2676715	2363501	3031435	1337668	1149238	1556993	399258	359987	442813	0.2325	0.1951	0.2771	406482	1.006
2008	21414758	15415186	29749358	2719618	2378252	3109983	1434468	1234043	1667445	257730	231318	287158	0.1394	0.1172	0.1659	257870	1.004
2009	35173993	25412040	48685969	3180979	2765919	3658324	1780448	1528170	2074372	165178	148207	184092	0.07257	0.06066	0.0868	168443	1.002
2010	27075893	19615768	37373198	3817217	3322813	4385185	1898246	1624846	2217649	186563	167820	207399	0.0787	0.06593	0.09394	187611	1.003
2011	24662241	17956491	33872215	3805239	3339474	4335966	2221861	1926424	2562606	228659	206707	252943	0.1024	0.08637	0.1213	226478	0.9938
2012	22821042	16602006	31369702	3730300	3296404	4221308	2264241	1964970	2609092	432753	391569	478269	0.186	0.1572	0.22	434710	1.011
2013	30576450	22064920	42371298	3633498	3224810	4093980	2077294	1805613	2389854	499198	452360	550886	0.2189	0.1851	0.2588	511416	1.001
2014	47591435	34146390	66330428	3880489	3433813	4385269	2053097	1782519	2364749	508899	460990	561786	0.2109	0.1783	0.2495	517356	1.003
2015	13105001	9386471	18296659	4053495	3551127	4626931	1909564	1653864	2204797	486016	439208	537812	0.2176	0.1829	0.2588	494099	1.002
2016	23845023	17320888	32826558	4009190	3509912	4579489	2194754	1890684	2547726	549483	497245	607208	0.2375	0.1996	0.2825	563610	1
2017	14290297	10293992	19838037	3482791	3056497	3968542	2024908	1736379	2361382	469415	420541	523968	0.1983	0.1669	0.2355	498437	1.001
2018	25779018	18620703	35689189	3326421	2925479	3782313	1821019	1554109	2133770	553266	492911	621011	0.226	0.1899	0.269	603536	1.001
2019	22973841	16181616	32617099	2857195	2504853	3259098	1554082	1321951	1826974	427510	383572	476480	0.1932	0.1606	0.2326	442138	1.002
2020	24676160	17021651	35772844	2852471	2441175	3333064	1509337	1255290	1814799	422345	378273	471552	0.197	0.1597	0.2429	426900	1.003
2021	30422344	16949010	54606082	2806426	2235661	3522907	1461740	1094737	1951778	407544	220419	753532	0.1967	0.09847	0.3928	.	.

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 ).  Tue Sep 07 09:28:12 2021"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2021         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	1.235	0.1814	0.8656	1.762
catch A	2	0.1649	0.1222	0.1298	0.2095
catch A	3	0.1649	0.1222	0.1298	0.2095
catch A	4	0.1649	0.1222	0.1298	0.2095
catch A	5	0.1649	0.1222	0.1298	0.2095
catch A	6	0.1649	0.1222	0.1298	0.2095
catch A	7	0.1751	0.23	0.1115	0.2747
catch A	8	0.1751	0.23	0.1115	0.2747
catch BD	0	0.4011	0.2169	0.2622	0.6136
catch BD	1	0.3147	0.317	0.1691	0.5858
catch BD	2	1.455	0.09095	1.218	1.739
catch BD	3	1.455	0.09095	1.218	1.739
catch BD	4	1.455	0.09095	1.218	1.739
catch BD	5	1.455	0.09095	1.218	1.739
catch C	1	0.7248	0.1789	0.5104	1.029
catch C	2	0.5464	0.1631	0.3969	0.7521
catch C	3	0.6662	0.09645	0.5515	0.8048
catch C	4	0.6662	0.09645	0.5515	0.8048
catch C	5	0.6662	0.09645	0.5515	0.8048
catch C	6	0.6662	0.09645	0.5515	0.8048
HERAS	1	0.4683	0.1544	0.346	0.6338
HERAS	2	0.2679	0.1524	0.1987	0.3612
HERAS	3	0.1481	0.2006	0.09993	0.2194
HERAS	4	0.2241	0.1024	0.1834	0.2739
HERAS	5	0.2241	0.1024	0.1834	0.2739
HERAS	6	0.2241	0.1024	0.1834	0.2739
HERAS	7	0.3124	0.1227	0.2456	0.3973
HERAS	8	0.3124	0.1227	0.2456	0.3973
IBTS-Q1	1	0.2884	0.1466	0.2164	0.3843
IBTS0	0	0.3313	0.1703	0.2373	0.4627
IBTS-Q3	0	0.4989	0.133	0.3844	0.6474
IBTS-Q3	1	0.4989	0.133	0.3844	0.6474
IBTS-Q3	2	0.3142	0.09695	0.2598	0.3799
IBTS-Q3	3	0.3142	0.09695	0.2598	0.3799
IBTS-Q3	4	0.3142	0.09695	0.2598	0.3799
IBTS-Q3	5	0.3142	0.09695	0.2598	0.3799
LAI-ORSH	0	1.188	0.04383	1.09	1.295
LAI-BUN	0	1.188	0.04383	1.09	1.295
LAI-CNS	0	1.188	0.04383	1.09	1.295
LAI-SNS	0	1.188	0.04383	1.09	1.295

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

fleet	age	value	CV	lbnd	ubnd
HERAS	1	0.9806	0.06662	0.8606	1.117
HERAS	2	0.9806	0.06662	0.8606	1.117
HERAS	3	1.12	0.05628	1.003	1.251
HERAS	4	1.12	0.05628	1.003	1.251
HERAS	5	1.12	0.05628	1.003	1.251
HERAS	6	1.12	0.05628	1.003	1.251
HERAS	7	1.12	0.05628	1.003	1.251

HERAS	8	1.12	0.05628	1.003	1.251
IBTS-Q1	1	0.1058	0.06779	0.09263	0.1208
IBTS0	0	3.314e-06	0.08558	2.802e-06	3.919e-06
IBTS-Q3	0	0.09559	0.1232	0.07509	0.1217
IBTS-Q3	1	0.04727	0.1194	0.0374	0.05973
IBTS-Q3	2	0.0433	0.08593	0.03658	0.05124
IBTS-Q3	3	0.03905	0.08515	0.03305	0.04614
IBTS-Q3	4	0.03252	0.08668	0.02744	0.03855
IBTS-Q3	5	0.0257	0.08786	0.02163	0.03053
LAI-ORSH	0	0.01635	0.1081	0.01323	0.02021
LAI-BUN	0	0.01635	0.1081	0.01323	0.02021
LAI-CNS	0	0.01635	0.1081	0.01323	0.02021
LAI-SNS	0	0.01635	0.1081	0.01323	0.02021

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	36091481	13537986	11419270	4906003	6771170	4278003	3792063	2028300	6168982
1948	33892967	16747602	7721976	7096065	3233478	4630114	2817765	2146830	4716763
1949	29482668	15747707	10840706	6315130	3821370	2078438	2978002	1774239	4062359
1950	40713854	13032597	9022685	8801495	4722514	2231857	1317625	1659443	3031159
1951	39447205	19375290	7061589	6114746	6445599	3353337	1414674	765467	2590145
1952	39156492	18115137	10834057	4165225	3605070	3702166	2042932	888102	2113075
1953	42927945	17841436	9660711	5980171	2695345	2114195	2175972	1161995	1660588
1954	40277237	20260646	9279772	5396124	3228220	1714130	1241904	1246920	1625204
1955	34677907	18040393	10902054	5261859	2763714	1836646	1041615	660316	1367198
1956	25929688	16113744	8468302	6169191	2916780	1525471	1072585	579509	1366827
1957	62903615	10988244	8088320	3825194	3538412	1694659	946012	661106	1168651
1958	26015253	34415399	4764022	4446586	1926867	2186966	946202	552439	1016390
1959	28936224	11551266	19559816	2218161	2332830	1107593	1171670	574716	1201679
1960	11961545	14457870	5244857	10804626	1094388	1198107	608071	623279	1103488
1961	56408557	4155489	7076768	2513496	7057165	677366	813566	348253	886431
1962	27848991	28524405	1705113	3133741	1385792	4315488	422969	528467	723846
1963	32461643	12872292	16621827	1029158	1305593	705695	2299353	207530	714308
1964	34432572	14405591	6611881	9662082	668640	757897	510141	1570801	561899
1965	17667215	16540035	5939055	3422440	5331110	392987	428468	323545	1397267
1966	17973901	8061377	7546474	2142145	1383116	2271615	176253	189890	851307
1967	23845334	7703018	3624379	3202467	841274	657552	877271	103098	468748
1968	23563186	10655836	3020820	1710265	1164615	291195	253130	275645	166515
1969	12455812	10436828	4297248	674243	306660	347820	78206	64946	95037
1970	23548155	5676028	4165422	1477186	204458	96988	112855	16228	42994
1971	19092786	10723280	2379198	1239441	377686	54962	29794	30434	17441
1972	12963480	8598963	3344744	755619	308239	95295	14423	1056	6484
1973	6834120	5549185	2627256	1156108	294120	123221	45547	7655	4442
1974	10923746	2754597	1547868	751638	267558	97135	40175	11350	5342
1975	2557935	5203388	902742	439282	230250	79788	28427	11877	5940
1976	3277208	864743	1782557	211506	90500	60730	14704	6472	2531
1977	4025291	1366855	336963	595729	53563	25527	18859	4936	2300
1978	4503801	1709767	670603	244794	253649	32838	12024	10367	3599
1979	8387216	1716219	835159	393597	183642	128751	22231	7408	7909
1980	13108018	3282945	774296	468599	226890	151486	68687	18170	8740
1981	27856842	4898919	1682719	354937	228450	138288	115301	58097	21575
1982	46737392	7967678	2020252	1035541	206700	128019	78377	70689	41951
1983	45668757	14282291	3297683	1127311	518752	129511	102982	53619	84885
1984	45787494	12751735	6006435	1819224	677337	274148	81267	67939	82699
1985	56566615	14565602	5550546	3446775	984486	357397	126672	47664	75758
1986	68930718	20642346	5319577	2881961	1539936	433891	168170	54806	61361
1987	61633334	26894194	8738396	2586204	1513551	769584	221895	76154	50639
1988	37750826	20609055	10126589	4597600	1333445	793428	388931	111889	66759
1989	30447113	12864632	6909331	5474249	2610375	690060	398524	192997	89372
1990	26908664	10271549	4412055	3897152	3539332	1514066	368985	213784	159192
1991	28853211	10292969	3981332	2280447	2278195	2106802	859787	208327	195166
1992	50993334	9931273	4441082	1778602	1305928	1305177	1254569	514500	239156
1993	52752166	15984005	3692692	1993886	929194	711849	716200	617470	397894
1994	41736350	15757145	5851567	1419262	827526	404655	335491	321853	453874
1995	42929269	13691273	6253101	2577217	709028	358765	198032	164562	363489
1996	33541123	13579029	5506426	3028952	1097418	336417	153199	95812	252413

1997	28452121	12735361	5915109	3053871	1578718	643347	202503	94529	206236
1998	18700856	11768659	8368506	3094144	1485205	847659	425954	129960	170551
1999	58576494	8171523	5470861	5155315	1652811	762989	424337	230322	151731
2000	37457677	23745948	5331188	2918284	3001151	963278	471727	259476	214050
2001	71084548	14148937	11574084	3500775	1673485	1632544	495439	267785	278770
2002	35817477	30065432	7558108	7985823	1902660	929551	1000762	298859	305067
2003	19252232	13732759	17222656	4372504	4953816	1056444	575743	620315	320950
2004	23056724	7146961	6024821	10643525	2943829	2989108	561343	364738	474891
2005	20430347	9782878	3637821	3882870	6386121	1745904	1622756	280714	407420
2006	21196987	7129946	4924001	2422099	2404704	4006409	861169	726915	291305
2007	24753162	7650218	3181929	2753871	1504725	1366982	2178186	441314	470394
2008	21897784	8911414	4352073	2079129	1639224	951523	834117	1375893	559880
2009	34023642	8739793	5242496	2616966	1381362	1074350	646791	608817	1507352
2010	2.7e+07	12556971	5487596	3773919	1902986	1034358	893398	490537	1628971
2011	24556210	10971971	6623126	3494297	2410555	1219836	710231	599378	1394813
2012	23216549	9103396	5860433	4820674	2607562	1671873	795502	471464	1136899
2013	31314955	8509017	4461268	4022213	3359386	1919569	1153011	496083	1005168
2014	47217742	13703536	5284538	3115163	3209723	2256970	1218244	677968	747092
2015	12565961	18431868	9402443	3004136	1937090	2037286	1354797	707957	806723
2016	23054821	4848165	11460624	6771575	1878578	1203080	1151361	694408	723170
2017	13617840	8535408	2476825	7842427	4736203	1255250	613032	546511	602183
2018	25135181	5557960	4201897	1891115	5628850	3243826	795445	401184	692790
2019	21266861	10193587	2437991	2650224	1433774	3436581	1899687	418589	552584
2020	24819948	9127402	6477433	1589571	1807318	1026679	2034066	941348	463095
2021	30078264	10478907	5229951	4201018	978802	1094204	612548	1099645	628494

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	0.002595	0.04858	0.106	0.1215	0.1566	0.2469	0.2765	0.2765
1948	0	0.002526	0.04615	0.1036	0.1205	0.1525	0.2219	0.2505	0.2505
1949	0	0.002836	0.05697	0.1205	0.1404	0.1755	0.2779	0.3254	0.3254
1950	0	0.003288	0.07406	0.1399	0.1569	0.1779	0.239	0.2586	0.2586
1951	0	0.004201	0.1139	0.1897	0.2047	0.2124	0.2512	0.2479	0.2479
1952	0	0.004758	0.1416	0.2051	0.2162	0.231	0.3027	0.331	0.331
1953	0	0.005246	0.1677	0.2223	0.2199	0.2324	0.2923	0.3155	0.3155
1954	0	0.006037	0.2145	0.2665	0.2521	0.2691	0.3714	0.3963	0.3963
1955	0	0.006218	0.2253	0.2528	0.2244	0.2299	0.2591	0.2366	0.2366
1956	0	0.006744	0.2594	0.2662	0.2267	0.2284	0.246	0.2422	0.2422
1957	0	0.007011	0.2772	0.2796	0.2416	0.253	0.2803	0.2707	0.2707
1958	0	0.007117	0.2841	0.2745	0.2262	0.2257	0.199	0.171	0.171
1959	0	0.007689	0.3251	0.3109	0.2647	0.2656	0.2922	0.287	0.287
1960	0	0.00696	0.2721	0.2524	0.2143	0.2163	0.2388	0.2646	0.2646
1961	0	0.007306	0.2961	0.284	0.2435	0.2362	0.2418	0.2322	0.2322
1962	0	0.007253	0.2917	0.323	0.2941	0.2998	0.3572	0.3415	0.3415
1963	0	0.005997	0.2078	0.2134	0.1776	0.1723	0.1299	0.1401	0.1401
1964	0	0.007479	0.3062	0.3229	0.2753	0.2645	0.2142	0.2094	0.2094
1965	0	0.01026	0.535	0.5924	0.5165	0.5009	0.5031	0.5109	0.5109
1966	0	0.009665	0.4801	0.5564	0.4881	0.4893	0.4256	0.5058	0.5058
1967	0	0.01077	0.5802	0.7332	0.6652	0.6866	0.79	0.9429	0.9429
1968	0	0.01467	1.001	1.237	0.9938	0.9478	1.196	1.224	1.224
1969	0	0.01242	0.7437	0.9224	0.8243	0.8471	1.196	1.062	1.062
1970	0	0.01296	0.801	0.9927	0.891	0.8534	1.193	0.9141	0.9141
1971	0	0.0138	0.8929	1.129	1.093	1.177	2.859	1.751	1.751
1972	0	0.01103	0.5996	0.68	0.5714	0.5327	0.5198	0.3139	0.3139
1973	0	0.01361	0.8685	1.018	0.8618	0.8606	1.046	0.7057	0.7057
1974	0	0.01316	0.8179	0.9587	0.8426	0.8973	0.937	0.8298	0.8298
1975	0	0.01492	1.02	1.27	1.112	1.213	1.321	1.602	1.602
1976	0	0.01235	0.7292	0.9867	0.8525	0.8981	0.8186	1.108	1.108
1977	0	0.00671	0.2474	0.367	0.3258	0.3803	0.2574	0.4082	0.4082
1978	0	0.005816	0.1918	0.2634	0.2285	0.2501	0.1306	0.2182	0.2182
1979	0	0.005558	0.1768	0.2272	0.1859	0.1881	0.07807	0.1321	0.1321
1980	0	0.005594	0.1786	0.2161	0.1673	0.1519	0.05139	0.08457	0.08457
1981	0	0.006217	0.215	0.2757	0.2521	0.2643	0.2061	0.3542	0.3542
1982	0	0.005514	0.1735	0.2209	0.1921	0.1752	0.1028	0.1472	0.1472
1983	0	0.00613	0.209	0.2745	0.2753	0.2731	0.2405	0.326	0.326
1984	0	0.006805	0.2511	0.3416	0.3738	0.376	0.3805	0.4877	0.4877

1985	0	0.007784	0.3181	0.4311	0.4791	0.4688	0.5201	0.5888	0.5888
1986	0	0.007581	0.3032	0.3885	0.4405	0.4464	0.52	0.5842	0.5842
1987	0	0.007341	0.286	0.3481	0.4048	0.4151	0.4451	0.4567	0.4567
1988	0	0.007131	0.2715	0.3207	0.3873	0.4102	0.4508	0.4727	0.4727
1989	0	0.007233	0.2781	0.3154	0.3771	0.3913	0.4148	0.4298	0.4298
1990	0	0.006783	0.2481	0.2651	0.3042	0.3103	0.2918	0.3122	0.3122
1991	0	0.007539	0.299	0.3041	0.3214	0.3063	0.2803	0.2636	0.2636
1992	0	0.00812	0.3409	0.3587	0.3807	0.3586	0.378	0.3641	0.3641
1993	0	0.008833	0.3955	0.4461	0.4671	0.4117	0.4455	0.4248	0.4248
1994	0	0.008624	0.3792	0.4734	0.4933	0.4055	0.395	0.3443	0.3443
1995	0	0.007437	0.2916	0.4097	0.4372	0.3942	0.4031	0.3371	0.3371
1996	0	0.004749	0.1317	0.1971	0.2098	0.2005	0.1513	0.1149	0.1149
1997	0	0.00427	0.1091	0.1756	0.1902	0.185	0.1441	0.1117	0.1117
1998	0	0.004841	0.1356	0.2255	0.2419	0.2401	0.2181	0.1422	0.1422
1999	0	0.004542	0.1199	0.2156	0.2309	0.2272	0.1885	0.1169	0.1169
2000	0	0.004328	0.1093	0.2065	0.2353	0.2368	0.1952	0.1265	0.1265
2001	0	0.003681	0.08146	0.1639	0.2032	0.2233	0.1979	0.1682	0.1682
2002	0	0.003355	0.06865	0.1407	0.1852	0.2126	0.1936	0.1733	0.1733
2003	0	0.003337	0.06751	0.1457	0.2066	0.2553	0.2478	0.2149	0.2149
2004	0	0.003213	0.06295	0.1455	0.2246	0.3015	0.3685	0.3273	0.3273
2005	0	0.00352	0.07289	0.1646	0.262	0.358	0.5222	0.5548	0.5548
2006	0	0.003706	0.07895	0.1674	0.2528	0.3283	0.4461	0.5148	0.5148
2007	0	0.003632	0.07522	0.1558	0.2271	0.2872	0.3715	0.4449	0.4449
2008	0	0.003397	0.06596	0.1121	0.1495	0.1806	0.176	0.2217	0.2217
2009	0	0.002775	0.04591	0.06802	0.08642	0.1046	0.07734	0.1061	0.1061
2010	0	0.002854	0.04805	0.07269	0.08638	0.1014	0.07167	0.08548	0.08548
2011	0	0.003118	0.0562	0.09337	0.1126	0.1315	0.1028	0.1115	0.1115
2012	0	0.003847	0.08106	0.1512	0.1909	0.2259	0.2428	0.2601	0.2601
2013	0	0.003588	0.07149	0.1491	0.2105	0.2685	0.3465	0.4002	0.4002
2014	0	0.003444	0.06727	0.1455	0.2107	0.2663	0.3256	0.3941	0.3941
2015	0	0.003051	0.05538	0.1271	0.1974	0.2761	0.4059	0.5552	0.5552
2016	0	0.003052	0.05626	0.1441	0.2194	0.2982	0.4598	0.6762	0.6762
2017	0	0.002715	0.04597	0.1316	0.1991	0.2496	0.3241	0.4732	0.4732
2018	0	0.002866	0.05072	0.1452	0.2256	0.2862	0.4022	0.5718	0.5718
2019	0	0.002684	0.04519	0.1276	0.1867	0.2409	0.3535	0.5208	0.5208
2020	0	0.003418	0.06886	0.1659	0.2072	0.2321	0.3427	0.5358	0.5358
2021	0	0.003418	0.06886	0.1659	0.2072	0.232	0.3427	0.5358	0.5358

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	0.001193	0.001183	0.000465	0.0008502	0.0008502	0.0008502	0	0	0
1948	0.001156	0.001087	0.0004452	0.0008363	0.0008363	0.0008363	0	0	0
1949	0.001772	0.00342	0.0007752	0.00108	0.00108	0.00108	0	0	0
1950	0.002595	0.009533	0.001289	0.001368	0.001368	0.001368	0	0	0
1951	0.003652	0.02385	0.002052	0.001699	0.001699	0.001699	0	0	0
1952	0.004615	0.04468	0.002813	0.001919	0.001919	0.001919	0	0	0
1953	0.005405	0.06832	0.003474	0.002088	0.002088	0.002088	0	0	0
1954	0.006514	0.0953	0.004092	0.002218	0.002218	0.002218	0	0	0
1955	0.006802	0.1382	0.004946	0.002386	0.002386	0.002386	0	0	0
1956	0.006237	0.1414	0.005062	0.00236	0.00236	0.00236	0	0	0
1957	0.006939	0.1708	0.005516	0.002427	0.002427	0.002427	0	0	0
1958	0.007493	0.1548	0.005297	0.002357	0.002357	0.002357	0	0	0
1959	0.01193	0.1859	0.005744	0.002385	0.002385	0.002385	0	0	0
1960	0.01829	0.199	0.005872	0.002327	0.002327	0.002327	0	0	0
1961	0.01871	0.1365	0.004885	0.00213	0.00213	0.00213	0	0	0
1962	0.01239	0.1002	0.004085	0.001958	0.001958	0.001958	0	0	0
1963	0.0164	0.1427	0.004824	0.002085	0.002085	0.002085	0	0	0
1964	0.02006	0.2514	0.006342	0.002415	0.002415	0.002415	0	0	0
1965	0.01912	0.245	0.006288	0.002446	0.002446	0.002446	0	0	0
1966	0.0263	0.2585	0.006398	0.002493	0.002493	0.002493	0	0	0
1967	0.03397	0.3225	0.007011	0.002617	0.002617	0.002617	0	0	0
1968	0.03639	0.3408	0.007263	0.002669	0.002669	0.002669	0	0	0
1969	0.02749	0.3165	0.006982	0.002613	0.002613	0.002613	0	0	0
1970	0.04183	0.3537	0.007382	0.00269	0.00269	0.00269	0	0	0
1971	0.05766	0.571	0.009239	0.002976	0.002976	0.002976	0	0	0
1972	0.07493	0.6284	0.009794	0.003073	0.003073	0.003073	0	0	0
1973	0.08549	0.6603	0.009973	0.003106	0.003106	0.003106	0	0	0
1974	0.1128	0.5532	0.009103	0.002978	0.002978	0.002978	0	0	0

1975	0.1446	0.5351	0.008851	0.002945	0.002945	0.002945	0	0	0
1976	0.1159	0.2432	0.005929	0.002427	0.002427	0.002427	0	0	0
1977	0.1089	0.1473	0.004503	0.002109	0.002109	0.002109	0	0	0
1978	0.1333	0.1325	0.004363	0.00206	0.00206	0.00206	0	0	0
1979	0.1604	0.1235	0.00433	0.002042	0.002042	0.002042	0	0	0
1980	0.1932	0.1116	0.004258	0.002019	0.002019	0.002019	0	0	0
1981	0.3787	0.2173	0.005755	0.002257	0.002257	0.002257	0	0	0
1982	0.3758	0.2095	0.005726	0.002234	0.002234	0.002234	0	0	0
1983	0.3663	0.2363	0.006198	0.002308	0.002308	0.002308	0	0	0
1984	0.2362	0.2166	0.006149	0.002315	0.002315	0.002315	0	0	0
1985	0.1595	0.2847	0.007363	0.002525	0.002525	0.002525	0	0	0
1986	0.1276	0.2917	0.007884	0.002578	0.002578	0.002578	0	0	0
1987	0.1612	0.3759	0.009472	0.002793	0.002793	0.002793	0	0	0
1988	0.1569	0.4774	0.01127	0.003002	0.003002	0.003002	0	0	0
1989	0.1458	0.4008	0.01132	0.002975	0.002975	0.002975	0	0	0
1990	0.1235	0.351	0.01179	0.002982	0.002982	0.002982	0	0	0
1991	0.1552	0.2881	0.01234	0.003014	0.003014	0.003014	0	0	0
1992	0.247	0.3355	0.01458	0.003248	0.003248	0.003248	0	0	0
1993	0.2734	0.31	0.01544	0.003357	0.003357	0.003357	0	0	0
1994	0.1989	0.1668	0.01249	0.00306	0.00306	0.00306	0	0	0
1995	0.1827	0.1467	0.01265	0.003084	0.003084	0.003084	0	0	0
1996	0.09692	0.0948	0.01122	0.002876	0.002876	0.002876	0	0	0
1997	0.03775	0.034	0.0081	0.002459	0.002459	0.002459	0	0	0
1998	0.03118	0.03169	0.008363	0.002438	0.002438	0.002438	0	0	0
1999	0.0344	0.02215	0.007688	0.002357	0.002357	0.002357	0	0	0
2000	0.04016	0.02387	0.008003	0.002139	0.002139	0.002139	0	0	0
2001	0.03014	0.009028	0.005286	0.001628	0.001628	0.001628	0	0	0
2002	0.03664	0.02214	0.008229	0.001563	0.001563	0.001563	0	0	0
2003	0.03951	0.03352	0.00916	0.001156	0.001156	0.001156	0	0	0
2004	0.04888	0.03866	0.009738	0.0009579	0.0009579	0.0009579	0	0	0
2005	0.06724	0.05172	0.009722	0.0006447	0.0006447	0.0006447	0	0	0
2006	0.05531	0.02546	0.006466	0.0004543	0.0004543	0.0004543	0	0	0
2007	0.04106	0.01388	0.003501	0.0001755	0.0001755	0.0001755	0	0	0
2008	0.04247	0.01452	0.002686	0.0001009	0.0001009	0.0001009	0	0	0
2009	0.03626	0.0145	0.002594	0.000129	0.000129	0.000129	0	0	0
2010	0.0376	0.01356	0.002795	0.0002424	0.0002424	0.0002424	0	0	0
2011	0.0431	0.01618	0.002597	0.0002345	0.0002345	0.0002345	0	0	0
2012	0.04586	0.02258	0.003501	0.0003167	0.0003167	0.0003167	0	0	0
2013	0.0361	0.01948	0.003457	0.0003033	0.0003033	0.0003033	0	0	0
2014	0.04544	0.01999	0.003234	0.000273	0.000273	0.000273	0	0	0
2015	0.06234	0.02239	0.002532	0.0001554	0.0001554	0.0001554	0	0	0
2016	0.07972	0.02485	0.002417	0.0001483	0.0001483	0.0001483	0	0	0
2017	0.06669	0.01692	0.001473	7.631e-05	7.631e-05	7.631e-05	0	0	0
2018	0.06802	0.01094	0.001048	7.599e-05	7.599e-05	7.599e-05	0	0	0
2019	0.05924	0.006744	0.0008703	0.0001058	0.0001058	0.0001058	0	0	0
2020	0.07518	0.003959	0.0008888	0.0001773	0.0001773	0.0001773	0	0	0
2021	0.0751	0.003956	0.0008885	0.0001773	0.0001773	0.0001773	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	0.0002726	0.0007331	2.531e-07	1.802e-07	1.802e-07	1.802e-07	0	0
1948	0	0.0002689	0.0007254	2.451e-07	1.747e-07	1.747e-07	1.747e-07	0	0
1949	0	0.0003095	0.0008074	3.398e-07	2.398e-07	2.398e-07	2.398e-07	0	0
1950	0	0.0003556	0.0008976	4.691e-07	3.279e-07	3.279e-07	3.279e-07	0	0
1951	0	0.0004075	0.000996	6.441e-07	4.459e-07	4.459e-07	4.459e-07	0	0
1952	0	0.0004647	0.001101	8.745e-07	5.999e-07	5.999e-07	5.999e-07	0	0
1953	0	0.0005271	0.001212	1.172e-06	7.969e-07	7.969e-07	7.969e-07	0	0
1954	0	0.0005962	0.001331	1.56e-06	1.052e-06	1.052e-06	1.052e-06	0	0
1955	0	0.0006743	0.001462	2.076e-06	1.387e-06	1.387e-06	1.387e-06	0	0
1956	0	0.0007609	0.001603	2.749e-06	1.822e-06	1.822e-06	1.822e-06	0	0
1957	0	0.0008552	0.001752	3.604e-06	2.368e-06	2.368e-06	2.368e-06	0	0
1958	0	0.0009602	0.001913	4.713e-06	3.072e-06	3.072e-06	3.072e-06	0	0
1959	0	0.001076	0.002086	6.129e-06	3.964e-06	3.964e-06	3.964e-06	0	0
1960	0	0.001202	0.00227	7.934e-06	5.091e-06	5.091e-06	5.091e-06	0	0
1961	0	0.001339	0.002462	1.017e-05	6.475e-06	6.475e-06	6.475e-06	0	0
1962	0	0.001483	0.002661	1.288e-05	8.143e-06	8.143e-06	8.143e-06	0	0

1963	0	0.001667	0.002908	1.689e-05	1.059e-05	1.059e-05	1.059e-05	0	0
1964	0	0.001867	0.003169	2.194e-05	1.365e-05	1.365e-05	1.365e-05	0	0
1965	0	0.002081	0.003442	2.822e-05	1.742e-05	1.742e-05	1.742e-05	0	0
1966	0	0.00231	0.003724	3.588e-05	2.2e-05	2.2e-05	2.2e-05	0	0
1967	0	0.00256	0.004025	4.548e-05	2.768e-05	2.768e-05	2.768e-05	0	0
1968	0	0.002851	0.004369	5.836e-05	3.526e-05	3.526e-05	3.526e-05	0	0
1969	0	0.003163	0.004727	7.42e-05	4.45e-05	4.45e-05	4.45e-05	0	0
1970	0	0.003504	0.005108	9.4e-05	5.597e-05	5.597e-05	5.597e-05	0	0
1971	0	0.003881	0.00552	0.0001191	7.038e-05	7.038e-05	7.038e-05	0	0
1972	0	0.004304	0.005971	0.0001513	8.876e-05	8.876e-05	8.876e-05	0	0
1973	0	0.004742	0.006425	0.0001892	0.0001103	0.0001103	0.0001103	0	0
1974	0	0.005207	0.006896	0.0002347	0.0001359	0.0001359	0.0001359	0	0
1975	0	0.005702	0.007386	0.0002892	0.0001664	0.0001664	0.0001664	0	0
1976	0	0.006204	0.007869	0.0003508	0.0002007	0.0002007	0.0002007	0	0
1977	0	0.006716	0.00835	0.0004203	0.0002391	0.0002391	0.0002391	0	0
1978	0	0.007737	0.009316	0.0005865	0.0003303	0.0003303	0.0003303	0	0
1979	0	0.008867	0.01035	0.0008084	0.0004507	0.0004507	0.0004507	0	0
1980	0	0.01005	0.01141	0.001085	0.0005993	0.0005993	0.0005993	0	0
1981	0	0.01146	0.01261	0.001478	0.000813	0.000813	0.000813	0	0
1982	0	0.0132	0.01407	0.002075	0.001134	0.001134	0.001134	0	0
1983	0	0.01502	0.01554	0.00282	0.001539	0.001539	0.001539	0	0
1984	0	0.01705	0.01713	0.003815	0.002075	0.002075	0.002075	0	0
1985	0	0.01981	0.01924	0.005454	0.002948	0.002948	0.002948	0	0
1986	0	0.02209	0.02092	0.007035	0.003782	0.003782	0.003782	0	0
1987	0	0.02436	0.02256	0.008844	0.004736	0.004736	0.004736	0	0
1988	0	0.0261	0.02376	0.01032	0.005502	0.005502	0.005502	0	0
1989	0	0.02788	0.02499	0.012	0.006354	0.006354	0.006354	0	0
1990	0	0.02915	0.02583	0.01317	0.006908	0.006908	0.006908	0	0
1991	0	0.03191	0.02774	0.0164	0.008486	0.008486	0.008486	0	0
1992	0	0.03311	0.0285	0.01782	0.009135	0.009135	0.009135	0	0
1993	0	0.03512	0.02983	0.02064	0.01045	0.01045	0.01045	0	0
1994	0	0.03633	0.03063	0.02263	0.01135	0.01135	0.01135	0	0
1995	0	0.03779	0.03152	0.02488	0.01235	0.01235	0.01235	0	0
1996	0	0.03723	0.03103	0.02364	0.0116	0.0116	0.0116	0	0
1997	0	0.03604	0.03024	0.02175	0.01053	0.01053	0.01053	0	0
1998	0	0.03263	0.02777	0.01638	0.007984	0.007984	0.007984	0	0
1999	0	0.03062	0.02655	0.01432	0.006866	0.006866	0.006866	0	0
2000	0	0.02888	0.02545	0.01269	0.005925	0.005925	0.005925	0	0
2001	0	0.0155	0.01547	0.00256	0.001073	0.001073	0.001073	0	0
2002	0	0.009867	0.0109	0.0008578	0.0003719	0.0003719	0.0003719	0	0
2003	0	0.01727	0.01736	0.003968	0.001884	0.001884	0.001884	0	0
2004	0	0.01706	0.01741	0.003992	0.001902	0.001902	0.001902	0	0
2005	0	0.01731	0.0175	0.003879	0.001579	0.001579	0.001579	0	0
2006	0	0.01458	0.01521	0.002493	0.000912	0.000912	0.000912	0	0
2007	0	0.01076	0.01192	0.001136	0.0003853	0.0003853	0.0003853	0	0
2008	0	0.007884	0.00939	0.0005666	0.0001857	0.0001857	0.0001857	0	0
2009	0	0.005458	0.00708	0.0002528	8.787e-05	8.787e-05	8.787e-05	0	0
2010	0	0.004849	0.006556	0.0002042	6.779e-05	6.779e-05	6.779e-05	0	0
2011	0	0.006592	0.008662	0.0005513	0.0001741	0.0001741	0.0001741	0	0
2012	0	0.007121	0.009385	0.0007618	0.0002363	0.0002363	0.0002363	0	0
2013	0	0.006717	0.009158	0.0007522	0.000215	0.000215	0.000215	0	0
2014	0	0.007192	0.009948	0.001111	0.0003107	0.0003107	0.0003107	0	0
2015	0	0.009589	0.01283	0.002872	0.0008588	0.0008588	0.0008588	0	0
2016	0	0.006304	0.009237	0.001065	0.0003044	0.0003044	0.0003044	0	0
2017	0	0.007434	0.01056	0.001648	0.0004411	0.0004411	0.0004411	0	0
2018	0	0.006445	0.009466	0.001198	0.0002879	0.0002879	0.0002879	0	0
2019	0	0.005239	0.008015	0.0007057	0.0001395	0.0001395	0.0001395	0	0
2020	0	0.008077	0.0115	0.002398	0.000488	0.000488	0.000488	0	0
2021	0	0.008076	0.0115	0.002397	0.0004878	0.0004878	0.0004878	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	36091481	20694563	62943826	7806568	6112768	9969707	4785959	3562383	6429798	852946	732993	992530	0.1367	0.09951	0.1877	248023
1948	33892967	20471371	56114130	6759839	5329587	8573915	3961165	2973630	5276658	666676	579910	766425	0.1297	0.09572	0.1757	385577
1949	29482668	17966318	48380961	6405088	5105734	8035115	3711112	2819633	4884450	730717	635510	840187	0.1552	0.1154	0.2088	370877
1950	40713854	25327614	65447061	6212986	5010108	7704664	3586841	2770287	4644077	648828	571889	736119	0.1588	0.1201	0.21	382794
1951	39447205	24721360	62944837	6212349	5070928	7610693	3300940	2577536	4227373	752730	662896	854739	0.196	0.1504	0.2555	358657
1952	39156492	24727056	62006206	6088586	4984672	7436975	3198501	2501452	4089788	838397	744619	943985	0.2213	0.1702	0.2876	371955
1953	42927945	27829221	66218470	5896661	4834899	7191589	3012363	2348815	3863367	835572	741703	941321	0.2291	0.1761	0.2981	480107
1954	40277237	26320051	61635740	5753458	4723064	7008645	2762402	2133514	3576664	953119	844264	1076009	0.2771	0.2112	0.3637	570865
1955	34677907	22821171	52694810	5504246	4505804	6723934	2795603	2161681	3615426	843486	737438	964785	0.241	0.1837	0.3162	666404
1956	25929688	17056532	39418840	5086498	4176973	6194068	2642466	2045193	3414165	838285	734299	956998	0.2481	0.1899	0.3241	524366
1957	62903615	4.1e+07	96501658	5053355	4164444	6132007	2392255	1851306	3091270	800990	704530	910655	0.2693	0.206	0.3518	408528
1958	26015253	17194987	39359925	5050176	4142359	6156946	2017648	1563358	2603949	749255	635460	883426	0.2447	0.1883	0.3181	259031
1959	28936224	18713703	44742886	5634058	4628457	6858141	2989676	2314602	3861643	1151368	968801	1368340	0.2947	0.2277	0.3814	172685
1960	11961545	7742274	18480173	4741837	3910910	5749307	2602365	2027066	3340938	822161	706008	957423	0.2418	0.1875	0.3118	187508
1961	56408557	36598385	86941686	4843868	4035337	5814399	2558058	2021916	3236366	734422	635844	848282	0.2631	0.2075	0.3336	224148
1962	27848991	18476837	41975058	4533116	3786044	5427602	1773734	1390162	2263142	712678	618479	821225	0.3157	0.2492	0.4	437236
1963	32461643	21878356	48164418	5276785	4408321	6316340	2910800	2324520	3644948	600669	505294	714046	0.183	0.1468	0.2282	511733
1964	34432572	23242774	51009488	5183388	4485970	5989232	2604326	2154520	3148040	915500	782226	1071480	0.28	0.2312	0.3391	517593
1965	17667215	11925776	26172760	4579220	4043115	5186411	1961604	1652746	2328180	1282125	1116340	1472531	0.533	0.4478	0.6344	494072
1966	17973901	12227120	26421686	3463874	3061889	3918634	1602573	1355963	1894033	930956	814037	1064668	0.4914	0.4155	0.5812	564880
1967	23845334	16247292	3.5e+07	2666531	2378117	2989923	963819	824256	1127013	859351	753121	980564	0.6948	0.5962	0.8097	499145
1968	23563186	1.6e+07	34705149	2207696	1942886	2508599	511290	436583	598781	821220	711372	948032	1.079	0.944	1.233	604449
1969	12455812	8354967	18569464	1722707	1483504	2e+06	467784	380337	575336	539444	453002	642381	0.9106	0.7905	1.049	451542
1970	23548155	15874082	34932137	1676959	1446760	1943785	458011	370955	565498	533604	451134	631151	0.9504	0.8279	1.091	434000
1971	19092786	12982740	28078394	1543230	1316058	1809617	286722	234809	350113	554017	449730	682487	1.435	1.268	1.624	.
1972	12963480	8808955	19077383	1381940	1181178	1616824	347030	282335	426547	428000	341480	536441	0.5858	0.4999	0.6864	248023
1973	6834120	4651034	10041895	1114654	970177	1280645	282198	233508	341042	449466	375205	538424	0.9363	0.8147	1.076	385577
1974	10923746	7289607	16369640	781071	679042	898430	192904	160744	231497	274825	234433	322177	0.8958	0.7773	1.032	370877
1975	2557935	1700220	3848343	604249	507741	719101	103834	85532	126053	252645	203317	313940	1.192	1.025	1.387	382794
1976	3277208	2106563	5098397	449711	370821	545385	142830	107173	190349	153385	126110	186559	0.8614	0.6736	1.102	358657
1977	4025291	2524518	6418241	317783	254142	397359	114235	82849	157509	54081	45198	64709	0.3197	0.2325	0.4395	371955
1978	4503801	2763199	7340849	374710	293694	478073	139023	103509	186721	48588	31777	74291	0.2172	0.1331	0.3545	480107
1979	8387216	5369155	13101762	497173	4e+05	617997	183425	142168	236655	60246	39444	92019	0.1758	0.1075	0.2875	570865
1980	13108018	8945967	19206435	682289	564039	825329	213609	171048	266758	79490	62893	100467	0.158	0.1237	0.2017	666404
1981	27856842	18983931	40876868	1129806	930095	1372399	284033	227951	353913	150569	117335	193217	0.2484	0.1977	0.3121	524366
1982	46737392	32126602	67992991	1738585	1428344	2116210	408528	331415	503583	250954	185200	340052	0.1793	0.1445	0.2224	408528
1983	45668757	31845854	65491583	2338425	1962429	2786462	571118	466918	698572	383194	295294	497260	0.2617	0.2146	0.3191	259031
1984	45787494	32191899	65124913	3060177	2616102	3579633	892756	729231	1092949	468538	391130	561266	0.3526	0.2926	0.425	172685
1985	56566615	39569836	80864170	3511088	3025432	4074704	960264	795155	1159656	620532	532662	722897	0.4531	0.3772	0.5443	187508
1986	68930718	48145277	98689721	3995626	3427547	4657858	997272	830671	1197287	746303	609063	914466	0.4307	0.3582	0.5179	224148
1987	61633334	4.3e+07	88345556	4e+06	3456714	4627920	1204638	1002212	1447950	772407	644548	925629	0.3925	0.3272	0.4708	437236

1988	37750826	26513409	53751098	3912488	3411729	4486747	1545207	1292235	1847702	968934	790276	1187980	0.3823	0.3205	0.4559	511733
1989	30447113	21349170	43422144	3444558	3063236	3873348	1578305	1358683	1833427	811013	702499	936288	0.3706	0.3134	0.4382	517593
1990	26908664	18822152	38469363	3427460	3050281	3851279	1698451	1465548	1968365	675842	583856	782320	0.3	0.2524	0.3566	494072
1991	28853211	20263653	41083797	3239140	2885519	3636098	1500496	1299267	1732892	669233	583342	767771	0.3204	0.2698	0.3806	564880
1992	50993334	37164246	69968326	3225149	2864487	3631222	1145570	988421	1327705	693551	601209	800077	0.383	0.3224	0.4549	499145
1993	52752166	38119163	7.3e+07	2979337	2616015	3393118	809410	690087	949365	674827	582320	782031	0.4547	0.3811	0.5425	604449
1994	41736350	30060961	57946347	2868509	2481565	3315789	866824	738108	1017985	623208	533569	727907	0.451	0.3782	0.5379	451542
1995	42929269	30777874	59878151	2779524	2402998	3215047	918702	775752	1087994	575839	498161	665628	0.4102	0.3404	0.4945	434000
1996	33541123	24261452	46370141	2733888	2359287	3167967	1088224	921042	1285751	284820	245131	330935	0.1999	0.1641	0.2437	.
1997	28452121	20380147	39721167	2710191	2358573	3114228	1207865	1028460	1418566	263084	230089	300810	0.1806	0.1487	0.2194	248023
1998	18700856	13673638	25576369	3006570	2631170	3435530	1373244	1179602	1598673	363341	318995	413850	0.229	0.1897	0.2764	385577
1999	58576494	42611183	80523597	3115788	2740640	3542287	1481882	1274312	1723263	352089	308125	402326	0.2117	0.1763	0.2542	370877
2000	37457677	27461252	51092994	3753811	3268034	4311796	1505116	1295252	1748983	365367	322101	414444	0.2107	0.1752	0.2533	382794
2001	71084548	51363508	98377489	4160378	3632154	4765422	1926494	1656384	2240651	349750	308572	396422	0.1803	0.1494	0.2175	358657
2002	35817477	26180224	4.9e+07	5007928	4359373	5752971	2340328	2015700	2717238	375329	330414	426349	0.1653	0.1372	0.1992	371955
2003	19252232	14126111	26238533	5281243	4610962	6048960	2337731	2025134	2698579	478304	422320	541708	0.1925	0.1607	0.2307	480107
2004	23056724	16880165	31493327	4565619	4034429	5166748	2305165	2003480	2652278	563004	496967	637816	0.2286	0.1901	0.2747	570865
2005	20430347	15052902	27728810	3837064	3407294	4321041	2094870	1810978	2423266	648335	571878	735014	0.2835	0.2367	0.3396	666404
2006	21196987	15569636	28858238	3223863	2862119	3631329	1691455	1463175	1955351	516107	456118	583986	0.2604	0.2172	0.3121	524366
2007	24753162	18017402	34007068	2657112	2352713	3000895	1323907	1142559	1534038	381321	336863	431648	0.227	0.1886	0.2733	408528
2008	21897784	15870756	30213618	2715577	2382673	3094994	1415712	1222121	1639968	247093	219988	277537	0.1395	0.1158	0.1681	259031
2009	34023642	24821169	46637942	3148229	2748963	3605486	1745423	1502192	2028039	172141	153153	193483	0.07857	0.06482	0.09523	172685
2010	2.7e+07	19746549	36929967	3744436	3272544	4284375	1846247	1584522	2151202	177650	158230	199454	0.07814	0.06463	0.09447	187508
2011	24556210	18046098	33414839	3771747	3323228	4280801	2201685	1916168	2529746	227331	202444	255277	0.1019	0.08499	0.1222	224148
2012	23216549	17022268	31664883	3726387	3304464	4202182	2262093	1971584	2595408	417061	370369	469640	0.1814	0.1516	0.2172	437236
2013	31314955	22764819	43076397	3620550	3223040	4067086	2070923	1807413	2372851	484483	430685	545001	0.2122	0.1775	0.2536	511733
2014	47217742	34214386	65163091	3858544	3426308	4345307	2044501	1782511	2344999	489065	435489	549232	0.2063	0.1725	0.2468	517593
2015	12565961	9110302	17332398	4032028	3548733	4581141	1913297	1664268	2199589	489265	435663	549461	0.2166	0.1805	0.2599	494072
2016	23054821	16903477	31444701	3995184	3507062	4551243	2196727	1899236	2540815	550954	489898	619619	0.2384	0.1984	0.2864	564880
2017	13617840	9896209	18739052	3425957	3015717	3892005	2007266	1729611	2329493	449422	394453	512052	0.1931	0.1609	0.2318	499145
2018	25135181	18290335	34541594	3244086	2856589	3684146	1780481	1524661	2079224	534780	466153	613510	0.2245	0.1866	0.2702	604449
2019	21266861	15028392	30094996	2772023	2434263	3156648	1503667	1282583	1762861	422496	370528	481752	0.1928	0.1581	0.2352	451542
2020	24819948	17063757	36101654	2764098	2371087	3222250	1463252	1217427	1758714	415420	365623	471998	0.2067	0.1645	0.2597	434000
2021	30078264	16734362	54062530	2716110	2182056	3380871	1399848	1051552	1863509	389894	208227	730056	0.2067	0.09909	0.4311	.

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 ).  Tue Sep 07 09:28:12 2021"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2021         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
```

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

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

Slot "timeout":
[1] 3600

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

Slot "fixVarToWeight":
[1] FALSE

Slot "simulate":
[1] FALSE

Slot "residuals":
[1] TRUE

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

Table 2.7.1. North Sea herring. Intermediate year (2021) assumptions for the stock.

Variable	Value	Notes
Fages (wr) 2–6 (2021)	0.186	Based on estimated catch 2020
SSB (2021)	1 383 486	Calculated based on catch constraint (in tonnes)
Rage (wr) 0 (2021)	30 422 344	Estimated by assessment model (in thousands)
Rage (wr) 0 (2022)	23 599 592	Weighted mean over 2010–2019 (in thousands)
Total catch (2021)	370 667	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 bycatch quota (for B and D fleets).

Table 2.7.2. North Sea herring. Intermediate year (2020), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	356 357	
	B-fleet TAC	7750	
	C-fleet TAC	21604	Total TAC in IIIa (including WBSS and NSAS)
	D-fleet TAC	6659	Total TAC in IIIa (including WBSS and NSAS)
TACs to catches variables	WBSS/NSAS split in the North Sea	0.016	Value from terminal year
	B-fleet uptake	0.79	Average over the last 3 years (2017-2019)
	C-fleet transfer	0.48	Value for the Intermediate year
	C-fleet NSAS/WBSS split	0.30	Average over the last 3 years (2017-2019)
	D-fleet NSAS/WBSS split	0.64	Average over the last 3 years (2017-2019)
	D-fleet uptake	0.08	Average over the last 3 years (2017-2019)
F by fleet and total	$F_{(wr)\ 2–6}$ A-fleet	0.185	
	$F_{(wr)\ 0–1}$ B-fleet	0.03	
	$F_{(wr)\ 1–3}$ C-fleet	0.004	
	$F_{(wr)\ 0–1}$ D-fleet	0.002	
	$F_{(wr)\ 2–6}$	0.186	
	$F_{(wr)\ 0–1}$	0.036	
NSAS catches by fleet	Catches A-fleet	360 884	Includes C-fleet transfer and split of WBSS/NSAS in the North Sea
	Catches B-fleet	6103	Includes fleet uptake
	Catches C-fleet	3330	Includes TAC transfer to the A fleet and WBSS/NSAS split.
	Catches D-fleet	351	Includes WBSS/NSAS split and fleet uptake

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.

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	0.3096	0.05088	1.514e-08	3.063e-08	0.31	0.05348	523438	8745	0.01542	0.005265	1280829	1286757
fmsyAR_transfer_Btarget	0.3097	0.0474	1.514e-08	3.057e-08	0.31	0.05	523477	8162	0.01542	0.005265	1280829	1286893
fmsyAR_no_transfer	0.3096	0.05088	2.911e-08	3.063e-08	0.31	0.05348	523438	8745	0.02965	0.005265	1280829	1286757
fmsyAR_no_transfer_Btarget	0.3097	0.0474	2.911e-08	3.057e-08	0.31	0.05	523477	8162	0.02965	0.005265	1280829	1286893
fmsy	0.3096	0.05088	2.911e-08	3.063e-08	0.31	0.05348	523438	8745	0.02965	0.005265	1280829	1286757
nf	0	0	0	0	0	0	0	0	0	0	1614283	1998030
tacro	0.1966	0.03231	2.863e-08	3.024e-08	0.1969	0.03396	356357	5625	0.02965	0.005265	1390323	1491932
-15%	0.1636	0.02689	2.849e-08	3.012e-08	0.1638	0.02826	302903	4699	0.02965	0.005265	1424745	1561713
+15%	0.2311	0.03797	2.877e-08	3.036e-08	0.2313	0.03991	409811	6585	0.02965	0.005265	1355606	1424192
fsq	0.1862	0.0306	2.858e-08	3.02e-08	0.1864	0.03216	339749	5334	0.02965	0.005265	1401049	1513391
fpa	0.3096	0.05088	2.911e-08	3.063e-08	0.31	0.05348	523438	8745	0.02965	0.005265	1280829	1286757
flim	0.3995	0.06565	2.949e-08	3.095e-08	0.4	0.06901	640910	11169	0.02965	0.005265	1202140	1153649
bpa	0.7428	0.122	3.092e-08	3.215e-08	0.7436	0.1283	995805	19986	0.02965	0.005265	956483	802300
blim	0.8863	0.1456	3.151e-08	3.265e-08	0.8874	0.1531	1111504	23480	0.02965	0.005265	874198	703021
MSYBtrigger	0.3635	0.05973	2.934e-08	3.082e-08	0.3639	0.06279	595343	10204	0.02965	0.005265	1232828	1204229

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

Basis	Fbar26A	Fbar01B	Fbar13C	Fbar01D	Fbar26	Fbar01	CatchA	CatchB	CatchC	CatchD	SSB1	SSB2
intermediate year	0.1847	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
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 2.7.6. 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	0.31	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 2.9.1. 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)

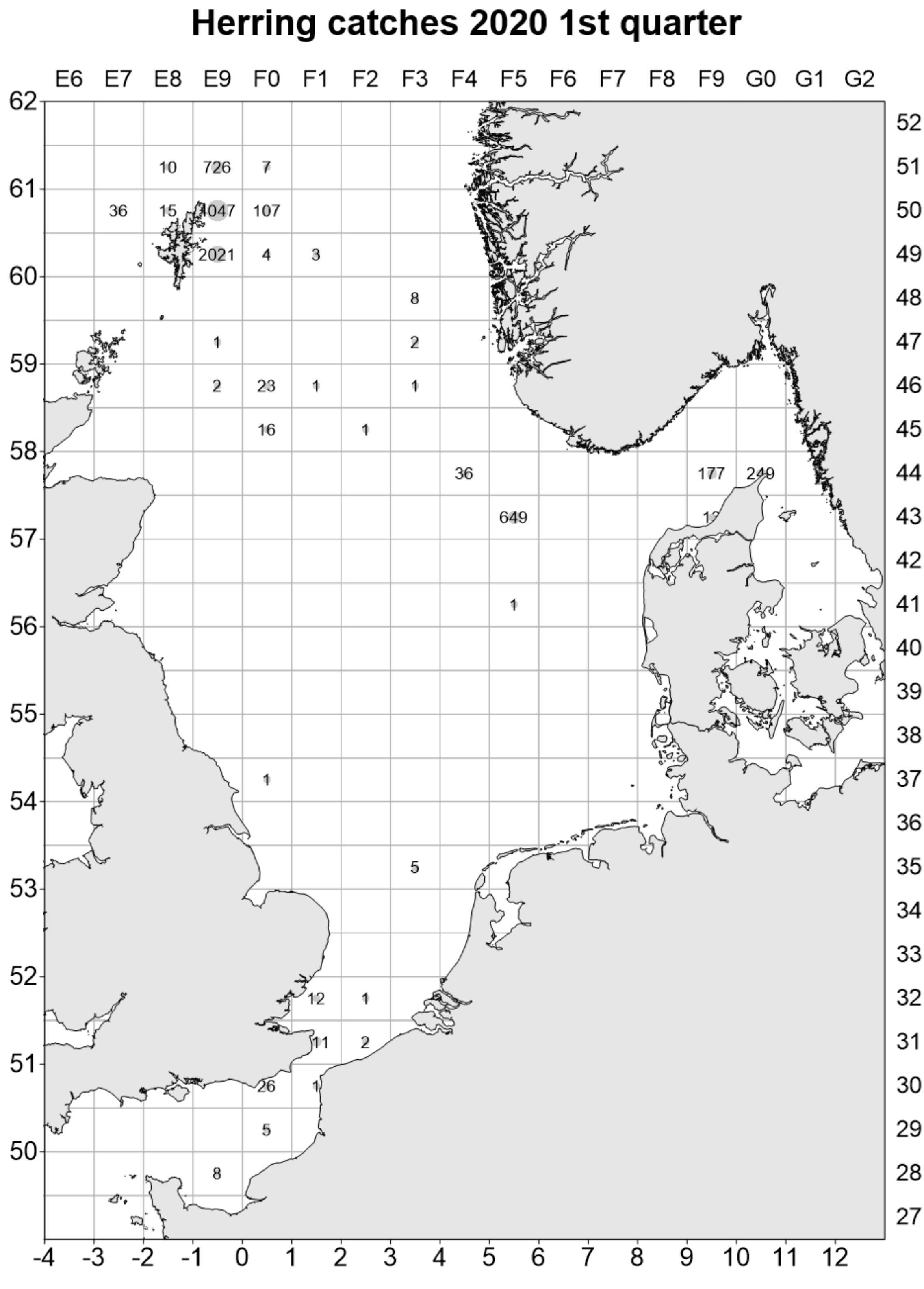


Figure 2.1.1a. Herring catches in the North Sea in the 1st quarter of 2020 (in tonnes) by statistical rectangle.

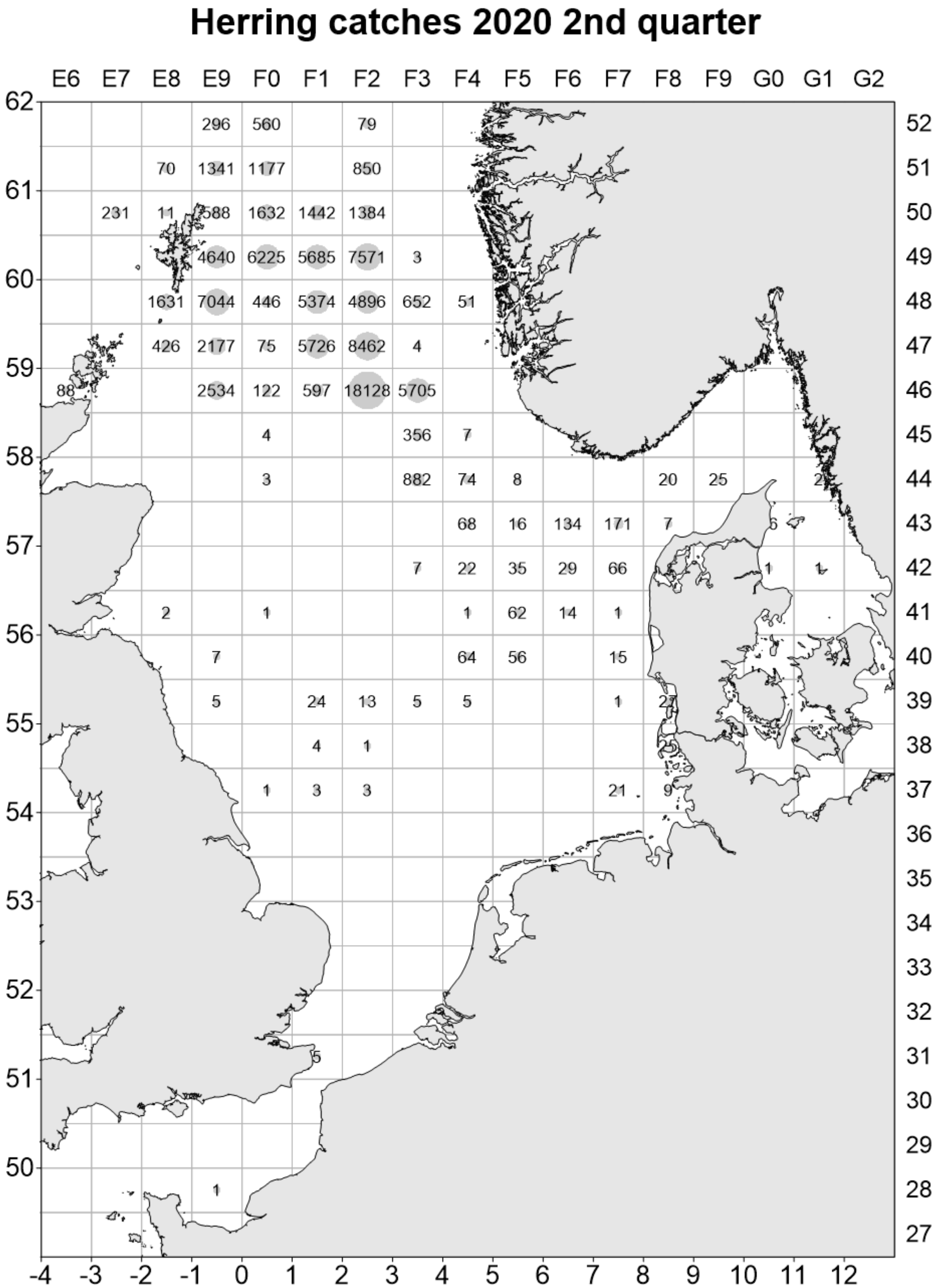


Figure 2.1.1b. Herring catches in the North Sea in the second quarter of 2020 (in tonnes) by statistical rectangle.

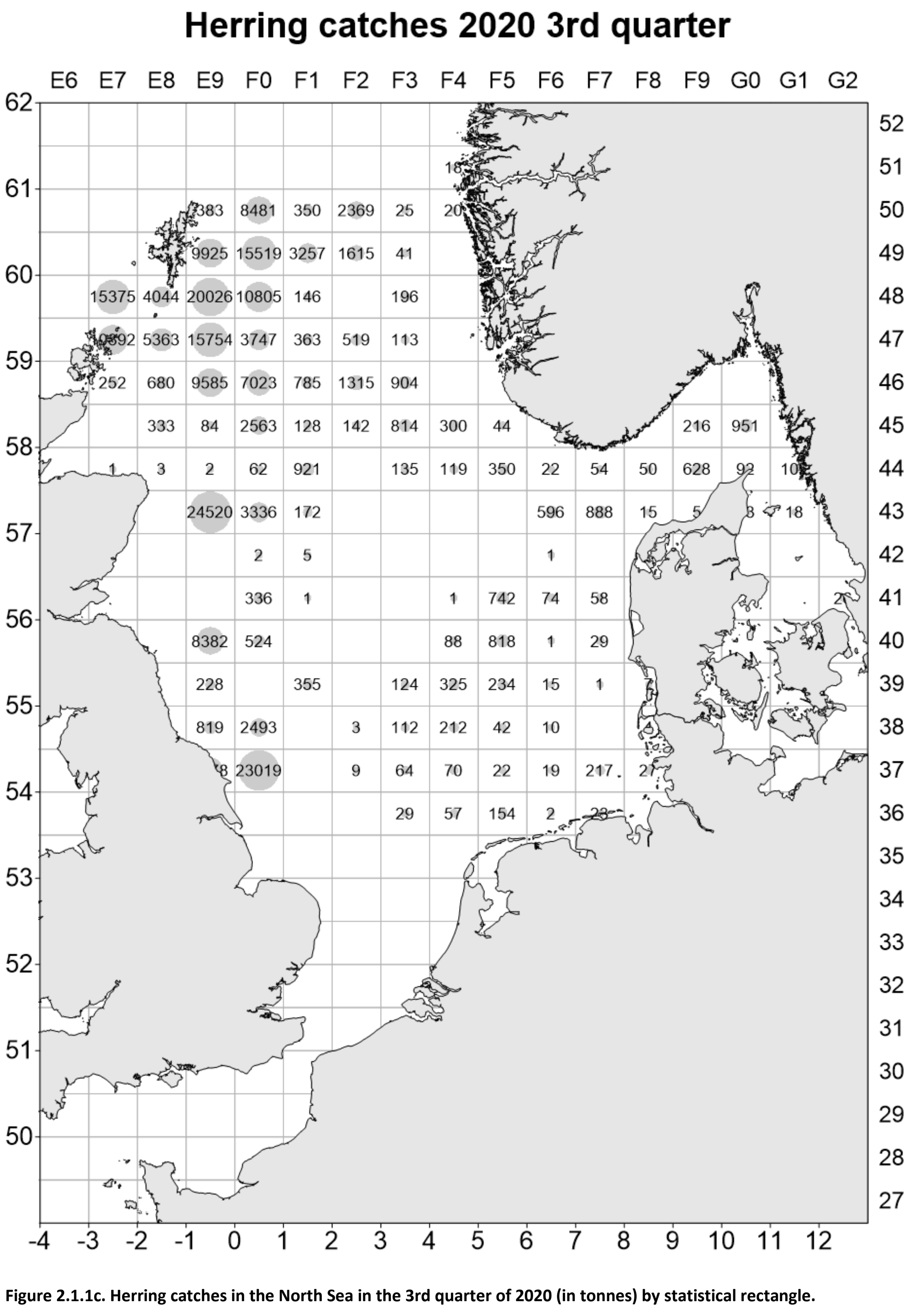


Figure 2.1.1c. Herring catches in the North Sea in the 3rd quarter of 2020 (in tonnes) by statistical rectangle.

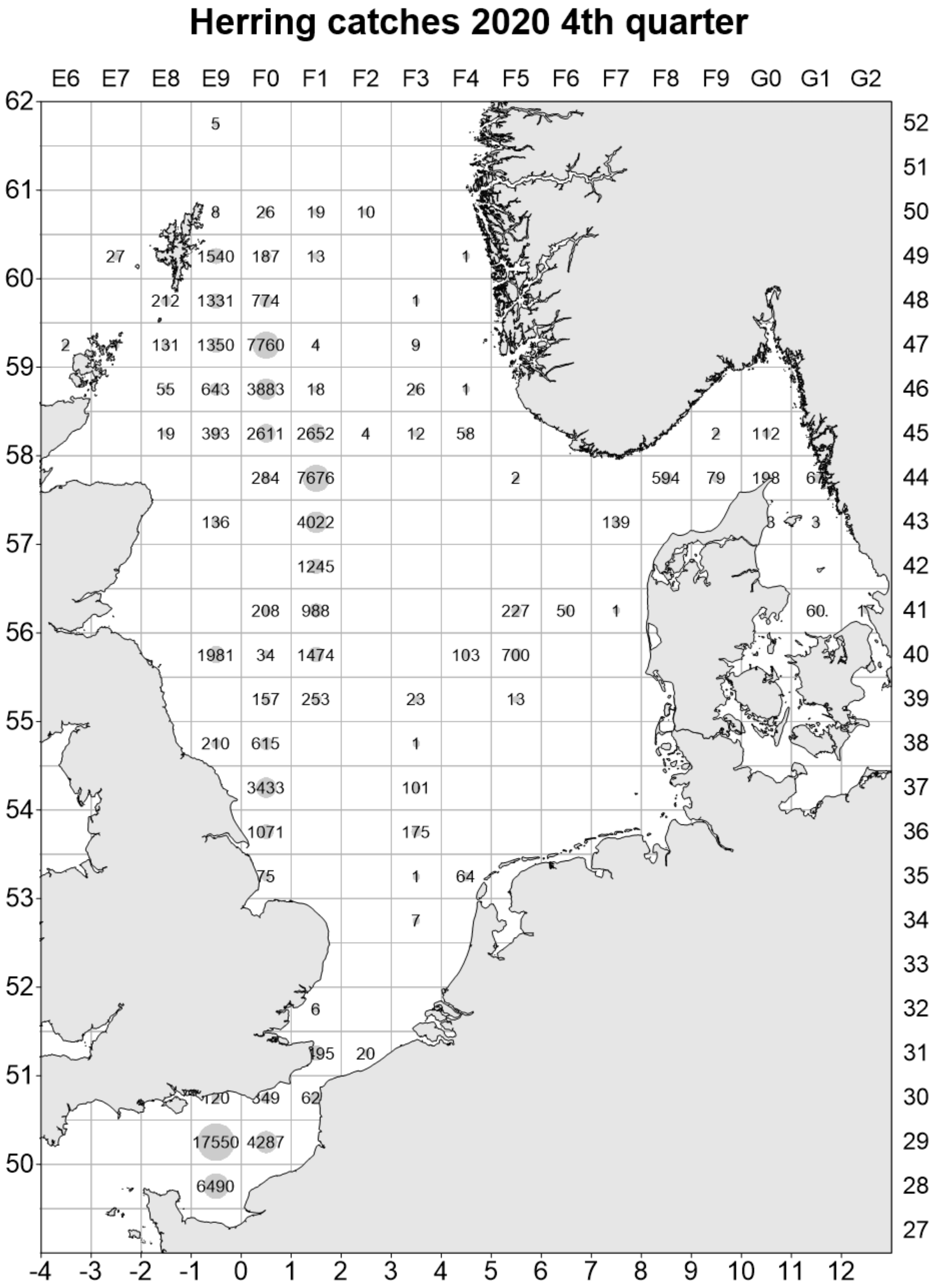


Figure 2.1.1d. Herring catches in the North Sea in the 4th quarter of 2020 (in tonnes) by statistical rectangle.

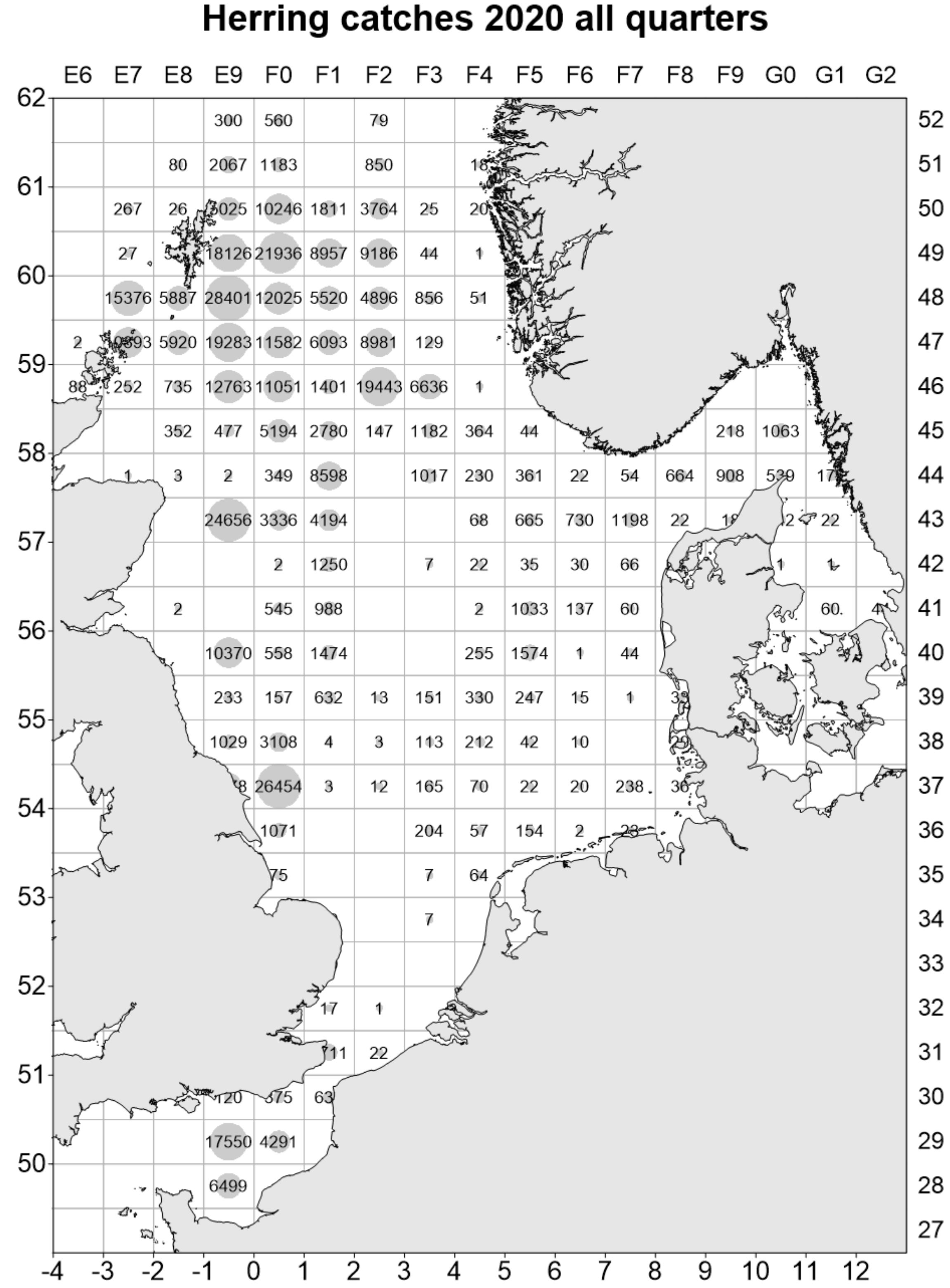


Figure 2.1.1e. Herring catches in the North Sea in all quarters of 2020 (in tonnes) by statistical rectangle.

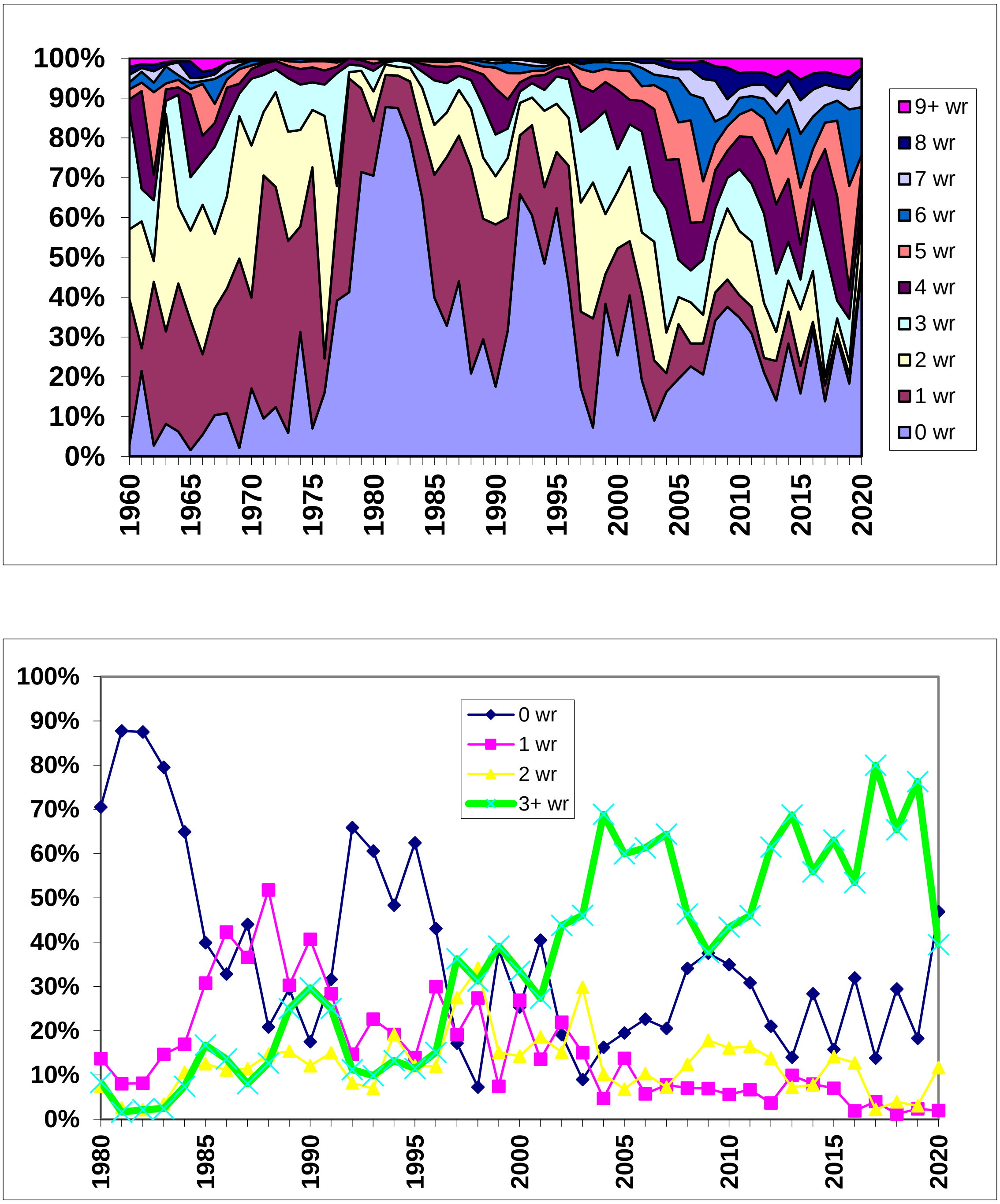


Figure 2.2.1. Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2020, and lower panel, 1980–2020).

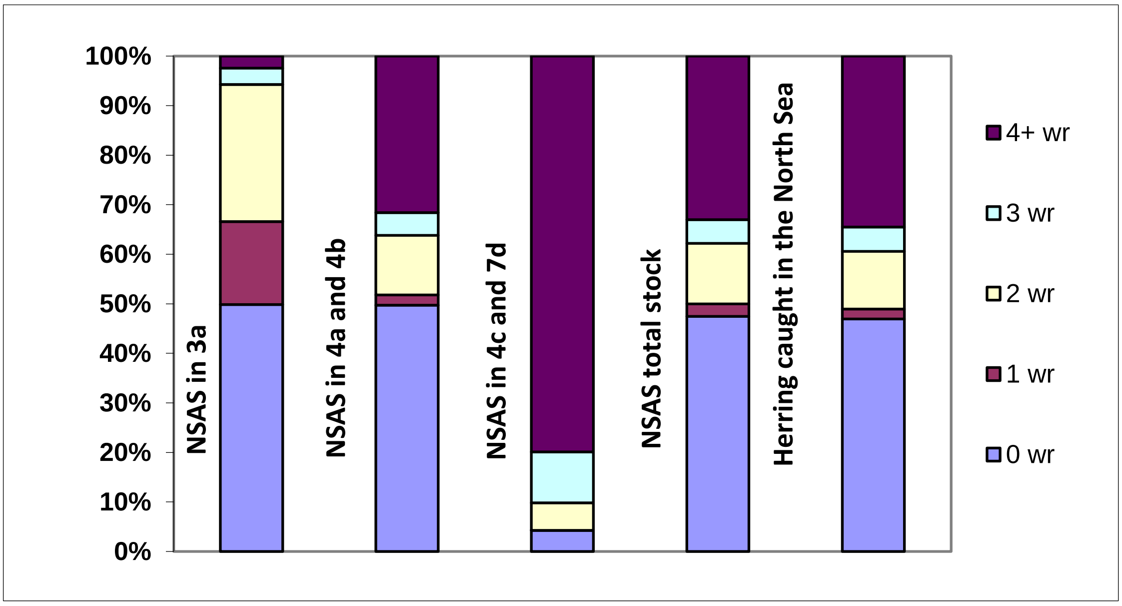


Figure 2.2.2. Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2020.

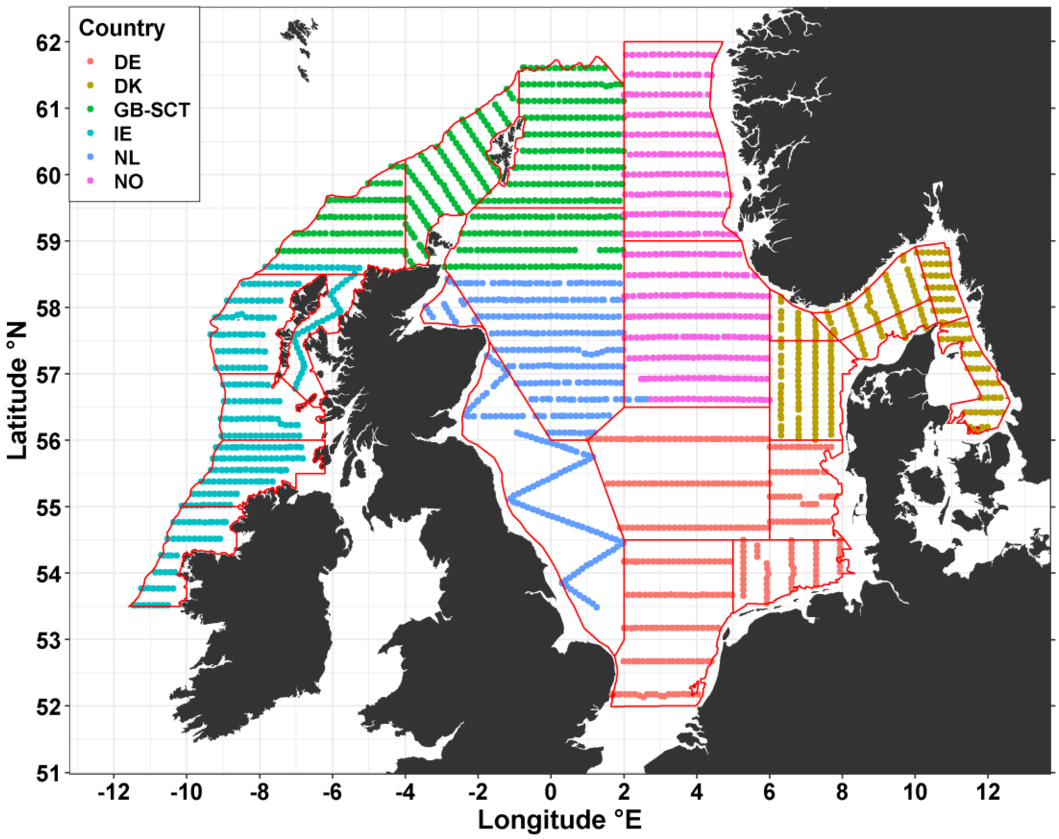


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2020 by nation.

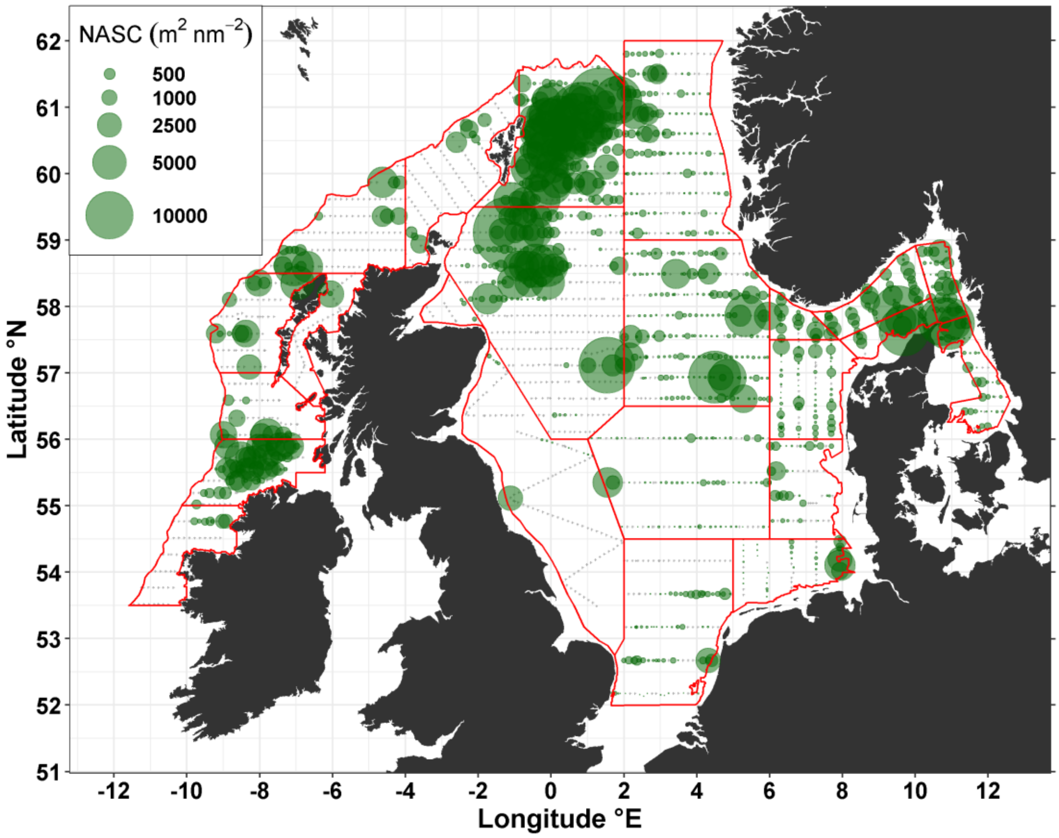


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2020. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

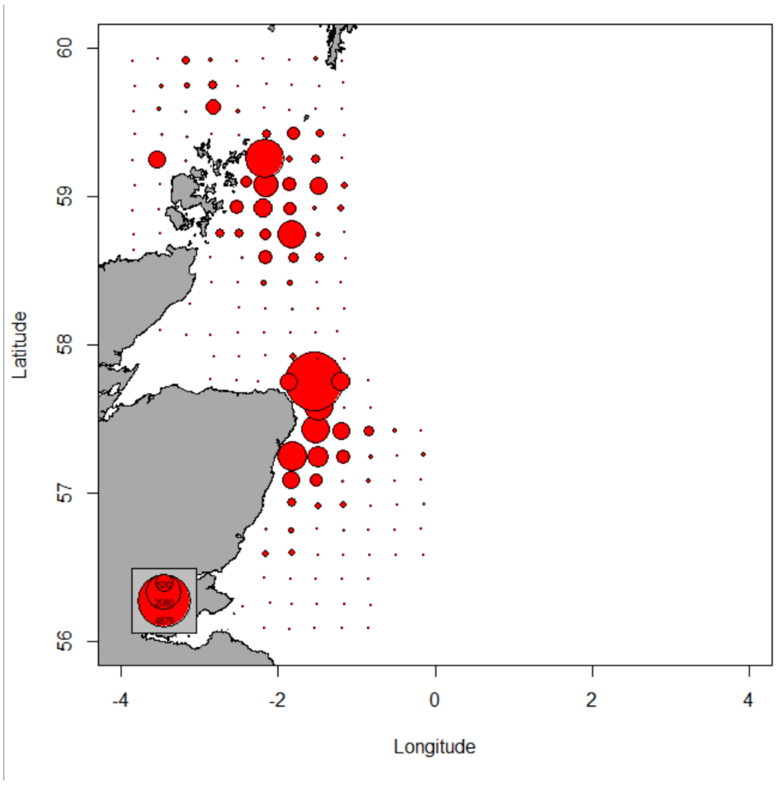


Figure 2.3.2.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands and Buchan area, second half of September 2020 (maximum circle size = 4700 n/m²).

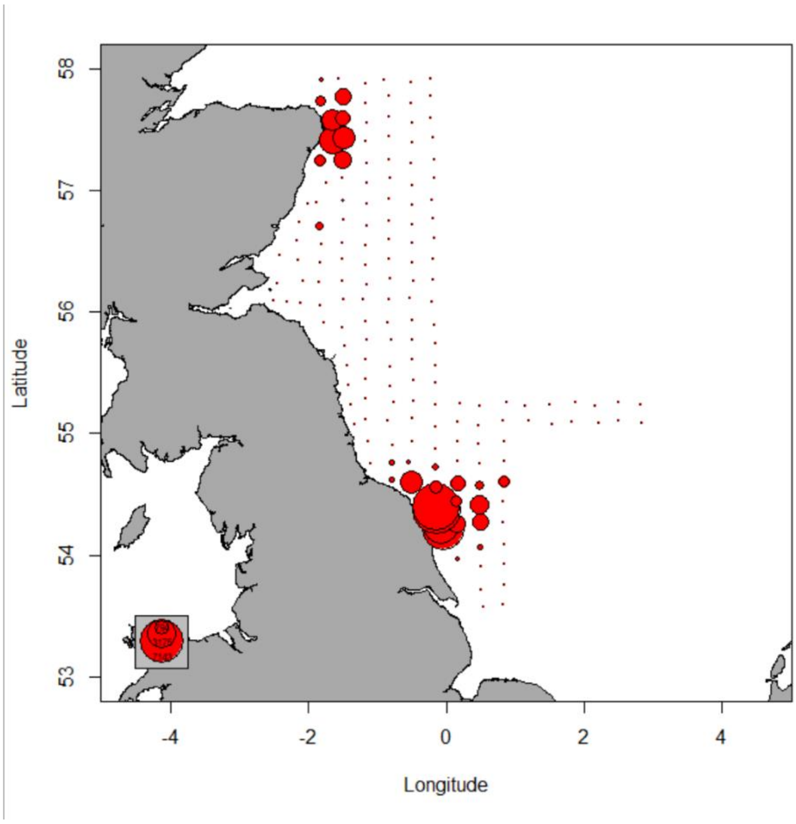


Figure 2.3.2.2: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan and central North Sea area, second half of September 2020 (maximum circle size = 7100 n/m²).

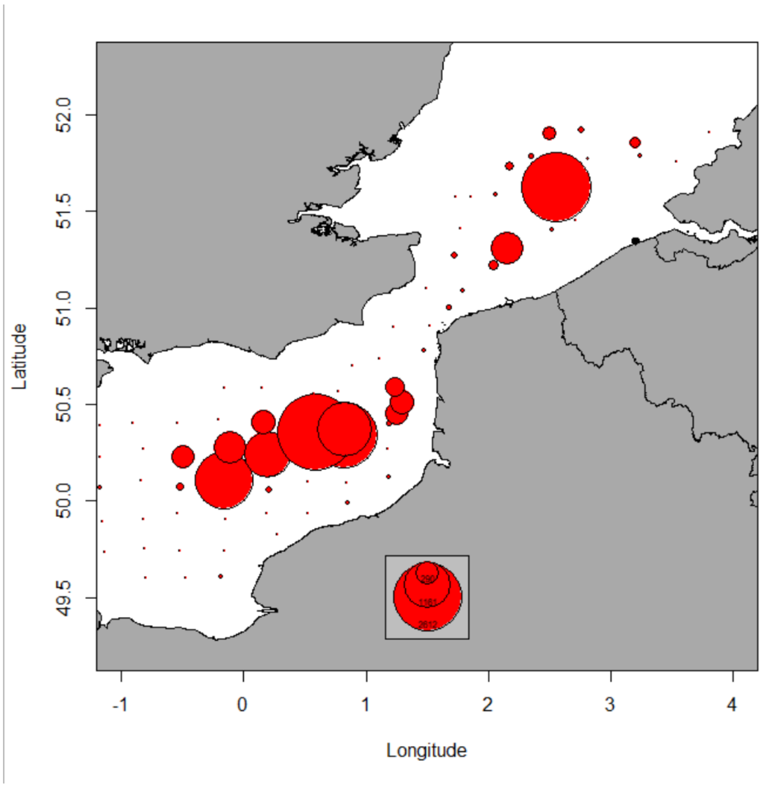


Figure 2.3.2.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2020 (maximum circle size = 2600 n/m²).

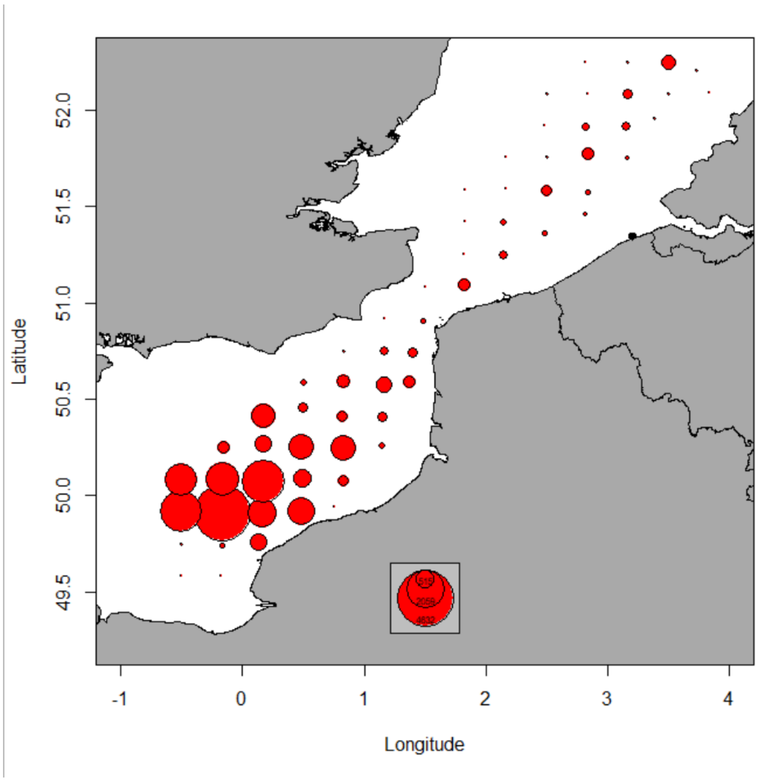


Figure 2.3.2.4. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2021 (maximum circle size = 4600n/m²).

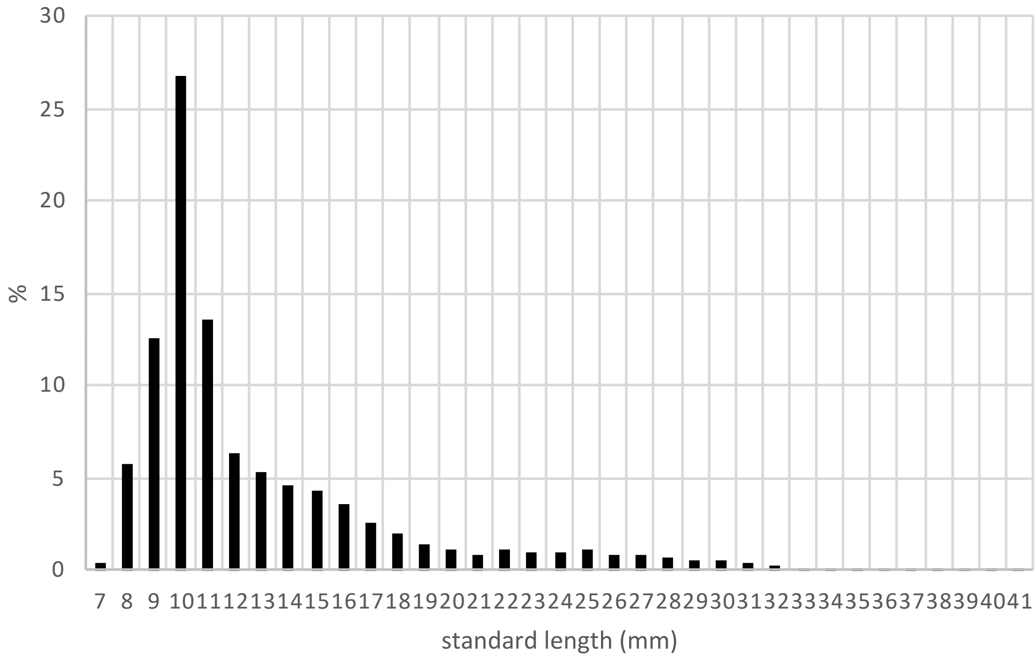


Figure 2.3.3.1.1 North Sea herring. Length distribution of all herring larvae caught during the 2021 Q1 IBTS.

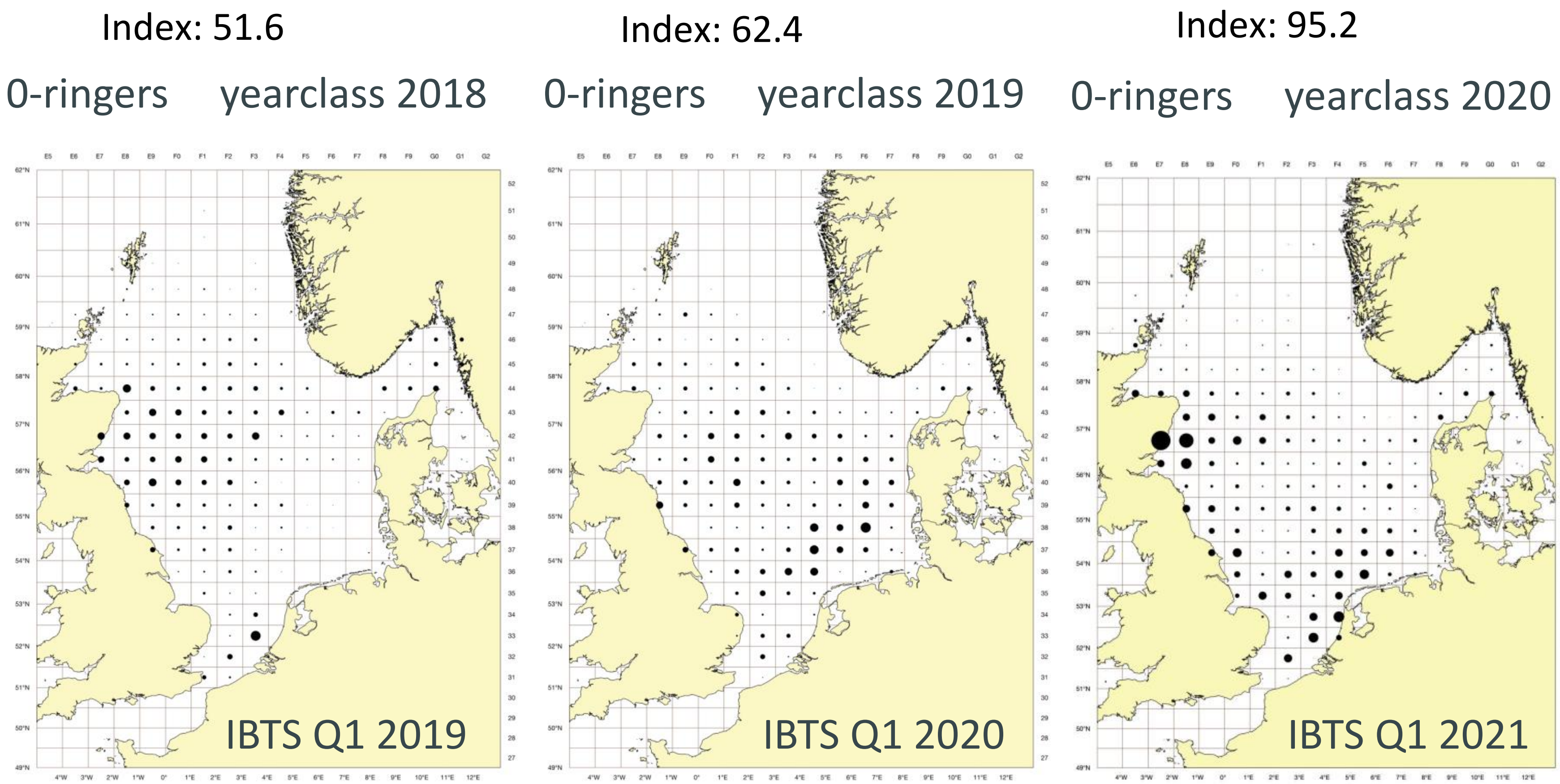


Figure 2.3.3.1.2 North Sea herring. Distribution of 0-ringer herring, year classes 2018–2020. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2019–2021. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 4.28 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

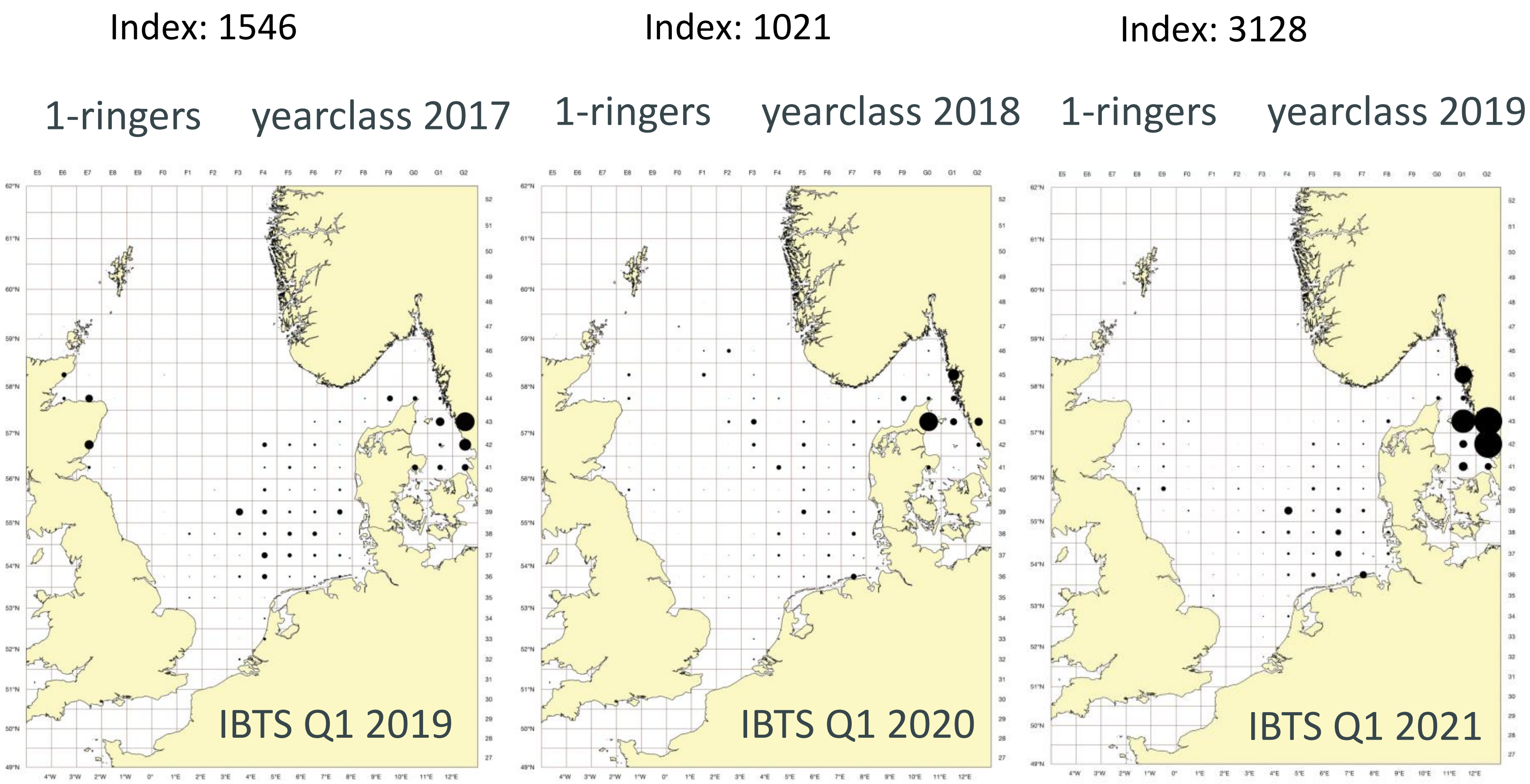


Figure 2.3.3.2.1 North Sea herring. Distribution of 1-ringer herring, year classes 2017–2019. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2019–2021. Areas of filled circles illustrate numbers per hour, scaled proportionally 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}.

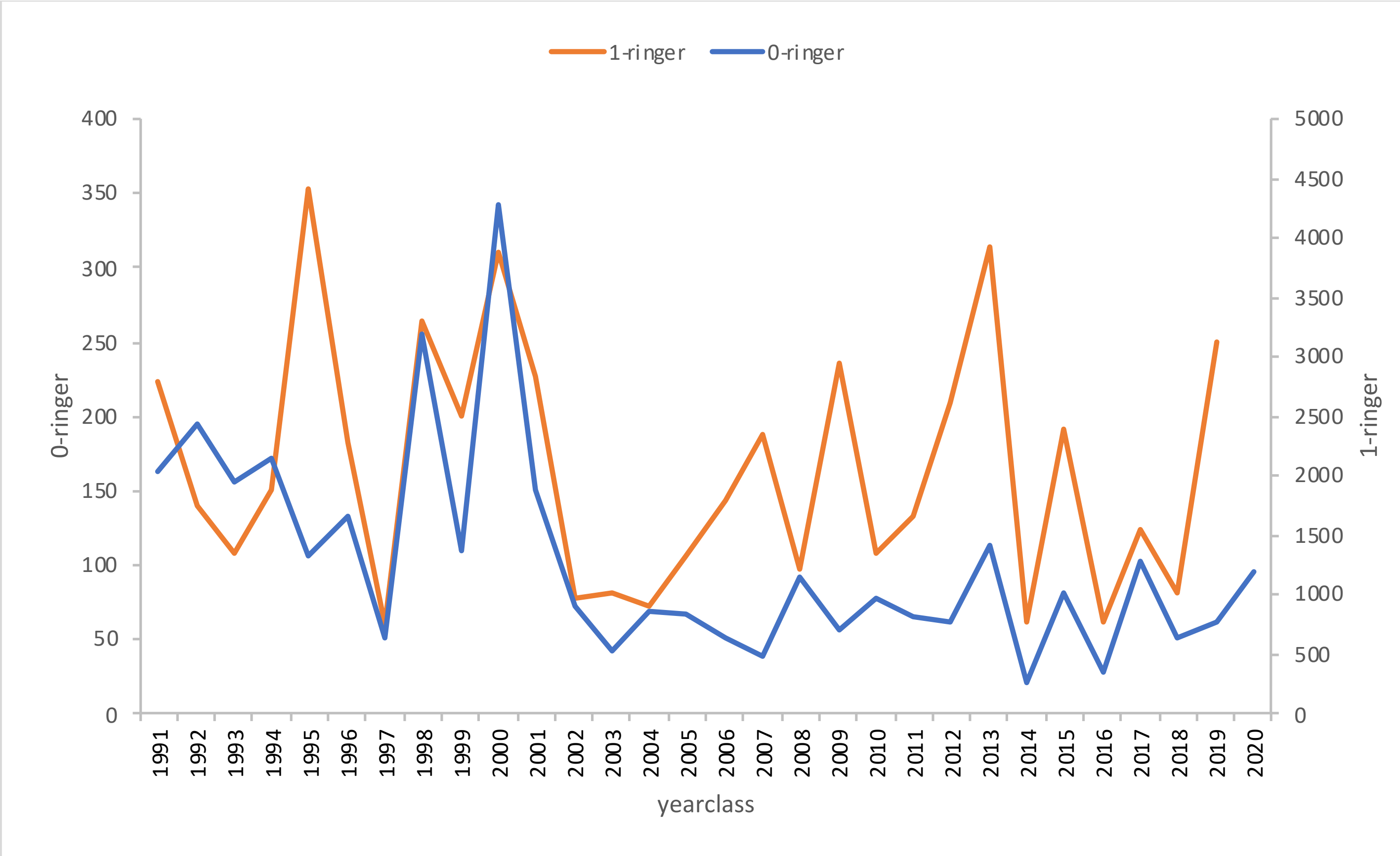
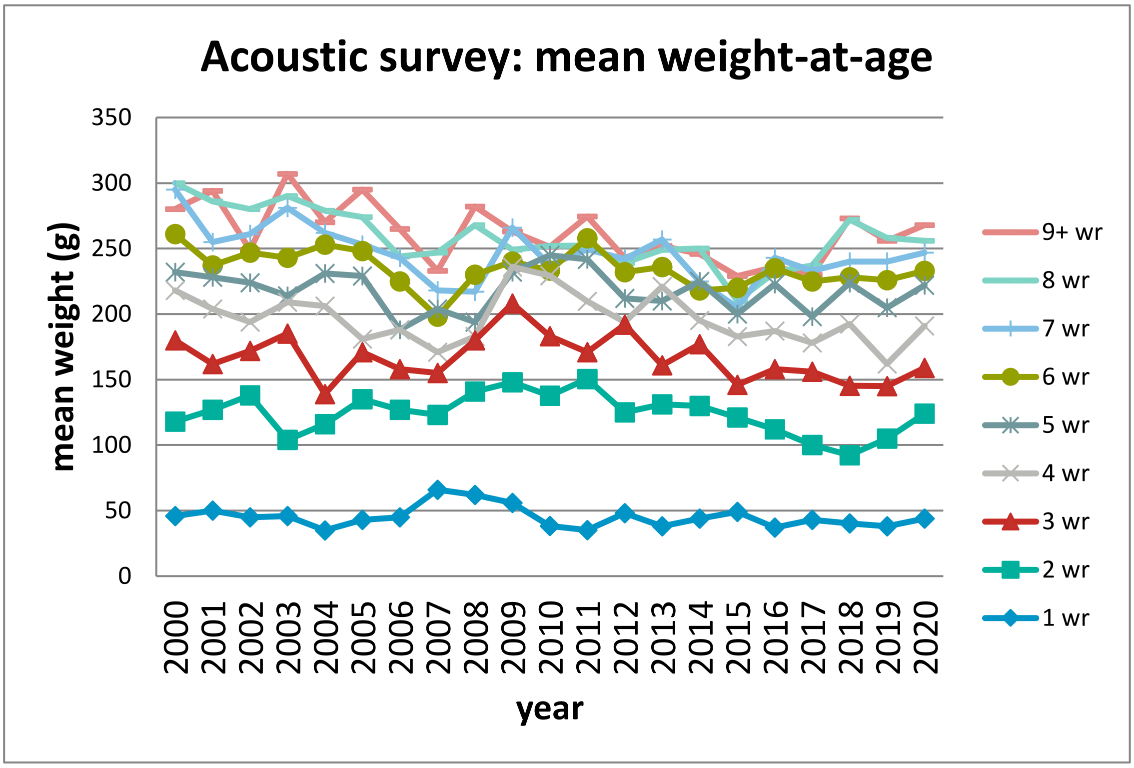


Figure 2.3.3.2.2 North Sea herring. Time series of 0-ringer (blue), and 1-ringer indices (red). Year classes 1991 to 2020 for 0-ringers, year classes 1991–2019 for 1-ringers.



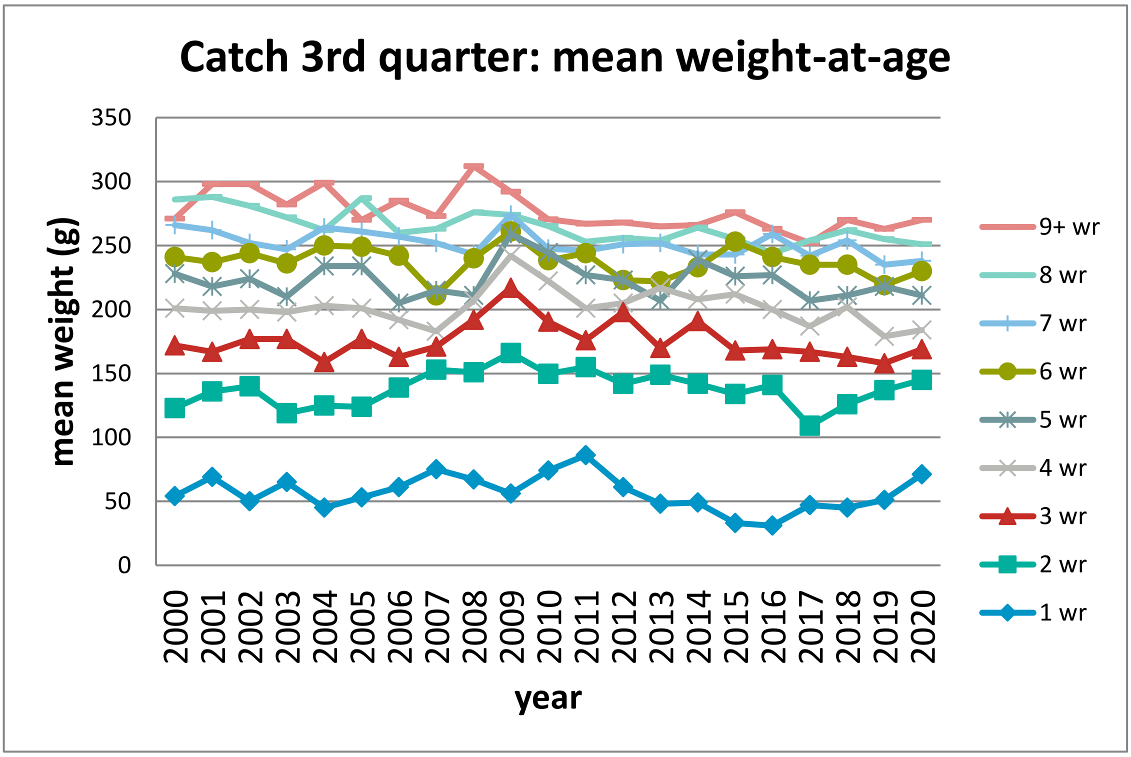


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

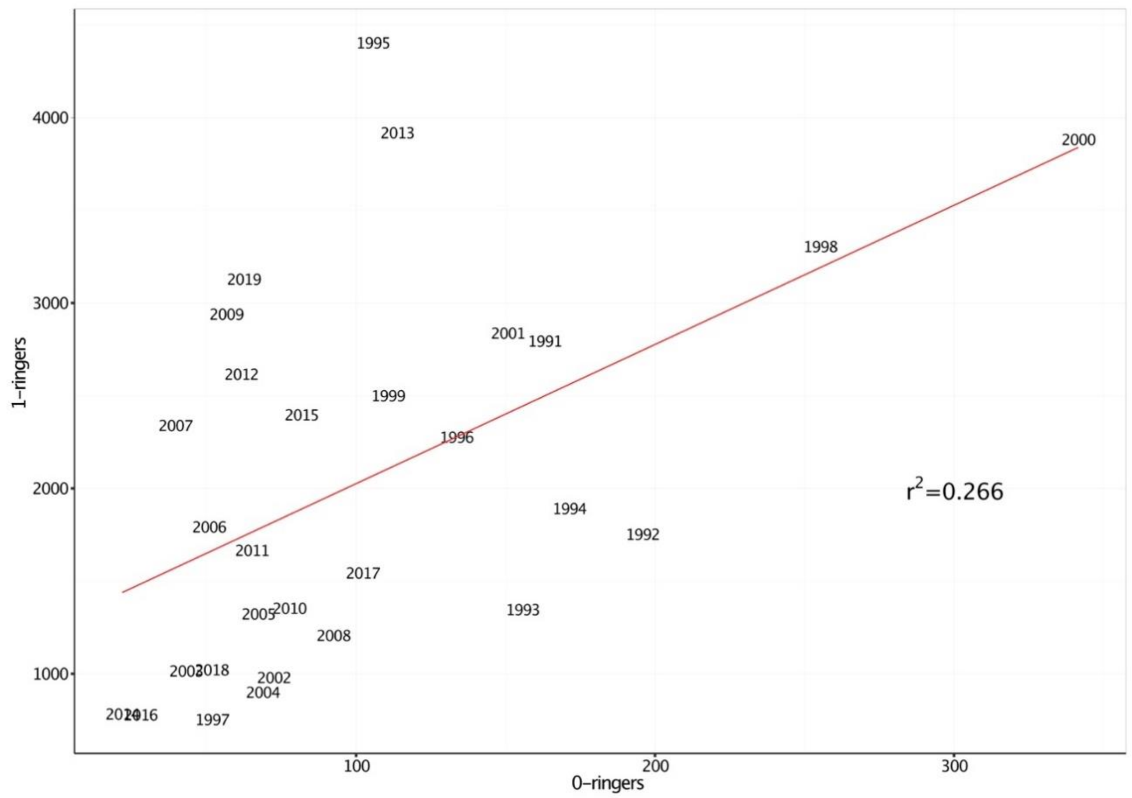


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers, calculated with the new algorithm, and 1-ringers for year classes 1991 to 2019.

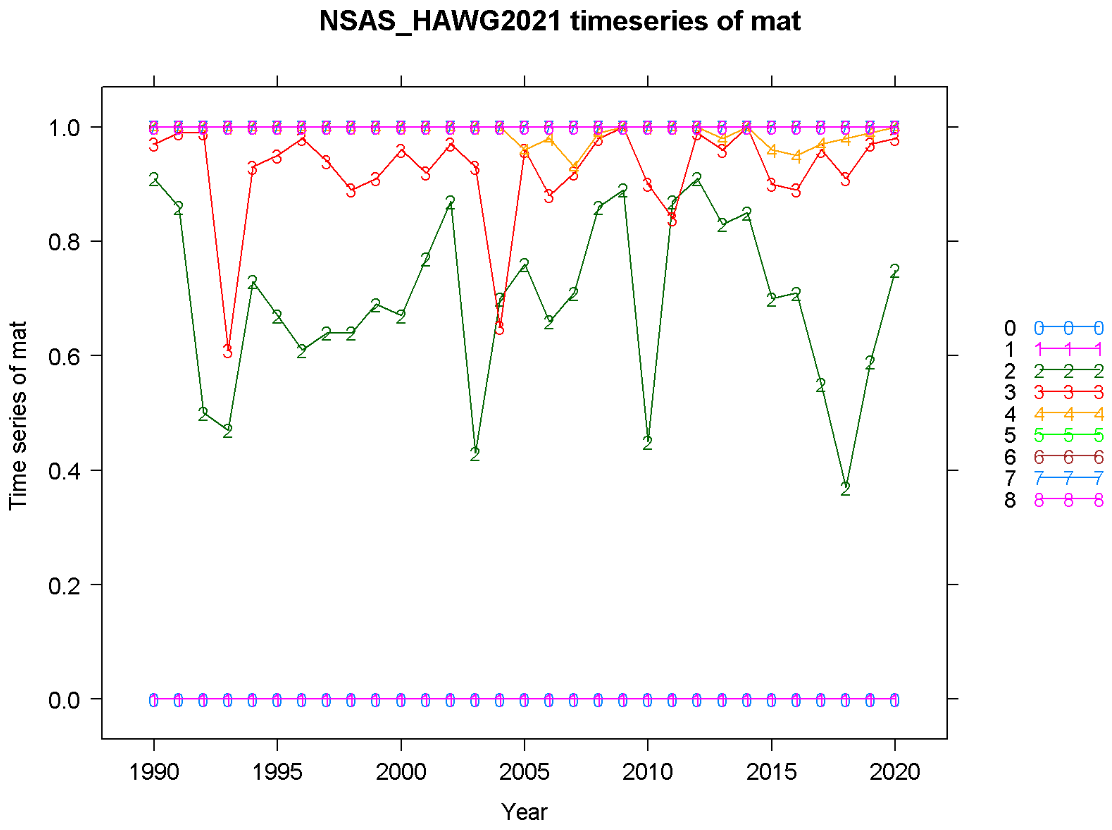


Figure 2.6.1.1. North Sea Herring. Time-series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

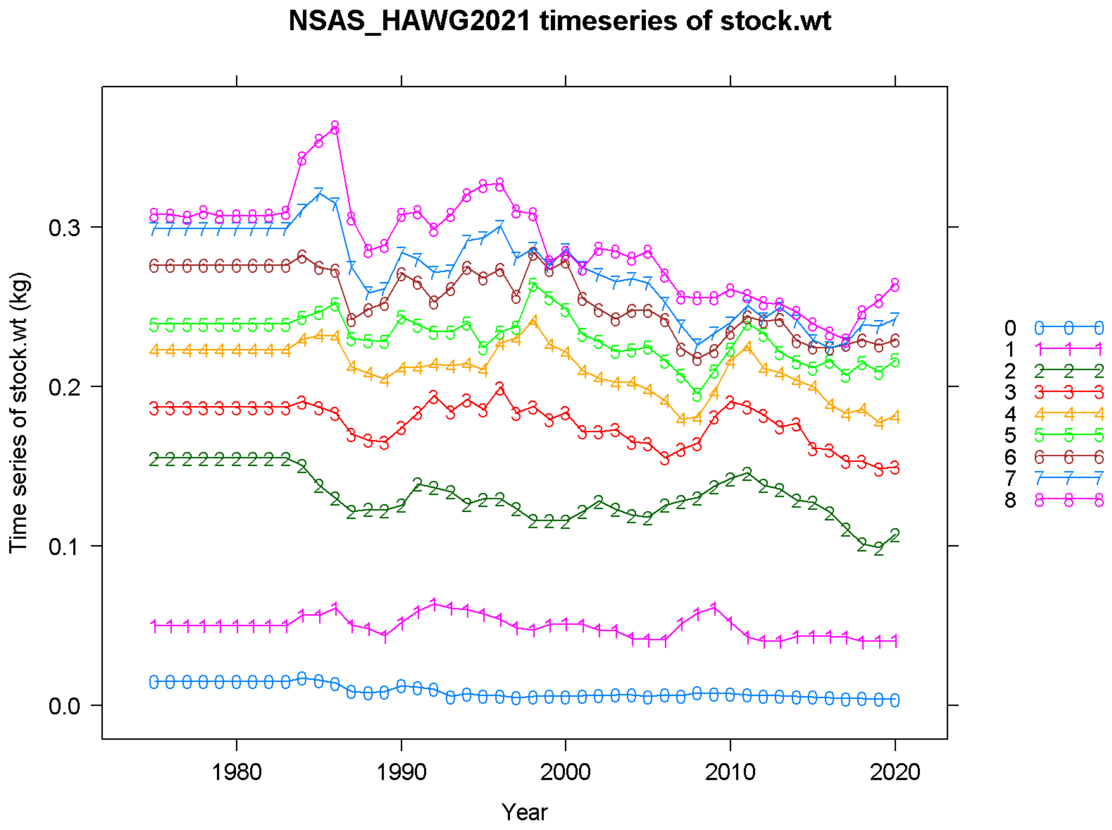


Figure 2.6.1.2. North Sea Herring. Time-series of stock weight at ages 0 to 8+ as used in the North Sea herring assessment.

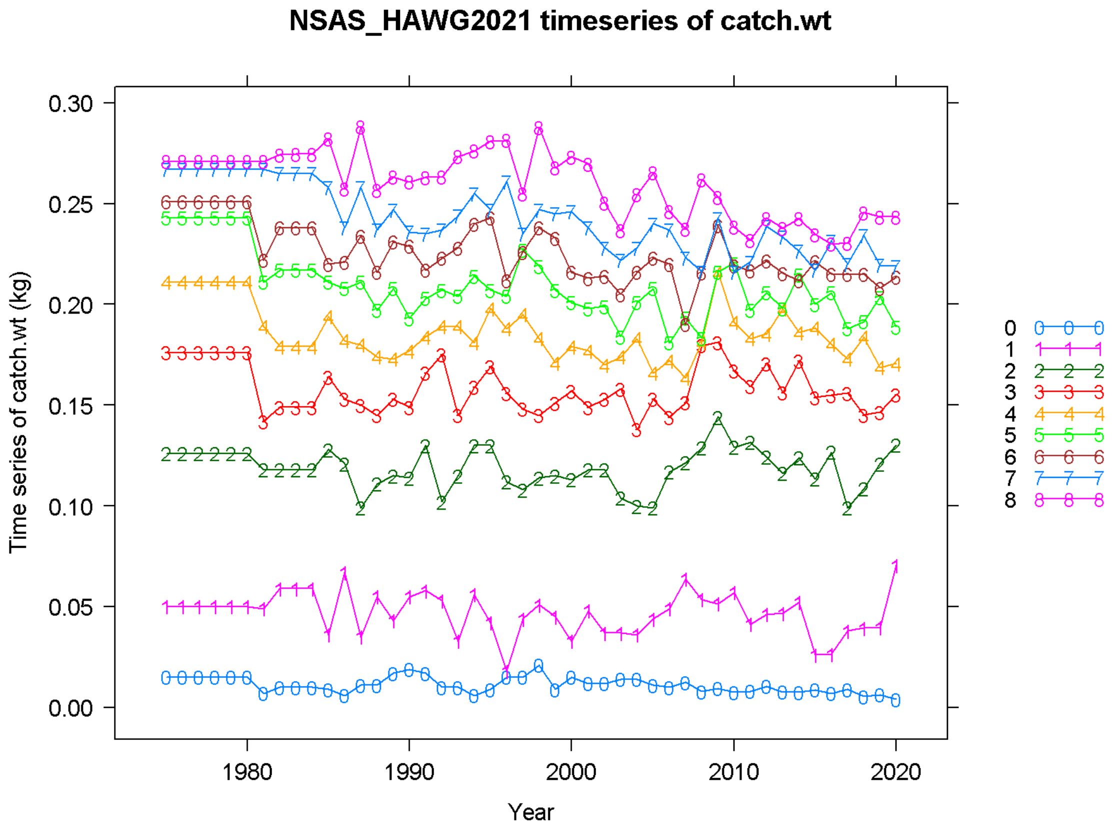


Figure 2.6.1.3. North Sea Herring. Time-series of catch weight at ages 0 to 8+ as used in the North Sea herring assessment.

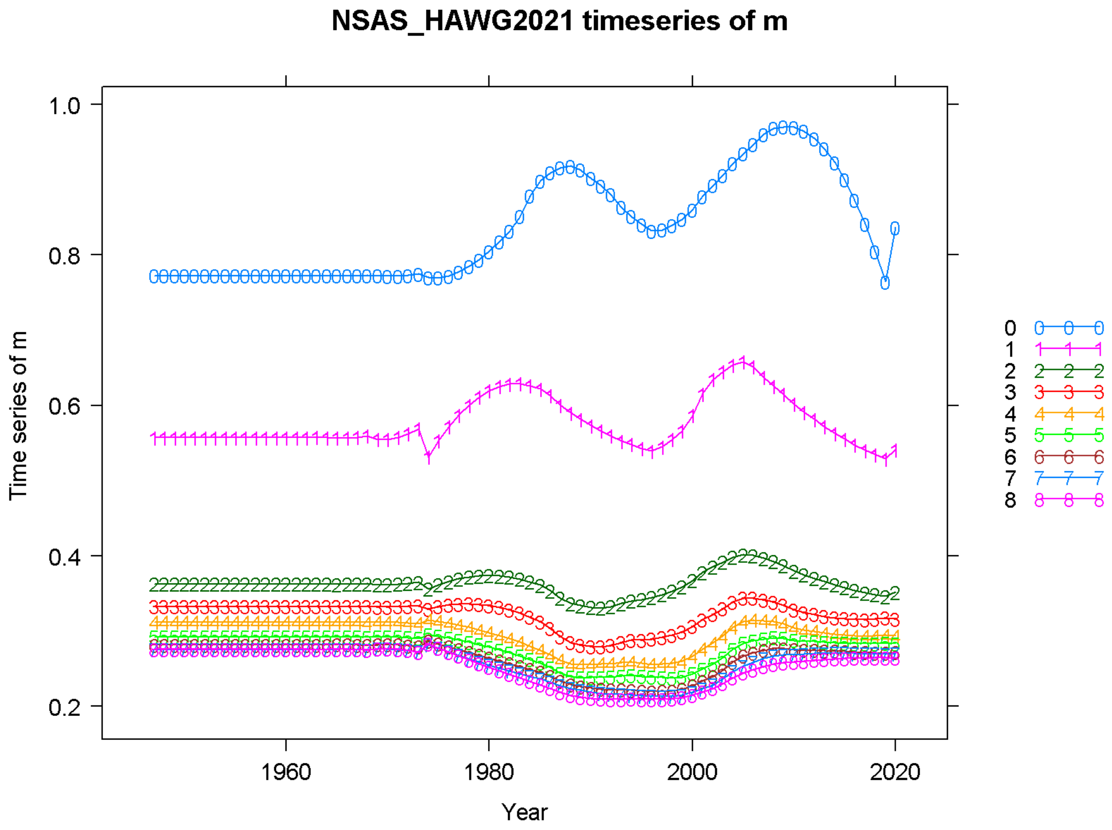


Figure 2.6.1.4. North Sea Herring. Time-series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2019 North Sea key-run (ICES WGSAM, 2021).

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.

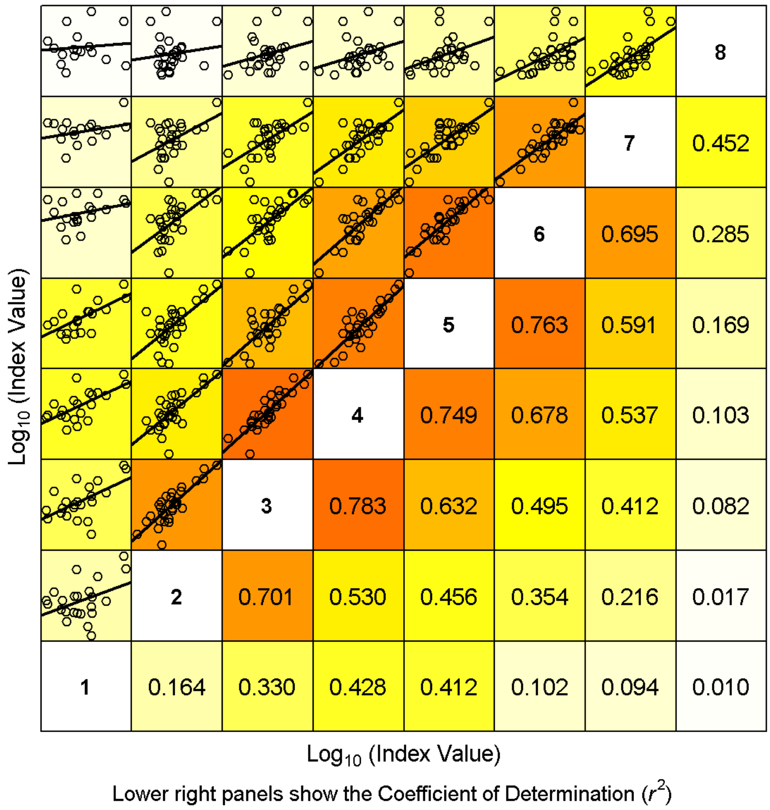


Figure 2.6.1.7. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r2 value that is associated with the linear regression is given.

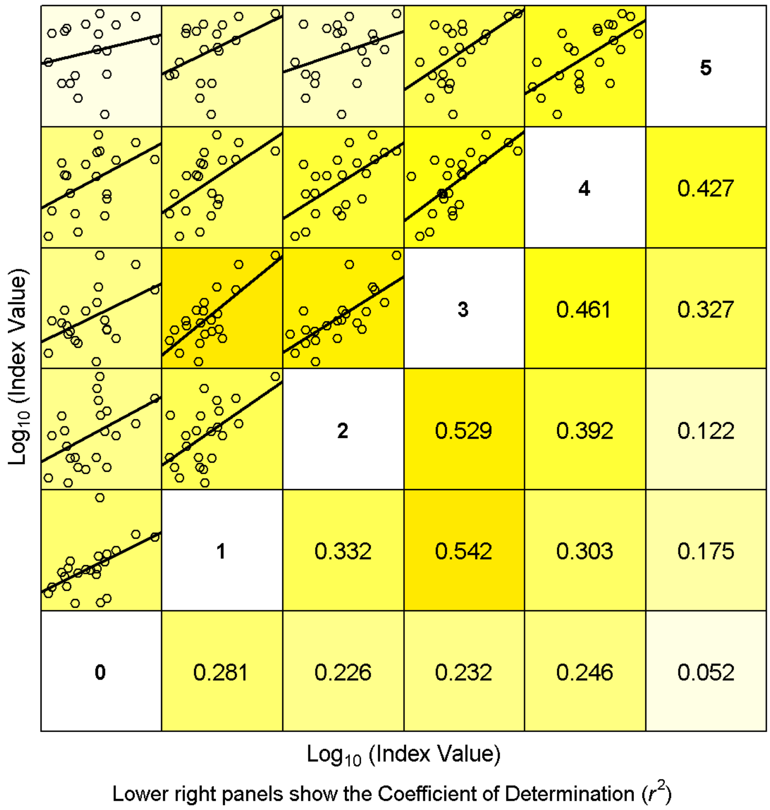


Figure 2.6.1.8. North Sea herring. Internal consistency plot of the IBTS in quarter 3. Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r2 value that is associated with the linear regression is given.

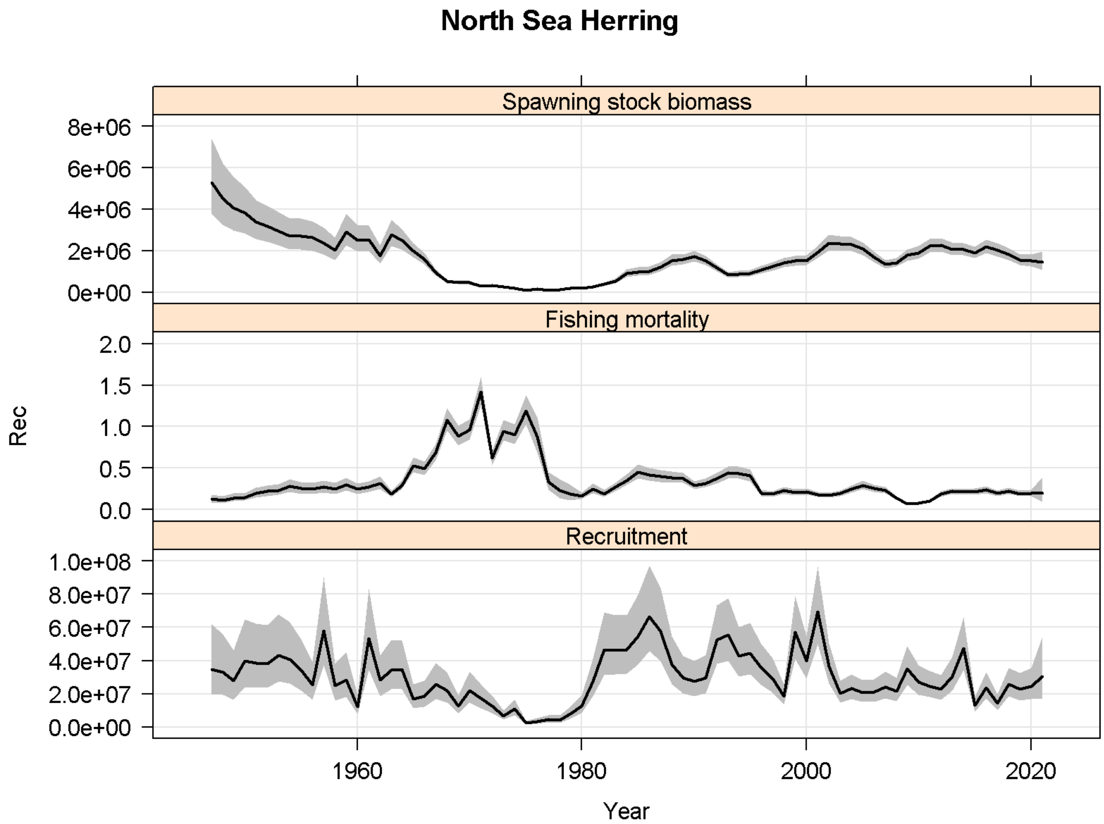


Figure 2.6.2.1. North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

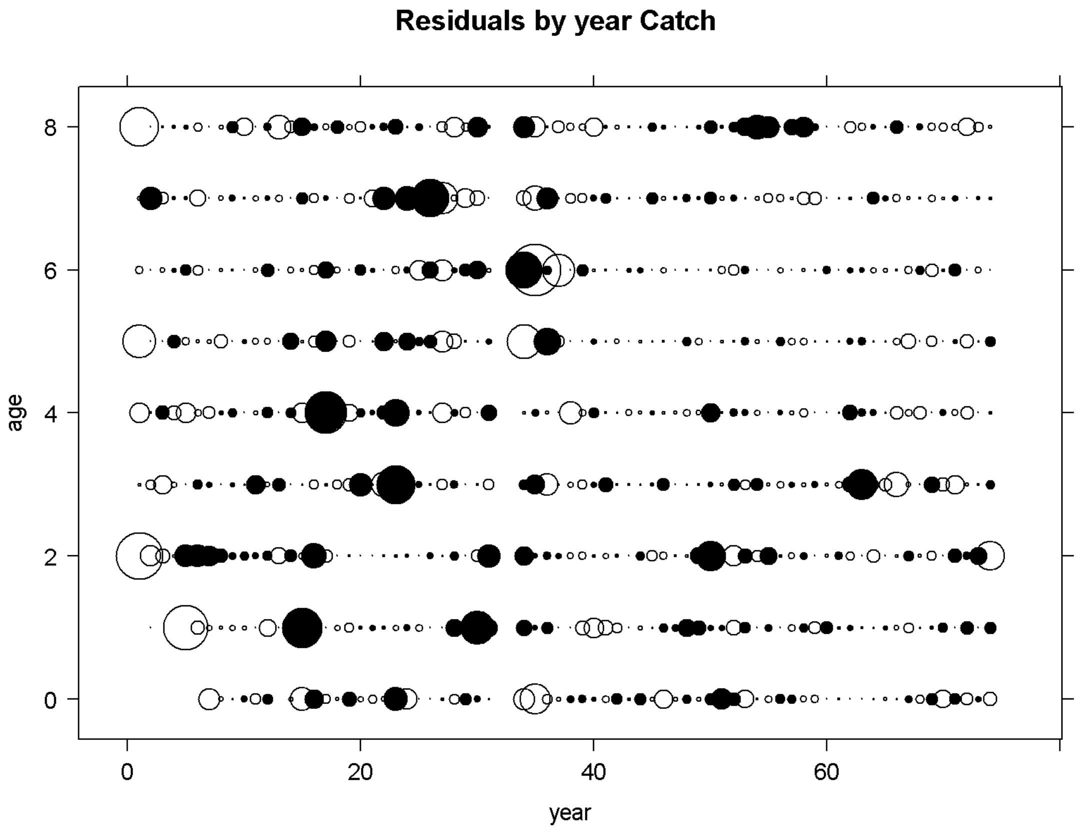


Figure 2.6.2.2. North Sea herring. Bubble plot of standardized catch residual at age.

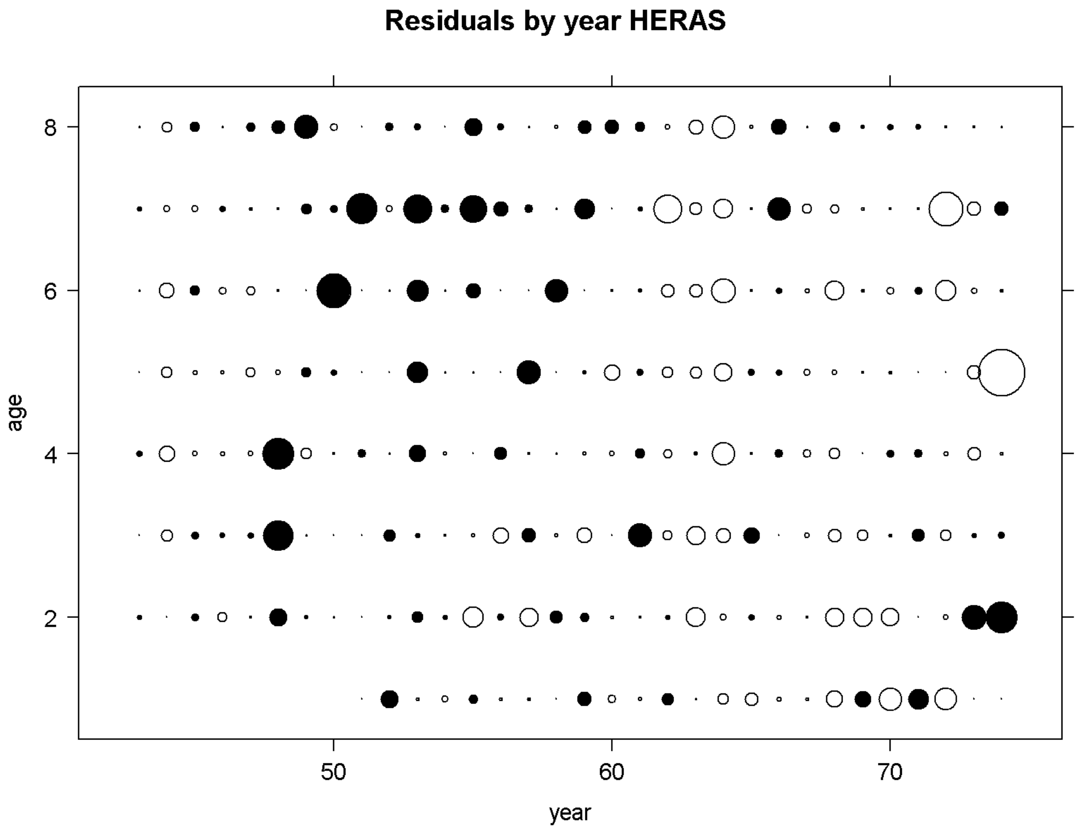


Figure 2.6.2.3. North Sea herring. Bubble plot of standardized acoustic survey residuals at age.

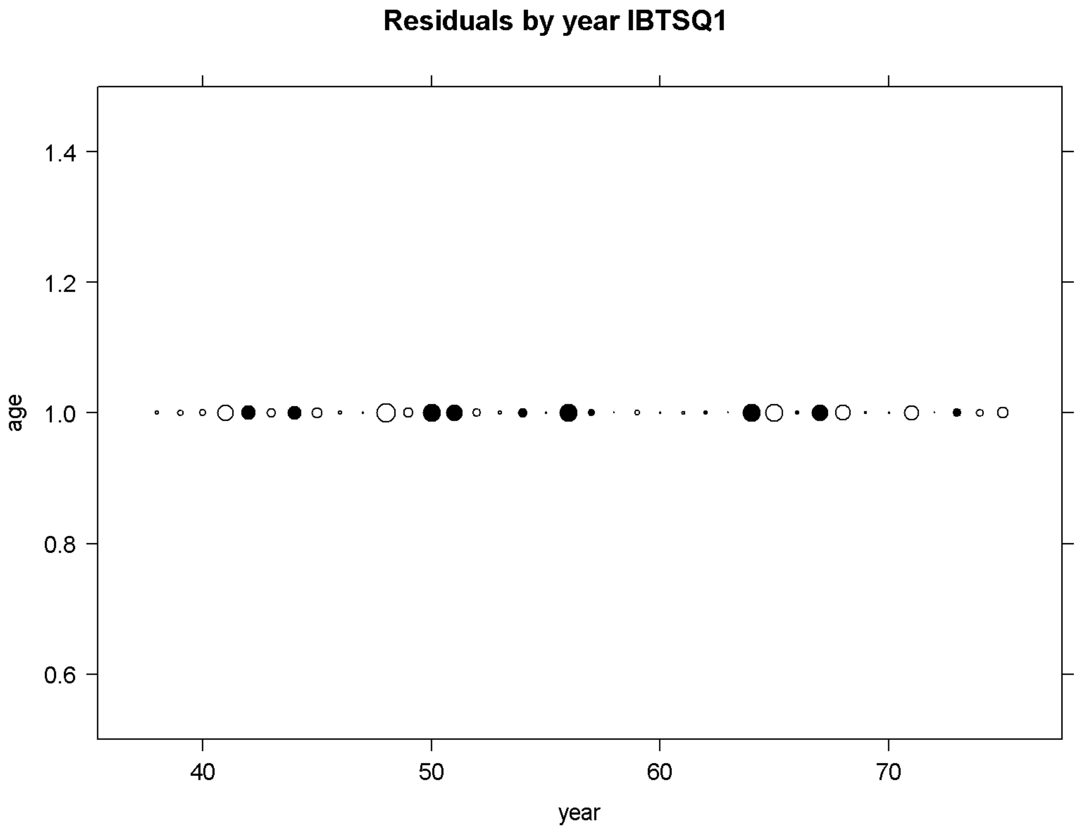


Figure 2.6.2.4. North Sea herring. Bubble plot of standardized IBTSQ1 residuals at age.

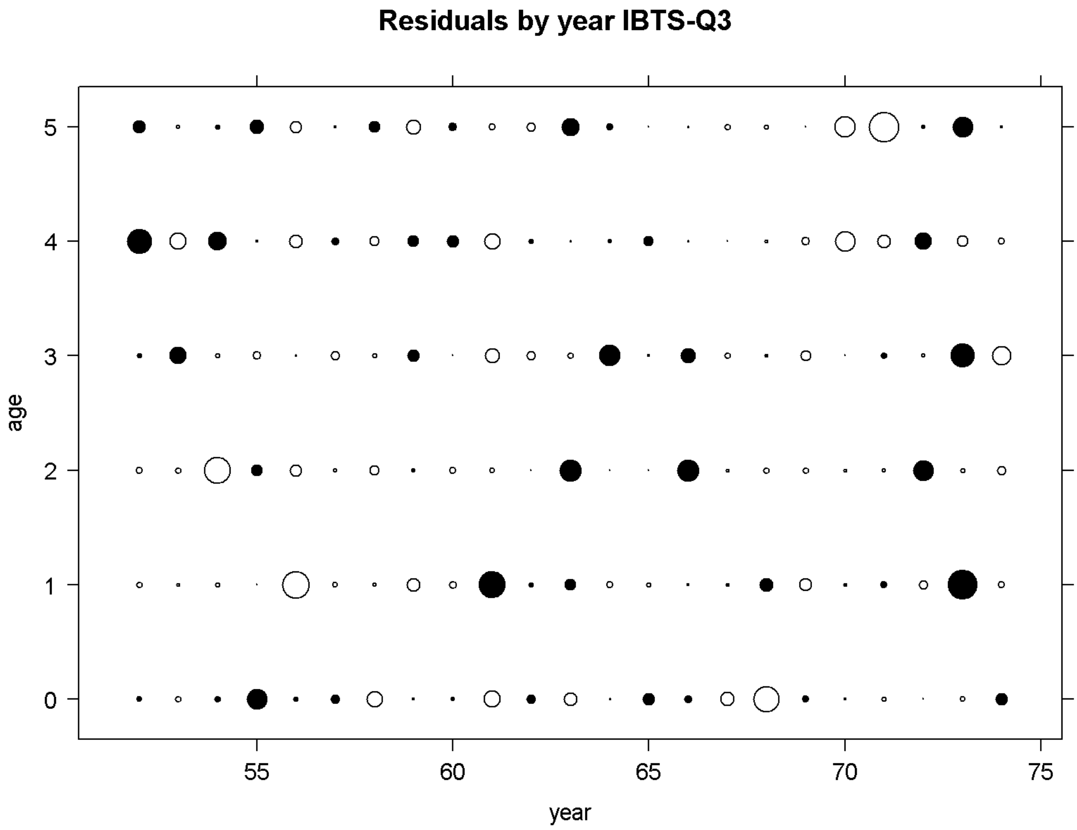


Figure 2.6.2.5. North Sea herring. Bubble plot of standardized IBTSQ3 residuals at age.

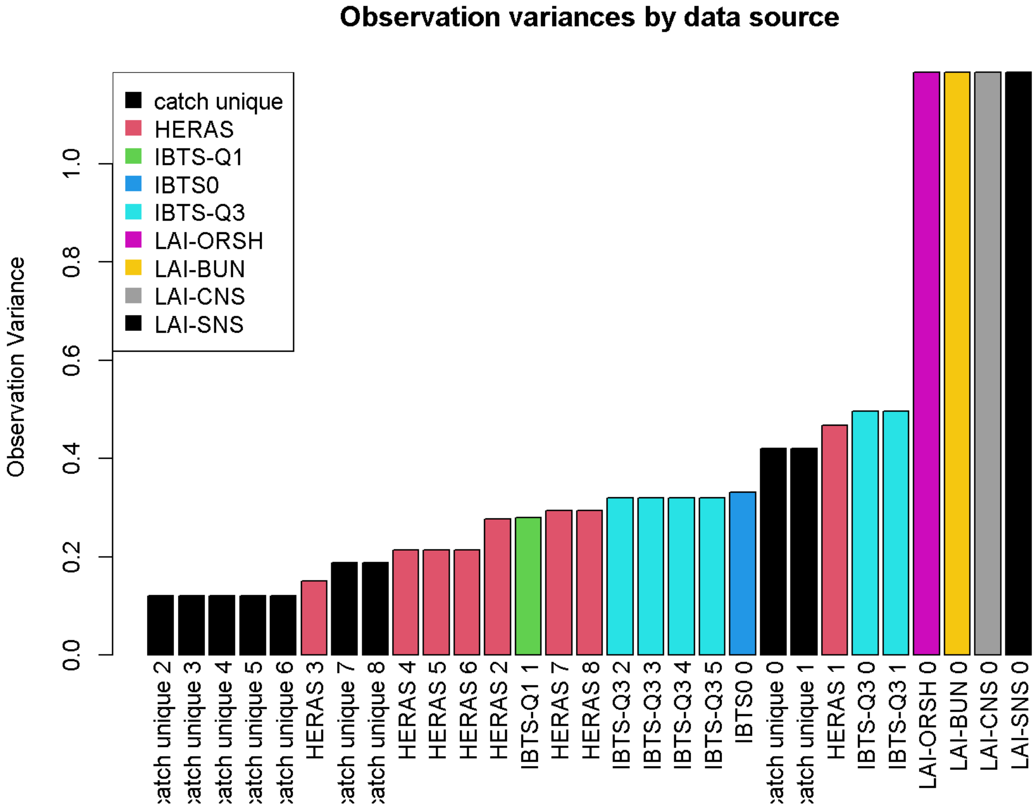


Figure 2.6.2.6. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby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

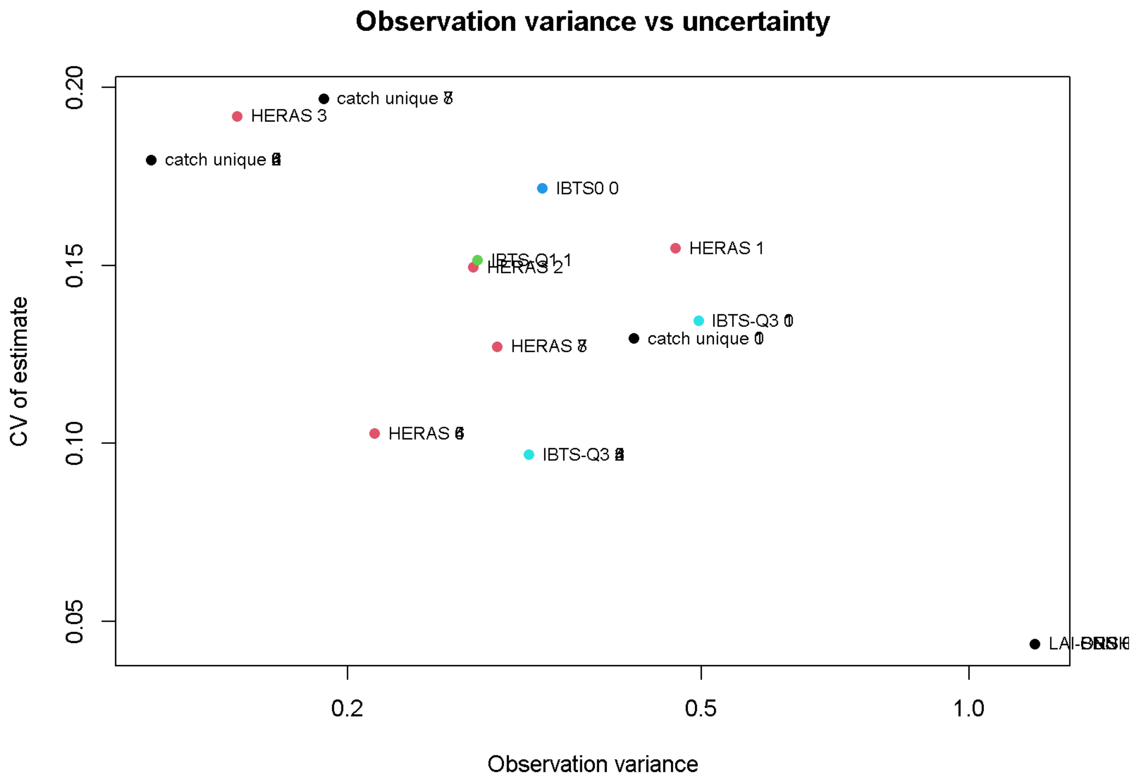


Figure 2.6.2.7. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

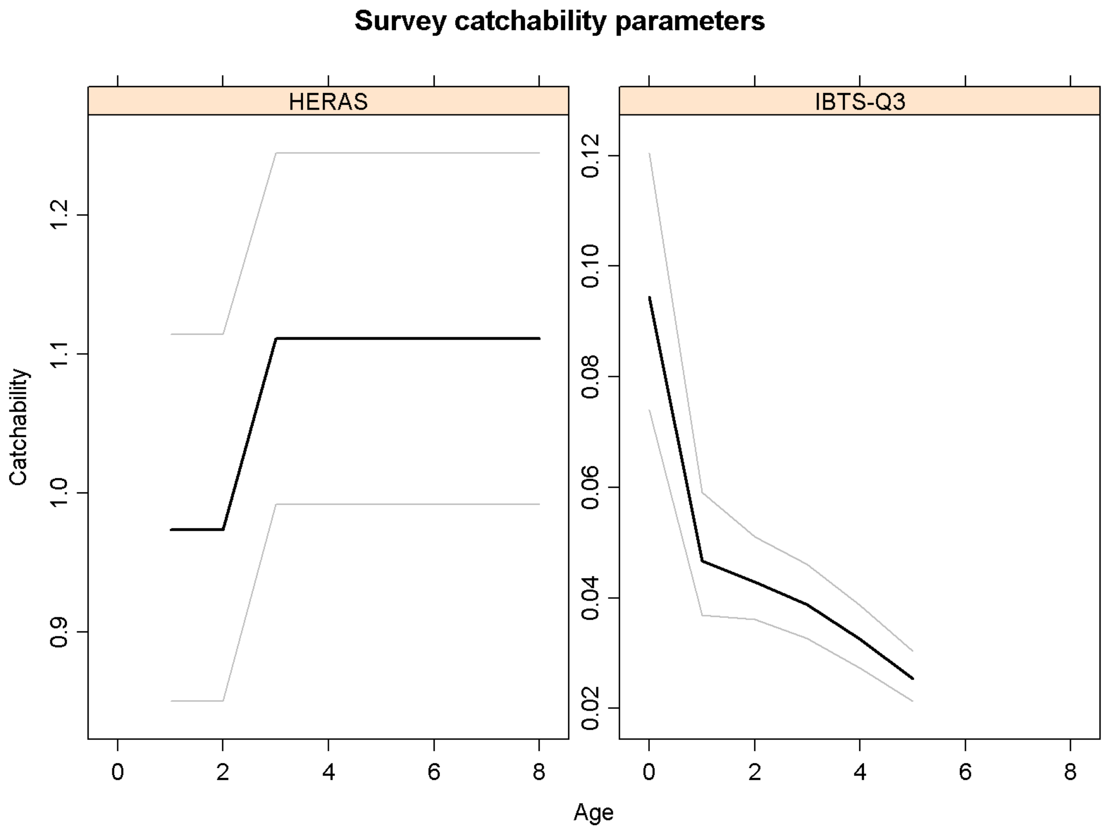


Figure 2.6.2.8. North Sea herring. Catchability at age for the HERAS and IBTSQ3 surveys.

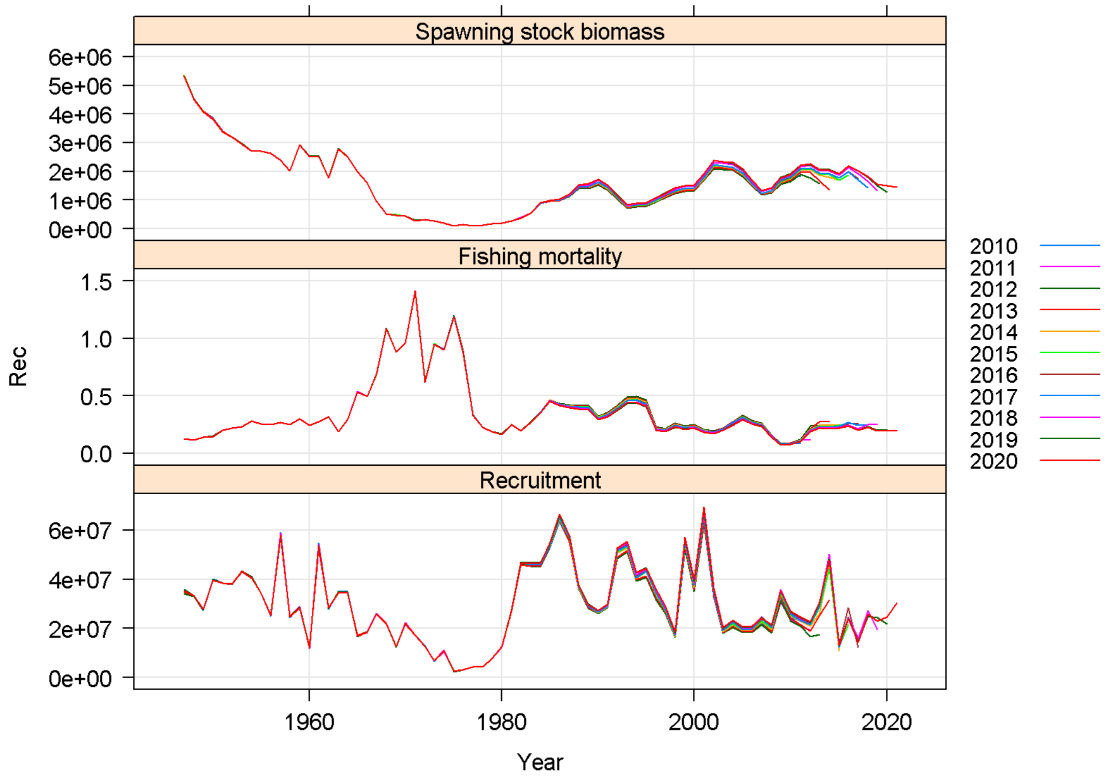


Figure 2.6.2.9. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

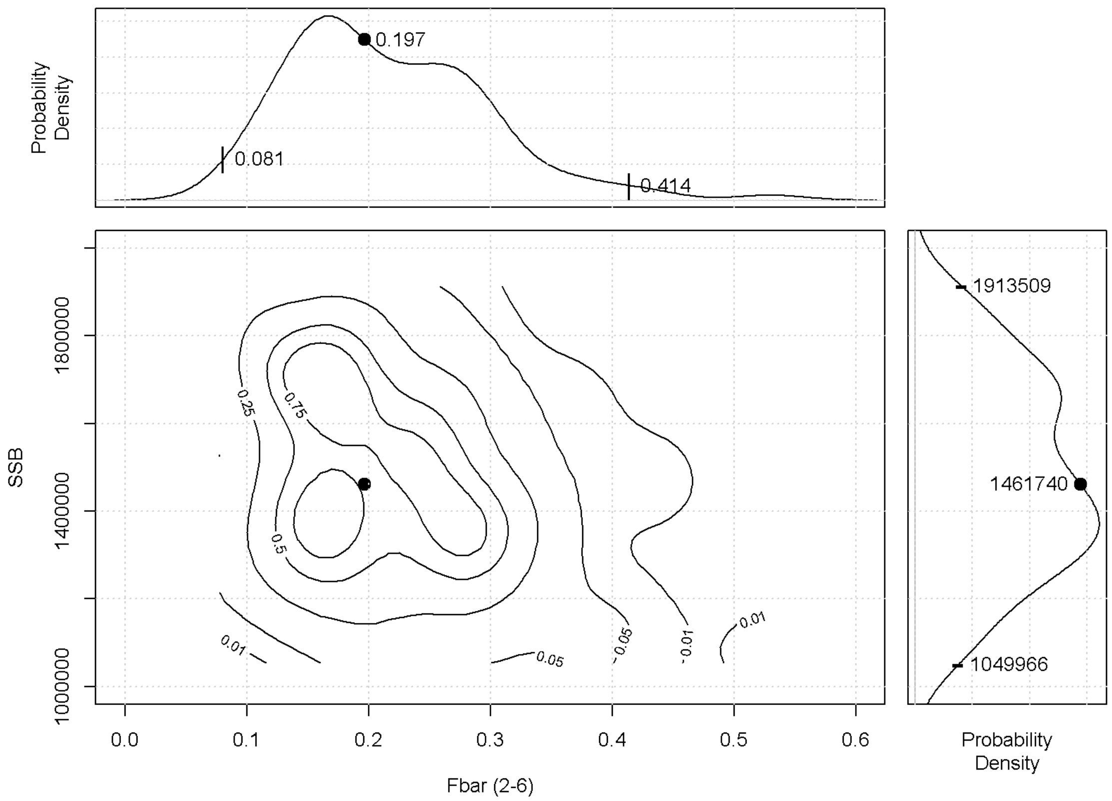


Figure 2.6.2.10. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F2–6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance/covariance estimates from the model.

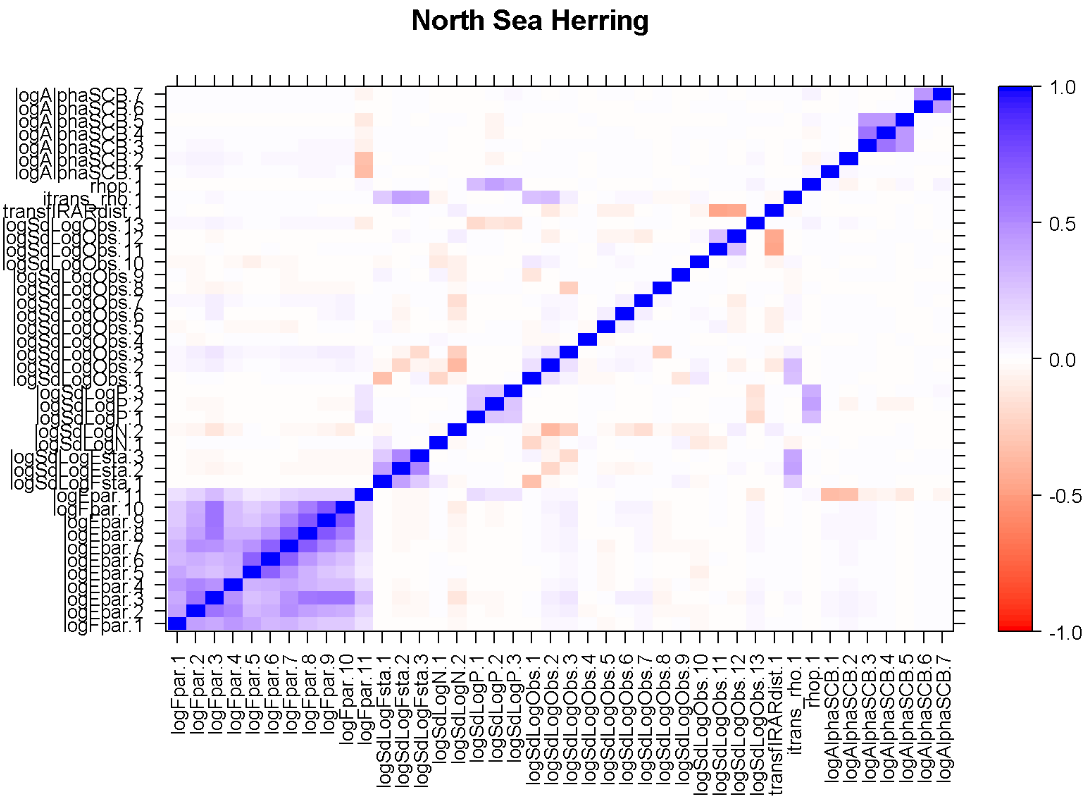


Figure 2.6.2.11. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

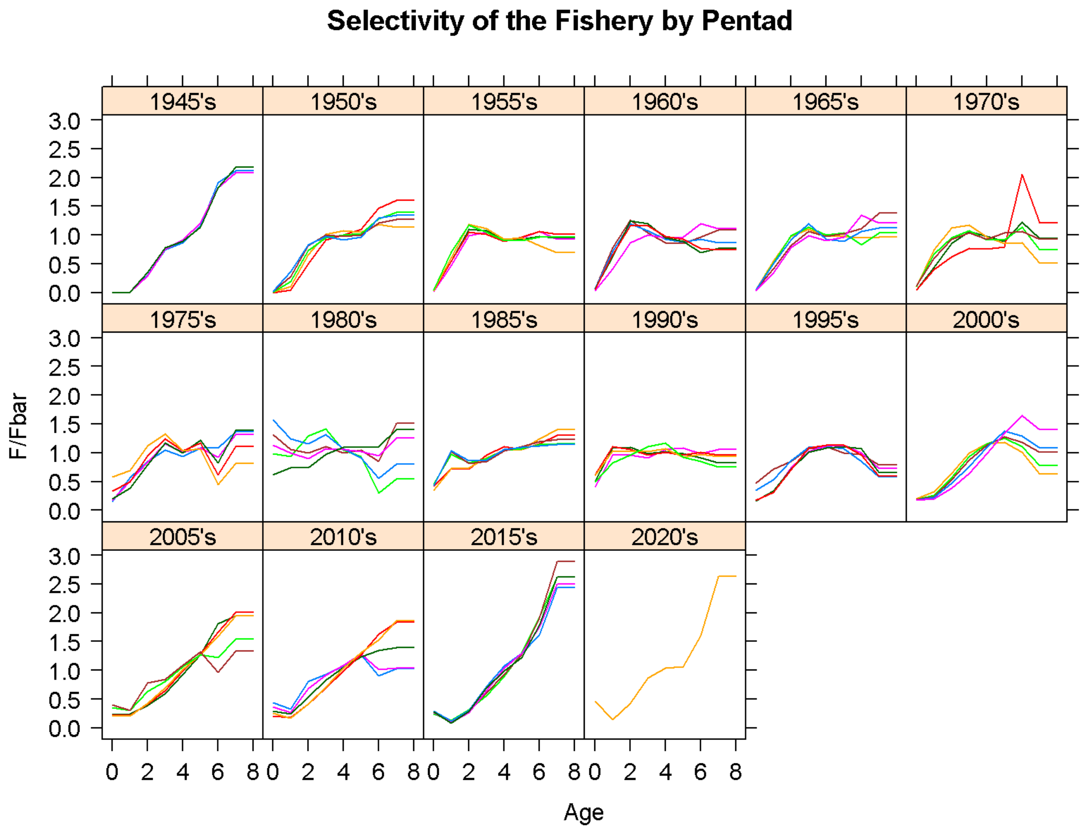


Figure 2.6.2.12. North Sea herring. Fishing selectivity by pentad.

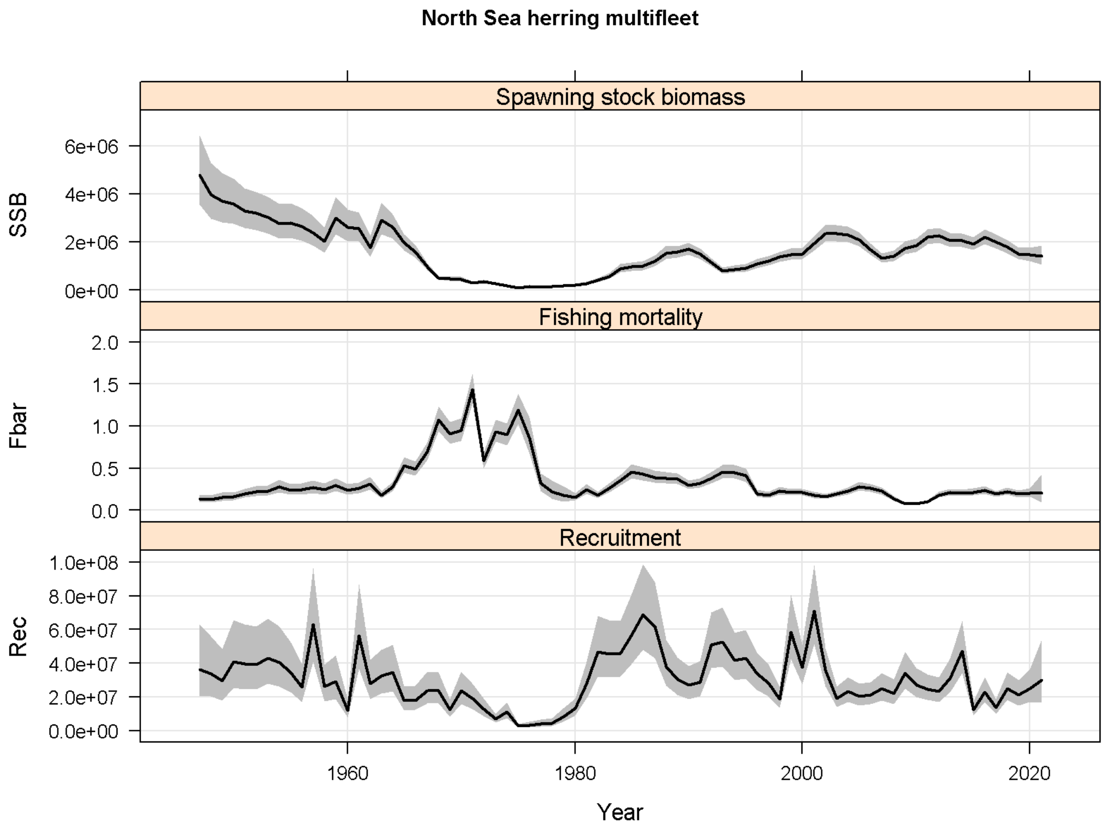


Figure 2.6.3.1 North Sea herring multi-fleet model. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

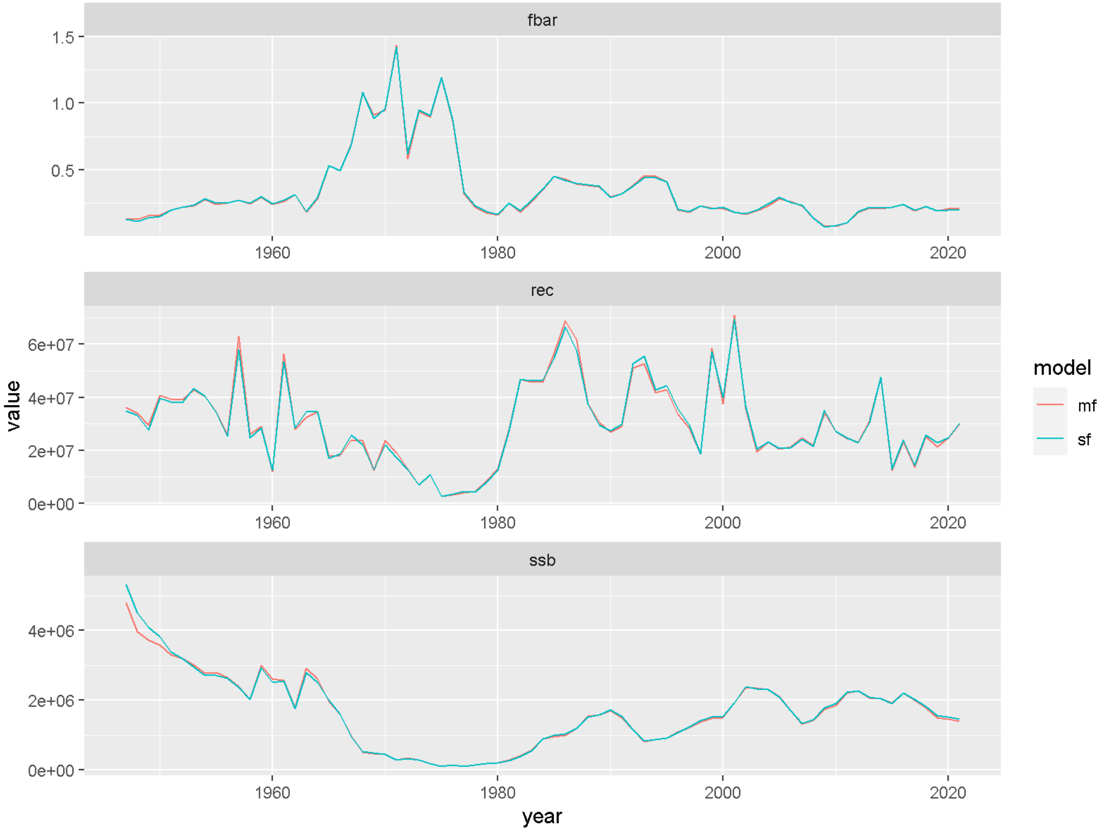


Figure 2.6.3.2 North Sea herring multi-fleet model. Comparison between single fleet and multi-fleet assessment models for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

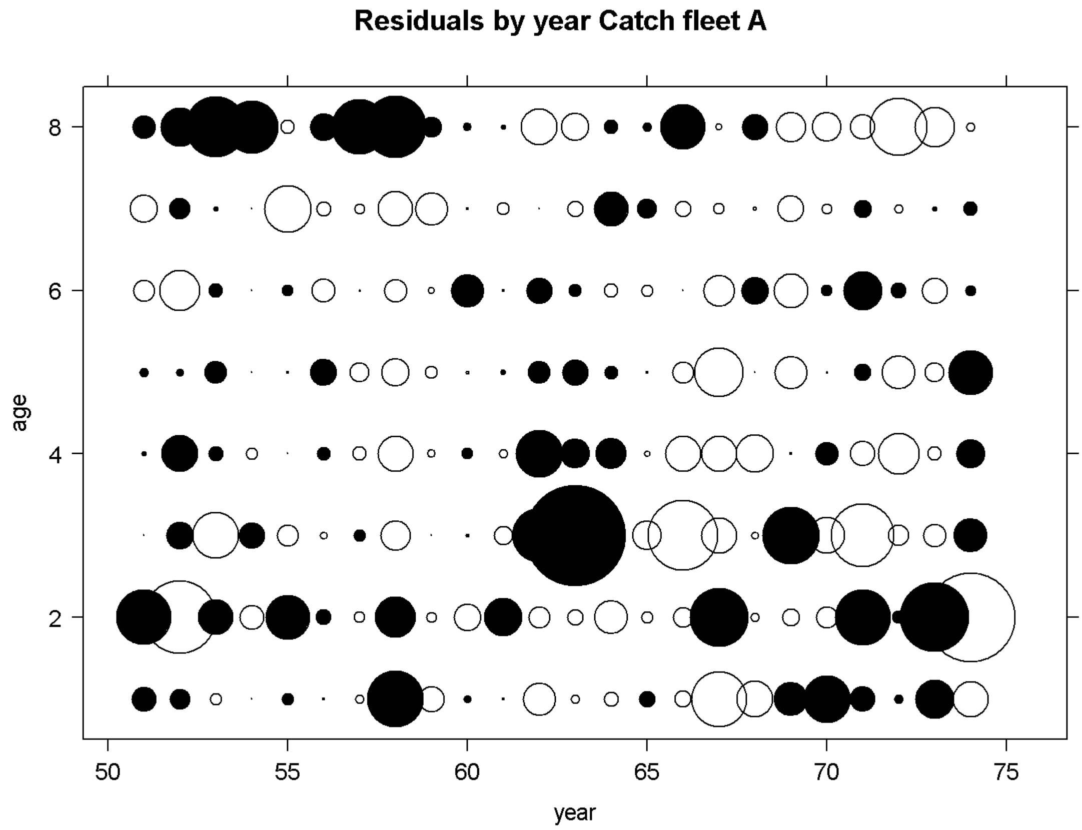


Figure 2.6.3.3. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet A.

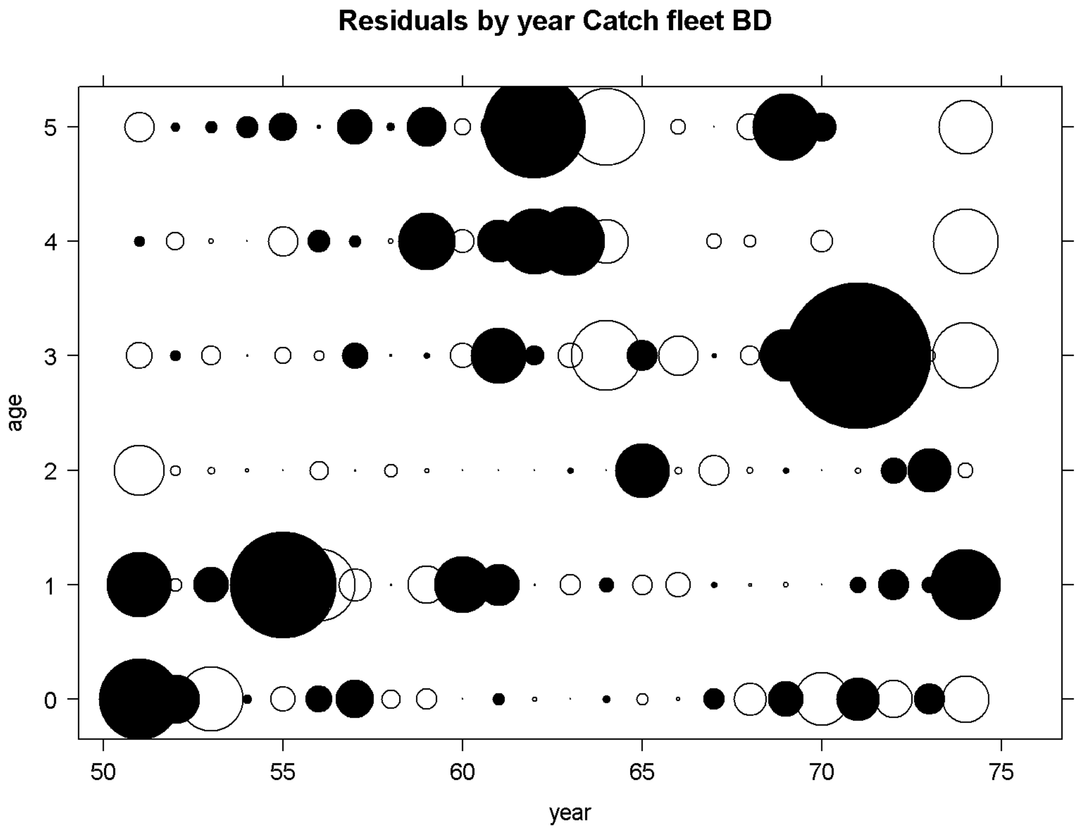


Figure 2.6.3.4. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet B&D.

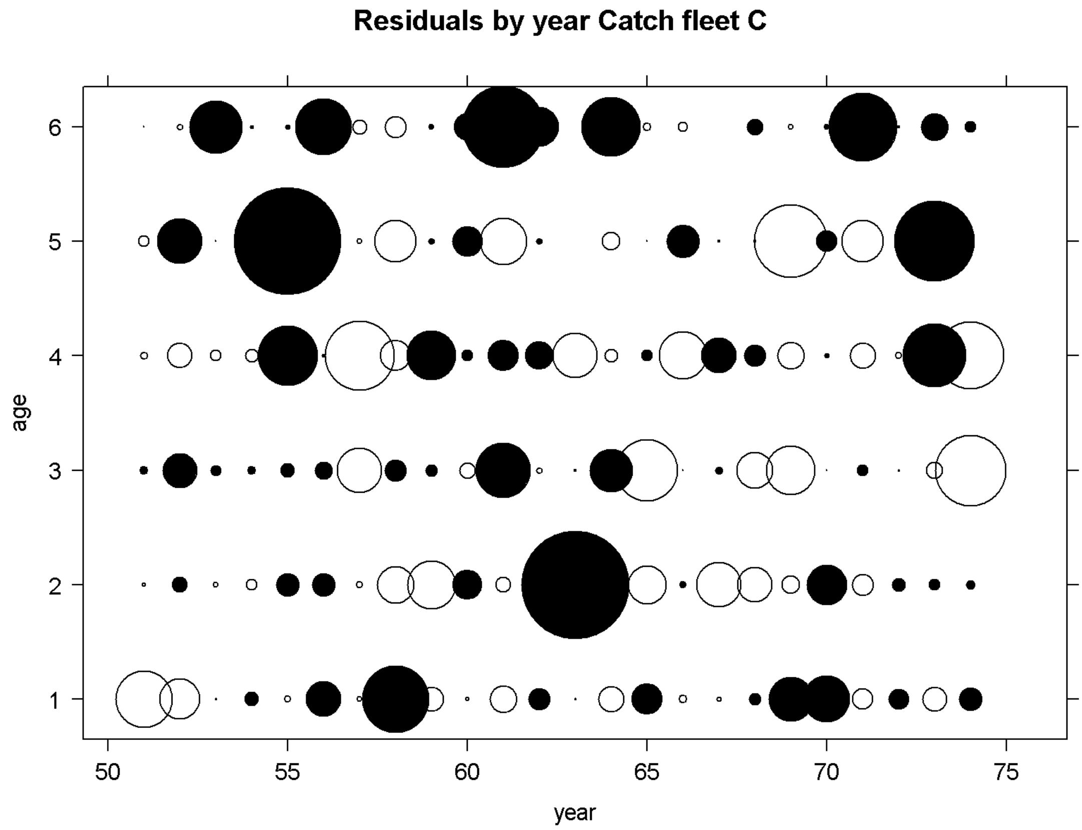


Figure 2.6.3.5. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet C.

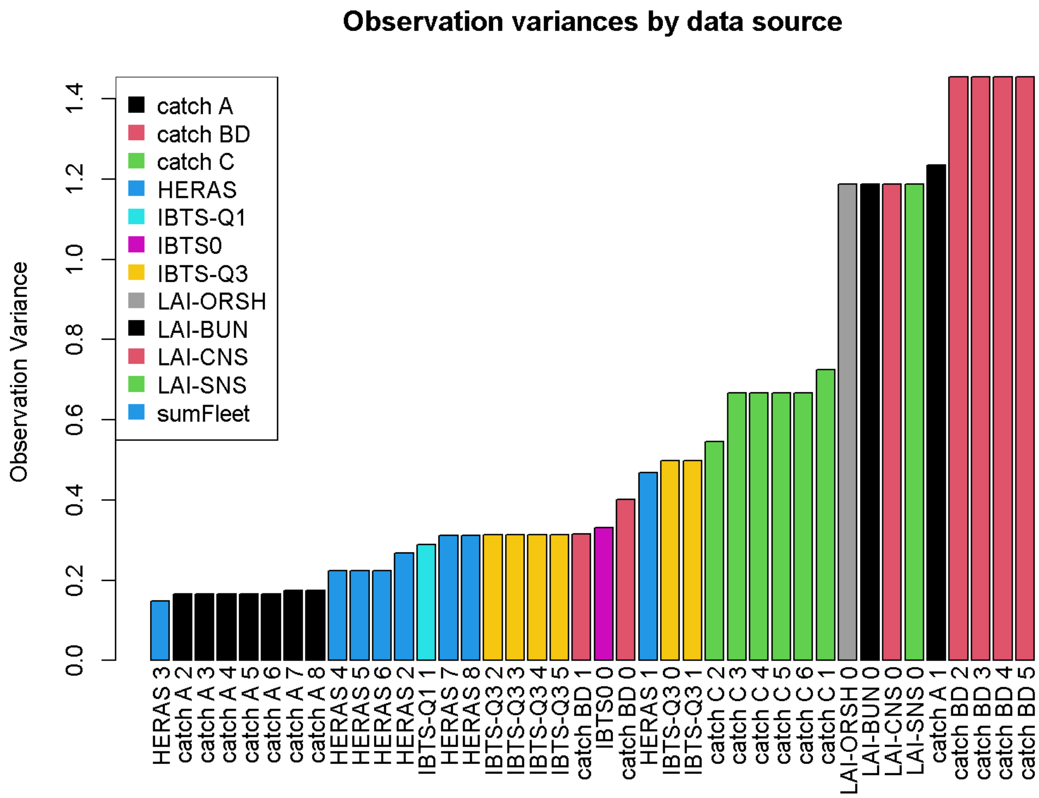


Figure 2.6.3.6. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for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

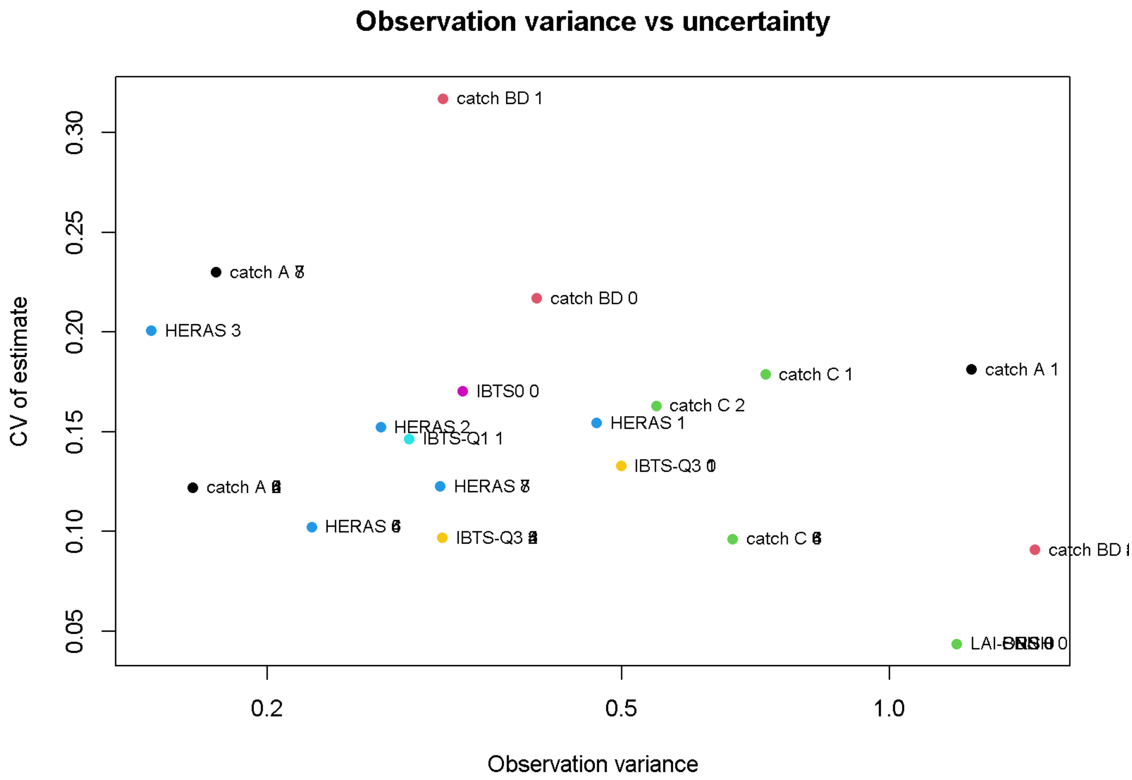


Figure 2.6.3.7. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

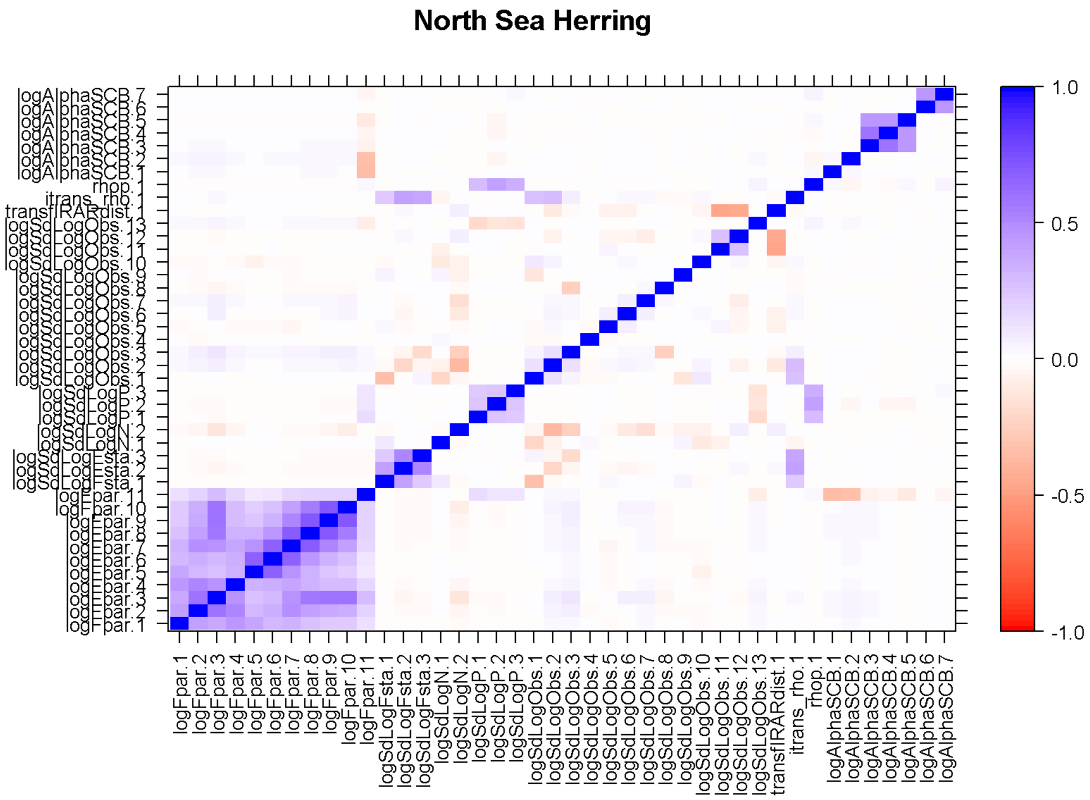


Figure 2.6.3.8. North Sea multifleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

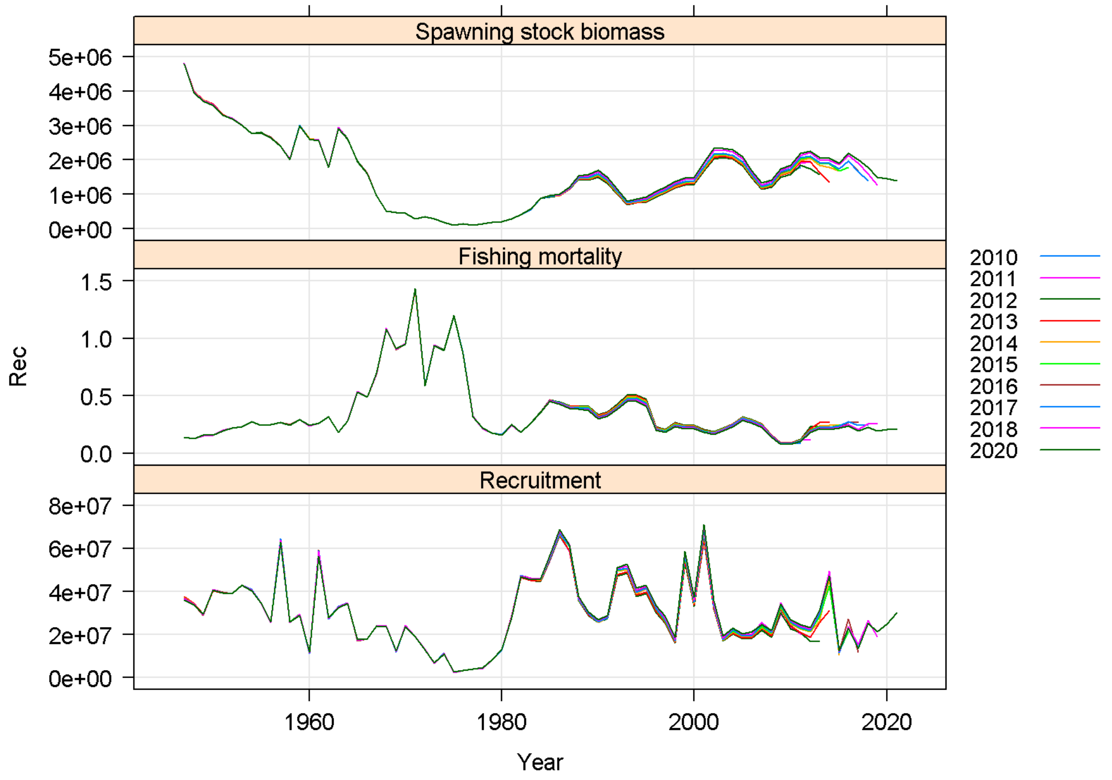


Figure 2.6.3.9. North Sea herring multifleet assessment model. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel).

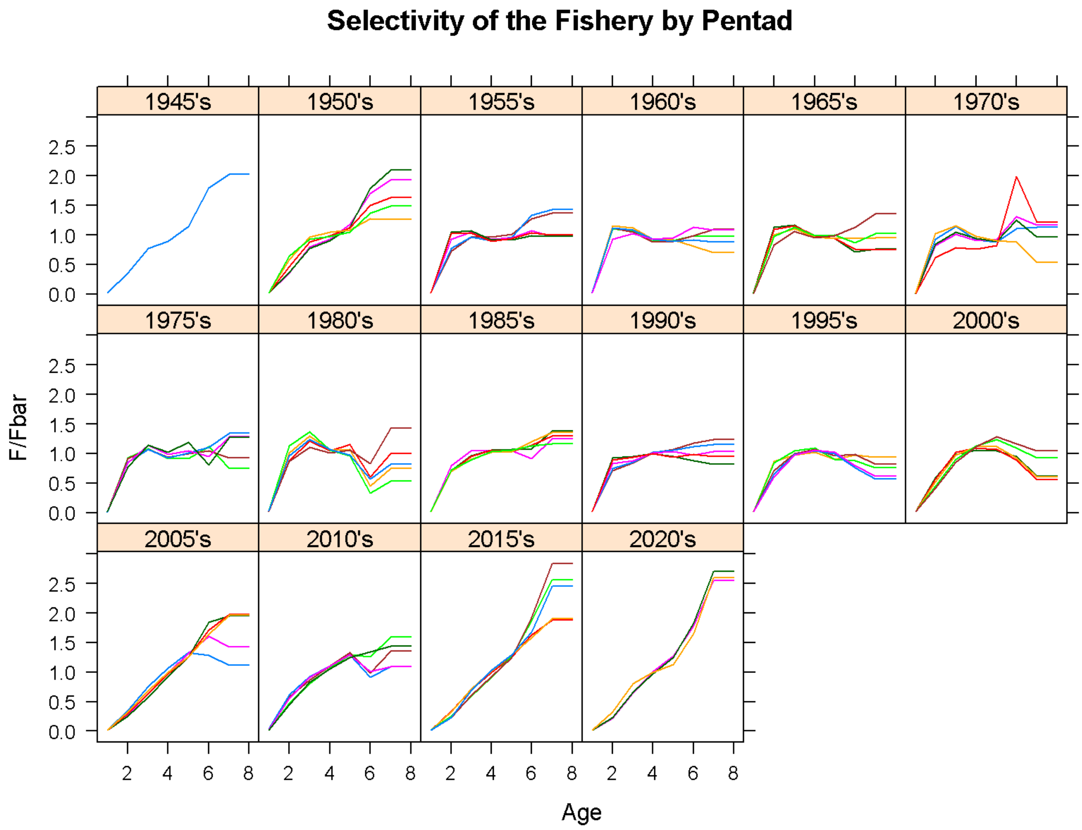


Figure 2.6.3.10. North Sea herring multifleet assessment model. Fishing selectivity fleet A.

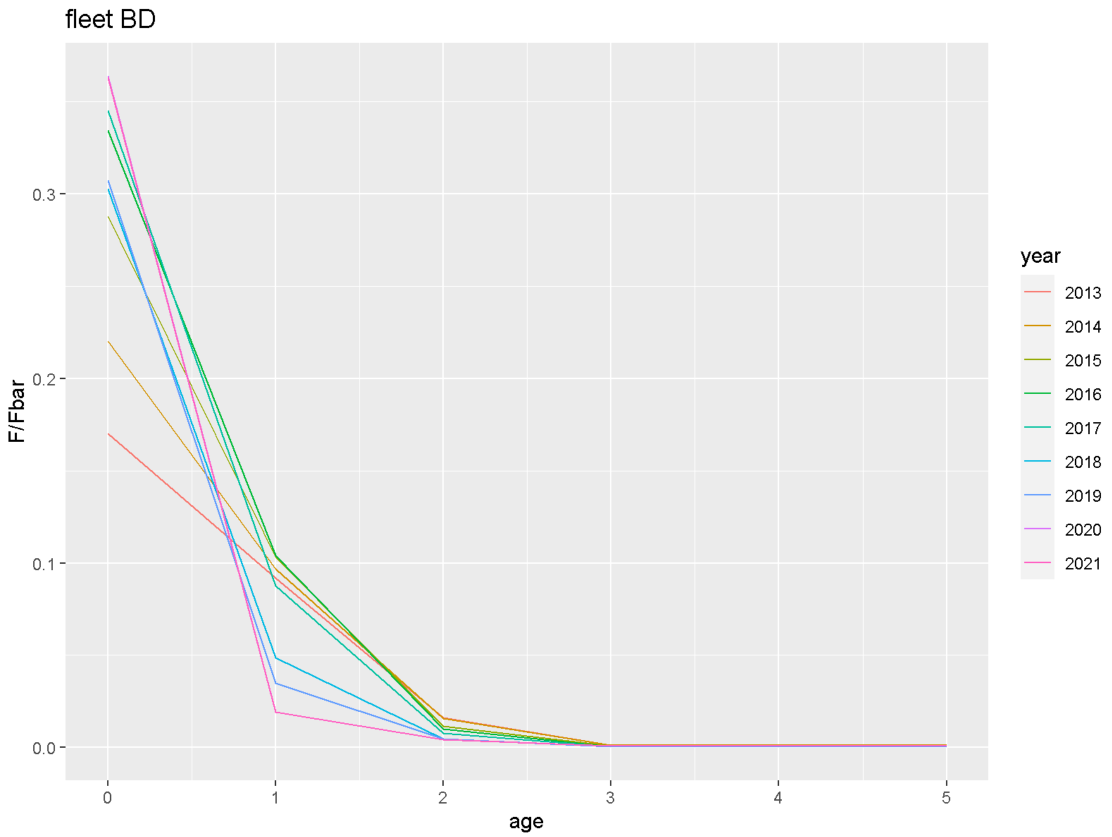


Figure 2.6.3.11. North Sea herring multifleet assessment model. Fishing selectivity fleet B and D combined.

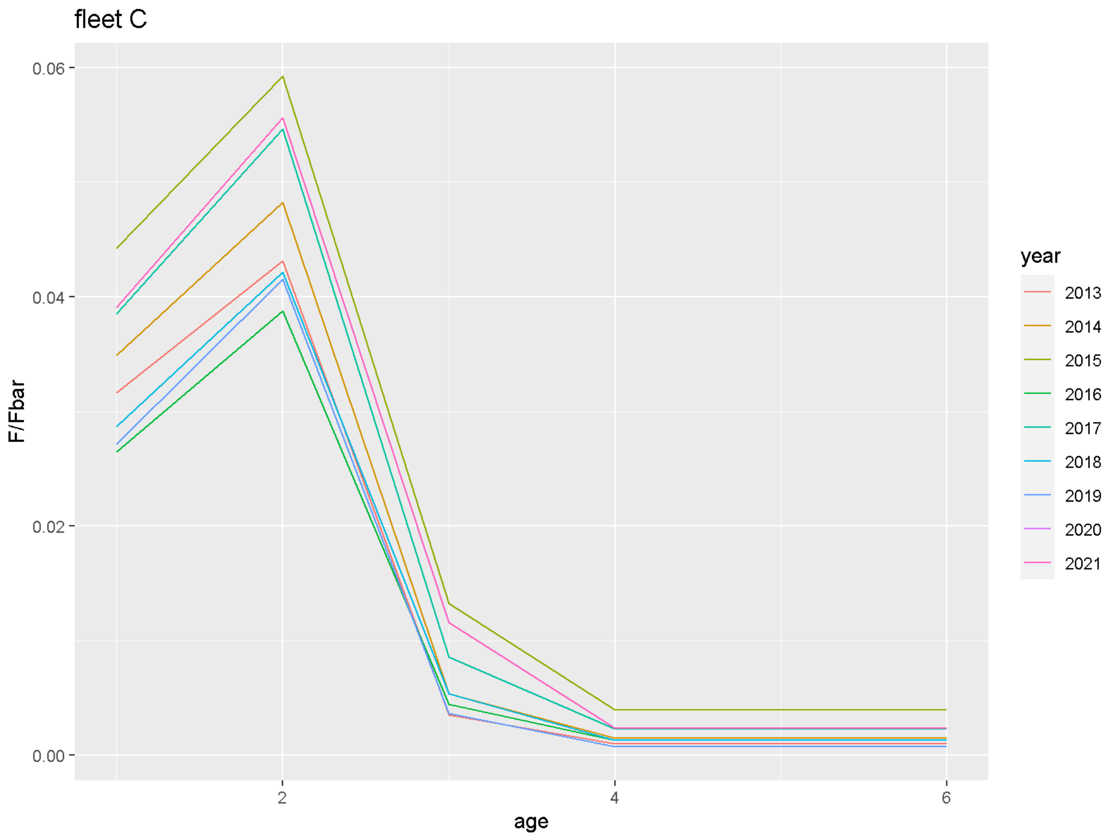


Figure 2.6.3.12. North Sea herring multifleet assessment model. Fishing selectivity fleet C.

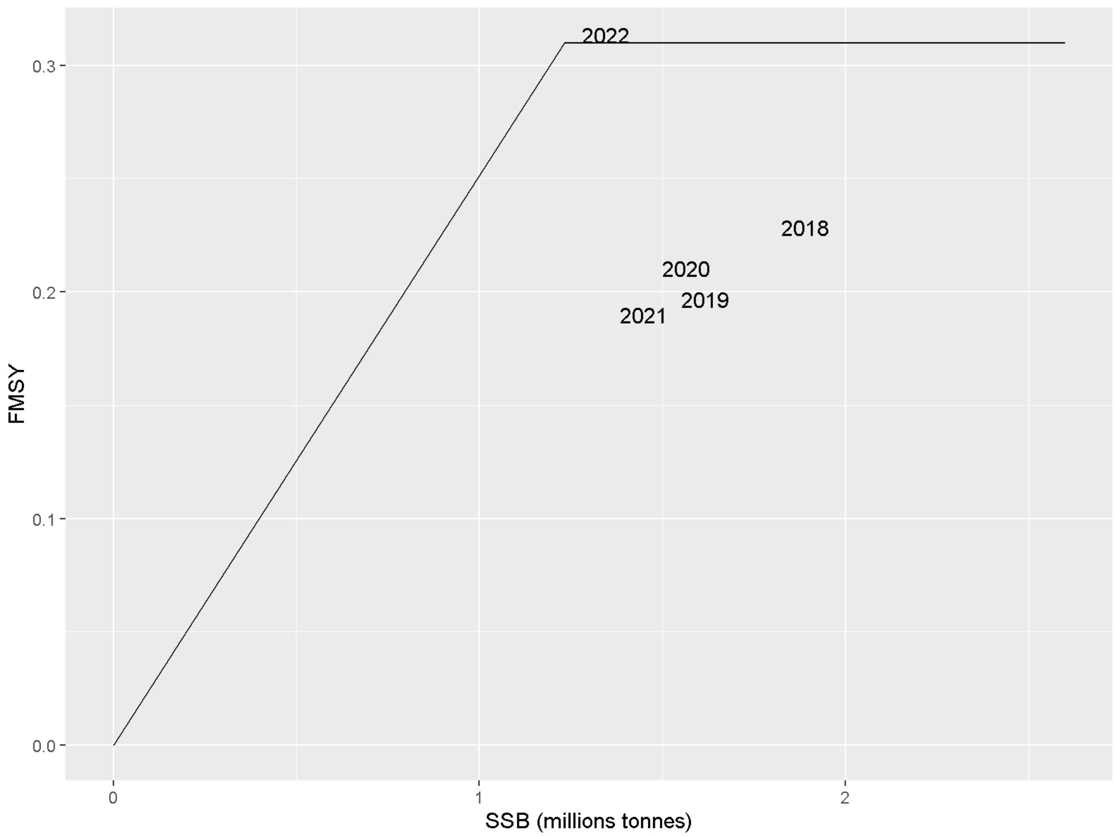


Figure 2.7.1.1. North Sea herring. FMSY advice rule and SSB/Fbar data point since 2018.

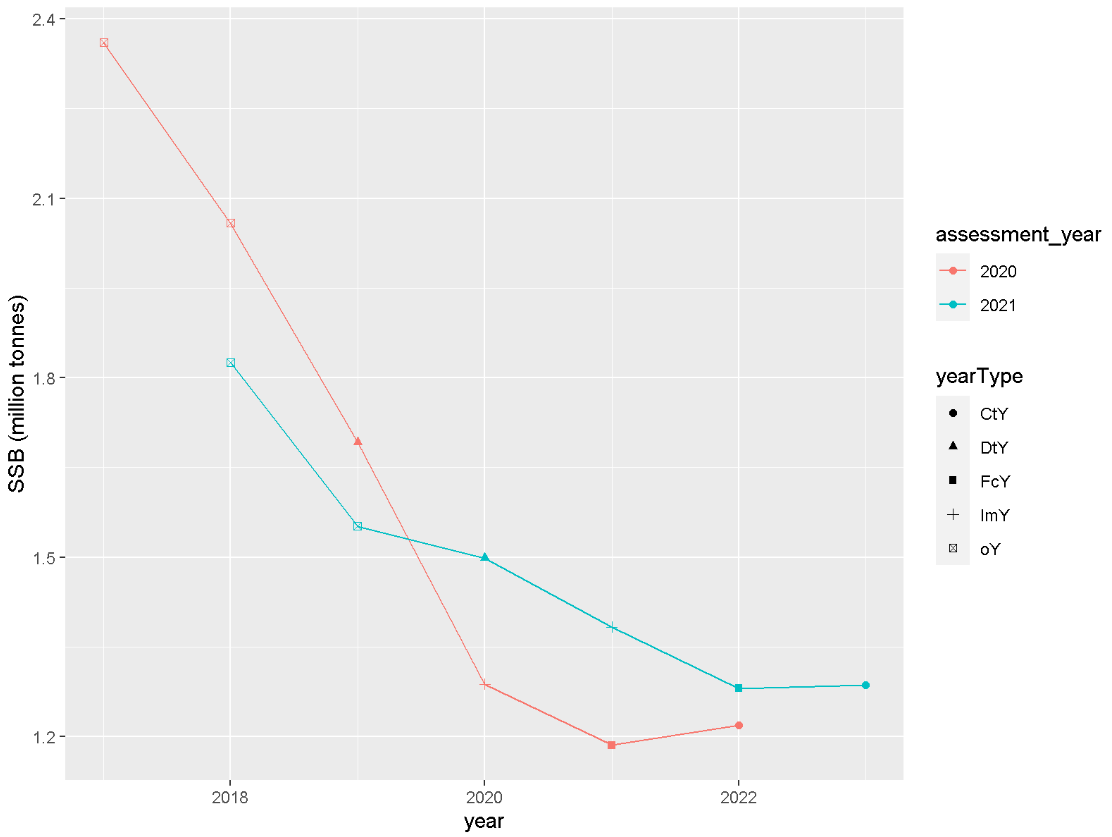


Figure 2.7.2.1. North Sea herring. comparison of SSB trajectory between short term forecasts applied to HAWG2020 and HAWG2021 data. oY: old years (prior to data year). DtY: data year. ImY: intermadiate year. FcY: forecast year. CtY: continuation year.

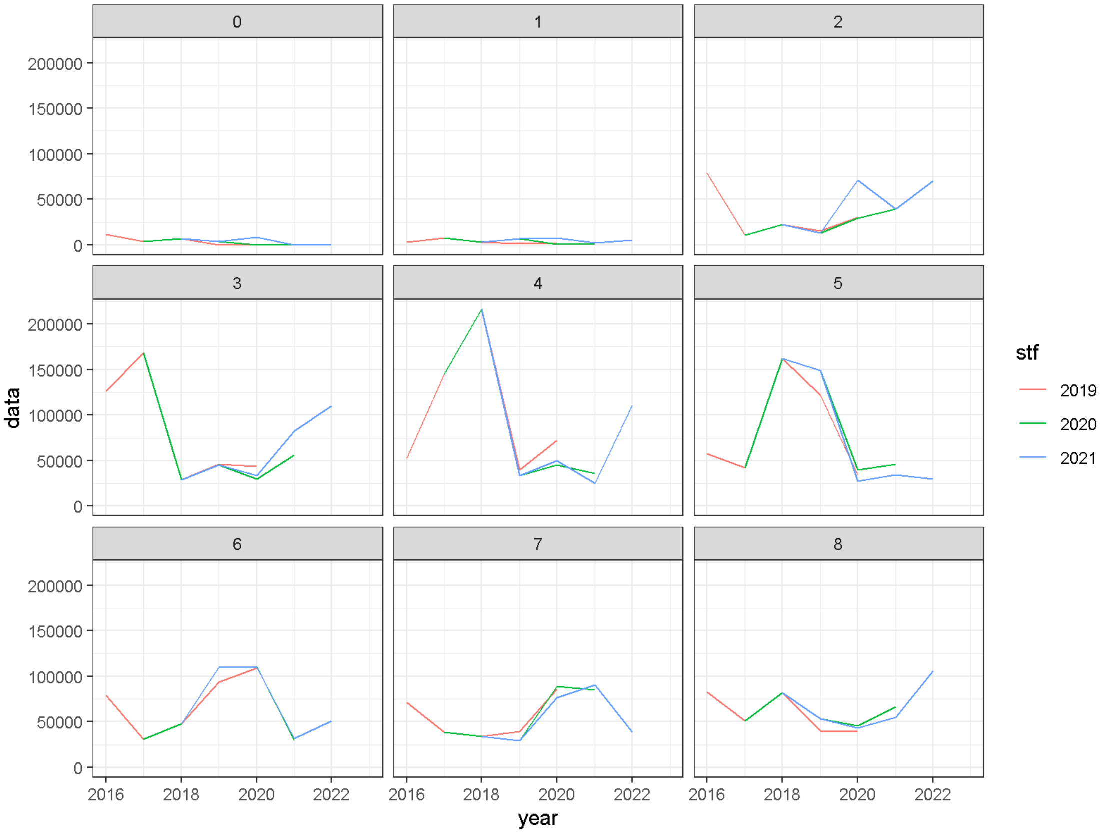


Figure 2.7.2.2. North Sea Herring. Realized and projected catch (in weight) by age (wr) between 2019 assessment (2020 as forecast year), 2020 assessment (2021 as forecast year) and 2021 assessment (2022 as forecast year).

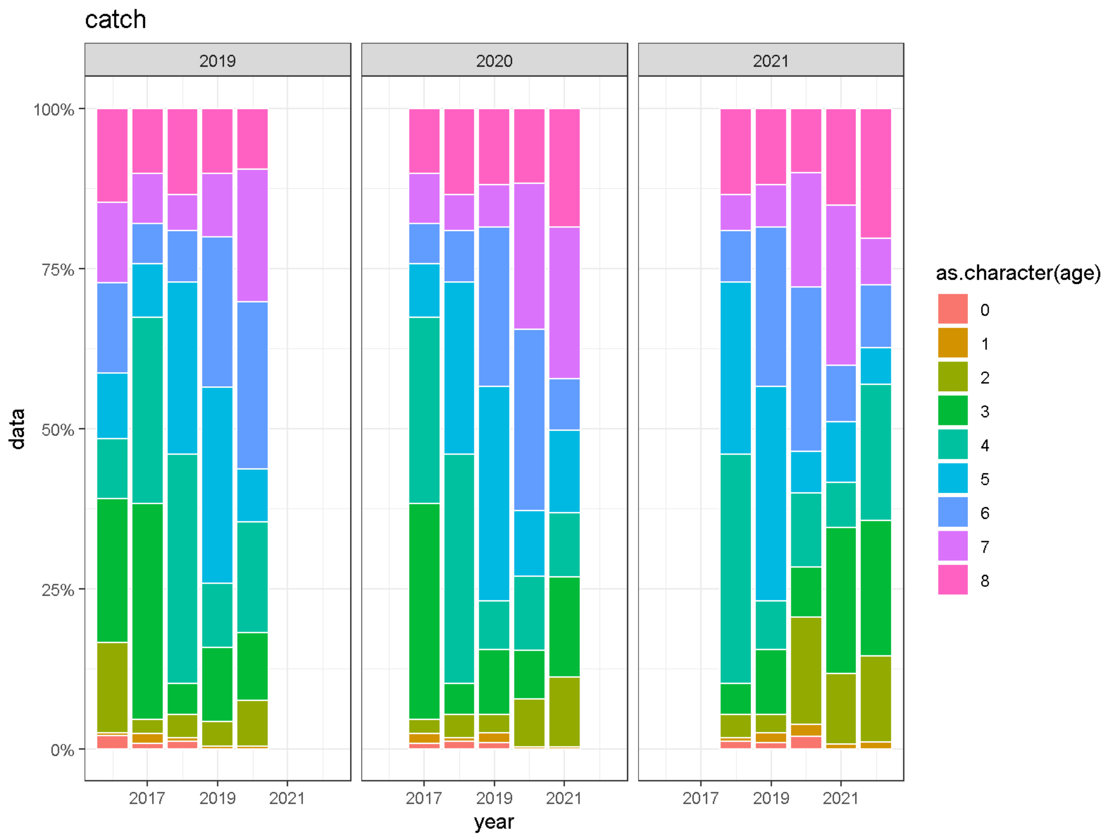


Figure 2.7.2.3. North Sea Herring. Catch proportions for the different ages between the 2019 short-term forecast (2020 as forecast year), 2020 short-term forecast (2021 as forecast year) and 2021 short term forecast (2022 as forecast year).

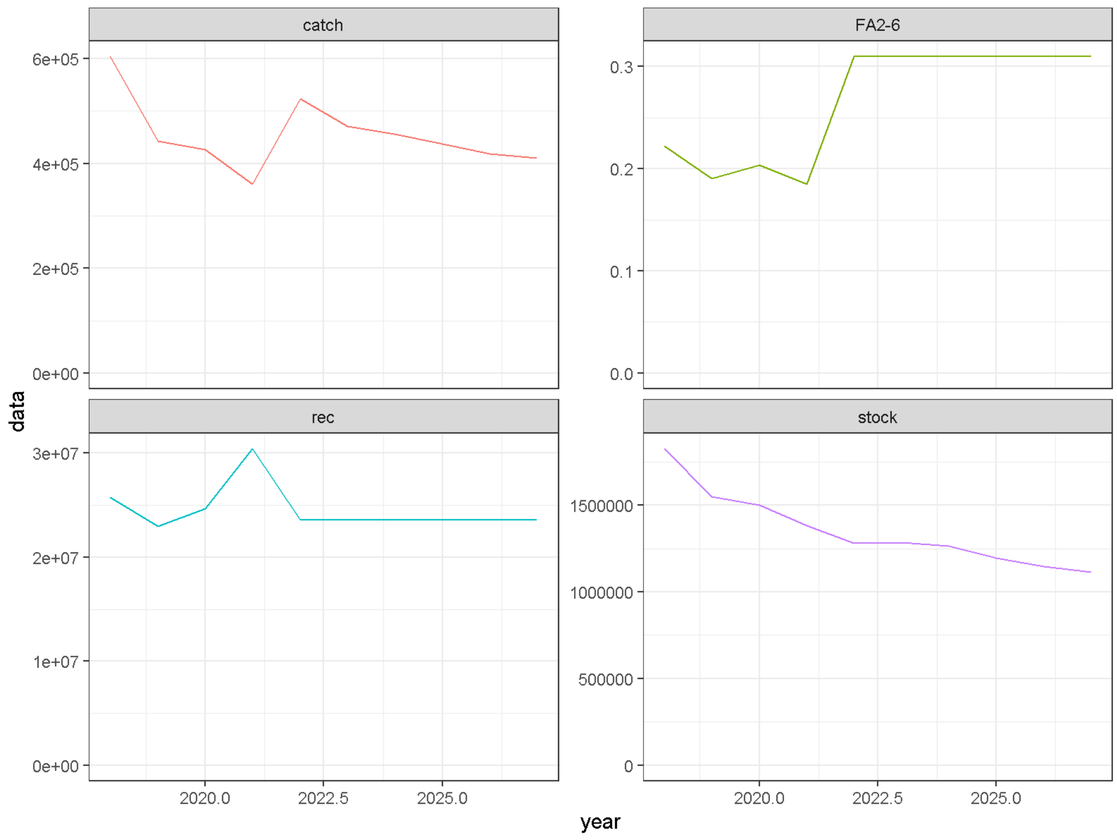
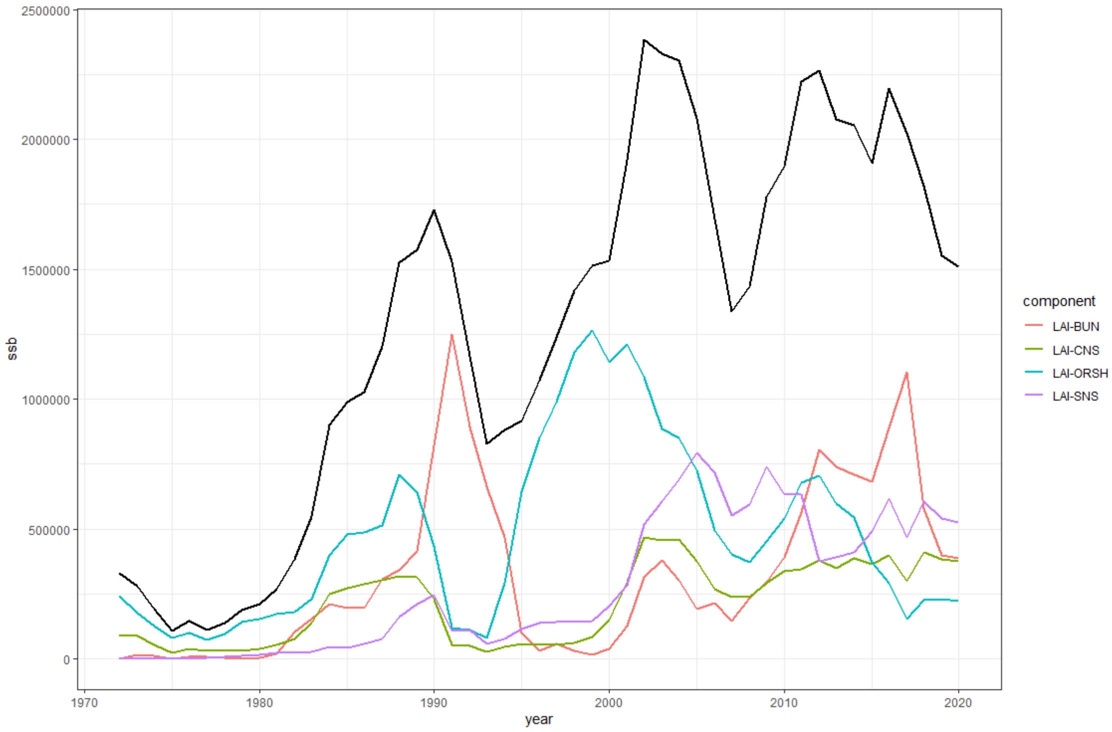


Figure 2.7.2.4. North Sea Herring. Short-term projections using an F status quo from TAC year (i.e. advice year). Intermediate year is in 2021 and the TAC year is 2022.



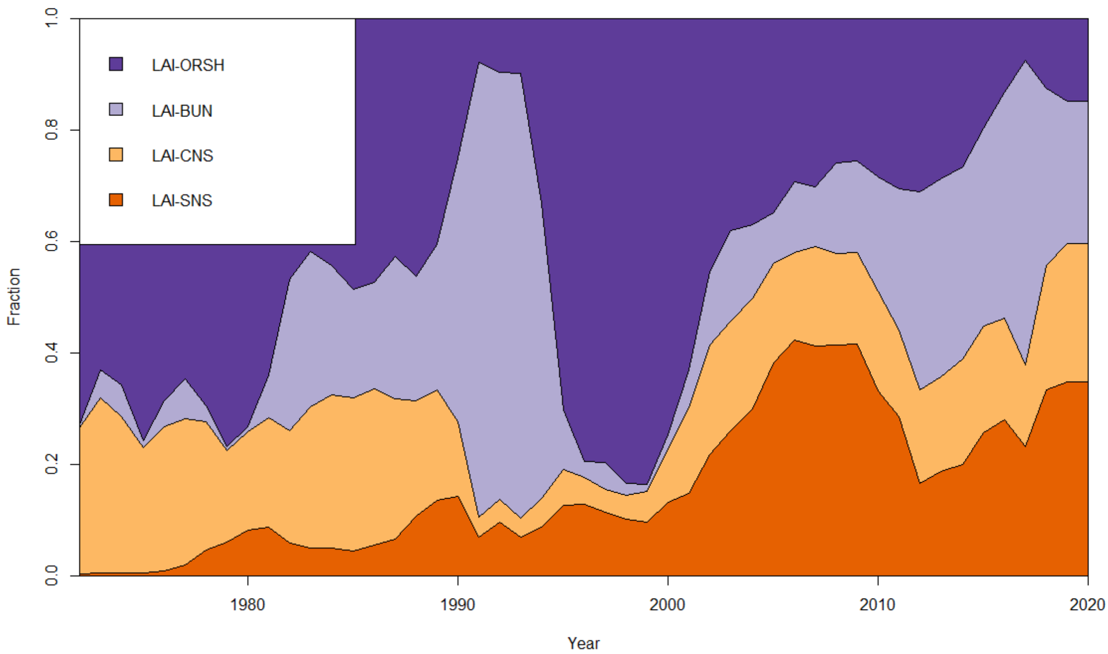


Figure 2.11.1. North Sea herring. Time-series of spawning-stock biomass of each component (top),; and contribution of each component to the total stock (bottom; Payne, 2010) as estimated from the LAI index Areas are arranged from top to bottom according to the south-to-north arrangement of the components.

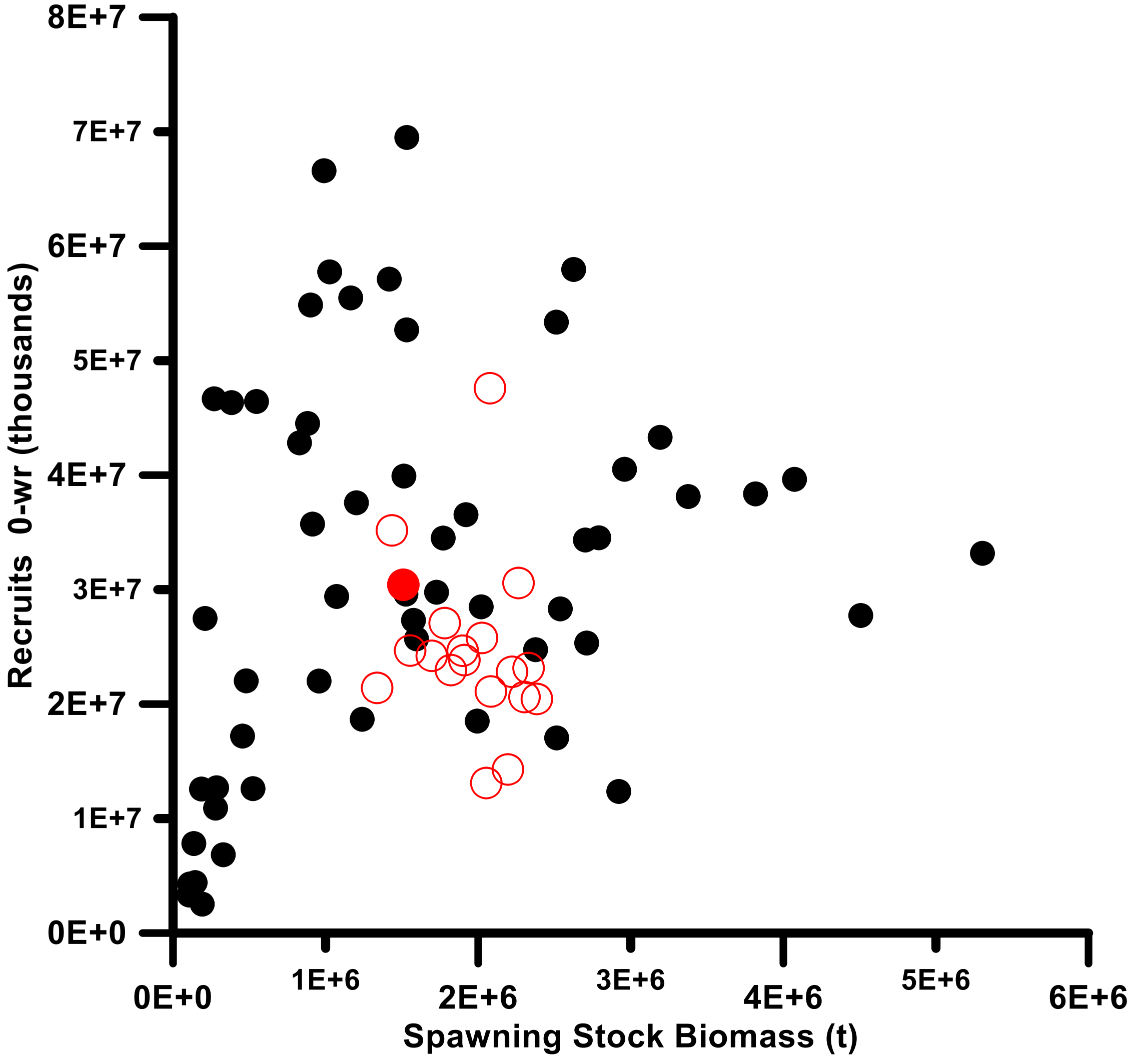


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning-stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent low recruitment. The most recent year class is plotted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

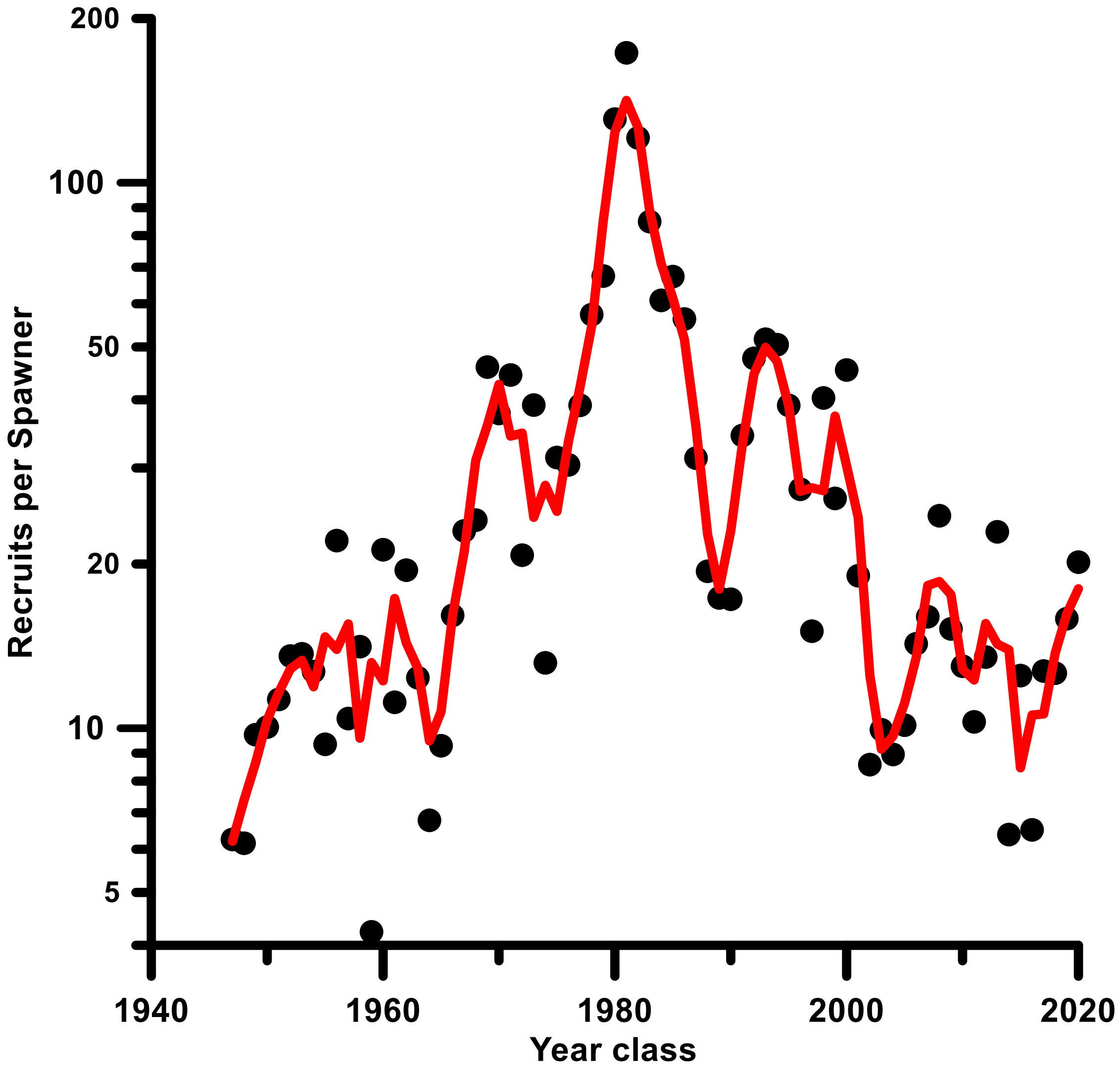


Figure 2.13.2. North Sea Autumn Spawning Herring time-series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black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

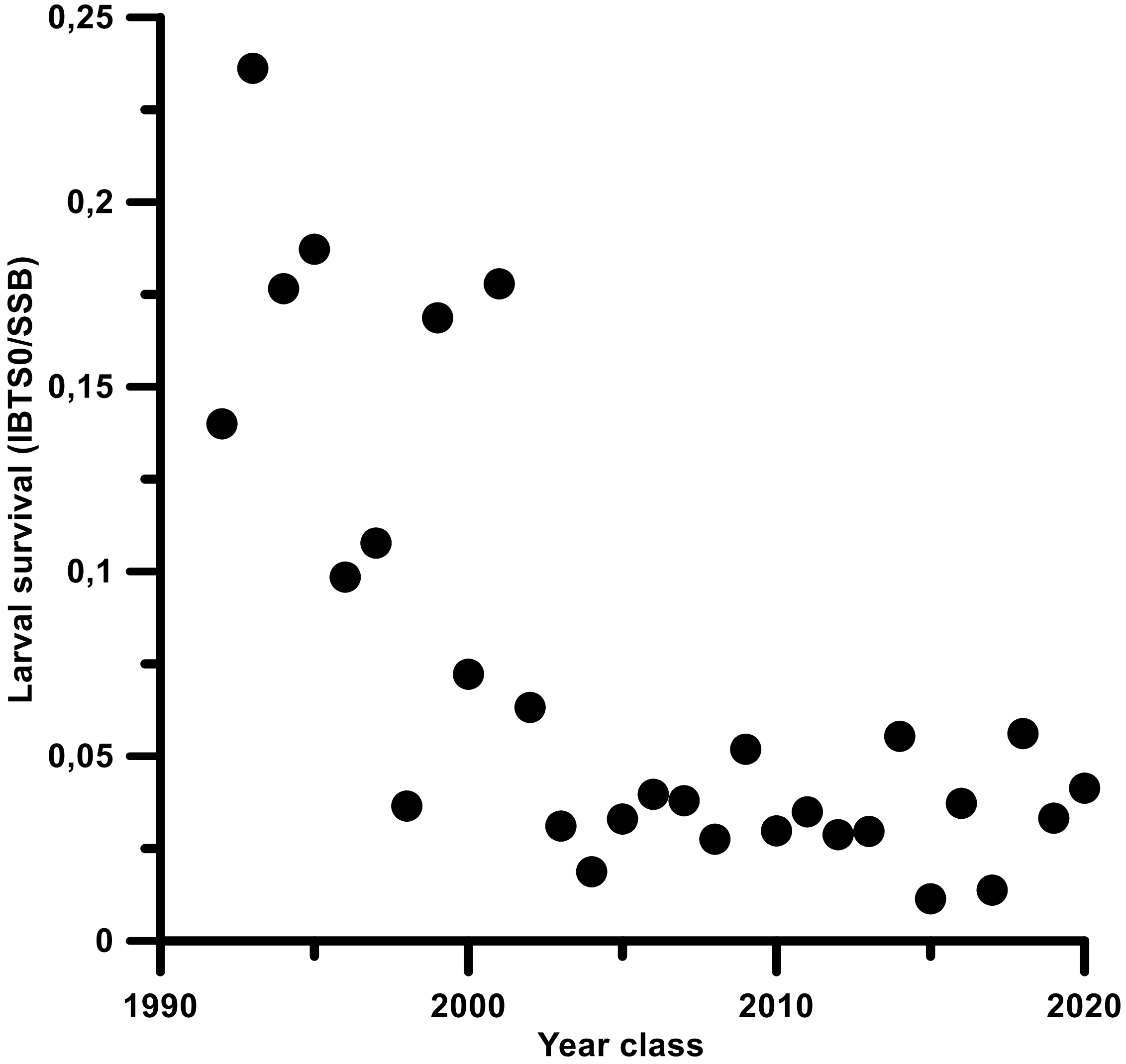


Figure 2.13.3. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is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

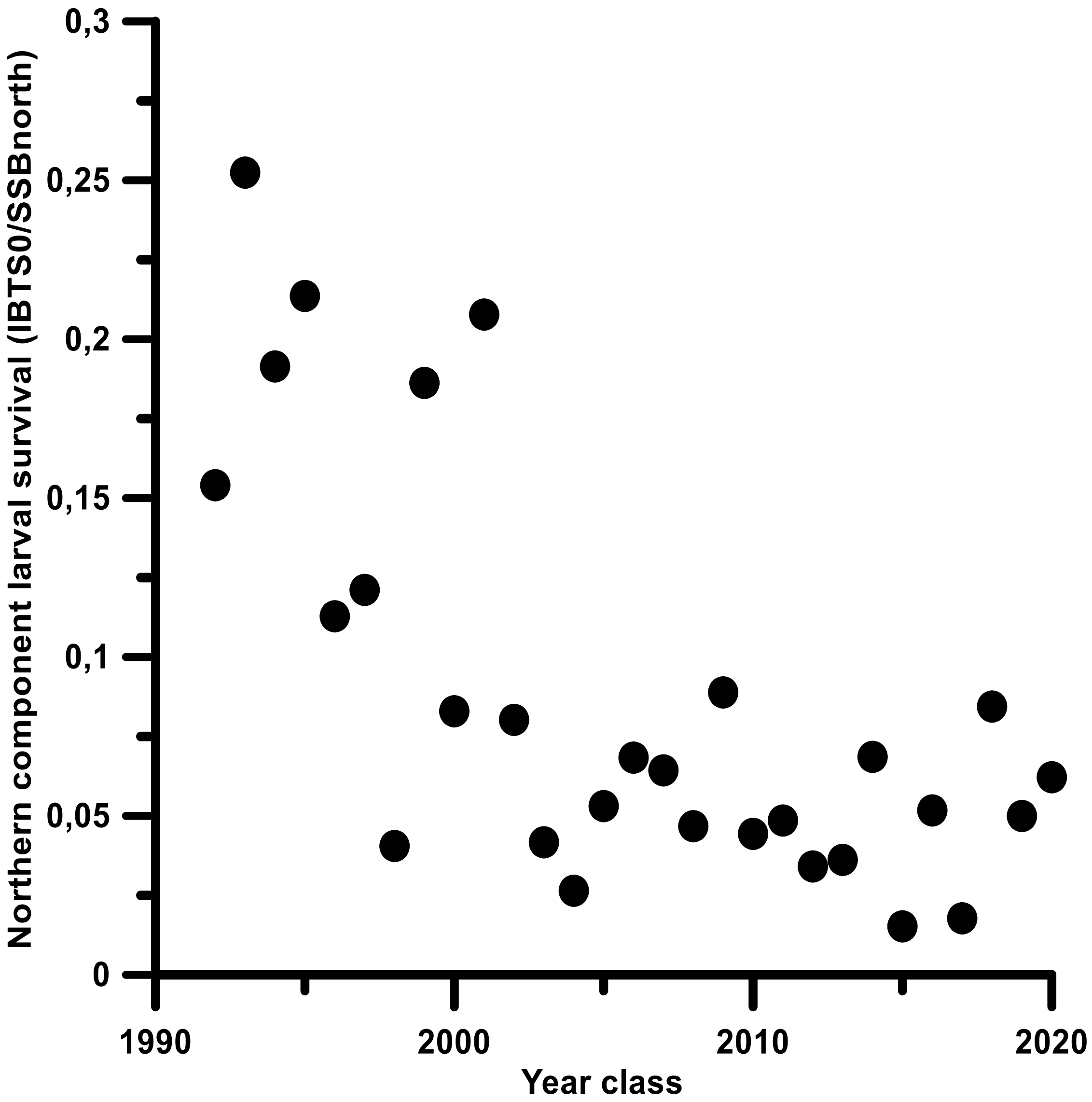


Figure 2.13.4. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the larvae indices for these components (representing 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 2020 on the basis of the MSY approach. This corresponds to zero catch in 2021 (ICES 2020).

The EU and Norway agreement on a herring TAC for 2020 was 24 528 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 2021, the EU and Norway agreement on herring TACs in Division 3.a was 21 604 t for the human consumption fleet and a bycatch ceiling of 6659 t to be taken in the small mesh fishery.

Prior to 2006, no separate TAC for subdivisions 22–24 was set. In 2020, a TAC of 3150 t was set on the Western Baltic stock component. The TAC for 2021 was set at 1575 t.

3.1.2 Landings in 2020

Herring caught in Division 3.a are a mixture of 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 spring spawners.

Landings from 1989 to 2020 are given in Table 3.1.1 and Figure 3.1.1. In 2020, the total landings in Division 3.a and subdivisions 22–24 have decreased to 21 745 t. Landings in 2020 increased by 24% in the Skagerrak, by 1% in the Kattegat and decreased by 60% in subdivisions 22–24. As in previous years the 2020 landing data are calculated by fleet according to the fleet definitions used when setting TACs.

3.1.2.1 Fleets

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

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

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

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

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

The definition used by HAWG, since 2010.

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

Fleet D: 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 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 2020 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
2020								
Div. 3.a fleet-C	24 528	10 309	165	0		10 783	21 257	3271
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	3150	442	1738	0	410	560	3150	
% 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%
	TAC	**DK**	**GER**	**FI**	**PL**	**SWE**	**EC**	**NOR**
2021								
Div. 3.a fleet-C	21 604	9800*	145*			9498*	18 723*	2881
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	1575	221	869	0	205	280	1575	
% 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%

*** preliminary**

3.1.3 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.

For the fishery in 2021, the Pelagic AC informed HAWG that the transfer of EU quotas from Division 3.a to Subarea 4 in 2021 is uncertain depending on the final outcome of still ongoing bilateral negotiations between EU, UK and Norway, but a likely transfer would be the EU-Norway bilateral agreed 3000 t to Norwegian waters of the North Sea. The Norwegian fishing industry informed HAWG that 50% of the predicted catches in the C-fleet probably will be taken in Division 3.a and 50% will be transferred to the North Sea.

HAWG decided to use these values for intermediate year catch predictions leading to an estimated transfer of 21% from the C-fleet in Kattegat-Skagerrak to the A-fleet in the North Sea.

The quota for the C fleet and the bycatch TAC for the D fleet (see above) 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.

3.1.4 Changes in fishing technology and fishing patterns

The amount of WBSS herring taken as bycatch in the sprat fishery 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 2020 the amount of WBSS taken was 481 t, an increase in relation to the recent 3 years but still lower than the 10 years average. However, the TAC utilization was 68.8% and higher than the 10 years average. Prediction of TAC utilization is further complicated by the merging of the sprat stocks in 3.a and the North Sea (ICES, 2028) 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.

3.1.5 Winter rings vs. ages

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

3.2 Biological composition of the landings

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 21 745 t of landed herring were submitted stratified by area, fleet and quarter, resulting in 55 strata with landings. 26 of these strata were sampled - accounting for 85% of the landings. Some strata with relatively large amount of landings were unsampled, but the main problem being that fleet C only was sampled in the first quarter in Skagerrak (Table 3.2.4). Unsampled strata accounted in total for 3 349 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).

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Division 3.a in 2020 was estimated to be 18 163 t, which represents an increase of 17% compared to 2019 (Table 3.2.13).

Total catches of WBSS from the North Sea, Division 3.a, and subdivisions 22–24 respectively, by quarter, were estimated to be 22 130 for 2020 (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 1993–2020, are presented in tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division 3.a amounted to 6 388 t in 2020, which represents the fourth 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 2020 were reallocated to the appropriate stocks as shown in the text table below:

Stock	Catch reallocation	Tonnes
WBSS	4.aE (A-fleet)	6802
NSAS	3.a (C+D-fleet)	6388

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 2021 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 2020 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 2020 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). Only a single country reported lack of sampling due to covid-19. Fortunately, 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 Danish and Swedish analyses of otolith micro-structure (OM) of hatch type. 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 also spawn during winter, which would lead to an assignment to OM hatch month 12. This leads to potential overlapping distributions in Division 3.a of herring from both stocks with the same OM hatch month 12 signal. These 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.

For Danish data, OM based classification was extended using discriminant analysis (DA) based on otolith shape (OS) as well as fish and sample parameters. These data were calibrated with stock hatch type (4 or 9) and applied on production samples using non-biased k = 1 nearest neighbour DA, with classification parameters: herring OS and otolith metrics as well as quarter, age, length and ICES Subdivision (see Stock Annex). The total sample size for hatch type was 1113 with 76% of the samples in Subdivision 20 (Skagerrak) and 24% 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 by relevant adjacent age classes, or from cruises in the same quarter and subdivision or from 2019 data. There were no samples available in the 2nd quarter therefore data from 2019 were used combined with samples of 1-2 wr from HERAS. Further, there were no samples from Kattegat in the 3rd quarter so in this case the Swedish IBTS samples were used as a basis for the split, since it was expected to best reflect the proportions in the local distribution.

Random samples of 50 individual herring from Norwegian commercial catches in the 4.aE are analysed for size at age distribution and stock affiliation based on vertebral series (vs) counts. Catches from the so called "transfer area" are split into proportions of NSAS and WBSS by quarter and age group based on the mean vs count in the two stocks using the formula:

Proportion (WBSS) = 1-MAX(MIN(1,(VSsample - VSWBSS)/(VSNSAS - VSWBSS),0)

Where the assumption is that VSWBSS = 55.8 and VSNSAS = 56.5.

A total of 12 649 tonnes of herring was caught in the transfer area in 2020, with catches constituting 59% in quarter 2 and 34% in quarter 3, however with only one sample (46 fish) from a single ICES stat. rect. from these two quarters being available for calculating stock proportions. No samples from the commercial fishery in other quarters in the transfer area were available.

For quarter 2 and 3, the same split was applied based on the combined samples from HERAS and the fishery in the transfer area (446 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.

Due to lack of sampling data in 2020 the split for quarters 1 and 4 had to be based on data from the time-series of samples from the commercial fishery with respectively 48 (from 2016 Q1) and 342 herring (from Q4 in 2008, 2012 and 2014) available for the analysis.

Based on vs mean counts 6802 tonnes of WBSS herring were caught in the transfer area in 2020, with 95% from quarter 2 and 3 (fishery in June and July).

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 1–21 October 2020 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, 2021). In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH 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 WBSSH in the area (Gröhsler et al., 2013; Gröhsler et al., 2016). The estimates of the growth parameters from baseline samples of WBSSH and CBH in 2011-2018 and 2020 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). The applicability of the SF could not be tested in 2019 due some higher degree of mixing of CBH/WBSSH in the baseline area of WBSSH in SDs 21 and 23.

The age-length distribution of herring in SDs 21 and in SD 23 in 2020 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 in 2020.

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 2020 was estimated to be 1.4 x 10^9 fish or about 37.0 x 10^3 tonnes in subdivisions 21–24. The biomass index in 2020 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 25 June to 9 July 2020 and covered the Skagerrak and the Kattegat and the North Sea. The 2020 estimate of Western Baltic spring-spawning herring was 161 tonnes and 1,764 million herring. Compared to the values in 2019, the 2020 estimates represent an increase of 11% in numbers and of 17% in biomass. The stock biomass is dominated by 1–4 winter ring (70%). The present numbers of older herring (3+ group) in the stock only represent 52% of the average of the whole times series (2020: 666 million; mean 1991–2019: 1274 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 at weekly intervals during the 2020 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 239 million larvae, the 2020 N20 recruitment index is the lowest of the time series and about 50% of the former record low of 2016 (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. 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 2020 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 = 0.74, 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 (1992–2020: 5 480 million). The 2020 N20 recruitment index is the lowest in the 29-year time-series (Table 3.3.3).

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

3.6.1 Input data

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

Only the input landings data differs 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 2020 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 (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 the both 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 1991–2019. 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").

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_2021) and the single fleet (WBSS_HAWG_2021_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.

3.6.4 Final run

The results of the assessment are given in Tables 3.6.11–3.6.14. The estimated SSB for 2020 is 58 434 [41 725, 81 834 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.193 [0.123, 0.301 (95% CI)] yr-1. This means that the F3-6 is now 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 100 000 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 69.5 kt. SSB has only slightly increased in the following period up to 84.7 kt in 2015 and then has declined to 57.8 kt in 2019, which is the lowest SSB of the time-series. A slight increase in SSB was then estimated for 2020 around 58.4 kt.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of 0.66 yr-1 in 1996. In 1999–2009, $F_{3–6}$ stabilized between 0.45 and 0.60. In 2010 and 2011, $F_{3–6}$ decreased significantly to a value of 0.41 and 0.32 yr-1, respectively. It stabilized between 0.32 and 0.43 yr-1 for few years until it increased again above 0.48 yr-1 from 2016 to 2018. $F_{3–6}$ then decreased to 0.29 yr-1 in 2019 and then to 0.19 yr-1 in 2020, which is the lowest estimated F_{3-6} of the entire time series (Table 3.6.11, Figure 3.6.4.2).

Recruitment was the highest (~4-5 billion) at the beginning of the time-series (1991-1999) and has been decreasing overall since 2000. The 2020 estimate of 582 158 thousand is the lowest on record (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 2020 recruitment has varied from about 1.5 billion to less than 1 billion at SSB between 58 kt and 103 kt, with a worrying trend of declining recruitment in the latest years since 2017.

The total catch is well fitted (Figure 3.6.4.5) but also 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. This year the model starts to accommodate the large catches of the A-fleet in the last two years, as the upper limit of the confidence interval on the catches has increased compared to the 2020 assessment.

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 an increasing trend in F for the last three decades, while there is a decreasing trend in F for the D- and F-fleet. The selectivity pattern for the D-fleet has a tendency of shifting its highest selectivity from age 1 to age 2 (wr) in later years. Total fishing mortality on the WBSS stock increased with herring age (Figure 3.6.4.8). It decreased overall over time but showed an increase in 2015-2018 and a decrease again up to 2020.

The model was constrained to have the same selectivity for the two oldest ages (wr) 7+ in all fleets. The fishing mortality was assumed to be independent across ages for the A-fleet (see $corFlag in Table 3.6.10). The estimated correlation parameter in the F random walk for the C-fleet was estimated to a very high value, which caused convergence problems in initial runs during the benchmark, and it was therefore assigned a fixed high value in the subsequent assessment runs resulting in parallel selection patterns.

The estimated survey catchability is rather different among the surveys. The HERAS and the GERAS surveys are relatively constant over the applied ages (wr) 3–6 and 1–4 respectively. Whereas both IBTS 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 Q3.4 surveys variance, the IBTS 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 2018–2020. 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 2018–2020 in the GERAS 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 N20 picks up the negative trend in the observations of the recruitment index (Figure 3.6.4.21) however still with negative residuals by the end of the time-series (Figure 3.6.4.13). Poorer fit is observed for the IBTS+BITS-Q1 for all ages (wr) 1–3, over the entire time-series (Figure 3.6.4.22) and likewise to the IBTS+BITS-Q3.4 for the two ages (wr) 2–3 (Figure 3.6.4.23) with large positive residuals for age (wr) 2 in recent years (Figure 3.6.4.13).

Retrospective patterns have decreased compared to last year assessment (Figure 3.6.4.24–27). While in the 2020 assessment, the SSB had a Mohn's rho of 25%, the Mohn's rho in this year assessment has decreased to 20% and the retrospective estimates for the 1- to 3-year peels are inside the confidence interval of the 2021 SSB estimates. Average fishing mortality retrospective estimates are also outside the confidence bounds for F for the 3 to 4-year peels (Mohn's rho = -13% compared to -18% in the 2020 assessment, Figure 3.6.4.25). The retrospective for recruitment is acceptable having a Mohn's rho = 7% (Figure 3.6.4.26). Retrospective is very small for total catch (Figure 3.6.4.27).

During the 2020 assessment, different exploratory runs were conducted to investigate why the retrospective patterns had increased. Two runs were made without the HERAS survey and without the GERAS survey. Both of them showed large retrospective patterns similar to the original fit suggesting that none of the two surveys was the main only responsible for the retrospective pattern in the model. The retrospective patterns seemed to be due to the catch-at-age data which was poorly fitted in the recent years (see large residuals for A-, C- and F-fleet Figure 3.6.4.13). In addition, the 2019 catch data were marked by an increase in the A-fleet catches and a decrease in the C- and F-fleets catches. This was notably clear in the small proportion of old fish in the C-fleet, the large proportion of old fish in the A-fleet and a decrease in the catches of all ages, except age 2, for the F-fleet. These contrasting signals in the catch data are the likely reason for the large retrospective patterns in the 2020 assessment. These sensitivity analyses were not re-run during the 2021 assessment.

Since the 2019 assessment, a decrease in stock perception was observed every year due to the model trusting the decrease in the GERAS survey indices. While the GERAS indices are still decreasing in 2020 and leaving out the GERAS survey from the dataset still induces an increase in the perception of the stock with increasing SSB in recent years (Figures 3.6.4.32–35), this year, the 2020 SSB estimates is slightly larger than the 2019 SSB estimates. The effect of GERAS on the stock perception is also observed in the single-fleet model (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.

The 2018 benchmark calculated a new F_{MSY} of 0.31. Fishing mortality ($F_{3–6}$) was reduced between 2007 and 2011 from above 0.50 to 0.32 (Tables 3.6.11, Figure 3.6.4.2). $F_{3–6}$ has then remained stable above F_{MSY} until 2018 (0.35-0.5), but showed an increase in 2016-2018 with an estimated $F_{3–6}$ between 0.48 and 0.50. $F_{3–6}$ then decreased in 2019 below F_{MSY} (0.29) and further in 2020 (0.19).

Recruitment has been declining since 2014 with a historical low value in 2020 of 582 158 thousand (Tables 3.6.11, Figure 3.6.4.3).

The lower level of fishing mortality since 2011 has allowed a slight increase in SSB (from 70 kt in 2011 to 85 kt in 2015) despite the general low recruitment level, but since the strong 2013 year-class, recruitment has declined to historic low values that will not support a rebuilding of the stock with present levels of fishing mortalities.

3.8 Comparison with previous years perceptions of the stock

The table below summarizes the differences between the current and the previous year assessment. Contrarily to the 2020 assessment, the addition of the 2020 data resulted in a positive change in the perception of the stock compared to last year assessment, but the increase is limited to less than 2.6%. The recent estimates of recruitment have increased by 3.3% in the current assessment and F appears to be larger than previously estimated in 2018 (+1.6%) but significantly smaller in 2019 (-32.5%) and SSB has increased for both 2018 and 2019 (2.6% and 2.1% respectively).

In this year assessment, recruitment for the 2013 year-class (most recent large year class) was estimated to be 1 685 120 thousand compared to 1 581 113 thousand in the 2020 assessment. This increase in recruitment induced an increase in the SSB estimates in the following years compared to the 2020 assessment.

Parameter	Assessment in 2020	Assessment in 2021	Difference (2021-2020)/2021
SSB (t) 2018	60 944	62 561	2.58%
$F_{(3–6)}$ 2018	0.473	0.480	1.59%
Recr. ('000) 2018	783 319	810 280	3.33%
SSB (t) 2019	56 621	57 841	2.11%
$F_{(3–6)}$ 2019	0.382	0.288	-32.48%

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 scrutinising 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 2021 assessment, recruitment for the forecasts was calculated on the period 2015–2019). 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 (2016–2020). Based on earlier considerations in HAWG, the different periods were chosen to reflect recent levels in recruitment and weights.

3.9.2 Intermediate year 2021

A catch constraint was assumed for the intermediate year (2021). Predicted 2021 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 C- and D-fleets do not use their entire TAC.

Fleets	TAC 2021 NSAS+WBSS (t)	TAC WBSS (t)	TAC WBSS given utilization or transfer (t)
A	356 357	5241	100% = 5241
C	21 604	70.36% = 15 201	15 201 - (70.36% (2811*0.5+3 000)) = 12 076
D	6659	35.83% = 2386	8.20% = 196
F	1575	1575	100% = 1575
Total	386 195	24 402	19 088

The amount of WBSS taken in Subdivision 4.aE by the A-fleet in 2021 is assumed equal to the average over the last 3 years (2018–2020) corresponding to 5241 t.

The expected catch of WBSS in Division 3.a was calculated assuming the same WBSS proportions in the catch of each fleet (stock split) in 2021 as the average of 2018–2020 in Division 3.a. This resulted in 70.36% of the C-fleet catch being WBSS herring. In addition, the EU–Norway agreement allows an optional transfer of 50% of the human consumption (C-fleet) TAC for herring in Division 3.a into the Subarea 4 in the North Sea (A-fleet). Based on information from the Norwegian fishing industry, 50% transfer is assumed for the Norwegian quotas (50% of 2881). Based on information from the Danish fishing industry, 3000 t of EU catch will be transferred to the North Sea (max allowed EU catches in Norwegian waters), which differs significantly from the assumption taken last year (50% transfer of EU quotas to the North Sea). This is discussed further in part 3.12. These assumptions result in a predicted catch for the C-fleet in Division 3.a of 12 076 tonnes.

Around 36% of the D-fleet 2021 TAC is assumed to be WBSS herring (average NSAS/WBSS split 2018–2020). In addition, the proportion of the TAC taken in the small-meshed fishery (D-fleet) has varied largely during the last 6 years from a maximum of 94% in 2015 to the minimum of 5.4–5.5% recorded for 2017-2019 due to choke species effects of restricting whiting quotas. In 2020, utilization for the D-fleet is estimated to have increased to 13.7%. The problems with bycatches under the landings obligation may persist and 8.2% utilization of the TAC in 2021 for the D-fleet is assumed as the average utilization over the last 3 years (2018–2020), resulting in a predicted catch for 2021 of 196 t.

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 1575 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 19 088 t of WBSS herring in 2020.

3.9.3 Catch scenarios for 2022–2024

The inputs and outputs of the short-term predictions based on a catch constraint in the intermediate year 2021 of 19 088 t are given in Tables 3.9.1–3.9.15.

Different catch options for the years after the intermediate year were explored with fleet-wise selection patterns and deterministic forecasts. To most closely resemble current WBSS management, a constraint is added to the forecasts so that, after the intermediate year, for all scenarios (except for the constant 2021 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.

3.9.4 Exploring a range of total WBSS catches for 2022 (advice year) to 2024

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because the forecasted SSB in 2023 is below B_{lim} even when F = 0, the MSY framework gives zero catch in 2022.

None of the catch scenarios for 2022, including zero catch, is expected to bring SSB above B_{lim} in 2023. Similarly, to last year, besides requested standard scenarios HAWG also calculated the potential development of the stock projections until 2024 with different low F scenarios, where F2023 = F2022. None of these scenarios, even when F = 0, can bring the SSB above B_{lim} in 2024.

The TAC for 2021 was set according to the agreed management rule between EU-Norway, however, ICES has not evaluated the rule after the 2018 benchmark revised the reference points for this stock. ICES advises that a recovery plan should be developed for the WBSS stock, taking advantage of the fleet-wise analysis and projection for this stock.

In 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 in the 1st of January (and the final year of assessment being 2020), this can be easily done because SSB in 2022 only depends on F in 2021 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 2022 and the F in 2022 can be estimated to obtain a SSB in 2023 equal to 2022. 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

2022 is in fact the result of catches assumed (agreed TACs) for the intermediate year (2021) and some catches in the first months of 2022. In other words, the SSB in 2022 depends on F in 2021 but also on a fraction of the F in 2022, which is the advice year. What to assume for the first months of 2022 is the real issue here. For instance, if a zero catch is assumed in 2022 according to the advice, it will be uninformative because the table of advice would still only show the average F in 2022 (so F = 0). If an F that makes SSB 2022 = SSB 2021 is assumed for 2022, it will be an unrealistic high F needed to compensate for the low catches assumed in 2021. Given the reasons described above, the constant SSB between 2022 and 2023 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 (2022)	$F_{3–6}$	SSB* (2022)	SSB* (2023)	% SSB change **	% advice change ***
ICES advice basis							
3.9.2	MSY approach: zero catch	0	0	68 903	83 794	22	0
Other scenarios							
3.9.3	MAP^: F = F_{MSY} × SSB_{y-1}/MSY $B_{trigger}$	12 499	0.134	67 797	71 788	6	
3.9.4	MAP^: F = $F_{MSY\ lower}$ × SSB_{y-1}/MSY $B_{trigger}$	8922	0.094	68 130	75 182	10	
3.9.5	MAP^: F = $F_{MSY\ upper}$ × SSB_{y-1}/MSY $B_{trigger}$	15 017	0.164	67 554	69 420	3	
3.9.6	F= F_{MSY}	26 098	0.31	66 384	59 264	-11	
3.9.7	F = F_{pa}	32 716	0.41	65 595	53 327	-19	
3.9.8	F = F_{lim}	35 167	0.45	65 283	51 161	-22	
	SSB (2022) = B_{lim} ^^						
	SSB (2022) = B_{pa} ^^						
	SSB (2022) = MSY $B_{trigger}$ ^^						
3.9.9	F = F_{2021}	15 811	0.174	67 476	68 733	2	
3.9.15	Catch for bycatch fleets only ^^^	5437	0.036	68 464	79 423	16	

*** 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 (2023) relative to SSB (2022).**

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

^ As SSB2021 is below MSY $B_{trigger}$, the F_{MSY}, F_{MSY} lower and F_{MSY} upper values in the MAP are adjusted by the SSB_{y-1}/MSY $B_{trigger}$ ratio.

^^ The B_{lim} and B_{pa} cannot be achieved in 2023 even with zero catch advice.

^^^ Only the A fleet that targets NSAS herring and the D fleet that targets sprat are allowed to fish assuming the same catch as in the intermediate year 2021 (C and F fleets have 0 catch).

Table	Basis	Total catch (2022)	Total catch (2023)	F_{3-6} (2022)	SSB* (2022)	SSB* (2023)	SSB* (2024)	% SSB change (2022–2023)	% SSB change (2023–2024)
Medium-term catch scenarios									
3.9.10	F = 0	0	0	0	68 903	83 794	102 194	22	22
3.9.11	F = 0.05	4889	5952	0.050	68 489	79 076	92 308	15	17
3.9.12	F = 0.1	9489	10 945	0.100	68 078	74 685	83 653	10	12
3.9.13	F = 0.15	13 821	15 131	0.150	67 670	70 596	76 048	4	8
3.9.14	Constant catch 2021–2023 **	19 088	19 088	0.169	67 529	68 201	71 588	1	5

*** 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).**

**** Assumptions for 2021 catches kept constant for 2022–2023.**

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. Contrarily to what was observed in the 2019 and 2020 assessments, the 2021 assessment is very consistent with the 2020 assessment and shows only a slight upward revision in the SSB estimates in recent years (see part 3.8).

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.

Interannual 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.

3.12 Considerations on the 2022 advice

This year assessment shows an SSB consistent with last year's assessment, if not slightly upward. Recruitment continues decreasing and it is estimated at its historical minimum in 2020 (582 158 thousands). Under these conditions, the stock is not expected to increase above B_{lim} in the short-term (2023) nor in the medium-term (2024) for any level of fishing mortality (SSB_{2024} = 102 194 t assuming F = 0).

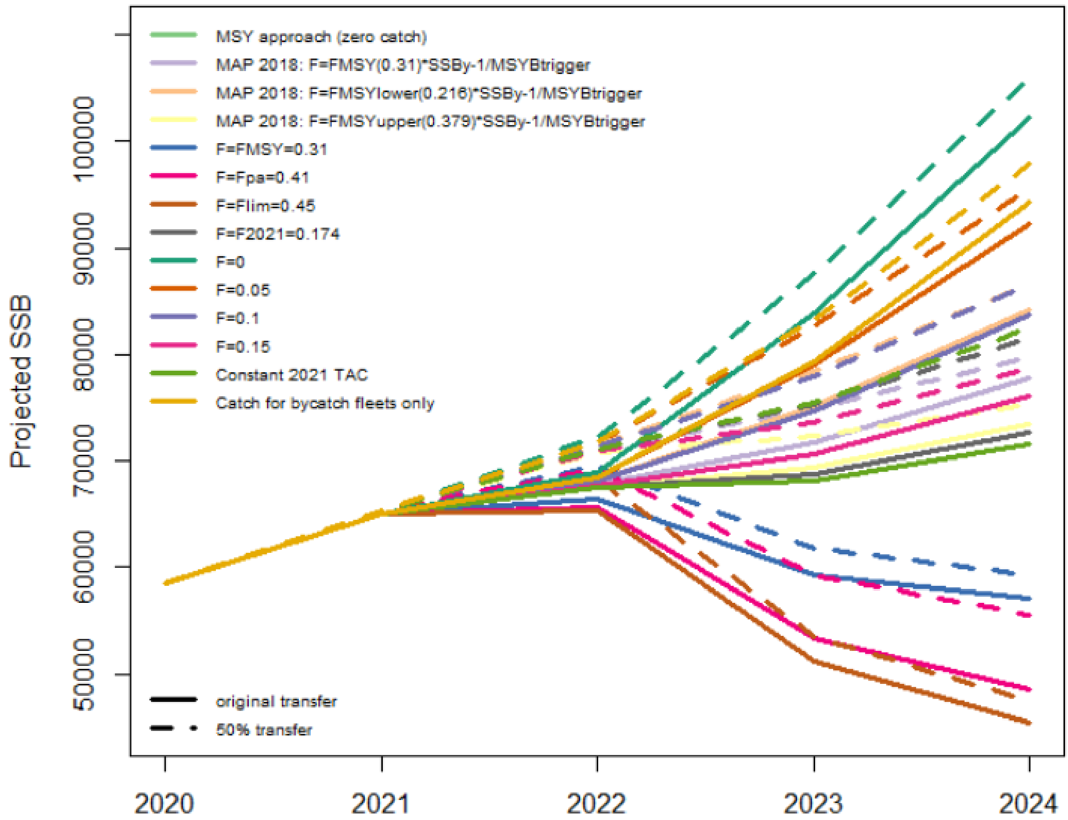
To explore the potential development of the stock, projections until 2024 with different low F scenarios (F = 0.05, 0.1, 0.15) are provided in the Table in section 3.9.4. The development of a rebuilding plan for this stock remains a high priority and it is recommended by HAWG.

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 over-exploitation of the WBSS stock.

WBSS herring is also caught in the herring fisheries operating in the eastern part of Division 4.a (so called "transfer area"). Estimation of the stock composition in the transfer area is highly uncertain which has implications for the quality of the input data for the assessment, but most importantly the amount and stock composition of herring catches in the transfer area remain unpredictable and represent an inevitable source of fishing mortality on the WBSS stock without area and/or time restrictions on the herring fishery in the North Sea.

As part of the Brexit process, access to important fishing grounds in the North Sea are likely to change. Consequently, changes in the exploitation pattern in the North Sea herring fisheries are foreseen for 2021–2022. Given the mixing of the WBSS and NSAS throughout parts of the North Sea, and the large differences in the size and quotas of the two stocks, changes in the distribution of the fisheries may result in unexpected catches of WBSS for which a zero catch advice is issued. Large uncertainties in the developments of the agreements and possible responses of the fisheries prevent reliable predictions in support of the forecasts. The forecasts and current advice should be interpreted in the light of such uncertainties.

For a number of years, the Pelagic Advisory Council has provided an estimate on the expected transfer of herring catches from Division 3.a to the North Sea to be assumed during the intermediate year. This information is highly uncertain for 2021. The transfer of the EU part of the human consumption quota from 3.a to the North Sea is assumed to be 3000 t (16% of EU quotas compared to approx. 50% used in recent years) which is equal to the reciprocal access in the EU-Norway agreement but high uncertainty remains on the remaining potentially transferable 34%. Sensitivity analysis assuming the usual 50% transfer showed marginal differences on the recovery in SSB (see figure and table below) and no effect on the catch advice for 2022. Because changes in fishing areas cannot be predicted, the results of the forecast need therefore to be considered with these limitations.



Relative difference (%) in forecasted SSB between the forecast with 50% transfer in the intermediate year and the forecast for advice:

	2021	2022	2023	2024
MSY approach: zero catch	0.44	4.82	4.47	3.65
MAP^: F = F_{MSY} × SSB_{y-1}/MSY $B_{trigger}$	0.44	4.78	4.18	2.59
MAP^: F = $F_{MSY\ lower}$ × SSB_{y-1}/MSY $B_{trigger}$	0.44	4.79	4.25	2.83
MAP^: F = $F_{MSY\ upper}$ × SSB_{y-1}/MSY $B_{trigger}$	0.44	4.77	4.14	2.45
F= F_{MSY}	0.44	4.74	4.36	3.68
F = F_{pa}	0.44	5.48	11.18	14.43
F = F_{lim}	0.44	4.71	4.50	4.11
F = F_{2021}	0.44	5.33	9.47	12.10
F=0	0.44	4.82	4.47	3.65
F=0.05	0.44	4.81	4.40	3.51
F=0.1	0.44	4.79	4.35	3.44
F=0.15	0.44	4.78	4.32	3.43
Constant 2021 TAC	0.44	5.35	10.60	15.17
Catch for bycatch fleets only ^^^	0.44	4.85	4.71	3.95

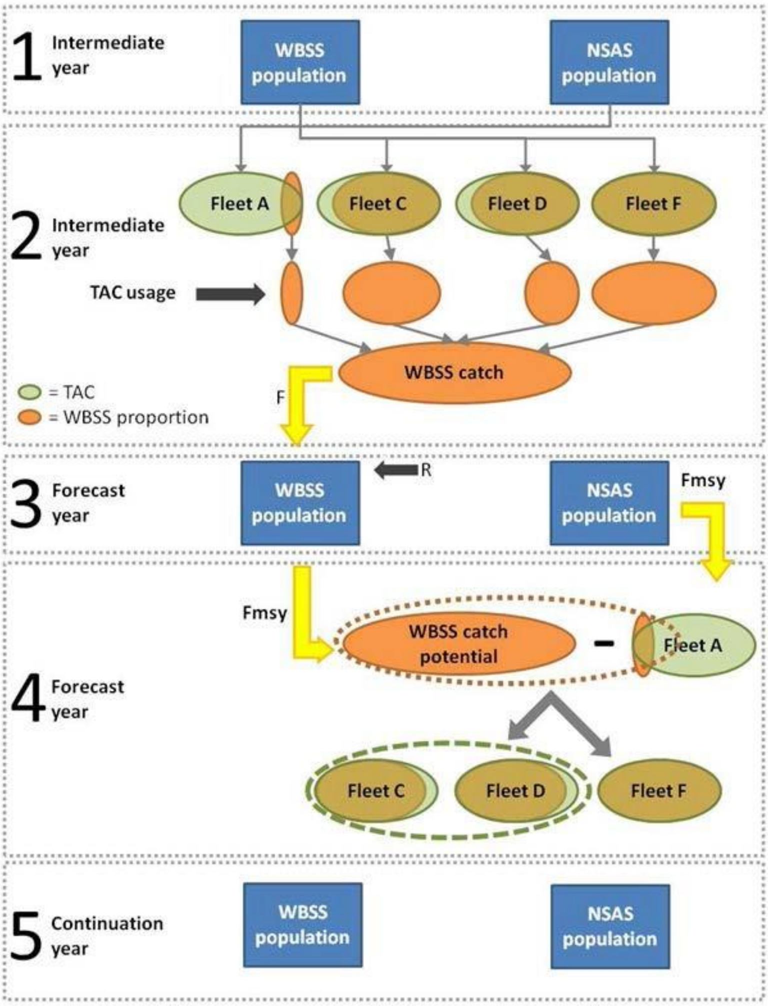
3.13 Management Considerations

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). Fifty percent of the EU and Norwegian quotas for human consumption can optionally be transferred from Division 3.a and taken in Subarea 4. ICES assumes that the transfer of 50% will not be applied in 2021 for the EU quotas but will instead be 3000 t (~ 16% cf. part 3.12).

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 3.a area where they take it as a mixture of mainly WBSS and partly 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 SSB for 2017 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 into more saline waters of Division 3.a and 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). 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).

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 gelatinous plankton (*Aurelia aurita*) in the Western Baltic Sea was described to a be a major impact on recruitment strength of the population in the 1980s (Möller, 1984). Currently, in the inshore nursery grounds around Rügen the bloom of *A. aurita* is rather seasonally decoupled from major larval production periods as the jelly fish occur in large quantities during summer (July–Sept.). The same is true for the invading ctenophore *Mnemiopsis leidyi*, that appears from August on (Polte and Kotterba, pers. obs.). The seasonal peaks of jelly fish blooms, however might be subjected to change and should be kept under close surveillance as in the past two years *A. aurita* became more abundant during June therefore increasing the temporal overlap with WBSS larvae (Polte, pers. obs. RHLS).

Besides this potential predator, in Greifswald Bay there is evidently significant predation pressure on herring eggs by three-spined sticklebacks and- to a lower percentage by juv. Perch (*Perca fluviliatis*) and 9-spined stickleback, *Pungitius pungitius* (Kotterba *et al.*, 2014; Kotterba *et al.*, 2017a). In contrast, the predation on larvae by the sticklebacks was found rather minor (Kotterba *et al.*, 2017b). Unfortunately, there are no historical baseline data available on stickleback densities in the system but they are considered to have increased speculatively by a trophic cascade including overfishing of predators (Bergstrom *et al.*, 2015).

The non-indigenous goby (*Neogobius melanostomus*) have 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 mis-match 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 lead 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 1989–2020 (1000 tonnes). (Data provided by Working Group members in HAWG 2021).

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**
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
Faroe Islands	0.4			0.0	0.6	0.4					0.5	0.3	0.4	0.1		
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

Lithuania						0.4										
Netherlands											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
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
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
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
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
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
Subdivisions 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
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
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
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
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
Subdivision 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
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
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
Grand Total	**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**

Table 3.1.2 Western Baltic spring spawning herring. Catch (SOP) in 2004–2020 by fleet and 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						
	2	0.3	0.7	2.5	3.5						
	3	12.3	1.7	1.1	15.0						
	4	5.2	1.1	3.5	9.9						
	Total	22.3	5.4	21.1	48.8						

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: 2020 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	6.55	25.4			6.55	25.4
	2	46.03	48.2			46.03	48.2
	3	3.46	73.4			3.46	73.4
	4	0.78	92.4			0.78	92.4
	5	0.36	121.6			0.36	121.6
	6	0.11	130.1			0.11	130.1
	7	0.23	148.8			0.23	148.8
	8+						
	Total	57.51		0.00		57.51	
	SOP		2,803		0		2,803
2	0			0.60	9.5	0.60	9.5
	1	0.81	25.4	0.30	53.1	1.11	32.9
	2	5.69	48.2	0.15	97.9	5.84	49.5
	3	0.43	73.4	0.06	114.7	0.48	78.3
	4	0.10	92.4	0.02	116.4	0.12	97.2
	5	0.04	121.6	0.01	116.8	0.06	120.7
	6	0.01	130.1	0.002	115.8	0.02	127.9
	7	0.03	148.8			0.03	148.8
	8+			0.0004	130.0	0.0004	130.0
	Total	7.10		1.15		8.25	
	SOP		346		47		394
3	0			5.52	9.5	5.52	9.5
	1	2.02	86.3	2.77	53.1	4.78	67.1
	2	16.81	131.1	1.37	97.9	18.18	128.6
	3	15.16	156.0	0.52	114.7	15.69	154.6
	4	10.22	172.8	0.22	116.4	10.44	171.6
	5	6.25	188.6	0.10	116.8	6.35	187.5

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	6	3.34	202.1	0.02	115.8	3.37	201.5
	7	3.46	220.5			3.46	220.5
	8+	1.07	194.9	0.003	130.0	1.07	194.7
	Total	58.34		10.53		68.86	
	SOP		9,337		434		9,770
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	71.73	13.6	0.31	9.5	72.04	13.6
	1	12.93	44.1	0.15	53.1	13.09	44.2
	2			0.08	97.9	0.08	97.9
	3			0.03	114.7	0.03	114.7
	4			0.01	116.4	0.01	116.4
	5			0.01	116.8	0.01	116.8
	6			0.001	115.8	0.001	115.8
	7						
	8+			0.0002	130.0	0.00	130.0
	Total	84.67		0.59		85.25	
	SOP		1,546		24		1,570
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	71.73	13.6	6.43	9.5	78.16	13.3
	1	22.31	41.8	3.22	53.1	25.53	43.2
	2	68.53	68.5	1.60	97.9	70.12	69.2
	3	19.05	139.1	0.61	114.7	19.66	138.4
	4	11.10	166.5	0.26	116.4	11.35	165.3
	5	6.65	184.5	0.11	116.8	6.77	183.4
	6	3.47	199.6	0.03	115.8	3.49	198.9
	7	3.72	215.5			3.72	215.5
	8+	1.07	194.9	0.004	130.0	1.08	194.7
	Total	207.62		12.26		219.88	
	SOP		14,032		505		14,537

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: 2020 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	10.29	24.2			10.29	24.2
	2	22.35	47.4			22.35	47.4
	3	2.41	74.8			2.41	74.8
	4	0.21	74.8			0.21	74.8
	5						
	6						
	7	0.10	58.6			0.10	58.6
	8+						
	Total	35.37		0.00		35.37	
	SOP		1,510.719		0		1,510.719
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	0			0.23	9.5	0.23	9.5
	1	0.0005	24.2	0.12	53.1	0.1170	53.0
	2	0.0010	47.4	0.06	97.9	0.0588	97.0
	3	0.0001	74.8	0.02	114.7	0.0222	114.5
	4	0.00001	74.8	0.01	116.4	0.0093	116.4
	5			0.004	116.8	0.0042	116.8
	6			0.001	115.8	0.0010	115.8
	7	0.000005	58.6			0.0000	58.6
	8+			0.0001	130.0	0.0001	130.0
	Total	0.0016		0.44		0.4451	
	SOP		0.1		18		18
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.95	19.7	2.17	9.5	3.11	12.6
	1	3.18	44.7	1.09	53.1	4.26	46.8
	2	0.29	69.6	0.54	97.9	0.83	88.0
	3	0.03	80.9	0.21	114.7	0.23	110.6
	4			0.09	116.4	0.09	116.4
	5			0.04	116.8	0.04	116.8

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	6			0.01	115.8	0.01	115.8
	7						
	8+			0.001	130.0	0.001	130.0
	Total	4.44		4.13		8.58	
	SOP		183		170		353

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	5.90	19.7	2.80	9.5	8.70	16.4
	1	19.77	44.7	1.40	53.1	21.18	45.3
	2	1.80	69.6	0.70	97.9	2.49	77.5
	3	0.18	80.9	0.27	114.7	0.44	101.2
	4			0.11	116.4	0.11	116.4
	5			0.05	116.8	0.05	116.8
	6			0.01	115.8	0.01	115.8
	7						
	8+			0.002	130.0	0.002	130.0
	Total	27.64		5.35		32.99	
	SOP		1,139		220		1,360

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	6.84	19.7	5.20	9.5	12.05	15.3
	1	33.24	38.4	2.61	53.1	35.85	39.4
	2	24.44	49.3	1.29	97.9	25.73	51.7
	3	2.61	75.3	0.49	114.7	3.11	81.5
	4	0.21	74.8	0.21	116.4	0.42	95.4
	5	0.00		0.09	116.8	0.09	116.8
	6	0.00		0.02	115.8	0.02	115.8
	7	0.10	58.6	0.00		0.10	58.6
	8+	0.00		0.003	130.0	0.003	130.0
	Total	67.46		9.92		77.38	
	SOP		2,833		409		3,242

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 (WBSS).
Subdivisions: 22–24 **Year: 2020** **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	0.000001	17.1			0.36	17.8	0.36	17.8
	2	0.000	57.5			0.34	52.0	0.34	52.0
	3	0.001	118.6	0.01	151.7	1.75	84.8	1.76	85.2
	4	0.002	144.6	0.02	172.8	1.71	107.9	1.73	108.6
	5	0.01	155.7	0.04	179.3	3.53	147.5	3.58	147.9
	6	0.01	167.8	0.04	199.0	1.75	163.6	1.80	164.5
	7	0.02	174.1	0.07	192.3	3.26	172.8	3.35	173.2
	8+	0.01	184.6	0.01	199.1	1.05	177.1	1.07	177.4
	Total	0.04		0.19		13.74		13.97	
	SOP		7		36		1,912		1,955
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.**
2	1	0.000004	17.1			0.020	27.5	0.020	27.5
	2	0.0001	57.1			0.06	42.2	0.06	42.2
	3	0.001	84.8	0.00003	151.7	0.49	54.8	0.50	54.9
	4	0.001	134.2	0.00004	172.8	0.26	73.0	0.26	73.2
	5	0.00	152.7	0.0001	179.3	0.39	83.3	0.40	83.9
	6	0.00	167.4	0.0001	199.0	0.39	109.7	0.39	110.4
	7	0.01	167.8	0.0002	192.3	0.29	149.3	0.31	150.0
	8+	0.003	174.6	0.00003	199.1	0.17	123.5	0.17	124.5
	Total	0.02		0.0005		2.08		2.10	
	SOP		4		0.1		189		193
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.**
3	0					0.01	15.8	0.01	15.8
	1	0.00001	64.2			0.19	38.2	0.19	38.2
	2	0.00002	86.1			0.26	47.7	0.26	47.7
	3	0.00004	79.1	0.07	151.7	0.51	56.1	0.57	67.0
	4	0.0001	138.0	0.11	172.8	0.52	58.1	0.63	78.0
	5	0.0003	162.9	0.28	179.3	0.37	63.5	0.65	113.9

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.
	6	0.0005	170.1	0.28	199.0	0.36	54.8	0.64	118.5
	7	0.0009	169.9	0.50	192.3	0.06	69.8	0.56	179.5
	8+	0.0003	175.9	0.07	199.1	0.04	70.9	0.11	147.8
	Total	0.0022		1.31		2.32		3.63	
	SOP		0.4		246		129		375

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	0.000001	19.9			0.02	19.9	0.02	19.9
	1	0.00004	55.6			1.12	45.1	1.12	45.1
	2	0.0001	81.9			1.83	76.2	1.83	76.2
	3	0.0003	87.0	0.10	179.8	1.66	100.7	1.75	105.1
	4	0.001	151.3	0.29	179.6	1.77	120.1	2.06	128.5
	5	0.004	159.4	0.12	188.6	1.96	161.5	2.08	163.0
	6	0.01	168.8	0.31	206.4	0.99	166.9	1.31	176.3
	7	0.02	168.3	0.13	205.0	0.96	166.4	1.11	171.0
	8+	0.01	175.1	0.08	198.6	0.14	182.4	0.23	188.0
	Total	0.03		1.03		10.45		11.52	
	SOP		6		200		1,238		1,443

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	0.000001	19.9			0.03	18.5	0.03	18.5
	1	0.0001	52.1			1.69	38.3	1.69	38.3
	2	0.0003	72.0	0.00003	151.7	2.49	69.1	2.49	69.1
	3	0.001	98.1	0.17	167.6	4.41	84.1	4.58	87.3
	4	0.004	143.7	0.42	177.5	4.25	104.8	4.67	111.3
	5	0.01	156.4	0.45	181.8	6.25	142.9	6.71	145.5
	6	0.02	168.1	0.64	202.6	3.49	147.4	4.15	155.9
	7	0.04	170.3	0.71	194.7	4.57	168.6	5.33	172.1
	8+	0.02	180.0	0.16	198.2	1.40	167.8	1.58	171.0
	Total	0.10		2.54		28.58		31.22	
	SOP		17		482		3,467		3,966

Table 3.2.4 Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2020 available to the Working Group.
1/2

	Country	Fleet	Quarter	Landings	Numbers of	Numbers of	Numbers of
				('000 tons)	samples	fish meas.	fish aged
Skagerrak	**Denmark**	**C**	**1**	0.26678	No data available		
		C	**2**	0.000003	No data available		
		C	**3**	1.54885	10	651	651
		C	**4**	0.86841	No data available		
	Total	**Total**		2.68404	10	651	651
	Denmark	**D**	**1**	0.000	-		
		D	**2**	0.047	No data available		
		D	**3**	0.434	8	82	36
		D	**4**	0.024	No data available		
	Total	**Total**		0.505	8	82	36
	Germany	**C**	**1**	0.000	-		
		C	**2**	0.000	-		
		C	**3**	0.000	-		
		C	**4**	0.155	No data available		
	Total	**Total**		0.155			
	Norway	**C**	**1**	0.058	No data available		
		C	**2**	0.197	No data available		
		C	**3**	1.764	2	130	99
		C	**4**	0.100	No data available		
	Total	**Total**		2.119	2	130	99
	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**	2.478	10	1,000	996
		C	**2**	0.149	No data available		

	Country	Fleet	Quarter	Landings	Numbers of	Numbers of	Numbers of
				('000 tons)	samples	fish meas.	fish aged
		C	**3**	6.024	5	260	260
		C	**4**	0.422	9	81	81
	Total	**Total**		9.073	24	1,341	1,337
Kattegat	**Denmark**	**C**	**1**	0.159	No data available		
		C	**2**	0.0001	No data available		
		C	**3**	0.027	No data available		
		C	**4**	0.077	No data available		
	Total	**Total**		0.263	0	0	0
	Denmark	**D**	**1**	0.000	-		
		D	**2**	0.018	No data available		
		D	**3**	0.170	No data available		
		D	**4**	0.220	No data available		
	Total	**Total**		0.409	0	0	0
	Sweden	**C**	**1**	1.352	6	660	660
		C	**2**	0.000	-		
		C	**3**	0.156	No data available		
		C	**4**	1.063	3	317	317
	Total	**Total**		2.570	9	977	977

Table 3.2.4 (continued) Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2020 available to the Working Group.
2/2

	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**F**	**1**	0.001		No data available	
		F	**2**	0.001		No data available	
		F	**3**	0.000		No data available	
		F	**4**	0.001		No data available	
	Total	**Total**		0.003	0	0	0
	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**	0.0065	3	1,135	186
		F	**2**	0.0027	1	864	84
		F	**3**	0.0002		No data available	
		F	**4**	0.0047		No data available	
	Total	**Total**		0.0141	4	1,999	270
Subdivision 23	**Denmark**	**F**	**1**	0.000		-	
		F	**2**	0.000		-	
		F	**3**	0.000		-	
		F	**4**	0.001	1	130	53
	Total	**Total**		0.001	1	130	53
	Sweden	**F**	**1**	0.036		No data available	
		F	**2**	0.000		-	
		F	**3**	0.246	1	60	60
		F	**4**	0.199		No data available	
	Total	**Total**		0.481	1	60	60
Subdivision 24	**Denmark**	**F**	**1**	0.342	4	687	215
		F	**2**	0.010		No data available	
		F	**3**	0.002	2	281	96
		F	**4**	0.229	2	258	106
	Total	**Total**		0.583	8	1226	417
	Finland	**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**	1.521	17	6,488	1,327
		F	**2**	0.044	2	741	92
		F	**3**	0.0004	2	389	123
		F	**4**	0.490	3	1,132	353
	Total	**Total**		2.0546	24	8,750	1,895
	Poland	**F**	**1**	0.048	6	1,058	388
		F	**2**	0.100	7	1,222	319
		F	**3**	0.041	1	282	84
		F	**4**	0.407		-	
	Total	**Total**		0.596	14	2562	791
	Sweden	**F**	**1**	0.000		-	
		F	**2**	0.036	1	150	150
		F	**3**	0.085	2	300	298
		F	**4**	0.112	1	108	107
	Total	**Total**		0.233	4	558	555
Total	**Skagerrak**	**C**	**1-4**	**14.032**	**36**	**2,122**	**2,087**
		D	**1-4**	**0.505**	**8**	**82**	**36**
	Kattegat	**C**	**1-4**	**2.833**	**9**	**977**	**977**
		D	**1-4**	**0.409**	**0**	**0**	**0**
	Subdivision 22	**F**	**1-4**	**0.017**	**4**	**1,999**	**270**
	Subdivision 23	**F**	**1-4**	**0.482**	**2**	**190**	**113**
	Subdivision 24	**F**	**1-4**	**3.467**	**50**	**13,096**	**3,658**
	Total	**Total**	**1-4**	**21.745**	**109**	**18,466**	**7,141**

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 2020.
1/2

	Country	Quarter	Fleet	Sampling
Skagerrak	Denmark	1	C	Sweden Q1 27.3.a.20 fleet-C
		2	C	Sweden Q1 27.3.a.20 fleet-C
		3	C	Denmark Q3 27.3.a.20 fleet-C
		4	C	Sweden Q4 27.3.a.20 fleet-C
	Germany	1	C	No landings
		2	C	No landings
		3	C	No landings
		4	C	Sweden Q4 27.3.a.20 fleet-C
	Sweden	1	C	Sweden Q1 27.3.a.20 fleet-C
		2	C	Sweden Q1 27.3.a.20 fleet-C
		3	C	Sweden Q3 27.3.a.20 fleet-C
		4	C	Sweden Q4 27.3.a.20 fleet-C
	Denmark	1	D	No landings
		2	D	Denmark Q3 27.3.a.20 fleet-D
		3	D	Denmark Q3 27.3.a.20 fleet-D
		4	D	Denmark Q3 27.3.a.20 fleet-D
	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 Q1 27.3.a.20 fleet-C
		2	C	Sweden Q1 27.3.a.20 fleet-C
		3	C	Norway Q3 27.3.a.20 fleet-C
		4	C	Sweden Q4 27.3.a.20 fleet-C
Kattegat	Denmark	1	C	Sweden Q1 27.3.a.21 fleet-C
		2	C	Sweden Q1 27.3.a.21 fleet-C
		3	C	Sweden Q4 27.3.a.21 fleet-C
		4	C	Sweden Q4 27.3.a.21 fleet-C

	Sweden	**1**	**C**	Sweden Q1 27.3.a.21 fleet-C
		2	**C**	No landings
		3	**C**	Sweden Q4 27.3.a.21 fleet-C
		4	**C**	Sweden Q4 27.3.a.21 fleet-C
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Denmark	**1**	**D**	No landings
		2	**D**	Denmark Q3 27.3.a.20 fleet-D
		3	**D**	Denmark Q3 27.3.a.20 fleet-D
		4	**D**	Denmark Q3 27.3.a.20 fleet-D
Subdivision 22	**Denmark**	**1**	**F**	Germany Q1 27.3.c.22 fleet-F
		2	**F**	Germany Q2 27.3.c.22 fleet-F
		3	**F**	Germany Q2 27.3.c.22 fleet-F
		4	**F**	Germany Q2 27.3.c.22 fleet-F
	Sweden	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	No landings
		4	**F**	No landings
	Germany	**1**	**F**	Germany Q1 27.3.c.22 fleet-F
		2	**F**	Germany Q2 27.3.c.22 fleet-F
		3	**F**	National imputation (see WD)
		4	**F**	National imputation (see WD)

Fleet C = Human consumption, Fleet D= Industrial catch,

Fleet F= All catch from Subdivisions 22–24. **Continued on next page**

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 2020.
2/2

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	Sweden Q3 27.3.b.23 fleet-F
		4	**F**	Denmark Q4 27.3.b.23 fleet-F
	Sweden	**1**	**F**	Sweden Q3 27.3.b.23 fleet-F
		2	**F**	Sweden Q3 27.3.b.23 fleet-F
		3	**F**	Sweden Q3 27.3.b.23 fleet-F
		4	**F**	Denmark Q4 27.3.b.23 fleet-F
Subdivision 24	**Denmark**	**1**	**F**	Denmark Q1 27.3.d.24 fleet-F
		2	**F**	Germany Q2 27.3.d.24 fleet-F
		3	**F**	Denmark Q3 27.3.d.24 fleet-F
		4	**F**	Denmark Q4 27.3.d.24 fleet-F
	Finland	**1**	**F**	No landings
		2	**F**	No landings
		3	**F**	No landings
		4	**F**	No landings
	Germany	**1**	**F**	Germany Q1 27.3.d.24 fleet-F
		2	**F**	Germany Q2 27.3.d.24 fleet-F
		3	**F**	Germany Q3 27.3.d.24 fleet-F
		4	**F**	Germany Q4 27.3.d.24 fleet-F
	Poland	**1**	**F**	Poland Q1 27.3.d.24 fleet-F
		2	**F**	Poland Q2 27.3.d.24 fleet-F
		3	**F**	Poland Q3 27.3.d.24 fleet-F
		4	**F**	Sweden Q4 27.3.d.24 fleet-F
	Sweden	**1**	**F**	No landings
		2	**F**	Sweden Q2 27.3.d.24 fleet-F
		3	**F**	Sweden Q3 27.3.d.24 fleet-F
		4	**F**	Sweden Q4 27.3.d.24 fleet-F

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: 2020

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	89.13%	10.87%	46	88.00%	12.00%	50
	2	54.00%	46.00%	50	34.00%	66.00%	50
	3	16.00%	84.00%	50	17.78%	82.22%	45
	4	7.14%	92.86%	14	0.00%	100.00%	4
	5	12.50%	87.50%	6	0.00%	100.00%	0
	6	12.50%	87.50%	1	0.00%	100.00%	0
	7	12.50%	87.50%	3	0.00%	100.00%	1
	8+	12.50%	87.50%	0	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	85.82%	14.18%	141	93.75%	6.25%	64
	2	26.92%	73.08%	26	19.61%	80.39%	51
	3	6.25%	93.75%	16	14.29%	85.71%	21
	4	0.00%	100.00%	2	0.00%	100.00%	13
	5	0.00%	100.00%	1	0.00%	100.00%	17
	6	5.26%	94.74%	0	0.00%	100.00%	11
	7	5.26%	94.74%	0	0.00%	100.00%	7
	8+	5.26%	94.74%	0	0.00%	100.00%	1
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	95.45%	4.55%	22	97.74%	2.26%	265
	1	89.85%	10.15%	32	63.29%	36.71%	286
	2	52.56%	47.44%	168	25.24%	74.76%	103
	3	27.02%	72.98%	148	5.26%	94.74%	38
	4	19.99%	80.01%	97	12.50%	87.50%	16
	5	3.85%	96.15%	49	5.26%	94.74%	19
	6	17.61%	82.39%	42	8.33%	91.67%	12
	7	22.17%	77.83%	39	42.86%	57.14%	7
	8	0.00%	100.00%	14	0.00%	100.00%	4
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	86.00%	14.00%	50	95.74%	4.26%	47

	1	8.33%	91.67%	12	12.00%	88.00%	50
	2	0.00%	100.00%	0	14.29%	85.71%	21
	3	0.00%	100.00%	0	0.00%	100.00%	2
	4	0.00%	100.00%	0	23.40%	76.60%	0
	5	0.00%	100.00%	0	23.40%	76.60%	0
	6	0.00%	100.00%	0	23.40%	76.60%	0
	7	0.00%	100.00%	0	23.40%	76.60%	0
	8	0.00%	100.00%	0	23.40%	76.60%	0

when *n for an age <12 data were borrowed according to the below table

borrowing either a mean of age groups or ages borrowed individually

Q	ages	**Skagerrak**	ages	**Kattegat**
1	5-8+	mean(5-8+)	4-8+	mean(4-8+)
2	1-2; 3-8+	HERAS; 2019 mean(3-8+)	1-8+	2019
3			0-8+	Q3 IBTS Kat
4	3-8+	2019 mean(3-8+)	4-8+	2019 mean(4-8+)

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: 2020** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	9.06	24			9.06	24
	2	7.60	47			7.60	47
	3	0.43	75			0.43	75
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	17.08		0.00		17.08	
	SOP		611.4		0.0		611.4
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	0			0.23	9.5	0.23	9
	1	0.0004	24	0.11	53	0.11	53
	2	0.0002	47	0.01	98	0.01	97
	3	0.00002	75	0.003	115	0.00	115
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	0.001		0.36		0.36	
	SOP		0.02		9.5		7.3
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.93	20	2.12	9	3.04	13
	1	2.01	45	0.69	53	2.70	47
	2	0.07	70	0.14	98	0.21	88
	3	0.00	81	0.01	115	0.01	111
	4			0.01	116	0.011	116
	5			0.00	117	0.002	117

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	6			0.00	116	0.0007	116
	7					0.00	
	8+					0.00	
	Total	3.01		2.97		5.98	
	SOP		113.3		72.6		186.0

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	5.65	20	2.68	9	8.33	16
	1	2.37	45	0.17	53	2.54	45
	2	0.26	70	0.10	98	0.36	77
	3					0.00	
	4			0.03	116	0.03	116
	5			0.01	117	0.01	117
	6			0.00	116	0.003	116
	7					0.00	
	8+			0.00	130	0.000	130
	Total	8.28		2.99		11.27	
	SOP		235.2		48.9		284.0

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	6.57	20	5.03	9	11.61	15
	1	13.44	31	0.97	53	14.40	32
	2	7.93	48	0.25	98	8.18	50
	3	0.43	75	0.01	115	0.44	76
	4	0.00		0.04	116	0.04	116
	5	0.00		0.01	117	0.01	117
	6	0.00		0.00	116	0.003	116
	7	0.00		0.00		0.00	
	8+	0.00		0.00	130	0.000	130
	Total	28.37		6.31		34.69	
	SOP		960		131		1,091

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: 2020** **Country: All**

		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	5.84	25			5.84	25
	2	24.86	48			24.86	48
	3	0.55	73			0.55	73
	4	0.06	92			0.06	92
1	5	0.05	122			0.05	122
	6	0.01	130			0.01	130
	7	0.03	149			0.03	149
	8+					0.00	
	Total	31.39		0.00		31.39	
	SOP		1,403.5		0.0		1,403.5
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			0.60	9.5	0.60	9.5
	1	0.69	25.4	0.26	53.1	0.95	32.9
	2	1.53	48.2	0.04	97.9	1.57	49.5
	3	0.03	73.4	0.004	114.7	0.03	78.3
	4					0.000	
2	5					0.000	
	6	0.001	130.1	0.0001	115.8	0.001	127.9
	7	0.001	148.8			0.00	148.8
	8+			0.00002	130.0	0.00002	130.0
	Total	2.25		0.90		3.16	
	SOP		93.7		23.8		111.8
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			5.27	9.5	5.27	9.5
	1	1.81	86.3	2.48	53.1	4.30	67.1
	2	8.84	131.1	0.72	97.9	9.56	128.6
	3	4.10	156.0	0.14	114.7	4.24	154.6
	4	2.04	172.8	0.04	116.4	2.09	171.6
3	5	0.24	188.6	0.00	116.8	0.24	187.5

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	6	0.59	202.1	0.00	115.8	0.59	201.5
	7	0.77	220.5			0.77	220.5
	8+					0.00	
	Total	18.39		8.67		27.05	
	SOP		2,641.1		274.5		2,915.6
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	61.69	13.6	0.27	9.5	61.96	13.6
	1	1.08	44.1	0.01	53.1	1.09	44.2
	2					0.00	
	3					0.00	
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	62.77		0.28		63.05	
	SOP		886.5		3.2		889.7
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	61.69	13.6	6.14	9.5	67.83	13.2
	1	9.42	39.3	2.76	53.1	12.18	42.4
	2	35.22	69.0	0.76	97.9	35.98	69.6
	3	4.68	145.7	0.15	114.7	4.82	144.8
	4	2.10	170.7	0.04	116.4	2.14	169.5
	5	0.29	178.0	0.004	116.8	0.29	177.2
	6	0.60	200.4	0.004	115.8	0.61	199.8
	7	0.80	217.8	0.00		0.80	217.8
	8+	0.00		0.00002	130.0	0.00002	130.0
	Total	114.80		9.85		124.65	
	SOP		5,024.8		301.5		5,326.3

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: 2020** **Country: All**

Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.23	24.2			1.23	24.2
	2	14.75	47.4			14.75	47.4
	3	1.98	74.8			1.98	74.8
	4	0.21	74.8			0.21	74.8
	5					0.00	
	6					0.00	
	7	0.10	58.6			0.10	58.6
	8+					0.00	
	Total	18.28		0.00		18.28	
	SOP		899.3		0.0		899.3
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00003	24.2	0.01	53	0.01	53
	2	0.001	47.4	0.05	98	0.05	97
	3	0.0001	74.8	0.02	115	0.02	115
	4	0.00001	74.8	0.01	116	0.01	116
	5			0.004	117	0.004	117
	6			0.001	116	0.001	116
	7	0.000005	58.6			0.000005	59
	8+			0.0001	130	0.0001	130
	Total	0.001		0.09		0.09	
	SOP		0.05		8.8		8.8
Quarter	W-rings	Fleet C		Fleet D		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.02	19.7	0.05	9.5	0.07	12.6
	1	1.17	44.7	0.40	53.1	1.57	46.8
	2	0.22	69.6	0.40	97.9	0.62	88.0
	3	0.03	80.9	0.19	114.7	0.22	110.6
	4			0.08	116.4	0.08	116.4
	5			0.04	116.8	0.04	116.8
	6			0.01	115.8	0.01	115.8

	7					0.00	
	8+			0.001	130.0	0.00	130.0
	Total	1.43		1.17		2.60	
	SOP		69.8		97.6		167.4
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.25	19.7	0.12	9.5	0.37	16
	1	17.40	44.7	1.24	53.1	18.63	45
	2	1.54	69.6	0.60	97.9	2.14	77
	3	0.18	80.9	0.27	114.7	0.44	101
	4			0.09	116.4	0.09	116
	5			0.04	116.8	0.04	117
	6			0.01	115.8	0.01	116
	7					0.00	
	8+			0.001	130.0	0.00	130
	Total	19.37		2.35		21.72	
	SOP		904		171		1,075.5
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.27	19.7	0.17	9.5	0.44	15.8
	1	19.80	43.4	1.64	53.1	21.44	44.2
	2	16.51	49.8	1.05	97.9	17.55	52.6
	3	2.18	75.4	0.48	114.7	2.66	82.5
	4	0.21	74.8	0.17	116.4	0.38	93.4
	5	0.00		0.08	116.8	0.08	116.8
	6	0.00		0.02	115.8	0.02	115.8
	7	0.10	58.6	0.00		0.10	58.6
	8+	0.00		0.003	130.0	0.00	130.0
	Total	39.08378		3.61		42.69	
	SOP		1,873.3		277.7		2,151.1

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: 2020** **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	0.71	25.4			0.71	25.4
	2	21.17	48.2			21.17	48.2
	3	2.91	73.4			2.91	73.4
	4	0.72	92.4			0.72	92.4
	5	0.32	121.6			0.32	121.6
	6	0.10	130.1			0.10	130.1
	7	0.20	148.8			0.20	148.8
	8+					0.00	
	Total	26.12		0.00		26.12	
	SOP		1,399.3		0		1,399.3
2	1	0.11	25.4	0.04	53.1	0.16	32.9
	2	4.16	48.2	0.11	97.9	4.26	49.5
	3	0.40	73.4	0.05	114.7	0.45	78.3
	4	0.10	92.4	0.02	116.4	0.12	97.2
	5	0.04	121.6	0.01	116.8	0.06	120.7
	6	0.01	130.1	0.002	115.8	0.02	127.9
	7	0.03	148.8			0.03	148.8
	8+			0.0004	130.0	0.0004	130.0
	Total	4.85		0.24		5.09	
	SOP		252.6		23.5		276.0
3	0			0.25	9.5	0.25	
	1	0.20	86.3	0.28	53.1	0.49	67.1
	2	7.98	131.1	0.65	97.9	8.63	128.6
	3	11.07	156.0	0.38	114.7	11.45	154.6
	4	8.18	172.8	0.18	116.4	8.36	171.6
	5	6.01	188.6	0.09	116.8	6.10	187.5
	6	2.76	202.1	0.02	115.8	2.77	201.5

	7	2.69	220.5			2.69	220.5
	8+	1.07	194.9	0.003	130.0	1.07	194.7
	Total	39.95		1.86		41.81	
	SOP		6,695.4		159.1		6,852.1
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	10.04	13.6	0.04	9.5	10.09	13.6
	1	11.86	44.1	0.14	53.1	12.00	44.2
	2			0.08	97.9	0.08	97.9
	3			0.03	114.7	0.03	114.7
	4			0.01	116.4	0.01	116.4
	5			0.01	116.8	0.01	116.8
	6			0.001	115.8	0.00	115.8
	7					0.00	
	8+			0.0002	130.0	0.00	130.0
	Total	21.90		0.31		22.21	
	SOP		659.5		21.0		680.5
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	10.04	13.6	0.29	9.5	10.34	13.5
	1	12.89	43.6	0.47	53.1	13.35	43.9
	2	33.30	68.1	0.84	97.9	34.14	68.8
	3	14.37	137.0	0.46	114.7	14.84	136.3
	4	9.00	165.5	0.21	116.4	9.21	164.3
	5	6.37	184.8	0.11	116.8	6.48	183.7
	6	2.86	199.4	0.02	115.8	2.89	198.7
	7	2.92	214.9	0.00		2.92	214.9
	8+	1.07	194.9	0.004	130.0	1.08	194.7
	Total	92.83		2.41		95.24	
	SOP		9,006.8		203.6		9,210.4

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: 2020** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	14.89	24.67			14.89	24.67
	2	32.45	48.01			32.45	48.01
	3	0.98	74.01			0.98	74.01
	4	0.06	92.40			0.06	92.40
1	5	0.05	121.60			0.05	121.60
	6	0.01	130.10			0.01	130.10
	7	0.03	148.80			0.03	148.80
	8+					0.00	
	Total	48.47		0.00		48.47	
	SOP		2,014.9		0.0		2,014.9
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			0.834419977	9.5	0.83	9.5
	1	0.69	25.4	0.37	53.1	1.06	35.0
	2	1.53	48.2	0.05	97.9	1.58	49.8
	3	0.03	73.4	0.01	114.7	0.03	81.7
	4					0.00	
2	5					0.00	
	6	0.001	130.1	0.0001	115.8	0.001	127.9
	7	0.001	148.8			0.001	148.8
	8+			0.00002	130.0	0.00002	130.0
	Total	2.25		1.26		3.52	
	SOP		93.7		33.3		119.1
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	0.93	19.7	7.39	9.5	8.31	10.6
	1	3.83	64.5	3.17	53.1	7.00	59.3
	2	8.91	130.6	0.86	97.9	9.77	127.8
	3	4.10	156.0	0.15	114.7	4.25	154.5
	4	2.044	172.8	0.06	116.4	2.10	171.3
3	5	0.24	188.6	0.01	116.8	0.25	186.9

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
	6	0.59	202.1	0.005	115.8	0.59	201.4
	7	0.77	220.5			0.77	220.5
	8+					0.00	
	Total	21.40		11.63		33.03	
	SOP		2,754.4		347.2		3,101.6
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	67.34	14.1	2.95	9.5	70.28	13.9
	1	3.45	44.5	0.18	53.1	3.63	44.9
	2	0.26	69.6	0.10	97.9	0.36	77.5
	3					0.00	
	4			0.03	116.4	0.03	116.4
	5			0.01	116.8	0.01	116.8
	6			0.003	115.8	0.003	115.8
	7					0.00	
	8+			0.0004	130.0	0.0004	130.0
	Total	71.04		3.27		74.31	
	SOP		1,121.7		52.1		1,173.7
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	68.26	14.2	11.17	9.5	79.43	13.5
	1	22.86	34.3	3.72	53.1	26.58	37.0
	2	43.15	65.2	1.01	97.9	44.16	66.0
	3	5.11	139.8	0.16	114.7	5.27	139.0
	4	2.10	170.7	0.08	116.4	2.18	168.6
	5	0.29	178.0	0.02	116.8	0.30	174.5
	6	0.60	200.4	0.01	115.8	0.61	199.4
	7	0.80	217.8	0.00		0.80	217.8
	8+	0.00		0.0004	130.0	0.0004	130.0
	Total	143.17		16.16		159.33	
	SOP		5,984.7		432.5		6,417.3

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: 2020** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.95	24.6			1.95	24.6
	2	35.93	47.9			35.93	47.9
	3	4.89	74.0			4.89	74.0
	4	0.93	88.4			0.93	88.4
	5	0.32	121.6			0.32	121.6
	6	0.10	130.1			0.10	130.1
	7	0.31	118.1			0.31	118.1
	8+					0.00	
	Total	44.41		0.00		44.41	
	SOP		2,298.6		0.0		2,298.6
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.11	25.4	0.05	53.1	0.16	33.8
	2	4.16	48.2	0.16	97.9	4.31	50.0
	3	0.40	73.4	0.07	114.7	0.47	79.7
	4	0.10	92.4	0.03	116.4	0.13	98.6
	5	0.04	121.6	0.01	116.8	0.06	120.4
	6	0.01	130.1	0.003	115.8	0.02	127.1
	7	0.03	148.8			0.03	148.8
	8+			0.0005	130.0	0.0005	130.0
	Total	4.85		0.33		5.18	
	SOP		252.6		32.3		284.9
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.02	19.7	0.30	9.5	0.32	10.1
	1	1.37	50.9	0.68	53.1	2.05	51.6
	2	8.19	129.5	1.05	97.9	9.24	125.9
	3	11.09	155.8	0.58	114.7	11.67	153.8
	4	8.18	172.8	0.25	116.4	8.43	171.1
	5	6.01	188.6	0.13	116.8	6.14	187.1
	6	2.76	202.1	0.03	115.8	2.78	201.3

	7	2.69	220.5			2.69	220.5
	8+	1.071	194.9	0.005	130.0	1.076	194.7
	Total	41.38		3.03		44.41	
	SOP		6,765		256.7		7,021.9
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	10.29	13.7	0.16	9.5	10.46	13.7
	1	29.26	44.5	1.38	53.1	30.63	44.8
	2	1.54	69.6	0.67	97.9	2.21	78.2
	3	0.18	80.9	0.30	114.7	0.47	102.1
	4			0.10	116.4	0.10	116.4
4	5			0.04	116.8	0.04	116.8
	6			0.01	115.8	0.01	115.8
	7					0.00	
	8+			0.002	130.0	0.002	130.0
	Total	41.27		2.66		43.93	
	SOP		1,563.7		192.3		1,756.0
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	**Numbers**	**Mean W.**	**Numbers**	**Mean W.**	Numbers	Mean W.
	0	**10.32**	**13.8**	**0.46**	**9.5**	10.78	13.6
	1	**32.69**	**43.5**	**2.11**	**53.1**	34.80	44.1
	2	**49.81**	**62.0**	**1.88**	**97.9**	51.69	63.3
	3	**16.56**	**128.9**	**0.94**	**114.7**	17.50	128.1
	4	**9.21**	**163.4**	**0.38**	**116.4**	9.59	161.5
Total	5	**6.37**	**184.8**	**0.19**	**116.8**	6.56	182.9
	6	**2.86**	**199.4**	**0.04**	**115.8**	2.90	198.2
	7	**3.02**	**209.5**	**0.00**		3.02	209.5
	8+	**1.07**	**194.9**	**0.01**	**130.0**	1.08	194.5
	Total	131.91		6.02		137.93	
	SOP		**10,880.1**		**481.3**		11,361.4

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 1993–2020.

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Num-bers	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	Num-bers	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	Num-bers	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	Num-bers	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	Num-bers	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	Num-bers	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	Num-bers	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	

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Num-bers	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	Num-bers	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	Num-bers	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	Num-bers	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
2004	Num-bers	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	Num-bers	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	Num-bers	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	

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	**Num-bers**	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	**Num-bers**	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	**Num-bers**	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	**Num-bers**	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	**Num-bers**	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	**Num-bers**	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	**Num-bers**		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

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

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

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: 2020 Country: All

Quarter	W-rings	North Sea		Division 3.a		Subdivision 22-24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	0							0.00	
	1	0.0053	104.00	1.95	24.64	0.36	17.80	2.31	23.76
	2	0.224	124.90	35.93	47.87	0.34	51.97	36.49	48.38
	3	0.123	141.80	4.89	73.97	1.76	85.20	6.77	78.12
	4	0.126	155.30	0.93	88.39	1.73	108.57	2.79	103.93
	5	0.158	165.20	0.32	121.60	3.58	147.90	4.05	146.52
	6	0.262	176.70	0.10	130.10	1.80	164.47	2.16	164.43
	7			0.31	118.11	3.35	173.20	3.65	168.59
	8+	0.193	200.33			1.07	177.37	1.26	180.89
	Total	1.092		44.41		13.97		59.47	
	SOP		176.7		2,298.6		1,955.2		4,430.5
Quarter	W-rings	North Sea		Division 3.a		Subdivision 22-24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.632	104.00	0.16	33.81	0.02	27.46	1.82	96.81
	2	2.169	125.00	4.31	49.99	0.06	42.19	6.54	74.80
	3	3.729	142.00	0.47	79.73	0.50	54.88	4.70	126.54
	4	4.899	156.00	0.13	98.60	0.26	73.23	5.29	150.52
	5	0.725	167.00	0.06	120.39	0.40	83.87	1.18	136.80
	6	6.149	178.00	0.02	127.15	0.39	110.36	6.56	173.81
	7	2.934	188.00	0.03	148.78	0.31	149.99	3.27	184.12
	8+	2.704	202.59	0.00	130.00	0.17	124.50	2.88	197.85
	Total	24.942		5.18		2.10		32.23	
	SOP		4,049.7		284.9		193.4		4,528.0
Quarter	W-rings	North Sea		Division 3.a		Subdivision 22-24		Total	
		Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.32	10.15	0.01	15.80	0.33	10.33
	1	0.17	113.90	2.05	51.64	0.19	38.23	2.41	55.08
	2	0.81	135.00	9.24	125.91	0.26	47.71	10.31	124.65
	3	1.99	153.00	11.67	153.78	0.57	66.97	14.24	150.17
	4	2.50	167.10	8.43	171.09	0.63	77.97	11.57	165.17
	5	0.34	178.00	6.14	187.07	0.65	113.93	7.13	179.96

Quarter	W-rings	North Sea Numbers	North Sea Mean W.	Division 3.a Numbers	Division 3.a Mean W.	Subdivision 22-24 Numbers	Subdivision 22-24 Mean W.	Total Numbers	Total Mean W.
	6	4.26	190.20	2.78	201.29	0.64	118.51	7.68	188.22
	7	2.39	200.10	2.69	220.50	0.56	179.52	5.64	207.77
	8+	1.64	215.50	1.08	194.66	0.11	147.83	2.82	204.93
	Total	14.10		44.41		3.63		62.14	
	SOP		2,553.5		7,021.9		374.7		9,950.2
		North Sea		**Division 3.a**		**Subdivision 22-24**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			10.46	13.68	0.02	19.89	10.48	13.69
	1			30.63	44.84	1.12	45.14	31.76	44.85
	2			2.21	78.20	1.83	76.18	4.04	77.28
	3			0.47	102.05	1.75	105.11	2.23	104.46
	4	0.006	166.20	0.10	116.40	2.06	128.53	2.16	128.09
4	5			0.04	116.79	2.08	163.04	2.13	162.09
	6	0.050	189.30	0.01	115.80	1.31	176.26	1.37	176.28
	7					1.11	171.03	1.11	171.03
	8+	0.054	215.01	0.00	130.00	0.23	188.03	0.28	192.81
	Total	0.110		43.93		11.52		55.56	
	SOP		22.0		1,756.0		1,443.0		3,221.0
		North Sea		**Division 3.a**		**Subdivision 22-24**		**Total**	
Quarter	W-rings	**Numbers**	**Mean W.**	Numbers	Mean W.	**Numbers**	**Mean W.**	Numbers	Mean W.
	0	**0.00**		10.78	13.58	**0.03**	**18.46**	10.809	13.59
	1	**1.81**	**104.95**	34.80	44.06	**1.69**	**38.34**	38.297	46.69
	2	**3.20**	**127.52**	51.69	63.30	**2.49**	**69.11**	57.385	67.14
	3	**5.84**	**145.75**	17.50	128.10	**4.58**	**87.25**	27.927	125.09
	4	**7.54**	**159.69**	9.59	161.51	**4.67**	**111.28**	21.804	150.11
Total	5	**1.22**	**169.80**	6.56	182.85	**6.71**	**145.53**	14.484	164.47
	6	**10.72**	**182.87**	2.90	198.23	**4.15**	**155.94**	17.773	179.09
	7	**5.32**	**193.43**	3.02	209.52	**5.33**	**172.08**	13.673	188.67
	8+	**4.59**	**207.25**	1.08	194.53	**1.58**	**171.04**	7.244	197.46
	Total	40.25		137.93		31.22		209.40	
	SOP		**6,801.9**		11,361.4		**3,966.3**		22,129.7

Single fleet assessment input
Multi fleet 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 1993–2020.

	W-rings	0	1	2	3	4	5	6	7	8+	Total
Year	**Area**										
1993	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	**North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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

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 1993–2020.

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	SOP
1993	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+Div. 3.a	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53,544
	Subdiv. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52,647
2003	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	Area										
2009	North Sea+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	North Sea+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	North Sea+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	North Sea+Div. 3.a	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	17,553
	Subdiv. 22-24	18.1	15.9	55.0	95.4	115.1	150.3	167.6	177.4	191.2	21,095
2013	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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	North Sea+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

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 1993–2020.

	W-Rings	0	1	2	3	4	5	6	7	8+	Total
Year	Ages										
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	

	W-Rings	0	1	2	3	4	5	6	7	8+	Total
Year	**Ages**										
	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 / Ages	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

Corrections for the years 1991–1998 was made in HAWG 2001, but are NOT included in the North Sea assessment.

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 1993–2020 (September/October).

									*	**			***	***
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
W-rings/Numbers in millions														
0	893.140	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
1	491.880	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
2	436.550	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
3	529.670	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
4	403.400	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
5	125.140	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
6	55.290	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
7	28.030	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
8+	12.940	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
Total	2,976.040	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+ group	1,154.470	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
W-rings/Biomass ('000 tonnnes)														
0	12.765	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
1	19.520	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
2	21.696	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
3	33.838	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
4	25.674	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
5	12.695	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	7.058	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
7	2.269	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
8+	1.781	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
Total	137.296	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
3+ group	83.315	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
W-rings/Mean weight (g)														
0	14.3	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
1	39.7	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
2	49.7	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
3	63.9	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

									*	**			***	***
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
4	63.6	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
5	101.4	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
6	127.7	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
7	81.0	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
8+	137.7	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
Total	46.1	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

	***	***	***	***	***	***	***	***	****	*****	***	***	5*	6*
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
W-rings/Numbers in millions														
0	2,588.922	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
1	558.851	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
2	260.402	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
3	117.412	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
4	76.782	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
5	43.919	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
6	12.144	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
7	9.262	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
8+	8.839	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
Total	3,676.532	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
3+ group	268.357	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
W-rings/Biomass ('000 tonnnes)														
0	25.202	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
1	22.782	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
2	20.202	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
3	11.366	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	9.679	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
5	6.724	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
6	2.001	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
7	1.703	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
8+	1.798	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
Total	101.456	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

									*	**			***	***
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
3+ group	33.270	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
W-rings/Mean weight (g)														
0	9.7	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
1	40.8	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
2	77.6	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
3	96.8	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
4	126.1	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
5	153.1	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
6	164.8	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
7	183.8	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
8+	203.4	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-	106.4	184.2	100.3	167.9
Total	27.6	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

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**

5* excl. Central Baltic Herring in SDs 21-24 based on SF

6* excl. Central Baltic Herring in SDs 21 and SD 24 (SD 23) based on SF

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 1991–2020 (July).

		*	*	*	*	*			**						
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
W-rings/Numbers in millions															
0		3,853	372	964											
1		277	103	5	2,199	1,091	128	138	1,367	1,509	66	3,346	1,833	1,669	2,687
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21
Total	5,177	10,509	5,779	3,339	6,867	2,673	2,088	3,248	3,201	4,696	1,481	7,002	3,807	3,926	4,939
3+ group	5,177	4,287	2,536	1,957	2,781	577	1,245	1,428	691	1,295	774	2,079	864	1,328	910
W-rings/Biomass ('000 tonnnes)															
0		34.3	1	8.7											
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3
W-rings/Mean weight (g)															
0		8.9	4.0	9.0											
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3

		*	*	*	*	*			**						
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
W-rings/Numbers in millions															
0			112				1		314	2	203	1		2	9
1	2,081	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106	418	815
2	2,217	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224	591	274
3	1,780	933	843	205	254	259	236	525	176	446	381	661	271	315	225
4	490	499	333	161	115	163	87	53	248	224	99	401	175	109	180
5	180	154	274	82	65	70	76	30	28	171	40	94	169	67	74
6	27	34	176	86	24	53	33	12	37	82	40	53	50	52	77
7	10	26	45	39	28	22	14	8	26	89	12	52	35	19	64
8+	0.1	14	44	65	34	46	60	15	42	115	28	92	44	13	46
Total	**6,786**	**9,199**	**8,839**	**1,601**	**2,030**	**4,066**	**2,606**	**1,319**	**1,799**	**4,322**	**1,483**	**2,474**	**1,074**	**1,586**	**1,764**
3+ group	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**	**1,353**	**744**	**575**	**666**
W-rings/Biomass ('000 tonnnes)															
0							0.0		1.0	0.03	1.00	0.00		0.00	0.00
1	112.6	193.2	284.4	26.8	53.0	90.0	44.0	3.0	26.0	61.5	16.0	31.0	4.0	15.0	35.0
2	160.5	273.4	100.9	48.8	34.0	47.0	87.0	51.0	48.0	106.2	20.0	41.0	19.0	49.0	23.0
3	158.6	90.9	101.8	30.6	28.0	31.0	26.0	59.0	21.0	54.7	51.0	101.0	28.0	32.0	29.0
4	56.3	59.6	47.1	29.4	17.0	25.0	12.0	7.0	43.0	33.8	15.0	63.0	25.0	15.0	26.0
5	23.7	18.5	45.3	17.5	11.0	12.0	13.0	4.0	6.0	30.3	7.0	16.0	28.0	12.0	13.0
6	4.1	4.6	30.9	21.4	5.0	10.0	6.0	2.0	8.0	16.7	8.0	10.0	9.0	9.0	13.0
7	1.6	2.6	9.4	10.6	6.0	5.0	3.0	1.0	6.0	17.7	3.0	11.0	7.0	3.0	13.0
8+	0.0	1.9	8.7	19.8	8.0	10.0	14.0	3.0	11.0	25.2	6.0	20.0	10.0	3.0	9.0
Total	517.5	644.7	628.5	204.9	162.0	230.0	205.0	130.0	169.0	346.0	126.0	293.0	130.0	138.0	161.0
3+ group	244.4	178.2	243.2	129.3	75.0	93.0	74.0	76.0	95.0	178.3	90.0	221.0	107.0	74.0	103.0
W-rings/Mean weight (g)															
0			6.3				3.0		4.3	14.2	4.0	23.0		4.0	4.6
1	54.1	49.3	48.6	47.5	52.7	30.2	42.9	58.1	51.6	31.5	37.0	45.0	42.0	35.8	43.2
2	72.4	75.5	87.0	122.7	65.8	98.8	80.4	80.8	114.9	85.4	79.0	97.1	82.9	82.7	85.2
3	89.1	97.4	120.8	149.1	111.4	121.2	110.6	111.7	122.4	122.7	134.0	153.4	104.6	102.1	127.0
4	114.8	119.5	141.4	182.9	150.9	150.6	142.9	128.5	175.0	150.9	151.0	157.3	145.4	139.6	145.2

Year	1991	1992 *	1993 *	1994 *	1995 *	1996 *	1997	1998	1999 **	2000	2001	2002	2003	2004	2005
5	131.6	120.0	165.5	213.3	175.6	168.7	170.8	138.3	210.6	177.1	173.0	173.4	164.9	170.8	178.5
6	153.2	136.6	175.6	248.3	198.0	190.8	182.0	157.2	220.2	202.3	194.0	182.0	172.6	178.6	171.9
7	169.2	101.5	208.5	272.1	215.9	211.0	194.0	155.5	213.3	198.9	214.0	202.7	187.3	187.5	201.0
8+	178.0	138.3	196.7	304.7	234.8	228.5	228.6	198.5	244.1	218.9	215.0	221.2	236.4	221.8	198.7
Total	76.3	70.1	71.1	128.0	79.8	56.6	78.5	97.9	94.6	80.1	50.0	118.8	121.3	87.2	91.7

* 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

* 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

	0
1992	1060
1993	3044
1994	12515
1995	7930
1996	21012
1997	4872
1998	16743
1999	20364
2000	3026
2001	4845
2002	11324
2003	5507
2004	5640
2005	3887
2006	3774
2007	1829
2008	1622
2009	6464
2010	7037
2011	4444
2012	1140
2013	3021
2014	539
2015	2478
2016	442
2017	1247
2018	1563
2019	1317
2020	239

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

	1	2	3
2002	1166345	53774	11703
2003	634554	115414	3207
2004	300694	62762	12182
2005	211643	109896	6337
2006	147220	28012	5867
2007	215066	32362	2947
2008	166945	31225	3786
2009	616668	35237	1103
2010	283447	70603	8757
2011	151203	63594	11692
2012	334504	72913	3546
2013	182103	68799	12056
2014	136922	17344	2917
2015	258998	58671	1899
2016	205037	93324	5638
2017	452975	65639	10504
2018	99906	57667	2710
2019	425325	36118	5299
2020	367697	80994	4912

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

	2	3
2002	3106	1306
2003	6290	1446
2004	3339	1216
2005	3382	600.5
2006	2638	1175
2007	3587	653.7
2008	2266	1169
2009	3022	555.1
2010	3727	1125
2011	2685	660.7
2012	5520	801.4
2013	4925	1424
2014	1228	1242
2015	9481	1392
2016	7624	2105
2017	4990	1507
2018	5241	1038
2019	9404	3168
2020	8325	2058

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: [e2a30d42316c , e2a30d42316c , e2a30d42316c]

TABLE 3.6.10 WESTERN BALTIC SPRING SPAWNING HERRING **1/3**
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

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
2/3

$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

continued

TABLE 3.6.10 WESTERN BALTIC SPRING SPAWNING HERRING
3/3

$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	5022943	3862967	6531238	294077	238967	361896	0.436	0.319	0.597	591241	496634	703870
1992	3630255	2880796	4574690	300530	245962	367206	0.506	0.393	0.652	518501	437446	614575
1993	3060821	2369000	3954675	284750	233802	346799	0.574	0.445	0.739	452238	379982	538234
1994	4514044	3526940	5777413	225900	185793	274666	0.598	0.468	0.766	372079	313585	441485
1995	4196456	3323087	5299361	193972	158677	237118	0.604	0.464	0.785	314615	264888	373678
1996	4185013	3327521	5263477	133192	110267	160884	0.656	0.513	0.840	277979	237488	325373
1997	3489204	2725647	4466663	147001	121995	177132	0.635	0.496	0.811	278869	237384	327603
1998	4590581	3631603	5802791	118707	99253	141973	0.618	0.480	0.794	263239	225753	306949
1999	4901369	3901140	6158050	119183	99572	142657	0.528	0.411	0.679	267183	229986	310396
2000	2993894	2385673	3757179	123386	103364	147287	0.573	0.457	0.718	256795	220967	298431
2001	2757400	2222439	3421131	136051	114973	160994	0.602	0.479	0.756	276821	238691	321043
2002	2740576	2202127	3410681	159982	135316	189145	0.493	0.392	0.621	285553	246200	331195
2003	2956361	2370559	3686924	129160	108886	153209	0.453	0.359	0.572	221619	191147	256947
2004	2064667	1654831	2576004	133609	112816	158235	0.497	0.393	0.628	227433	196301	263504
2005	1769476	1420549	2204110	121380	102745	143394	0.528	0.422	0.660	213085	183495	247446
2006	1361515	1086272	1706499	133027	112128	157821	0.478	0.383	0.596	225861	193571	263538
2007	1421277	1135240	1779384	109135	91526	130132	0.534	0.428	0.666	177349	151211	208006
2008	1169516	936407	1460655	89005	75015	105604	0.575	0.461	0.716	155360	133252	181136
2009	1148604	922140	1430684	79609	67504	93885	0.524	0.413	0.665	139032	120200	160815
2010	1487230	1193680	1852970	74031	62977	87026	0.406	0.318	0.517	123334	106753	142491
2011	1359643	1095129	1688048	69532	58786	82242	0.319	0.247	0.411	114133	98150	132719
2012	1179901	946166	1471377	72538	61555	85482	0.379	0.293	0.489	124511	107489	144230
2013	1685120	1275657	2226013	80985	68786	95348	0.401	0.309	0.521	137015	118257	158748
2014	1156414	909546	1470288	83868	70353	99980	0.347	0.267	0.450	141249	121553	164137
2015	940624	737352	1199933	84718	70660	101573	0.425	0.334	0.542	143826	122570	168770
2016	900718	688624	1178135	80484	66987	96701	0.482	0.375	0.619	124974	105335	148274
2017	969757	718431	1309003	73684	61120	88832	0.504	0.378	0.673	116270	97673	138407
2018	810280	561813	1168633	62561	49773	78634	0.480	0.348	0.664	98793	80122	121816
2019	676518	423391	1080977	57841	43056	77703	0.288	0.202	0.411	102047	78062	133402
2020	582158	295053	1148633	58434	41725	81834	0.193	0.123	0.301	94523	68953	129574

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

Year Age	0	1	2	3	4	5	6	7	8
1991	0.027	0.209	0.324	0.362	0.412	0.458	0.513	0.561	0.561
1992	0.027	0.224	0.351	0.403	0.473	0.535	0.615	0.684	0.684
1993	0.035	0.261	0.387	0.449	0.534	0.606	0.706	0.789	0.789
1994	0.043	0.291	0.408	0.467	0.558	0.630	0.739	0.823	0.823
1995	0.067	0.364	0.439	0.481	0.562	0.632	0.741	0.821	0.821
1996	0.047	0.318	0.439	0.505	0.607	0.694	0.819	0.915	0.915
1997	0.049	0.310	0.426	0.486	0.582	0.669	0.801	0.922	0.922
1998	0.052	0.316	0.430	0.479	0.568	0.651	0.772	0.914	0.914
1999	0.036	0.249	0.384	0.421	0.487	0.555	0.650	0.777	0.777
2000	0.030	0.242	0.397	0.444	0.526	0.606	0.717	0.861	0.861
2001	0.032	0.251	0.400	0.452	0.551	0.637	0.767	0.908	0.908
2002	0.027	0.208	0.344	0.377	0.450	0.521	0.624	0.742	0.742
2003	0.024	0.191	0.318	0.347	0.414	0.477	0.574	0.684	0.684
2004	0.025	0.205	0.331	0.373	0.455	0.523	0.636	0.756	0.756
2005	0.018	0.184	0.337	0.391	0.489	0.555	0.676	0.806	0.806
2006	0.016	0.179	0.344	0.375	0.447	0.498	0.593	0.700	0.700
2007	0.013	0.175	0.364	0.412	0.502	0.560	0.661	0.764	0.764
2008	0.013	0.183	0.386	0.436	0.539	0.607	0.716	0.813	0.813
2009	0.014	0.191	0.384	0.403	0.488	0.551	0.654	0.740	0.740
2010	0.008	0.126	0.294	0.314	0.379	0.424	0.506	0.575	0.575
2011	0.005	0.094	0.228	0.245	0.298	0.333	0.400	0.457	0.457
2012	0.006	0.100	0.232	0.270	0.352	0.402	0.490	0.555	0.555
2013	0.006	0.104	0.237	0.279	0.371	0.430	0.525	0.600	0.600
2014	0.005	0.092	0.220	0.249	0.319	0.370	0.449	0.525	0.525
2015	0.007	0.120	0.266	0.296	0.385	0.461	0.560	0.679	0.679
2016	0.006	0.119	0.295	0.333	0.426	0.525	0.643	0.811	0.811
2017	0.005	0.107	0.297	0.345	0.434	0.552	0.686	0.901	0.901
2018	0.004	0.101	0.280	0.325	0.407	0.528	0.662	0.921	0.921
2019	0.002	0.068	0.204	0.215	0.246	0.304	0.388	0.583	0.583
2020	0.002	0.064	0.193	0.172	0.171	0.186	0.241	0.381	0.381

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	0.018	0.016	0.018	0.017	0.017	0.017
1992	0.000	0.000	0.004	0.018	0.016	0.018	0.018	0.019	0.019
1993	0.000	0.000	0.004	0.018	0.016	0.018	0.019	0.020	0.020
1994	0.000	0.000	0.004	0.018	0.017	0.018	0.020	0.021	0.021
1995	0.000	0.000	0.004	0.018	0.017	0.018	0.022	0.023	0.023
1996	0.000	0.000	0.004	0.018	0.018	0.020	0.023	0.026	0.026
1997	0.000	0.000	0.004	0.018	0.018	0.020	0.023	0.031	0.031
1998	0.000	0.000	0.004	0.017	0.018	0.022	0.023	0.038	0.038
1999	0.000	0.000	0.004	0.018	0.019	0.024	0.025	0.043	0.043
2000	0.000	0.000	0.004	0.017	0.021	0.026	0.028	0.046	0.046
2001	0.000	0.000	0.003	0.016	0.021	0.027	0.030	0.047	0.047
2002	0.000	0.000	0.003	0.016	0.020	0.025	0.029	0.046	0.046
2003	0.000	0.000	0.002	0.015	0.019	0.022	0.026	0.043	0.043
2004	0.000	0.000	0.002	0.015	0.018	0.020	0.024	0.037	0.037
2005	0.000	0.000	0.002	0.013	0.017	0.017	0.024	0.039	0.039
2006	0.000	0.000	0.001	0.010	0.014	0.015	0.022	0.041	0.041
2007	0.000	0.000	0.001	0.007	0.010	0.009	0.018	0.029	0.029
2008	0.000	0.000	0.001	0.005	0.008	0.007	0.014	0.024	0.024
2009	0.000	0.000	0.001	0.004	0.008	0.006	0.015	0.030	0.030
2010	0.000	0.000	0.000	0.004	0.007	0.005	0.014	0.025	0.025
2011	0.000	0.000	0.000	0.004	0.006	0.004	0.013	0.019	0.019
2012	0.000	0.000	0.000	0.003	0.006	0.003	0.017	0.017	0.017
2013	0.000	0.000	0.000	0.004	0.007	0.005	0.019	0.022	0.022
2014	0.000	0.000	0.001	0.005	0.008	0.007	0.023	0.033	0.033
2015	0.000	0.000	0.001	0.006	0.009	0.009	0.025	0.043	0.043
2016	0.000	0.000	0.001	0.007	0.010	0.011	0.027	0.051	0.051
2017	0.000	0.000	0.001	0.009	0.011	0.012	0.026	0.061	0.061
2018	0.000	0.000	0.002	0.010	0.015	0.015	0.035	0.101	0.101
2019	0.000	0.000	0.002	0.012	0.018	0.019	0.046	0.138	0.138
2020	0.000	0.000	0.003	0.013	0.021	0.018	0.055	0.150	0.150

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	0.042	0.142	0.111	0.089	0.079	0.074	0.075	0.075
1992	0.001	0.042	0.143	0.112	0.089	0.080	0.074	0.076	0.076
1993	0.001	0.042	0.144	0.113	0.090	0.080	0.075	0.077	0.077
1994	0.001	0.044	0.149	0.117	0.093	0.083	0.078	0.079	0.079
1995	0.001	0.046	0.155	0.122	0.097	0.086	0.081	0.082	0.082
1996	0.001	0.046	0.155	0.122	0.097	0.086	0.081	0.082	0.082
1997	0.001	0.046	0.157	0.123	0.098	0.087	0.081	0.083	0.083
1998	0.001	0.049	0.166	0.130	0.104	0.092	0.086	0.088	0.088
1999	0.001	0.051	0.175	0.137	0.109	0.097	0.091	0.093	0.093
2000	0.001	0.053	0.181	0.142	0.113	0.101	0.094	0.096	0.096
2001	0.001	0.050	0.171	0.134	0.107	0.095	0.089	0.091	0.091
2002	0.001	0.050	0.171	0.134	0.107	0.095	0.089	0.091	0.091
2003	0.001	0.046	0.156	0.122	0.097	0.087	0.081	0.083	0.083
2004	0.001	0.041	0.139	0.109	0.087	0.077	0.072	0.074	0.074
2005	0.001	0.044	0.151	0.118	0.094	0.084	0.078	0.080	0.080
2006	0.001	0.049	0.168	0.132	0.105	0.094	0.087	0.089	0.089
2007	0.001	0.053	0.180	0.141	0.112	0.100	0.093	0.095	0.095
2008	0.001	0.055	0.189	0.148	0.118	0.105	0.098	0.100	0.100
2009	0.001	0.058	0.198	0.155	0.123	0.110	0.103	0.105	0.105
2010	0.001	0.054	0.184	0.145	0.115	0.103	0.096	0.098	0.098
2011	0.001	0.044	0.151	0.118	0.094	0.084	0.078	0.080	0.080
2012	0.001	0.039	0.132	0.103	0.082	0.073	0.068	0.070	0.070
2013	0.001	0.036	0.121	0.095	0.076	0.067	0.063	0.064	0.064
2014	0.001	0.037	0.127	0.099	0.079	0.071	0.066	0.067	0.067
2015	0.001	0.041	0.140	0.110	0.087	0.078	0.073	0.074	0.074
2016	0.001	0.051	0.175	0.137	0.109	0.098	0.091	0.093	0.093
2017	0.001	0.058	0.196	0.154	0.122	0.109	0.102	0.104	0.104
2018	0.001	0.055	0.188	0.148	0.117	0.105	0.098	0.100	0.100
2019	0.001	0.047	0.159	0.124	0.099	0.088	0.082	0.084	0.084
2020	0.001	0.047	0.161	0.126	0.100	0.090	0.084	0.086	0.086

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

Year Age	0	1	2	3	4	5	6	7	8
1991	0.015	0.041	0.017	0.008	0.004	0.003	0.004	0.004	0.004
1992	0.013	0.034	0.014	0.007	0.004	0.003	0.004	0.003	0.003
1993	0.019	0.048	0.019	0.009	0.005	0.003	0.005	0.004	0.004
1994	0.026	0.070	0.027	0.012	0.006	0.004	0.006	0.005	0.005
1995	0.050	0.140	0.051	0.021	0.009	0.006	0.009	0.007	0.007
1996	0.029	0.076	0.027	0.012	0.005	0.004	0.006	0.005	0.005
1997	0.032	0.077	0.026	0.011	0.005	0.004	0.005	0.004	0.004
1998	0.035	0.088	0.030	0.012	0.005	0.004	0.005	0.004	0.004
1999	0.023	0.054	0.020	0.008	0.004	0.003	0.004	0.003	0.003
2000	0.016	0.037	0.014	0.005	0.003	0.002	0.003	0.003	0.003
2001	0.019	0.049	0.020	0.009	0.005	0.005	0.009	0.009	0.009
2002	0.018	0.052	0.021	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.057	0.032	0.014	0.009	0.008	0.009	0.007	0.007
2004	0.016	0.065	0.043	0.022	0.014	0.012	0.012	0.009	0.009
2005	0.008	0.037	0.025	0.012	0.006	0.005	0.004	0.003	0.003
2006	0.009	0.048	0.042	0.022	0.013	0.013	0.011	0.009	0.009
2007	0.005	0.031	0.030	0.015	0.007	0.008	0.008	0.007	0.007
2008	0.005	0.034	0.033	0.014	0.005	0.006	0.005	0.005	0.005
2009	0.008	0.058	0.050	0.015	0.004	0.004	0.003	0.003	0.003
2010	0.003	0.021	0.015	0.003	0.000	0.000	0.000	0.000	0.000
2011	0.001	0.012	0.008	0.001	0.000	0.000	0.000	0.000	0.000
2012	0.001	0.011	0.009	0.001	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.015	0.015	0.002	0.000	0.000	0.000	0.000	0.000
2014	0.001	0.013	0.012	0.001	0.000	0.000	0.000	0.000	0.000
2015	0.002	0.029	0.028	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.018	0.019	0.002	0.000	0.000	0.000	0.000	0.000
2017	0.000	0.003	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2018	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
2019	0.000	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000
2020	0.001	0.009	0.014	0.003	0.000	0.001	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	0.161	0.224	0.304	0.357	0.417	0.465	0.465
1992	0.013	0.148	0.190	0.266	0.364	0.434	0.519	0.586	0.586
1993	0.015	0.170	0.219	0.308	0.423	0.505	0.608	0.688	0.688
1994	0.016	0.177	0.228	0.320	0.442	0.525	0.635	0.718	0.718
1995	0.016	0.178	0.229	0.320	0.439	0.521	0.630	0.709	0.709
1996	0.017	0.197	0.252	0.353	0.487	0.584	0.710	0.802	0.802
1997	0.016	0.187	0.239	0.334	0.462	0.558	0.691	0.803	0.803
1998	0.016	0.179	0.230	0.319	0.440	0.533	0.658	0.784	0.784
1999	0.013	0.143	0.186	0.258	0.355	0.431	0.531	0.638	0.638
2000	0.013	0.151	0.199	0.279	0.390	0.477	0.592	0.716	0.716
2001	0.013	0.152	0.205	0.293	0.417	0.510	0.639	0.761	0.761
2002	0.009	0.105	0.149	0.220	0.320	0.398	0.503	0.602	0.602
2003	0.007	0.088	0.129	0.196	0.290	0.361	0.457	0.551	0.551
2004	0.008	0.099	0.148	0.227	0.338	0.415	0.528	0.637	0.637
2005	0.009	0.104	0.159	0.249	0.371	0.449	0.570	0.684	0.684
2006	0.007	0.082	0.132	0.211	0.315	0.376	0.473	0.561	0.561
2007	0.007	0.091	0.153	0.249	0.372	0.441	0.543	0.632	0.632
2008	0.008	0.093	0.163	0.270	0.408	0.490	0.599	0.683	0.683
2009	0.006	0.075	0.136	0.229	0.353	0.431	0.534	0.602	0.602
2010	0.004	0.051	0.094	0.163	0.257	0.316	0.396	0.452	0.452
2011	0.003	0.037	0.069	0.122	0.197	0.245	0.308	0.357	0.357
2012	0.004	0.050	0.092	0.163	0.263	0.326	0.405	0.467	0.467
2013	0.004	0.054	0.100	0.178	0.289	0.358	0.444	0.514	0.514
2014	0.003	0.042	0.080	0.143	0.231	0.293	0.360	0.425	0.425
2015	0.004	0.050	0.097	0.177	0.288	0.373	0.461	0.561	0.561
2016	0.004	0.050	0.100	0.187	0.307	0.417	0.525	0.667	0.667
2017	0.004	0.047	0.096	0.182	0.301	0.431	0.558	0.737	0.737
2018	0.003	0.043	0.087	0.167	0.275	0.407	0.529	0.720	0.720
2019	0.002	0.020	0.040	0.078	0.129	0.196	0.259	0.361	0.361
2020	0.001	0.007	0.015	0.029	0.049	0.077	0.102	0.145	0.145

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	5022943	4152570	2234165	1865106	912334	551552	162991	48728	17450
1992	3630255	3664762	2031597	1326664	1062780	491264	283982	80561	31300
1993	3060821	2619490	1810037	1159149	732820	540773	234094	125693	46312
1994	4514044	2149891	1222277	1028223	596889	357288	239879	94336	63870
1995	4196456	3248778	980058	654342	545136	271261	158360	93064	56645
1996	4185013	2897531	1376282	519838	328110	253247	117781	61899	53973
1997	3489204	2962747	1272778	738092	257265	144882	101716	42416	38486
1998	4590581	2421862	1315605	681338	375272	117773	61326	36548	26394
1999	4901369	3240278	1057901	694730	347096	176022	49916	23518	20280
2000	2993894	3555608	1536881	583867	369918	176353	82834	21425	16481
2001	2757400	2124105	1700921	858468	301753	178733	78197	33527	13093
2002	2740576	1966506	981372	938531	458828	139904	78023	29090	15570
2003	2956361	1959900	970767	562380	526293	241963	67356	34289	17401
2004	2064667	2170704	986406	581835	325296	282538	123276	31131	21256
2005	1769476	1475182	1085830	590538	326347	169126	136688	53711	20106
2006	1361515	1290691	728552	638464	337045	161936	81031	56290	27107
2007	1421277	981767	659708	419942	355561	180304	77970	38073	33449
2008	1169516	1050873	491319	376163	226479	175315	86126	32793	27508
2009	1148604	851006	538476	272732	196091	109412	77084	34886	21966
2010	1487230	826643	425736	298234	150470	99515	51991	31823	22510
2011	1359643	1103191	436711	257221	177098	84140	53924	25852	24749
2012	1179901	1000824	620659	283480	162985	107300	49466	29633	26228
2013	1685120	857532	543225	411781	176723	93929	58122	25025	26306
2014	1156414	1280360	457103	347514	258746	98132	50272	28122	23464
2015	940624	850890	736866	300604	220232	148898	56254	26113	25499
2016	900718	686374	455163	475833	184023	121850	74489	26413	21775
2017	969757	661829	368408	269154	288210	99424	59208	31266	17627
2018	810280	725604	362438	223014	149031	158374	47823	24140	15946
2019	676518	600134	396893	222502	132423	80618	77067	20594	12708
2020	582158	499048	341652	261726	143557	86485	48738	43227	15148

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	115644.93	655619.77	612525.11	563331.02	304193.61	199847.69	64442.81	20664.07	7400.12
1992	84390.94	613309.74	598567.12	439651.95	396662.03	201216.92	129128.85	39633.64	15398.54
1993	91145.61	508051.29	582526.49	421248.45	301591.19	243999.87	117961.04	68430.18	25213.51
1994	164828.60	463877.92	414633.21	387585.29	255161.37	166302.07	125178.77	53050.35	35917.34
1995	237673.26	871034.30	357823.85	254301.82	235510.10	127094.99	83198.58	52483.36	31944.94
1996	169423.01	679544.75	497376.42	208997.31	149949.32	126941.89	66194.30	37494.07	32692.71
1997	145501.04	678322.78	448681.18	287652.95	113909.88	70788.10	56344.89	25930.28	23527.54
1998	202855.25	566243.42	468883.76	263079.34	163532.42	56672.08	33248.77	22399.38	16176.55
1999	150989.19	605080.88	339746.11	240766.67	134150.13	75349.81	24002.06	13010.61	11219.31
2000	75937.00	642528.59	507237.58	211684.81	152616.81	80895.62	42889.02	12751.22	9808.87
2001	76740.04	399193.76	566401.86	315938.61	128874.57	85097.39	42607.71	20702.67	8084.56
2002	64070.57	309951.36	284541.12	295146.15	166444.88	56936.31	36485.44	15600.65	8350.01
2003	61872.73	285474.91	263182.99	164389.87	177694.34	91484.77	29486.14	17287.02	8772.72
2004	44006.06	337917.44	278547.37	181234.28	118586.34	114560.82	57974.68	16709.83	11409.15
2005	26702.82	206765.38	309377.01	190944.82	125750.18	71593.56	67092.22	30130.55	11279.00
2006	18780.56	177025.44	212867.89	200394.98	121627.66	63566.51	36399.19	28957.48	13944.49
2007	16228.22	131393.06	201963.33	142561.26	140781.88	77266.98	37943.96	20718.05	18201.72
2008	13430.98	146200.01	158780.60	134229.43	94826.04	79883.17	44292.19	18588.72	15592.84
2009	14256.14	124397.07	173851.19	91123.66	75968.22	46290.39	37198.31	18629.12	11729.56
2010	9731.58	80380.46	105881.96	78966.39	46895.69	33861.50	20487.83	13982.68	9890.37
2011	5935.46	80076.79	85312.93	53940.97	44266.64	23092.72	17386.36	9333.96	8935.82
2012	5681.47	76997.15	124000.18	65075.75	46927.88	34387.84	18724.10	12381.91	10959.18
2013	8491.64	68792.66	111010.62	97137.95	53082.70	31742.69	23204.33	11100.12	11668.26
2014	4910.51	91209.63	86624.36	73946.71	68371.96	29361.21	17806.17	11364.10	9481.71
2015	5386.47	78605.16	168534.68	75140.20	68751.62	53752.74	23849.88	12958.99	12654.42
2016	4624.98	63192.00	114010.70	133084.04	63260.93	49379.97	35482.43	15101.80	12449.86
2017	3885.64	54696.88	91876.53	77834.39	101253.88	42170.59	29765.23	19427.96	10953.05
2018	2981.88	56265.66	85653.93	61036.44	49619.26	64866.27	23489.92	15557.16	10276.56
2019	1364.66	31666.86	68894.81	41241.77	28051.34	20619.05	24699.44	9609.51	5929.63
2020	939.00	24566.38	55923.79	38853.92	21483.65	14040.23	10236.54	14009.67	4909.42

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	11.17	7576.77	30060.89	12939.17	9112.96	2542.39	756.10	270.77
1992	0.00	9.86	6902.56	21105.01	15082.34	7897.34	4631.88	1352.63	525.53
1993	0.00	7.05	6098.20	18728.15	10661.13	8630.42	4023.18	2259.98	832.70
1994	0.00	5.78	4122.09	16229.62	9195.49	5704.19	4382.04	1812.03	1226.82
1995	0.00	8.74	3295.35	10473.48	8520.12	4491.35	3078.39	1914.86	1165.51
1996	0.00	7.80	4587.40	8279.49	5203.78	4445.93	2407.24	1430.63	1247.43
1997	0.00	7.97	4227.87	11695.71	4124.40	2622.65	2137.95	1182.57	1072.99
1998	0.00	6.52	4400.15	10634.63	6219.69	2324.12	1280.86	1224.92	884.62
1999	0.00	8.72	3543.79	11125.63	5910.43	3843.25	1103.70	890.81	768.16
2000	0.00	9.57	5115.75	9165.97	6955.76	4165.15	2063.53	872.10	670.86
2001	0.00	6.26	5220.93	12554.86	5757.11	4289.93	2115.33	1381.80	539.60
2002	0.00	5.27	2482.29	13247.05	8225.31	3156.28	2034.77	1191.86	637.93
2003	0.00	5.10	1729.58	7419.14	8792.79	4766.77	1595.56	1301.70	660.58
2004	0.00	5.86	1969.03	7747.81	5156.37	4983.91	2641.21	1022.73	698.30
2005	0.00	4.44	1876.52	6690.62	5011.20	2627.49	2901.19	1853.03	693.66
2006	0.00	4.59	923.54	5552.97	4290.57	2205.78	1564.34	2027.97	976.57
2007	0.00	3.57	512.04	2593.25	3323.38	1538.57	1228.00	996.48	875.45
2008	0.00	4.11	288.27	1600.45	1677.47	1039.69	1083.90	705.56	591.85
2009	0.00	3.79	276.42	1101.21	1473.55	590.08	1042.39	936.04	589.37
2010	0.00	4.41	160.31	1039.63	1005.27	429.06	662.72	706.92	500.02
2011	0.00	6.53	143.72	823.34	1035.86	288.38	655.46	444.29	425.34
2012	0.00	7.11	194.35	880.54	915.12	294.05	739.65	460.26	407.38
2013	0.00	7.92	215.22	1445.05	1040.30	394.79	972.66	486.53	511.43
2014	0.00	16.76	267.03	1585.39	1926.45	602.77	1032.13	816.07	680.89
2015	0.00	15.29	480.93	1601.01	1800.05	1260.82	1274.96	1007.06	983.39
2016	0.00	16.70	397.73	3143.41	1649.49	1174.89	1780.05	1185.85	977.61
2017	0.00	21.60	370.62	2152.92	2945.43	1061.21	1400.20	1665.32	938.87
2018	0.00	34.51	527.91	2018.63	2006.96	2204.39	1472.16	2105.54	1390.85
2019	0.00	41.85	871.05	2461.90	2158.39	1361.33	3153.60	2406.24	1484.79
2020	0.00	40.90	882.70	3163.04	2756.26	1424.75	2374.39	5486.16	1922.52

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	2567.31	133649.23	268813.75	178397.88	70188.97	38059.50	10514.28	3209.82	1149.49
1992	1865.65	118583.06	245690.64	127554.36	82192.52	34078.27	18416.28	5334.84	2072.70
1993	1589.84	85650.29	221079.82	112577.47	57255.00	37898.76	15337.78	8409.38	3098.49
1994	2426.83	72711.19	154156.87	103168.64	48197.11	25882.44	16247.26	6524.32	4417.24
1995	2344.03	114072.21	128075.79	68066.88	45654.85	20384.79	11127.72	6677.26	4064.23
1996	2338.14	101760.41	179890.22	54085.84	27484.34	19034.68	8277.92	4442.08	3873.24
1997	1968.14	105031.03	167844.27	77489.01	21747.28	10989.83	7214.74	3072.01	2787.35
1998	2742.29	90816.02	182943.75	75496.09	33503.92	9437.76	4596.13	2796.65	2019.71
1999	3086.07	127916.87	154406.07	80870.09	32575.64	14832.08	3934.27	1892.49	1631.93
2000	1950.13	145096.18	231408.25	70155.65	35852.46	15348.51	6744.08	1780.89	1369.95
2001	1698.79	82090.03	243346.93	97915.25	27741.45	14750.98	6036.32	2642.47	1031.91
2002	1687.37	75953.50	140322.35	106982.95	42155.89	11539.30	6019.07	2291.37	1226.42
2003	1659.49	69150.85	127445.79	58769.75	44279.62	18266.92	4754.86	2471.85	1254.40
2004	1032.60	68390.99	116302.07	54512.64	24506.11	19089.28	7785.78	2008.06	1371.06
2005	959.97	50339.83	138112.22	59757.04	26576.65	12357.09	9337.71	3747.31	1402.76
2006	825.14	49088.63	102669.86	71705.29	30503.72	13156.91	6157.39	4368.18	2103.50
2007	920.09	39825.96	98777.85	50167.28	34258.39	15601.49	6311.28	3147.19	2764.95
2008	795.22	44722.92	76945.04	47043.97	22859.61	15896.54	7306.64	2841.01	2383.13
2009	816.19	37806.76	87783.54	35535.31	20633.56	10345.38	6820.41	3151.99	1984.61
2010	986.83	34351.61	65206.31	36460.84	14842.28	8817.30	4309.74	2693.93	1905.50
2011	739.39	37736.12	55678.61	26090.76	14458.10	6164.00	3693.74	1808.76	1731.61
2012	559.03	29903.21	69577.61	25233.72	11660.11	6884.45	2966.54	1815.46	1606.85
2013	734.28	23596.82	56286.73	33843.28	11664.31	5558.38	3214.31	1413.90	1486.27
2014	526.93	36815.24	49399.65	29805.91	17830.16	6064.08	2903.64	1659.44	1384.56
2015	474.41	27033.26	87587.40	28395.72	16731.45	10149.04	3584.82	1699.96	1660.01
2016	567.78	27129.71	66521.45	55457.18	17294.11	10285.41	5882.42	2130.52	1756.39
2017	684.68	29219.39	59717.91	34864.28	30149.29	9347.84	5209.89	2809.79	1584.10
2018	549.24	30787.25	56610.01	27812.83	15001.04	14324.32	4047.43	2086.75	1378.44
2019	385.67	21499.36	52868.44	23594.20	11308.10	6180.10	5525.08	1508.23	930.67
2020	337.36	18167.17	46205.11	28184.53	12451.71	6734.68	3549.57	3215.88	1126.94

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	64214.50	132623.17	34160.55	14220.25	3444.85	1533.36	634.48	157.13	56.27
1992	41302.57	96166.65	26167.23	8598.62	3474.12	1207.57	1004.93	240.96	93.62
1993	49623.51	97102.87	31241.28	9746.02	3025.21	1641.04	1010.19	451.99	166.54
1994	101512.11	115036.22	29770.74	11523.55	3190.66	1361.75	1276.45	410.40	277.86
1995	178398.74	336326.40	44033.59	12531.73	4640.90	1561.57	1217.97	562.73	342.52
1996	104744.99	166916.17	33491.72	5522.89	1625.87	900.21	588.61	256.28	223.46
1997	94385.25	173050.57	30149.24	7305.12	1170.56	475.02	472.88	167.14	151.65
1998	138374.66	160602.88	35407.34	7177.63	1767.64	395.44	287.78	147.05	106.20
1999	95228.91	134666.04	18744.69	4866.17	1106.94	414.34	168.90	70.94	61.17
2000	40311.20	102504.07	19023.13	2849.39	844.31	306.70	213.45	50.93	39.18
2001	44075.21	80166.25	31029.53	6711.47	1417.30	813.53	637.05	283.58	110.74
2002	41149.28	79223.40	18504.85	6169.19	1562.72	366.71	258.97	76.26	40.82
2003	41151.63	85979.29	27375.28	7250.88	4135.26	1674.76	564.73	231.56	117.51
2004	28177.79	108140.97	37352.19	11649.97	3969.08	2989.77	1314.58	252.26	172.24
2005	12606.99	41703.52	23991.76	6173.76	1823.59	744.49	515.67	143.61	53.76
2006	10036.03	48040.50	27449.26	12801.52	3814.40	1873.26	799.61	441.98	212.83
2007	6150.95	23871.48	17422.59	5515.23	2402.64	1379.59	541.44	243.28	213.73
2008	4994.60	27451.97	14390.31	4620.32	1072.43	926.21	379.20	161.54	135.51
2009	7417.50	37899.90	23663.16	3703.79	694.28	387.36	186.15	105.83	66.63
2010	3422.77	13329.26	5736.95	766.74	53.89	26.89	6.84	5.45	3.86
2011	1680.95	10513.21	3026.12	238.04	11.51	4.01	1.44	1.16	1.11
2012	1126.17	8961.16	4796.41	253.21	7.59	3.69	0.95	1.05	0.93
2013	1609.89	9785.25	7360.38	762.42	16.15	6.12	1.70	1.29	1.35
2014	1104.56	13066.90	5067.43	447.74	13.48	5.24	1.11	1.11	0.93
2015	1761.05	19001.40	18488.38	824.82	28.85	28.49	3.26	2.28	2.22
2016	1051.52	9716.53	7669.06	707.11	12.45	17.61	3.65	2.12	1.75
2017	204.83	1732.71	1283.87	81.28	4.23	3.48	1.10	1.23	0.70
2018	151.78	1601.40	1090.55	70.27	2.46	5.88	1.09	1.16	0.77
2019	96.95	975.64	903.00	72.41	2.91	4.02	2.28	1.11	0.69
2020	314.13	3494.39	4202.95	669.21	34.32	44.88	11.59	11.90	4.17

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	48863.12	389336.20	301974.04	340652.00	217620.62	151141.87	50751.66	16541.02	5923.59
1992	41222.72	398550.17	319806.69	282393.96	295913.05	158033.74	105075.76	32705.21	12706.69
1993	39932.26	325291.08	324107.19	280196.81	230649.85	195829.65	97589.89	57308.83	21115.78
1994	60889.66	276124.73	226583.51	256663.48	194578.11	133353.69	103273.02	44303.60	29995.42
1995	56930.49	420626.95	182419.12	163229.73	176694.23	100657.28	67774.50	43328.51	26372.68
1996	62339.88	410860.37	279407.08	141109.09	115635.33	102561.07	54920.53	31365.08	27348.58
1997	49147.65	400233.21	246459.80	191163.11	86867.64	56700.60	46519.32	21508.56	19515.55
1998	61738.30	314818.00	246132.52	169770.99	122041.17	44514.76	27084.00	18230.76	13166.02
1999	52674.21	342489.25	163051.56	143904.78	94557.12	56260.14	18795.19	10156.37	8758.05
2000	33675.67	394918.77	251690.45	129513.80	108964.28	61075.26	33867.96	10047.30	7728.88
2001	30966.04	236931.22	286804.47	198757.03	93958.71	65242.95	33819.01	16394.82	6402.31
2002	21233.92	154769.19	123231.63	168746.96	114500.96	41874.02	28172.63	12041.16	6444.84
2003	19061.61	130339.67	106632.34	90950.10	120486.67	66776.32	22570.99	13281.91	6740.23
2004	14795.67	161379.62	122924.08	107323.86	84954.78	87497.86	46233.11	13426.78	9167.55
2005	13135.86	114717.59	145396.51	118323.40	92338.74	55864.49	54337.65	24386.60	9128.82
2006	7919.39	79891.72	81825.23	110335.20	83018.97	46330.56	27877.85	22119.35	10651.59
2007	9157.18	67692.05	85250.85	84285.50	100797.47	58747.33	29863.24	16331.10	14347.59
2008	7641.16	74021.01	67156.98	80964.69	69216.53	62020.73	35522.45	14880.61	12482.35
2009	6022.45	48686.62	62128.07	50783.35	53166.83	34967.57	29149.36	14435.26	9088.95
2010	5321.98	32695.18	34778.39	40699.18	30994.25	24588.25	15508.53	10576.38	7480.99
2011	3515.12	31820.93	26464.48	26788.83	28761.17	16636.33	13035.72	7079.75	6777.76
2012	3996.27	38125.67	49431.81	38708.28	34345.06	27205.65	15016.96	10105.14	8944.02
2013	6147.47	35402.67	47148.29	61087.20	40361.94	25783.40	19015.66	9198.40	9669.21
2014	3279.02	41310.73	31890.25	42107.67	48601.87	22689.12	13869.29	8887.48	7415.33
2015	3151.01	32555.21	61977.97	44318.65	50191.27	42314.39	18986.84	10249.69	10008.80
2016	3005.68	26329.06	39422.46	73776.34	44304.88	37902.06	27816.31	11783.31	9714.11
2017	2996.13	23723.18	30504.13	40735.91	68154.93	31758.06	23154.04	14951.62	8429.38
2018	2280.86	23842.50	27425.46	31134.71	32608.80	48331.68	17969.24	11363.71	7506.50
2019	882.04	9150.01	14252.32	15113.26	14581.94	13073.60	16018.48	5693.93	3513.48
2020	287.51	2863.92	4633.03	6837.14	6241.36	5835.92	4300.99	5295.73	1855.79

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

2020

wr	N	M	Mat	PM	PF	SWt
0	582158	0.3	0.00	0.25	0.1	0.0001
1	499048	0.5	0.00	0.25	0.1	0.0238
2	341652	0.2	0.20	0.25	0.1	0.0484
3	261726	0.2	0.75	0.25	0.1	0.0781
4	143557	0.2	0.90	0.25	0.1	0.1039
5	86485	0.2	1.00	0.25	0.1	0.1465
6	48739	0.2	1.00	0.25	0.1	0.1644
7	43227	0.2	1.00	0.25	0.1	0.1686
8+	15148	0.2	1.00	0.25	0.1	0.1809

2021

wr	N	M	Mat	PM	PF	SWt
0	859579	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0187
2		0.2	0.20	0.25	0.1	0.0487
3		0.2	0.75	0.25	0.1	0.0801
4		0.2	0.90	0.25	0.1	0.1111
5		0.2	1.00	0.25	0.1	0.1414
6		0.2	1.00	0.25	0.1	0.1637
7		0.2	1.00	0.25	0.1	0.1743
8+		0.2	1.00	0.25	0.1	0.1845

2022

wr	N	M	Mat	PM	PF	SWt
0	859579	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0187
2		0.2	0.20	0.25	0.1	0.0487
3		0.2	0.75	0.25	0.1	0.0801
4		0.2	0.90	0.25	0.1	0.1111
5		0.2	1.00	0.25	0.1	0.1414
6		0.2	1.00	0.25	0.1	0.1637
7		0.2	1.00	0.25	0.1	0.1743
8+		0.2	1.00	0.25	0.1	0.1845

Input units are thousands and kg

M =	Natural mortality
MAT =	Maturity ogive
PF =	Proportion of F before spawning
PM =	Proportion of M before spawning
SWt =	Weight in stock (kg)

N_{2020} wr 0-8+:	Populations numbers from the assessment
$N_{2021/2022}$ wr 0:	Average of wr 0 for the years 2015-2019
Natural Mortality (M):	Constant
Weight in the Stock 2021-2022 (SWt):	Average for 2016-2020

TABLE 3.9.2 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. MSY approach (zero catch)**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.000	0.000	0.000
fbar:low	0.193	0.174	0.000	0.000	0.000
fbar:high	0.193	0.174	0.000	0.000	0.000
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68903	83794	102194
ssb:low	58434	65046	68903	83794	102194
ssb:high	58434	65046	68903	83794	102194
catch:Estimate	19436	19088	0	0	0
catch:low	19436	19088	0	0	0
catch:high	19436	19088	0	0	0

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	0	0	0
Fleet C : Estimate	11759	12076	0	0	0
Fleet D : Estimate	643	196	0	0	0
Fleet F : Estimate	4156	1575	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	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.134	0.140	0.148
fbar:low	0.193	0.174	0.134	0.140	0.148
fbar:high	0.193	0.174	0.134	0.140	0.148
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	67797	71788	77726
ssb:low	58434	65046	67797	71788	77726
ssb:high	58434	65046	67797	71788	77726
catch:Estimate	19436	19088	12499	14444	16553
catch:low	19436	19088	12499	14444	16553
catch:high	19436	19088	12499	14444	16553

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	1989	2349	2770
Fleet C : Estimate	11759	12076	4188	4781	5408
Fleet D : Estimate	643	196	73	92	99
Fleet F : Estimate	4156	1575	6250	7222	8277

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

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.094	0.098	0.108
fbar:low	0.193	0.174	0.094	0.098	0.108
fbar:high	0.193	0.174	0.094	0.098	0.108
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68130	75182	84139
ssb:low	58434	65046	68130	75182	84139
ssb:high	58434	65046	68130	75182	84139
catch:Estimate	19436	19088	8922	10821	13389
catch:low	19436	19088	8922	10821	13389
catch:high	19436	19088	8922	10821	13389

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	1433	1814	2351
Fleet C : Estimate	11759	12076	2977	3531	4268
Fleet D : Estimate	643	196	51	66	75
Fleet F : Estimate	4156	1575	4461	5411	6694

TABLE 3.9.5 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. MAP 2018: F=FMSYupper(0.379)*SSBy-1/MSYBtrigger**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.164	0.171	0.175
fbar:low	0.193	0.174	0.164	0.171	0.175
fbar:high	0.193	0.174	0.164	0.171	0.175
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	67554	69420	73471
ssb:low	58434	65046	67554	69420	73471
ssb:high	58434	65046	67554	69420	73471
catch:Estimate	19436	19088	15017	16762	18221
catch:low	19436	19088	15017	16762	18221
catch:high	19436	19088	15017	16762	18221

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	2373	2667	2943
Fleet C : Estimate	11759	12076	5047	5605	6054
Fleet D : Estimate	643	196	88	109	114
Fleet F : Estimate	4156	1575	7509	8381	9111

TABLE 3.9.6 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. F=FMSY=0.31**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.310	0.310	0.310
fbar:low	0.193	0.174	0.310	0.310	0.310
fbar:high	0.193	0.174	0.310	0.310	0.310
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	66384	59264	57166
ssb:low	58434	65046	66384	59264	57166
ssb:high	58434	65046	66384	59264	57166
catch:Estimate	19436	19088	26098	24439	23508
catch:low	19436	19088	26098	24439	23508
catch:high	19436	19088	26098	24439	23508

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	3995	3500	3206
Fleet C : Estimate	11759	12076	8894	8538	8369
Fleet D : Estimate	643	196	160	182	179
Fleet F : Estimate	4156	1575	13049	12220	11754

TABLE 3.9.7 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. F=Fpa=0.41**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.410	0.410	0.410
fbar:low	0.193	0.174	0.410	0.410	0.410
fbar:high	0.193	0.174	0.410	0.410	0.410
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	65595	53327	48490
ssb:low	58434	65046	65595	53327	48490
ssb:high	58434	65046	65595	53327	48490
catch:Estimate	19436	19088	32716	28002	25412
catch:low	19436	19088	32716	28002	25412
catch:high	19436	19088	32716	28002	25412

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	4906	3728	3075
Fleet C : Estimate	11759	12076	11246	10047	9413
Fleet D : Estimate	643	196	206	226	218
Fleet F : Estimate	4156	1575	16358	14001	12706

TABLE 3.9.8 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. F=Flim=0.45**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.450	0.450	0.450
fbar:low	0.193	0.174	0.450	0.450	0.450
fbar:high	0.193	0.174	0.450	0.450	0.450
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	65283	51161	45523
ssb:low	58434	65046	65283	51161	45523
ssb:high	58434	65046	65283	51161	45523
catch:Estimate	19436	19088	35167	29079	25854
catch:low	19436	19088	35167	29079	25854
catch:high	19436	19088	35167	29079	25854

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	5232	3761	2985
Fleet C : Estimate	11759	12076	12128	10537	9711
Fleet D : Estimate	643	196	223	242	231
Fleet F : Estimate	4156	1575	17584	14540	12927

TABLE 3.9.9 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. F=F2021=0.174**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.174	0.174	0.174
fbar:low	0.193	0.174	0.174	0.174	0.174
fbar:high	0.193	0.174	0.174	0.174	0.174
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	67476	68733	72726
ssb:low	58434	65046	67476	68733	72726
ssb:high	58434	65046	67476	68733	72726
catch:Estimate	19436	19088	15811	16891	17898
catch:low	19436	19088	15811	16891	17898
catch:high	19436	19088	15811	16891	17898

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	2493	2673	2875
Fleet C : Estimate	11759	12076	5319	5662	5962
Fleet D : Estimate	643	196	93	111	113
Fleet F : Estimate	4156	1575	7905	8445	8949

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

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.000	0.000	0.000
fbar:low	0.193	0.174	0.000	0.000	0.000
fbar:high	0.193	0.174	0.000	0.000	0.000
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68903	83794	102194
ssb:low	58434	65046	68903	83794	102194
ssb:high	58434	65046	68903	83794	102194
catch:Estimate	19436	19088	0	0	0
catch:low	19436	19088	0	0	0
catch:high	19436	19088	0	0	0

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	0	0	0
Fleet C : Estimate	11759	12076	0	0	0
Fleet D : Estimate	643	196	0	0	0
Fleet F : Estimate	4156	1575	0	0	0

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

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.050	0.050	0.050
fbar:low	0.193	0.174	0.050	0.050	0.050
fbar:high	0.193	0.174	0.050	0.050	0.050
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68489	79076	92308
ssb:low	58434	65046	68489	79076	92308
ssb:high	58434	65046	68489	79076	92308
catch:Estimate	19436	19088	4889	5952	7031
catch:low	19436	19088	4889	5952	7031
catch:high	19436	19088	4889	5952	7031

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	793	1031	1306
Fleet C : Estimate	11759	12076	1624	1910	2173
Fleet D : Estimate	643	196	28	35	36
Fleet F : Estimate	4156	1575	2445	2976	3515

TABLE 3.9.12 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. F=0.1**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.100	0.100	0.100
fbar:low	0.193	0.174	0.100	0.100	0.100
fbar:high	0.193	0.174	0.100	0.100	0.100
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68078	74685	83653
ssb:low	58434	65046	68078	74685	83653
ssb:high	58434	65046	68078	74685	83653
catch:Estimate	19436	19088	9489	10945	12343
catch:low	19436	19088	9489	10945	12343
catch:high	19436	19088	9489	10945	12343

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	1522	1828	2164
Fleet C : Estimate	11759	12076	3168	3577	3938
Fleet D : Estimate	643	196	55	67	69
Fleet F : Estimate	4156	1575	4745	5472	6172

TABLE 3.9.13 WESTERN BALTIC SPRING SPAWNING HERRING
Multi fleet/**Forecast table. F=0.15**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.150	0.150	0.150
fbar:low	0.193	0.174	0.150	0.150	0.150
fbar:high	0.193	0.174	0.150	0.150	0.150
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	67670	70596	76048
ssb:low	58434	65046	67670	70596	76048
ssb:high	58434	65046	67670	70596	76048
catch:Estimate	19436	19088	13821	15131	16347
catch:low	19436	19088	13821	15131	16347
catch:high	19436	19088	13821	15131	16347

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	2191	2437	2702
Fleet C : Estimate	11759	12076	4638	5032	5372
Fleet D : Estimate	643	196	81	97	99
Fleet F : Estimate	4156	1575	6910	7565	8174

TABLE 3.9.14 WESTERN BALTIC SPRING SPAWNING HERRING
***Multi fleet/*Forecast table. Constant 2021 TAC**

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.169	0.157	0.145
fbar:low	0.193	0.174	0.169	0.157	0.145
fbar:high	0.193	0.174	0.169	0.157	0.145
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	67529	68201	71588
ssb:low	58434	65046	67529	68201	71588
ssb:high	58434	65046	67529	68201	71588
catch:Estimate	19436	19088	19088	19088	19088
catch:low	19436	19088	19088	19088	19088
catch:high	19436	19088	19088	19088	19088

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	5241	5241	5241
Fleet C : Estimate	11759	12076	12076	12076	12076
Fleet D : Estimate	643	196	196	196	196
Fleet F : Estimate	4156	1575	1575	1575	1575

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

Year	2020	2021	2022	2023	2024
fbar:Estimate	0.193	0.174	0.036	0.028	0.022
fbar:low	0.193	0.174	0.036	0.028	0.022
fbar:high	0.193	0.174	0.036	0.028	0.022
rec:Estimate	582158	859579	859579	859579	859579
rec:low	582158	859579	859579	859579	859579
rec:high	582158	859579	859579	859579	859579
ssb:Estimate	58434	65046	68464	79423	94210
ssb:low	58434	65046	68464	79423	94210
ssb:high	58434	65046	68464	79423	94210
catch:Estimate	19436	19088	5437	5437	5437
catch:low	19436	19088	5437	5437	5437
catch:high	19436	19088	5437	5437	5437

Per fleet

Year	2020	2021	2022	2023	2024
Fleet A : Estimate	2878	5241	5241	5241	5241
Fleet C : Estimate	11759	12076	0	0	0
Fleet D : Estimate	643	196	196	196	196
Fleet F : Estimate	4156	1575	0	0	0

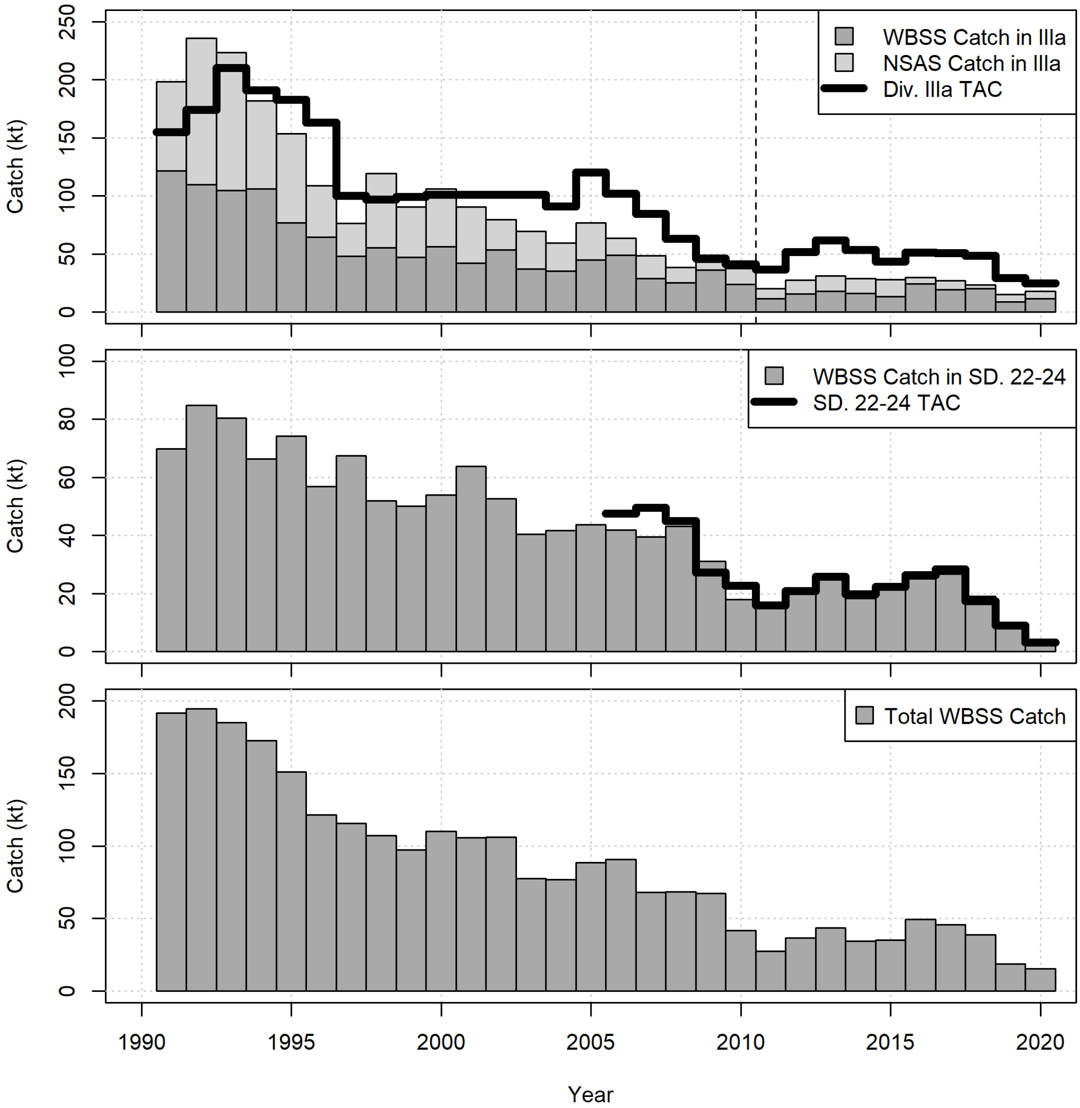


Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for Division 3.a excludes the by-catch TAC, while the CATCH includes the by-catch.

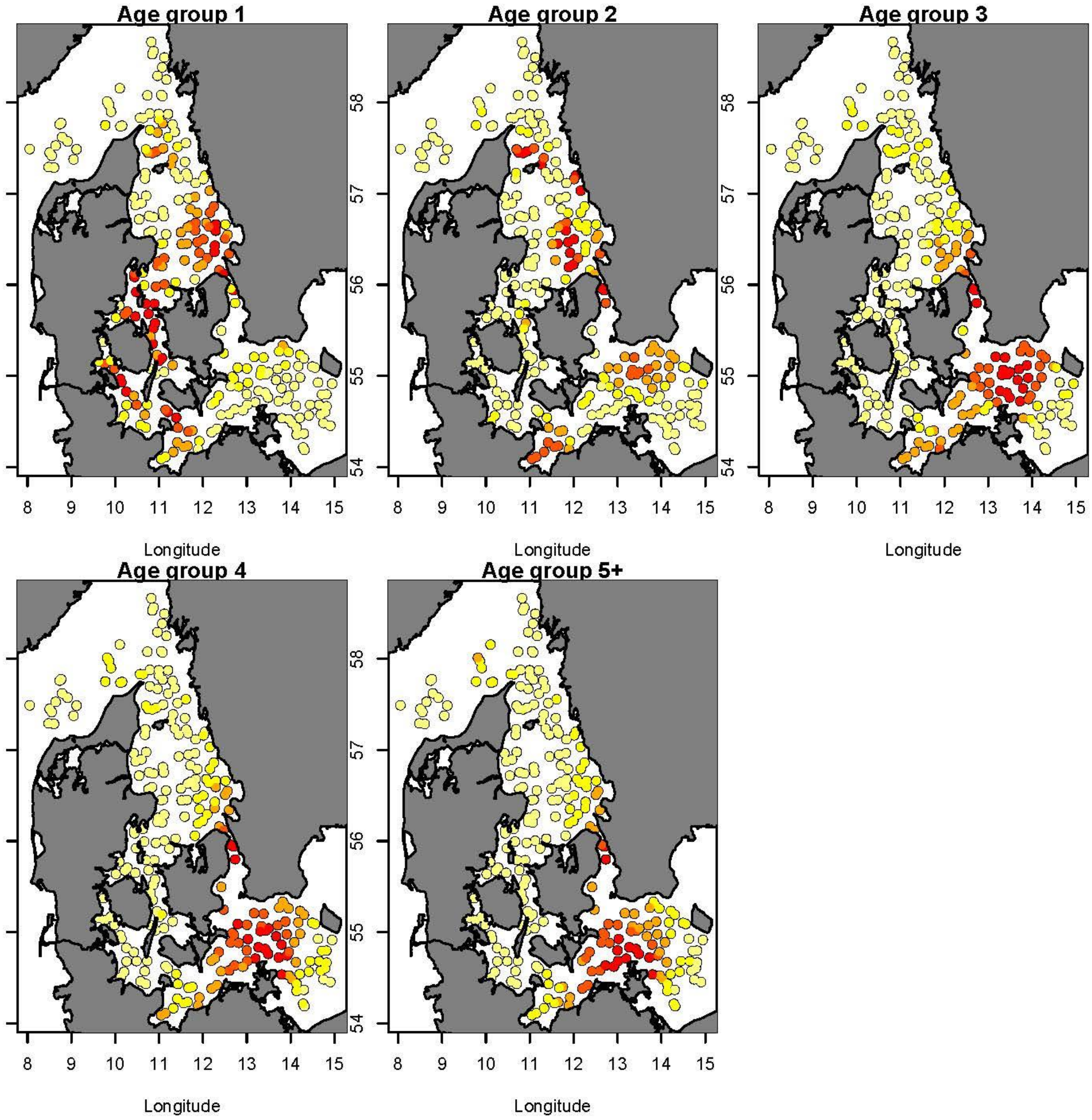


Figure 3.3.1 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q1 survey.

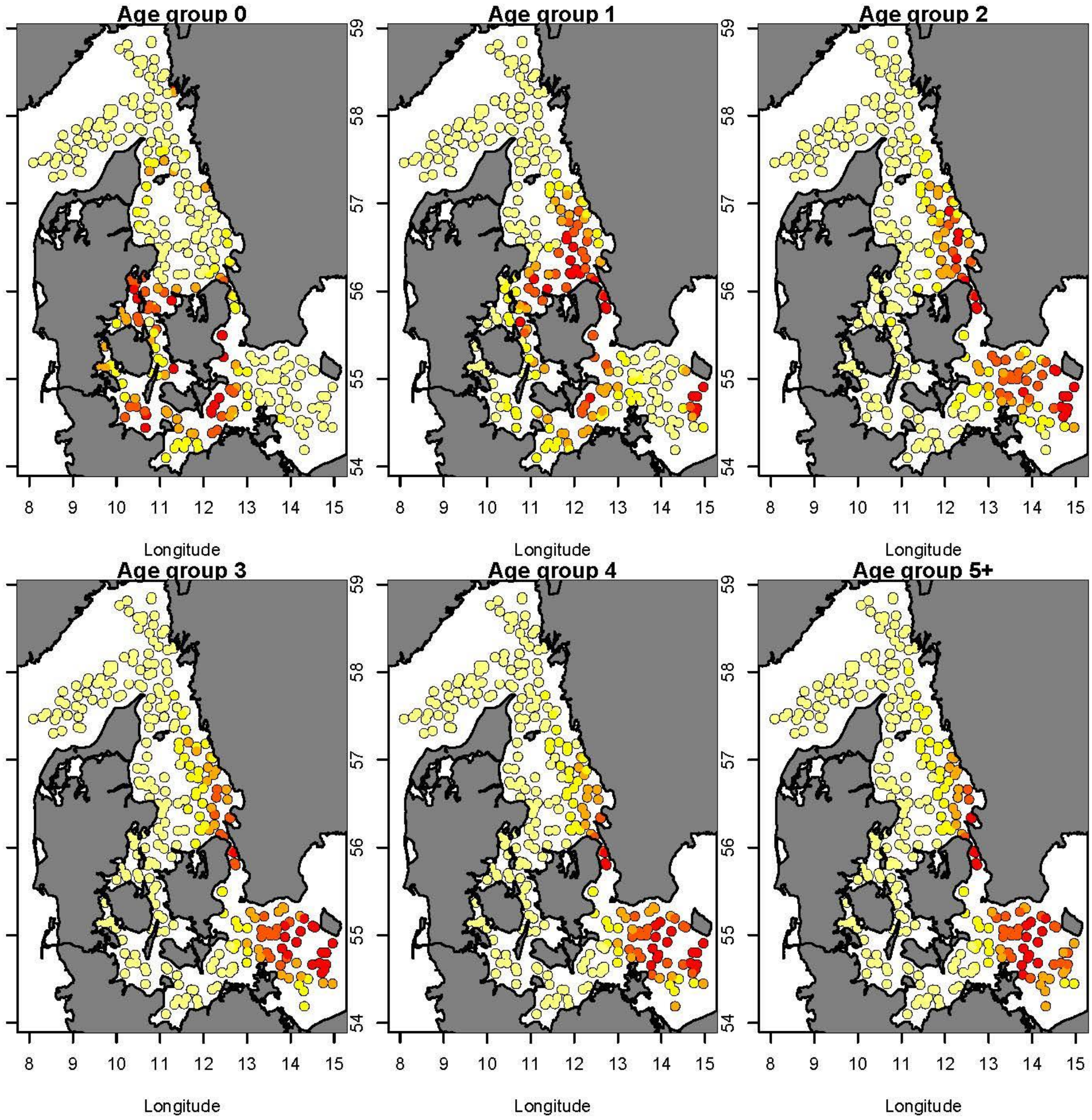


Figure 3.3.2 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q3.4 survey.

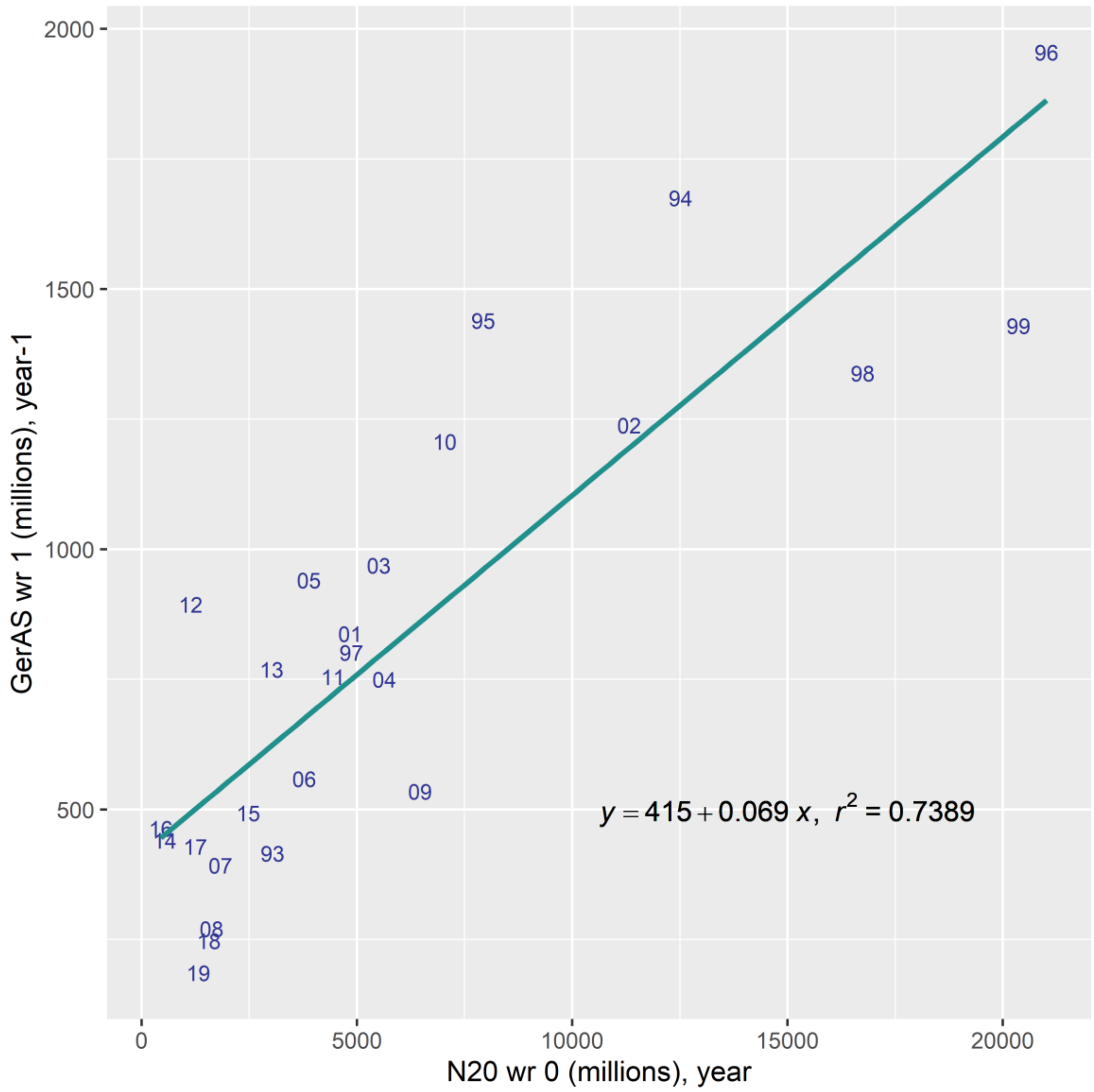


Figure 3.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N20.

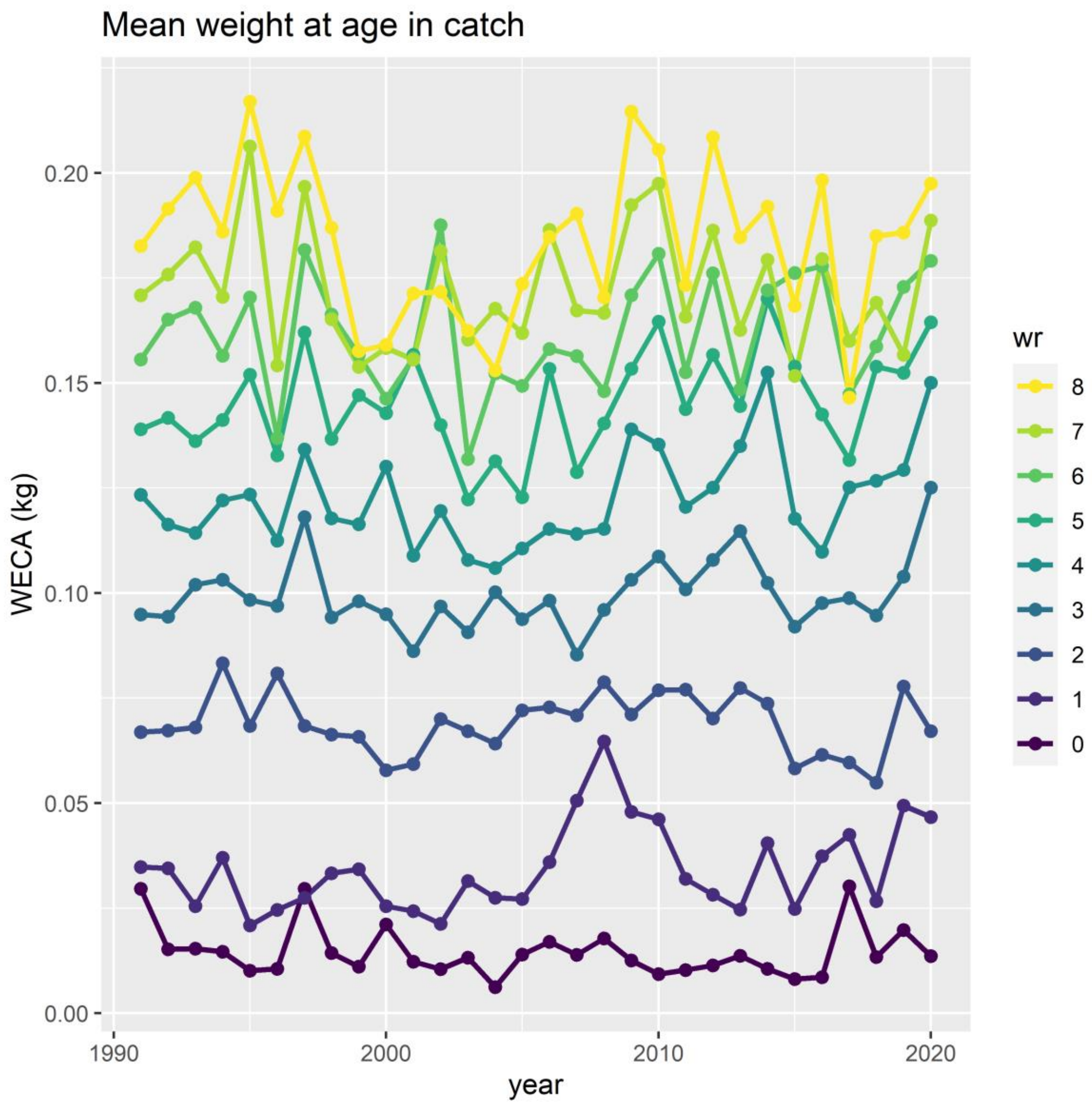


Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WECA).

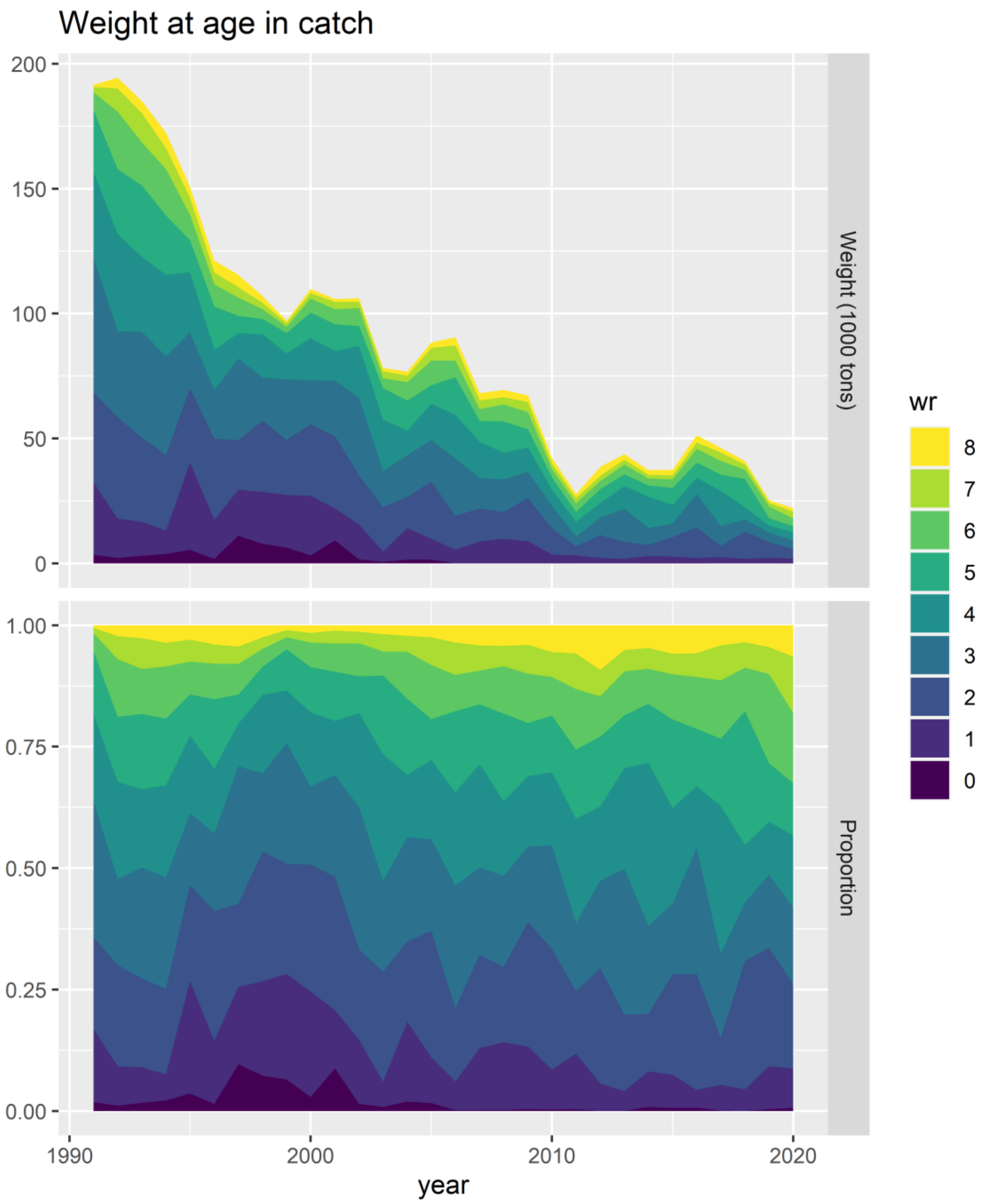


Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in weight. Upper panel: Catch in weight (1000 tons) at age as W-ringers (wr). Lower panel: Proportion (by weight) of a given age as W-ringers (wr) in the catch.

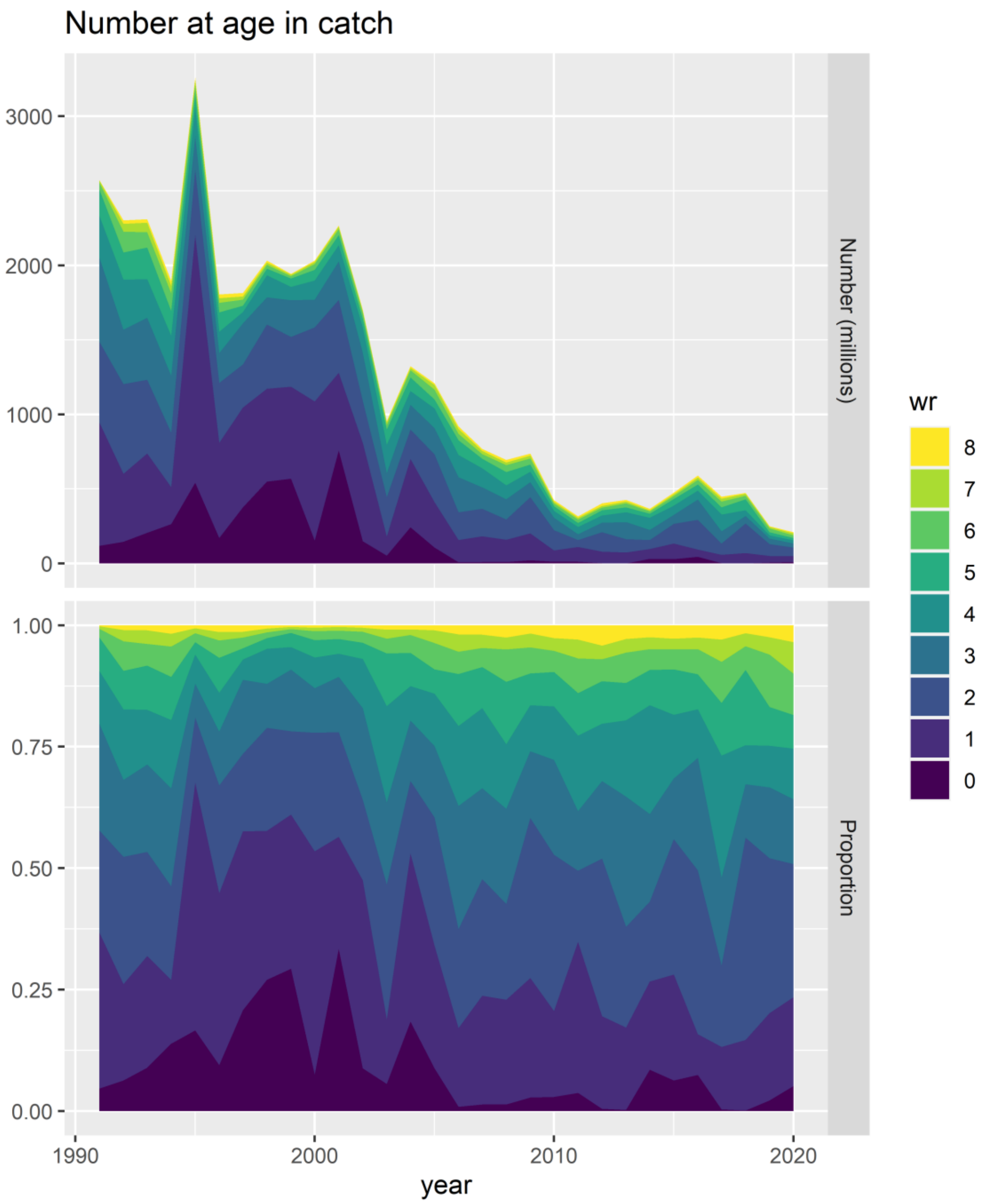


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in Numbers. Upper panel: Catch in numbers (millions) at age as W-ringers (wr). Lower panel: Proportion (by number) of a given age as W-ringers (wr) in the catch.

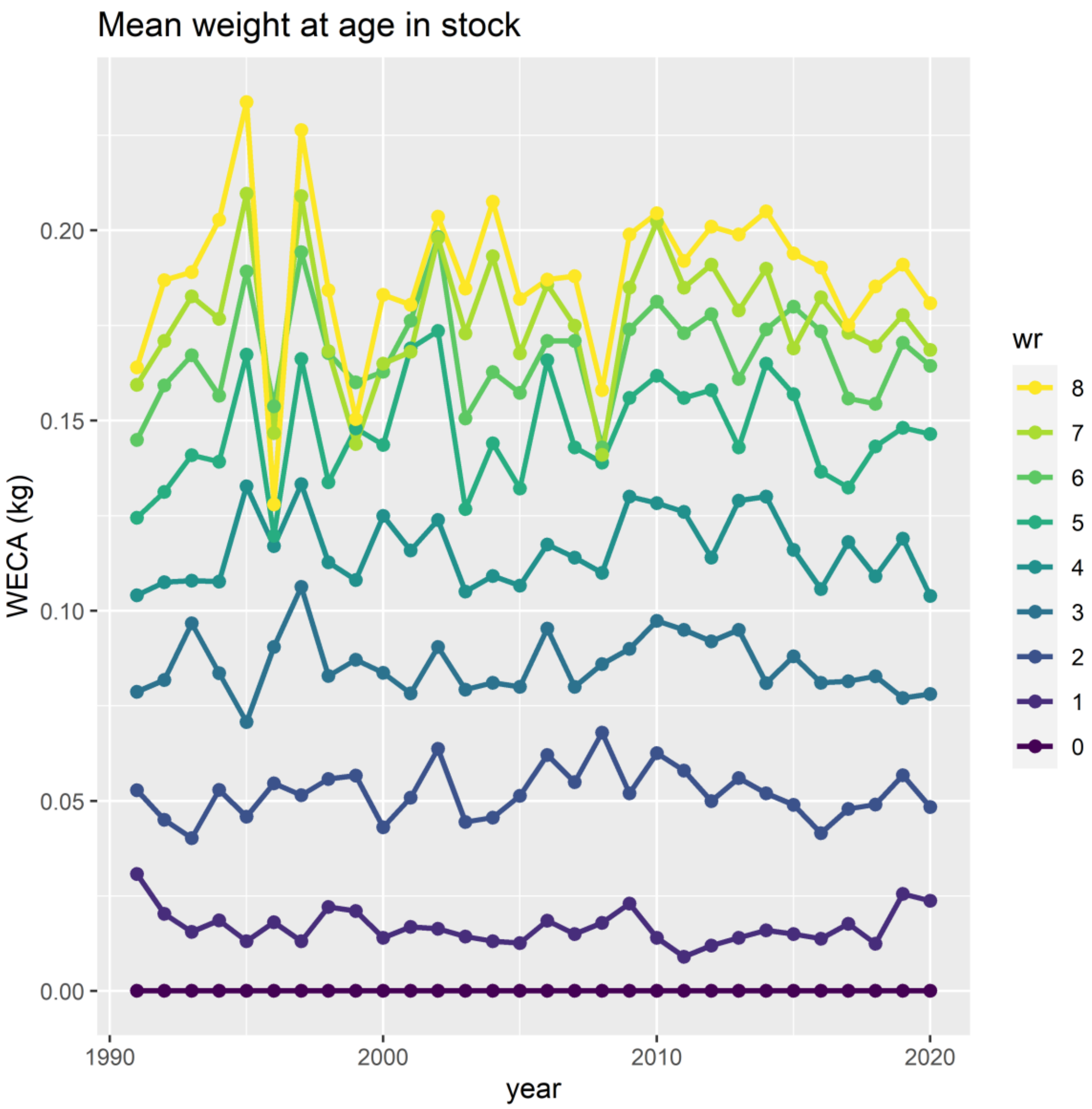


Figure 3.6.1.4 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WEST).

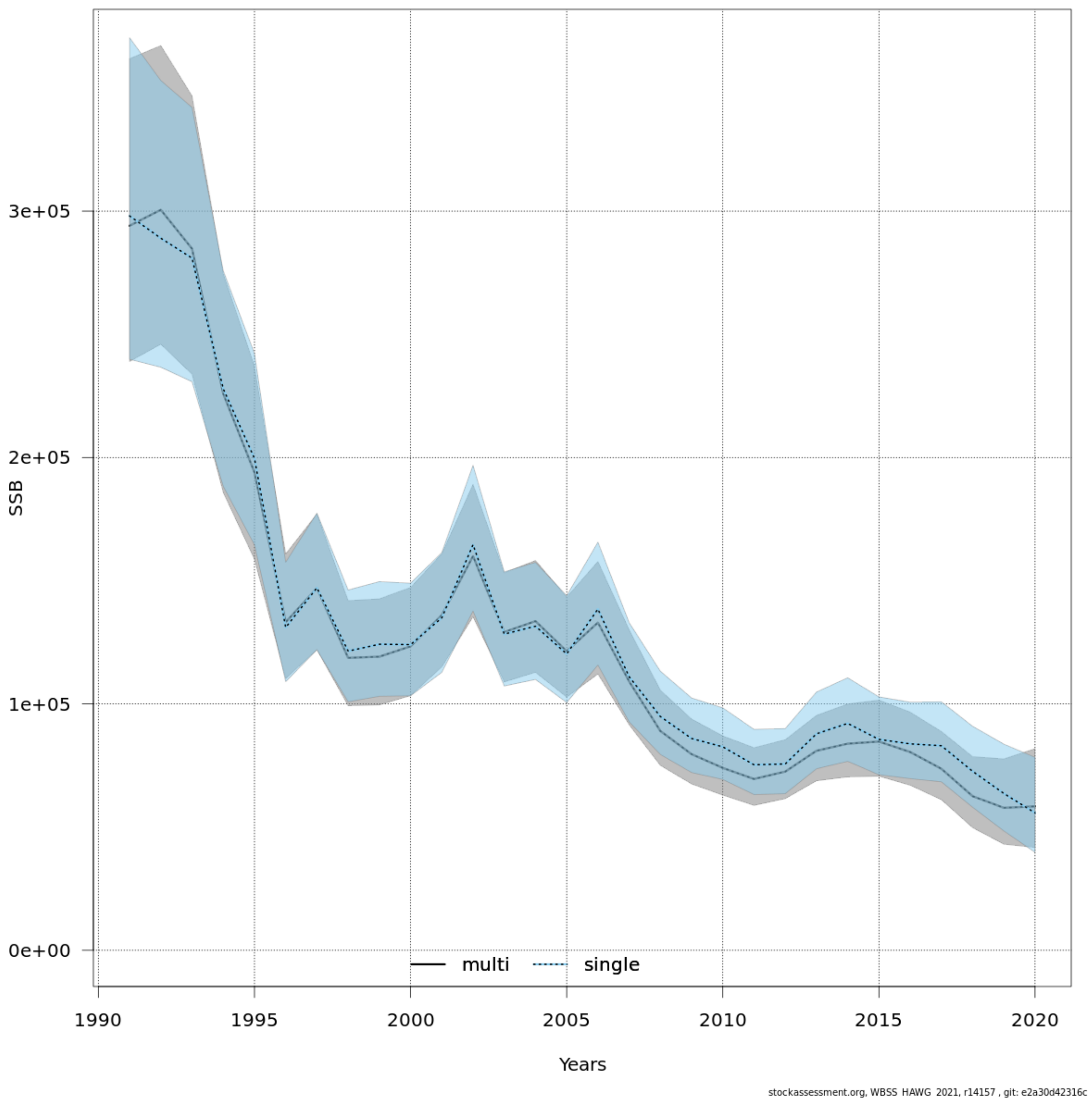


Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Spawning stock biomass (SSB). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

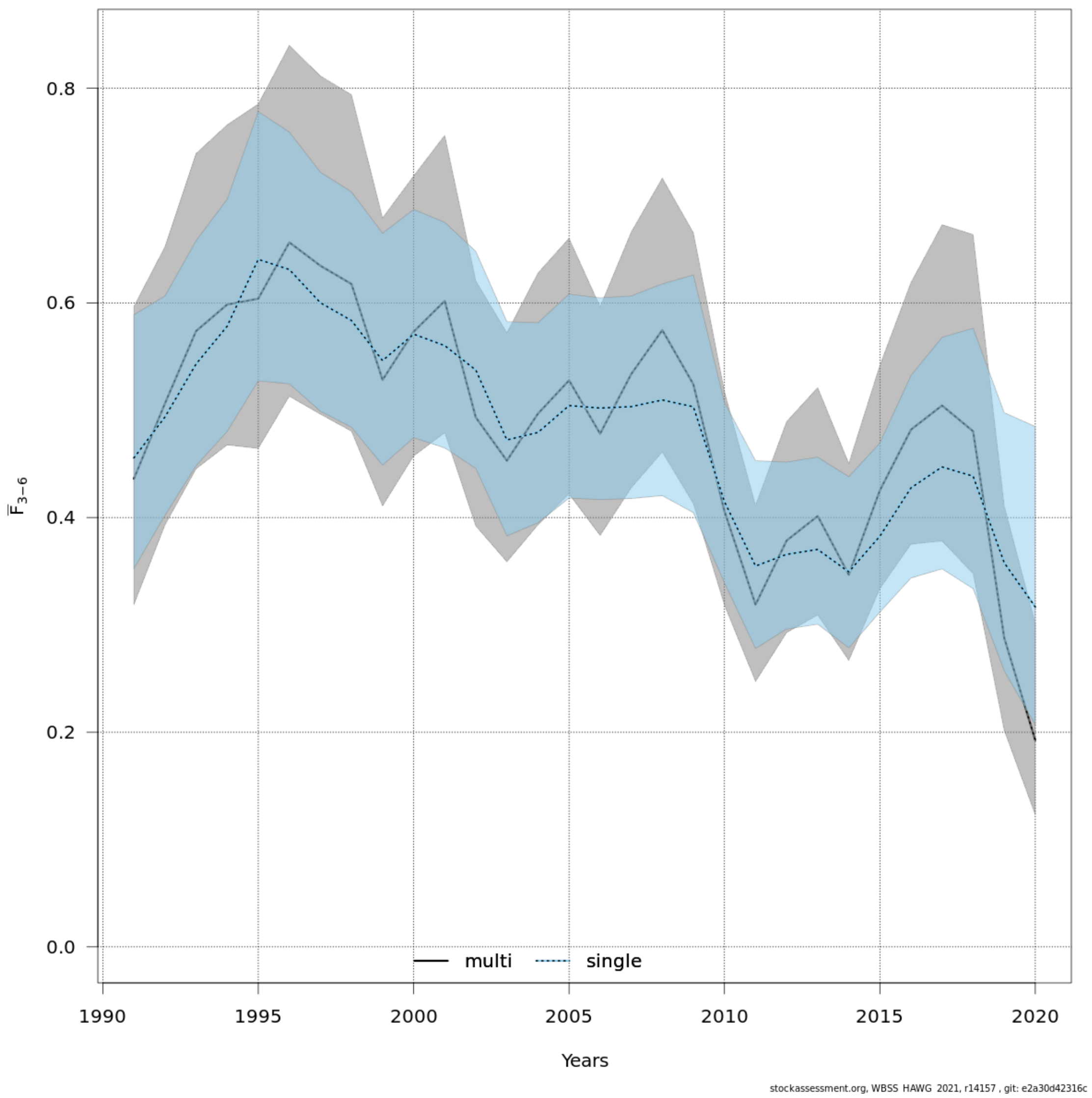


Figure 3.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Average fishing mortality (F) for the shown age range. Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

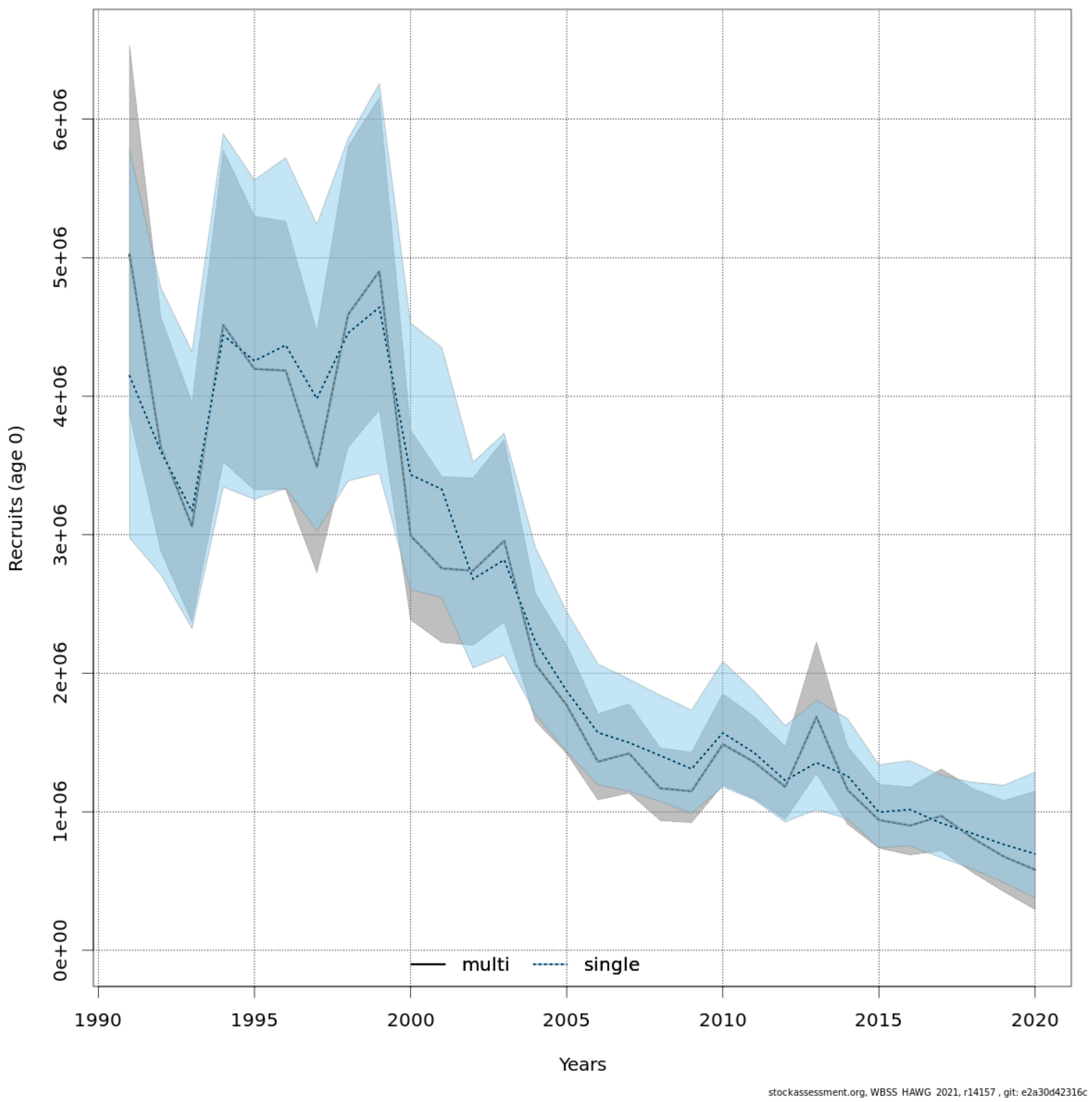


Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

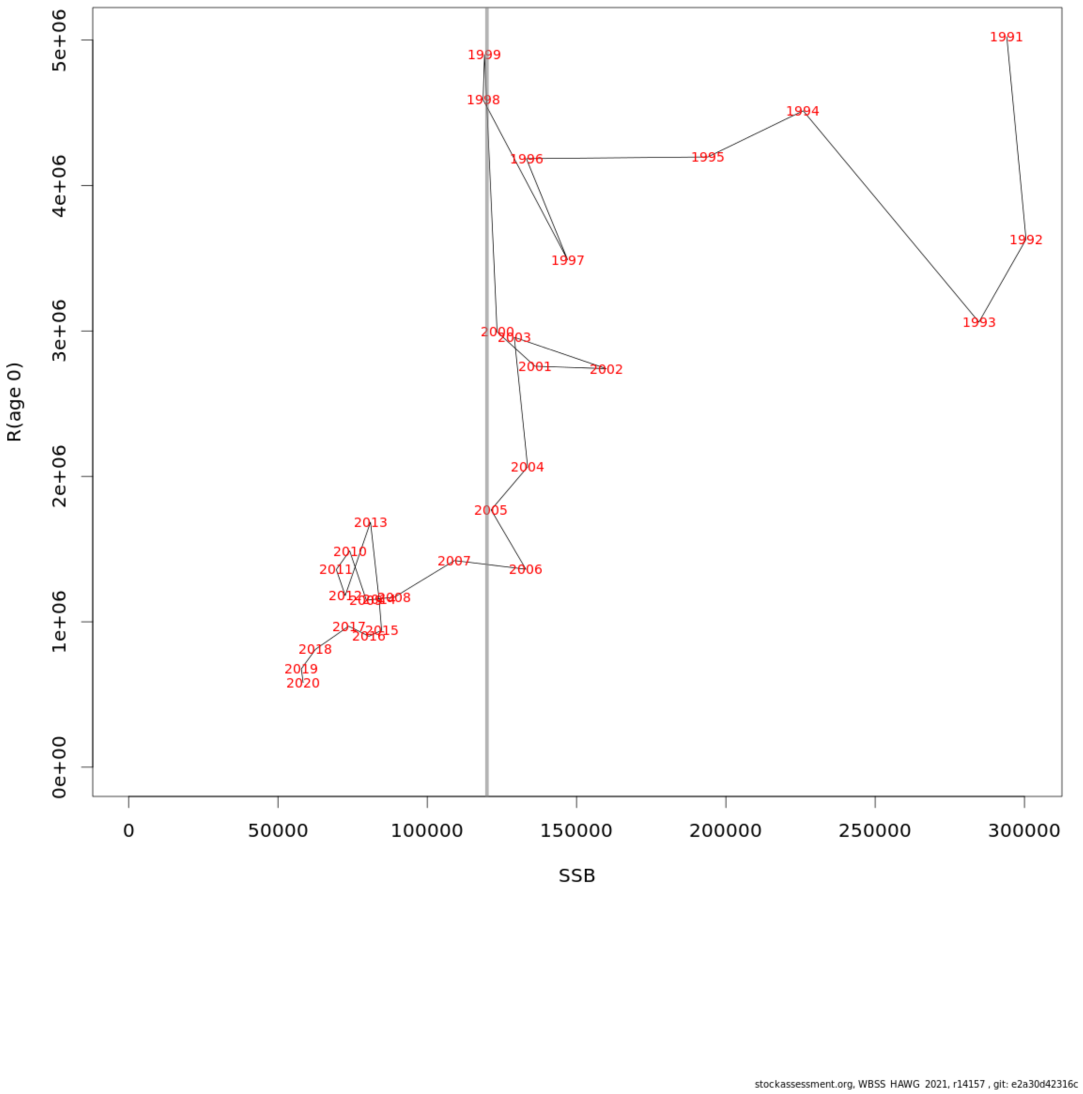


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

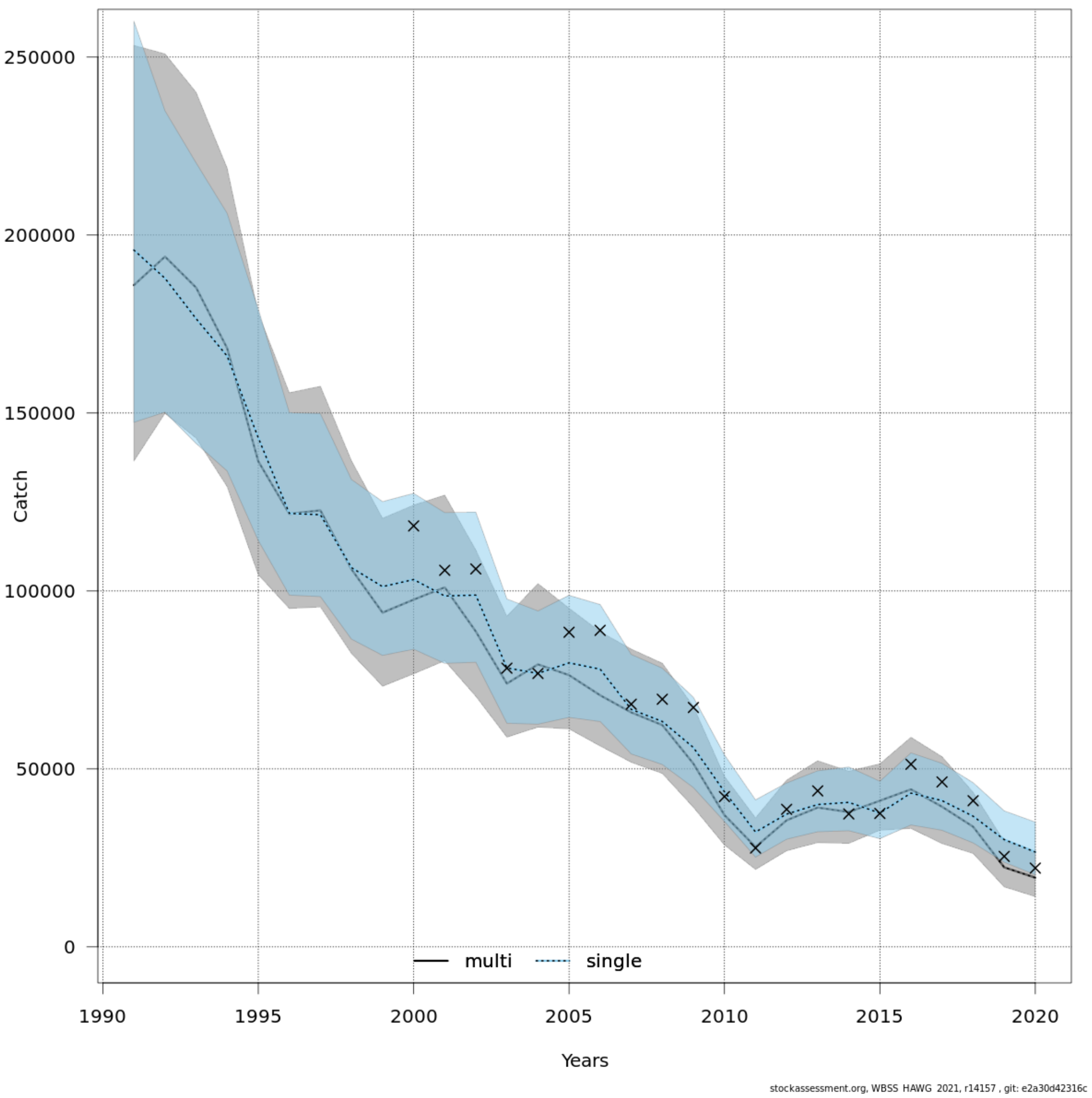


Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tonnes). Prediction from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area. The yearly observed total catch weight (crosses)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

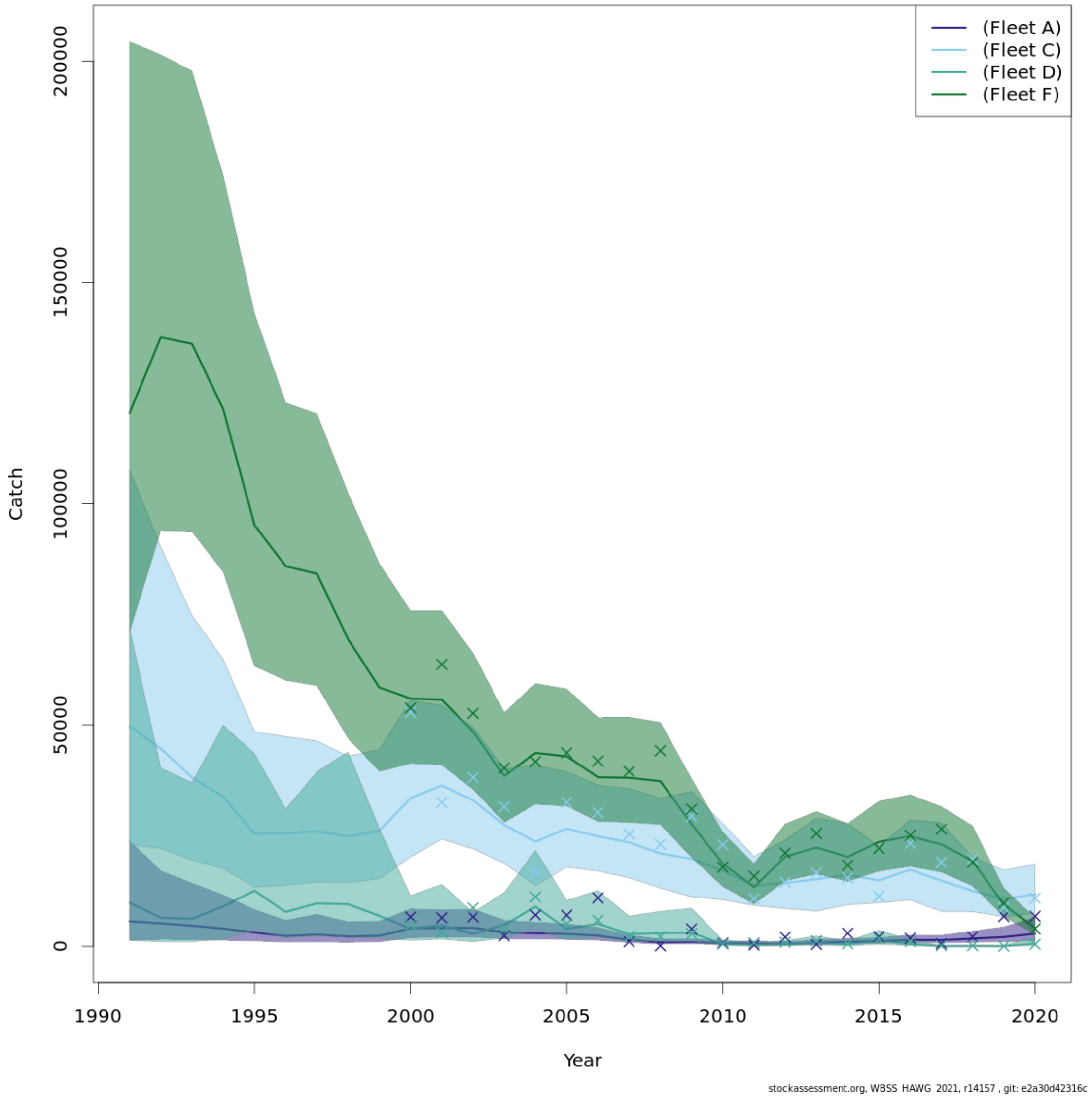


Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tonnes) by fleet. Prediction from the WBSS multi fleet assessment run and point wise 95% confidence intervals are shown by line and shaded area. The plot also shows the observed total catch weight per fleet (crosses)

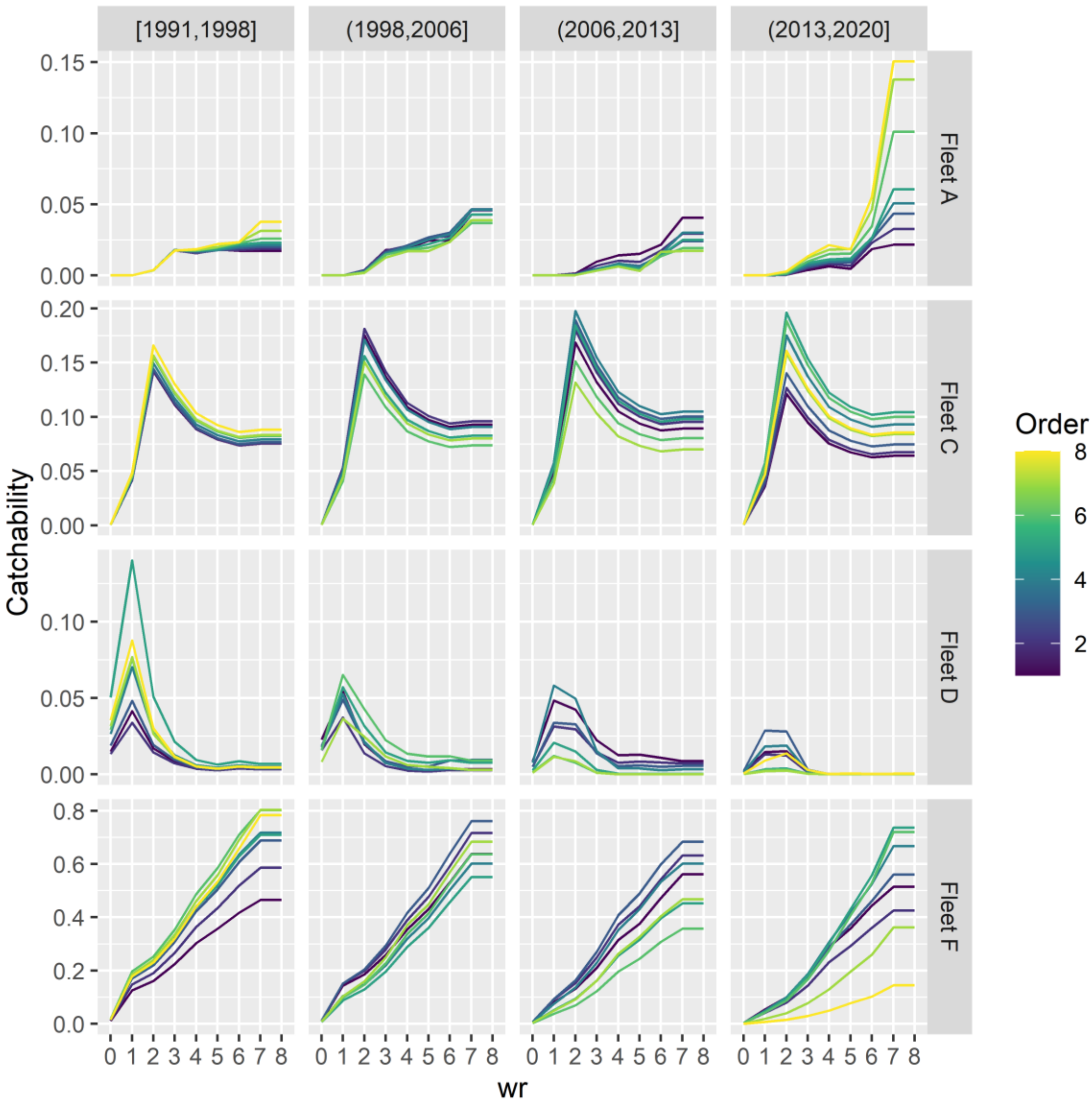


Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated selection pattern at age as W-ringers (wr) per fleet and year. Order: 1 equal 1st year in the respective time span.

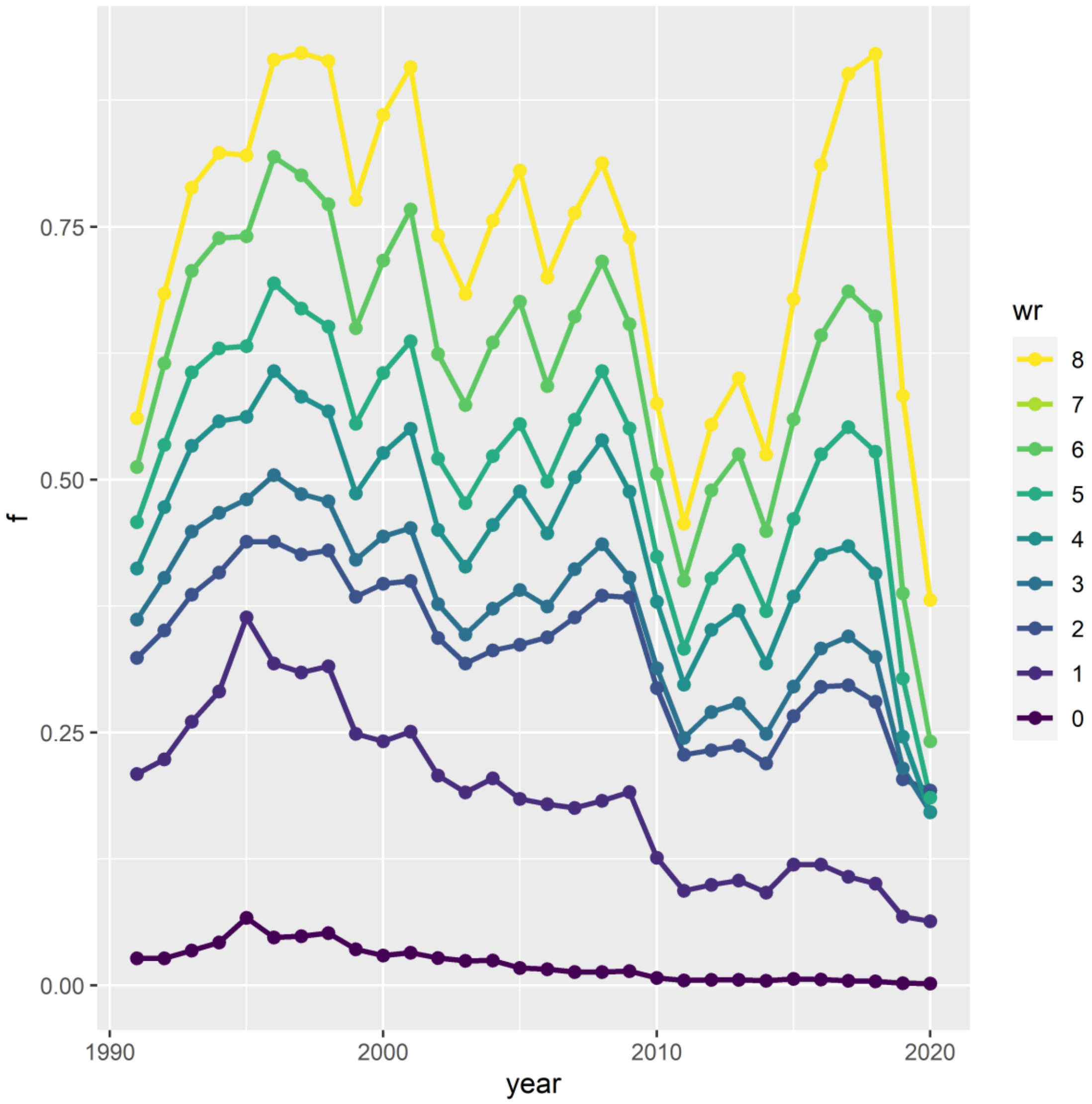


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr).

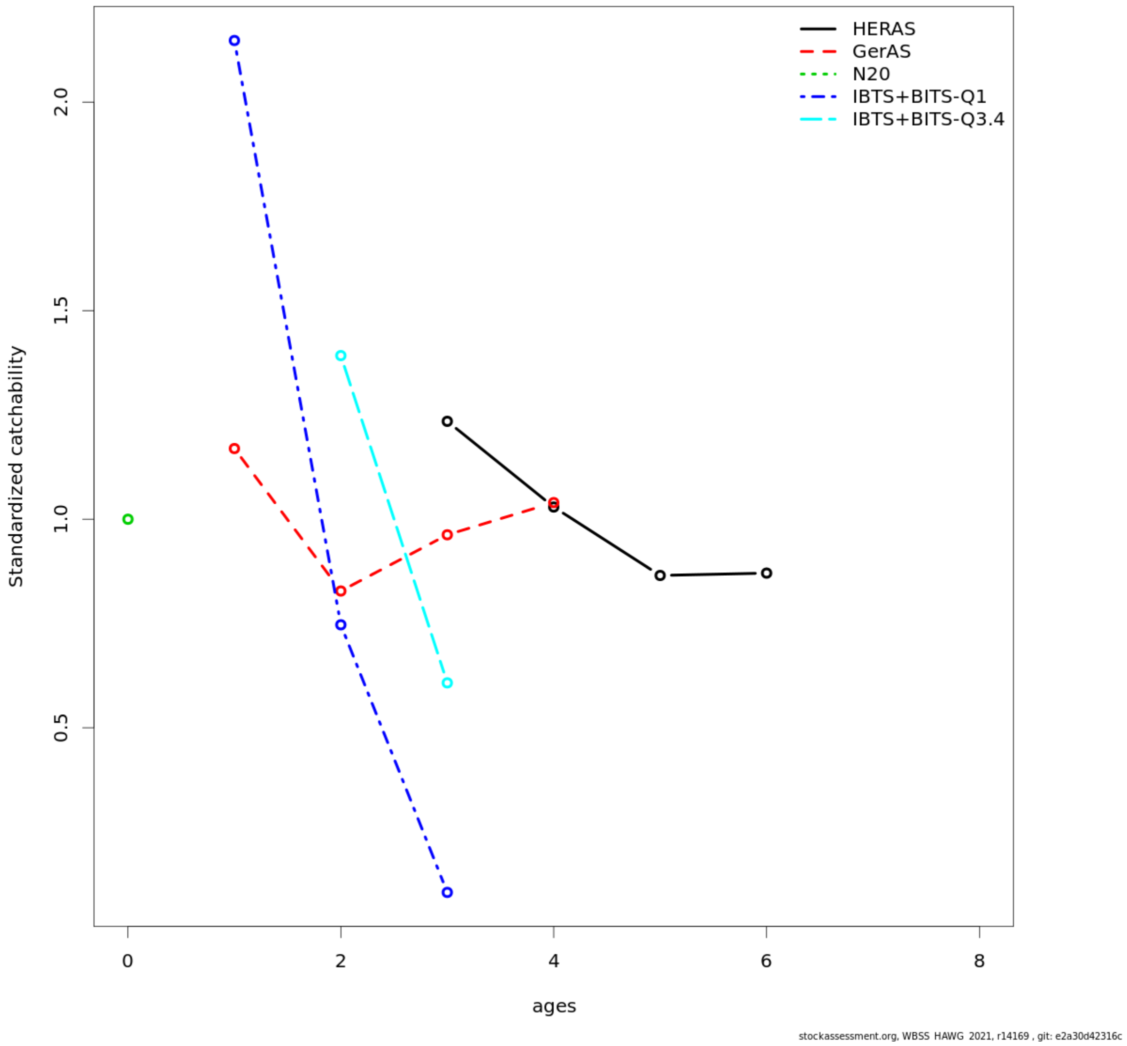


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Estimated survey catchabilities. N20 only covers age 0 and therefore only shows one point.

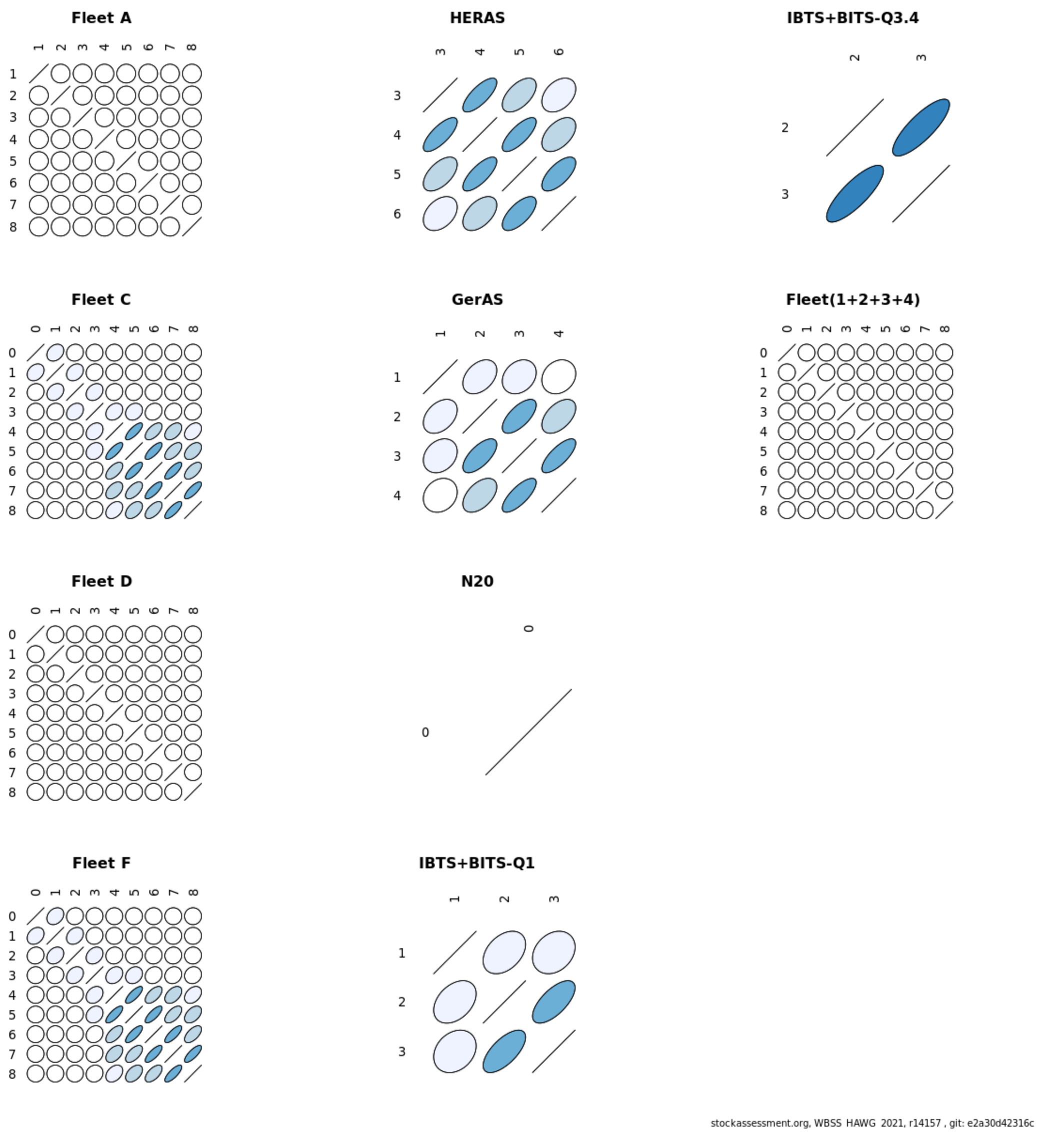


Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. Estimates correlations between age groups for each fleet.

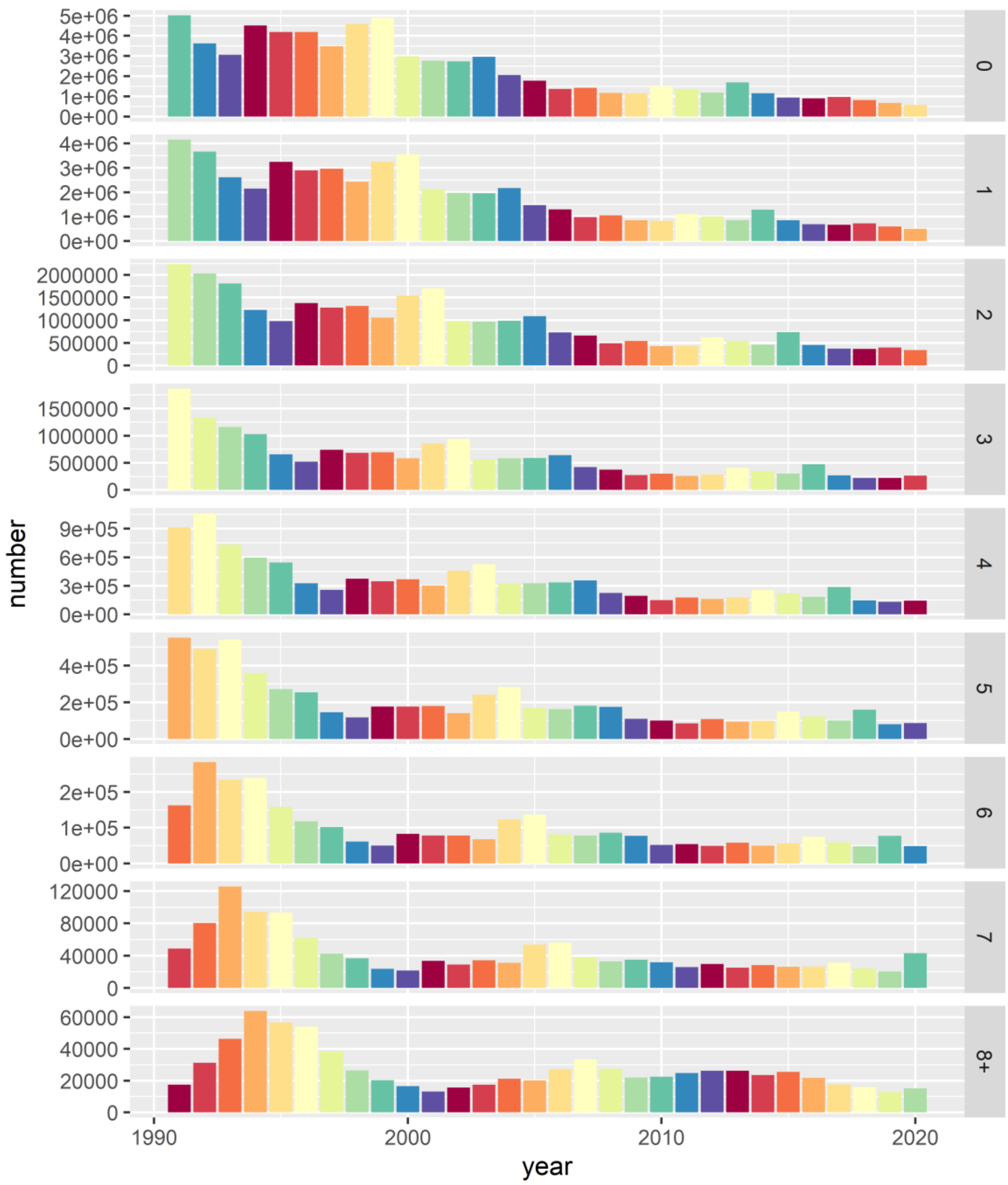


Figure 3.6.4.11 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated age distribution in the stock. Colours represent a cohort.

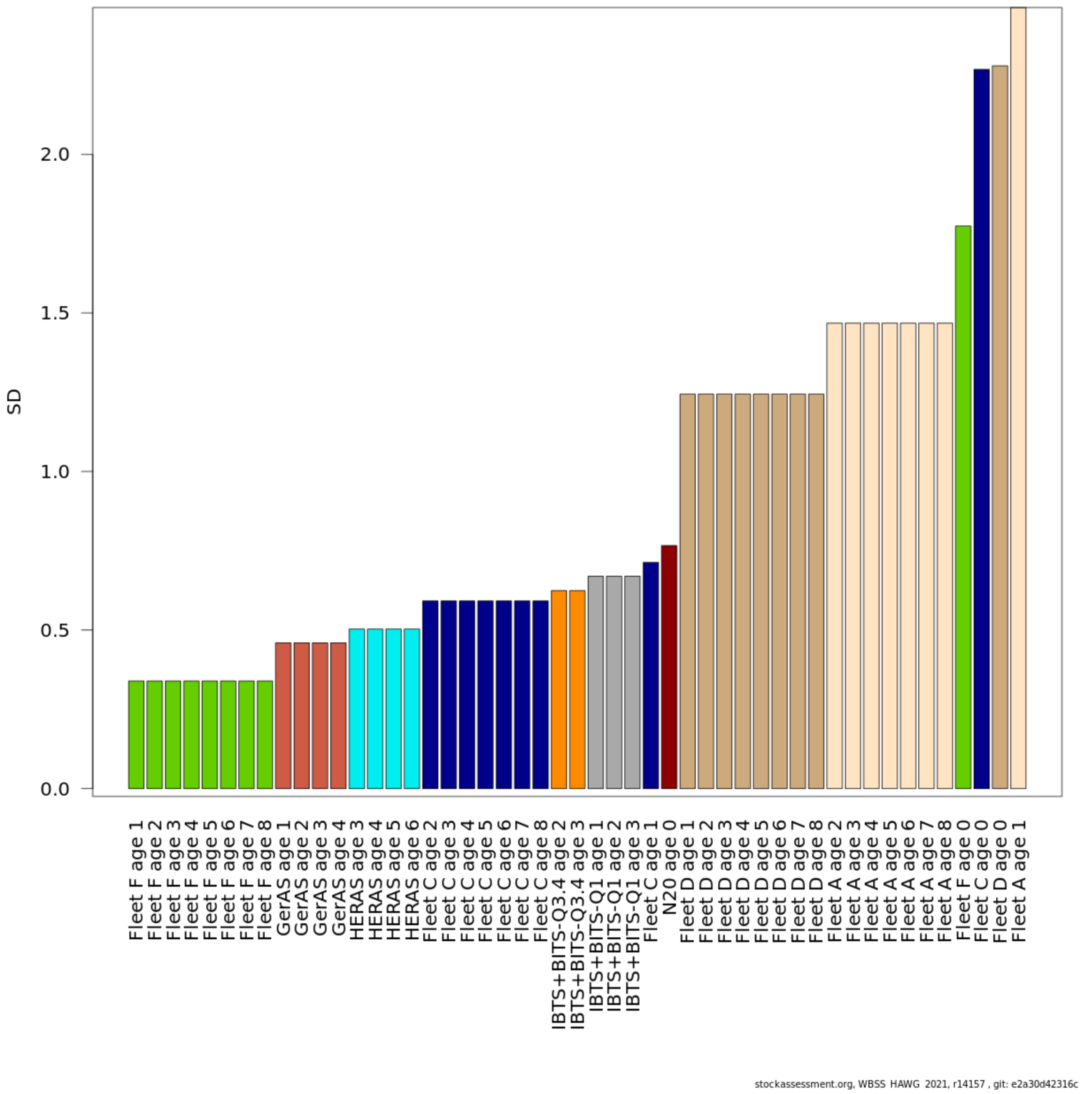


Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated observation variance in the WBSS multi fleet assessment run.

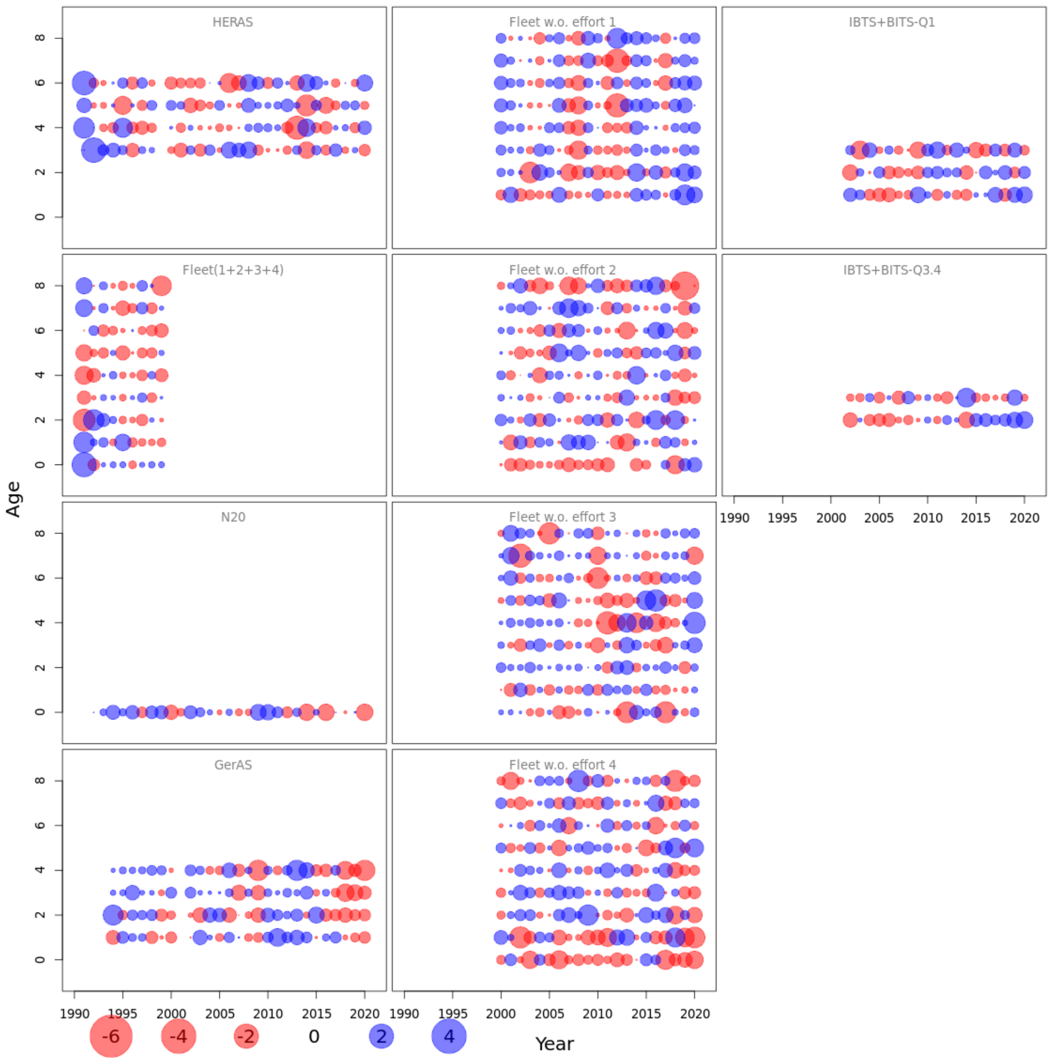


Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. BUBBLE PLOT. Standardized one-observation-ahead residuals from multi fleet run.

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

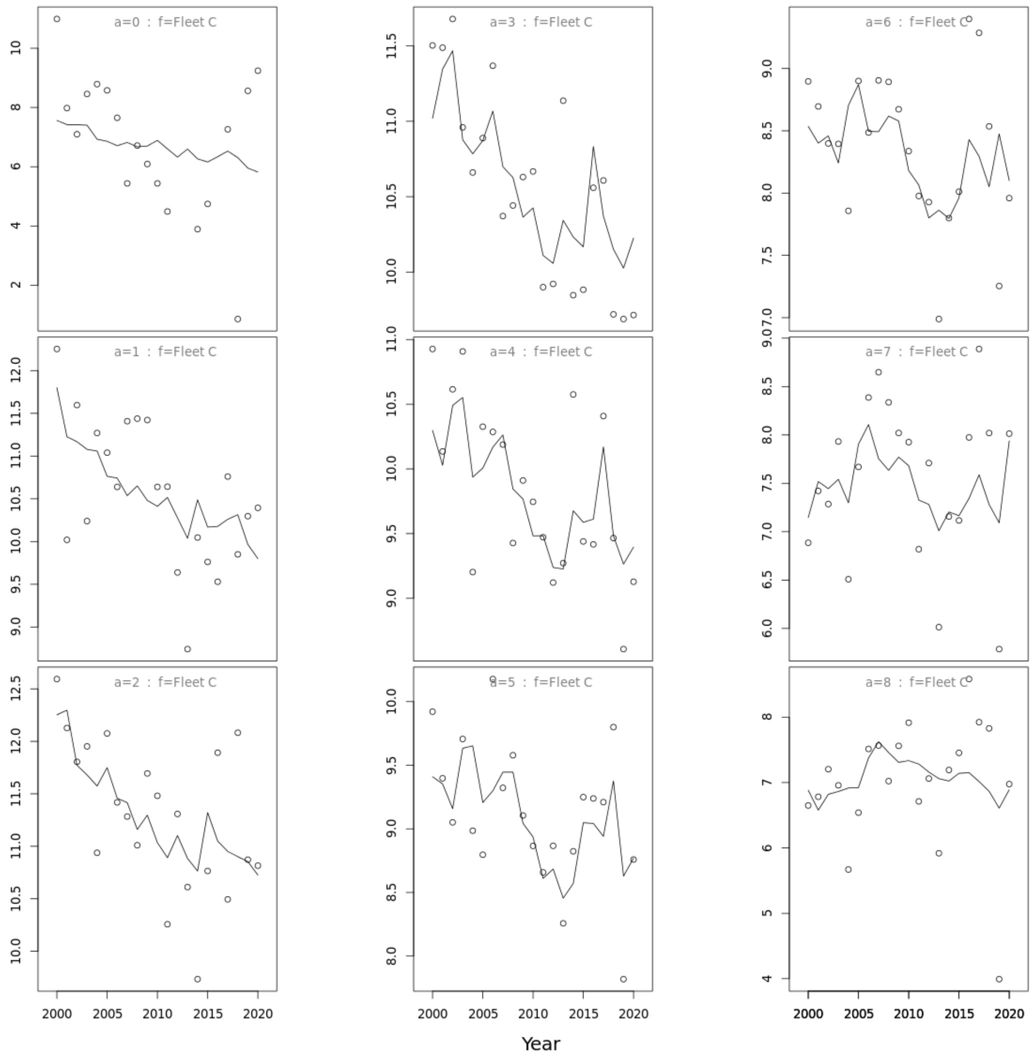


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

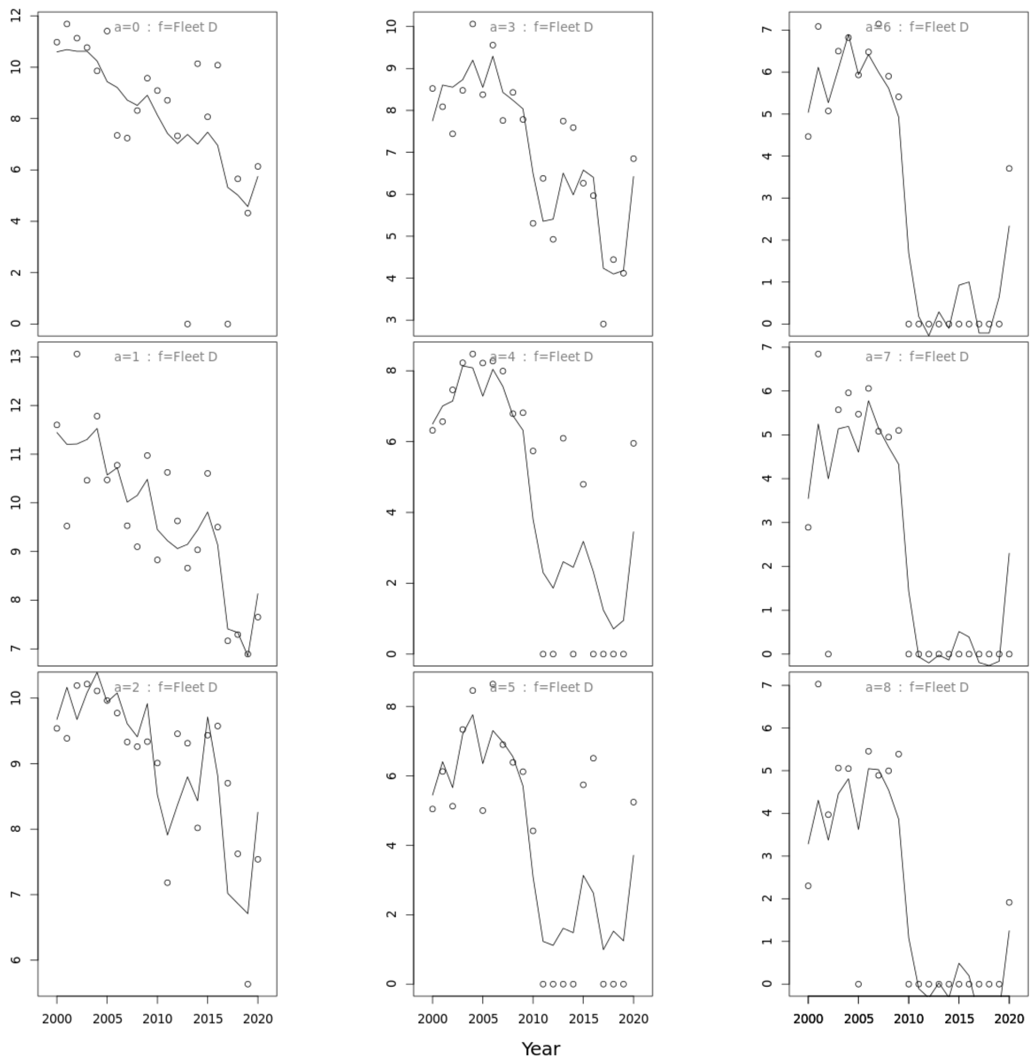


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

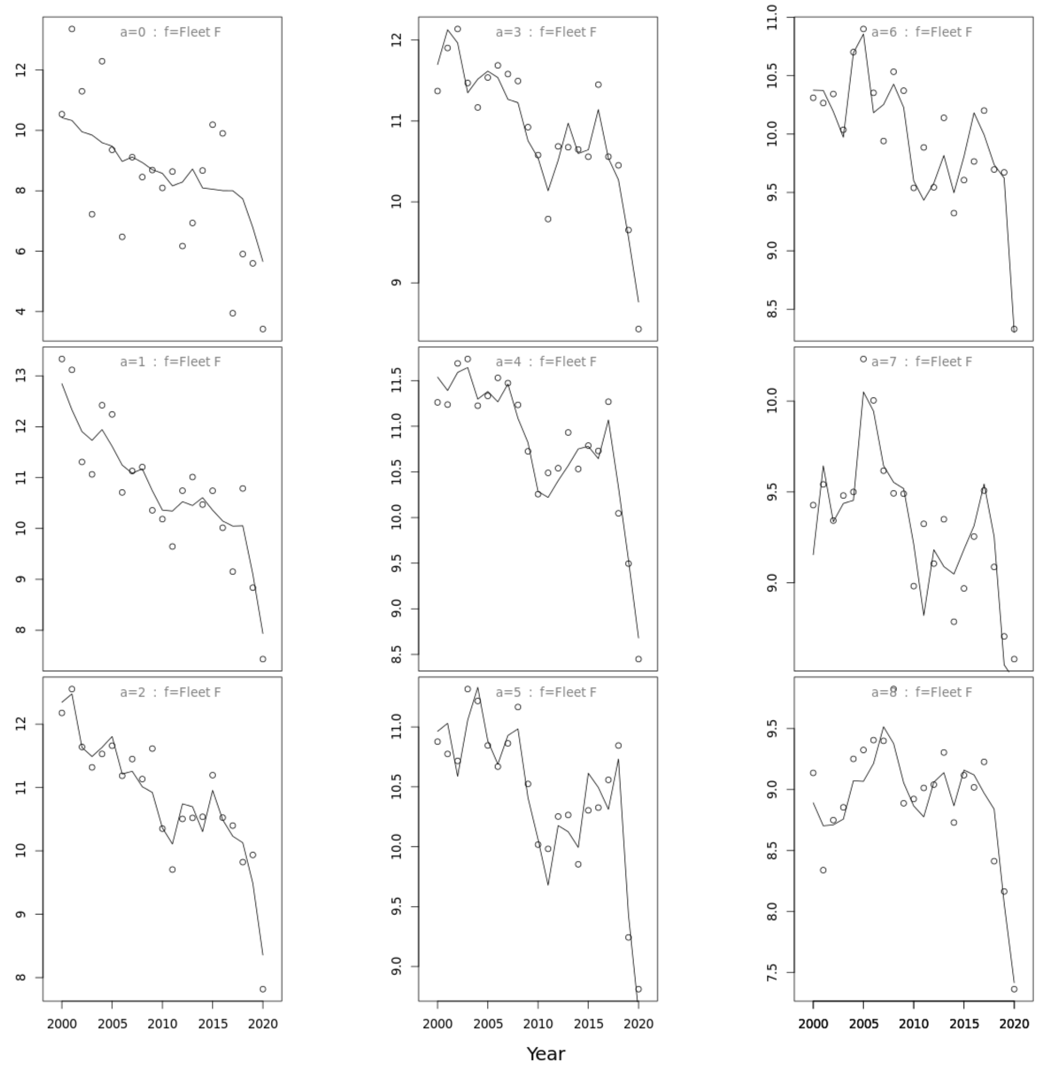


Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet F. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

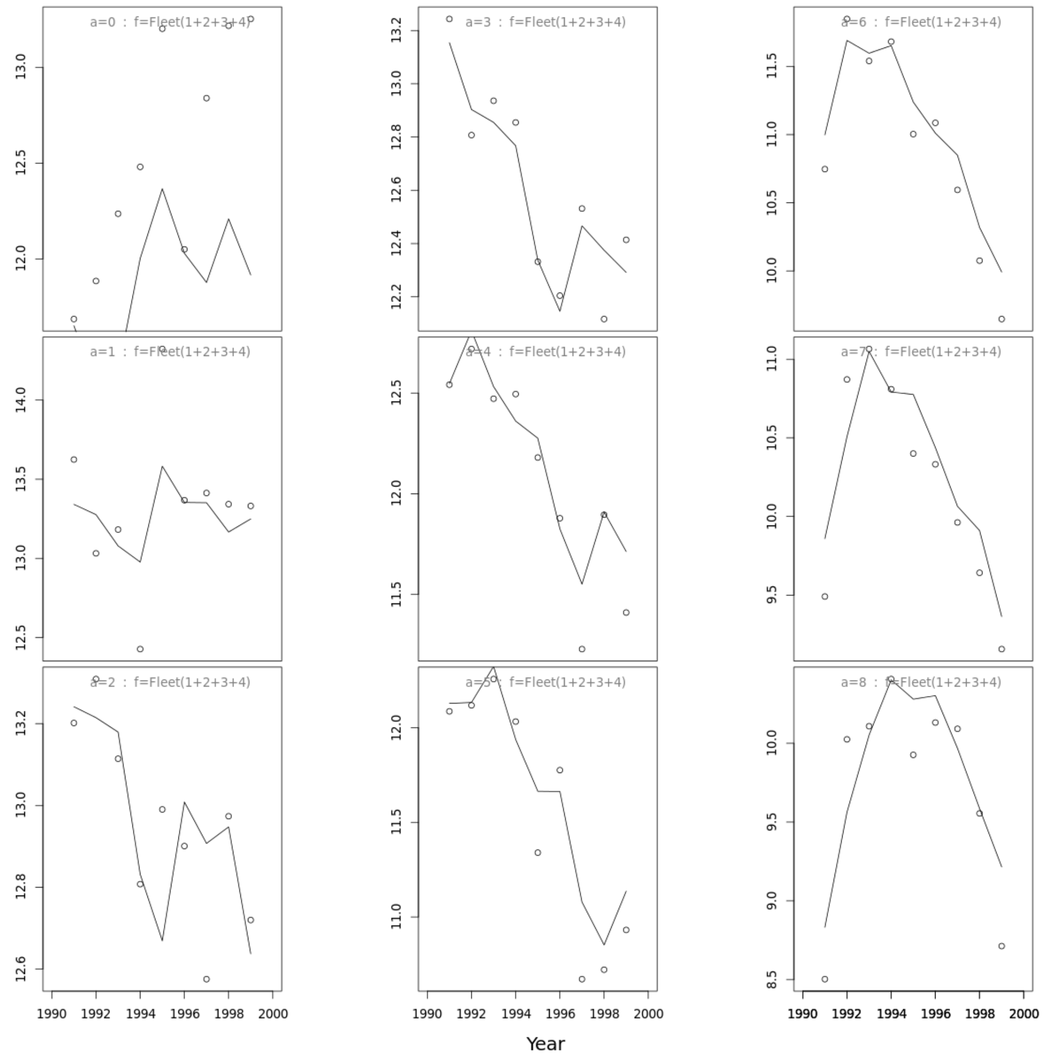


Figure 3.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. sum of fleets Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

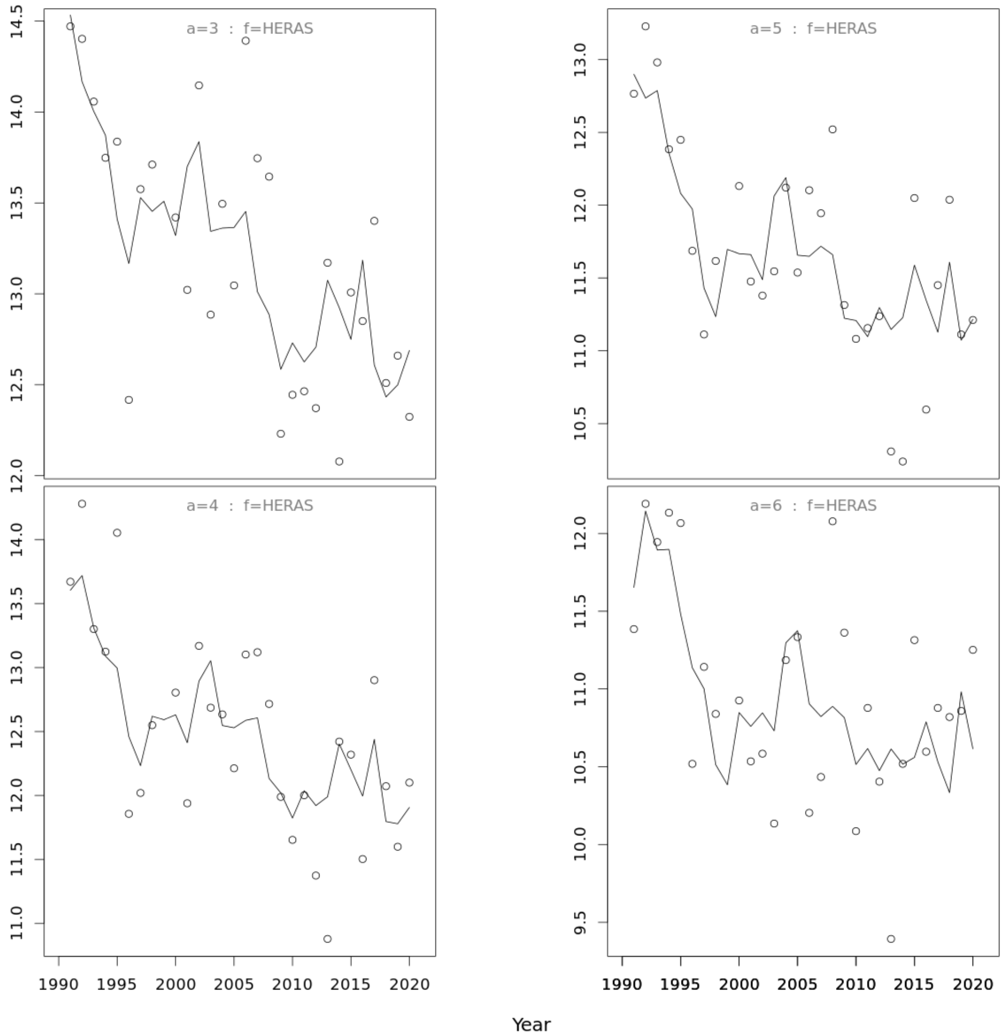


Figure 3.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the HERAS index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

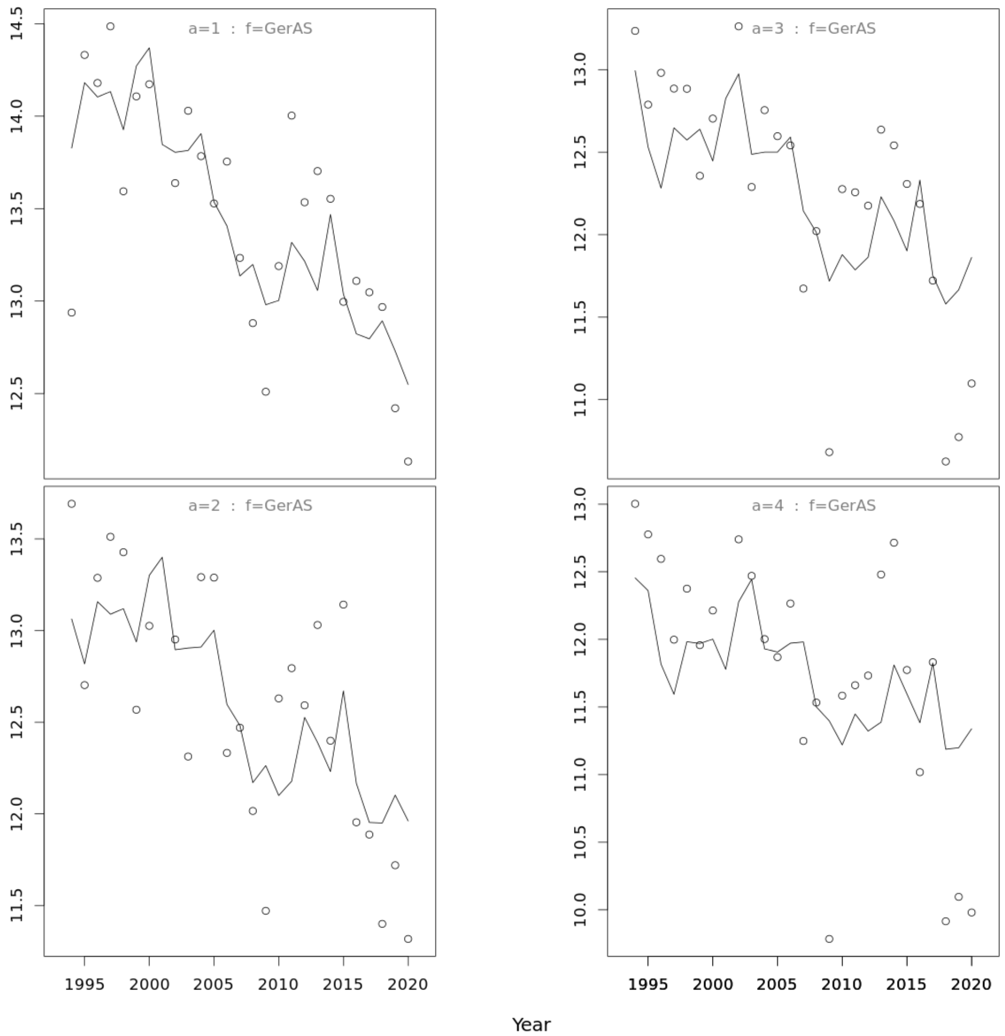


Figure 3.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the GERAS-index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

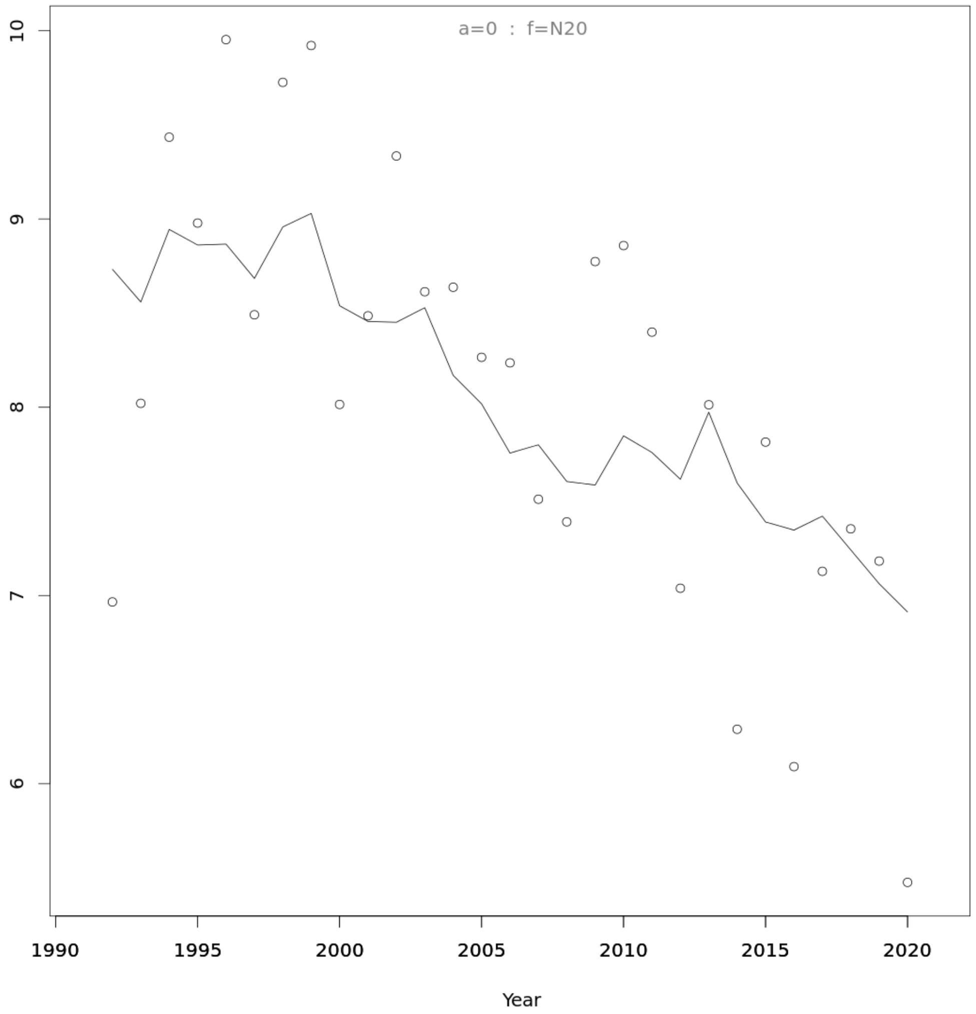


Figure 3.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the N20 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

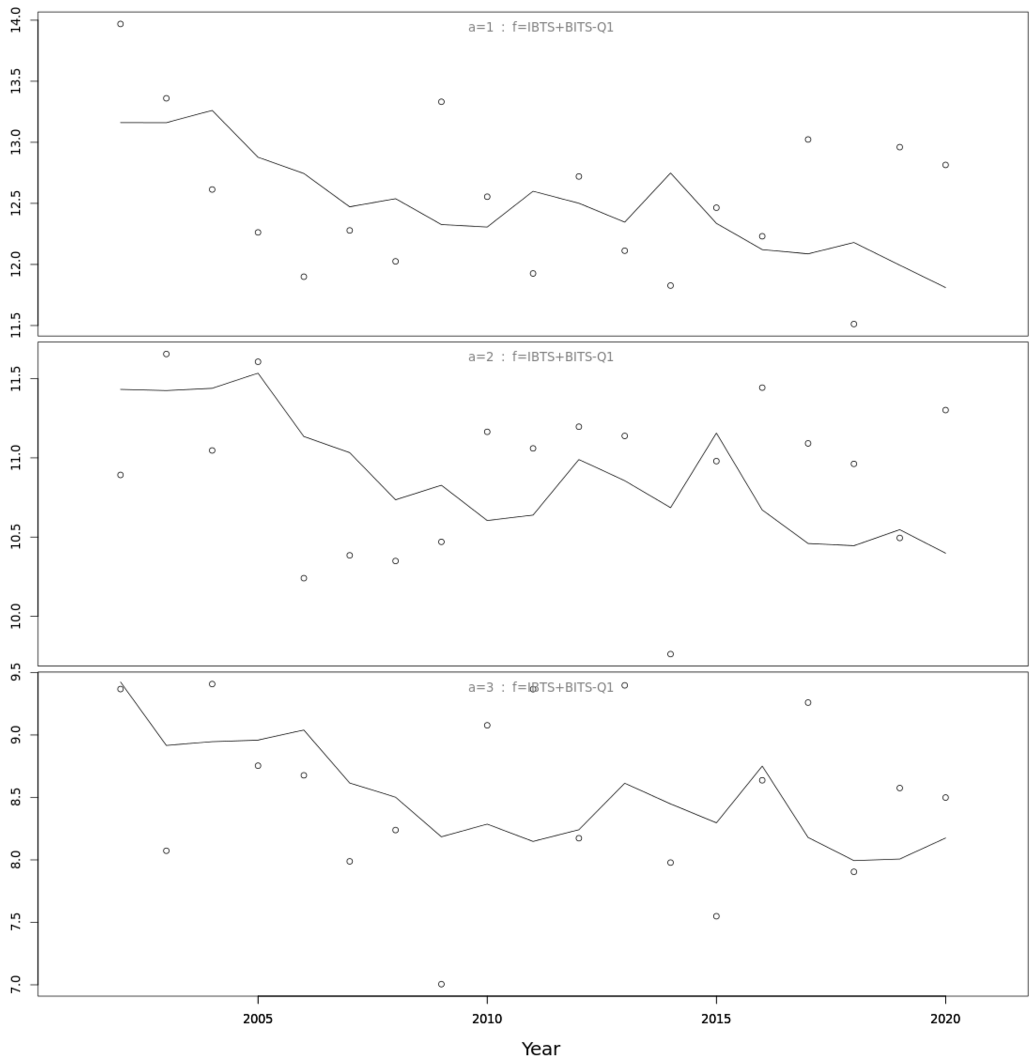


Figure 3.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q1 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

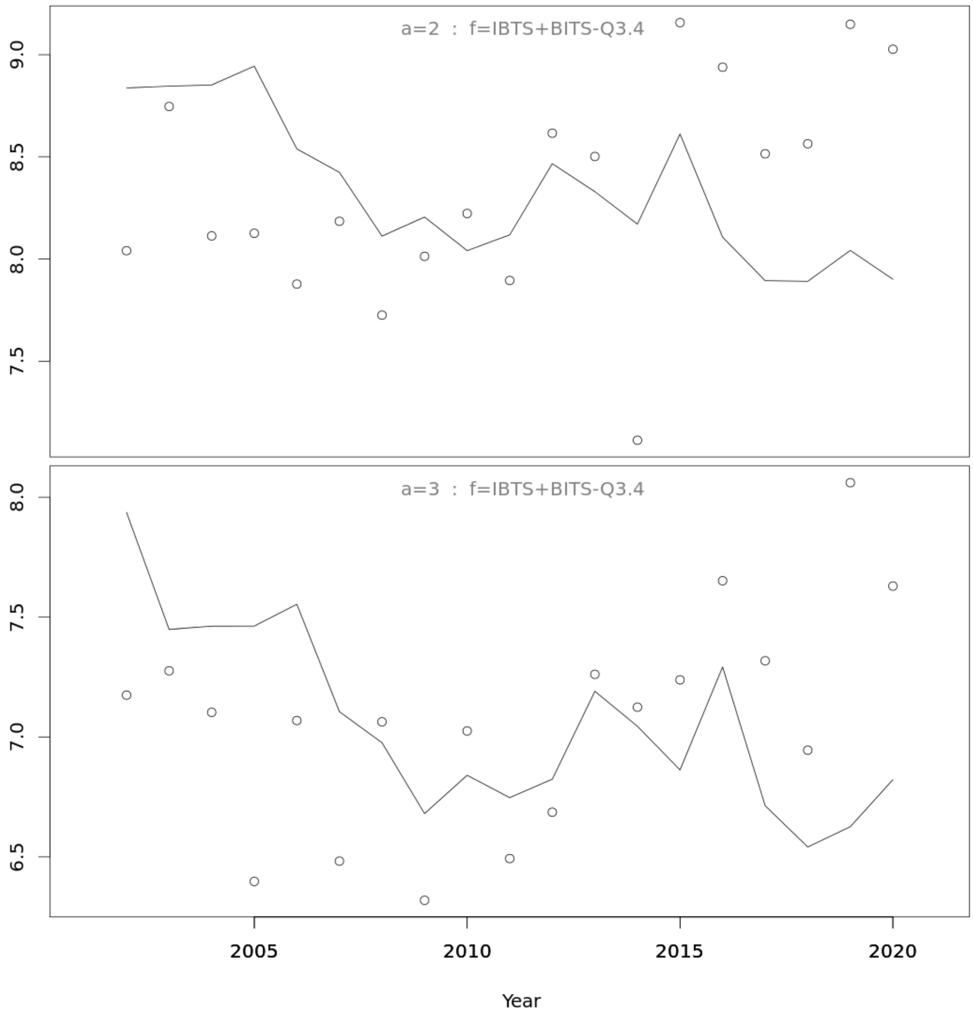


Figure 3.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q3.4 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

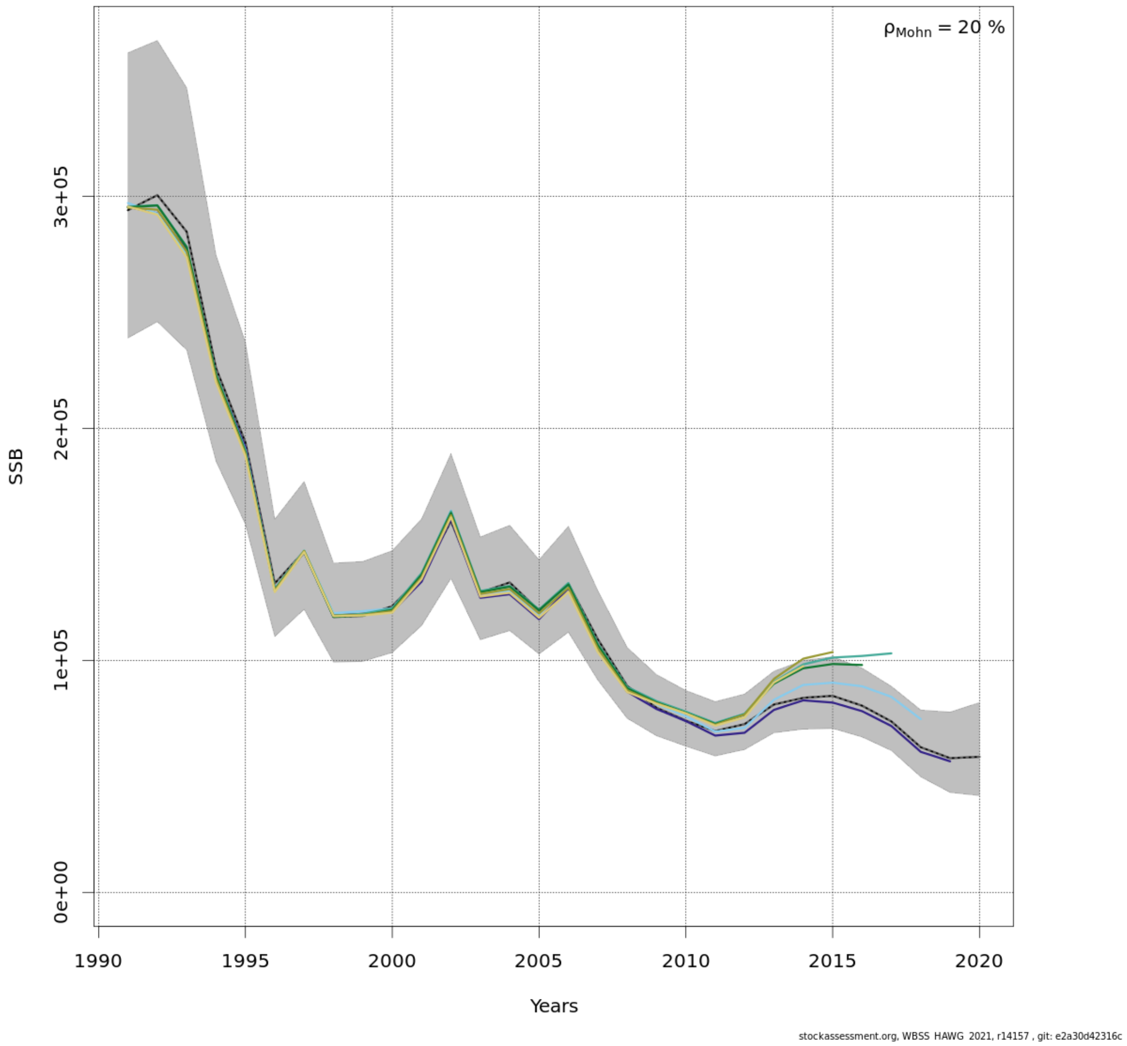


Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Spawning stock biomass.

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.

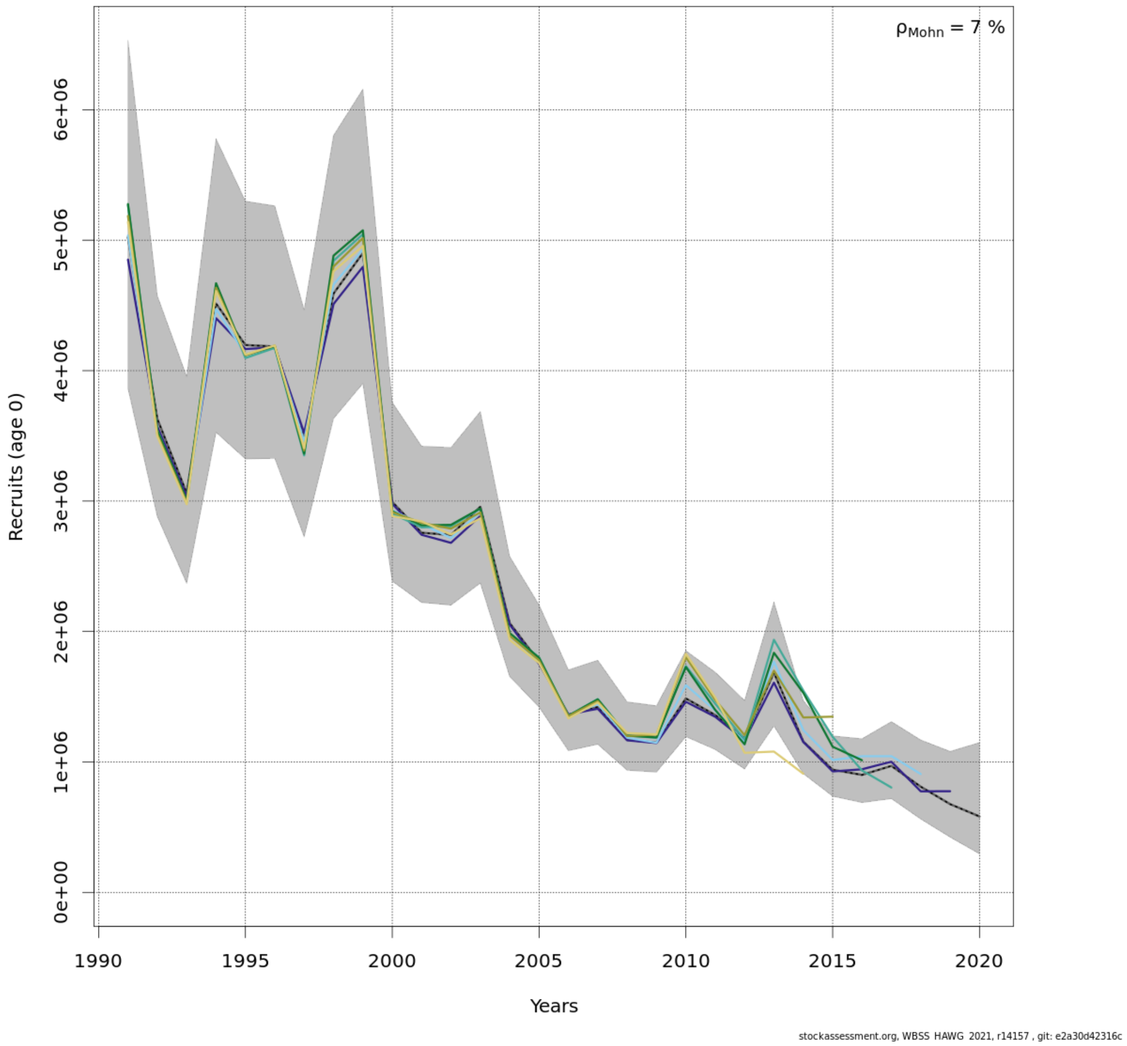


Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

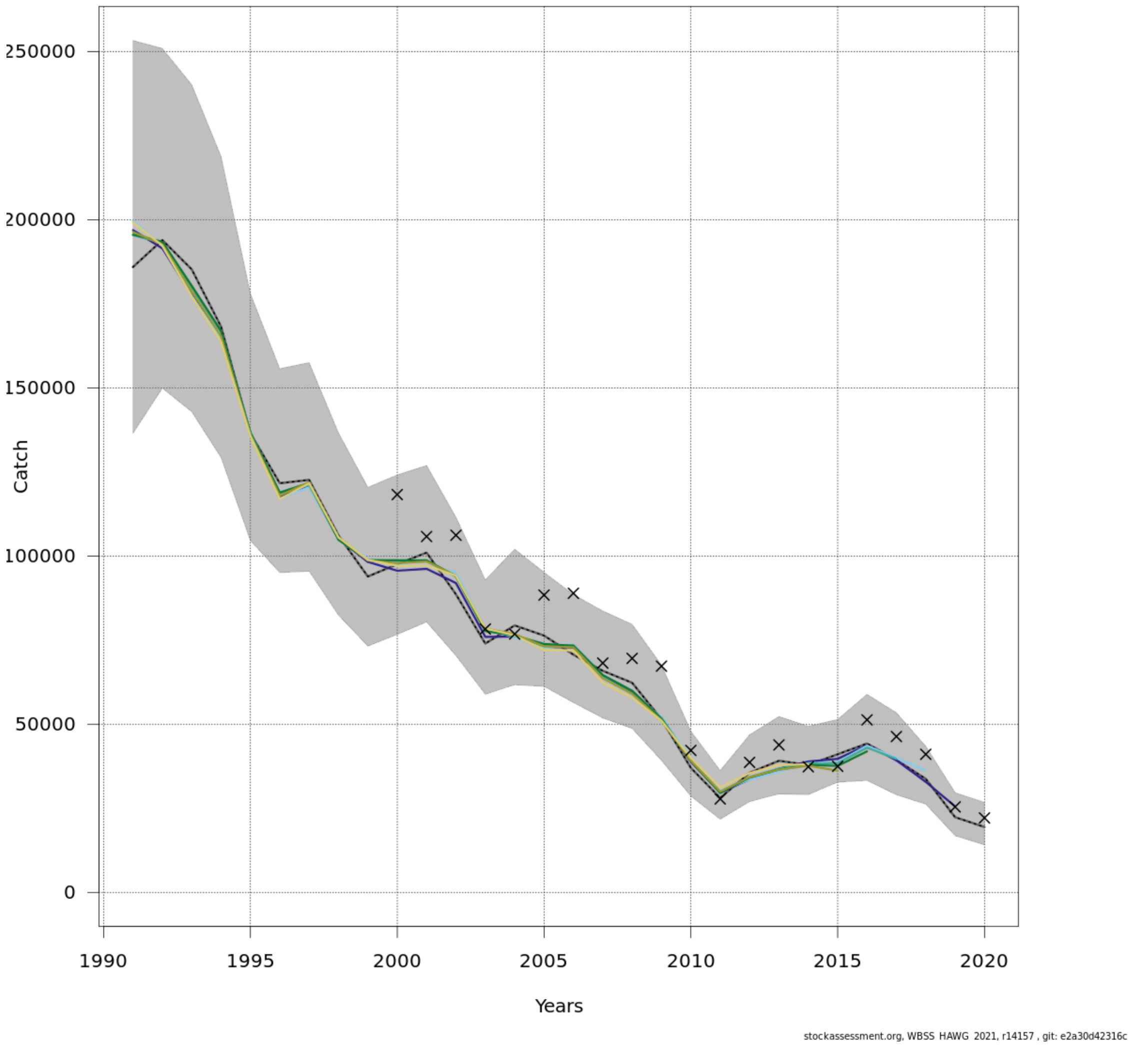


Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Catch.

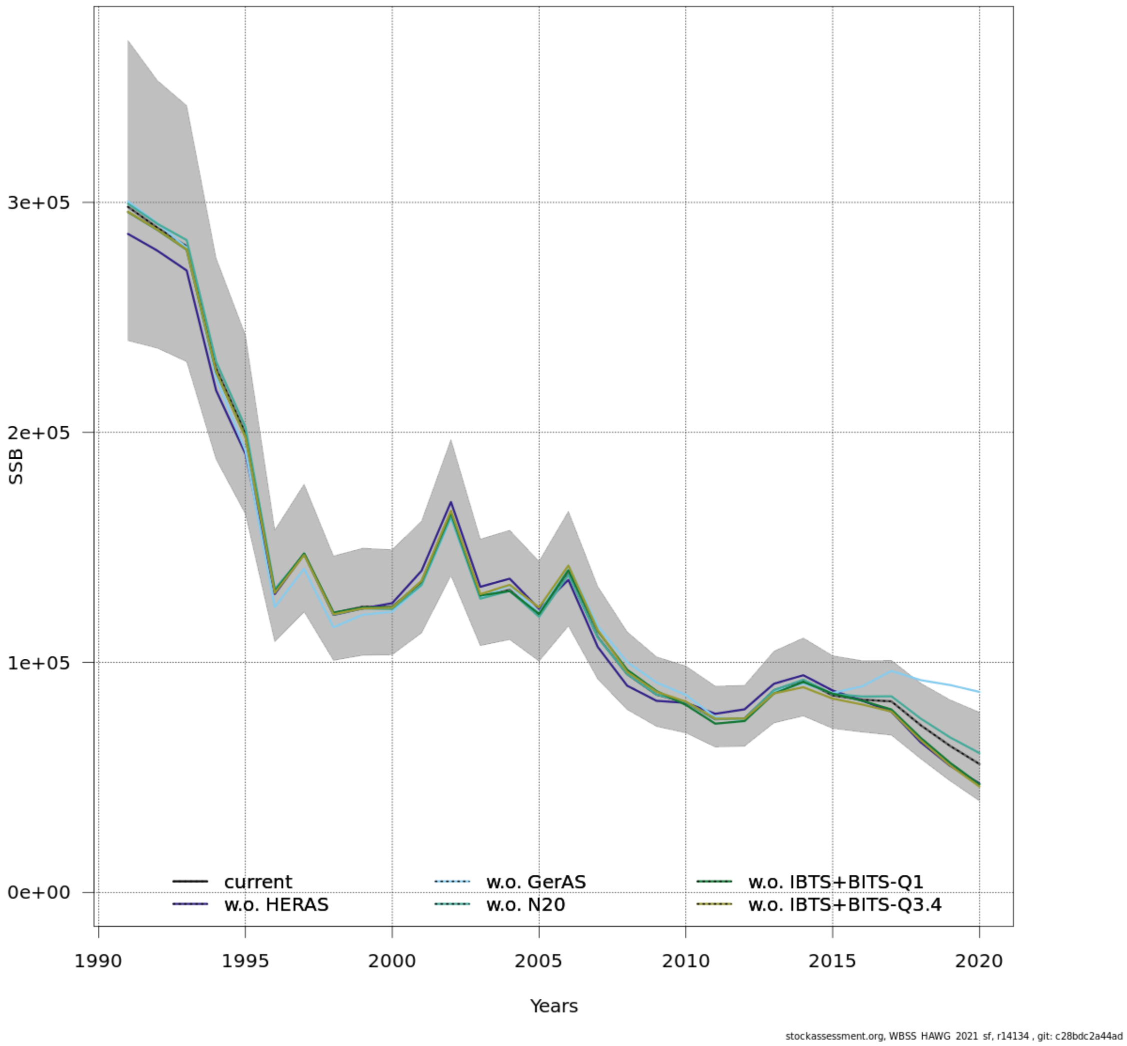


Figure 3.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Spawning stock biomass.

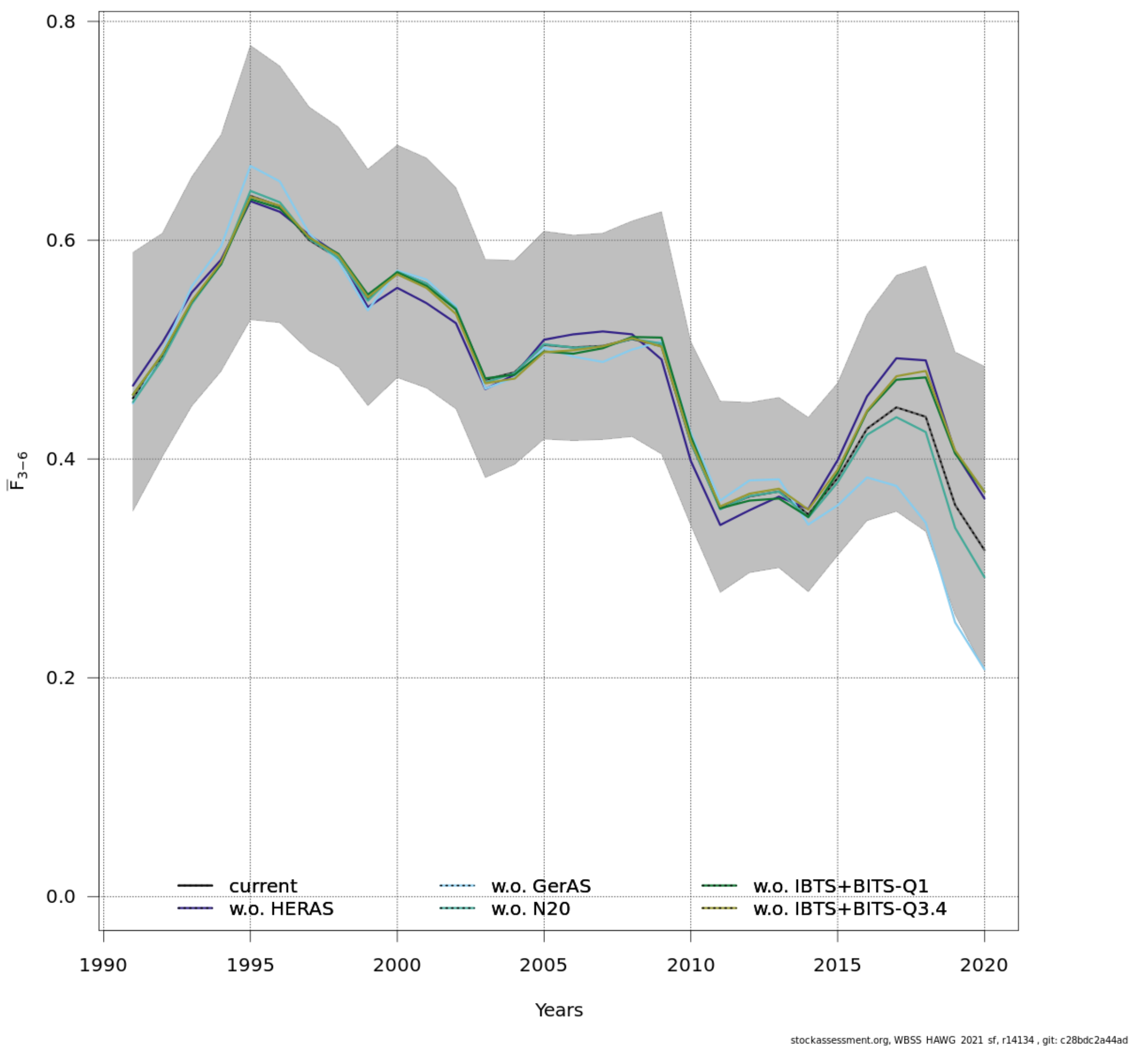


Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Average fishing mortality for the shown age range.

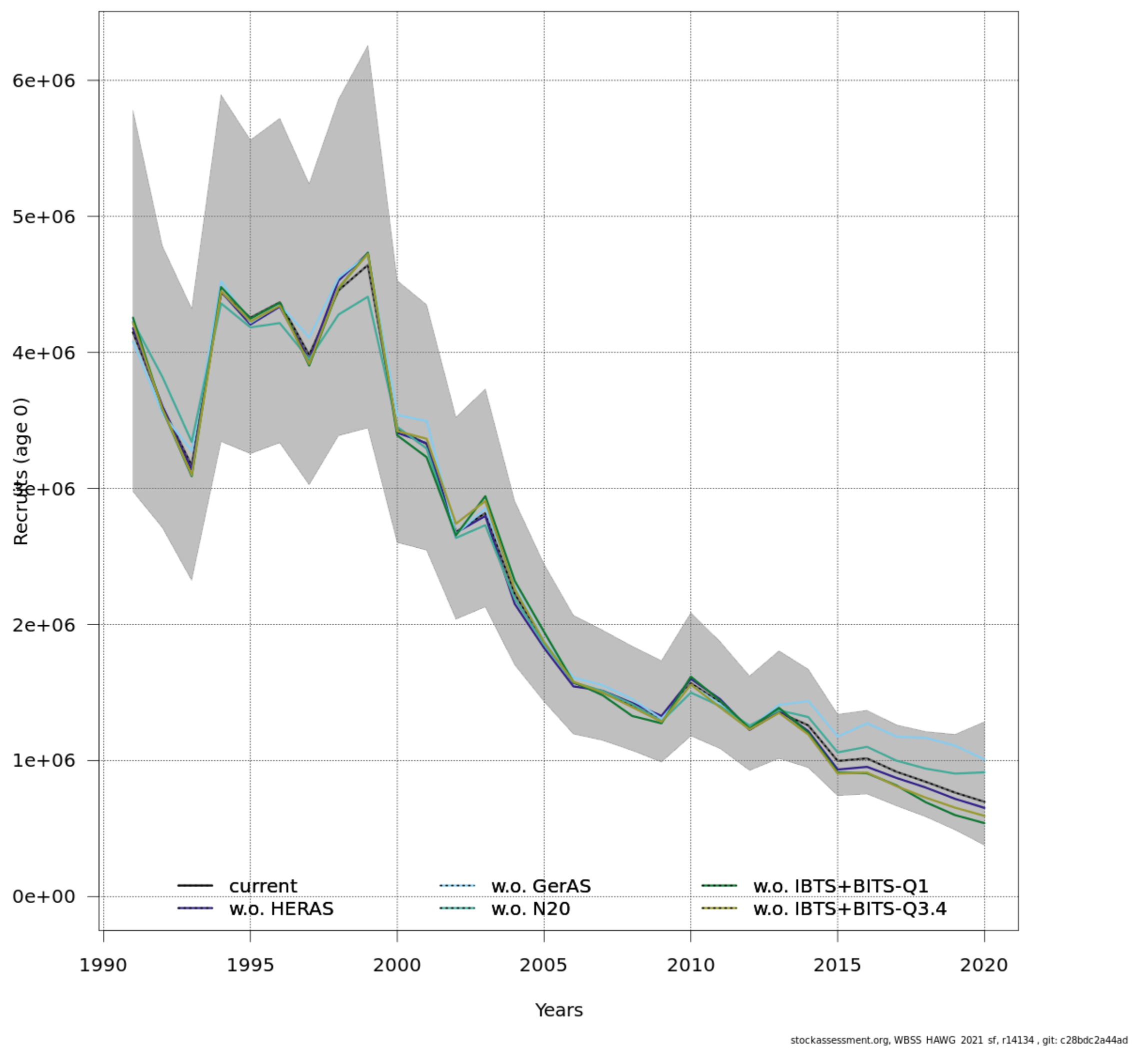


Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Recruitment.

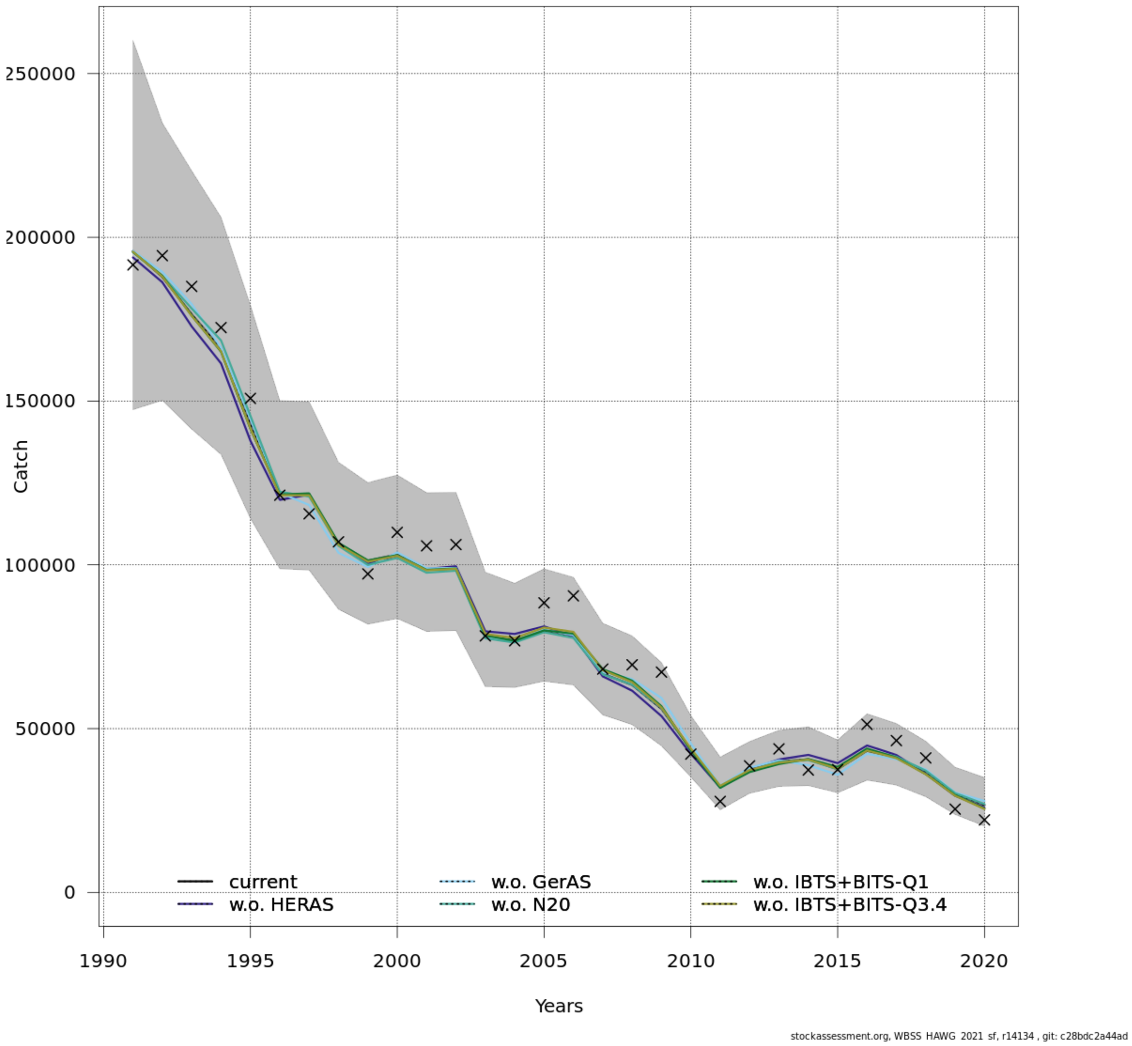


Figure 3.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Catch.

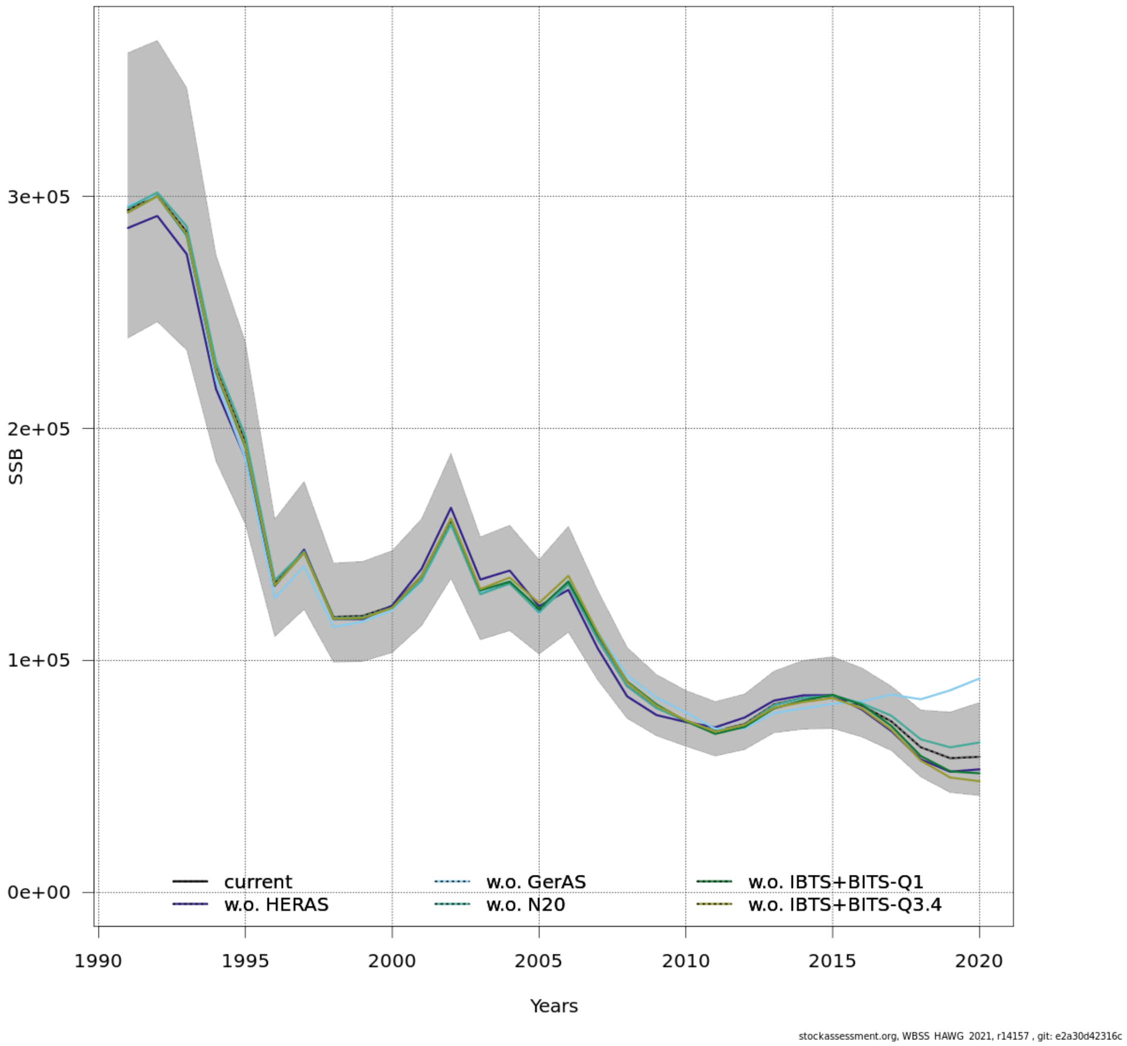


Figure 3.6.4.32 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Spawning stock biomass.

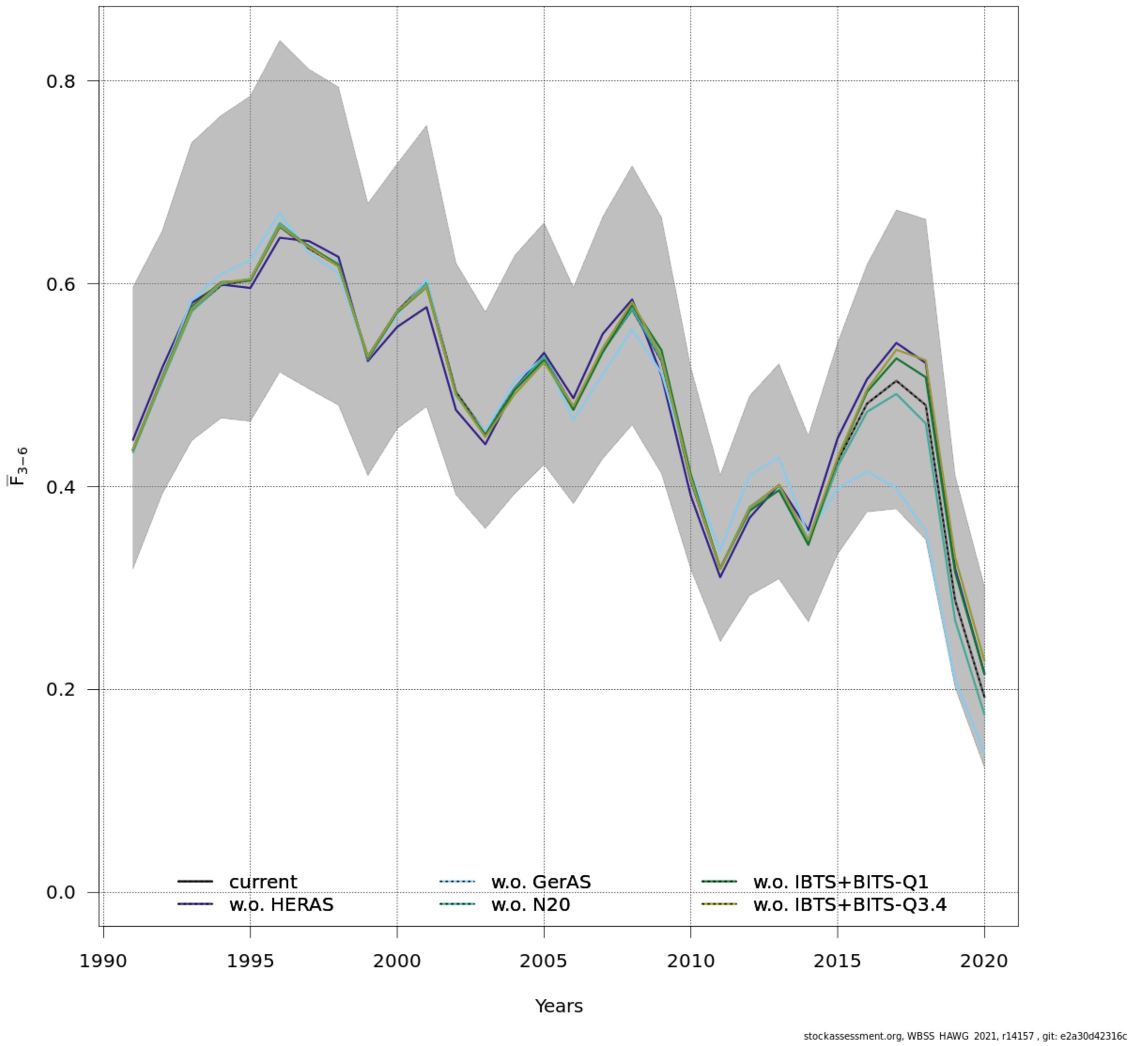


Figure 3.6.4.33 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

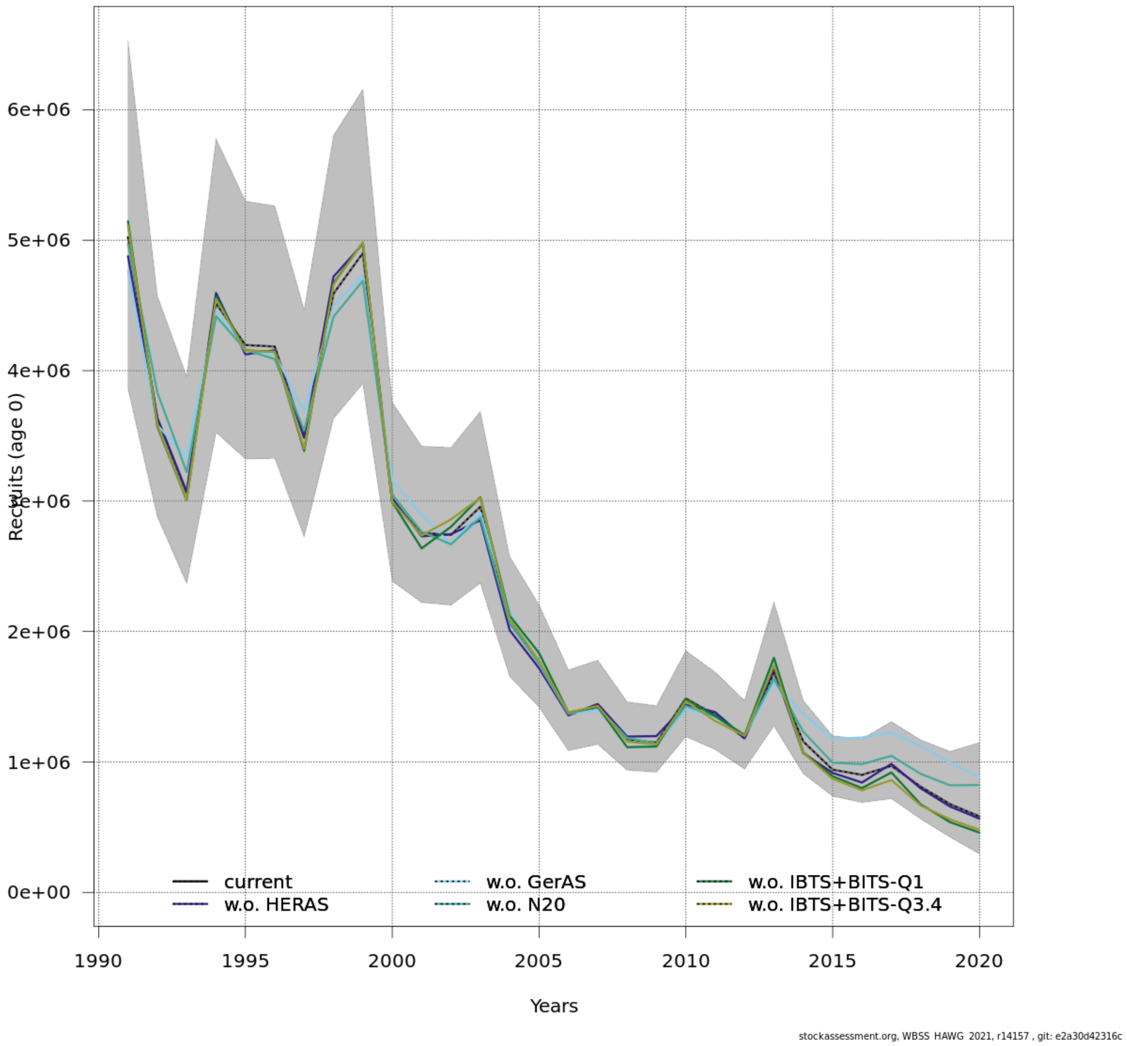


Figure 3.6.4.34 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Recruitment.

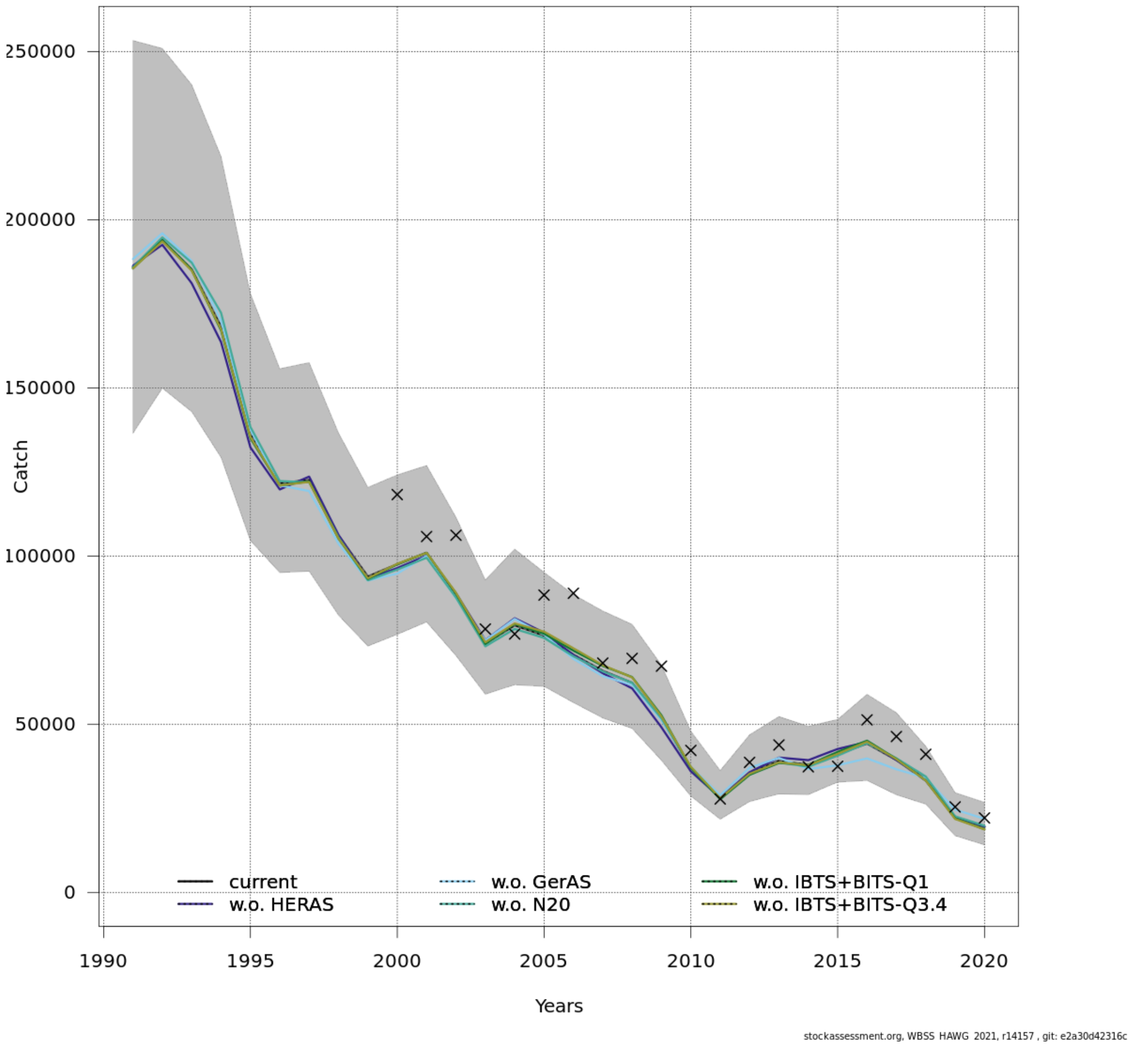


Figure 3.6.4.35 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Catch.

4 Herring (*Clupea harengus*) in divisions 6.a (combined) and 7.b–c

This is the seventh time since 1982 that the working group presents a joint assessment of herring in Division 6.aN and 6.aS/7.b and 7.c. This follows from the benchmark workshop, ICES, WKWEST (2015). This benchmark was unable to differentiate the two stocks and although HAWG still considers them to be discrete, they will be assessed together as a meta-population until the combined survey indices can be successfully split.

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, specific to the 6.a, 7.b and 7.c autumn, winter and spring spawners, 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 applicable to 2016–2020

ICES gave separate advice for the constituent stocks up to 2015 and advice for the combined stocks since 2016.

After the benchmarking process in early 2015 (WKWEST, 2015), 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, 2016a)). 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 EC 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 2016/0203, and the same for 2017 (EU 2017/127), 2018 (EU2018/120), and 2019 (EU 2019/124). This was reduced to 4840 t, split of 3480 t in 6.aN and 1360 t in 6.aS and 7.b-c for 2020 (EU 2020/123).

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. 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.

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.

Since 2016 the fishery has been restricted to a monitoring fishery with a combined TAC of 5800 t between 2016 – 2019, and 4840 t in 2020, a significant reduction on the 2015 TAC of 22 690 t for 6.aN; in 6.aS and 7.b–c the TAC was already zero in 2015. For a detailed description of the monitoring fisheries in 6.aN and 6.aS/7.b– c see Section 5, this report.

4.1.3 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. 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.

4.1.4 Catches in 2020

The Working Group's best estimate of removals from the stock is shown in Table 5.1.2 for the 6.aS and 7.b–c constituent stock and in Table 5.2.1 for the 6.aN constituent stock.

4.2 Biological Composition of the Catch

Catch and sample data for the 6.aS, 7.b–c and 6.aN constituent stocks were combined to construct the input data for the Herring in Division 6.a (Combined) and 7.b–c assessment. Catch number- and weight-at-age information is given in the stock assessment report Section 4.6 (cf tables 4.6.1a, b and 4.6.2a, b respectively).

The 2018 and 2019 year class (age 1 and 2-wr) dominates both the catches and the survey indices in 2020. Previously strong cohorts (2013) are less influential in the stock with small amounts of older fish present.

4.3 Fishery-independent Information

4.3.1 Acoustic surveys (A9526 & 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 co-ordinated summer survey on recommendation from WESTHER, HAWG and SGHERWAY (Hatfield *et al.*, 2007; HAWG ICES, 2007; HAWG ICES, 2010a). 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.

The Malin Shelf herring estimate of SSB for 2020 is 226 000 tonnes and 1435 million individuals (Table 4.3.1.2), an increase compared to the 128 000 tonnes and 740 million herring estimate in 2019. The estimate is still very low in the time-series (Table 4.3.1.3). In 2019 and 2020, 55% and 60% of the biomass was observed north of 56°N (the geographic area included in the West of Scotland (6.aN index). This is not typical for the time-series; generally, the vast majority of herring are found north of 56°N. For instance, in 2018, 86% of the biomass was observed north of 56°N. The West of Scotland (6.aN) estimate of SSB is 158 000 tonnes and 943 million individuals (Table 5.2.4), a large increase compared to the 76 000 tonnes and 406 million herring estimate in 2019, and more in line with the 152 000 tonnes and 975 million herring estimated in 2018. Long-term indices of abundance per age class for West of Scotland herring are provided in Table 5.2.5. In 2019, the total biomass of herring located in 6.aS and 7.b–c during the MSHAS was 163 000 tonnes compared to 66 500 tonnes in 2019 and 34 900t in 2018.

Herring has in the past been found in high densities to the east of the 4°W line in association with a specific bathy- metric 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 again. 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 2013-year class (age 6 winter rings in 2020) are still relatively strong in the stock and comprised 6% of total abundance and 18% of the spawning stock biomass. The stock is otherwise dominated by 1- and 2 winter ringers (2018 and 2019 year classes), making up 66% of the abundance and 52% of the biomass. Age disaggregated survey abundance indices for the West of Scotland and Malin Shelf (WoS_MSHAS) herring since 2008 are given in Table 4.3.1.3 and Figure 4.3.1.3.

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.

4.3.1.1 Industry–Science Acoustic survey

In 2016–2020 industry acoustic surveys of herring during the spawning and prespawning 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 aims to provide estimates of minimum spawning stock size in each of the areas. Full results from the surveys can be found in (WGIPS ICES, 2021) and a summary for each of the components is in Section 05 of this report. Consistent with observations from the HERAS survey on the Malin shelf, the industry acoustic/trawl survey in 6aN recorded an abundance of 1-2 WR herring in several hauls. The relative length frequency distributions from the survey samples are presented in Figure 4.3.1.1.1.

4.3.2 Scottish Bottom-trawl surveys (SCOWGFS G4748 and G4815 and SWC-IBTS G1179 and G4299)

Marine Scotland Science carries out two annual bottom-trawl surveys in western waters covering the herring stocks in ICES Division 6.a. The Scottish West Coast Groundfish survey in quarter 1 has been carried out in a consistent manner since 1987 and in quarter 4 since 1996. For quarter 1 in the years 1990–1993 age-data were not available on haul resolution and therefore the survey index for quarter 1 starts in 1994. For quarter 4 there were no survey in 2010, and in 2013 only parts of the area were covered and the data were not included in the survey calculations. The two indices were recalculated in 2019 following an Interbenchmark procedure (IBPher6a7bc, ICES 2019).

The internal consistencies in the trawl surveys indicate ability to follow cohorts in both the Q1 and Q4 indices (figures 4.3.2.1 and 4.3.2.2)..

The abundance of 2 winter ring fish was at higher levels earlier in the time-series particularly in quarter 1, but since 2003 older fish have been numerically more abundant in the index in both quarters (figures 4.3.2.3 and 4.3.2.4). The stronger 2013 year-class which was age 6 wr in 2020 is still evident especially in Q1, but its effect on overall stock size is waning and overall abundance has decreased in both quarters. Full details for the survey can be found in the Stock Annex.

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 acoustic surveys and are given in Table 4.3.1.2 (for the current year) and Table 4.6.3 (for the time-series). The weights-at-age in the stock have been declining since 2010 particularly for younger ages. Weights-at-age in the catches for 6.aN and 6.aS, 7.bc are presented separately in Table 4.6.2a and 4.6.2b and are used separately in the

multi fleet assessment. Both areas show fluctuations in catch weights over time. In several years no 1 winter ring fish have been taken in the 6.aN fishery. In 2020 the catch weights have decreased markedly across age classes, due to the very low catch in 6a.N, leading to the slower growing 6.aS, 7.bc forming a larger than typical share of the catch.

4.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 4.3.1.2, Figure 4.4.2.1). The Malin Shelf Acoustic Survey (MSHAS) provides estimated values for the period 2008 to 2020 (cf. Table 4.6.5). For earlier years, the maturity ogive is as per the 6.aN stock, and from 1991 is taken from the geographically split west of Scotland acoustic survey. The proportion mature of ages 2 and 4-wr in 2020 were similar to 2019. A lower proportion of mature 3 wr fish were found in 2020 (75%) than in 2019 (90%). In 2016 and 2017 (Figure 4.4.2.1) almost 100% of 3 wr fish were mature. A greater proportion of immature fish were encountered in the surveys in 2018-2020 than in 2016-2017.

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; ICES, 2011).

The most recent benchmark of herring in Division 6.a and 7.b–c (WKWEST 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 (Table 4.6.4). 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.

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.a and 7.b–c herring

The assessment presented here follows the procedure agreed by the recent interbenchmark (IB-Pher6a7bc, ICES 2019). The tool for the assessment of herring in 6.a and 7.b–c is a multifleet implementation of the State–space Assessment Model (www.stockassessment.org), embedded inside the FLR library (Kell *et al.*, 2007).

Data Exploration

A comparison of the age structure in each of the data sources is presented in Figure 4.3.1.1 there is generally good agreement between the catch data and the tuning indices. In some years the acoustic survey picks up a larger proportion of 1 winter ring fish but this is variable between years. In 2018, 2019 and 2020 the age profile of the catch data has diverged somewhat from that of the surveys, which may represent the effect of the switch to the monitoring fishery.

The internal consistency from the combined acoustic survey is presented in Figure 4.3.1.2. The best agreement is seen for older ages and is poor for the younger ages. The survey estimates of both numbers-at-age and biomass were higher in 2020 compared to 2018 and 2019. The internal consistency for the IBTS survey Q1 (Figure 4.3.2.1) and Q4 (Figure 4.3.2.2) is similar across all ages. The poorest consistency can be seen for 9 wr in the IBTS Q4.

The two trawl surveys and the West of Scotland acoustic surveys were updated and the methods used are the same as the interbenchmark (IBPher6a7bc, ICES 2019). Both of the trawl surveys have obvious year effects (1998 and 2004 in IBTS-Q1 and 2000–2002 in IBTS-Q4), and are generally noisy with low internal consistencies (Figures 4.3.2.1 and 4.3.2.2). Similarly, for the West of Scotland acoustic survey which has a marked year effect in 2005.

Assessment

The catch residuals are presented for 6.aN in Figure 4.6.1. The biggest residuals can be seen in the earliest part of the time-series. The residuals from 6.aS, 7.b, c are presented in Figure 4.6.2 and show the biggest residuals at older ages in the most recent years. This is unsurprising because there are very few older ages present in this tuning series. There are no age or year effects in the residuals.

The residuals from each of the tuning series are also presented. The combined acoustic survey (Figure 4.6.3) shows the smallest residuals overall. The IBTS Q1 (Figure 4.6.4) and IBTS Q4 (Figure 4.6.5) both show the largest residuals for younger and older age classes. In the previous assessment strong year effects were seen in both of these surveys. Adding correlation to the survey observations in the updated assessment has fixed this problem.

The estimated observation variance parameters for each dataset fitted by the model are presented in Figure 4.6.6. The model is influenced largely by information from the catch in both North and South followed by the acoustic survey (combined WOS MSHERAS) ages 3–6. The youngest age (1 wr) in both the catch data from the North and South and from the acoustic survey have a higher variance compared to older ages and contribute less to the model fit.

The observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter and presented in Figure 4.6.7. The uncertainty associated with the parameters estimated is low for most data. The IBTS Q4 age 2 wr have a low observation variance and a high CV value. The CVs do not indicate a lack of convergence of the assessment model.

The estimated catchability for each of the tuning indices is presented in Figure 4.6.8. The catchability in the acoustic survey remains a concern in this assessment. Catchability is free for all ages and is only bound for the two oldest ages. The assessment shows catchability to be increasing towards the oldest ages reaching values of almost 6. It is not clear what is causing this catchability pattern or why the catchability is so high. The IBTS surveys show a similar catchability pattern but the magnitude of the estimates is lower.

Figure 4.6.9 shows the correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

Uncertainty estimates from this assessment of recruitment, SSB and Mean F are shown in Figure 4.6.10. The highest uncertainty can be seen for recruitment in the terminal year. This is unsurprising given that there is no independent index of recruitment in this assessment.

Figure 4.6.11 shows the trajectories for SSB, recruitment and mean F over the complete time-series from 1957–2020. SSB peaked in the early 1970s and has been declining steadily since 2004. Recruitment also peaked in the early period of the time-series with no comparatively strong year classes evident in recent years. Since 2010, recruitment has dropped to an even lower level. Fishing mortality was at its highest in the early 1970s. The zero catch advice in 2016–2021 and the resulting monitoring fishery has decreased F.

The analytical retrospective for this stock is shown in Figure 4.6.12. The changes applied to the assessment following the interbenchmark have improved the retrospective. A retrospective pattern is still present however the Mohn's Rho on 5 year peels in the 2021 assessment of SSB is -0.12, down from -0.17 in 2020 and -0.23 in 2019.

The diagnostics of the assessment model fit to each of the individual data sources, catch N, catch S, WOS_MSHAS, IBTSQ1 and IBTS Q4 by age are presented in figures 4.6.13–4.6.57. These plots show a good fit to the catch data. Some divergence can be seen between observed and predicted values at some ages in the tuning data particularly the IBTS Q4 in more recent years.

4.6.1 Final Assessment for 6.a and 7.b–c herring

In accordance with the settings described in the Stock Annex, the final assessment of 6.a and 7.b–c herring was carried out by fitting a State–space model (multi fleet SAM, in the FLR environment). This follows on from the interbenchmark in early 2019 (IBPher6a7bc, ICES 2019).

4.6.2 State of the combined stocks

Fishing mortality has been reduced since the introduction of zero catch advice and in line with the monitoring TAC in 2016. However, there is no information on the F on each of the constituent stocks. Unless the two stocks are of equal size, F on the smaller stock will be higher than indicated in the overall F. SSB has decreased steadily since 2003. SSB in 2020 is estimated to have increased by 38% from 2019 levels, however it remains at a very low level relative to the long term mean. 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 Short-term Projections

4.7.1 Short-term projections

Given the current zero catch advice for herring, in divisions 6.a and 7.b–c and that a monitoring TAC has been agreed for 2021, exploratory forecasts were carried out with different catches assumed in the intermediate year (2021).

The two scenarios considered were

1. Full Uptake of the monitoring TAC (4840 t) in the intermediate year (2021).
2. Partial uptake of the monitoring TAC (1540 t) in the intermediate year (2021). This assumes full uptake in 6aS, 7b-c (1360 t) and uptake based on the 2020 catches in 6aN (180 t).

The results of these forecasts are presented in Tables 4.7.1.1-Table 4.7.1.4. All catch options show an increase in SSB in 2022 (17-21%) and a small decrease in SSB in 2023 (4-5%).

4.7.2 Yield-per-recruit

No yield-per-recruit analysis was conducted at HAWG 2021.

4.8 Precautionary and Yield Based Reference Points

The change in perception of SSB and recruitment had a profound effect on the breakpoints estimated by the segmented regression analysis. IBPher6a7bc concluded that after a considerable amount of work being carried out within the interbenchmark and given all the uncertainties and the inability to estimate several reference points, the IBP decided not to present any reference points for 6.a, 7.bc herring. A full benchmark will be carried out in early 2022 which hopefully will allow the two separate stocks to again be assessed independently. That would also be the time to revisit the estimation of reference points (IBPher6a7bc, ICES 2019).

4.9 Quality of the Assessment

This assessment combines two separate stocks, as estimation of independent stock sizes was not possible. These stocks are 6.aN herring and 6.aS/7.b–c herring. The stock went through an interbenchmark in 2019. Improvements were made to the input data. The IBTS data series was recalculated using the delta GAM method and the acoustic surveys were combined into a single tuning index. The model was changed to a multi fleet SAM assessment with data from 6.aN and 6.aS 7.bc treated separately. The updated assessment provides the best statistical fit to the input data, but the assessment still has a strong retrospective bias. There is also a pattern of increasing catchability with age for the acoustic survey data which cannot be explained, given what would reasonably be expected for an acoustic survey.

The assessment does not provide any information on the state of either constituent stock. The fishing mortality information from this assessment is not informative of the mortality being experienced by either stock. The overall F may mask important differences in F between the stocks. Unless the two stocks are of equal size, which is not likely, the smaller stock may be experiencing a much higher F than the overall F estimates imply.

SSB remains at a very low level. In this assessment, estimates of recruitment in 2019 and 2020, while still well below the long term average, are estimated to be stronger than any year since 2010 and 2002 respectively. There is, however, considerable uncertainty about these estimates. Since 2012, there have been very few 1-wr herring observed in the 6.a (combined) and 7.b–c fishery. An increase in the proportion of 1 winter ring fish in the catch data was seen in 2019, corresponding to an increase in the number of 2 winter ring fish in 2020 in 6.a (south) and 7.b-c. Catch data in 6.a (north) was insufficient to track cohorts.

The assessment shows a similar perception of the stock to the 2020 assessment, with an improving retrospective pattern.

Concerns remain as to the quality of the combined assessment and how well it is able to represent the dynamics of the separate stocks and fisheries in 6.aN and 6.aS/7.bc. The model remains sensitive to assumptions on age-dependent catchabilities, lack of information on recruitment and the abundance of fish of younger ages. Given unresolved issues with the assessment it was used as indicative of trends only.

4.10 Management Considerations

There is anecdotal evidence that the stocks in 6.aN and 6.aS/7.bc are not of the same size and managers are advised to ensure that any exploitation pattern imposed in this area ensures that the smaller, more vulnerable, stock is not overexploited. There is a clear need to determine the relative stock sizes and to ensure that exploitation is properly balanced to productivity to protect either component from overexploitation.

The working group suggests that it returns to assessing each discrete, constituent stock in this area separately when methods allow doing so. Until that is possible, a joint assessment is necessary.

A research project was carried out to assess the identity of herring stocks in this area through genetics, body morphometric and otolith shape analysis. The project aimed to develop methods, which can be used in future to discriminate the stocks even during times of mixing. The final results of this project were delivered at the end of 2020 and a final report available in April 2021 (Farrell, et al 2021). The genetic assignments developed during this project will be used as the basis for splitting survey indices into the different populations. This results of this will be presented at the benchmark data meeting in late 2021.

In its autumn 2015 plenary report, STECF noted that from a stock assessment perspective, it would be beneficial to allow small catches to maintain an uninterrupted time-series of fishery-dependent catch data from the stocks in both management areas (6.aN and 6.aS/7.b–c). The monitoring TAC taken in 2016–2019 and agreed for 2020 (4 840 t) is associated with decreased F and a continuation of the catch sampling programme.

4.11 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, WGSAM 2012). Recent work, using length-based ecosystem modelling, suggests a link between herring biomass and North Sea cod (Speirs *et al.*, 2010), via the predation of cod eggs by herring.

There is no ecosystem model that covers the whole of the 6.a and 7.b–c area, so it is difficult to predict the impact of increasing or reducing the herring biomass on the ecosystem functioning as a whole. However, 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.

4.12 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). Temperature trends are similar for the sea area to the west of Scotland and the North Sea. The broad trend in oceanic temperatures over the period 1900–2006 is for warming. Oceanic temperatures around the Scottish coast for the period (1970–2006) have increased by ~0.5°C (Baxter *et al.*, 2008). Salinity and surface temperature of coastal waters around the Scottish coast also shows a slight increasing trend over the same time period.

The environmental conditions in the North Sea and west of Scotland are similarly impacted by climate change, with trends in oceanic temperature, sea surface temperature and salinity all increasing over recent decades around the coast of Scotland. Climate models predict a future increase in air and water temperature and a change in wind, cloud cover and precipitation in Europe (Drinkwater, 2010).

Table 4.3.1.2. Herring in Divisions 6.a (combined) and 7.b–c. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (6.a.N-S, 7.b and 7.c) June–July 2020. 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	1175	68.1	0.00	58.0	19.0
2	1226	142.0	0.32	115.8	23.4
3	609	85.6	0.68	140.5	24.9
4	235	38.3	1.00	163.0	26.2
5	110	19.6	1.00	178.4	27.0
6	209	41.1	1.00	196.9	27.8
7	42	8.9	1.00	211.5	28.5
8	18	3.8	1.00	214.2	28.4
9+	10	2.4	1.00	231.1	29.6
Immature	2199	184		83.6	21.0
Mature	1435	226		157.4	25.7
Total	3634	410	0.39	112.8	22.9

Table 4.3.1.3. Herring in Divisions 6.a (combined) and 7.b–c. Numbers-at-age (millions) and SSB (thousands of tonnes) of Malin Shelf herring acoustic survey combined with West of Scotland acoustic survey (WoS_MSHAS) (6.a.N-S, 7.b and 7.c) time-series. Age (rings) from acoustic surveys 1991 to 2020.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9	SSB
1991	338	294	328	368	488	176	99	90	58	410
1992	74	503	211	258	415	240	106	57	63	351
1993	2	579	690	689	565	900	296	158	161	845
1994	494	542	608	286	307	268	407	174	132	534
1995	441	1103	473	450	153	187	169	237	202	452
1996	41	576	803	329	95	61	77	78	115	370
1997	792	642	286	167	66	50	16	29	24	175
1998	1222	795	667	471	179	79	28	14	37	376
1999	534	322	1388	432	308	139	87	28	35	460
2000	448	316	337	900	393	248	200	95	65	445
2001	313	1062	218	173	438	133	103	52	35	359

Year\Age (Rings)	1	2	3	4	5	6	7	8	9	SSB
2002	425	436	1437	200	162	424	152	68	60	549
2003	439	1039	933	1472	181	129	347	114	75	739
2004	564	275	760	442	577	56	62	82	76	396
2005	50	243	230	423	245	153	13	39	27	223
2006	112	835	388	285	582	415	227	22	59	472
2007	0	126	294	203	145	347	243	164	32	299
2008	50	267	996	720	363	331	744	386	274	841
2009	773	265	274	444	380	225	193	500	456	593
2010	133	375	374	242	173	146	102	100	297	366
2011	63	257	900	485	213	228	205	113	264	494
2012	796	548	832	517	249	115	111	57	105	427
2013	0	209	434	672	195	71	61	29	37	282
2014	1012	278	242	502	534	148	33	19	13	285
2015	0	212	397	747	423	476	90	24	2	430
2016	0	30	108	88	112	79	62	6	1	88
2017	0	25	339	155	106	110	47	13	5	145
2018	1289	447	106	343	153	52	72	27	13	159
2019	24	231	225	123	169	95	14	17	21	128
2020	1175	1226	609	235	110	209	42	18	10	226

TABLE 4.6.1 Herring in 6a and 7bc. CATCH IN NUMBER

```
Units  :  thousands
   year
age  1957   1958   1959   1960  1961  1962  1963  1964   1965   1966   1967
  1  6496  15695  54063   3940 14473 55278 11890 26609 299701 211675 207947
  2 80817  33616  74615 115501 50809 99167 82849 87652  23351 517616  28648
  3 66094 152801  38547  65703 72914 27189 57688 74309  72085  45317 273723
  4 26882  43895 124307  25388 38321 76706 13310 29583  67768  70793  49755
  5 38989  28108  27898  50558 24455 49002 42796  8857  24525  38471  48320
  6 21547  32025  18942  12196 14296 22707 28698 27075   7001  22691  36143
  7  9643  19986  18833  11096  5791 27787 10171 21347  28806  12656  15226
```

8	1658	10795	8158	6770	5370	7614	14585	10109	21475	20790	10397
9	4817	8887	9364	4856	2887	8435	7885	17655	23515	33175	33967

year

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220870	39160	238361	208594	535964	57593	312390	180239	85666	39321	32695
2	105348	107189	134128	341260	650282	276017	154350	243395	348615	92251	86604
3	26031	84565	279726	419854	195671	855656	192141	114183	139060	109230	47666
4	243304	27604	125140	313064	60396	148347	563757	92893	62046	39293	54000
5	19679	264558	31636	110783	77859	70503	100323	211920	50512	22292	17564
6	28436	25795	182580	29495	35773	67025	58565	41304	91289	22135	9189
7	17699	45908	24591	194977	14585	27433	45530	18206	16126	26526	6370
8	7275	27932	28740	19104	102945	8475	32742	22499	7510	4118	9916
9	14389	29258	25993	34159	20936	83203	51591	45727	27717	5636	4868

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	6166	5548	38360	14052	83440	5001	50400	34686	31612	1708	8457
2	50213	40337	100226	268146	121498	270259	83988	182073	110114	148511	43682
3	19238	65041	147394	89183	142277	78488	215754	113890	125676	88035	188343
4	19988	25191	92801	121764	54578	52855	29970	185243	73529	69429	45072
5	9362	22139	34285	76732	74317	22138	26452	33480	149341	43142	39590
6	8430	7757	25369	31701	45638	24202	14269	25988	23655	74247	22597
7	5447	6954	15044	15605	21404	15274	16092	8274	19946	10198	39929
8	4424	4345	4044	17063	11766	6435	10910	6849	9590	4704	5835
9	4090	5334	6546	6902	12735	5979	4357	4098	16170	4324	6541

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	15172	27071	7845	17910	13437	550	6728	8651	16529	10027	8612
2	65844	57450	39988	115850	92710	116647	62278	112139	146944	86506	57525
3	60279	53039	67454	41376	71418	65812	100206	60912	115183	155239	60750
4	226257	40632	50572	52945	22884	39889	40347	70399	70231	59979	82126
5	50882	137961	34382	36648	29205	24509	17350	37701	53037	23456	28850
6	33469	31454	107176	28348	21745	20286	17815	23477	23510	13416	11737
7	26192	22446	14886	86451	19112	14554	12858	18682	13923	5131	5362
8	29640	18203	12520	12382	43887	16556	20921	8631	6259	2343	2526
9	6652	12116	11797	9753	20299	24002	37580	14147	6269	2038	2178

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012

1	2463	5050	1787	1401	392	730	207	483	2126	11345	1788	6122
2	105035	71122	66151	22358	37756	28727	58903	20163	24083	33847	54795	27797
3	37149	131724	75580	56475	54133	45886	61713	32700	22553	36458	25098	63034
4	27103	27896	77956	49142	47489	44226	29954	33911	28683	16499	19448	13746
5	43625	29737	16895	57400	21012	63024	28003	14330	20906	22196	10576	9873
6	19498	38231	9521	9076	15235	36862	36040	11678	10928	13102	8851	6865
7	8555	11787	15343	9647	2363	23391	23342	17570	9555	6885	6035	4415
8	5769	3153	10111	9999	2053	3874	13816	8887	12647	6050	3591	1233
9	1537	2067	1711	4589	1674	5458	4374	9236	9461	13388	7321	4035

	year							
age	2013	2014	2015	2016	2017	2018	2019	2020
1	61	34	258	81	30	6	3499	285
2	16799	9171	12697	10131	2173	3076	3960	5275
3	22714	23970	14536	7593	17171	5054	4294	2889
4	65355	27799	18270	4566	8160	10153	3517	1938
5	13347	54375	21086	5816	3101	7542	4995	753
6	8885	9537	22306	4906	3694	3681	2169	874
7	5524	3989	6493	3972	2478	1545	596	382
8	4707	3291	1942	782	1247	1112	543	110
9	5234	3715	1251	440	349	710	213	69

TABLE 4.6.2 Herring in 6a and 7bc. WEIGHTS AT AGE IN THE CATCH

Units : kg

	year											
age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.080	0.086	0.085	0.079	0.080	0.079	0.079	0.079	0.079	0.079
2	0.108	0.109	0.107	0.112	0.111	0.107	0.108	0.108	0.109	0.105	0.105	0.106
3	0.139	0.134	0.134	0.138	0.142	0.140	0.137	0.136	0.136	0.139	0.137	0.135
4	0.161	0.167	0.161	0.168	0.169	0.165	0.170	0.169	0.164	0.163	0.166	0.165
5	0.176	0.176	0.171	0.168	0.172	0.171	0.171	0.187	0.170	0.215	0.172	0.173
6	0.178	0.185	0.176	0.176	0.185	0.180	0.182	0.185	0.188	0.178	0.179	0.176
7	0.188	0.195	0.187	0.189	0.189	0.191	0.201	0.198	0.194	0.209	0.192	0.184
8	0.199	0.193	0.190	0.192	0.195	0.199	0.192	0.202	0.191	0.191	0.208	0.188
9	0.194	0.209	0.191	0.192	0.198	0.199	0.220	0.207	0.197	0.195	0.198	0.195

	year											
age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980

1	0.080	0.079	0.079	0.079	0.092	0.090	0.091	0.094	0.092	0.096	0.109	0.100
2	0.108	0.111	0.104	0.105	0.122	0.123	0.122	0.122	0.125	0.125	0.129	0.129
3	0.136	0.133	0.131	0.134	0.158	0.159	0.160	0.160	0.159	0.162	0.165	0.165
4	0.164	0.161	0.159	0.161	0.177	0.176	0.180	0.182	0.182	0.179	0.191	0.191
5	0.174	0.170	0.168	0.170	0.188	0.190	0.189	0.198	0.199	0.200	0.209	0.209
6	0.181	0.181	0.177	0.185	0.209	0.208	0.210	0.209	0.213	0.215	0.222	0.222
7	0.184	0.186	0.191	0.195	0.222	0.221	0.222	0.222	0.221	0.227	0.231	0.231
8	0.187	0.186	0.189	0.208	0.227	0.228	0.229	0.230	0.228	0.229	0.237	0.237
9	0.192	0.189	0.189	0.197	0.234	0.234	0.236	0.234	0.237	0.236	0.241	0.241

	year											
age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.091	0.082	0.080	0.095	0.071	0.113	0.078	0.080	0.081	0.080	0.084	0.092
2	0.123	0.139	0.136	0.140	0.106	0.144	0.127	0.109	0.140	0.132	0.128	0.128
3	0.160	0.173	0.172	0.177	0.142	0.171	0.162	0.144	0.143	0.165	0.152	0.160
4	0.180	0.202	0.199	0.207	0.171	0.195	0.187	0.163	0.175	0.167	0.189	0.175
5	0.195	0.226	0.222	0.229	0.188	0.214	0.191	0.183	0.181	0.193	0.179	0.204
6	0.214	0.245	0.241	0.245	0.203	0.228	0.209	0.180	0.193	0.203	0.204	0.186
7	0.221	0.260	0.258	0.259	0.212	0.240	0.218	0.201	0.201	0.207	0.211	0.207
8	0.233	0.275	0.271	0.272	0.224	0.217	0.229	0.201	0.196	0.229	0.227	0.215
9	0.238	0.273	0.277	0.263	0.231	0.274	0.233	0.216	0.224	0.242	0.245	0.236

	year											
age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.081	0.093	0.084	0.092	0.096	0.083	0.092	0.084	0.099	0.101	0.085
2	0.130	0.141	0.141	0.134	0.135	0.137	0.138	0.132	0.136	0.137	0.139	0.145
3	0.155	0.166	0.170	0.174	0.168	0.149	0.153	0.157	0.149	0.156	0.156	0.160
4	0.176	0.180	0.183	0.188	0.192	0.177	0.168	0.179	0.173	0.161	0.168	0.184
5	0.190	0.191	0.186	0.212	0.214	0.194	0.189	0.192	0.188	0.166	0.184	0.211
6	0.207	0.192	0.201	0.212	0.221	0.209	0.203	0.208	0.192	0.183	0.198	0.205
7	0.202	0.220	0.202	0.235	0.218	0.218	0.216	0.230	0.208	0.190	0.198	0.202
8	0.242	0.212	0.216	0.239	0.235	0.217	0.220	0.260	0.224	0.231	0.188	0.192
9	0.246	0.243	0.241	0.282	0.256	0.207	0.224	0.217	0.252	0.263	0.282	0.302

	year											
age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.107	0.103	0.116	0.111	0.109	0.084	0.064	0.087	0.083	0.105	0.078	0.091
2	0.134	0.142	0.157	0.157	0.159	0.145	0.146	0.141	0.140	0.145	0.138	0.140
3	0.156	0.146	0.157	0.172	0.191	0.177	0.171	0.187	0.168	0.169	0.178	0.162
4	0.172	0.169	0.174	0.176	0.219	0.203	0.197	0.204	0.192	0.191	0.198	0.192

age												
5	0.192	0.194	0.195	0.188	0.218	0.223	0.221	0.216	0.199	0.215	0.209	0.200
6	0.212	0.213	0.216	0.216	0.231	0.225	0.223	0.227	0.209	0.227	0.229	0.212
7	0.215	0.240	0.215	0.244	0.249	0.230	0.233	0.239	0.228	0.241	0.238	0.227
8	0.248	0.253	0.261	0.277	0.252	0.238	0.239	0.278	0.234	0.251	0.245	0.249
9	0.256	0.273	0.301	0.286	0.273	0.255	0.252	0.247	0.247	0.278	0.269	0.256

year

age	2017	2018	2019	2020
1	0.072	0.085	0.074	0.066
2	0.122	0.113	0.109	0.092
3	0.156	0.142	0.132	0.109
4	0.166	0.164	0.167	0.124
5	0.189	0.179	0.184	0.143
6	0.186	0.201	0.185	0.155
7	0.200	0.197	0.194	0.169
8	0.212	0.222	0.186	0.156
9	0.234	0.243	0.187	0.183

TABLE 4.6.3 Herring in 6a and 7bc. WEIGHTS AT AGE IN THE STOCK

Units : kg

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233

```
   5 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246
   6 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252
   7 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258
   8 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269
   9 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292
    year
age  1981  1982  1983  1984  1985  1986  1987  1988  1989  1990  1991  1992
   1 0.090 0.090 0.090 0.090 0.090 0.090 0.090 0.090 0.090 0.090 0.090 0.068
   2 0.164 0.164 0.164 0.164 0.164 0.164 0.164 0.164 0.164 0.164 0.164 0.152
   3 0.208 0.208 0.208 0.208 0.208 0.208 0.208 0.208 0.208 0.208 0.208 0.186
   4 0.233 0.233 0.233 0.233 0.233 0.233 0.233 0.233 0.233 0.233 0.233 0.206
   5 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.233
   6 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.253
   7 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.273
   8 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.299
   9 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.302
    year
age  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004
   1 0.073 0.052 0.042 0.045 0.054 0.066 0.054 0.062 0.062 0.062 0.064 0.059
   2 0.164 0.150 0.144 0.140 0.142 0.138 0.137 0.141 0.132 0.153 0.138 0.138
   3 0.196 0.192 0.191 0.180 0.180 0.176 0.166 0.173 0.170 0.177 0.176 0.159
   4 0.206 0.220 0.202 0.209 0.199 0.194 0.188 0.183 0.190 0.198 0.190 0.180
   5 0.225 0.221 0.225 0.219 0.213 0.214 0.203 0.194 0.198 0.212 0.204 0.189
   6 0.234 0.233 0.227 0.222 0.222 0.226 0.219 0.204 0.212 0.215 0.213 0.202
   7 0.253 0.241 0.247 0.229 0.231 0.234 0.225 0.211 0.220 0.225 0.217 0.213
   8 0.259 0.270 0.260 0.242 0.242 0.225 0.235 0.222 0.236 0.243 0.223 0.214
   9 0.276 0.296 0.293 0.263 0.263 0.249 0.245 0.230 0.254 0.259 0.228 0.206
    year
age   2005  2006  2007  2008  2009  2010  2011  2012       2013  2014
   1 0.0751 0.075 0.075 0.055 0.059 0.068 0.057 0.066 0.06366667 0.064
   2 0.1300 0.135 0.168 0.172 0.151 0.162 0.132 0.150 0.15500000 0.108
   3 0.1540 0.166 0.183 0.191 0.206 0.194 0.160 0.183 0.16500000 0.158
   4 0.1670 0.185 0.191 0.208 0.223 0.227 0.208 0.189 0.20200000 0.180
   5 0.1800 0.192 0.195 0.214 0.233 0.239 0.236 0.206 0.21000000 0.206
   6 0.1910 0.204 0.195 0.214 0.231 0.248 0.245 0.217 0.23600000 0.214
   7 0.2130 0.211 0.202 0.221 0.232 0.258 0.238 0.214 0.24300000 0.231
   8 0.2030 0.224 0.203 0.224 0.232 0.226 0.222 0.218 0.24500000 0.244
```

```
  9 0.2280 0.231 0.214 0.238 0.238 0.212 0.253 0.215 0.25400000 0.264
   year
age       2015       2016       2017       2018       2019       2020
  1 0.06373333 0.06373333 0.06373333 0.06373333 0.06373333 0.06373333
  2 0.15500000 0.13700000 0.13500000 0.11000000 0.11700000 0.12600000
  3 0.18300000 0.14000000 0.17000000 0.15500000 0.15000000 0.15100000
  4 0.19500000 0.17500000 0.18100000 0.17600000 0.17900000 0.17100000
  5 0.20400000 0.20200000 0.19800000 0.19000000 0.19600000 0.18400000
  6 0.21100000 0.20800000 0.19900000 0.21000000 0.20500000 0.20200000
  7 0.21700000 0.20900000 0.21400000 0.20900000 0.21700000 0.21500000
  8 0.21500000 0.21000000 0.22300000 0.21800000 0.22400000 0.21700000
  9 0.22000000 0.24200000 0.23600000 0.22200000 0.21800000 0.23100000
```

TABLE 4.6.4 Herring in 6a and 7bc. NATURAL MORTALITY

```
Units  :  NA
   year
age     1957     1958     1959     1960     1961     1962     1963     1964
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1965     1966     1967     1968     1969     1970     1971     1972
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
```

```
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1973     1974     1975     1976     1977     1978     1979     1980
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1981     1982     1983     1984     1985     1986     1987     1988
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1989     1990     1991     1992     1993     1994     1995     1996
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1997     1998     1999     2000     2001     2002     2003     2004
```

```
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     2005     2006     2007     2008     2009     2010     2011     2012
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     2013     2014     2015     2016     2017     2018     2019     2020
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
```

TABLE 4.6.5 Herring in 6a and 7bc. PROPORTION MATURE

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	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
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
9	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

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	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
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
9	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

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	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
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
9	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

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.91	0.67	0.88	0.50	0.62	0.35	0.18	0.48	0.97
3	1.00	1.00	0.97	1.00	0.97	1	0.99	0.99	0.99	0.93	0.99	0.72	0.73	0.85	0.99
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	0.98	0.99	0.99	1.00
5	1.00	1.00	1.00	1.00	1.00	1	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	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	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	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	2017	2018	2019	2020
1	0.00	0.00	0.00	0.00
2	0.95	0.40	0.43	0.46
3	1.00	0.85	0.90	0.75
4	1.00	0.98	1.00	1.00
5	1.00	0.98	1.00	1.00
6	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00

TABLE 4.6.6 Herring in 6a and 7bc. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year															
age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year															
age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year															
age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year				
age	2017	2018	2019	2020
1	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67

3	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67

TABLE 4.6.7 Herring in 6a and 7bc. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

```
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
  1 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 2017 2018 2019 2020
  1 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67
```

TABLE 4.6.8 Herring in 6a and 7bc. SURVEY INDICES

WOS_MSHAS - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1991.00	2020.00	0.52	0.57

Index type : number

WOS_MSHAS - Index Values

Units : NA

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	338312	74310	2357	494150	441200	41220	792320	1221700	534200	447600
2	294484	503430	579320	542080	1103400	576460	641860	794630	322400	316200
3	327902	210980	689510	607720	473300	802530	286170	666780	1388000	337100
4	367830	258090	688740	285610	450300	329110	167040	471070	432000	899500
5	488288	414750	564850	306760	153000	95360	66100	179050	308000	393400
6	176348	240110	900410	268130	187200	60600	49520	79270	138700	247600
7	98741	105670	295610	406840	169200	77380	16280	28050	86500	199500
8	89830	56710	157870	173740	236700	78190	28990	13850	27600	95000
9	58043	63440	161450	131880	201700	114810	24440	36770	35400	65000

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	313100	424700	438800	564000	50200	112300	-1	50389	772520	132551
2	1062000	436000	1039400	274500	243400	835200	126000	267367	265151	375304
3	217700	1436900	932500	760200	230300	387900	294400	995596	273910	373804
4	172800	199800	1471800	442300	423100	284500	202500	719782	443603	242388
5	437500	161700	181300	577200	245100	582200	145300	363484	380436	173333
6	132600	424300	129200	55700	152800	414700	346900	331462	225046	145891
7	102800	152300	346700	61800	12600	227000	242900	743706	192866	101960
8	52400	67500	114300	82200	39000	21700	163500	386202	500074	100421
9	34700	59500	75200	76300	26800	59300	32100	273892	456113	297021

age \ year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	62834	796012	-1	1012160	-1	-1	-1	1287728	24011	1174546

2	257258	548481	209403	277504	212467	29593	25426	447304	231310	1226180
3	899637	832257	434425	241674	396545	108126	338563	106491	224691	609403
4	484732	517267	671507	502471	747121	87773	155357	342609	122704	235219
5	212913	249024	194706	534431	423139	111676	105728	153194	169202	109825
6	227515	114507	70507	148259	476249	79130	110226	51928	95226	208543
7	205093	111385	61392	32565	90102	62045	47158	72276	14485	42037
8	113298	56526	28597	18677	23931	5530	13069	26636	16839	17781
9	263837	104571	37398	13003	2086	957	4721	12887	21113	10495

IBTS_Q1 - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1997.00	2020.00	0.00	0.25

Index type : number

IBTS_Q1 - Index Values

Units : NA

year

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	102570	8604	78192	81810	80911	36889	107012	97048	119263	254674	25294
3	175949	48593	311999	128644	74495	145883	117986	323390	136461	321912	77348
4	84804	33925	197058	167097	55846	38200	122297	196806	279782	144542	50369
5	29128	16914	88257	69200	104206	15123	20574	196390	219800	390607	45323
6	20409	5879	38894	60327	55815	42052	15851	53047	211784	379889	80054
7	11742	6933	26446	32652	42177	13886	29896	48651	30304	226230	61328
8	27953	2668	18926	9590	18492	14425	13192	55728	63030	37997	33408
9	27223	7411	31068	17727	19703	15951	17391	49353	56681	111004	30862

year

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	26413	39960	13671	85727	8348	49739	8635	4877	11977	5905	6445
3	32251	81500	39015	95261	117952	51240	34463	8627	18638	55938	28640
4	34616	79777	20855	80806	46095	111007	26037	22638	6798	22971	198984
5	27254	79270	20022	40123	25576	46691	43654	10460	14785	11185	46187
6	24567	59290	21239	47967	13617	37813	8287	12750	18521	11843	35126
7	30661	55935	23288	35036	13111	26229	5504	3740	6151	10785	17461

```
  8 35212  98504 18939 27134  10996  23004  5236  3135  1396  5825  14331
  9 21896 119197 40723 74931  29733  34201  5112   986   598  3167   5411
   year
age   2019  2020
  2   7889  7645
  3  18175 12111
  4  29504  7537
  5 112902  6205
  6  13339 28441
  7   9542  4448
  8   6376  4023
  9   5991  5506

IBTS_Q4 - Configuration

Malin Shelf assessment  . Imported from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     2.00      9.00      9.00   1996.00   2020.00      0.75      1.00
Index type : number

IBTS_Q4 - Index Values

Units  :  NA
   year
age  1996  1997  1998  1999  2000  2001 2002  2003  2004 2005 2006 2007 2008
  2 16909 13398 12430  6649  5468 32480 9940 14459 15894 5181 6811 6786 3018
  3 16090  8730 10050 15452  4130  6612 7696  9878 18196 3707 2383 4038 3669
  4  6688  6728  8166 10630 10052  7071 1134 15392 13176 7075 3053 2659 3515
  5  5224  4243 11176  9829  4409 14695 1715  2286  9045 8771 6315 4877 2107
  6  2237  3113  6433  9196  5744 10462 3403  3311  2177 6096 7959 3711 2970
  7  2059   780  1960  4431  3307  6458 2294  3434  2812  907 4440 4360 5672
  8  4133  1734   876  1441  2274  3162 1781  2111  1474 2177 1062 1252 3580
  9  5665  1707  3713  3281  1665  1649  827  2264  1143 2452 1875  466 3897
   year
age 2009 2010  2011 2012 2013  2014  2015  2016  2017  2018 2019 2020
  2 7138   NA 10250 2143   NA  3354  6161 13158  5480  3806 2409 6610
  3 3623   NA  4460 5790   NA  7920  5975 10953 31449  4475 1958  865
```

```
  4 3460   NA  3713 3450   NA  6477  9724 11277 16558 12982 2406 1288
  5 4625   NA  2211 3773   NA 11445 11463 14003 22941  6280 4456 1543
  6 1760   NA  2149 2668   NA  2983  5252 14743 11878  3701 2562 1911
  7 1980   NA   818 2549   NA   922   640  6358  8563  2400 1813  380
  8 2245   NA   538  840   NA   939   592  1406  3208  1682  722  421
  9 3236   NA  2311 5492   NA   244   460   589   617   222  726  468
```

TABLE 4.6.9 Herring in 6a and 7bc. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         9         9      1957      2020         3         6
```

TABLE 4.6.10 Herring in 6a and 7bc. sam CONFIGURATION SETTINGS

```
name            : Herring in 6aN and 6aS,7bc multifleet
desc             : Imported from a VPA file. ( ./data/index.txt ).  Mon Mar 29
18:00:30 2021
range            :        min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range           :         1         9         9      1957      2020         3
6
fleets          :   catch N   catch S WOS_MSHAS   IBTS_Q1   IBTS_Q4
fleets          :         0         0         2         2         2
plus.group      : TRUE
states          :            age
states          : fleet        1  2  3  4  5  6  7  8  9
states          :   catch N    0  1  2  3  4  5  6  7  7
states          :   catch S    8  9 10 11 12 13 14 15 15
states          :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
states          :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
states          :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
logN.vars       : 0 1 1 1 1 1 1 1 1
logP.vars       :
catchabilities :            age
catchabilities : fleet        1  2  3  4  5  6  7  8  9
catchabilities :   catch N   -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   catch S   -1 -1 -1 -1 -1 -1 -1 -1 -1
```

```
catchabilities :   WOS_MSHAS  0  1  2  3  4  5  6  7  7
catchabilities :   IBTS_Q1   -1  8  9 10 11 12 13 14 14
catchabilities :   IBTS_Q4   -1 15 16 17 18 19 20 21 21
power.law.exps :            age
power.law.exps : fleet        1  2  3  4  5  6  7  8  9
power.law.exps :   catch N   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   catch S   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :            age
f.vars         : fleet        1  2  3  4  5  6  7  8  9
f.vars         :   catch N    4  5  5  5  5  5  5  5  5
f.vars         :   catch S    0  1  2  2  2  2  2  3  3
f.vars         :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :            age
obs.vars       : fleet        1  2  3  4  5  6  7  8  9
obs.vars       :   catch N    4  5  6  6  6  6  6  7  7
obs.vars       :   catch S    0  1  2  2  2  2  3  3  3
obs.vars       :   WOS_MSHAS  8  9 10 10 10 10 11 11 11
obs.vars       :   IBTS_Q1   -1 12 13 13 13 14 14 15 15
obs.vars       :   IBTS_Q4   -1 16 17 17 17 17 18 18 18
srr            : 0
scaleNoYears   : 0
scaleYears     : NA
scalePars      :
cor.F          : 2
cor.obs        : NA NA 0 -1 -1 NA NA 0 2 3 NA NA 1 2 4 NA NA 1 2 5 NA NA 1 2 6
NA NA 1 2 6 NA NA 1 2 6 NA NA 1 2 6
cor.obs.Flag   : ID ID AR AR AR
biomassTreat   : -1 -1 -1 -1 -1
timeout        : 3600
likFlag        : LN LN LN LN LN
fixVarToWeight : FALSE
simulate       : FALSE
```

```
residuals      : TRUE
sumFleets      :
```

TABLE 4.6.11 Herring in 6a and 7bc. FLR, R SOFTWARE VERSIONS

FLSAM.version	2.1.1
FLCore.version	2.6.15
R.version	R version 3.6.3 (2020-02-29)
platform	x86_64-w64-mingw32
run.date	2021-03-29 18:05:58

TABLE 4.6.12 Herring in 6a and 7bc. STOCK SUMMARY

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
	Age 1									(Ages 3-6)				SOP
										f	f	f	tonnes	
1957	1666802	1078079	2577016	767290	584400	1007416	354434	262672	478254	0.1510	0.1041	0.2191	48508	0.7531
1958	2921925	1921963	4442148	836794	638339	1096947	362050	264905	494819	0.1953	0.1341	0.2842	66494	0.7733
1959	4027555	2659241	6099937	975963	739520	1288002	366629	267713	502092	0.1776	0.1201	0.2626	70447	0.7446
1960	1613618	1049378	2481245	893413	682355	1169753	446263	330117	603273	0.1246	0.0850	0.1826	69160	0.6012
1961	2637163	1752234	3969008	910073	702003	1179813	460765	343377	618285	0.0893	0.0626	0.1272	52535	0.6332
1962	3583533	2397924	5355347	1002361	779986	1288136	432542	325182	575347	0.1315	0.0934	0.1852	65594	0.7990
1963	3616950	2431811	5379663	1065633	834068	1361489	459274	349961	602730	0.1010	0.0720	0.1417	54089	0.7245
1964	2511576	1684231	3745339	1045370	829696	1317108	514580	397535	666086	0.0954	0.0689	0.1320	70403	0.6145
1965	10422401	6786407	16006472	1722886	1310390	2265232	519935	405753	666250	0.0998	0.0729	0.1366	76685	0.8730
1966	1814645	1219171	2700965	1614060	1271026	2049675	780345	611056	996533	0.1229	0.0908	0.1664	112834	1.0130
1967	3794868	2605341	5527499	1630596	1322397	2010624	887509	692853	1136854	0.1231	0.0923	0.1642	109281	0.8399
1968	5146091	3569379	7419289	1711798	1418289	2066048	839231	674076	1044849	0.0949	0.0725	0.1243	105345	0.8364
1969	3774978	2625027	5428690	1642101	1393642	1934856	813645	673241	983330	0.1484	0.1145	0.1924	126777	0.7945
1970	4140676	2889655	5933301	1566557	1346763	1822221	734710	618180	873207	0.2146	0.1675	0.2751	186236	0.7750
1971	8352037	5751462	12128484	1818068	1514432	2182581	560413	476116	659636	0.4218	0.3330	0.5343	222211	1.0255
1972	3330564	2324860	4771322	1518057	1281980	1797608	629119	528710	748597	0.2562	0.2029	0.3234	188230	1.0349
1973	2034280	1413990	2926678	1259998	1087581	1459749	587340	493172	699488	0.3900	0.3140	0.4845	246989	1.0331
1974	2151696	1500816	3084853	936031	813929	1076450	375023	318571	441479	0.5635	0.4588	0.6920	214749	1.1069
1975	2258775	1562477	3265368	704017	601800	823595	246400	209004	290486	0.5229	0.4249	0.6435	152765	0.9806
1976	1514032	1044263	2195130	549428	464781	649490	193549	160363	233603	0.5205	0.4176	0.6487	126409	0.9888

1977	1813138	1246782	2636764	478858	395357	579994	171298	138970	211147	0.3386	0.2648	0.4329	61908	0.9200
1978	2551185	1753198	3712385	550627	444877	681514	180131	145651	222774	0.2277	0.1764	0.2941	41871	0.9961
1979	2794882	1934431	4038068	655621	532548	807136	236084	192428	289643	0.1161	0.0855	0.1578	22668	0.9380
1980	1796802	1248610	2585673	681913	570477	815117	312631	259131	377177	0.1211	0.0903	0.1623	30430	1.0375
1981	2390610	1667326	3427655	733819	623908	863093	309123	258897	369091	0.2520	0.2024	0.3139	76342	0.9699
1982	1942708	1344319	2807456	679861	578818	798544	266325	224107	316495	0.3752	0.3008	0.4680	111569	1.0235
1983	4982914	3416442	7267629	880106	708068	1093945	230938	191735	278157	0.3835	0.3060	0.4807	96511	1.0182
1984	2574537	1783076	3717307	878665	718339	1074775	323602	262042	399625	0.2624	0.2073	0.3322	83462	0.9756
1985	2974744	2059255	4297235	922556	765911	1111238	392423	317734	484671	0.2209	0.1744	0.2797	62485	1.0078
1986	2693134	1861799	3895677	922824	773681	1100716	397574	327410	482774	0.2519	0.1996	0.3180	99549	1.0389
1987	4745061	3244708	6939178	1069568	877302	1303972	373774	308942	452210	0.2772	0.2190	0.3510	92960	1.0148
1988	2059559	1412648	3002717	971498	805150	1172215	437112	359709	531170	0.2117	0.1666	0.2691	64691	1.0126
1989	1700327	1188999	2431553	875395	735975	1041226	459852	377121	560732	0.1836	0.1450	0.2326	63236	1.0086
1990	1339950	942929	1904137	752292	642083	881418	395605	328214	476833	0.2266	0.1804	0.2848	88662	0.9933
1991	1050381	737459	1496082	604056	520402	701158	321171	269219	383147	0.2127	0.1694	0.2669	66229	1.0315
1992	1490916	1053403	2110143	489934	424251	565787	238990	201765	283083	0.2316	0.1860	0.2882	60841	1.0024
1993	1275979	904892	1799246	449467	388414	520117	235896	200405	277672	0.2412	0.1948	0.2986	68541	0.9932
1994	1915841	1368682	2681737	409557	354138	473647	178035	152370	208023	0.2662	0.2150	0.3295	58338	0.9999
1995	1549957	1131809	2122591	382455	330345	442786	139837	119918	163064	0.2877	0.2338	0.3541	57367	0.9748
1996	1755450	1287804	2392913	376320	327056	433005	178525	152979	208338	0.2993	0.2424	0.3695	58639	1.0233
1997	2064130	1492806	2854111	411554	355883	475933	152840	131545	177582	0.4330	0.3598	0.5211	62458	1.0033
1998	1044229	760403	1433997	381458	329867	441117	181807	154156	214417	0.4793	0.3973	0.5783	72248	0.9994
1999	917625	664978	1266259	304306	264274	350403	146721	124805	172486	0.3486	0.2855	0.4255	55845	0.9998
2000	2620471	1898840	3616351	373516	314412	443729	116979	99933	136933	0.3050	0.2487	0.3739	43008	0.9990
2001	1778194	1294801	2442052	407346	345596	480129	197165	165080	235486	0.2852	0.2320	0.3506	40007	1.0028
2002	1949044	1415526	2683649	467346	398970	547439	227601	191572	270406	0.3297	0.2680	0.4057	50740	0.9998
2003	1094076	790201	1514809	409310	351154	477096	213464	180217	252843	0.2733	0.2208	0.3382	44583	1.0021
2004	935311	676476	1293181	335318	289534	388342	184279	155978	217715	0.2545	0.2040	0.3175	40186	1.0119
2005	942432	682457	1301443	302976	261658	350818	159956	136852	186962	0.1798	0.1443	0.2240	30360	1.0021
2006	822342	596539	1133616	289788	251882	333398	144696	124179	168603	0.2850	0.2314	0.3509	46539	0.9990
2007	532968	387165	733681	248577	216061	285986	139814	118991	164280	0.2996	0.2427	0.3699	47407	0.9990
2008	646806	469835	890436	205077	178577	235508	113799	97454	132884	0.2443	0.1953	0.3056	29394	1.0008
2009	713154	511348	994604	196710	170887	226437	93215	79984	108635	0.2846	0.2296	0.3527	28976	1.0312
2010	1163677	844419	1603639	227052	193303	266693	93240	79163	109821	0.3442	0.2781	0.4259	30118	0.9960
2011	516559	371385	718481	183641	157654	213912	78145	66540	91775	0.2908	0.2342	0.3610	24678	0.9992
2012	506443	359684	713083	178361	153490	207261	90161	76241	106623	0.2692	0.2152	0.3367	25087	1.0017
2013	247199	175337	348514	145151	125313	168130	62136	52700	73262	0.3968	0.3189	0.4936	26947	0.9978

2014	318736	221246	459186	103895	88397	122111	40081	33411	48083	0.4647	0.3722	0.5802	27123	1.0091
2015	519002	346276	777885	104571	83735	130590	33236	26535	41630	0.5837	0.4580	0.7440	19885	0.9982
2016	216836	142395	330193	81410	62038	106830	48261	36222	64301	0.2067	0.1517	0.2817	6937	1.0011
2017	258103	166595	399874	83473	62424	111619	48382	35486	65964	0.1771	0.1249	0.2510	6424	0.9986
2018	354564	222032	566202	81663	59213	112625	35329	24959	50010	0.1757	0.1185	0.2604	5557	0.9978
2019	1025677	598873	1756655	127996	86746	188861	38410	26632	55397	0.0844	0.0560	0.1270	3429	0.9978
2020	1320911	443066	3938022	191442	104087	352108	54817	37509	80112	0.0351	0.0221	0.0558	1397	0.9999

TABLE 4.6.13 Herring in 6a and 7bc. ESTIMATED FISHING MORTALITY

Units : f

, , area = N

year

age	1957	1958	1959	1960	1961	1962
1	0.01291923	0.01573261	0.01548640	0.01321415	0.01149022	0.01645332
2	0.05811951	0.07410374	0.07168915	0.05791613	0.04739392	0.07268736
3	0.10189298	0.12736937	0.11455697	0.08414434	0.06284234	0.09439099
4	0.12269948	0.15793986	0.14739845	0.10200146	0.07136381	0.10755394
5	0.14942791	0.19608415	0.18473977	0.13002892	0.08630132	0.12929849
6	0.16447049	0.21910425	0.19912978	0.13329150	0.08243370	0.13037977
7	0.20003092	0.28214451	0.25710336	0.16846310	0.09990907	0.15735939
8	0.20291031	0.29969966	0.27753249	0.17988950	0.10658970	0.17113659
9	0.20291031	0.29969966	0.27753249	0.17988950	0.10658970	0.17113659

year

age	1963	1964	1965	1966	1967	1968
1	0.01383333	0.01328812	0.01298415	0.01610277	0.01529155	0.01232650
2	0.05689716	0.05223114	0.04910679	0.06293942	0.05878848	0.04522708
3	0.07491268	0.06927264	0.06675582	0.08074535	0.07722351	0.06015445
4	0.08277692	0.07821052	0.08152240	0.09918699	0.09477750	0.07033978
5	0.09609888	0.08671492	0.09069883	0.11004862	0.10548991	0.07648427
6	0.09905168	0.09260255	0.09669171	0.12023855	0.12039153	0.08885289
7	0.11967045	0.11809756	0.12638566	0.14989420	0.15300737	0.11644923
8	0.13674420	0.14352344	0.16047687	0.19029458	0.19126951	0.14327788
9	0.13674420	0.14352344	0.16047687	0.19029458	0.19126951	0.14327788

year

```
age       1969       1970       1971       1972       1973       1974
  1 0.01693637 0.02585181 0.05092843 0.03188604 0.04268641 0.05010418
  2 0.06930743 0.12124477 0.29615084 0.16801550 0.25419509 0.32565058
  3 0.09969470 0.17990758 0.43577470 0.23533123 0.34918212 0.43742950
  4 0.11687884 0.19095954 0.41840448 0.22451101 0.34333442 0.46774092
  5 0.13050576 0.18891026 0.37538467 0.20945297 0.32435251 0.47624746
  6 0.15271916 0.19626280 0.35332823 0.20304748 0.31672821 0.51639503
  7 0.21003355 0.24595077 0.38790508 0.21279526 0.29785426 0.48344557
  8 0.25997120 0.29058039 0.42509312 0.22104569 0.28603637 0.44098822
  9 0.25997120 0.29058039 0.42509312 0.22104569 0.28603637 0.44098822
   year
age       1975       1976       1977       1978         1979          1980
  1 0.04356979 0.04109164 0.02471393 0.01434337 0.0000893622 0.00009693455
  2 0.28884212 0.28604786 0.16110198 0.08683371 0.0001493293 0.00017813862
  3 0.36594741 0.34940648 0.20089853 0.10506522 0.0001654374 0.00018909283
  4 0.37905948 0.34405065 0.19948637 0.10869854 0.0001543472 0.00017528381
  5 0.39943230 0.34771769 0.19311323 0.09756888 0.0001342135 0.00015005358
  6 0.46963208 0.44867859 0.25648663 0.12403284 0.0001656883 0.00017585980
  7 0.46061274 0.47073031 0.28238430 0.14122339 0.0001959736 0.00021251487
  8 0.41170869 0.42029487 0.24449631 0.12397768 0.0001642861 0.00017220381
  9 0.41170869 0.42029487 0.24449631 0.12397768 0.0001642861 0.00017220381
   year
age       1981       1982       1983       1984        1985       1986
  1 0.01673753 0.02306787 0.01754562 0.01099009 0.008730894 0.01000122
  2 0.13466442 0.22379371 0.17403940 0.10593056 0.085576266 0.11068888
  3 0.15351737 0.26502964 0.21848332 0.13588316 0.108215329 0.13720426
  4 0.14982422 0.26870013 0.22796481 0.13947627 0.107787219 0.13546359
  5 0.13966842 0.27615917 0.25939816 0.15893390 0.124062636 0.15311762
  6 0.16085547 0.32063310 0.31188933 0.18107230 0.140374156 0.16322841
  7 0.18824429 0.38618384 0.39162986 0.21404094 0.154209724 0.16054018
  8 0.15019646 0.34867889 0.39052296 0.21771019 0.158193147 0.16425362
  9 0.15019646 0.34867889 0.39052296 0.21771019 0.158193147 0.16425362
   year
age        1987        1988        1989        1990        1991        1992
  1 0.007066574 0.005402601 0.004613033 0.005691674 0.004554726 0.004963241
  2 0.078020562 0.060652182 0.053557883 0.075489839 0.061985354 0.076607584
  3 0.098596175 0.077125900 0.067967693 0.094866924 0.076359811 0.091366341
```

age						
4	0.103855728	0.079579033	0.067520633	0.097177319	0.076574947	0.085629639
5	0.129388163	0.099324014	0.083810814	0.122248928	0.093779231	0.100102217
6	0.150622051	0.112094397	0.092959730	0.139163373	0.107265745	0.113161488
7	0.170280400	0.129313874	0.114799600	0.177349633	0.133120555	0.138360210
8	0.198966149	0.158571589	0.150265541	0.245369642	0.175281887	0.174637622
9	0.198966149	0.158571589	0.150265541	0.245369642	0.175281887	0.174637622

year

age	1993	1994	1995	1996	1997	1998
1	0.005020354	0.004251855	0.004126713	0.002841044	0.004361192	0.004054092
2	0.086157047	0.078275890	0.083669907	0.056512599	0.104944444	0.101752366
3	0.098337908	0.094147597	0.105197773	0.075370616	0.151159796	0.152212098
4	0.083487582	0.079000301	0.095762369	0.077920882	0.183323380	0.187987953
5	0.095494582	0.089289697	0.107303668	0.101278642	0.272522114	0.278377420
6	0.106847315	0.100899029	0.116836826	0.119675069	0.347222024	0.348552148
7	0.143822171	0.150548145	0.186149768	0.202288186	0.557889640	0.523879201
8	0.177280830	0.195591511	0.237327152	0.254918894	0.567128333	0.472243459
9	0.177280830	0.195591511	0.237327152	0.254918894	0.567128333	0.472243459

year

age	1999	2000	2001	2002	2003	2004
1	0.003355364	0.002741395	0.002123772	0.002226596	0.001671471	0.001360294
2	0.085981951	0.072261394	0.056711417	0.063739089	0.046469513	0.036555716
3	0.132563416	0.119208427	0.101294692	0.125391207	0.098550456	0.081226944
4	0.147920989	0.135971499	0.118392645	0.152235266	0.127098106	0.114137036
5	0.195453073	0.183022361	0.175439162	0.233819624	0.195854376	0.192883553
6	0.218336853	0.198126880	0.198990507	0.256752527	0.211819468	0.224113080
7	0.291957871	0.255044293	0.269713761	0.337271062	0.304073786	0.321088642
8	0.251386292	0.216751098	0.238706299	0.296290027	0.298970542	0.349851132
9	0.251386292	0.216751098	0.238706299	0.296290027	0.298970542	0.349851132

year

age	2005	2006	2007	2008	2009	2010
1	0.0009223725	0.001291125	0.001688509	0.00122478	0.001909373	0.00242526
2	0.0228193452	0.035333562	0.049469102	0.03238399	0.055902337	0.07488283
3	0.0485754727	0.073847252	0.092371071	0.05848782	0.101087437	0.13333670
4	0.0597304223	0.098768930	0.110916683	0.06720997	0.123304556	0.16535347
5	0.0895157948	0.171164860	0.184962643	0.10228890	0.174055503	0.23347312
6	0.1033837302	0.230691927	0.264994075	0.14761932	0.226000015	0.27927018
7	0.1367997698	0.335708363	0.393175642	0.22783075	0.321357069	0.36161909

```
  8 0.1473905914 0.387548552 0.485917793 0.30159759 0.428717413 0.48755513
  9 0.1473905914 0.387548552 0.485917793 0.30159759 0.428717413 0.48755513
   year
age        2011        2012        2013        2014        2015         2016
  1 0.002204892 0.002220117 0.002640679 0.002586721 0.002974951 0.0009892286
  2 0.066556173 0.067758270 0.085357083 0.084086644 0.101520916 0.0250992765
  3 0.119225594 0.127180941 0.172394008 0.180544512 0.237827753 0.0622888457
  4 0.149513861 0.164633977 0.254060551 0.283558575 0.384804582 0.1036745762
  5 0.210231546 0.234312733 0.375732063 0.440280134 0.598743309 0.1572419222
  6 0.249748405 0.287954322 0.492576446 0.599753964 0.924642062 0.2411009000
  7 0.313463083 0.349607716 0.621327683 0.777588674 1.246162015 0.3464020391
  8 0.435623429 0.507841094 1.001398508 1.254265450 1.713100259 0.4630001288
  9 0.435623429 0.507841094 1.001398508 1.254265450 1.713100259 0.4630001288
   year
age         2017         2018         2019          2020
  1 0.0008070984 0.0008541556 0.0003455628 0.00006077613
  2 0.0189482853 0.0198913633 0.0061730900 0.00067677427
  3 0.0515903287 0.0574004150 0.0181473881 0.00216910462
  4 0.0855724973 0.1029279386 0.0338066480 0.00430195288
  5 0.1209514013 0.1498811282 0.0439046407 0.00570945771
  6 0.1631858998 0.1873543212 0.0462983715 0.00606806280
  7 0.2052779144 0.1980636311 0.0422495616 0.00608489211
  8 0.2515115378 0.2072364712 0.0347509592 0.00465894431
  9 0.2515115378 0.2072364712 0.0347509592 0.00465894431

, , area = S

   year
age         1957         1958         1959         1960         1961
  1 0.0001602408 0.0002040849 0.0001812764 0.0001503225 0.0001718929
  2 0.0064389725 0.0077369602 0.0069467805 0.0059750409 0.0066518037
  3 0.0123738875 0.0147728858 0.0127927060 0.0106730670 0.0119957800
  4 0.0141311370 0.0175671233 0.0147137219 0.0116410998 0.0130786624
  5 0.0177655071 0.0218037753 0.0169976453 0.0123150983 0.0134998824
  6 0.0211890829 0.0264452842 0.0201343538 0.0142199002 0.0155941342
   year
age         1962         1963         1964         1965         1966
```

```
  1 0.0001761371 0.0001093366 0.0001010802 0.0001107238 0.0001495062
  2 0.0069619633 0.0049476476 0.0047144753 0.0050657024 0.0062824775
  3 0.0132483640 0.0098889696 0.0098185974 0.0109476867 0.0138325099
  4 0.0152367327 0.0118898737 0.0124881277 0.0143950849 0.0186594876
  5 0.0162180773 0.0129991591 0.0141392293 0.0163927550 0.0213399221
  6 0.0197487306 0.0165426355 0.0183818047 0.0216017598 0.0276785729
   year
age         1967         1968         1969         1970         1971
  1 0.0001802079 0.0001762941 0.0002206153 0.0002593171 0.0002583204
  2 0.0071481879 0.0069411506 0.0081161673 0.0091576850 0.0089209111
  3 0.0157166390 0.0145141434 0.0161611758 0.0175186406 0.0167709019
  4 0.0218402735 0.0197388877 0.0215926655 0.0230111459 0.0222641301
  5 0.0250853663 0.0223282903 0.0251636974 0.0273852522 0.0279437460
  6 0.0319331397 0.0272751548 0.0309921167 0.0346203972 0.0373754318
   year
age         1972         1973        1974        1975        1976        1977
  1 0.0004755321 0.0009609356 0.001901085 0.002919789 0.003842138 0.002963473
  2 0.0137637367 0.0227693276 0.037800699 0.051903336 0.063761622 0.053161613
  3 0.0246918888 0.0383700453 0.062152857 0.084204551 0.103354522 0.085815648
  4 0.0320838180 0.0487607311 0.078357238 0.107695266 0.135422668 0.113676356
  5 0.0404787220 0.0598458011 0.094494774 0.127177406 0.161161521 0.138442949
  6 0.0550987576 0.0794984226 0.121188330 0.158338942 0.192025460 0.166380658
   year
age       1978        1979        1980        1981        1982        1983
  1 0.00262179 0.002232641 0.002109685 0.001496757 0.001213083 0.001772645
  2 0.04930748 0.044864023 0.044343764 0.035296242 0.030916367 0.041958247
  3 0.08129580 0.076994123 0.080014429 0.066516588 0.060761331 0.084269727
  4 0.10611706 0.102449287 0.106839485 0.089058232 0.081831282 0.114201008
  5 0.12971047 0.126329622 0.132184568 0.109998671 0.100864274 0.141055546
  6 0.15845913 0.158162727 0.164503378 0.138668380 0.126798052 0.176901946
   year
age       1984        1985       1986        1987        1988         1989
  1 0.00133625 0.001087931 0.00105386 0.001700073 0.001117057 0.0009162591
  2 0.03384900 0.029009265 0.02888744 0.041968521 0.031125079 0.0273182772
  3 0.06962480 0.061677460 0.06315343 0.093325944 0.071125183 0.0624482721
  4 0.09401013 0.085228194 0.08882157 0.133156799 0.102355904 0.0901873599
  5 0.11783283 0.109848911 0.11524909 0.173372700 0.132209084 0.1163860955
```

```
  6 0.15282223 0.146289499 0.15139753 0.226660669 0.173086879 0.1531573247
   year
age        1990        1991        1992        1993       1994        1995
  1 0.001058441 0.001255458 0.001482648 0.001648427 0.00223253 0.002192188
  2 0.031379205 0.036721153 0.042667540 0.047664538 0.06029820 0.060784197
  3 0.069388307 0.079255640 0.091914907 0.103198926 0.12719946 0.130211202
  4 0.098979204 0.108211754 0.122235166 0.138669390 0.17054028 0.177159539
  5 0.124478009 0.135475444 0.142670676 0.155909487 0.18953293 0.197921811
  6 0.160223162 0.173684969 0.179147174 0.182752796 0.21409225 0.220550044
   year
age        1996        1997       1998        1999        2000        2001
  1 0.002721118 0.002782702 0.00391027 0.002815089 0.002200145 0.001754557
  2 0.071292151 0.072503001 0.09457984 0.075163492 0.063816569 0.055024103
  3 0.150359284 0.147795670 0.18933407 0.148229103 0.128173798 0.115610188
  4 0.204142139 0.197831108 0.24632810 0.185253723 0.155902309 0.145846811
  5 0.222270098 0.209208073 0.25386785 0.182965095 0.151406798 0.143666933
  6 0.246038022 0.222981613 0.26070863 0.183527844 0.147990363 0.141681469
   year
age        2002        2003        2004        2005        2006       2007
  1 0.001646261 0.001263834 0.001067731 0.001132012 0.001621358 0.00146384
  2 0.053720152 0.045370075 0.041510209 0.045521759 0.061739926 0.05865808
  3 0.113567579 0.096804439 0.089950108 0.100551026 0.140841958 0.13705434
  4 0.147034676 0.121736729 0.108785712 0.116778267 0.164315110 0.16222912
  5 0.146583169 0.122035387 0.104647670 0.104785218 0.141160870 0.13723407
  6 0.143584219 0.119210854 0.102367354 0.095812867 0.119056428 0.10875864
   year
age        2008        2009        2010         2011         2012         2013
  1 0.001499992 0.001133621 0.001203845 0.0008057174 0.0004458143 0.0003754586
  2 0.059862510 0.048278767 0.049768866 0.0362520883 0.0226060098 0.0202562053
  3 0.141845563 0.115921615 0.120114550 0.0883648911 0.0547334867 0.0529911244
  4 0.175416146 0.145035611 0.152416209 0.1136586766 0.0680939252 0.0712443284
  5 0.156868472 0.136535626 0.151573400 0.1164831498 0.0693112585 0.0792469501
  6 0.127561489 0.116507061 0.141151870 0.1157851006 0.0704153565 0.0887858160
   year
age         2014        2015         2016        2017         2018         2019
  1 0.0003765394 0.000165528 0.0002497383 0.000281344 0.0002118981 0.0002507671
  2 0.0207091096 0.011192169 0.0152353554 0.016739467 0.0134590831 0.0148433653
```

age						
3	0.0581814217	0.031637756	0.0430744679	0.046663838	0.0363815785	0.0382884973
4	0.0825995683	0.043829506	0.0593623466	0.063902797	0.0466422404	0.0457690167
5	0.0986836889	0.052176307	0.0721981395	0.077308444	0.0541221123	0.0496766367
6	0.1152058735	0.061192222	0.0879427797	0.099111112	0.0681137174	0.0615192181

year

age	2020
1	0.0001532206
2	0.0102125671
3	0.0260652194
4	0.0297145261
5	0.0303272015
6	0.0359629308

TABLE 4.6.14 Herring in 6a and 7bc. ESTIMATED POPULATION ABUNDANCE

Units : NA

year

age	1957	1958	1959	1960	1961	1962
1	1666801.57	2921924.99	4027555.40	1613618.37	2637163.17	3583533.43
2	1785795.34	751829.09	1373352.29	1914415.28	699386.58	1202412.31
3	614169.90	1159119.19	484213.45	900737.77	1219258.01	398130.34
4	266424.69	357783.23	711033.61	328008.90	602286.03	779240.32
5	295521.50	177394.12	199851.17	407244.71	232975.53	417002.34
6	133658.47	176205.80	109599.46	111774.94	248552.85	162273.15
7	59064.04	79695.28	95087.11	67565.49	69699.61	172537.80
8	10933.65	35124.59	41018.92	50392.63	42239.66	46528.79
9	34327.22	27423.64	32591.24	38036.30	50678.36	60846.13

year

age	1963	1964	1965	1966	1967	1968	1969
1	3616949.65	2511576.2	10422400.98	1814645.38	3794867.65	5146090.87	3774978.3
2	1660868.80	1704798.3	1080735.74	5421156.86	741846.14	1745324.07	2393142.9
3	732388.37	1077530.2	1112305.88	698671.17	3816702.33	456289.39	1099018.4
4	227768.81	441599.2	712279.31	725172.21	454259.32	2710478.01	292964.5
5	478470.45	141425.0	274092.63	448712.64	460152.56	278624.05	1855197.3
6	276339.97	311742.9	91736.59	173931.13	277775.22	294365.58	183688.8
7	102818.75	185196.2	205747.80	61258.27	105162.28	167770.74	194793.8

```
  8  107945.94   67488.9   120346.12  127400.05   38507.04   61787.55  105120.9
  9   66481.08  114513.4   117493.51  147584.03  160930.32  114177.57  108968.2
   year
age      1970       1971       1972       1973      1974       1975       1976
  1 4140675.6 8352036.68 3330564.11 2034279.55 2151696.2 2258774.61 1514032.01
  2 1682803.2 1846477.40 3950973.70 1454984.91  872788.1  938146.17 1007551.56
  3 1573588.7  969154.22  952808.28 2407037.44  720057.5  408696.64  443906.45
  4  697163.6  902839.79  407122.08  518144.28 1196252.5  303345.73  184296.06
  5  186626.5  398746.18  411810.63  229935.69  250623.6  500608.15  133322.27
  6 1152899.2  111973.08  192130.48  233860.36  116077.1  101439.28  216308.35
  7  111994.2  676931.92   56472.38  108337.24  115523.1   43842.33   38962.04
  8  109596.7   61812.59  330502.10   30812.17   55364.3   45623.60   16504.30
  9  114226.0  116546.47   82554.47  223175.66  120341.1   64678.29   37171.83
   year
age       1977       1978       1979       1980       1981       1982
  1 1813138.36 2551185.07 2794882.17 1796802.10 2390610.00 1942708.24
  2  646133.24  811805.98 1167985.98 1314736.06  792533.40 1113598.01
  3  479861.45  345542.36  478567.91  756301.73  850631.71  434122.65
  4  191945.90  255419.43  202646.02  310265.64  491972.31  471415.24
  5   81775.77  100672.24  137777.28  136166.62  194376.91  274598.53
  6   57941.65   42523.79   59348.47   87906.90   90960.65  109245.79
  7   85189.03   26011.53   23398.79   37179.34   59405.32   49092.97
  8   14232.02   39240.36   13497.47   13796.71   21472.27   32315.42
  9   15923.80   12844.41   24851.33   20644.78   18104.34   19898.07
   year
age       1983       1984       1985       1986       1987       1988
  1 4982913.69 2574536.60 2974743.67 2693133.63 4745061.11 2059558.97
  2  853698.47 2442595.26 1159910.49 1353962.99 1210005.74 2290694.99
  3  595533.03  456302.57 1546475.85  716302.82  780461.73  717555.10
  4  217175.88  305912.80  247945.90  963776.13  416267.37  446451.21
  5  232036.60  109383.33  172080.95  146578.20  560168.21  238572.68
  6  135519.92  107981.39   60142.11  102246.39   79476.62  302438.70
  7   51831.39   60261.89   56061.78   32269.21   54468.03   38509.56
  8   21667.36   21114.35   30029.85   28927.84   17615.68   25436.61
  9   23053.31   16560.94   17587.69   23663.07   27824.84   18862.08
   year
age       1989       1990       1991       1992       1993       1994
```

1	1700327.49	1339949.82	1050380.92	1490916.34	1275979.24	1915840.66
2	936377.04	780429.11	614873.62	466388.75	703820.35	597400.62
3	1528981.03	612829.41	473526.93	377678.61	266035.36	404868.75
4	423583.99	957420.30	405562.72	292104.14	223745.74	140651.92
5	257919.26	263086.52	532688.13	283629.82	173245.16	130428.13
6	138614.58	148409.10	150694.79	284980.24	182750.26	101434.97
7	161717.65	84230.71	78985.98	84185.91	147257.28	104910.12
8	20126.85	85228.61	46465.97	41437.44	45934.17	75549.74
9	22465.77	21857.76	47255.92	45301.65	42619.11	45620.91

year

age	1995	1996	1997	1998	1999	2000
1	1549956.98	1755449.56	2064130.04	1044229.436	917624.615	2620471.359
2	899137.54	734319.46	818966.76	984040.891	458481.942	397499.282
3	347015.46	522767.90	444074.07	468292.840	645958.552	259696.452
4	211786.92	189068.05	260144.03	237238.837	230976.787	367411.344
5	77394.43	100852.51	101690.76	123315.436	110932.177	115911.822
6	73629.34	41407.69	54837.56	47087.518	48817.261	56646.825
7	58205.69	41263.02	21247.20	22480.567	18878.036	24386.187
8	54346.79	30937.29	22566.41	7209.928	7082.103	8340.331
9	55241.88	48255.98	30009.07	17602.107	8847.407	7805.699

year

age	2001	2002	2003	2004	2005	2006	2007
1	1778193.593	1949044.28	1094076.32	935310.69	942432.24	822341.98	532968.50
2	1281007.840	823006.96	923967.64	504602.96	424040.25	450606.00	393461.44
3	216144.948	813565.35	501022.20	579044.02	311136.34	245567.96	273139.59
4	137608.767	110571.21	448427.72	306426.71	366505.10	175117.31	125966.01
5	201687.230	78539.86	56614.86	230331.40	196578.68	234739.78	99557.34
6	63011.574	111623.96	42207.28	28548.87	117888.42	135250.79	124490.87
7	30987.916	33997.45	52098.48	27524.70	13542.90	70201.34	74487.68
8	12109.552	14862.89	16256.80	23077.57	15697.54	8454.46	33095.24
9	8452.598	10733.05	12850.18	15408.77	17458.11	20571.05	14038.66

year

age	2008	2009	2010	2011	2012	2013	2014
1	646805.75	713154.32	1163676.50	516559.060	506443.021	247199.110	318736.346
2	248126.59	303508.25	323952.95	561032.343	232765.838	230899.558	110318.548
3	227705.01	151452.75	183640.06	189392.686	366098.510	151871.053	136990.749
4	145804.63	123364.39	82973.30	97211.203	103400.216	216344.959	94965.022

```
  5  66595.91  80499.34   66106.86  42383.036  49718.345  55005.259 111294.640
  6  52388.68  38545.13   38863.30  32666.778  23011.877  24612.807  24731.249
  7  65588.76  29548.11   20608.39  16758.340  16248.758  13026.753   9801.471
  8  34474.60  35690.24   14846.63   9444.112   7239.809   7730.462   5137.261
  9  22375.59  30670.27   32407.72  21846.764  14841.080   9621.701   4192.704
   year
age       2015        2016        2017        2018         2019         2020
  1 519001.724 216836.3235 258102.666 354563.553 1025677.097 1320910.801
  2 146043.579 258315.4882  97655.010 119690.182  161748.082  480505.476
  3  66494.800  86172.5362 187714.593  67347.896   80614.251  105299.482
  4  75849.683  37664.7343  56025.433 124022.753   48287.699   56329.201
  5  49704.601  32859.2500  24514.100  36414.712   76155.999   30898.789
  6  41821.623  20410.8330  17530.158  14649.042   21178.828   50824.275
  7   8445.954  10214.1385  10559.518   8959.962    8036.753   12847.253
  8   3466.617   1749.5584   4089.956   5522.842    4576.380    5365.815
  9   1612.313    662.4485   1159.662   2526.755    4259.643    5632.593
```

TABLE 4.6.15 Herring in 6a and 7bc. PREDICTED CATCH NUMBERS AT AGE

```
Units  :  NA
<0 x 0 matrix>
```

TABLE 4.6.16 Herring in 6a and 7bc. CATCH AT AGE RESIDUALS

```
Units  :  NA
<0 x 0 matrix>
```

TABLE 4.6.18 Herring in 6a and 7bc. PREDICTED INDEX AT AGE catch N

```
Units  :  NA
   year
age      1957       1958       1959       1960       1961       1962       1963
  1 14951.462  31878.111  43257.934  14802.985  21052.165  40874.915  34727.158
  2 83606.286  44522.260  78794.421  89341.885  26831.170  69914.833  76217.836
  3 49932.534 116299.297  43993.959  61020.354  62261.616  30076.985  44377.432
  4 26014.955  44178.316  82441.165  26911.948  35043.982  67129.764  15299.385
```

5	34965.320	26910.725	28774.642	42411.464	16423.952	43120.510	37397.861
6	17305.254	29573.398	16918.656	11936.137	16796.032	16929.695	22255.671
7	9142.211	16705.994	18443.301	8974.774	5662.435	21432.866	9900.975
8	1713.709	7730.549	8507.935	7123.846	3655.842	6244.930	11792.903
9	5380.351	6035.652	6759.910	5377.070	4386.211	8166.554	7262.941

	year						
age	1964	1965	1966	1967	1968	1969	1970
1	23169.381	93959.681	20260.747	40249.354	44054.43	44312.56	73903.13
2	71981.122	42957.134	274260.539	35108.680	63951.75	132816.36	159451.44
3	60534.993	60257.099	45424.474	237501.557	22305.64	87359.43	217453.47
4	28077.846	47091.846	57743.756	34583.173	155039.47	27228.81	102272.86
5	10012.836	20238.444	39750.209	39089.732	17415.68	192725.48	27295.28
6	23522.567	7203.155	16751.613	26732.624	21261.12	22103.33	174482.92
7	17587.237	20786.154	7233.504	12630.751	15661.86	31375.85	20747.18
8	7698.768	15188.477	18703.658	5661.742	7021.03	20536.66	23575.46
9	13063.070	14828.458	21666.877	23661.799	12974.20	21288.29	24571.27

	year						
age	1971	1972	1973	1974	1975	1976	1977
1	290490.27	73120.645	59497.196	73600.38	67347.29	42603.257	30915.612
2	395043.84	506792.271	270542.298	200114.32	192698.79	204137.632	78311.731
3	289678.77	167430.410	593066.330	211700.96	102690.94	106375.996	71129.478
4	262354.49	68876.595	126206.593	371325.72	78278.70	43301.579	28131.085
5	106573.36	65766.986	53550.518	79033.29	134930.60	31522.305	11607.194
6	28398.72	29712.909	53038.472	38675.59	30862.78	62538.176	10517.427
7	185275.57	9068.872	23127.050	36163.23	12973.30	11572.717	16703.251
8	18271.01	54564.112	6214.613	15280.83	11357.85	4046.150	2315.775
9	34449.65	13629.297	45013.064	33214.76	16101.45	9112.943	2591.054

	year						
age	1978	1979	1980	1981	1982	1983	1984
1	25364.226	174.227993	121.506994	27719.699	30964.301	60539.062	19651.971
2	54945.692	141.775867	190.421211	81917.137	184118.746	111690.650	201346.594
3	28026.608	64.266086	115.920795	99282.998	83427.220	95317.627	47451.659
4	21320.400	25.287679	43.879374	55989.220	91527.508	35906.270	32489.256
5	7566.739	14.919353	16.440443	20702.310	54622.981	42909.039	13095.653
6	3973.241	7.838829	12.287662	10937.993	24524.065	29064.320	14393.439
7	2723.343	3.617589	6.212120	8198.119	12831.907	13398.952	9292.198
8	3457.084	1.655327	1.758945	2329.155	7621.819	5382.759	3231.048

```
  9  1131.595   3.047762   2.632007  1963.827   4693.100   5727.066   2534.257
   year
age       1985       1986      1987       1988      1989      1990      1991
  1  18058.789  18717.903 23325.463   7747.868  5464.015  5309.945  3332.334
  2  78136.762 116633.306 74130.768 110520.511 40094.549 46541.178 30221.734
  3 130167.210  75389.677 59254.791  43473.363 82305.152 45335.886 28308.236
  4  20727.631  99827.574 32866.373  27694.539 22543.134 72056.186 24176.900
  5  16396.557  16970.676 53963.173  18218.936 16859.019 24558.279 38448.321
  6   6347.840  12392.236  8643.964  25507.703  9867.842 15440.471 12185.328
  7   6408.172   3821.529  6573.322   3693.713 13988.917 10928.612  7790.883
  8   3450.504   3446.705  2334.852   2912.622  2226.950 14758.021  5835.780
  9   2020.869   2819.416  3688.014   2159.804  2485.741  3784.848  5934.991
   year
age      1992      1993      1994      1995      1996      1997      1998
  1  5152.734  4460.205  5672.175  4454.172  3474.184  6266.558  2945.920
  2 28064.925 47315.774 36408.619 58417.180 32469.710 65743.807 75940.697
  3 26676.429 20057.442 28962.856 27562.289 29879.168 49257.895 51325.871
  4 19268.645 14297.085  8399.731 15170.941 10975.091 33996.695 31059.898
  5 21718.417 12605.910  8764.554  6176.306  7534.384 19066.690 23108.307
  6 24186.344 14662.489  7598.179  6322.916  3596.644 12642.077 10717.297
  7  8602.817 15593.172 11463.381  7744.883  5868.008  7232.750  7192.552
  8  5177.934  5817.292 10214.948  8793.371  5253.281  7656.730  2066.208
  9  5660.798  5397.458  6168.324  8938.196  8194.067 10182.006  5044.381
   year
age      1999      2000      2001      2002      2003       2004       2005
  1  2144.253  5005.588  2632.646  3025.308  1275.354   887.5018   606.4679
  2 30378.994 22389.701 57262.144 41239.634 34154.003 14766.5642  7781.0058
  3 63348.321 23248.242 16669.492 76899.644 37962.069 36561.7380 11867.5571
  4 24878.430 37053.303 12234.465 12443.611 43098.366 26759.2078 17107.0097
  5 15608.092 15572.773 26152.338 13208.080  8199.843 33155.2195 13761.1611
  6  7613.213  8217.043  9202.443 20484.827  6589.801  4725.6124  9535.0770
  7  3837.283  4473.129  6004.518  8008.588 11350.427  6330.1716  1446.4627
  8  1260.217  1332.865  2131.871  3179.016  3555.369  5818.2748  1833.9005
  9  1574.342  1247.426  1488.069  2295.686  2810.340  3884.8302  2039.5837
   year
age      2006       2007       2008       2009      2010       2011      2012
  1   740.473   627.5497   552.5302   949.5946  1967.630   794.2868   784.227
```

2	12634.411	15367.4119	6390.5608	13419.9856	19008.109	29553.0135	12554.324
3	13820.768	19100.8746	10216.2256	11655.8638	18337.863	17264.5585	36017.153
4	12995.394	10450.2104	7431.0797	11402.0225	10058.981	10919.9460	12966.770
5	29786.837	13591.3581	5172.3414	10395.3828	11077.983	6563.2507	8670.196
6	22806.918	23858.2099	5845.0565	6388.1206	7689.261	5921.8353	4825.082
7	16745.118	20414.1892	11161.3042	6824.9816	5212.536	3768.2795	4063.223
8	2327.388	11003.8178	7709.5632	10748.7164	4932.380	2869.3784	2498.271
9	5662.907	4667.7054	5003.8575	9236.8706	10766.567	6637.6419	5121.273

	year						
age	2013	2014	2015	2016	2017	2018	2019
1	455.2306	574.9899	1076.698	149.7044	145.3963	211.3829	247.4374
2	15578.6038	7335.0742	11681.229	5281.7160	1510.6575	1945.7938	820.7491
3	19857.3981	18646.0100	11758.712	4300.4502	7784.4430	3113.8562	1198.9875
4	40163.2535	19323.4388	20377.701	3070.3235	3793.1435	10099.3996	1333.9948
5	14385.6202	32890.2000	19047.739	3976.3727	2314.5137	4249.2988	2739.1873
6	8011.2318	9265.1599	21644.453	3630.4802	2174.7241	2092.9112	800.1513
7	5104.4988	4454.9235	5227.438	2500.3951	1617.8790	1346.6921	277.3850
8	4264.8728	3190.6590	2530.389	554.1544	764.2370	877.8962	132.1629
9	5308.2638	2604.0120	1176.876	209.8237	216.6910	401.6463	123.0157

	year
age	2020
1	56.05402
2	268.57370
3	189.67679
4	202.28200
5	148.47078
6	259.53055
7	65.82870
8	21.30598
9	22.36527

TABLE 4.6.19 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS catch N

Units : NA

year

age	1957	1958	1959	1960	1961	1962
1	2.738267365	0.00042246759	0.8345279	-1.17507614	-0.04072748	1.34938301
2	2.773025772	2.48099665085	0.4834641	0.07143911	-0.11032265	0.02571661
3	0.008832846	0.10362496575	-0.7131441	-0.09347119	-0.07767514	-1.41249884
4	2.747304618	-1.46162339968	1.0190350	0.16620324	1.24149822	0.79032501
5	0.007689976	-0.00003942468	-0.6291319	-0.03499483	1.19598642	0.81427240
6	4.012937536	-2.73998988496	0.2327993	-0.70797337	-1.04678085	1.45684664
7	0.000335778	-0.03433154155	-0.7153010	0.87693673	0.02905646	1.05229018
8	0.392774019	-2.00637088443	-0.5597752	-0.45967395	1.37076221	1.15201239
9	1.496855651	-0.00085028720	-0.3198755	-1.69431370	-0.21377992	0.12220547

year

age	1963	1964	1965	1966	1967	1968
1	-0.4006621910	0.24589996	1.0995369	2.00831328	0.58319259	1.2355700
2	0.1592545033	0.04097371	-1.9522247	0.73375008	-1.61378299	-0.2432530
3	-0.0406793461	0.20454570	1.4201624	-1.33237574	2.48944394	-0.8664334
4	-1.5120490519	-0.45670176	0.4845245	-0.29827859	0.63647209	0.5361185
5	-0.0007984914	-1.24302534	-0.4776931	-0.64101518	-0.02614713	-1.1688641
6	1.1063344172	0.33477828	-1.1394671	-0.06572614	0.16280933	0.2947427
7	-0.2542036324	0.66347216	0.4020401	-1.02193858	-0.48164997	-0.2271377
8	0.7961495488	0.79654568	0.6650987	-0.28812582	0.03441710	-0.5138562
9	0.4298029914	0.84861135	0.8702735	0.54244250	0.19990169	-0.2473821

year

age	1969	1970	1971	1972	1973	1974
1	-0.24180248	1.0126313	0.95043519	0.23273729	-0.34927982	0.3933181
2	0.08026832	-0.2715237	0.19753047	1.10166563	-0.08366549	-0.5025531
3	0.34913052	1.3170030	0.09762978	-0.42608801	1.32910186	-0.3521968
4	0.20840870	-0.2073455	-0.34968698	-1.03604058	-0.03059812	2.4371438
5	1.28496762	-0.4205221	-0.59484736	0.09896694	0.37611645	0.5785555
6	0.09031009	-1.1616071	-0.35466037	-0.26260015	-0.02408087	1.3951882
7	1.20224012	-0.4586583	-0.90652157	0.21275494	-1.24261101	-0.0644686
8	0.27726635	-0.2372672	-0.78234950	-0.72091468	-0.46115118	0.6867742
9	0.27171035	-0.4547379	-0.99316292	0.06704591	-0.87391355	-1.0087429

year

age	1975	1976	1977	1978	1979	1980
1	0.06197592	-0.325611111	-0.5045566	-0.37955988	-2.5799687	1.04473018
2	-0.38276058	1.111875169	-0.7962940	-0.08961234	-3.0121656	-0.02126671
3	-0.48912617	-0.630493792	0.8853495	-1.15729541	-2.2681602	-1.09524714
4	-0.68096404	-0.680560298	-0.7701975	1.77810396	-2.3856984	0.28323872
5	1.04761852	-0.733568233	-0.2838097	-1.15378178	-1.5223789	-0.36374496
6	0.02883519	1.034474432	0.5882325	-0.70818453	-0.2857750	-0.99488684
7	-0.15343698	-0.005968159	0.8938317	-1.09523157	0.2021739	1.01305468
8	0.10901803	-0.376690701	-0.1891111	1.05481676	-1.6320467	-1.28179730
9	-0.23039019	0.321541116	-1.9061637	-0.07214844	0.0000000	0.00000000

year

age	1981	1982	1983	1984	1985	1986
1	2.056503	-0.74088421	0.6459666	-1.5921182	0.04424960	-0.2474453
2	3.388304	1.94772714	-0.2249438	1.9945366	-0.27381390	0.2351617
3	2.728118	-0.49617558	0.1926591	-0.5925464	0.62991614	0.1929341
4	1.637689	0.08241607	-0.8422236	-0.7213418	-1.48518056	0.4211869
5	1.141386	0.65251284	0.2404323	-0.2238268	-0.20361194	-0.2791053
6	1.197581	-0.19093251	-0.2255353	-1.6423943	0.03764504	0.3052885
7	1.469925	-0.30134463	0.2856370	-0.7780691	-0.58150300	-2.4613655
8	-1.160819	2.23069741	1.3133440	0.4079912	-0.21375457	-1.9272497
9	-1.398658	-0.49554318	0.4367651	-1.3707701	-0.61274504	-0.7648786

year

age	1987	1988	1989	1990	1991	1992
1	-0.2581704	-1.5385576	-0.5328550	0.06102022	0.30694659	-0.36474831
2	-0.1322853	1.3588014	0.1085871	0.03169344	-0.68600432	0.03418524
3	-0.5989250	-0.5503570	1.2684669	0.43670756	-0.08381661	0.25896953
4	0.6504909	-0.3185622	-1.4426124	0.38218514	1.33256821	0.80851309
5	0.5331864	0.2035957	-0.2703157	0.24429630	-0.78336778	0.75429507
6	0.1156270	-0.1713580	-0.8559917	-0.58874327	0.32496844	0.22133541
7	0.9313464	-0.8091470	0.3634388	0.45350493	-0.38692974	-0.87035965
8	2.0538645	-0.3328094	-0.1130256	0.88463752	0.54500395	-0.35018121
9	0.5067161	-0.3099062	0.3973412	-0.06362524	-1.69365567	0.06608976

year

age	1993	1994	1995	1996	1997	1998
1	0.45631630	-0.6557356	-1.8530285	-0.5597062	-0.7638305	-0.05508909
2	1.12741967	0.9260616	1.8586750	0.6202514	1.0595145	0.11812368
3	-1.21722133	-0.1594763	-0.2733714	-0.6503292	-0.2160618	-0.38997166

```
  4 -0.84537852 -1.7865268  0.3190898 -0.5162119  0.3962233  0.68109319
  5  0.51011673 -0.1431833 -0.8008211 -0.1255034  1.5748066  0.04497291
  6  0.79108993  0.5219998 -1.1323010 -0.2504339  1.6981804  1.00780510
  7  1.07162221  0.8321637  1.4505018  0.8035744  0.9806860  0.12678184
  8  0.02523248  0.8759184  0.1307362  1.6714762 -1.0337248  0.09401553
  9 -0.06946946  1.6045001  0.5452096  2.6639308 -0.7780529 -0.61711458
   year
age        1999       2000       2001       2002       2003        2004
  1 -0.23582014 -0.1924166 -1.7921976 -0.7121110 -2.2199798  0.00000000
  2 -0.35985649 -0.3898411  2.1638018  0.5466615  1.2149594 -0.74793135
  3  2.25511577  0.3495823 -1.0181935  0.8450532  0.5877006  0.31390645
  4 -0.90760305  1.3831401 -0.6497070 -1.3493625  0.4413543  1.67592815
  5 -1.22234758 -0.1597484  0.8233401  1.3726291 -0.6615260  1.27770449
  6 -1.05576799  0.1532700  0.7643728  0.6321818 -0.9113702 -0.05664467
  7 -1.00398838 -0.5106459  0.9825024 -0.1043623  0.6291592  1.86762485
  8 -0.23674759  0.4265253  1.7254197 -1.7282246  2.5214549  0.83322559
  9 -0.01981255 -1.4134963 -0.9131195 -0.8000473 -1.3066670  0.27830313
   year
age        2005        2006        2007       2008        2009       2010
  1 -1.02790585 -0.64705366 -0.63558173  0.0000000  0.91822842  1.2651605
  2  0.28474024  0.58944415  2.15064595  0.1367804  0.01864254 -0.5403566
  3  0.79678815 -0.84006305 -1.30077581 -0.5703410 -0.31579845 -0.3388569
  4 -0.86158081  1.06870139 -2.16974368 -1.3670065  1.18898892  0.1360535
  5 -1.64314478  2.21772888  0.31929015 -1.6109821 -1.03197246  0.7889436
  6 -0.43930020  2.05908359  0.98818646  0.2339863 -0.64323706 -1.5021990
  7 -1.99506224  1.16666464  0.48577606  1.2491221 -0.26094810 -0.9220286
  8  0.01587533  1.11063022  0.64279173  0.4421223  0.10418591  0.2518617
  9 -0.68374650  0.03665972  0.06075916  1.7039217  0.03758788  0.5168589
   year
age        2011       2012       2013       2014       2015        2016
  1 -0.02168584 -0.1695708  0.0000000  0.0000000 -0.4432362 -1.93723124
  2  0.34508759 -0.1897759 -0.4314816 -0.3227769  0.4251327  1.08434999
  3 -0.78097231  1.1831121  1.2360296  0.1571322  0.5860693 -1.69657987
  4 -0.07563986 -1.0987506  1.5710817  1.5813347 -0.5953349  0.34171219
  5  0.25799659 -0.2227711 -0.7773433  0.8454477  0.4011084 -1.49710085
  6 -0.37090708  1.3010276 -0.2925139 -0.8822561 -0.0984991 -0.02016763
  7 -1.21294480 -0.5313384  0.8224835 -1.1051970  0.4243864  0.12248771
```

age						
8	-0.18036304	-2.0271912	0.3121499	0.2927277	-0.6190010	0.14805383
9	0.47828440	-0.1544604	-0.2399892	-0.3165956	-1.2671535	0.89206908

year

age	2017	2018	2019	2020
1	0.0000000	0.00000000	1.3554135	-0.1313598
2	-0.7166020	0.01842351	-1.1582775	-2.3585986
3	2.1902192	0.45834448	-1.3787230	0.3339537
4	-0.3428280	-0.37922089	1.3415001	0.6547358
5	-0.6070494	1.46272687	-0.8627675	-0.1949470
6	-2.0420803	0.84286600	-0.9172657	-0.9019673
7	-1.2452375	-2.71307422	-2.0332888	1.8468275
8	-1.5484642	-1.10580968	-2.9465379	-1.7401780
9	0.1770651	-0.05863907	-3.1305644	-0.4669229

TABLE 4.6.20 Herring in 6a and 7bc. PREDICTED INDEX AT AGE catch S

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963
1	185.4472	413.5260	506.3566	168.3969	314.9390	437.5766	274.4782
2	9262.6138	4648.4421	7635.2918	9217.1453	3765.7931	6696.4117	6627.7301
3	6063.8091	13488.9276	4912.8549	7739.9660	11884.9277	4221.4922	5858.1150
4	2996.1081	4913.8067	8229.5054	3071.3743	6422.4202	9510.0032	2197.5660
5	4157.0324	2992.3653	2647.5141	4016.8091	2569.1545	5408.6616	5058.7558
6	2229.4728	3569.4283	1710.6743	1273.3796	3177.3362	2564.3548	3716.9228
7	1370.9337	2244.2812	2074.8654	1089.4799	1263.3787	3949.5963	2079.4291
8	261.6064	1196.5093	900.8573	646.1119	640.2610	1075.9405	2033.6241
9	821.3378	934.1786	715.7687	487.6845	768.1733	1407.0176	1252.4560

year

age	1964	1965	1966	1967	1968	1969	1970
1	176.2451	801.2518	188.111	474.3307	630.0684	577.2211	741.3155
2	6497.1432	4431.3229	27376.097	4268.9218	9814.8873	15553.3076	12043.4560
3	8580.1361	9881.9231	7781.680	48336.6581	5381.9344	14161.5458	21174.7007
4	4483.2808	8315.3971	10863.006	7969.2541	43507.4793	5030.3588	12324.1584
5	1632.6347	3657.8626	7708.106	9295.4882	5084.2131	37160.7013	3956.8428
6	4669.2802	1609.2468	3856.174	7090.6702	6526.5212	4485.5480	30778.4657

```
  7 4195.1533 5388.4120  1978.553  3767.1093  4904.5561  5936.6663  3679.7253
  8 1501.5862 3225.5586  4551.716  1576.8019  1615.6073  2742.1717  3046.4783
  9 2547.8526 3149.1019  5272.844  6589.8399  2985.4900  2842.5332  3175.1594
   year
age      1971      1972      1973      1974      1975      1976      1977
  1  1473.432  1090.484  1339.372  2792.593  4513.216  3983.478  3707.123
  2 11899.851 41516.142 24233.616 23228.766 34626.909 45503.386 25841.880
  3 11148.362 17567.465 65169.380 30079.863 23629.199 31466.045 30383.609
  4 13960.401  9842.832 17923.999 62205.501 22239.901 17044.047 16030.364
  5  7933.352 12710.078  9880.527 15681.413 42961.282 14610.078  8321.202
  6  3004.046  8062.865 13312.596  9076.444 10405.549 26765.088  6822.564
  7 23205.190  3089.232  8005.386 11407.111  5465.483  5574.663 11287.369
  8  1926.126 21545.824  3300.455  9563.769 10725.679  4513.176  3096.827
  9  3631.675  5381.824 23905.525 20788.031 15205.257 10164.804  3464.951
   year
age      1978      1979      1980      1981      1982      1983      1984
  1  4636.265  4352.943  2644.480  2478.840  1628.337  6116.300  2389.421
  2 31200.256 42594.686 47401.251 21470.906 25435.401 26926.914 64338.192
  3 21686.010 29909.258 49051.761 43017.712 19126.724 36764.319 24313.626
  4 20814.062 16784.918 26745.481 33281.006 27874.246 17987.567 21898.485
  5 10059.408 14042.974 14482.646 16304.520 19950.478 23333.080  9709.054
  6  5076.045  7482.791 11494.166  9429.295  9698.324 16485.125 12147.840
  7  3541.452  3461.929  5698.724  7041.826  4851.508  6808.400  7607.916
  8  8263.269  3116.421  3347.892  3620.372  4041.209  3963.198  3376.406
  9  2704.788  5737.905  5009.636  3052.517  2488.356  4216.703  2648.268
   year
age      1985      1986      1987      1988      1989       1990       1991
  1  2250.252  1972.365  5611.629  1601.972  1085.284   987.4535   918.5198
  2 26487.367 30438.807 39876.138 56716.172 20451.033 19345.9833 17903.8569
  3 74188.961 34700.939 56087.463 40090.954 75621.436 33159.9279 29381.7831
  4 16389.499 65455.539 42139.043 35621.187 30110.881 73392.2689 34165.5443
  5 14518.021 12773.547 72307.549 24251.022 23411.721 25006.0733 55543.2502
  6  6615.337 11494.040 13007.701 39386.881 16257.925 17777.0987 19730.5148
  7  7107.706  4177.062  9885.502  5553.615 21190.508 10922.7660 11293.9341
  8  4636.823  4395.554  4344.395  4140.206  2813.188 11471.6571  7532.9380
  9  2715.665  3595.578  6862.185  3070.098  3140.106  2942.0258  7661.0025
   year
```

age	1992	1993	1994	1995	1996	1997	1998
1	1539.254	1464.503	2978.301	2366.141	3327.532	3998.440	2841.412
2	15631.106	26176.437	28046.621	42438.692	40961.406	45420.444	70587.634
3	26836.595	21048.917	39130.682	34115.920	59606.920	48161.639	63843.390
4	27505.734	23746.862	18132.746	28066.106	28753.249	36687.103	40699.020
5	30954.172	20581.073	18604.293	11392.207	16535.256	14636.997	21073.750
6	38289.663	25078.880	16122.170	11935.616	7394.281	8118.582	8016.281
7	12121.450	21303.353	16896.124	9187.204	7035.816	2858.995	3464.564
8	6820.510	7582.077	15030.261	10301.339	6479.941	3502.074	1397.871
9	7456.551	7034.878	9076.063	10471.001	10107.410	4657.097	3412.721

year

age	1999	2000	2001	2002	2003	2004
1	1798.9886	4017.3056	2174.9641	2236.7993	964.3221	696.6239
2	26556.6343	19773.1293	55558.4453	34757.3119	33345.9416	16767.9157
3	70834.5113	24996.6846	19025.3119	69648.4751	37289.4956	40488.1939
4	31157.3208	42484.6056	15071.5252	12018.5183	41280.3483	25504.6001
5	14610.8521	12882.7084	21416.1200	8280.2381	5109.2605	17988.1406
6	6399.4540	6137.6990	6552.1500	11455.7701	3708.7045	2158.5016
7	2300.9879	2420.7744	2800.6354	2907.7581	3641.8128	1602.3943
8	891.2791	740.4751	873.4939	947.9165	664.2358	643.5319
9	1113.4417	693.0091	609.7081	684.5257	525.0449	429.6827

year

age	2005	2006	2007	2008	2009	2010
1	744.3074	929.8654	544.0494	676.6859	563.7872	976.6873
2	15522.1399	22076.6765	18221.9368	11813.0921	11589.8617	12633.2301
3	24565.7936	26359.0593	28340.6660	24776.5458	13366.3154	16519.4134
4	33445.7196	21619.5475	15284.7017	19394.9098	13411.5020	9271.9665
5	16108.5120	24565.4152	10084.1844	7932.2122	8154.5258	7191.9524
6	8836.8166	11770.2871	9791.8663	5050.8571	3293.1907	3886.3928
7	778.7558	4233.9300	3693.5535	3938.0196	1552.6732	1366.8341
8	374.3931	202.3235	476.0076	585.3561	446.6838	293.5630
9	416.3835	492.2854	201.9175	379.9228	383.8561	640.7994

year

age	2011	2012	2013	2014	2015	2016
1	290.2504	157.47803	64.72588	83.69915	59.90812	37.79401
2	16097.0562	4188.46535	3696.97965	1806.50395	1287.79667	3206.02150
3	12795.7494	15500.31260	6103.84239	6008.77513	1564.23815	2973.88086

age						
4	8301.2143	5363.15927	11262.68524	5628.84654	2321.03416	1758.01645
5	3636.5052	2564.70146	3034.12096	7371.95711	1659.87775	1825.76445
6	2745.4041	1179.90896	1444.00682	1779.73119	1432.41606	1324.23612
7	1027.5297	649.48668	635.86701	609.12951	245.99416	624.55283
8	180.1334	74.96785	134.13312	149.19528	33.43771	53.18545
9	416.6970	153.67863	166.94847	121.76366	15.55177	20.13801

year

age	2017	2018	2019	2020
1	50.68326	52.43965	179.5597	141.31591
2	1334.55885	1316.58150	1973.5140	4052.79434
3	7041.08696	1973.62688	2529.6989	2279.26638
4	2832.59791	4576.58659	1806.0244	1397.20588
5	1479.36652	1534.42285	3099.2991	788.63941
6	1320.82077	760.88964	1063.2055	1538.13161
7	823.96311	509.71730	459.4593	447.02414
8	208.51179	178.42091	155.0594	78.79500
9	59.12123	81.62935	144.3276	82.71254

TABLE 4.6.21 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS catch S

Units : NA

year

age	1957	1958	1959	1960	1961	1962
1	0.0000000000000	-0.07855290	1.78337599	0.68075410	0.99653160	-0.8117938
2	2.6189949346334	1.85856923	0.06361703	0.09981635	-1.17778618	-0.4632582
3	0.3953326365220	-0.16357473	-0.02290094	-0.10785263	0.08755328	0.1519307
4	0.3705483792729	2.27844808	1.31457787	1.69633263	0.77300255	0.5104304
5	5.0542671640955	0.56256682	-0.11951782	-2.42413421	0.40543740	0.5629290
6	1.7000330637591	0.23898321	-0.14214188	-0.74250981	0.19881264	1.5253970
7	0.0000001340854	0.78640883	-0.16172115	0.06527083	-0.48389485	0.8544587
8	0.0642666012502	-0.02352481	-1.47392341	-0.36936587	1.45953334	1.1954926
9	-2.9775537250838	0.86665278	-0.82126289	-2.02671354	-0.29095881	1.0688112

year

age	1963	1964	1965	1966	1967	1968
1	-1.0423619	-0.93699088	0.02432629	0.00000000	0.0000000	0.24444669
2	-0.5606308	0.23183829	0.21857626	0.10798461	-2.1941799	0.12999125

```
  3 -0.8497768 -0.44898715  0.62807369  2.00313252  1.6819449 -0.68625254
  4 -0.4957890  0.16677745  0.47279686  0.30068769  1.5322699  1.52757272
  5 -1.0536553  1.14832760 -0.93511401  0.09298223  0.1468127 -0.24176652
  6  0.5934040  0.01992177  1.05921855 -0.37762337 -0.4347129 -1.24987087
  7  0.6480923  0.34045390  0.42822067  2.04551680 -0.4575512 -1.92530817
  8 -0.2647212  0.48758254 -0.32497121 -0.94039949  1.3608632 -1.62074879
  9  2.0557704  1.43681889  1.03913218  0.30334329 -0.2302539 -0.05135304
   year
age        1969        1970       1971         1972        1973       1974
  1  1.04935255 -0.95512835  0.2176951  0.842195592  1.62985639  0.7417059
  2  0.50745614  1.82468690 -2.2618810  0.110720255  0.65231450  0.3860149
  3 -0.47003715 -0.31703631 -0.3205637  1.307430146 -0.44103400  0.6326678
  4 -0.45706653 -0.42813753 -0.7719317 -0.333646939  0.09145423 -0.7568075
  5  1.22535496  0.01895863  0.5488526 -0.004246179 -0.51056644  0.3508157
  6  0.45118085  0.95837286  2.0306699  0.856451872 -0.16389095 -0.4391827
  7 -1.01151371 -0.23429738  0.2804521  0.792168336  0.35193496 -0.2477277
  8 -0.80561033 -0.99779793  1.3675057  1.535266147 -0.31490554  0.3787638
  9  0.06476194 -0.89845160 -0.7617035 -0.502465816  1.74793251  0.8957415
   year
age       1975       1976       1977        1978       1979        1980
  1  0.7141864  0.8973339  0.1046658  0.85523215  0.1327450 -0.69371066
  2 -0.2964170 -1.5705657 -0.1120212 -0.08301753 -0.2426144 -0.65929783
  3 -0.3119014 -0.1132790 -3.1324899 -0.01303075 -1.2339856  1.12822225
  4  0.5125712  0.9363374 -0.2668039 -2.07262305  0.7476951 -0.17831124
  5 -1.6936800  1.0651782  0.5864799 -0.08494481 -1.1786197  1.21231050
  6 -0.3321843 -2.1919141  0.1254967 -0.11362539  0.4268384 -0.91184983
  7 -0.3625384 -0.7563165 -1.7772707 -0.11594014  0.4592772 -0.03449135
  8 -0.1639293 -0.6311072 -1.5760550 -1.21666320  0.7845194  0.62390305
  9  1.3591763  0.4986624  0.1143097  0.27801198 -0.8323308 -0.37432744
   year
age       1981        1982       1983       1984       1985       1986
  1 -0.4818547 -0.64625522  0.1998651  0.2227332  0.9035720 -0.8106234
  2 -0.8560484 -0.43634045  1.4596400  0.6668407 -1.2869020 -0.1930286
  3 -0.4388287 -0.18621800  0.9750832 -0.4865624  0.2124670  0.3050720
  4 -0.3986487 -0.04862526  0.6313514 -1.2381437 -0.5239459  0.3074800
  5 -0.9802244 -0.45993935  0.1218833 -1.2468069 -0.3423946  0.4806793
  6  0.5913137 -0.51963144 -0.2387722 -0.1756035  0.3553617 -1.2743573
```

```
  7 -1.3339021 -0.25400309 -0.3834782 -0.5178024  0.3605528  0.3112589
  8 -0.1621269 -0.38983040 -0.4179564 -0.8465768  0.5318741  0.2393719
  9  0.3830480 -0.07015209 -0.3707683  0.3774307 -0.8885301 -1.3543816
   year
age        1987         1988        1989       1990        1991         1992
  1  1.41928328  0.000000000  0.22750219 -0.1186071 -0.38076934  0.526980845
  2  0.68190087 -0.951171097 -1.59863059  1.0357629  1.34549960 -0.004209043
  3  1.45033900  0.096674523  0.54504756 -0.3638062 -0.09427018  1.232385009
  4  0.40200603  0.008254849 -0.14258859  1.8591584 -1.76572070  0.195040466
  5  1.01033616 -0.465072309 -0.33243850 -0.2262688  1.36720902 -1.273099085
  6  0.25178059 -0.095783701  0.04911465 -0.0268440 -0.28335308  1.359753442
  7  0.08935928 -0.199696654 -0.04704360  0.3726518  0.22340993 -0.361242521
  8  0.33861731 -1.275544231  0.53951959 -0.9478763  1.06705689  0.293283910
  9 -0.02635400 -1.373743943 -0.73890058 -1.9132511 -0.39251806 -0.249658200
   year
age         1993       1994       1995       1996       1997        1998
  1 -1.824782572  1.8605283 -1.2314569  1.0201280  1.1652281  0.56102566
  2  0.004710759  1.4946338  0.3411954  0.1982629  0.9682183  0.71943109
  3  0.457377426 -1.1343684  0.2922726  0.8397428 -1.1887334  1.07766795
  4  2.118416109 -0.1303922 -1.1020523  0.3927335 -0.3457385 -0.09015064
  5  0.630183991  0.7422978  1.4394424 -1.8052787 -0.4613558  0.64196786
  6 -0.808904618 -0.1156032  1.0043783  1.7015832 -1.2423539 -0.03577696
  7  1.753962692 -0.8102203 -0.6642388  0.2994099  1.4154336  0.46316166
  8  0.150474495  1.3072393 -0.1322582  1.0162576  0.3866141  1.17654691
  9  0.043890177  0.2858937  0.5638861 -0.9565142 -0.2312327  0.05715848
   year
age       1999       2000         2001       2002       2003         2004
  1 -0.4780282  0.3483377 -0.009952588  0.5947092  0.2166374  0.262720845
  2  0.3024037  0.3755073 -0.936823576  0.2896322  0.3769318  0.386082855
  3 -0.2858459  0.5780323  0.116232886 -1.2420232 -0.7009093 -0.009762988
  4 -0.2068298 -1.0818065  0.570307246  1.0672588 -1.4361833 -0.580739637
  5 -1.1918385 -0.1988691 -0.064368568  0.7310831  1.4272312 -2.061152511
  6 -0.6216192 -1.8550920  1.339257941 -0.2178654  1.0792877  1.930192031
  7 -0.2920884 -0.6063770 -0.832510067 -0.1566659 -0.9738191  0.202330077
  8  0.1045226 -0.2597372 -0.337434291  0.2271488 -0.5280576 -0.337383120
  9  0.1564768  1.3479180 -0.532150376 -0.6135451 -1.3573179 -0.916570585
   year
```

age	2005	2006	2007	2008	2009	2010
1	-1.11707481	0.12747249	-1.9144960	-0.212399887	-0.8712117	0.33216093
2	0.86863926	1.19630803	0.1532992	-0.212498725	0.1647697	-0.34453823
3	0.44399744	1.20517571	0.9502346	-0.959090777	-0.5730133	0.32332018
4	-0.07803954	0.97305700	0.8154675	1.018160836	-0.9311826	-1.08482603
5	-0.33214839	0.07368337	0.6870527	1.216318693	1.0118162	0.02588731
6	-1.32258607	-0.28253518	-1.6518164	0.818251327	1.3658018	1.43620865
7	0.79295848	-0.93102356	-1.0227243	-0.291887475	0.5354773	1.47249179
8	0.93197380	1.27966561	-1.8890029	-0.005962772	0.2183961	1.62087037
9	-1.63312054	-1.31207145	-0.8521331	-0.632635265	-4.6239664	-1.41877014

year

age	2011	2012	2013	2014	2015	2016
1	-1.44847762	1.9724471	-1.00660747	-0.7805518	-0.73616192	0.68915470
2	-0.52659700	0.0035048	-0.62596568	-2.0443104	-0.22507349	0.22268399
3	-1.06550044	-1.0882715	-0.02091648	1.8372511	-1.92751530	1.38387112
4	-0.09335218	-1.8492495	0.46673486	1.1654162	-0.57753135	-0.35396213
5	-0.53249545	-1.8728774	-0.86163204	1.4366060	-0.21176455	1.20041246
6	0.62538472	-2.2323591	1.07758085	0.5988100	-2.80763335	1.29183611
7	1.40760499	-0.2598616	0.14754739	0.7261197	-1.43043419	-0.07035479
8	2.38226268	0.5899000	2.64071253	1.6462705	-0.05982866	-0.21847834
9	-2.24834565	-2.4727672	0.57072699	-0.3876158	-0.92971464	-0.98260675

year

age	2017	2018	2019	2020
1	-0.01919717	-1.0336414	2.53175948	0.11155885
2	0.19547385	1.0949500	0.12998757	0.92368506
3	-0.14481247	-0.1697891	0.62887186	-0.55609642
4	0.95436424	-1.0930450	-0.84230874	-0.38310827
5	-0.86389538	0.1796686	-1.85898034	-1.78300006
6	1.09415948	-1.5983594	-0.42258840	-2.51684872
7	0.41793710	0.1056432	-0.44981975	-1.36847088
8	1.21331505	0.2903369	1.46238298	0.09988218
9	0.63591616	-1.8877102	-0.06575532	-1.17512955

TABLE 4.6.22 Herring in 6a and 7bc. PREDICTED INDEX AT AGE WOS_MSHAS

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998
1	204028.6	289499.0	247733.4	372000.9	300984.0	341029.0	400650.39	202595.71
2	528408.8	396336.3	593382.3	502358.3	753671.9	621129.2	674238.03	801844.72
3	808584.0	635264.6	443047.9	667016.7	567339.4	859199.4	701307.81	722586.70
4	951108.1	676467.9	514140.1	318413.1	473380.4	420499.6	548160.00	485619.85
5	1393430.5	736486.1	447745.1	332086.6	194240.8	250599.7	231811.64	273473.18
6	469107.2	881658.3	566219.3	309959.2	222262.9	123081.4	145810.42	122566.51
7	278301.3	295459.0	514846.2	360423.1	196241.0	136276.9	58506.98	61977.12
8	184315.8	164088.6	181532.0	286608.2	202610.9	111992.2	71006.84	23120.81
9	187449.3	179390.5	168430.8	173069.1	205947.9	174685.4	94425.70	56446.46

age	1999	2000	2001	2002	2003	2004	2005
1	178206.68	509247.86	345764.57	378987.12	212849.32	182012.25	183435.46
2	380827.00	334714.93	1093080.50	700082.33	797014.64	438550.31	370491.70
3	1030283.89	421819.04	356959.50	1327536.13	837204.39	980412.35	533171.70
4	499595.11	812789.22	309038.27	243622.18	1015558.01	703836.94	863398.35
5	267524.93	286316.41	502370.03	189202.60	141111.91	580503.76	524109.36
6	142274.84	170186.52	189871.05	325592.03	127852.10	86693.45	383703.24
7	61597.79	82843.30	105130.14	111373.68	176161.40	93032.61	50821.72
8	27672.49	34264.71	49767.64	59501.98	66148.37	92191.95	70354.47
9	34570.20	32068.27	34738.35	42968.59	52286.95	61556.06	78245.16

age	2006	2007	2008	2009	2010	2011	2012
1	159986.20	103675.18	125848.59	138733.9	226304.24	100490.92	98541.46
2	387585.65	336400.47	213986.58	260051.2	274489.14	481062.22	200945.35
3	406041.10	448017.55	379462.40	250107.3	297297.39	314370.43	616245.45
4	393521.73	281521.44	331324.20	276430.1	180981.60	218441.43	236236.01
5	586863.17	247563.77	171388.69	201443.4	158848.97	105132.38	124889.65
6	405536.50	368422.41	163597.65	116030.9	112124.88	97109.17	68675.46
7	234933.47	243408.22	233360.30	100302.7	67632.85	56748.65	54826.89
8	33178.04	123949.93	142613.99	138142.5	55313.09	36228.34	26877.39
9	80727.48	52578.28	92562.97	118712.3	120739.29	83805.87	55096.69

year

age	2013	2014	2015	2016	2017	2018	2019
1	48089.74	62008.27	100958.964	42223.89	50263.679	69049.60	199796.98
2	197684.46	94491.22	124552.212	229166.28	86854.969	106588.88	145014.64
3	249655.80	223563.17	106713.886	151231.95	330716.137	118943.28	145300.52
4	469958.31	201746.80	155743.268	89382.96	133941.440	296489.05	119925.31
5	127230.05	245912.91	103324.856	85946.08	65217.543	96575.27	214500.85
6	65047.48	60770.68	88661.592	61894.42	55128.335	46239.66	72452.73
7	37463.09	25481.65	17456.745	33953.25	37537.141	32496.15	31817.48
8	21736.90	12400.67	6645.710	6550.75	16959.551	23801.86	21682.77
9	27054.78	10120.64	3090.899	2480.36	4808.695	10889.59	20182.08

year

age	2020
1	257360.71
2	433179.64
3	192733.24
4	143413.93
5	89802.13
6	180216.73
7	52691.32
8	26177.18
9	27478.66

TABLE 4.6.23 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS WOS_MSHAS

Units : NA

year

age	1991	1992	1993	1994	1995	1996
1	-0.30668993	-0.521885521	-2.3587720	0.34063152	0.6869089	-0.9228596
2	-1.41973004	0.763922867	1.2120090	-0.08648409	0.4835738	0.7764924
3	-0.94736265	-1.504194017	0.8392884	-0.45979430	-0.7393770	-0.3136438
4	0.19162635	0.480008958	0.5711961	0.17569219	-0.1708378	-0.7907580
5	-1.67245291	1.973991291	0.5195261	0.44890387	-0.2371524	-2.6971821
6	-0.08485924	-3.017797403	1.8779826	0.19744398	0.6854758	0.2733911
7	-0.21933815	1.177024094	-2.9573226	0.77362366	0.2663684	0.8180318
8	0.53886418	-0.007449669	1.5194851	-1.44638349	0.8196700	0.3216749
9	-1.59250305	0.112769111	0.6130351	0.72978864	-0.2940664	-0.4782516

```
   year
age        1997        1998       1999        2000        2001        2002
  1  0.57326055  0.60092105  0.4801441  0.52912969  0.45988312  0.37375702
  2 -0.16544450 -0.24950564 -0.6777131 -0.20414464  0.95852070 -0.25735485
  3 -1.37753213 -0.17698594  1.4185767 -0.03905089 -1.08355018  0.53620143
  4 -2.33034413 -0.05378014 -1.0290266  1.41662982 -0.23152451 -1.31220895
  5 -0.73723443 -1.29218922  1.1705935  0.77352716  1.10790985  0.05495251
  6  0.07969709 -0.06796496 -0.3461205  0.84341878 -0.63518948  1.34708688
  7 -0.37613158 -0.50059408  1.2948672  1.09724720  0.89908585  0.29955657
  8  1.62792592  1.11768630 -0.2627522  0.52231961  0.02208773 -0.28717279
  9 -1.72402858  1.05285771  1.1275075  0.16962384  0.24905952  0.55433630
   year
age        2003        2004       2005       2006        2007       2008
  1  0.61825050  0.77175499 -0.6407741  0.1187135  0.00000000 -0.4467696
  2  0.74230097 -0.30252069 -0.8196870  1.5685445 -1.78308225  0.2702680
  3  0.12823982  0.04392717 -1.3831601 -0.8612019 -0.42360272  1.1904265
  4  0.78919502 -0.79319732  1.0005673 -0.8494764  0.07803731  0.0986367
  5 -0.27505980  0.63981309  0.4057233  1.2708496 -0.31708157  0.4512747
  6  0.02280014 -1.19682360 -1.1519121  0.6953555  1.25181907  0.2164398
  7  0.98322069  0.93521014 -1.1338229 -0.3906921  0.63938376  1.2169323
  8  0.02097525 -0.26258734  2.0736924 -0.7389290  0.53486011  0.2697028
  9  0.18365857  1.11894595 -1.6264295  0.3341892 -1.36620094  0.8519944
   year
age        2009         2010        2011        2012        2013        2014
  1  1.09186253 -0.426318270 -0.58119396  0.57640892  0.00000000  2.02999711
  2 -0.23467525  0.104197264 -0.57320455  0.29328957  0.46112406  1.16574757
  3  0.03195037  0.005259728  1.95948644  0.23564172  1.19490026 -0.63779838
  4  0.56499784  0.079294463 -0.45183539  1.29184266 -1.05331989  2.23810358
  5  0.92318467 -0.864391110 -0.18414955 -0.15579756 -0.01903541 -0.78484214
  6  0.59349093  0.116771345  0.39704448 -0.25380649 -1.54374247  0.09381305
  7  0.18158196  0.867289408  0.47093932  0.05197856  1.05000809 -1.91152818
  8  1.83599801  0.454974895  0.02186036 -0.40098912 -1.53606452 -0.61919641
  9  1.24027371  1.131432226  0.88357406  0.25751132 -0.33627225 -1.73454464
   year
age       2015        2016         2017       2018       2019        2020
  1  0.0000000  0.00000000  0.000000000  2.1442804 -1.2474624  1.14258264
  2  1.4890090 -2.05840543 -1.125744089  1.4442269  0.7504954  1.67619749
```

3	2.0892881	0.17914171	0.828121801	-0.8505018	0.7224551	1.15754246
4	1.4694972	0.73952406	0.001002937	0.5916152	-0.8535351	-1.04357154
5	0.3841348	0.25366194	1.144514071	0.3865503	-0.9428262	-0.75845233
6	0.6214652	0.04162194	0.030254969	-1.0673225	0.9007108	0.21331631
7	-0.5223897	-0.18819473	-1.231515519	1.2707618	-2.3088472	-1.70735840
8	0.1136514	-1.34109465	-1.926607590	-1.4666005	0.3445952	-0.09693202
9	-4.2453426	-1.79986783	1.056022554	-0.3009342	0.7478204	-1.73951647

TABLE 4.6.24 Herring in 6a and 7bc. PREDICTED INDEX AT AGE IBTS_Q4

Units : NA

age \ year	1996	1997	1998	1999	2000	2001	2002
2	13891.923	14834.708	17532.7288	8424.223	7465.687	24577.378	15711.303
3	13101.853	10438.857	10605.4783	15427.809	6386.483	5459.118	20155.296
4	7621.982	9616.302	8371.0168	8904.207	14685.006	5634.676	4390.895
5	7040.612	6181.517	7171.9110	7381.259	8015.245	14134.823	5216.856
6	3969.291	4395.437	3647.4364	4533.853	5524.005	6174.020	10380.830
7	4359.288	1676.460	1777.1770	1956.040	2695.687	3418.134	3545.206
8	4141.312	2412.096	794.4806	1071.739	1367.964	1987.324	2338.599
9	6459.617	3207.632	1939.6217	1338.884	1280.275	1387.173	1688.789

age \ year	2003	2004	2005	2006	2007	2008	2009
2	18038.529	9970.760	8450.474	8756.941	7572.811	4842.427	5861.719
3	12895.064	15221.796	8338.433	6214.284	6823.452	5835.086	3824.855
4	18610.977	13009.186	16204.708	7177.794	5117.899	6084.255	5033.318
5	3971.958	16449.918	15366.511	16549.133	6958.422	4918.588	5683.816
6	4170.604	2832.236	13073.162	13147.357	11849.890	5435.911	3770.682
7	5716.038	3017.969	1756.442	7575.525	7736.364	7809.084	3262.307
8	2625.524	3618.737	2960.773	1288.337	4678.891	5717.493	5319.623
9	2075.344	2416.211	3292.842	3134.730	1984.737	3710.913	4571.399

age \ year	2010	2011	2012	2013	2014	2015	2016
2	6145.503	10848.360	4550.135	4453.8271	2129.4599	2799.59200	5275.54207
3	4492.178	4822.588	9533.931	3807.4116	3394.5051	1603.95297	2399.56719
4	3242.047	3984.232	4352.301	8397.7761	3556.7769	2689.70956	1685.06045

age							
5	4373.213	2950.616	3531.929	3422.8150	6434.8524	2605.65478	2490.82603
6	3551.254	3131.890	2220.110	1953.6408	1746.4716	2330.13988	2020.35322
7	2155.199	1843.005	1776.747	1102.0715	705.1699	420.44398	1090.38839
8	2081.343	1387.542	1009.184	689.7882	358.7827	167.23600	247.23850
9	4543.225	3209.758	2068.753	858.5432	292.8155	77.78094	93.61378

age \ year	2017	2018	2019	2020
2	2002.5207	2459.4003	3359.6717	10069.419
3	5259.7319	1894.4758	2342.9804	3136.894
4	2536.4092	5614.3491	2323.9833	2821.259
5	1909.6353	2822.4666	6501.5551	2774.099
6	1839.5714	1546.4472	2544.1114	6467.029
7	1255.4631	1100.1395	1135.8653	1921.723
8	680.8999	978.1908	943.7144	1159.672
9	193.0617	447.5321	878.3987	1217.329

TABLE 4.6.25 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS IBTS_Q4

Units : NA

age \ year	1996	1997	1998	1999	2000	2001
2	0.8178791	0.05793861	-0.14980481	-0.7173909	-0.5710625	1.61515130
3	-0.7416322	-0.22280247	0.14908880	1.3237789	0.1896555	-1.54012863
4	-1.3157047	-1.00731482	-0.02718096	0.7852305	0.6308550	0.53836483
5	-0.4522882	0.05875687	1.62059132	0.5482873	-0.7927971	-0.63620275
6	-0.6993594	0.05467170	0.76637629	1.2500209	1.3708797	1.17076148
7	-0.2990185	-0.73814282	-0.60994558	0.5352676	0.3494037	0.29996281
8	1.2950211	1.46438488	0.82307769	-0.6204466	0.7990178	-0.09399218
9	-0.3660508	-0.46735193	1.84809710	1.6529744	-0.4020470	-0.46313555

age \ year	2002	2003	2004	2005	2006	2007
2	-0.09669524	-0.03432222	1.40096716	-1.43834939	-0.4788390	-0.4158494
3	-1.37542110	-0.03515361	-1.16389056	0.22757028	-1.8876544	-0.7661947
4	-2.17078628	0.03781482	-0.38560474	0.43612819	0.9072488	-0.5472321
5	0.80486193	-1.15639801	-2.37491895	1.12423744	-0.4523164	1.2832296
6	-0.50562822	1.02983037	0.53730910	-0.78513166	0.8957283	-1.8462308

7	1.41148078	-1.05362827	0.98636368	0.13897357	-0.2493972	1.2753980
8	0.14323979	0.56838349	-2.22159009	0.58689971	0.6541238	-1.6706001
9	-1.16056002	0.62770539	-0.01738045	-0.05258613	-0.7604215	-0.6672993

year

age	2008	2009	2010	2011	2012	2013	2014
2	-1.3819574	0.3948515	0	-0.1200091	-1.98177295	0	0.9021843
3	0.6887225	-0.9326534	0	-0.5162412	1.36162805	0	0.5948622
4	-0.3113265	-1.6982519	0	-0.2259289	0.43768128	0	-1.2810092
5	-1.0610620	0.2946874	0	-0.7969036	0.69748950	0	-0.6601509
6	0.3292110	-1.2576152	0	-0.6718126	0.32215245	0	-0.2654621
7	0.6674713	0.5694632	0	-1.5410683	0.03233811	0	-0.7352208
8	-0.3182928	-0.9948897	0	-0.6530709	-1.62436921	0	0.5475298
9	1.0915820	0.8693629	0	0.9953384	2.25005737	0	-2.8724403

year

age	2015	2016	2017	2018	2019	2020
2	1.7674039	2.7018353	2.4582706	0.9720859	-0.97130548	-0.2432754
3	0.5932989	-0.3054724	0.6015737	0.5931333	0.90732814	-2.4707922
4	-0.4210318	1.8172530	0.3171823	-0.6590504	0.67046519	2.1400049
5	1.2908170	-0.7798330	2.1597324	-0.2472389	-1.56327458	0.5386020
6	-1.5926693	0.9880914	-1.0565245	0.2487108	0.59724370	-1.7181071
7	-0.6766159	-0.4765041	0.3621291	-0.3276997	1.03234225	-1.2400472
8	2.4745584	0.9820720	-0.4365795	-0.2155124	-1.64912229	0.8040222
9	1.6104059	0.9913599	-0.3591152	-2.6238727	0.04155989	-0.2413239

TABLE 4.6.26 Herring in 6a and 7bc. PREDICTED INDEX AT AGE IBTS_Q1

Units : NA

year

age	1997	1998	1999	2000	2001	2002	2003
2	67928.43	81427.90	38105.92	33141.14	107128.34	68777.34	77462.13
3	135149.42	141763.41	197037.74	79547.13	66459.66	249464.20	154468.48
4	110084.53	99726.88	98329.86	157221.43	59088.84	47271.54	192924.81
5	54345.29	65487.07	60054.62	63096.41	109998.60	42508.06	30881.99
6	42285.16	36132.28	38443.40	44921.10	50002.38	87920.23	33533.68
7	21214.34	22451.94	19596.96	25549.99	32456.86	35324.39	54526.40
8	34544.56	11085.02	11393.31	13572.69	19708.17	24044.13	26397.27

9	45937.74	27062.65	14233.24	12702.65	13756.52	17363.16	20865.71

year

age	2004	2005	2006	2007	2008	2009	2010	2011
2	42377.00	35654.59	37752.48	32919.30	20800.98	25405.82	27047.89	46970.49
3	179063.48	96481.32	75527.48	83852.88	70159.30	46567.67	56207.78	58301.79
4	132260.13	159111.66	75205.77	54029.29	62777.50	52945.20	35390.91	41747.80
5	125960.14	108898.13	128133.74	54276.80	36594.07	43950.45	35758.20	23093.39
6	22694.97	95218.60	107205.60	98381.18	41914.39	30580.19	30533.79	25842.05
7	28804.79	14516.85	73299.04	77350.62	69451.68	30952.86	21421.54	17545.24
8	37315.01	26060.52	13614.59	52726.86	56191.40	57292.13	23624.96	15129.14
9	24915.03	28983.37	33126.47	22366.19	36470.78	49233.79	51569.37	34997.77

year

age	2012	2013	2014	2015	2016	2017	2018
2	19517.85	19324.49	9233.744	12211.864	21796.118	8244.712	10108.027
3	113060.40	46647.42	42006.807	20311.751	26868.111	58580.386	21029.115
4	44575.01	92191.55	40261.523	31907.198	16379.032	24404.772	54023.879
5	27168.51	29494.22	59053.768	26007.119	18123.166	13573.288	20148.104
6	18220.56	18952.44	18728.265	30615.931	16220.431	14047.885	11749.112
7	16997.80	13136.81	9658.107	7895.879	10648.413	11179.185	9529.489
8	11511.11	11532.39	7400.212	4736.578	2787.198	6670.004	9086.830
9	23596.94	14353.76	6039.580	2202.967	1055.338	1891.207	4157.316

year

age	2019	2020
2	13680.960	40693.546
3	25289.264	33149.851
4	21218.793	24893.790
5	42722.424	17458.910
6	17302.675	41865.265
7	8721.141	14054.719
8	7695.000	9083.095
9	7162.419	9534.689

TABLE 4.6.27 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS IBTS_Q1

Units : NA

age \ year	1997	1998	1999	2000	2001	2002
2	0.55277912	-2.1784745	0.5133014	0.86448328	0.38944014	-0.2390052
3	0.31858151	0.2139073	1.0653687	0.42973119	0.02866255	-0.7301654
4	-1.78965016	-0.6948971	1.1102948	-0.65820134	-0.09462279	0.3234922
5	-1.05714593	-1.1995909	-0.3838693	0.05126629	-0.14383731	-2.2033438
6	-0.48719841	-1.6630078	-0.7790111	0.87790444	0.56820285	0.2634784
7	0.05978633	1.0292827	0.9715627	-0.02179749	0.43709776	-0.6148019
8	1.43197472	-1.0462057	1.0418647	-1.66948877	-0.87448652	0.7395284
9	-0.87596519	0.5214387	1.7449214	2.04250154	1.34764643	0.8787474

age \ year	2003	2004	2005	2006	2007	2008
2	0.6002231	1.2565051	0.9575004	2.00763312	-0.430667834	0.05220872
3	-1.1290079	0.4069359	-0.5643233	0.53928676	0.006628811	-2.79702856
4	-0.8435095	-0.1471560	1.3950892	-1.25847610	-0.030031146	0.17545766
5	-0.1523616	-0.3422976	1.2585945	1.68822114	0.123669268	0.64339638
6	-0.4403413	1.4622230	0.2894747	1.19537663	-0.205996505	-0.64423205
7	-0.5561608	0.1942236	0.3507599	0.02339286	0.234209659	-0.92811887
8	-0.4791816	-0.7635707	1.1776136	0.65338588	-0.948256390	0.63968819
9	1.4351125	1.0885380	-0.2134547	1.08986076	2.340987549	-0.11874453

age \ year	2009	2010	2011	2012	2013	2014
2	0.50753982	-0.99140733	0.63915124	-1.5042915	1.0757734	0.04251665
3	0.57375643	-0.11972612	-0.26123794	1.9867976	-0.9241709	-0.37120452
4	-0.72338050	-0.81091185	0.54701685	-0.3227323	-0.1638314	-1.32485759
5	0.69458195	-0.58404435	-0.16569138	-0.4264081	0.4944612	-0.36741012
6	0.49388670	0.03712544	0.07157970	-0.5718599	0.5496877	-1.81861255
7	0.30399955	1.23101542	-0.25034342	-0.5169086	0.1281714	0.17712778
8	-0.01393181	-0.90869872	-0.05566304	-0.2683090	-0.3940330	-0.42637932
9	1.57504135	-0.12868611	1.03638882	0.9136143	0.2531835	-0.84136846

age \ year	2015	2016	2017	2018	2019	2020
2	-0.6592520	0.1284854	0.1206639	-0.4862957	-0.88191454	-1.4280603
3	-1.1551230	-0.8779596	0.1452583	1.7041618	0.17269326	-1.1439270

4	0.8465811	-1.6480306	-0.3168585	2.7063606	1.80290298	-0.5623538
5	-1.5623403	0.8612535	-0.4551773	-1.2008603	1.89035546	-0.1180418
6	-0.8255133	0.8760830	-0.7617581	0.9528242	-3.45790264	1.4178308
7	-0.1107114	-2.6769726	0.1577571	-1.4229558	1.07173842	-2.6425885
8	0.8193162	-0.3516141	-0.9591290	-0.2073744	-1.36995478	0.4539104
9	-1.0098582	0.5111954	2.0485495	-0.8092327	-0.07941602	0.3642607

TABLE 4.6.29 Herring in 6a and 7bc. FIT PARAMETERS

	name	value	std.dev
1	logFpar	-1.21746378	0.34304280
2	logFpar	0.11192533	0.14114680
3	logFpar	0.81370624	0.11960868
4	logFpar	1.13770208	0.11941502
5	logFpar	1.26059648	0.12046397
6	logFpar	1.45959080	0.12365227
7	logFpar	1.60436557	0.15571360
8	logFpar	1.76397811	0.16548037
9	logFpar	-2.41931695	0.20889180
10	logFpar	-1.10778686	0.14153081
11	logFpar	-0.76999375	0.14086664
12	logFpar	-0.52643914	0.14127361
13	logFpar	-0.14946699	0.14800416
14	logFpar	0.13410452	0.15309241
15	logFpar	0.56745348	0.15740326
16	logFpar	-3.51917042	0.12226969
17	logFpar	-3.17769137	0.17831993
18	logFpar	-2.66782336	0.17846268
19	logFpar	-2.09939697	0.17982731
20	logFpar	-1.75050296	0.18318052
21	logFpar	-1.58997351	0.19854492
22	logFpar	-1.24430347	0.20877212
23	logSdLogFsta	-0.83930191	0.23514595
24	logSdLogFsta	-1.17981977	0.17314866
25	logSdLogFsta	-1.24067177	0.13856787
26	logSdLogFsta	-0.70980213	0.17747801

```
27   logSdLogFsta  0.03193858 0.16734356
28   logSdLogFsta  0.26241664 0.08932920
29      logSdLogN -0.51949506 0.12008948
30      logSdLogN -2.14823542 0.13334765
31    logSdLogObs  0.16260415 0.10370422
32    logSdLogObs -0.60790311 0.11463162
33    logSdLogObs -0.93182376 0.06232043
34    logSdLogObs -0.43029717 0.06641453
35    logSdLogObs  0.35912746 0.11013427
36    logSdLogObs -0.86034059 0.13578615
37    logSdLogObs -1.28363892 0.07290240
38    logSdLogObs -0.80858728 0.09722850
39    logSdLogObs  0.52149466 0.14315539
40    logSdLogObs -0.33304563 0.13294138
41    logSdLogObs -0.51647992 0.10392995
42    logSdLogObs -0.27573909 0.10841419
43    logSdLogObs -0.01939255 0.13559402
44    logSdLogObs -0.44764913 0.11887042
45    logSdLogObs -0.40920774 0.12080419
46    logSdLogObs -0.47019348 0.12568328
47    logSdLogObs -0.68900111 0.15391291
48    logSdLogObs -0.21362356 0.12557651
49    logSdLogObs -0.15892923 0.12644375
50 transfIRARdist  0.38826234 0.36623888
51 transfIRARdist -1.39467410 0.23861868
52 transfIRARdist -1.36693214 0.25064163
53 transfIRARdist -1.72140222 0.51223926
54 transfIRARdist -2.69057349 0.45856672
55 transfIRARdist -2.17705709 0.42851273
56 transfIRARdist -1.38934420 0.29683798
57     itrans_rho  2.86914201 0.19475923
58     itrans_rho  1.71249464 0.20274549
```

TABLE 4.6.30 Herring in 6a and 7bc. NEGATIVE LOG-LIKELIHOOD

1618.31607634768

Table 4.7.1.1: Herring in divisions 6.a and 7bc. Assumptions made for the intermediate year and in the forecast for scenario 1.

Variable	Notes
$F_{ages\ (wr)\ 3–6}$ (2021)	F corresponding to the assumed total catch for 2021
$R_{age\ (wr)\ 1}$ (2021-2023)	Geometric mean 2016–2020
SSB (2021)	Tonnes; Calculated in the short-term forecast based on the assumptions for the intermediate year
Total catch (2021)	Tonnes; Monitoring TAC 4840 t

Table 4.7.1.2: Herring in divisions 6.a and 7.bc. Catch Scenarios based on full uptake of the TAC.

Basis	Total catch (2022)	% SSB change 2022 relative to 2021	% SSB change 2023 relative to 2022	% TAC change 2022 relative to 2021
Precautionary approach: zero catch	0	+21%	-4%	-100%
Other scenarios				
TAC=Monitoring TAC	4840	+17%	-5%	0

Table 4.7.1.3: Herring in divisions 6.a and 7.bc. Assumptions made for the intermediate year and in the forecast for scenario 2.

Variable	Notes
$F_{ages\ (wr)\ 3–6}$ (2021)	F corresponding to the assumed total catch for 2021
$R_{age\ (wr)\ 1}$ (2021-2023)	Geometric mean 2016–2020
SSB (2021)	Tonnes; Calculated in the short-term forecast based on the assumptions for the intermediate year
Total catch (2021)	Tonnes; Monitoring TAC 1540 t

Table 4.7.1.4: Herring in divisions 6.a and 7.bc. Catch Scenarios based on partial uptake of the monitoring TAC.

Basis	Total catch (2022)	% SSB change 2022 relative to 2021	% SSB change 2023 relative to 2022	% TAC change 2022 relative to 2021
Precautionary approach: zero catch	0	+21%	-4%	-100%
Other scenarios				
TAC=Partial uptake of the Monitoring TAC	1540	+18%	-5%	-68%

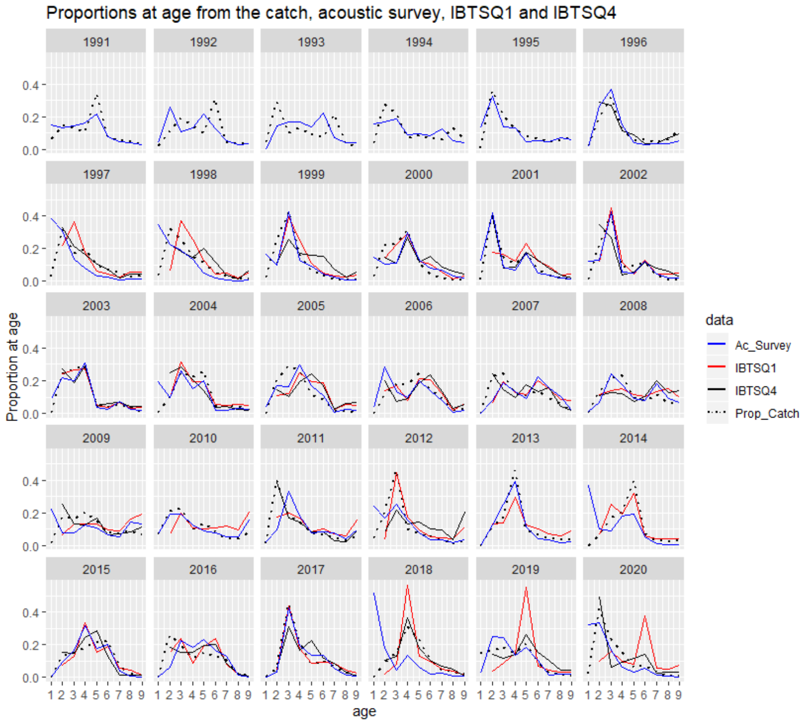


Figure 4.3.1.1. Herring in 6.a (combined) and 7.b–c. Comparison of the proportions-at-age, by age (-wr), of the catch, acoustic survey (WOS MSHAS), IBTS Q1 and IBTSQ4.

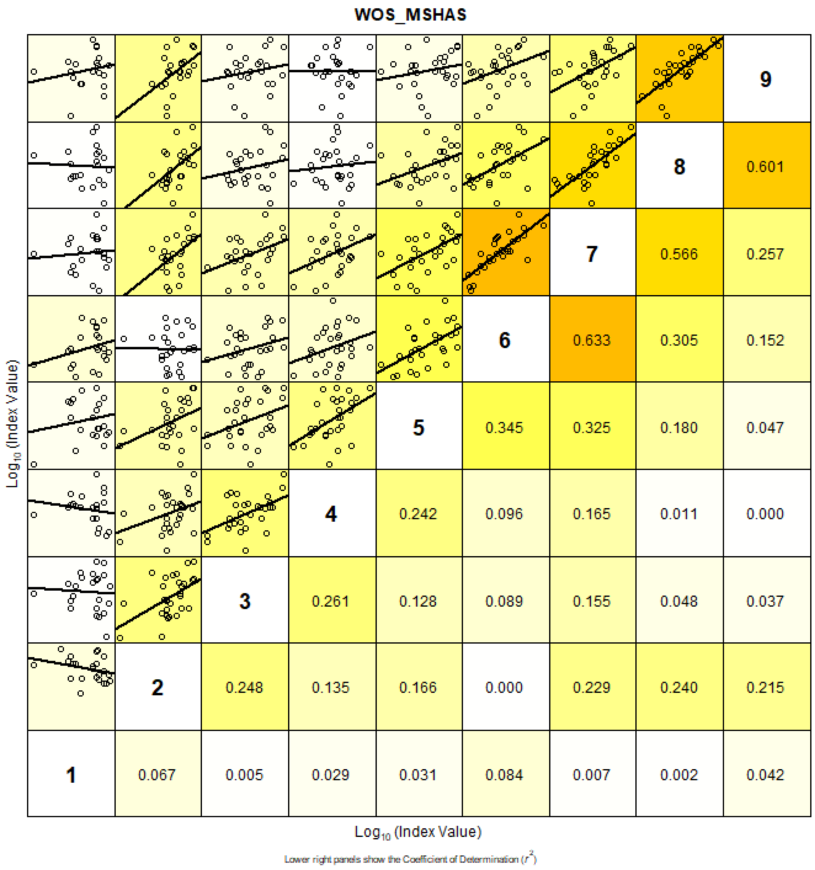


Figure 4.3.1.2. Herring in 6.a (combined) and 7.b–c. Internal consistency between ages (rings) in the WoS_MSHAS herring acoustic survey time-series (1991–2020).

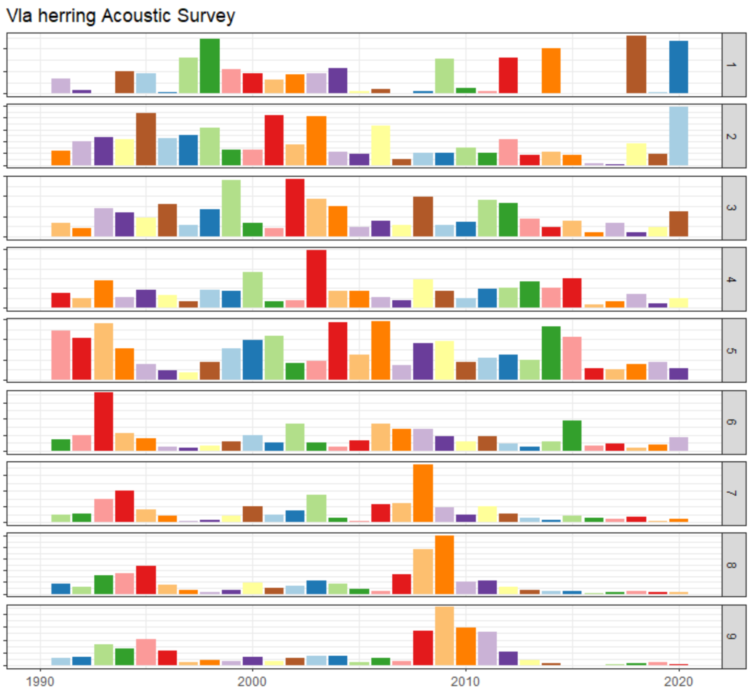


Figure 4.3.1.3 Herring in Divisions 6.a (combined) and 7.b–c. Catch numbers-at-age from Malin Shelf herring acoustic survey combined with West of Scotland acoustic survey (WoS_MSHAS) (6.a.N-S, 7.b and 7.c) time-series. Age (rings) from acoustic surveys 1991 to 2020.

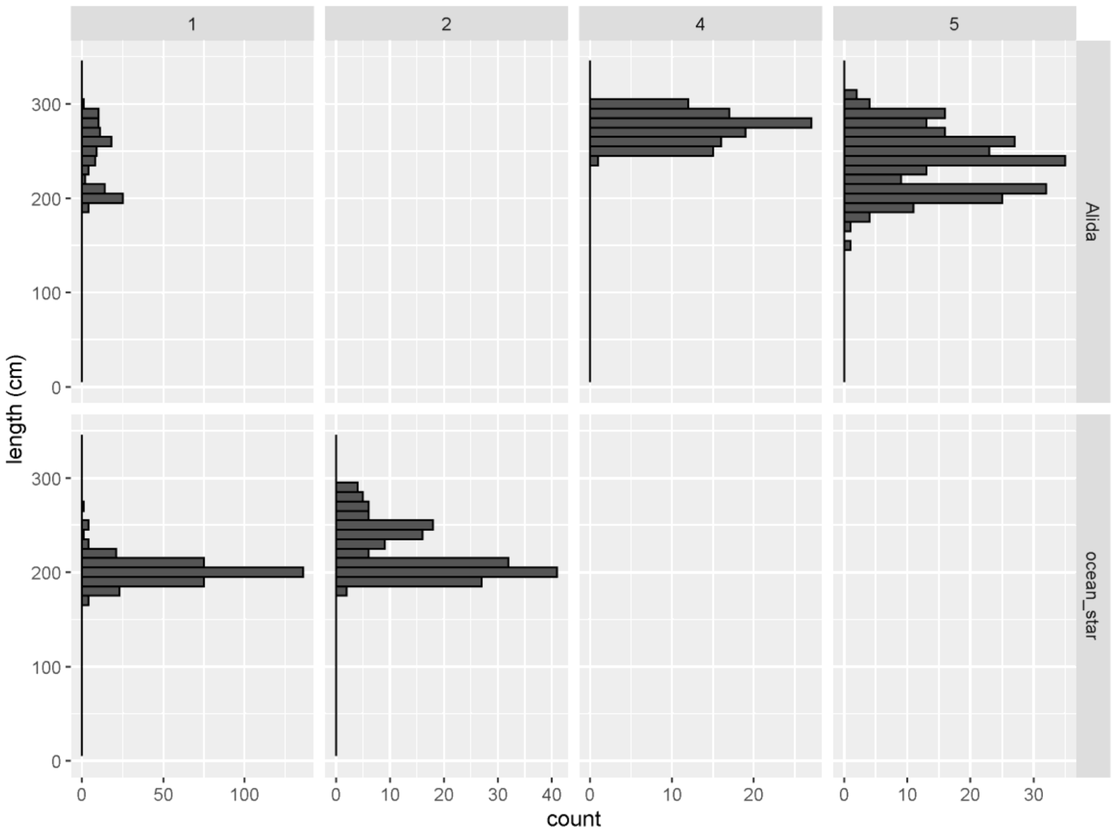


Figure 4.3.1.1.1 Relative Length-frequency distributions recorded from industry survey samples in 6aN.

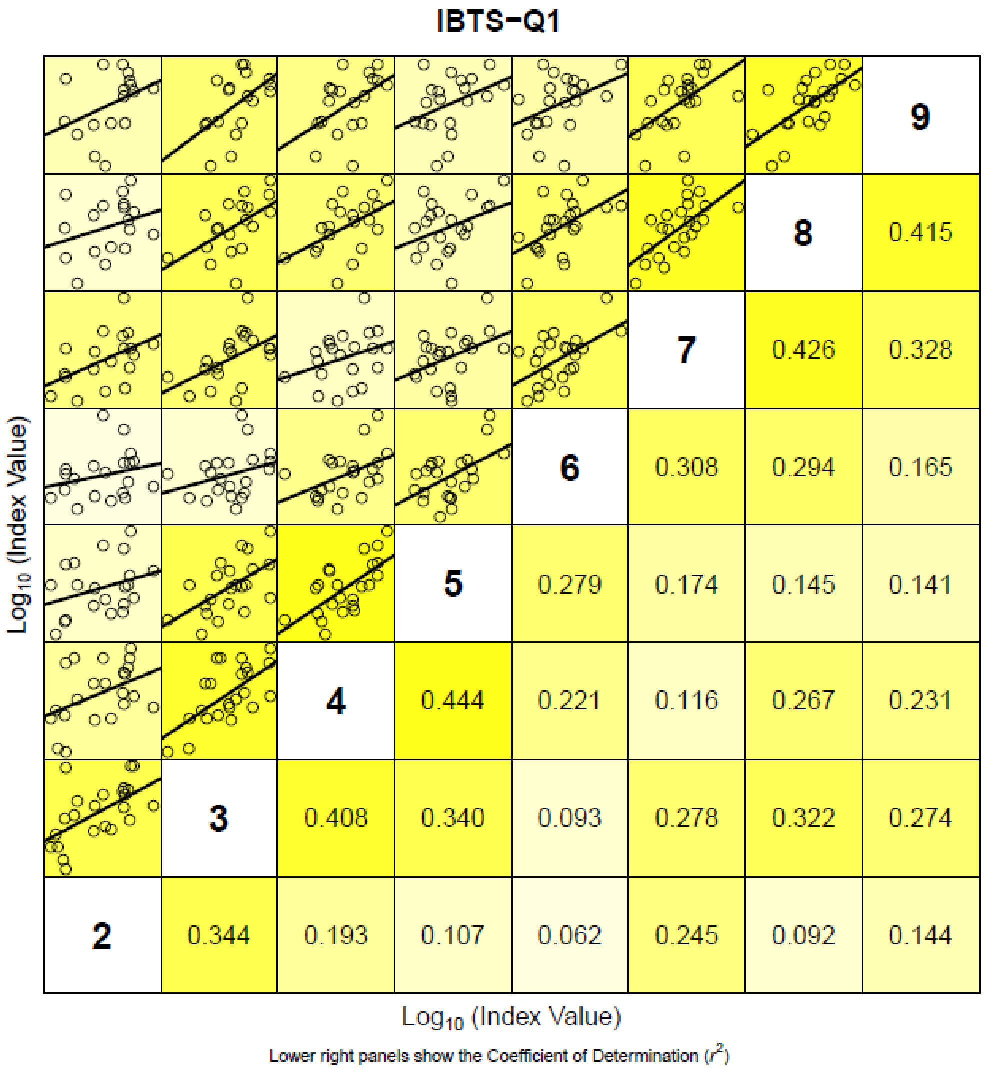


Figure 4.3.2.1. Herring in divisions 6.a (combined) and 7.b–c. Internal consistency plot of the quarter 1 Scottish bottomtrawl survey (1994–2020). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is associated with the linear regression is given.

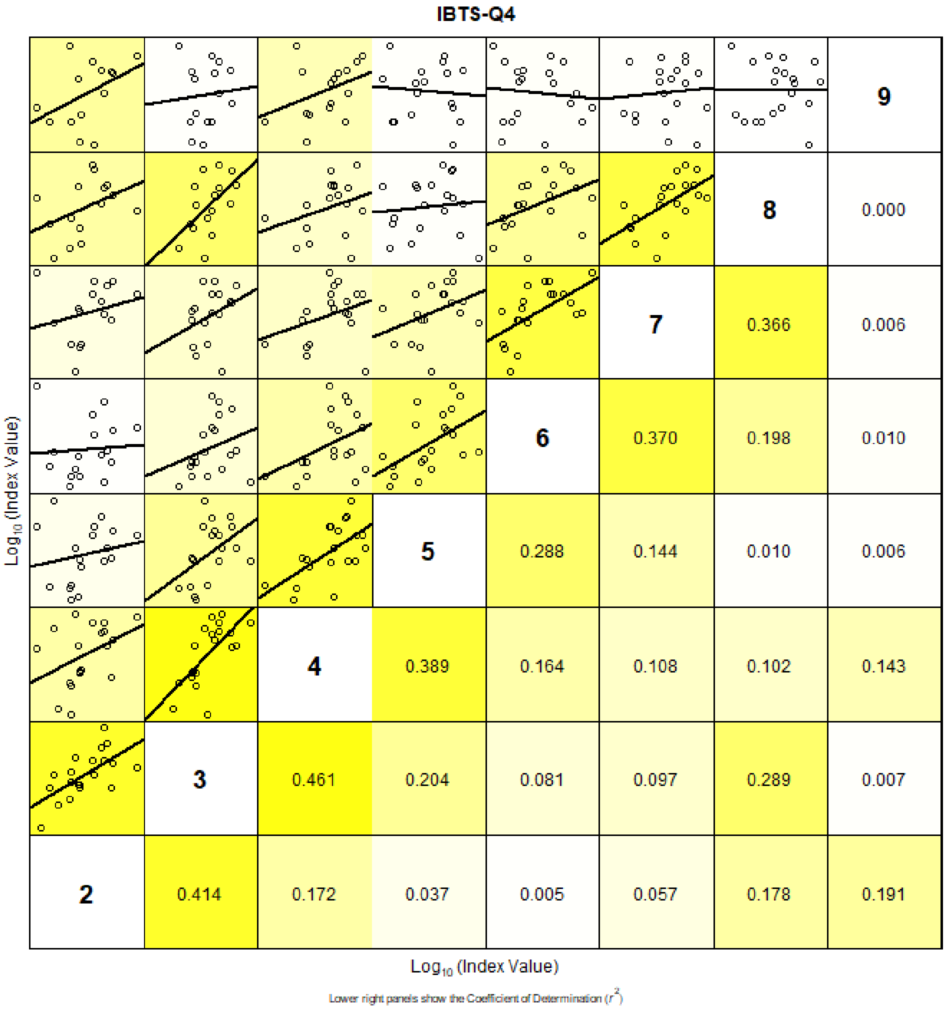


Figure 4.3.2.2. Herring in divisions 6.a (combined) and 7.b–c. Internal consistency plot of the quarter 4 Scottish bottomtrawl survey in (1996–2020). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r² value that is associated with the linear regression is given.

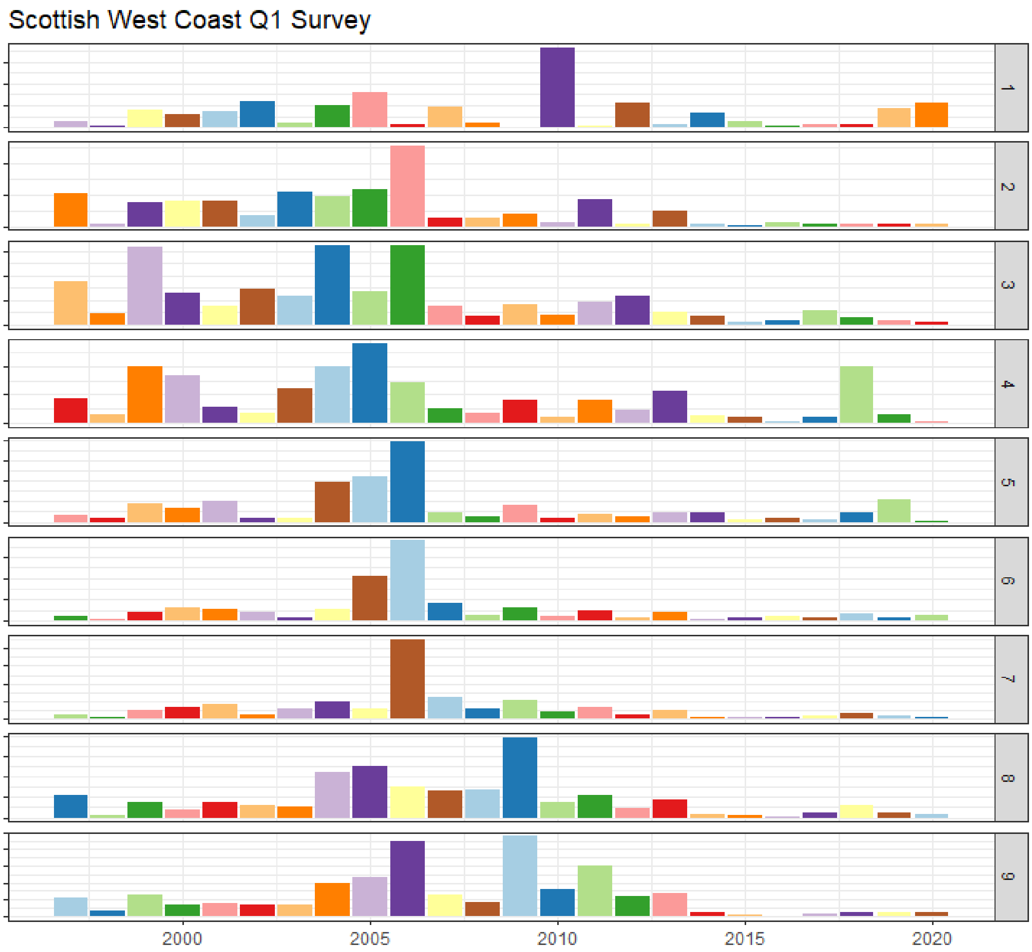


Figure 4.3.2.3. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish groundfish survey in Quarter 1.

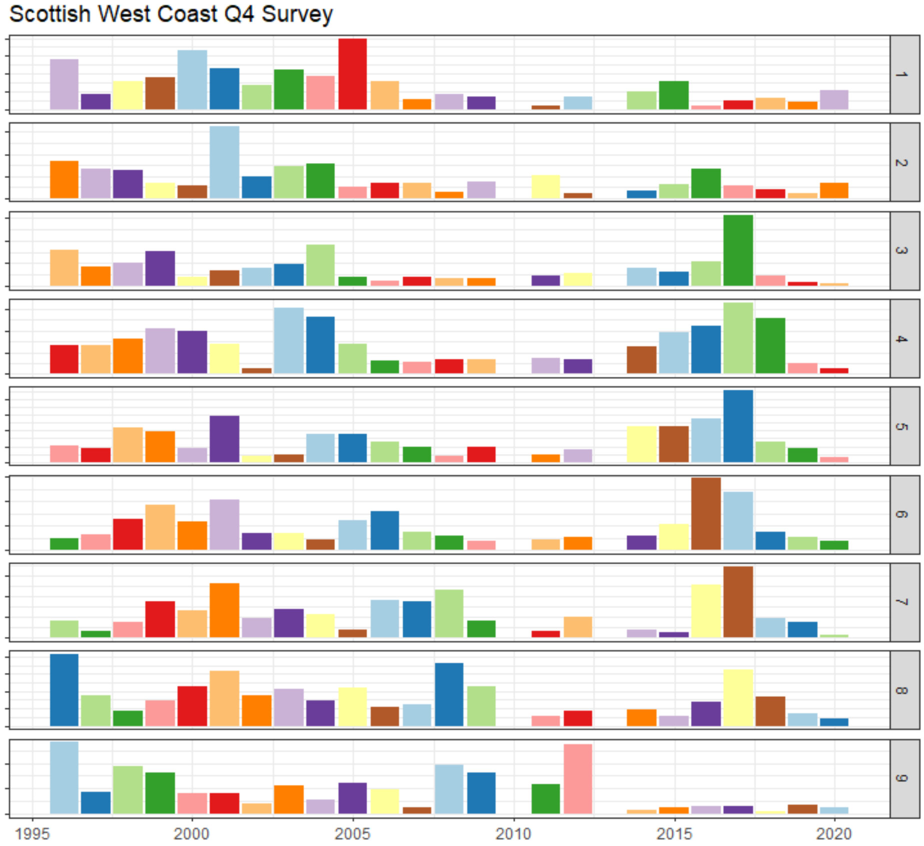


Figure 4.3.2.4. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish groundfish survey in Quarter 4. There was no survey in 2010 and in 2013 only half of the survey was completed and the data were not used for the index.

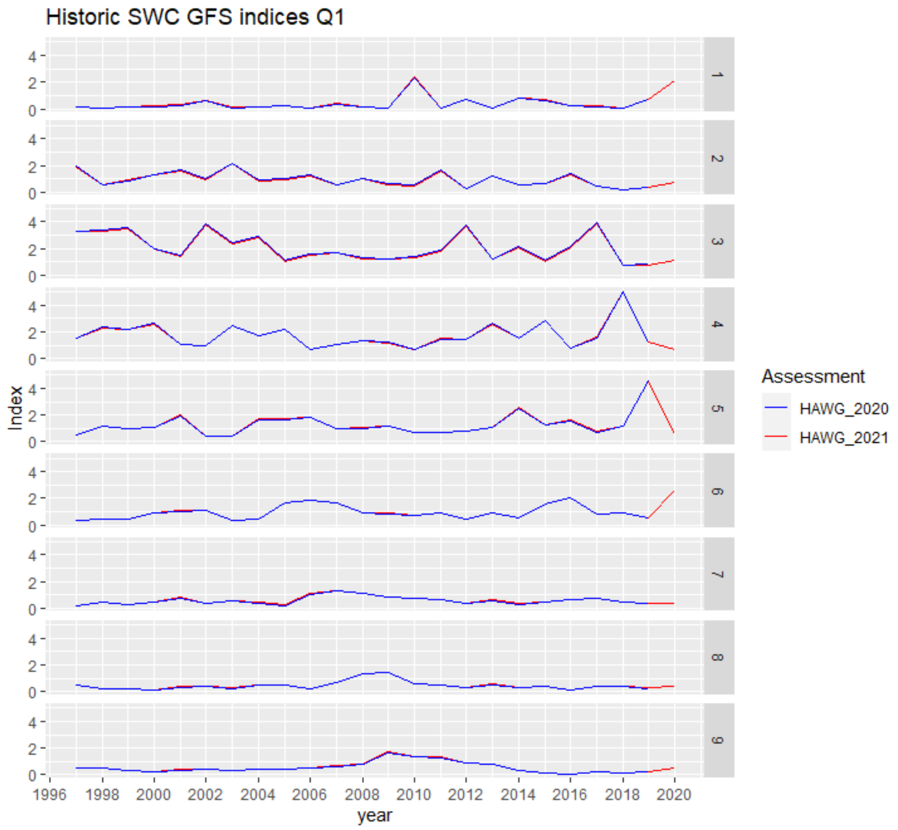


Figure 4.3.2.5 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish groundfish survey in Quarter 1 from HAWG 2020 and HAWG 2021. Each index was mean standardized by year.

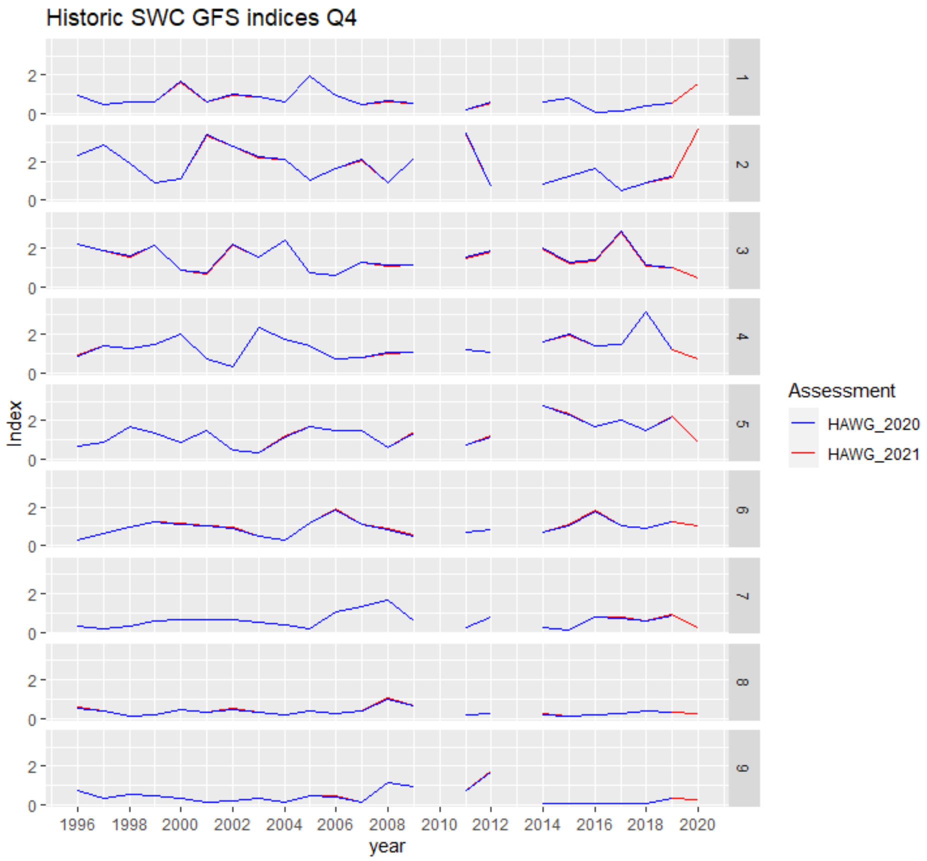


Figure 4.3.2.6 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish groundfish survey in Quarter 4 from HAWG 2020 and from HAWG 2021. Each index was mean standardized by years.

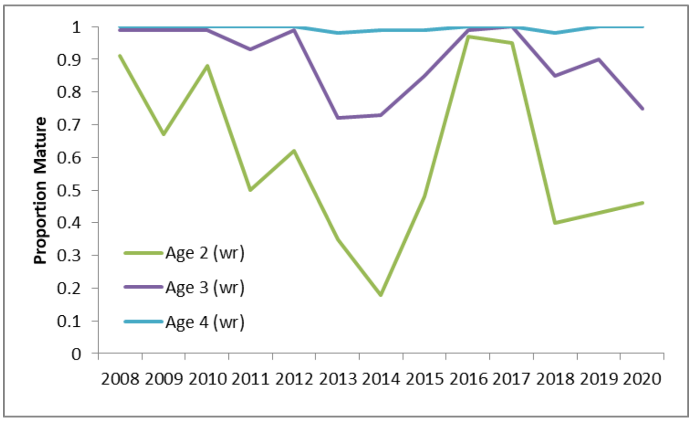


Figure 4.4.2.1. Herring in 6.a (combined) and 7.b–c. Maturity-at-ages 2–4 wr for the years 2008 to 2020.

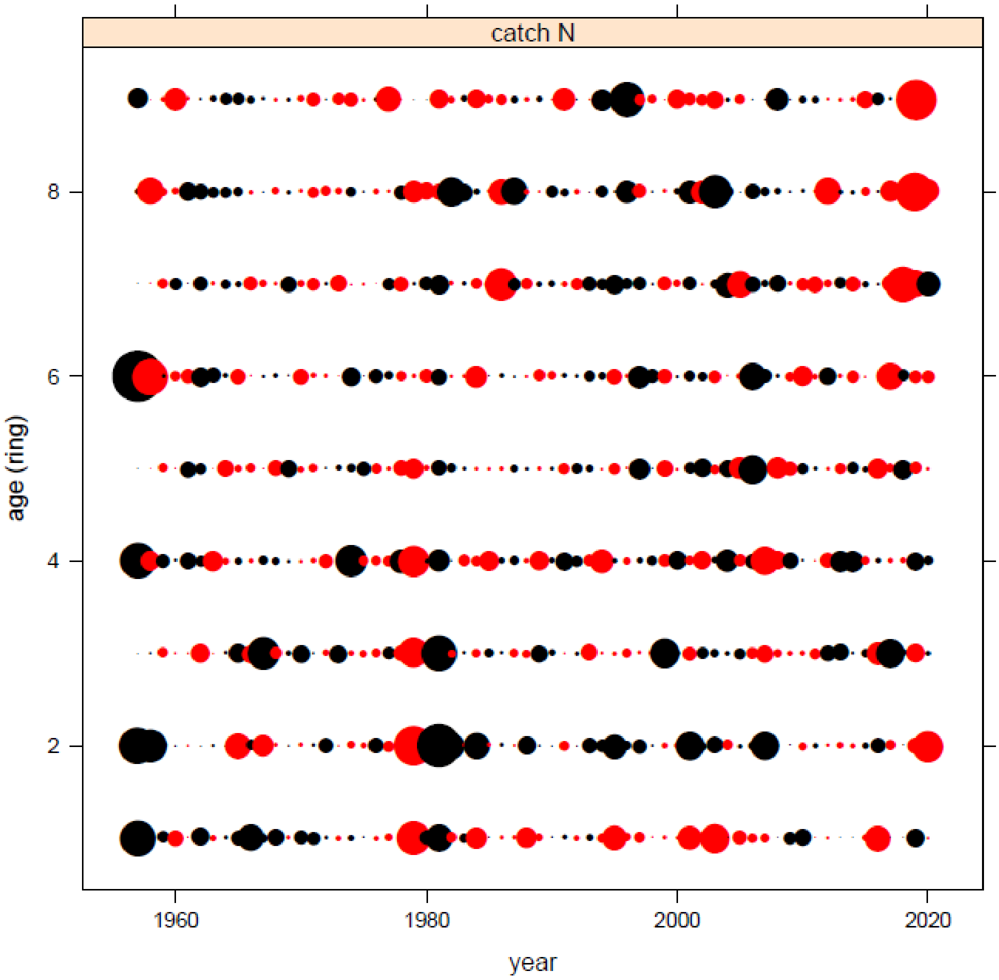


Figure 4.6.1. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch N residuals (1957–2020).

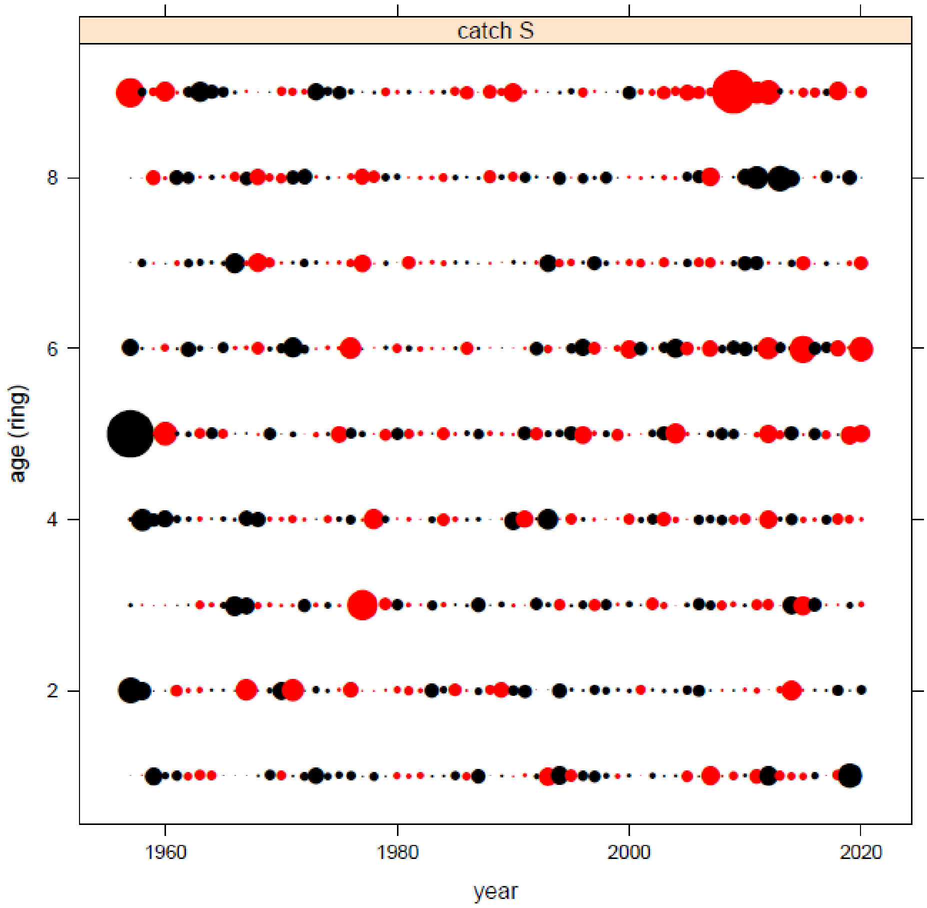


Figure 4.6.2. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch S residuals (1957–2020).

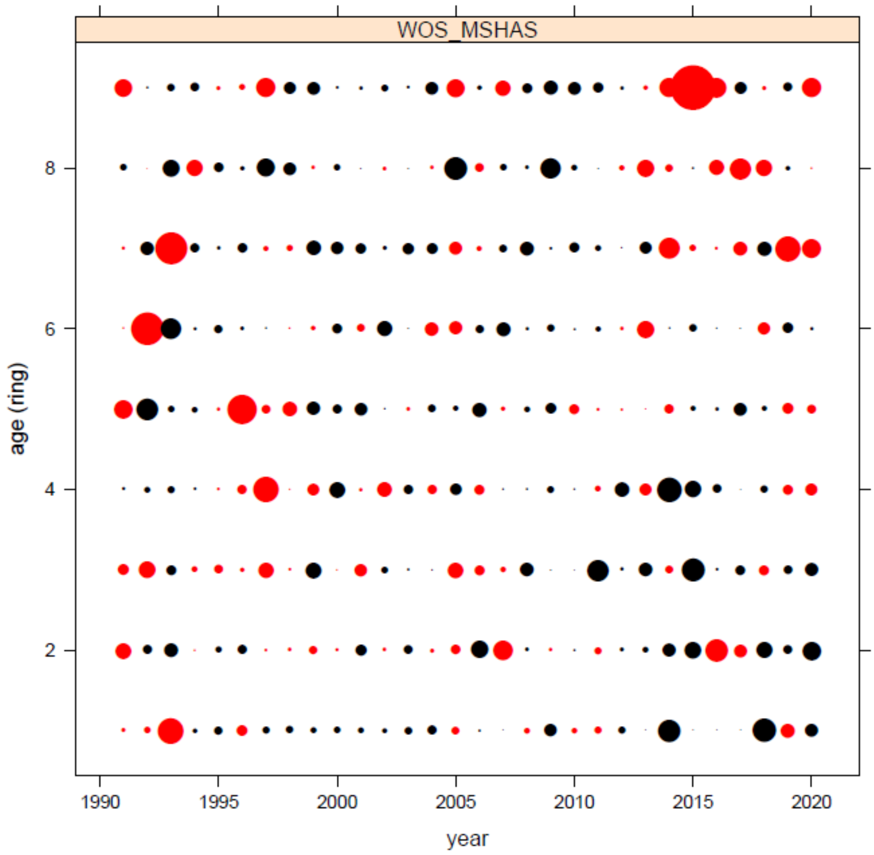


Figure 4.6.3. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the WoS_MSHAS acoustic survey (1991–2020).

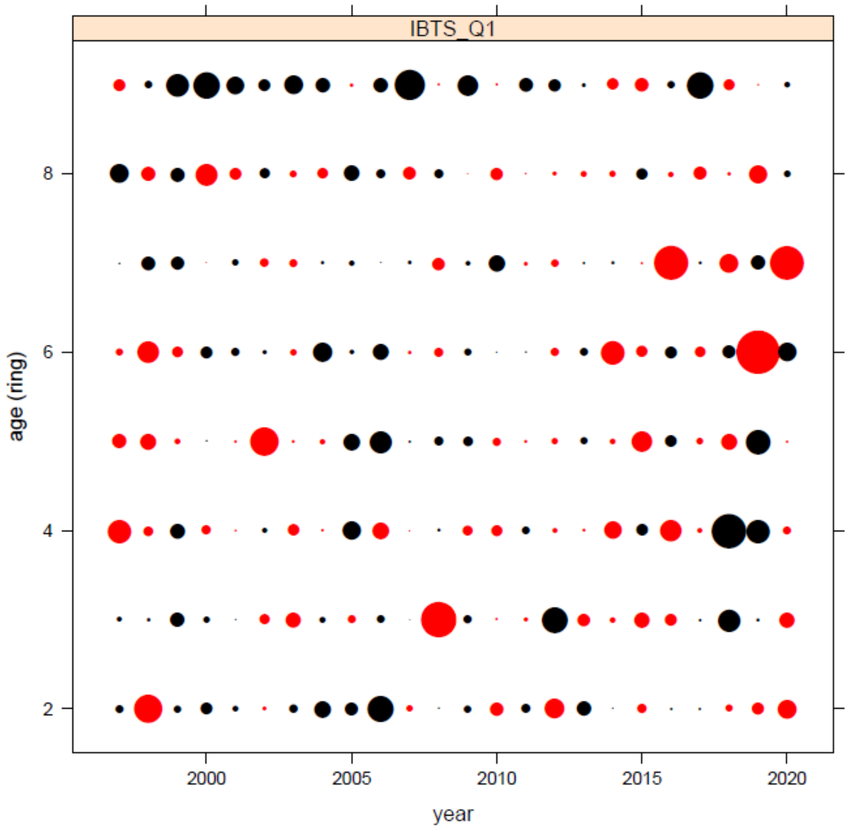


Figure 4.6.4. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the Scottish bottom-trawl survey in quarter 1 (1994–2020).

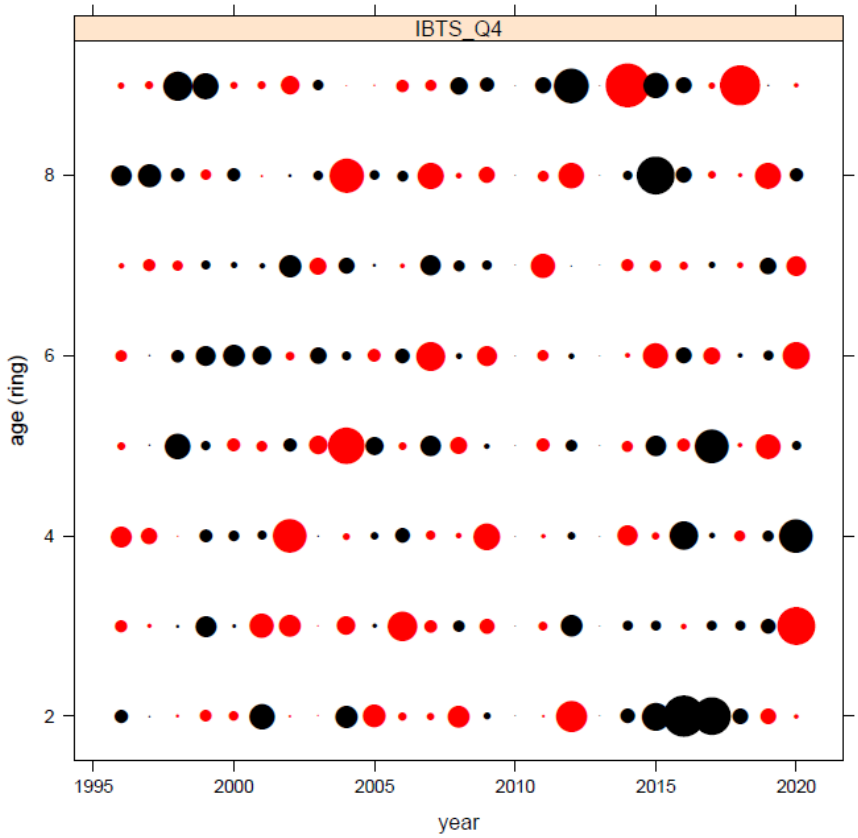


Figure 4.6.5. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the Scottish bottom-trawl survey in quarter 4 (1996–2020).

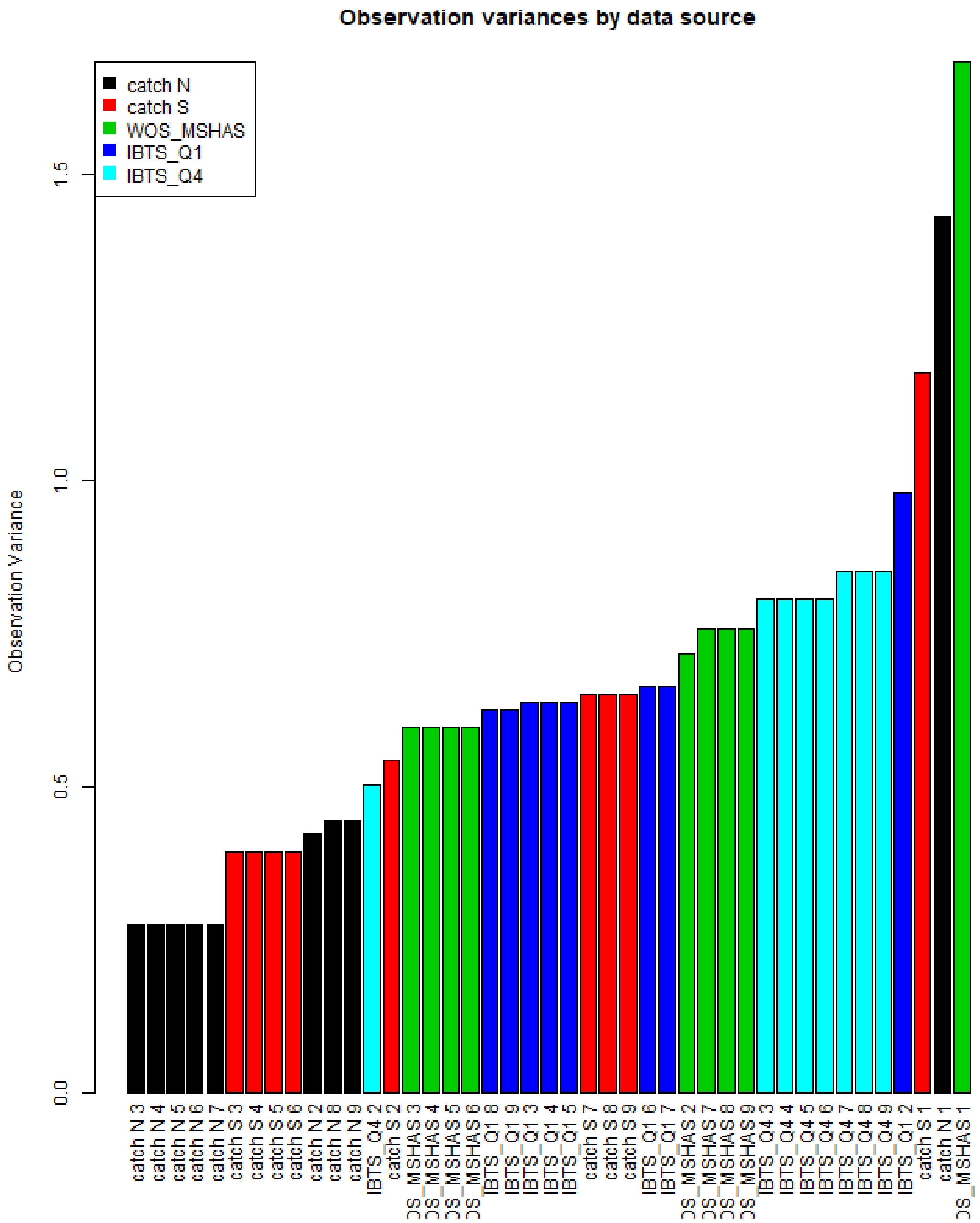


Figure 4.6.6. Herring in 6.a (combined) and 7.b–c. Observation variance by data source, ordered from least (left) to most (right). Colours indicate the different data sources. In cases where parameters are bound, observation variances have equal values.

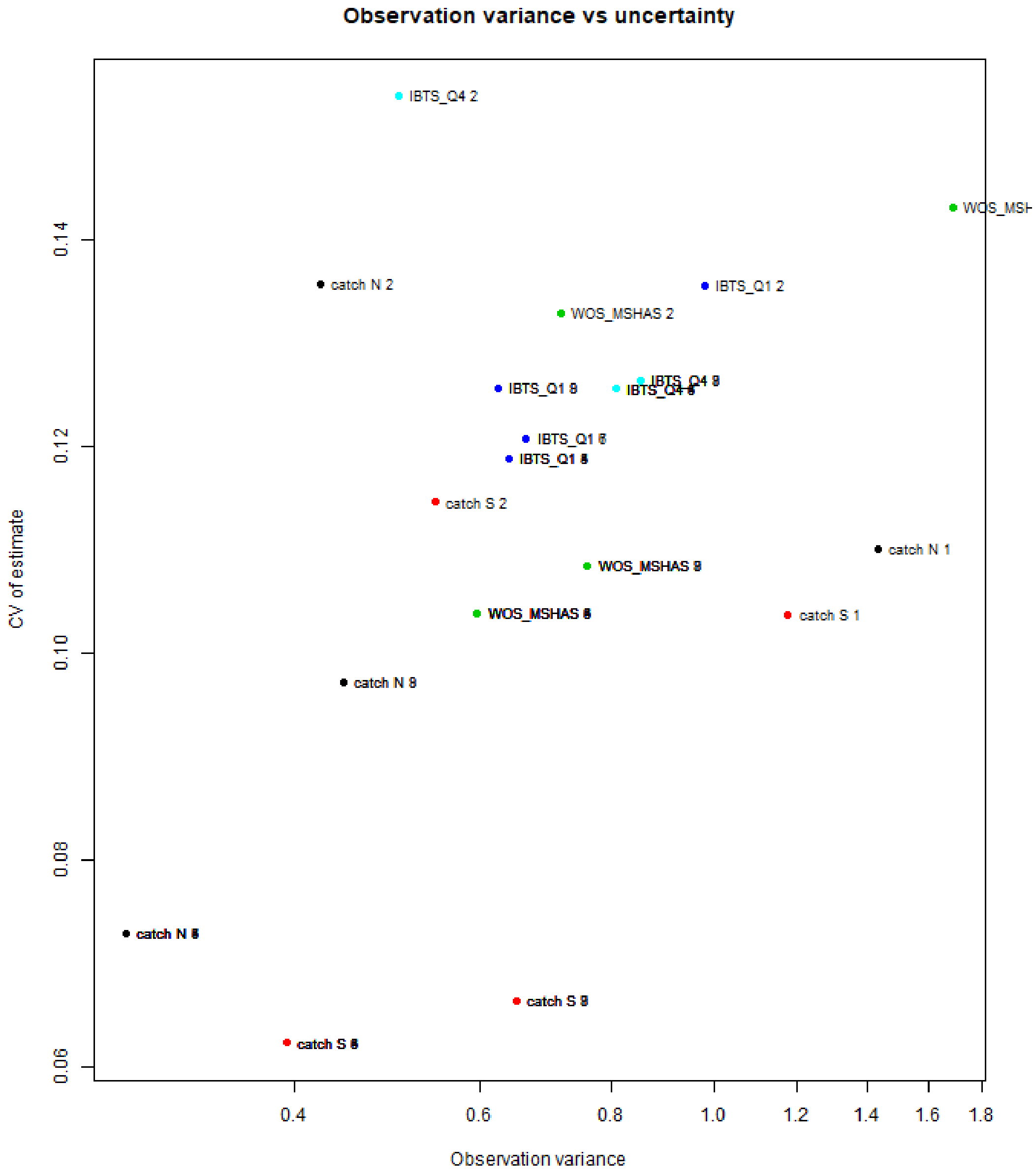


Figure 4.6.7. Herring in 6.a (combined) and 7.b–c. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

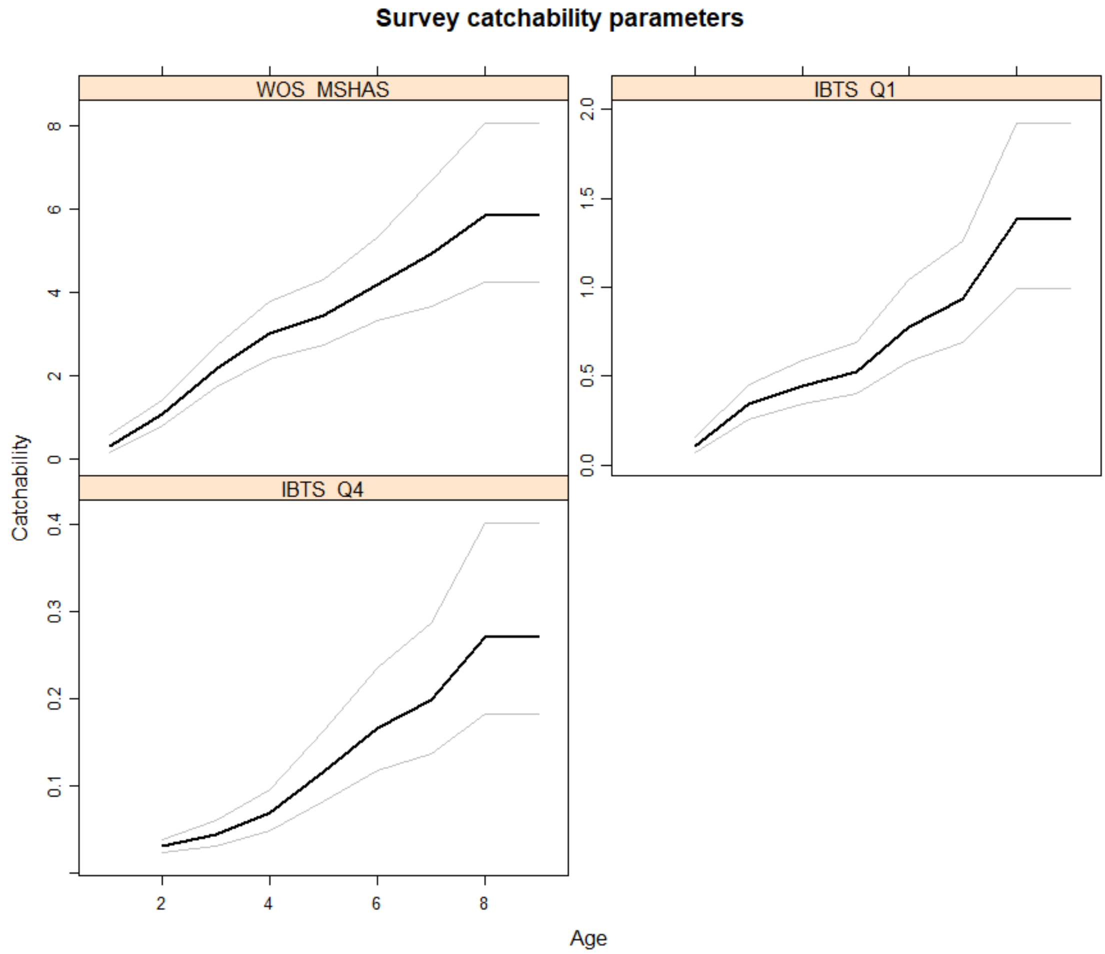


Figure 4.6.8. Herring in 6.a (combined) and 7.b–c. Survey catchability parameters from the WOS_MSHAS acoustic survey (top left), Scottish groundfish survey index quarter 1 (IBTS_Q1, top right) and Scottish groundfish survey index quarter 4 (IBTS_Q4, bottom left).

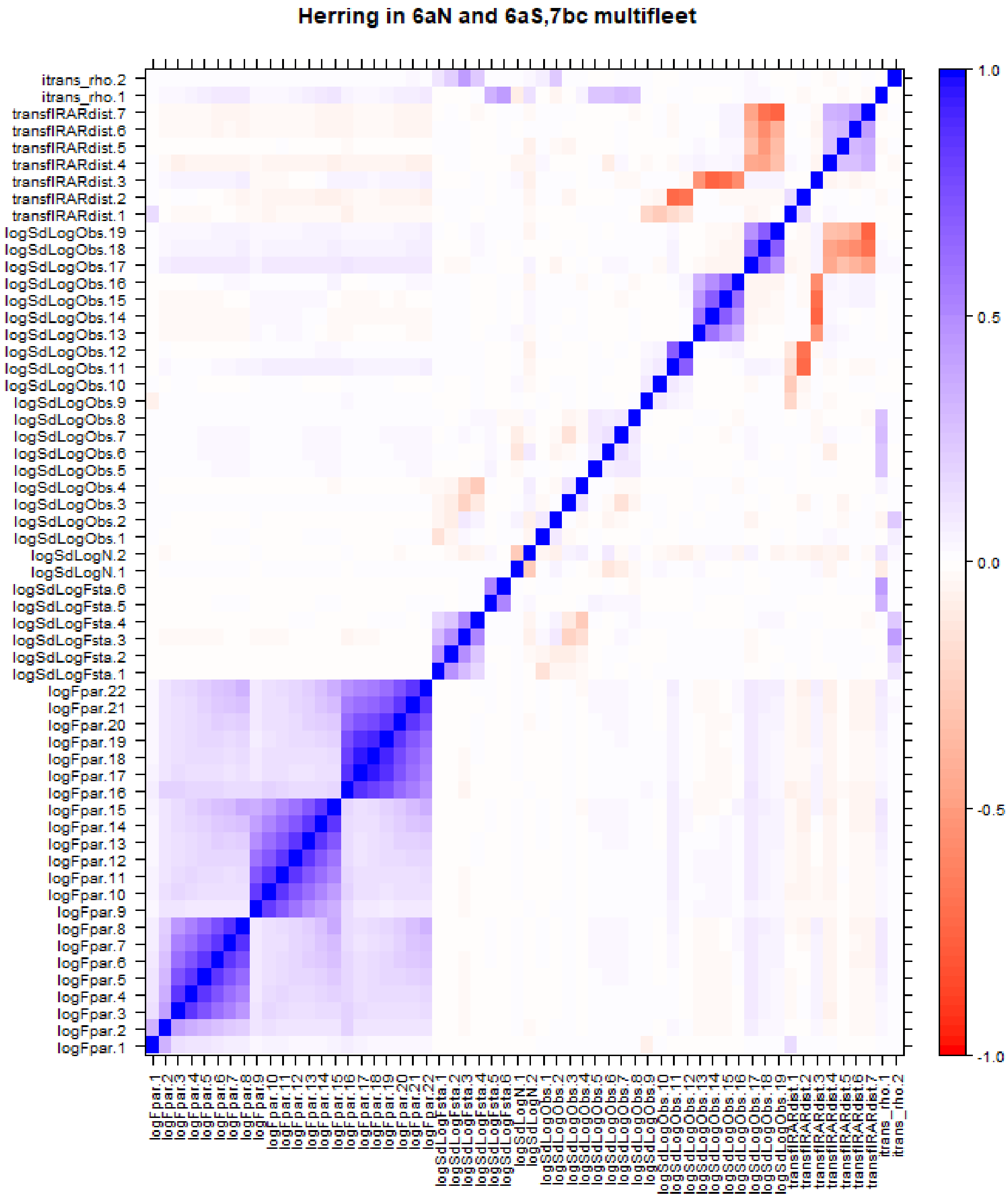


Figure 4.6.9. Herring in 6.a (combined) and 7.b–c. Correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

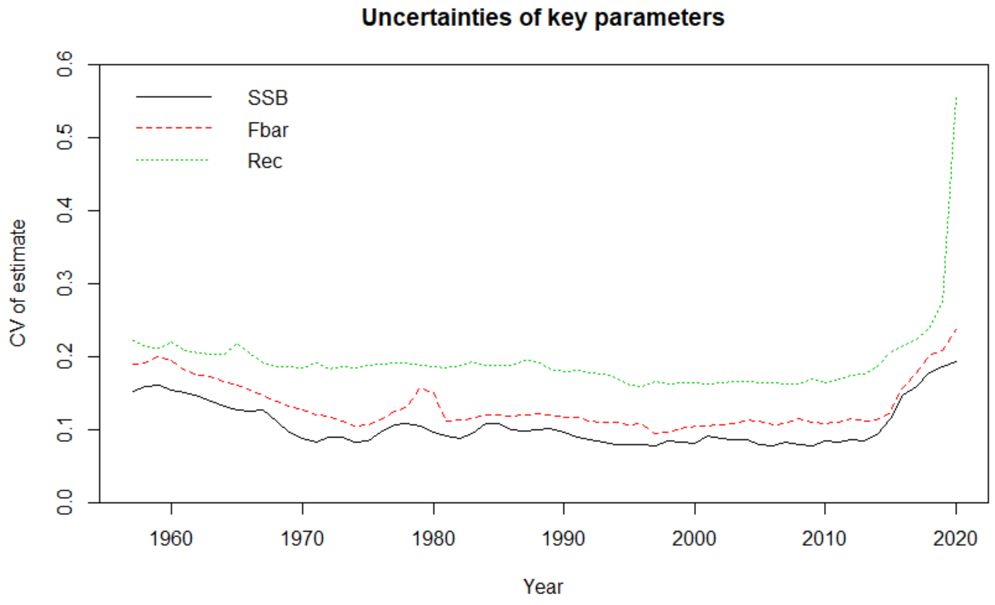


Figure 4.6.10. Herring in 6.a (combined) and 7.b–c. Uncertainty estimates in SSB, F_{bar} and recruitment parameters (1957–2020).

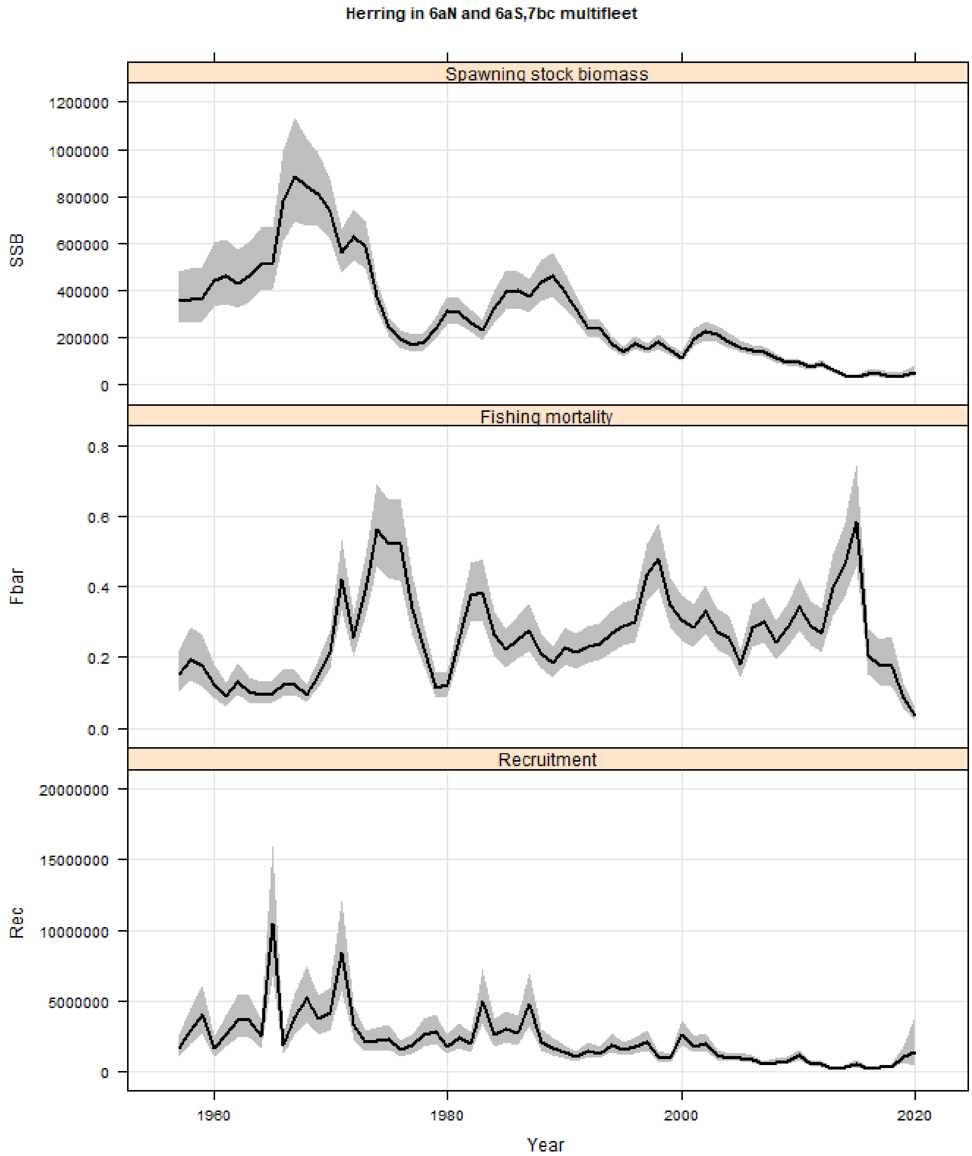


Figure 4.6.11. Herring in 6.a (combined) and 7.b–c. Stock summary plot with associated uncertainty for SSB (top panel), F ages 3–6 (middle panel) and recruitment (bottom panel).

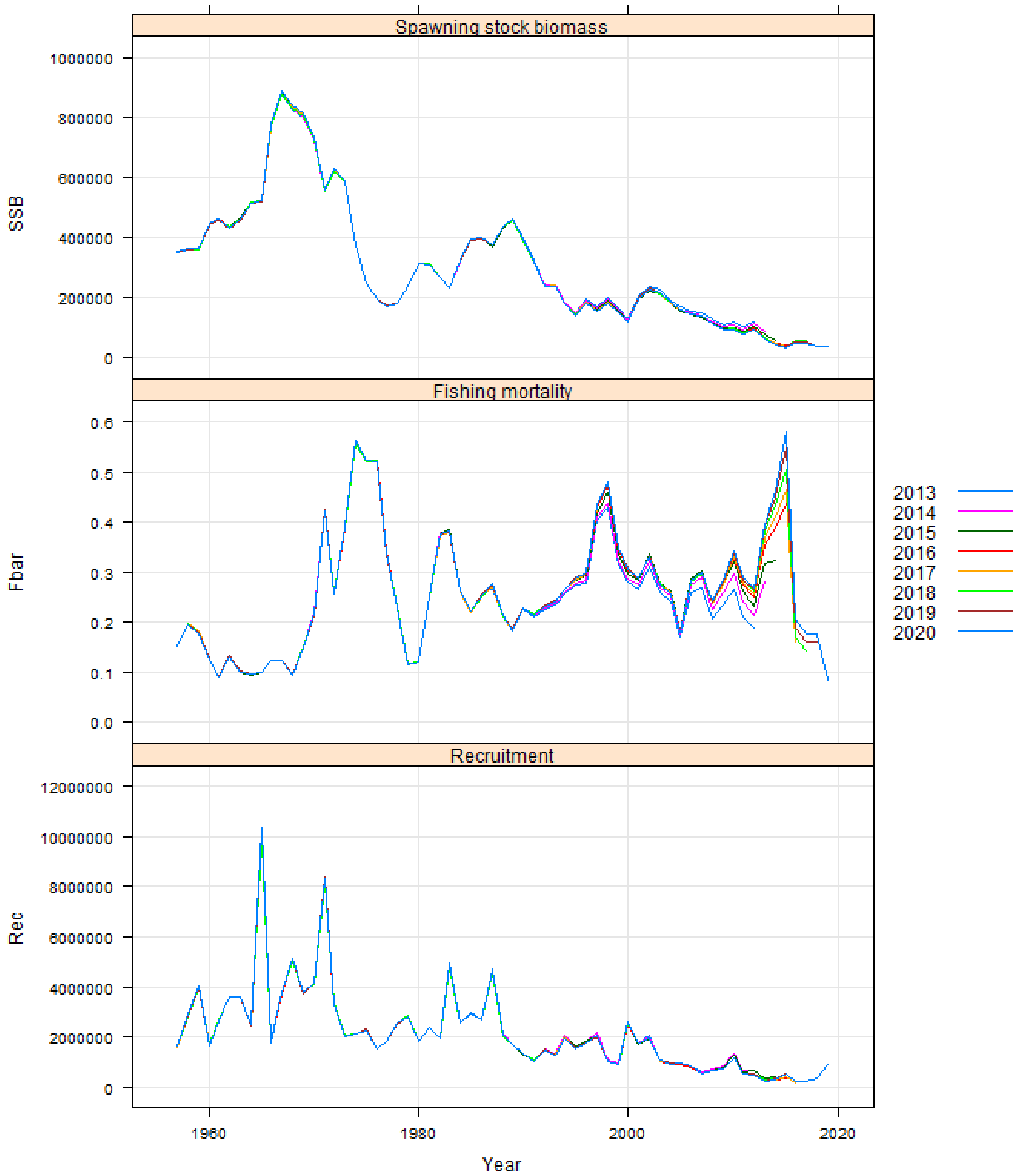


Figure 4.6.12. Herring in 6.a (combined) and 7.b–c. Analytical retrospective of the estimated spawning–stock biomass (top panel), fishing mortality (middle panel) and recruitment (bottom panel) as estimated over the years 2013–2020.

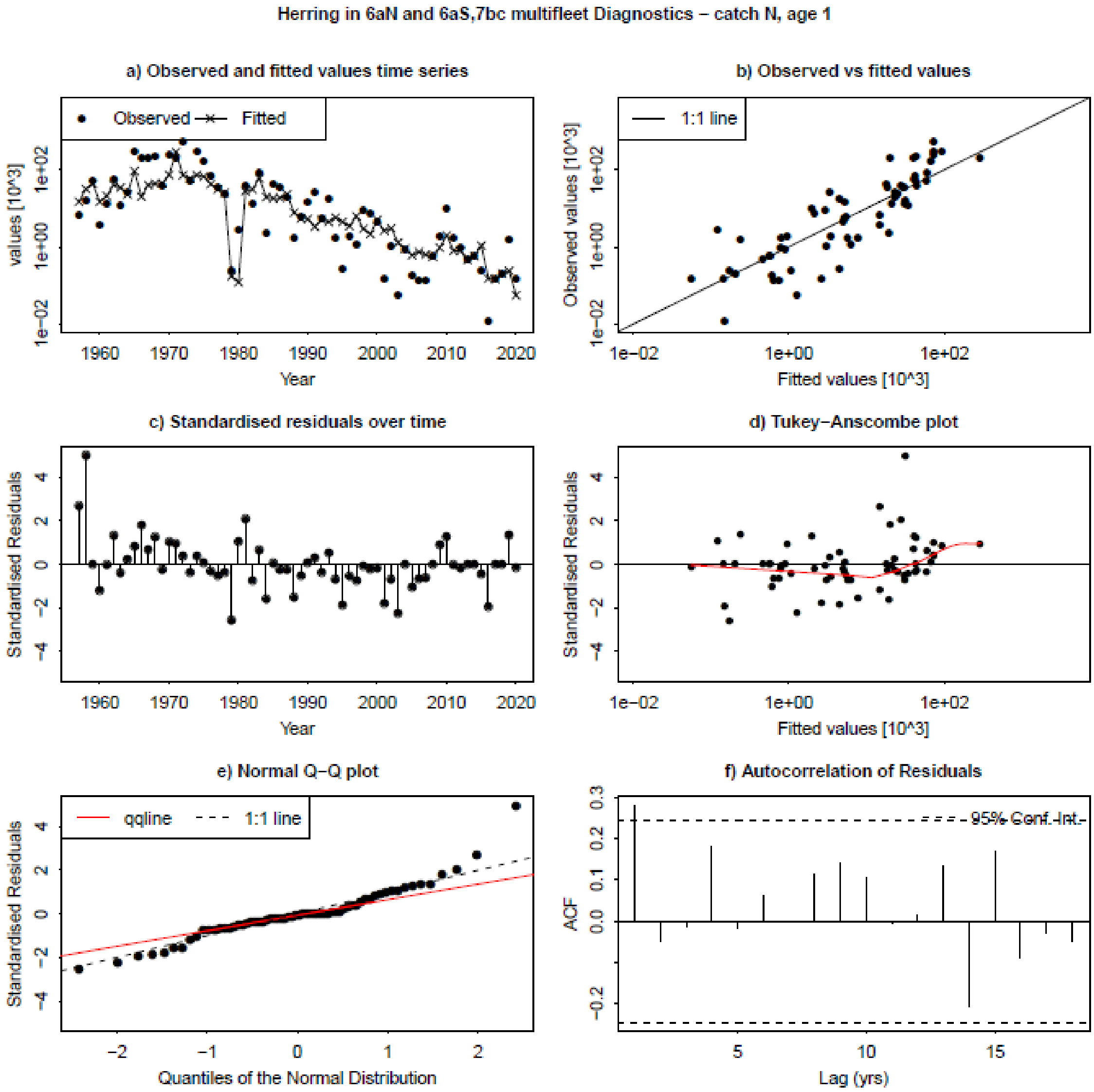


Figure 4.6.13. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

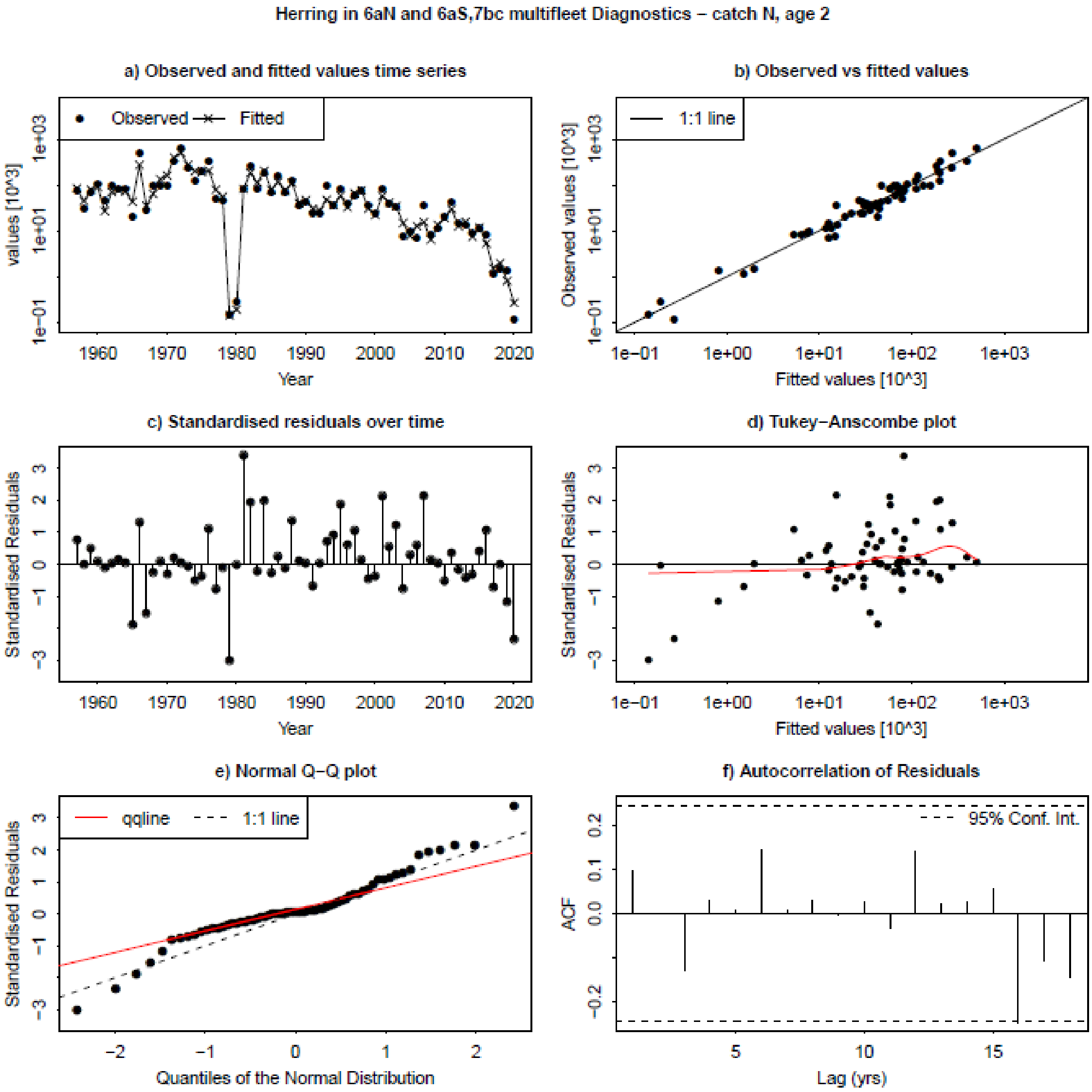


Figure 4.6.16. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

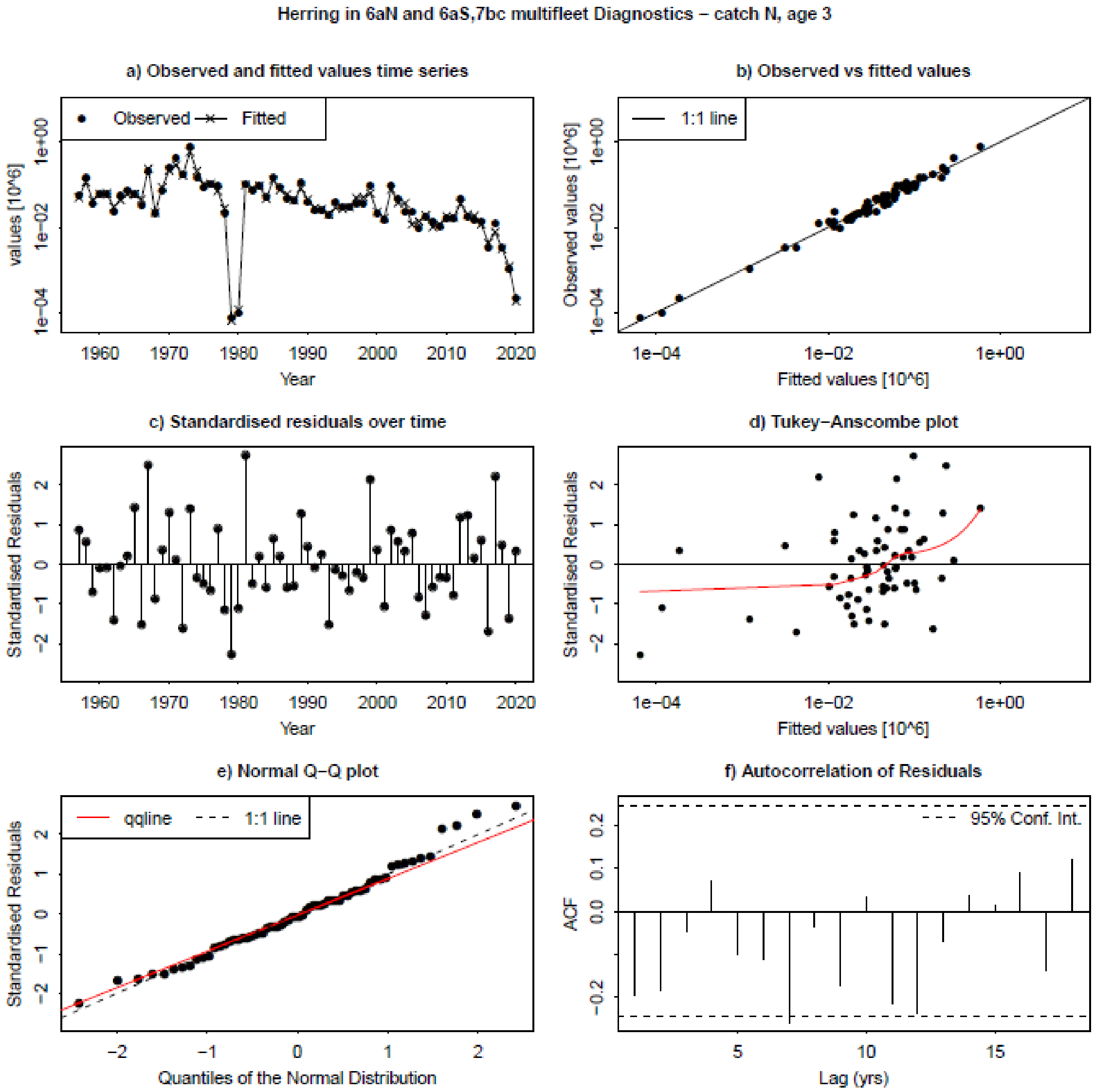


Figure 4.6.17. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

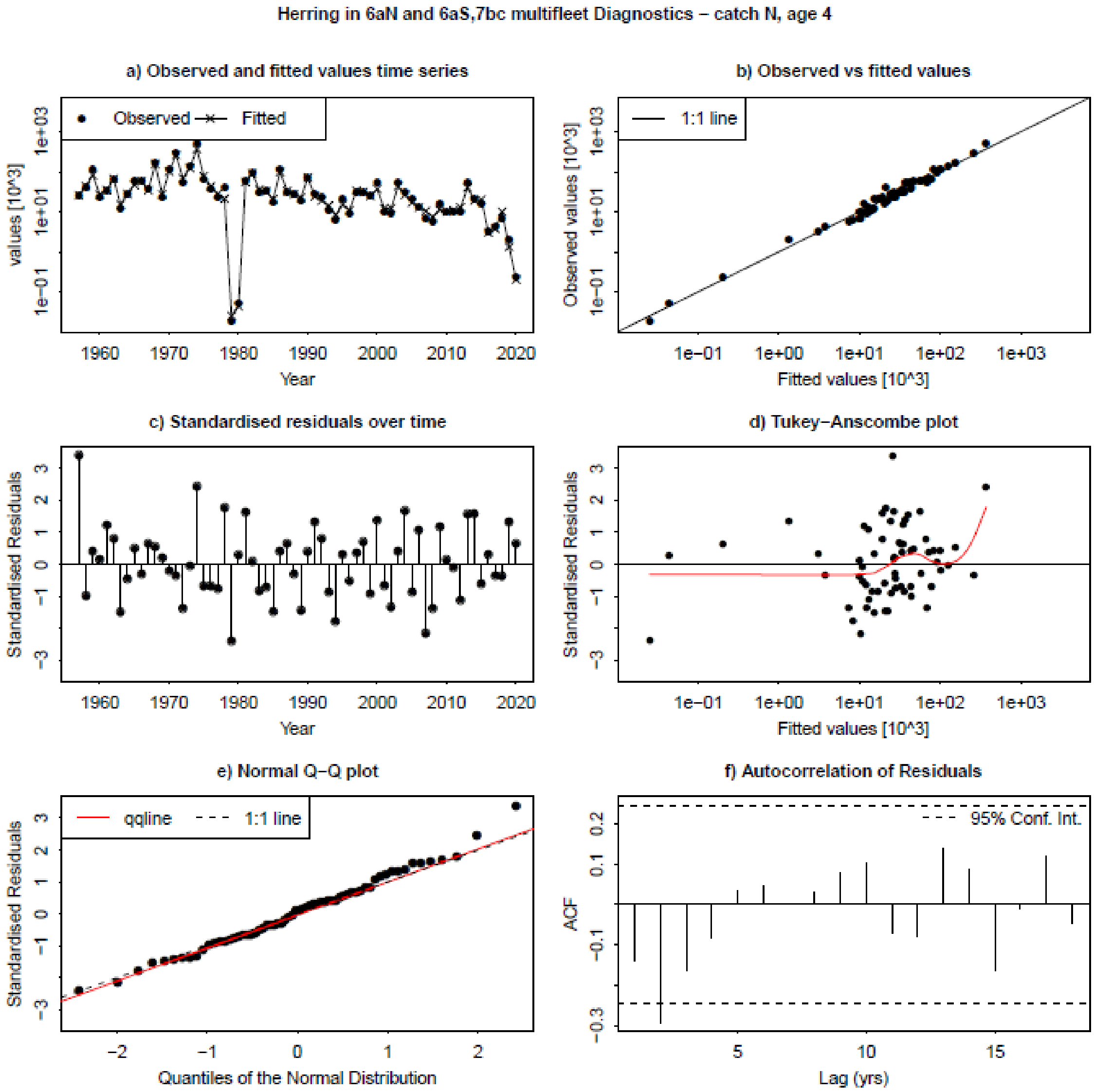


Figure 4.6.18. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

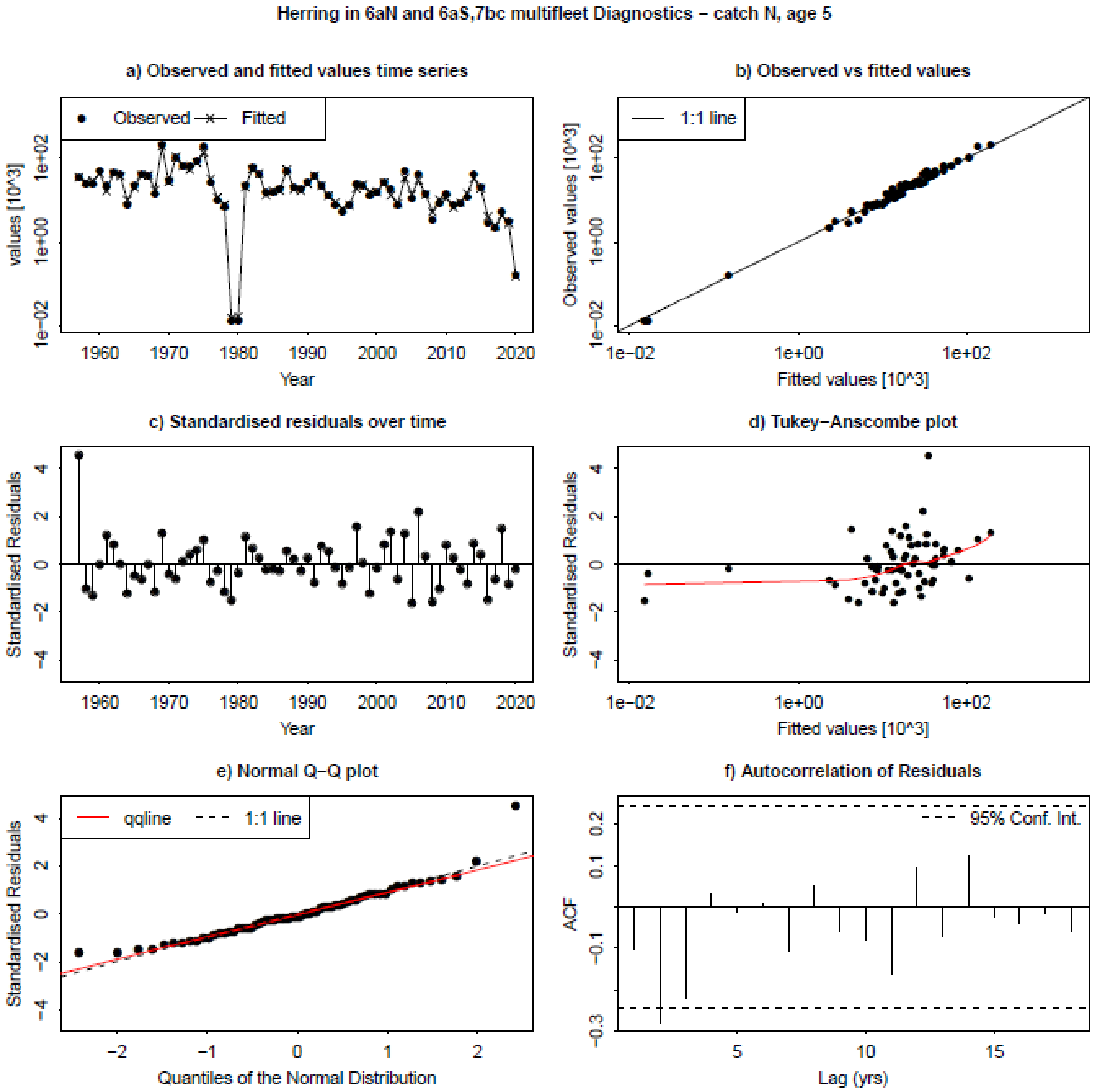


Figure 4.6.19. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

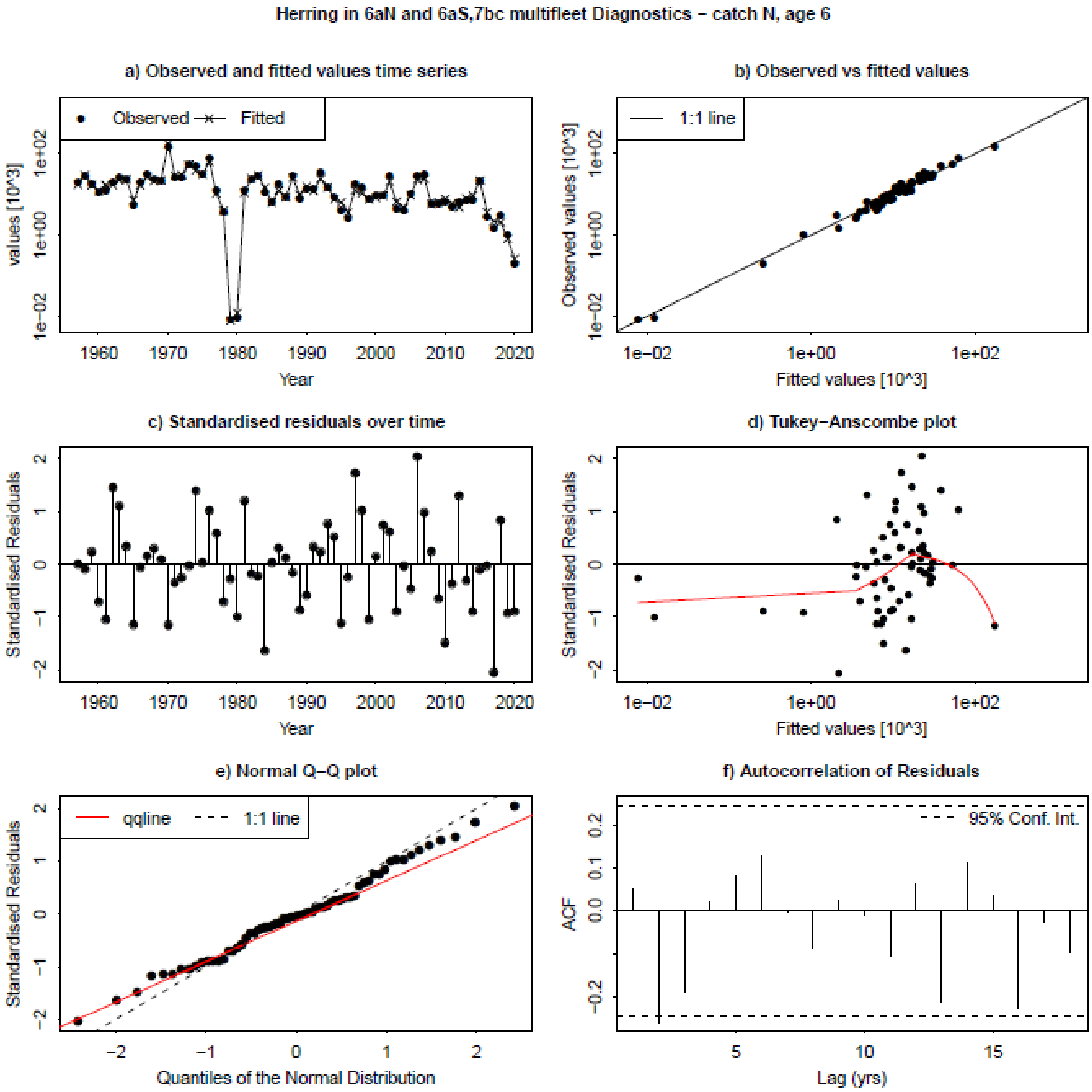


Figure 4.6.20. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

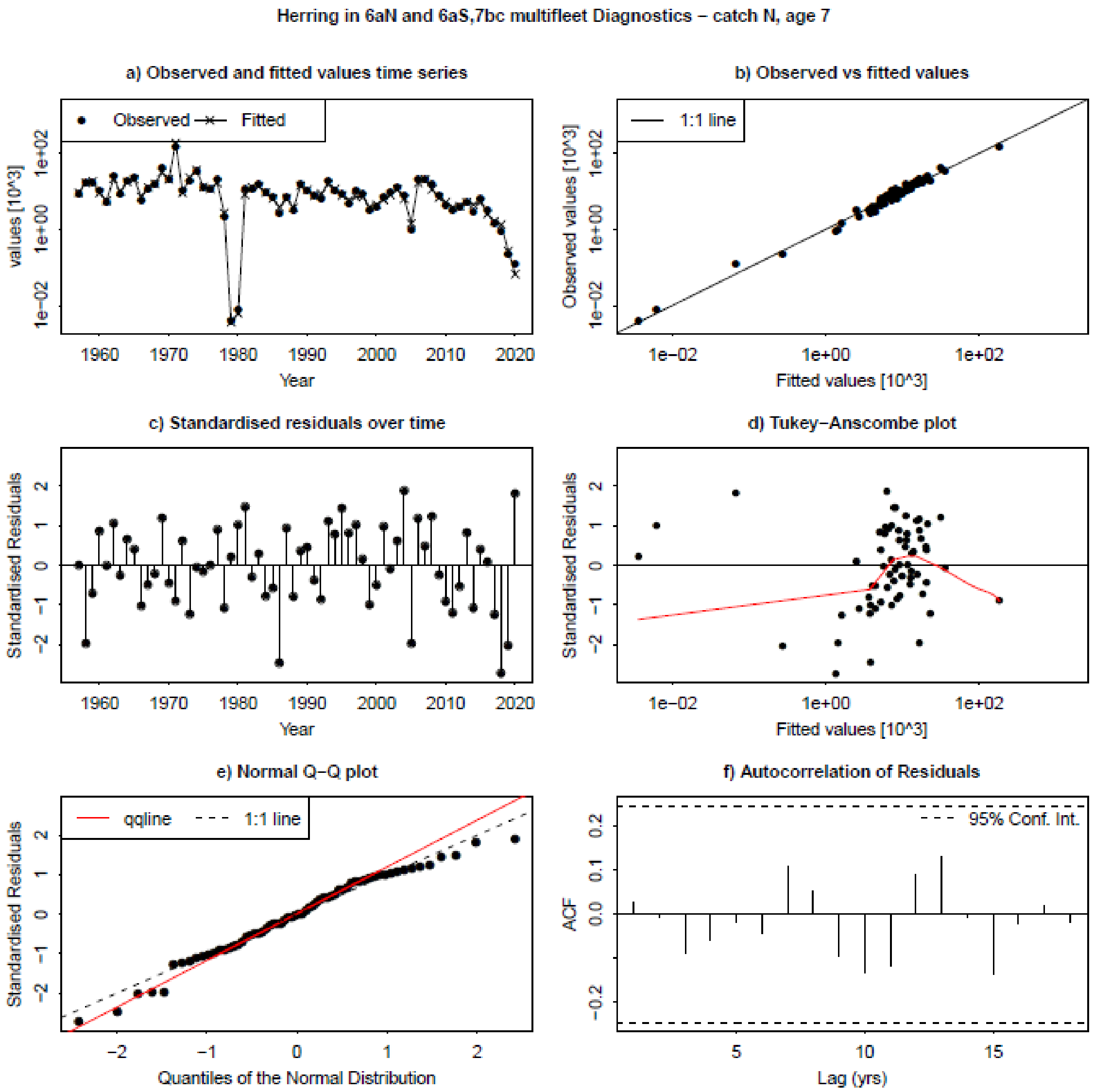


Figure 4.6.21. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

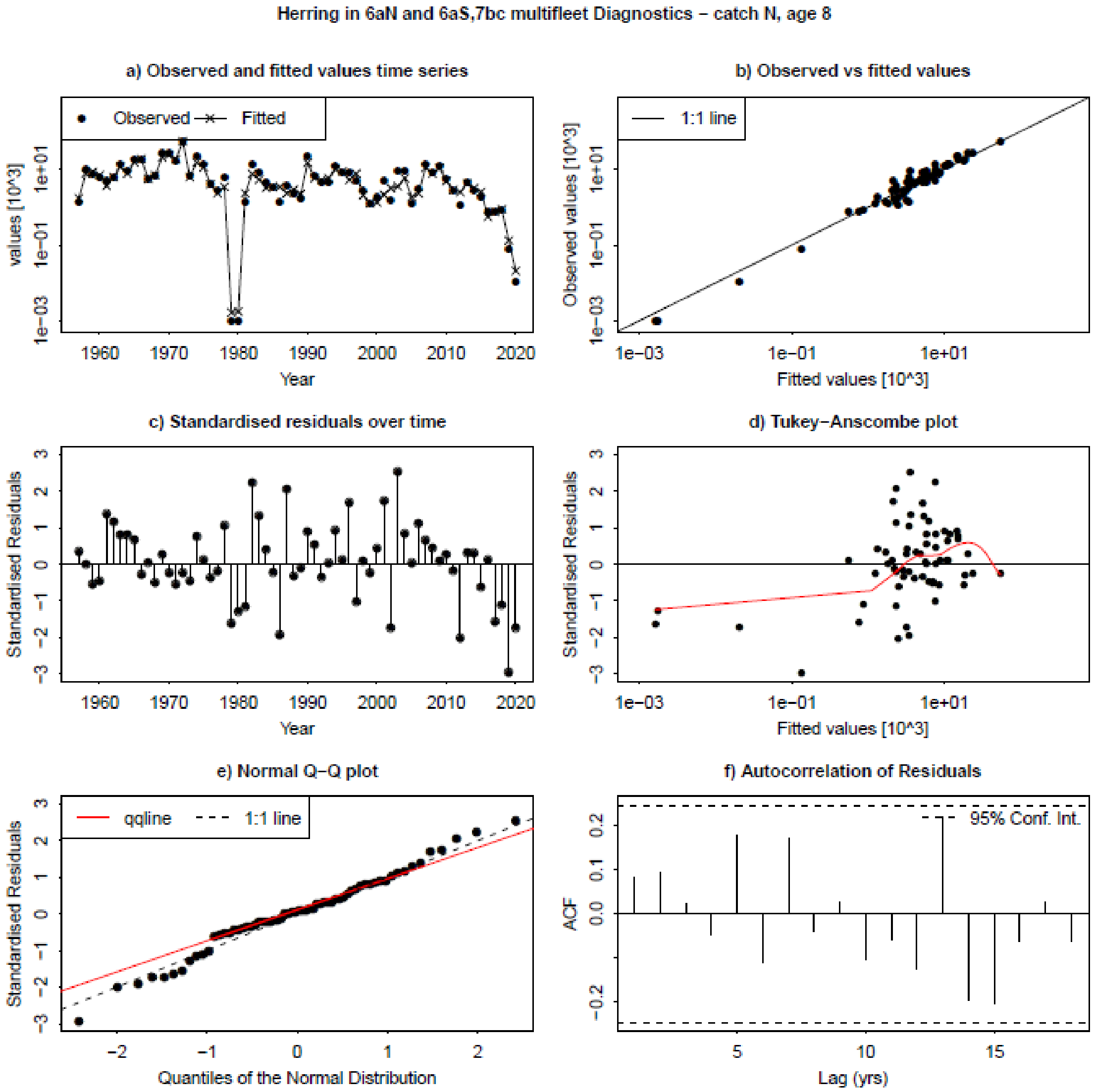


Figure 4.6.22. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

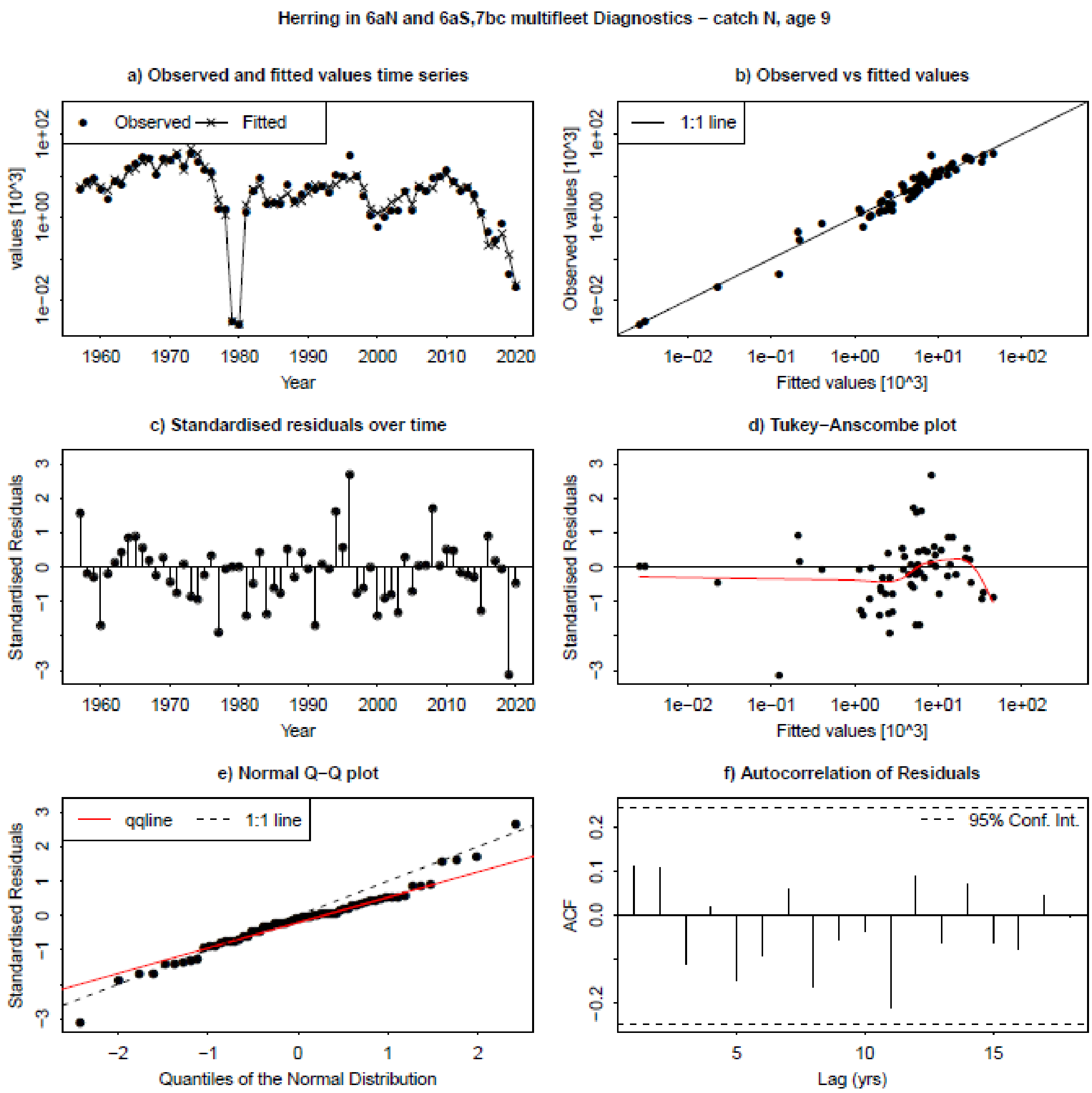


Figure 4.6.23. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

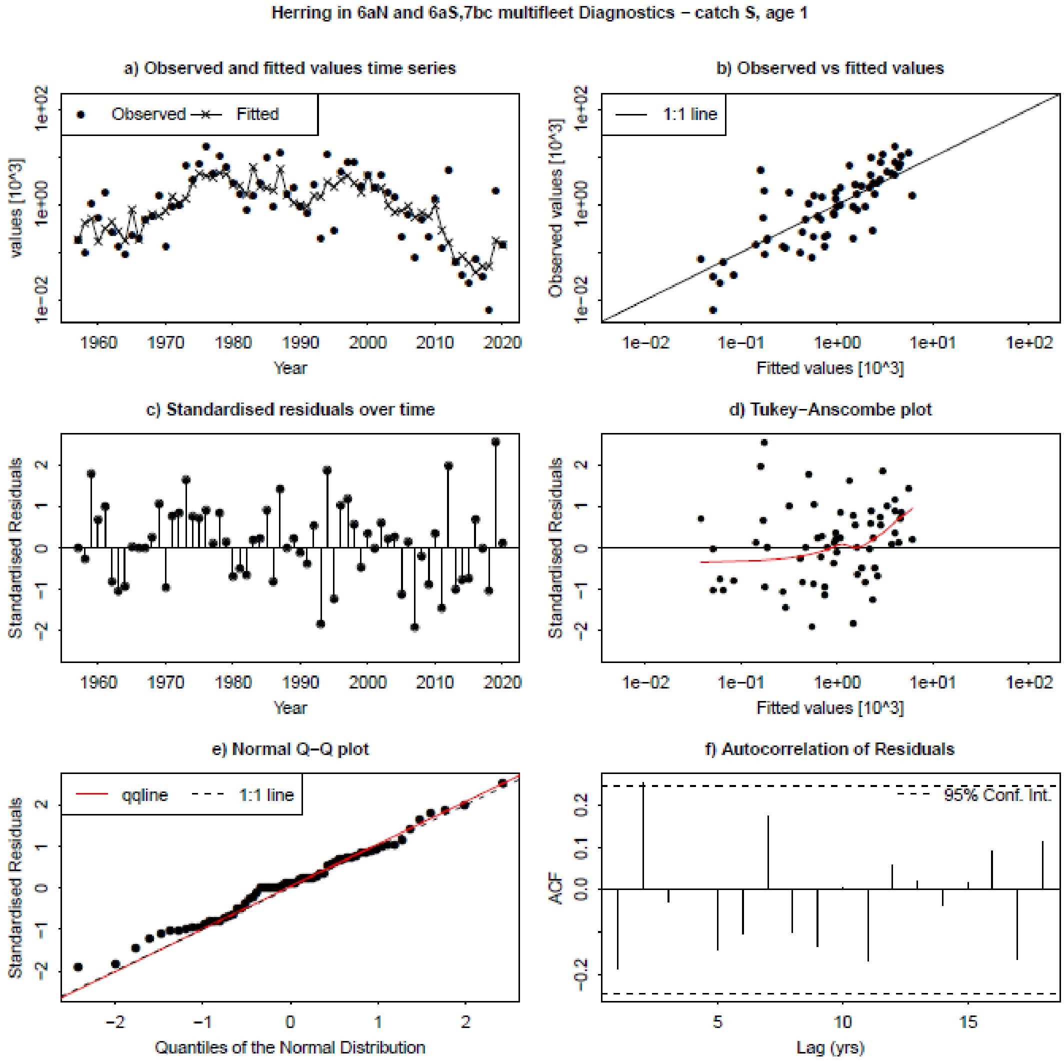


Figure 4.6.24. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

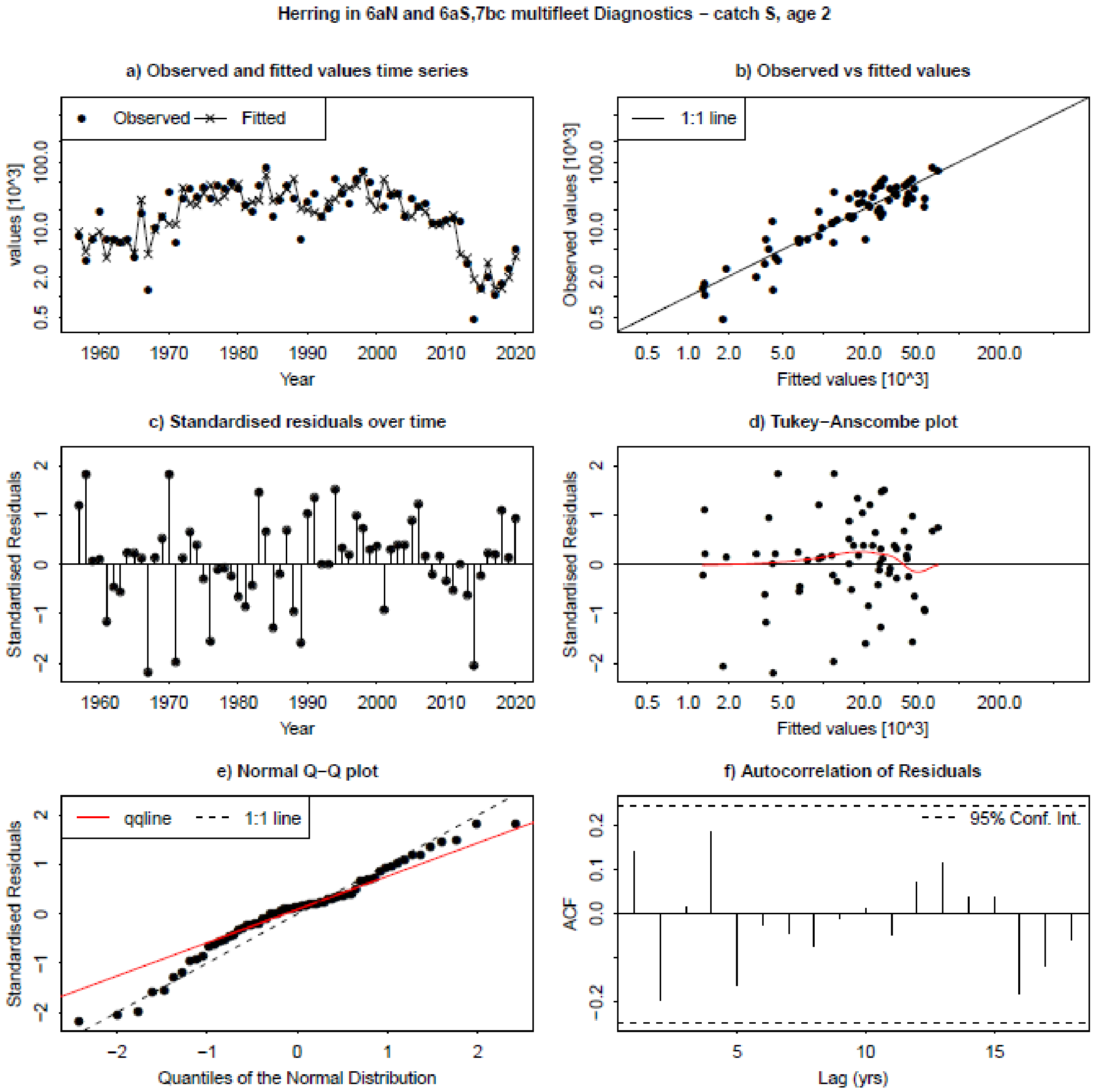


Figure 4.6.25. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

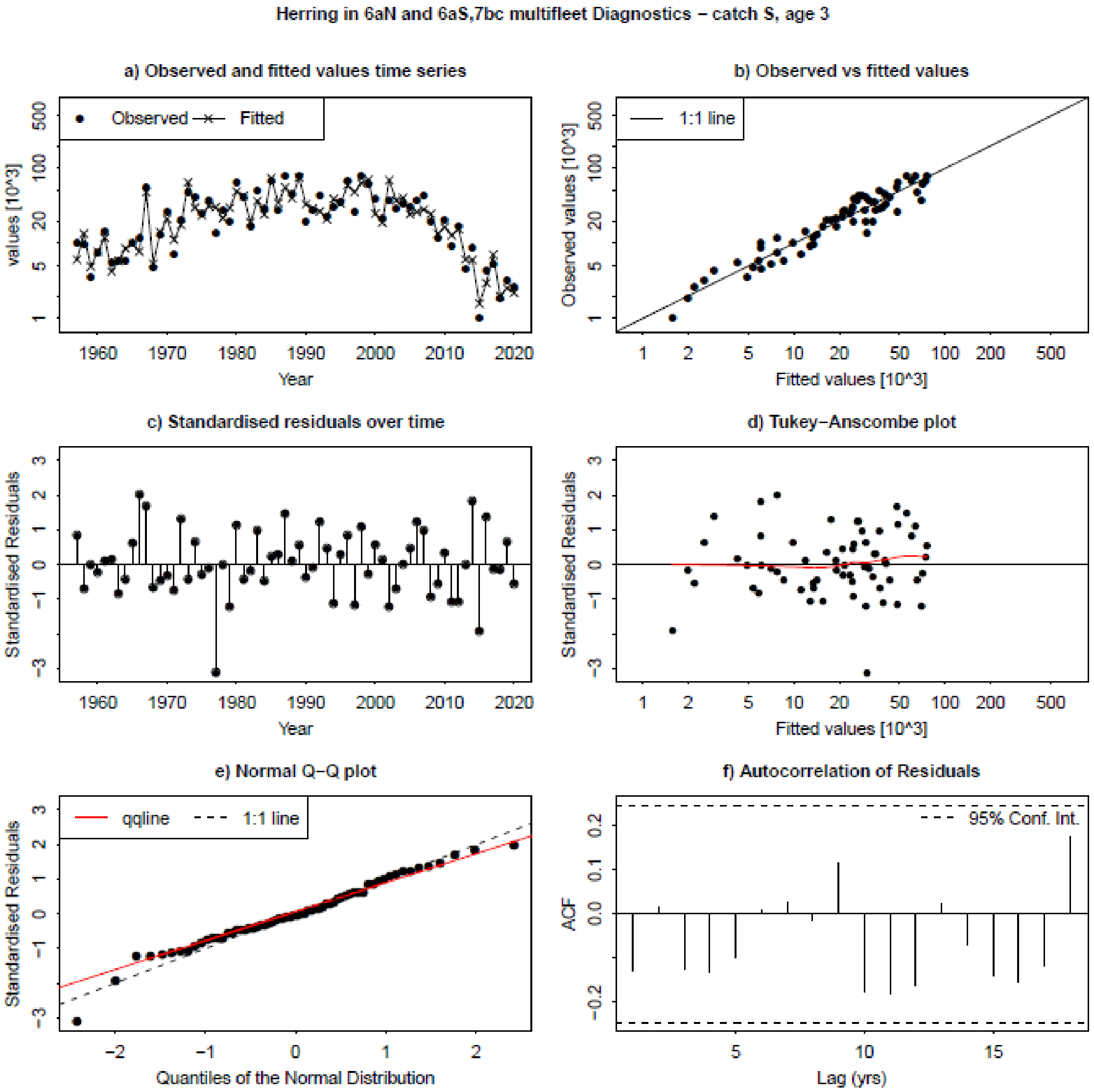


Figure 4.6.26. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

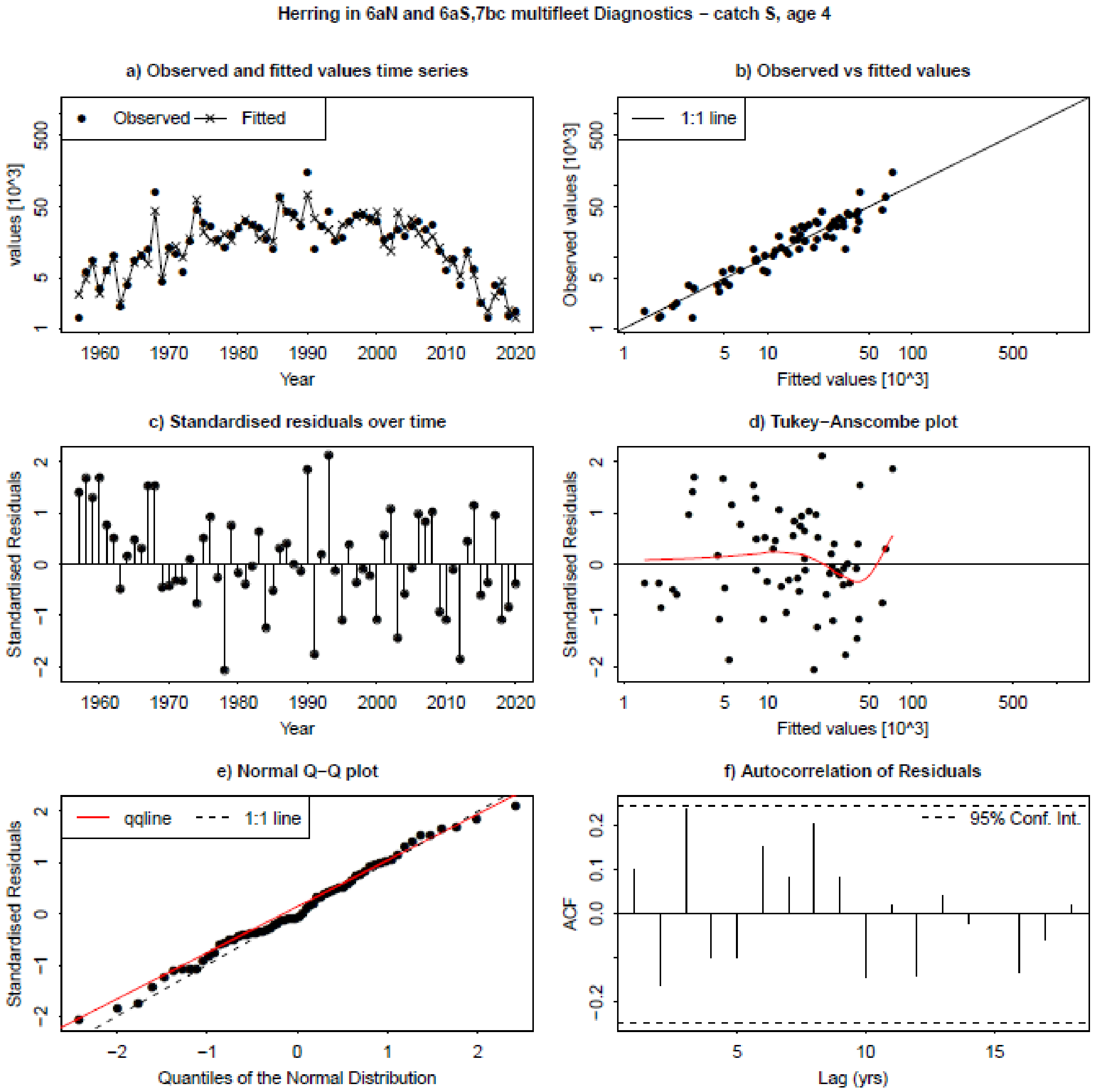


Figure 4.6.27. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

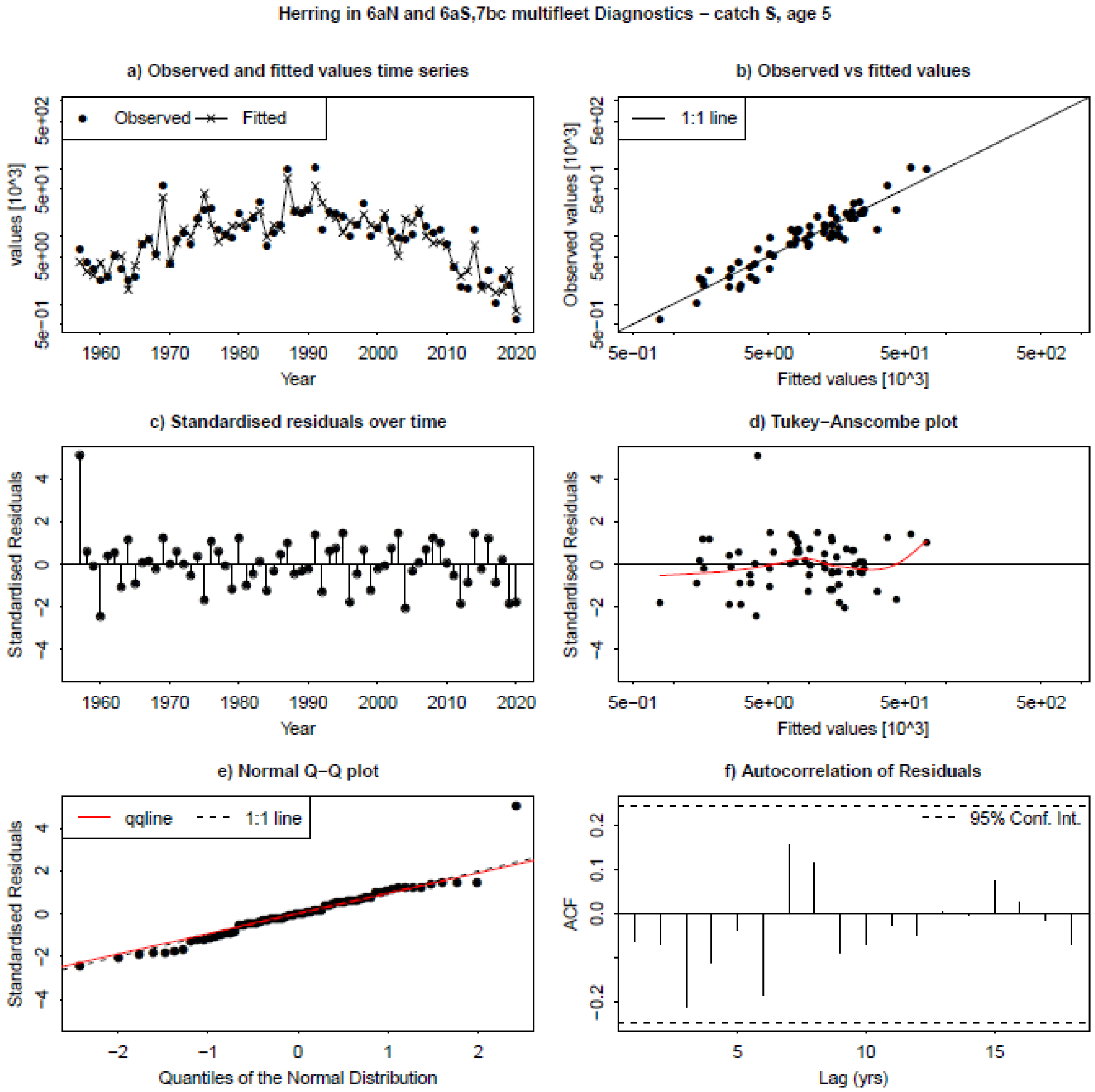


Figure 4.6.28. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

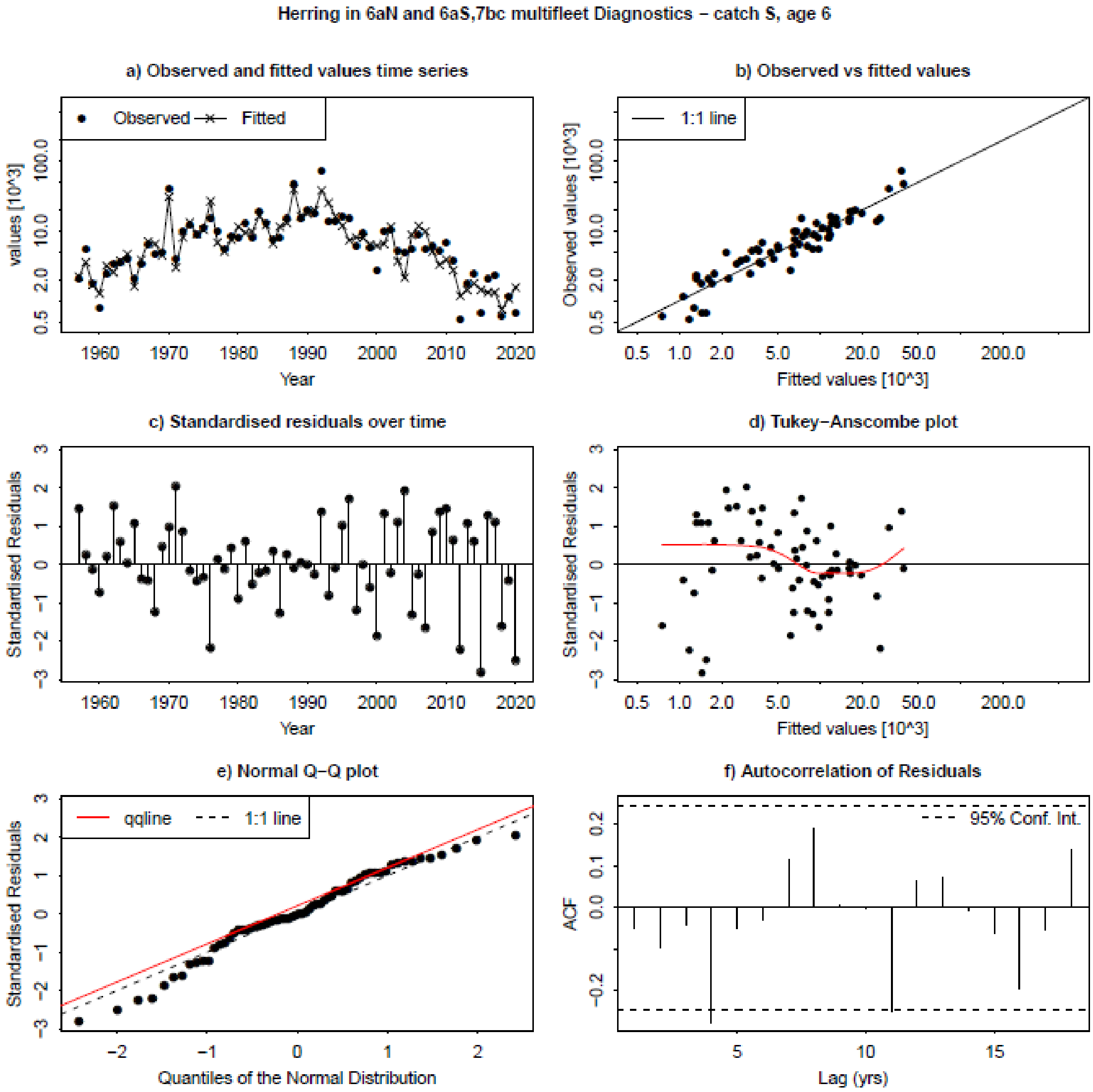


Figure 4.6.29. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

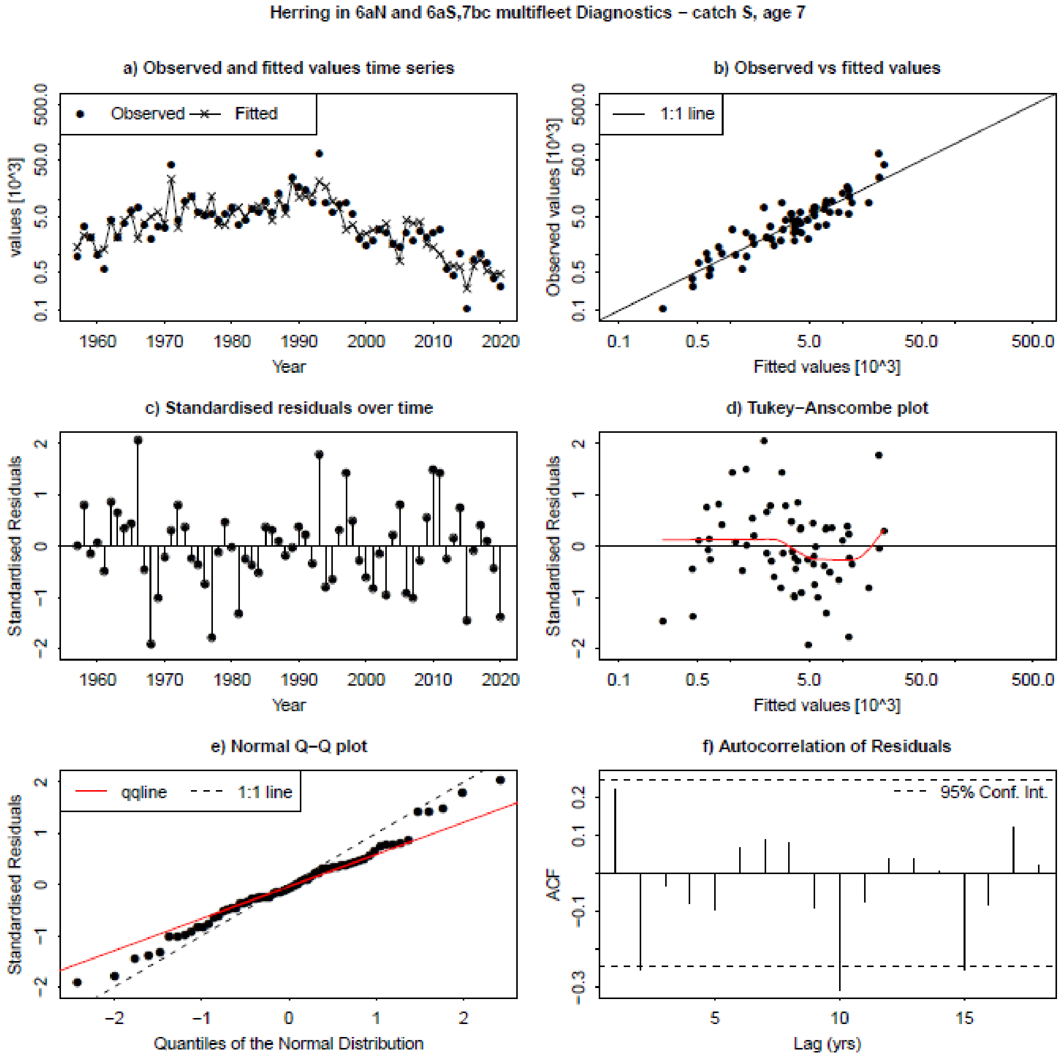


Figure 4.6.30. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

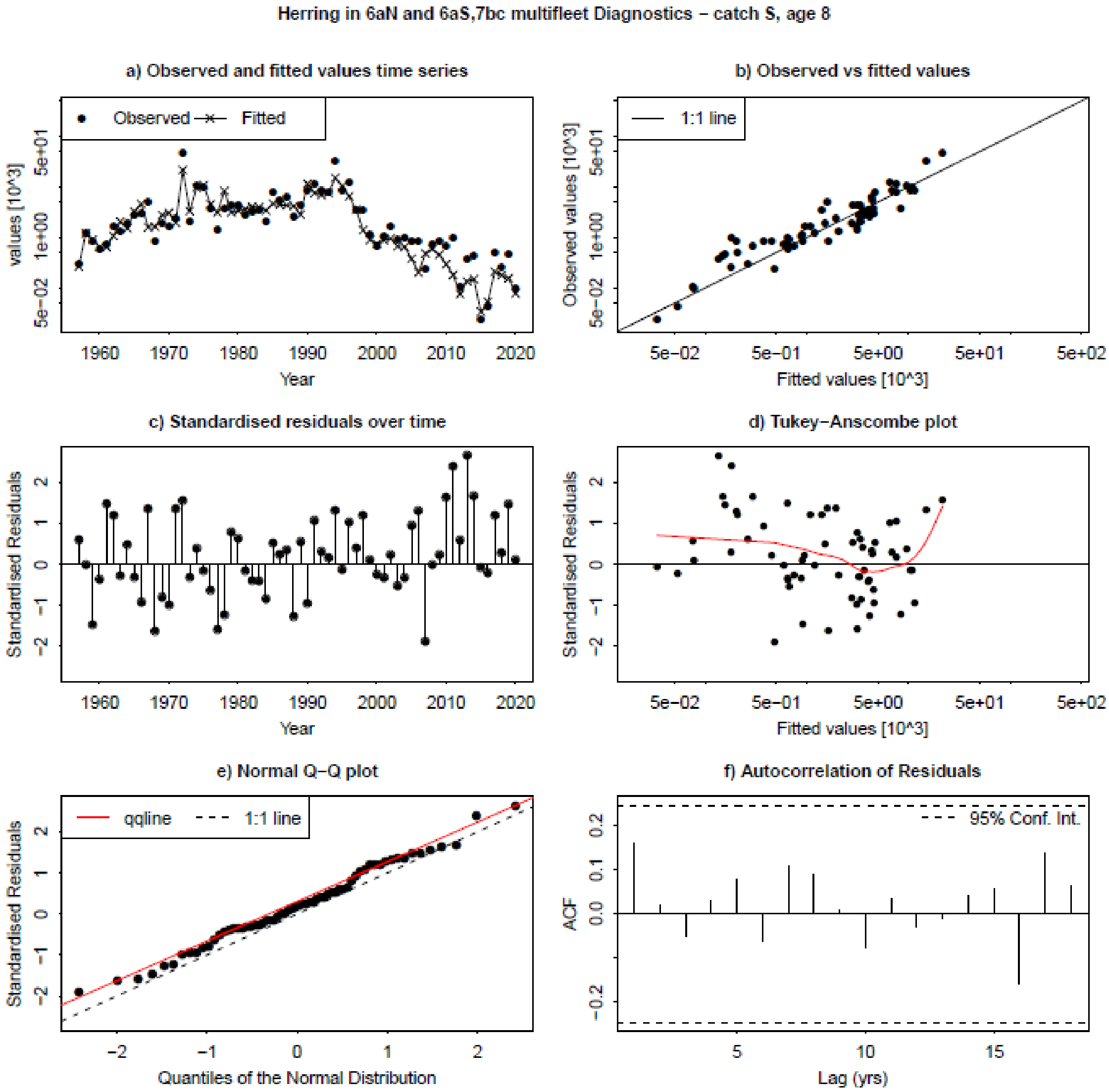


Figure 4.6.31. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

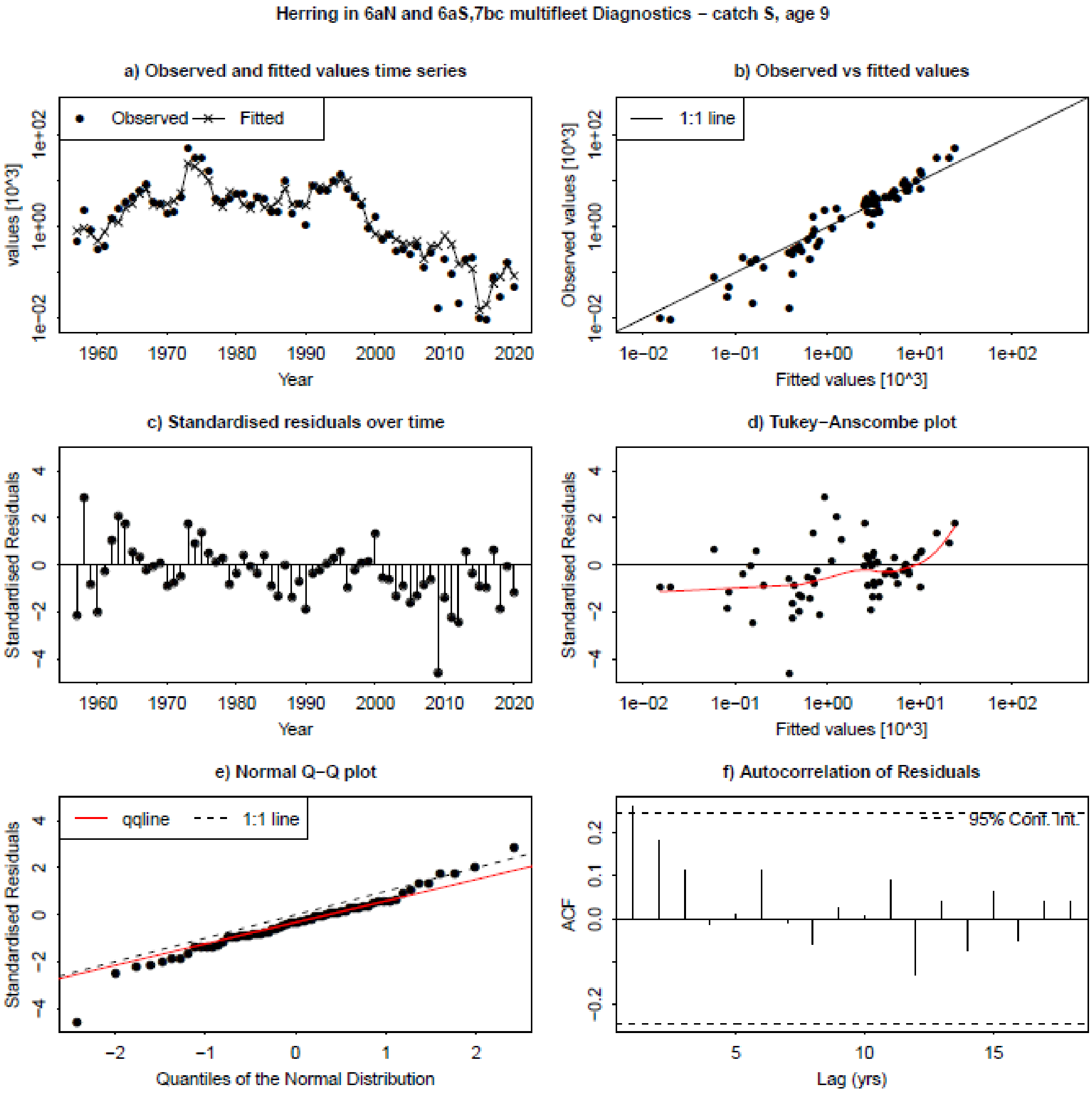


Figure 4.6.32. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

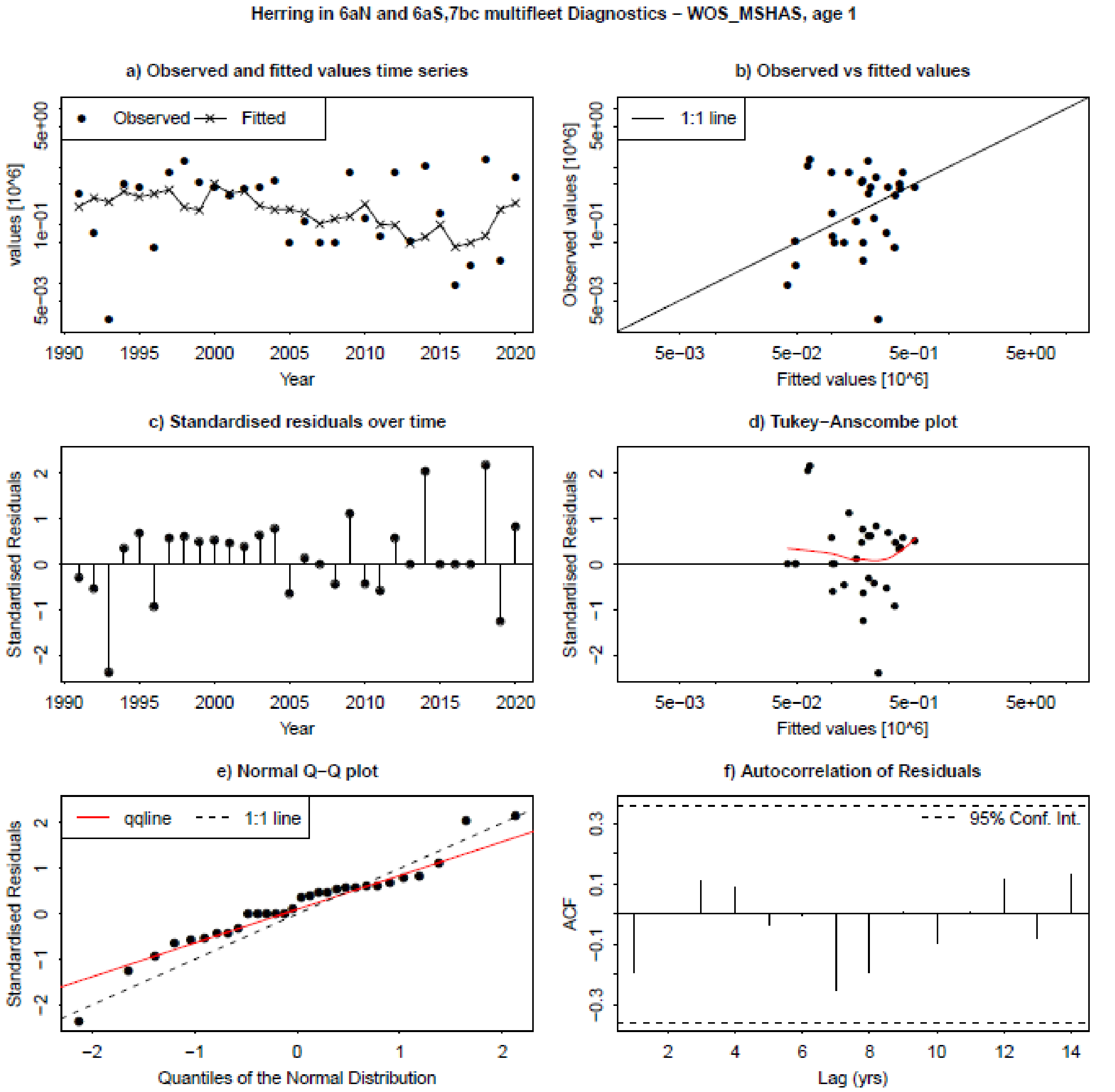


Figure 4.6.33. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 1-winter ring. Middle right: index observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot. There were no observations of 1 winter ring fish in this survey in 2015 and 2016, therefore the figure stops at 2014.

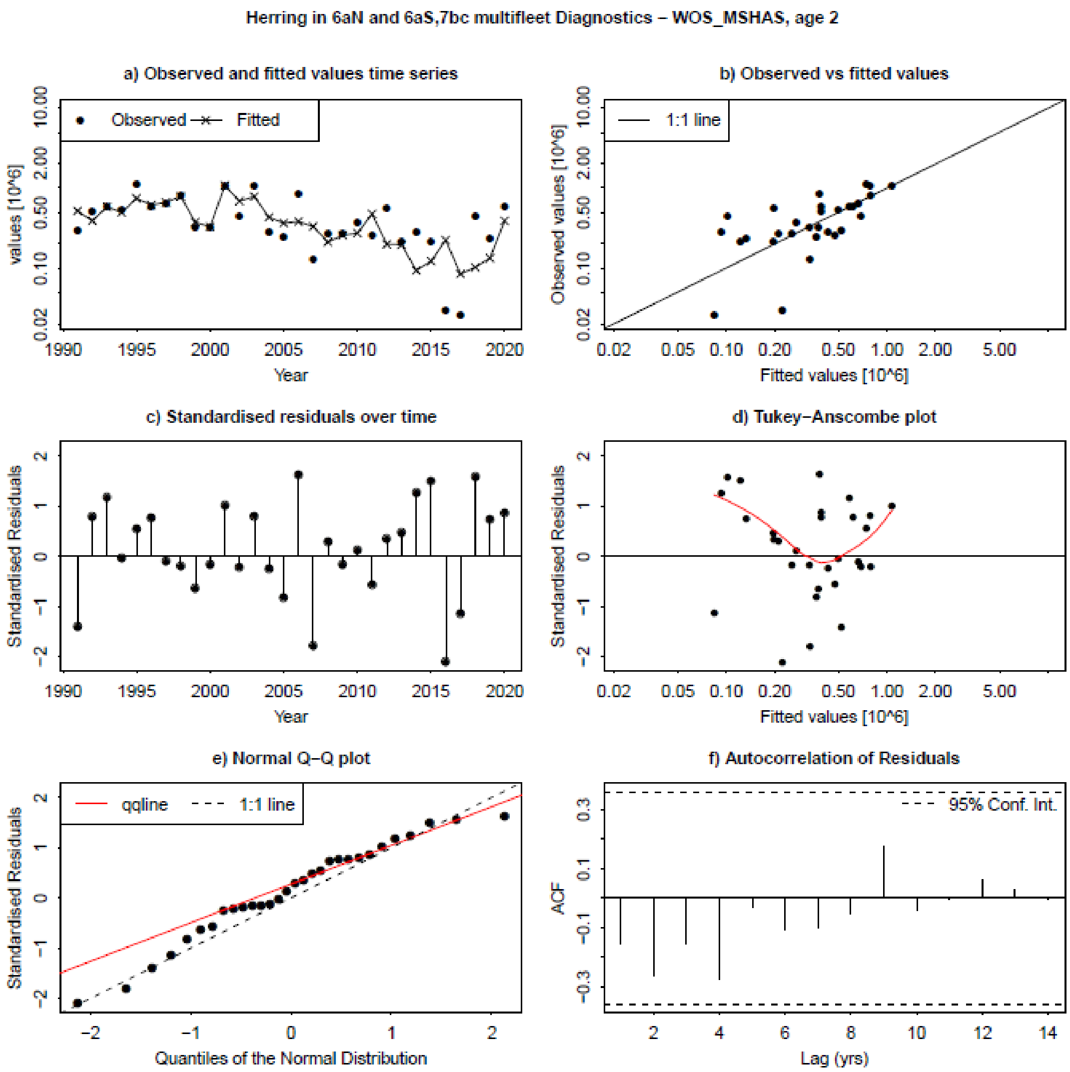


Figure 4.6.34. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

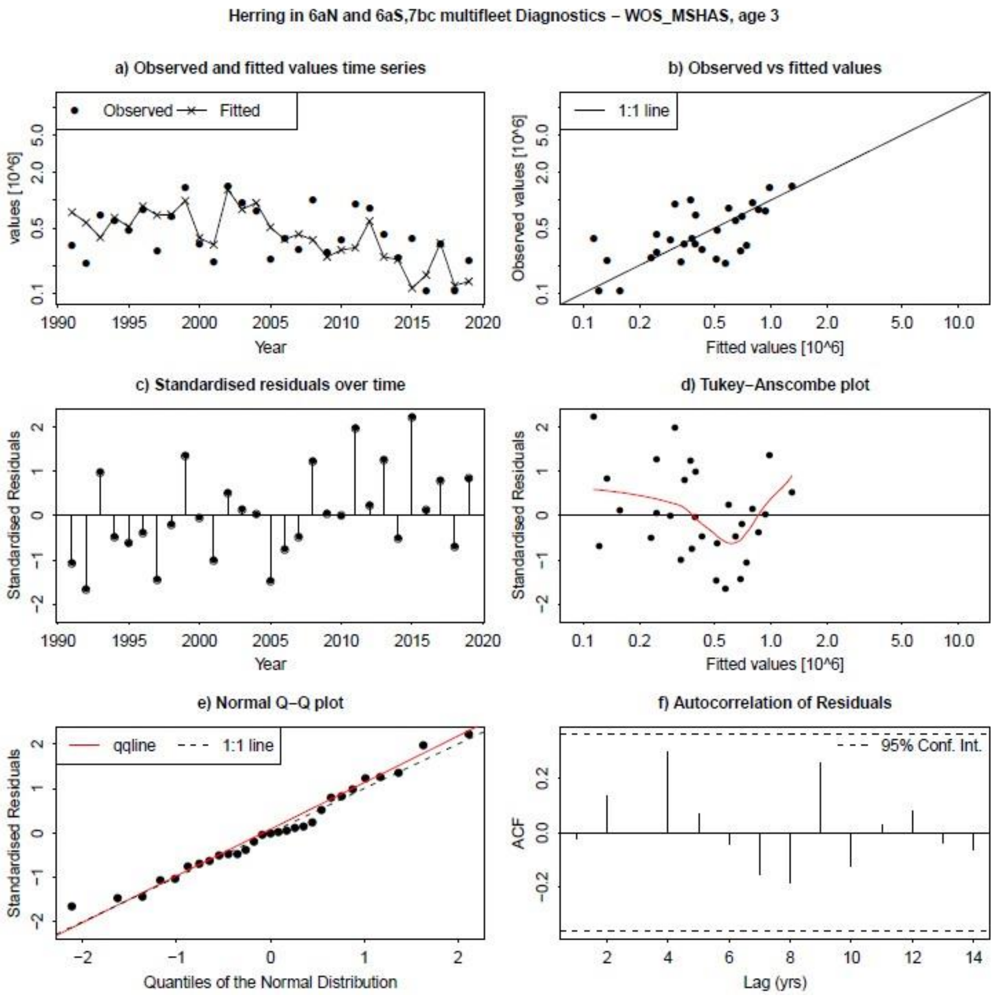


Figure 4.6.35. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

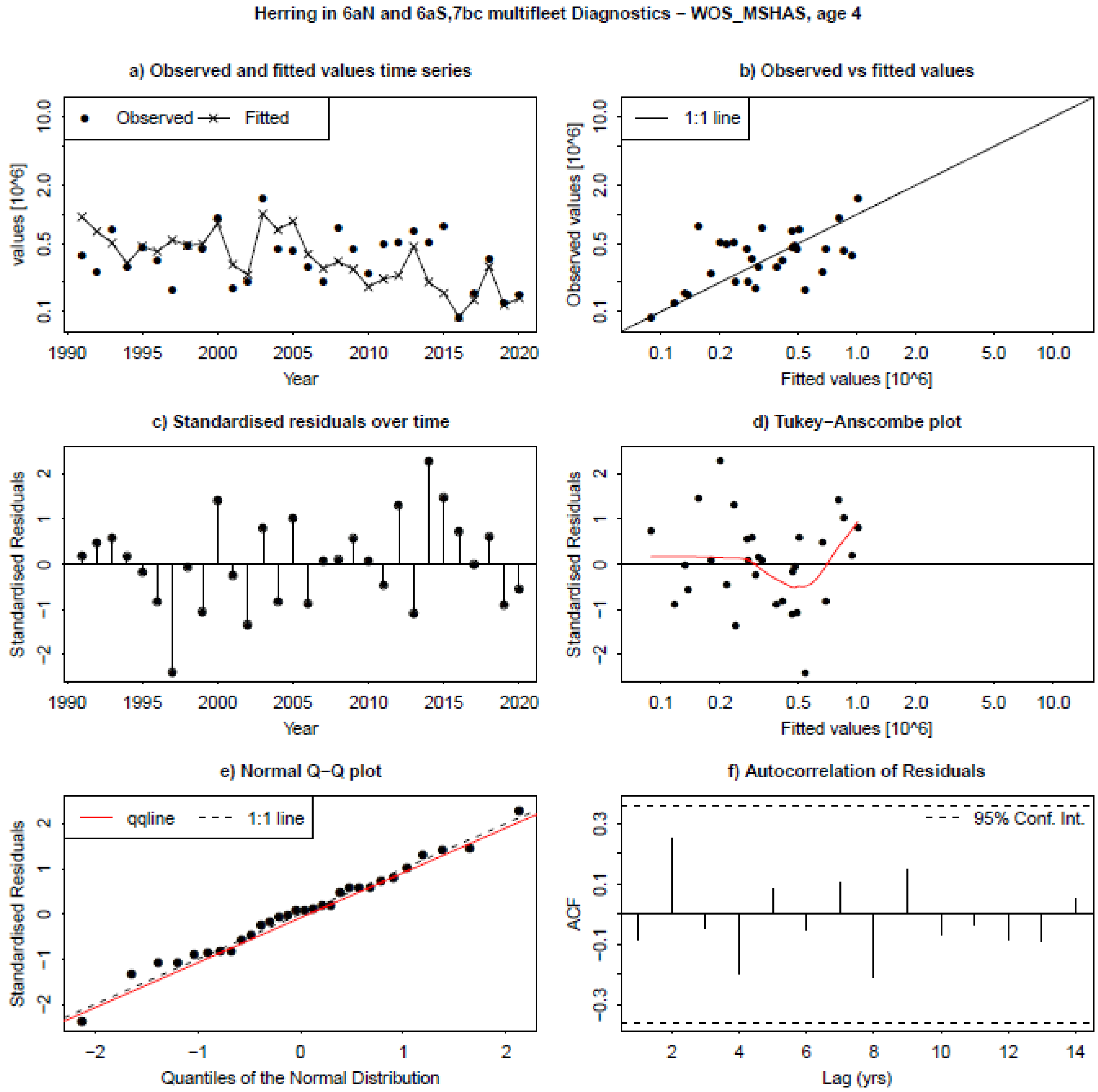


Figure 4.6.36. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

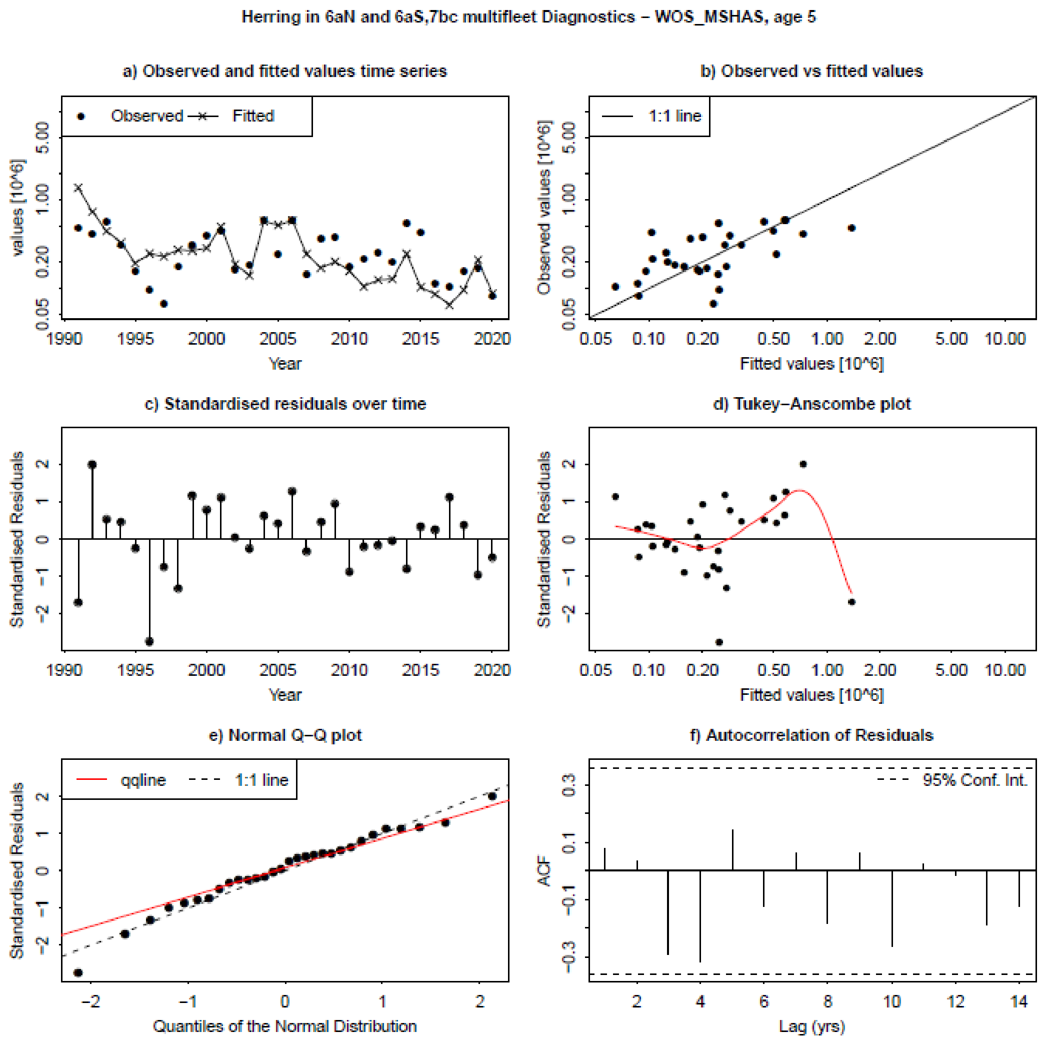


Figure 4.6.37. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

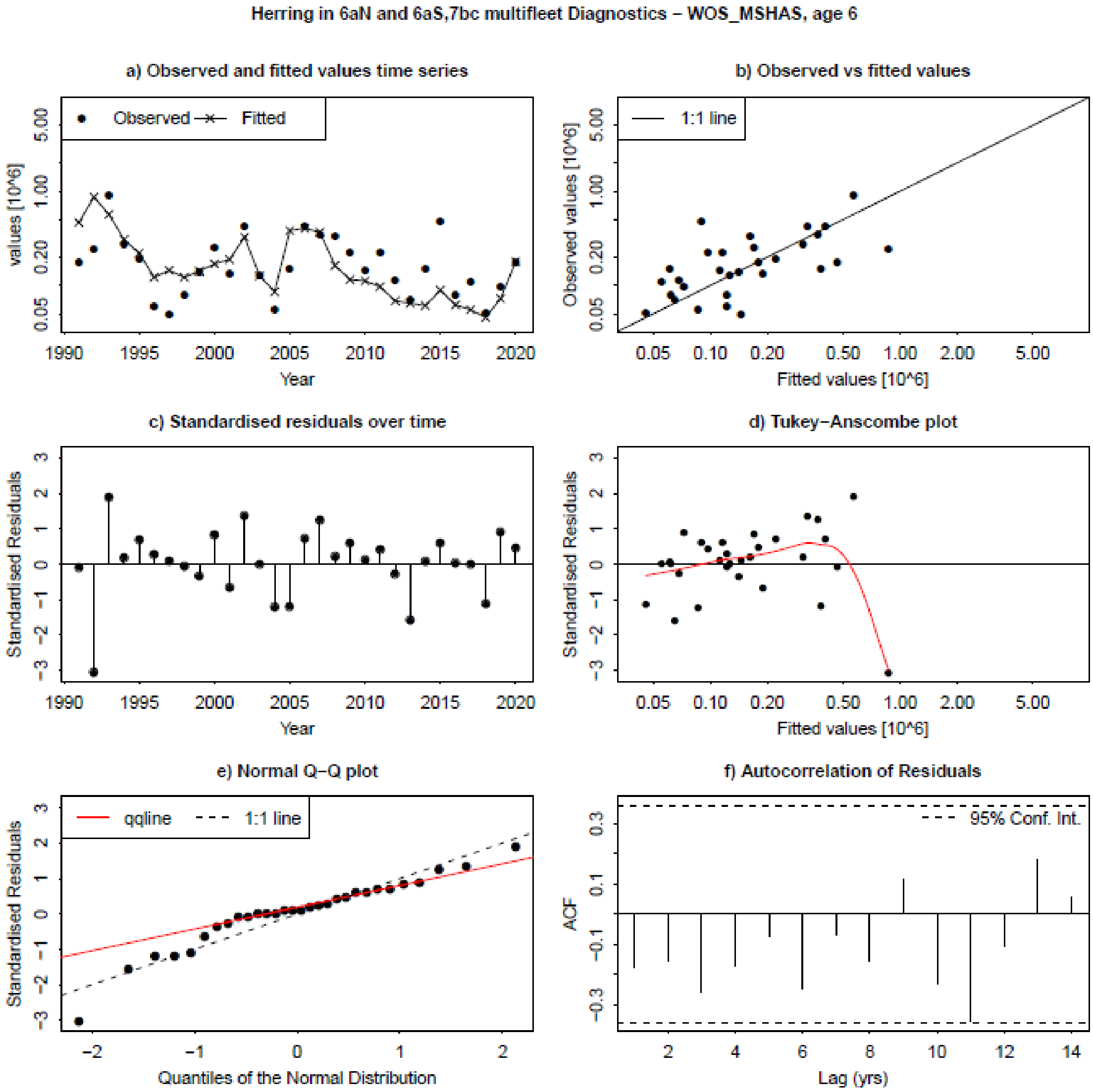


Figure 4.6.38. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

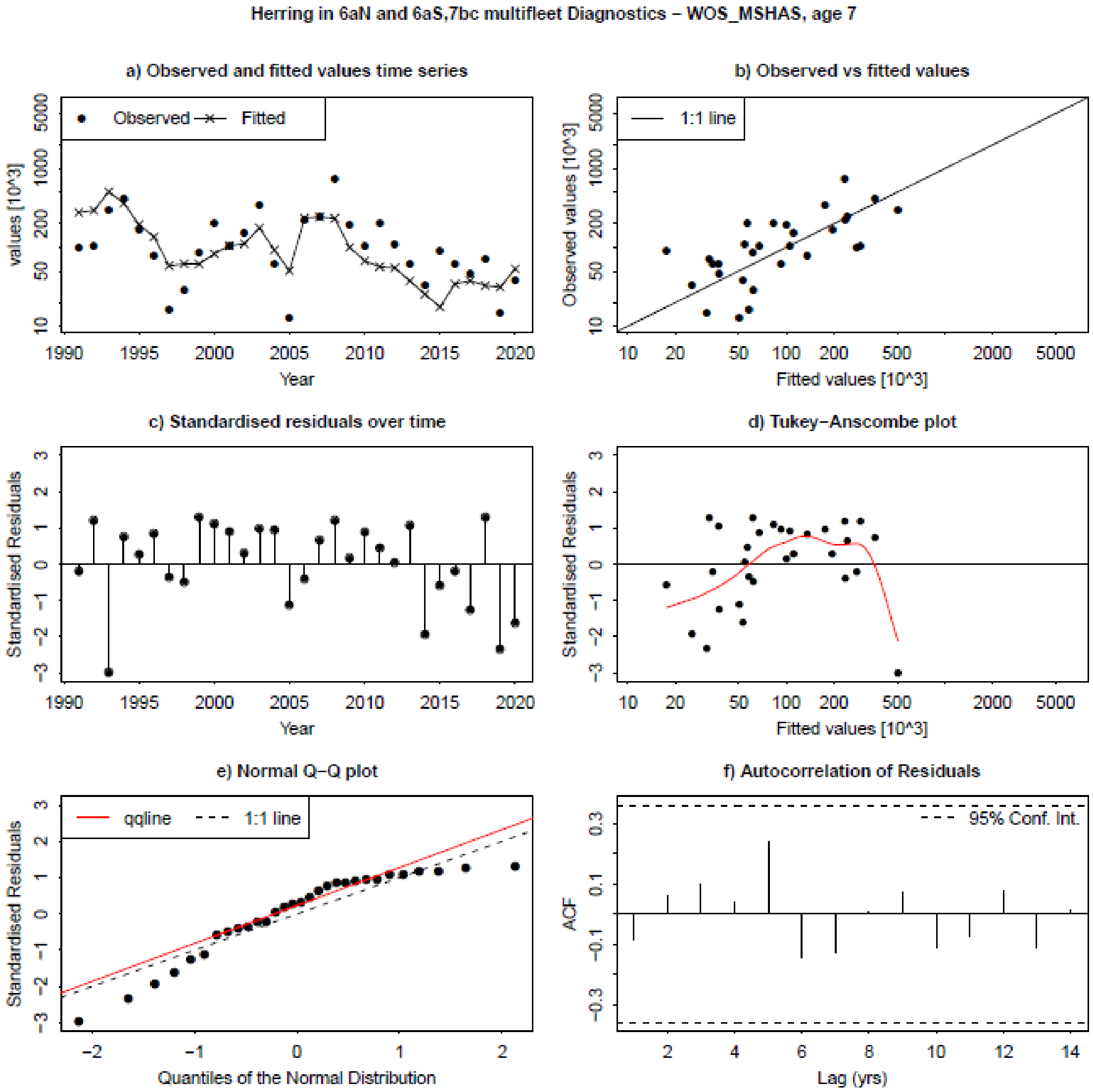


Figure 4.6.39. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

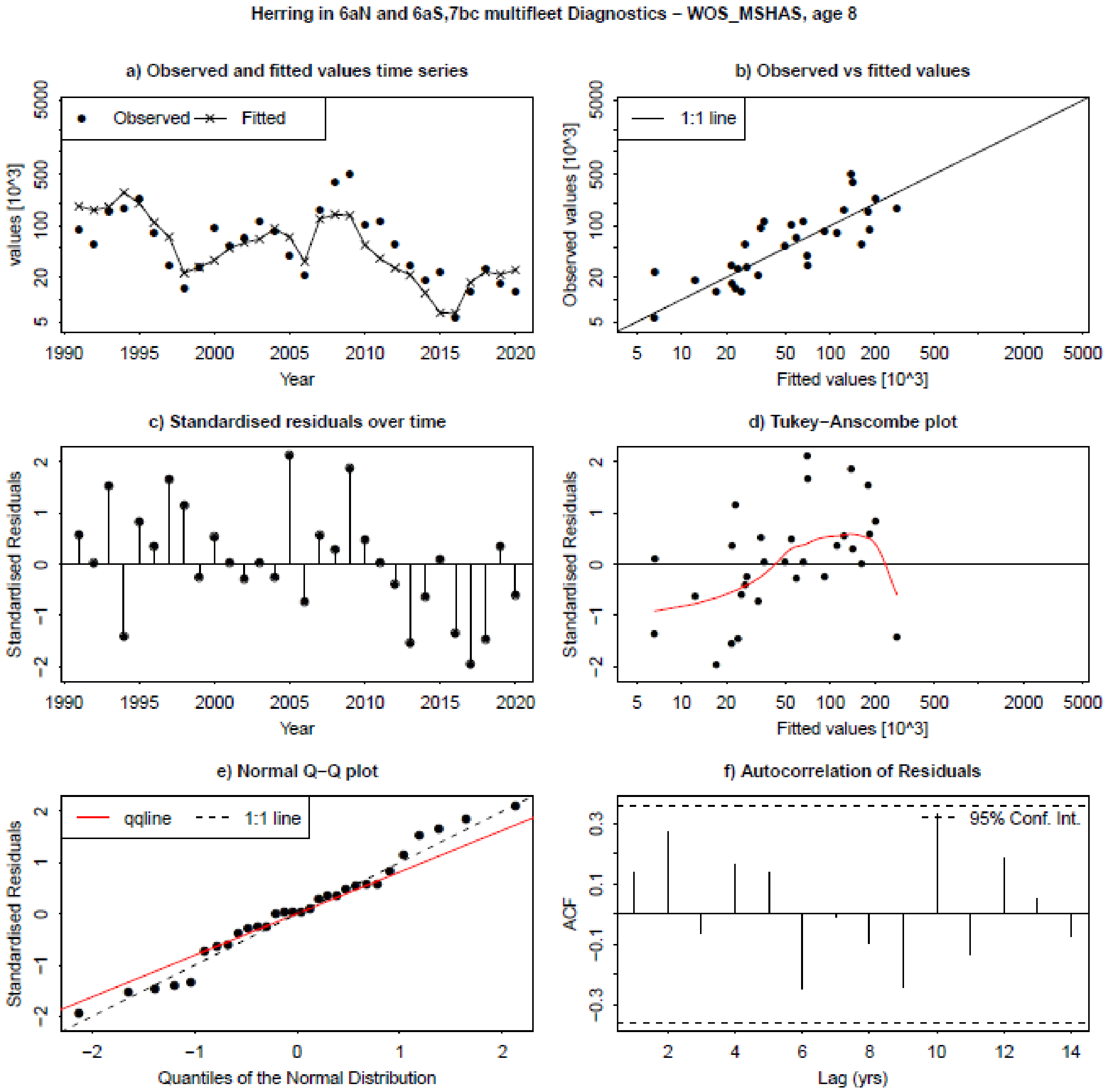


Figure 4.6.40. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

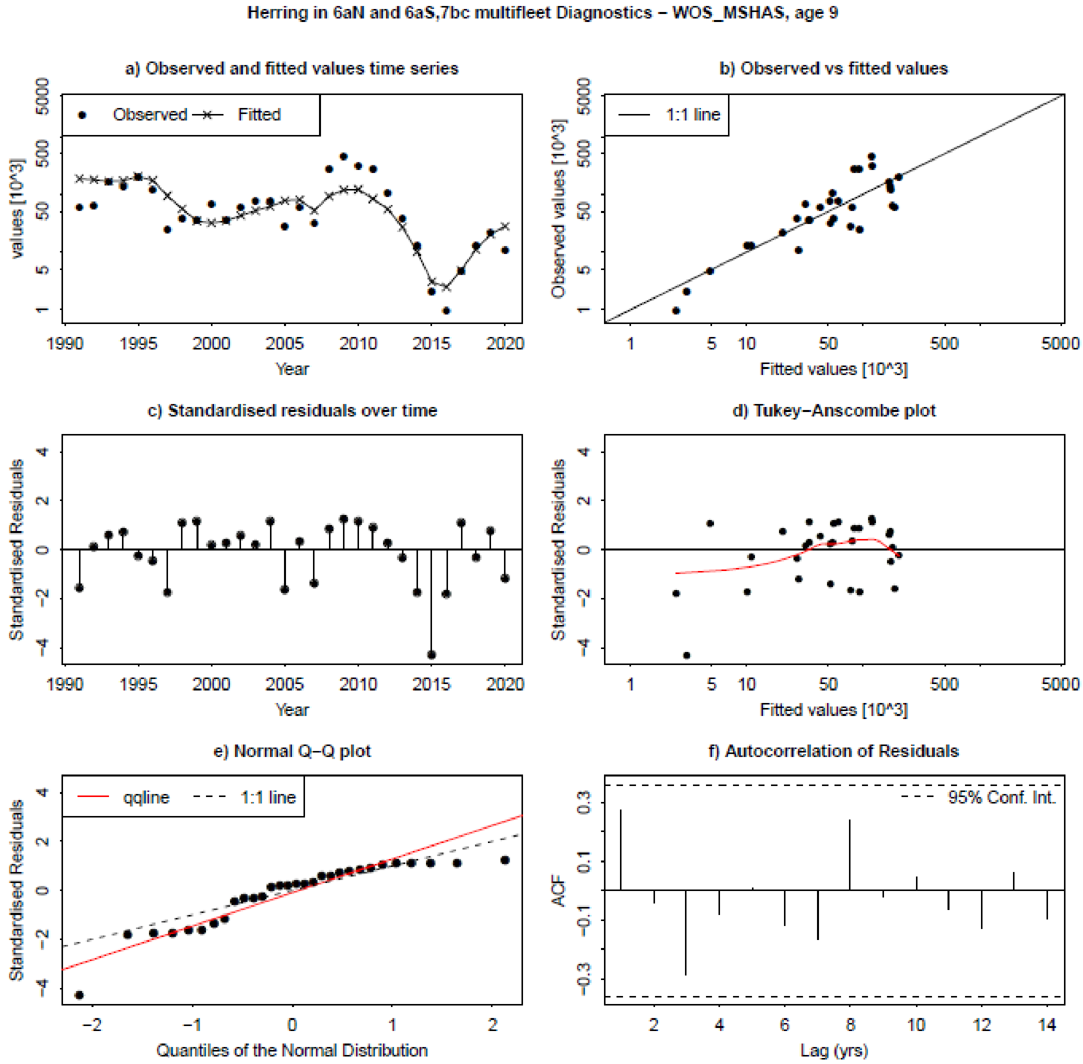


Figure 4.6.41. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

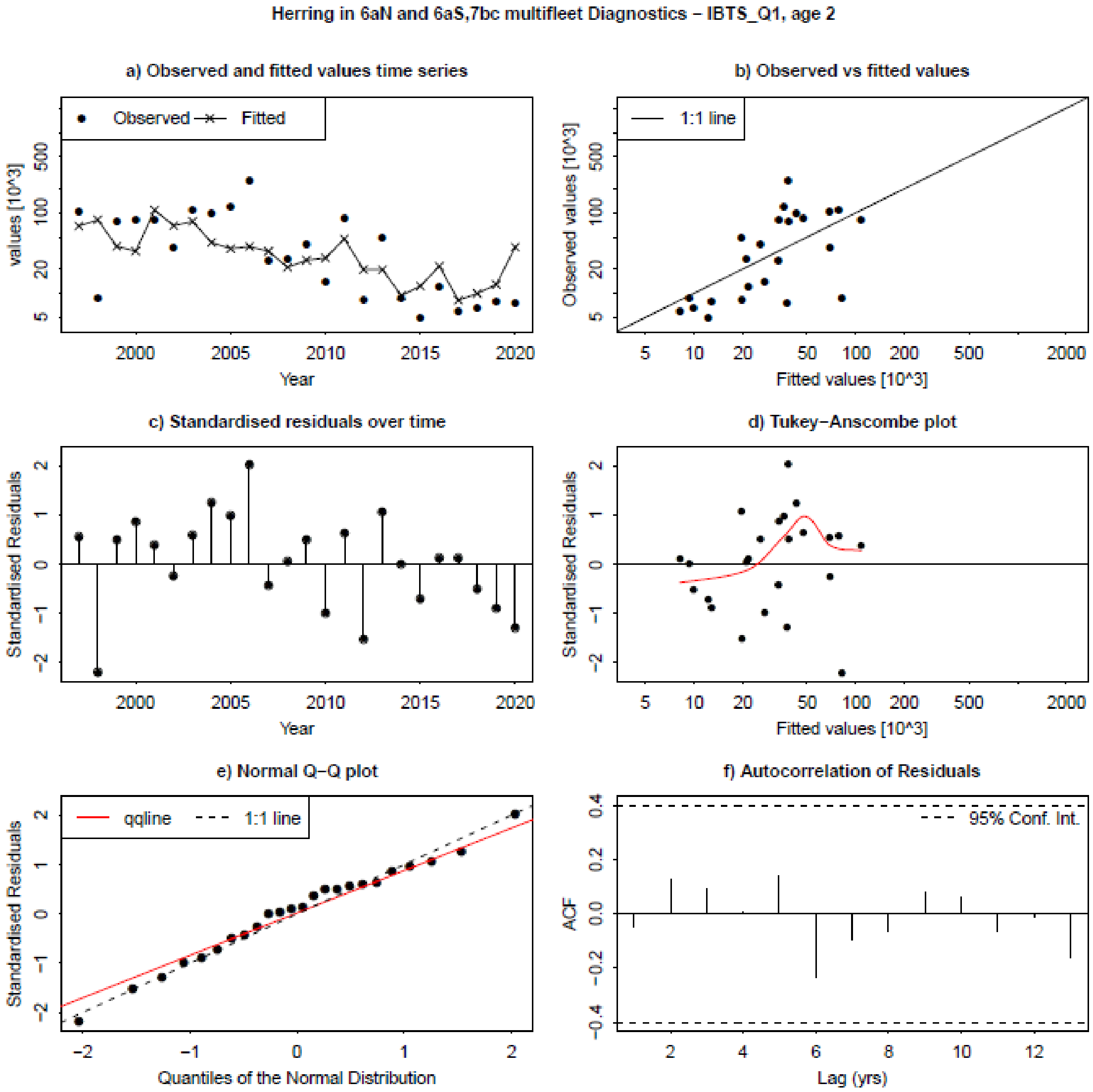


Figure 4.6.42. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

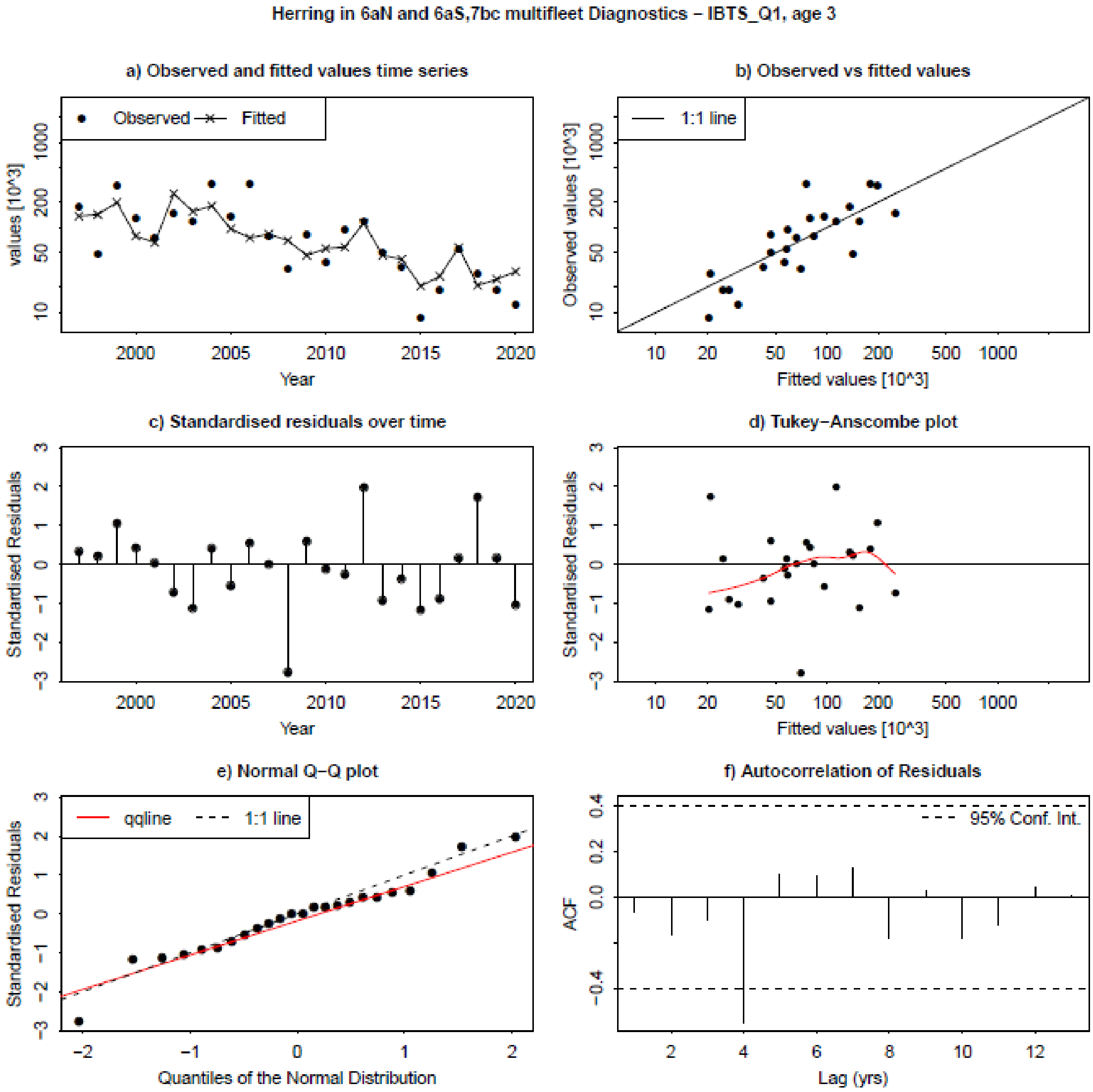


Figure 4.6.43. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

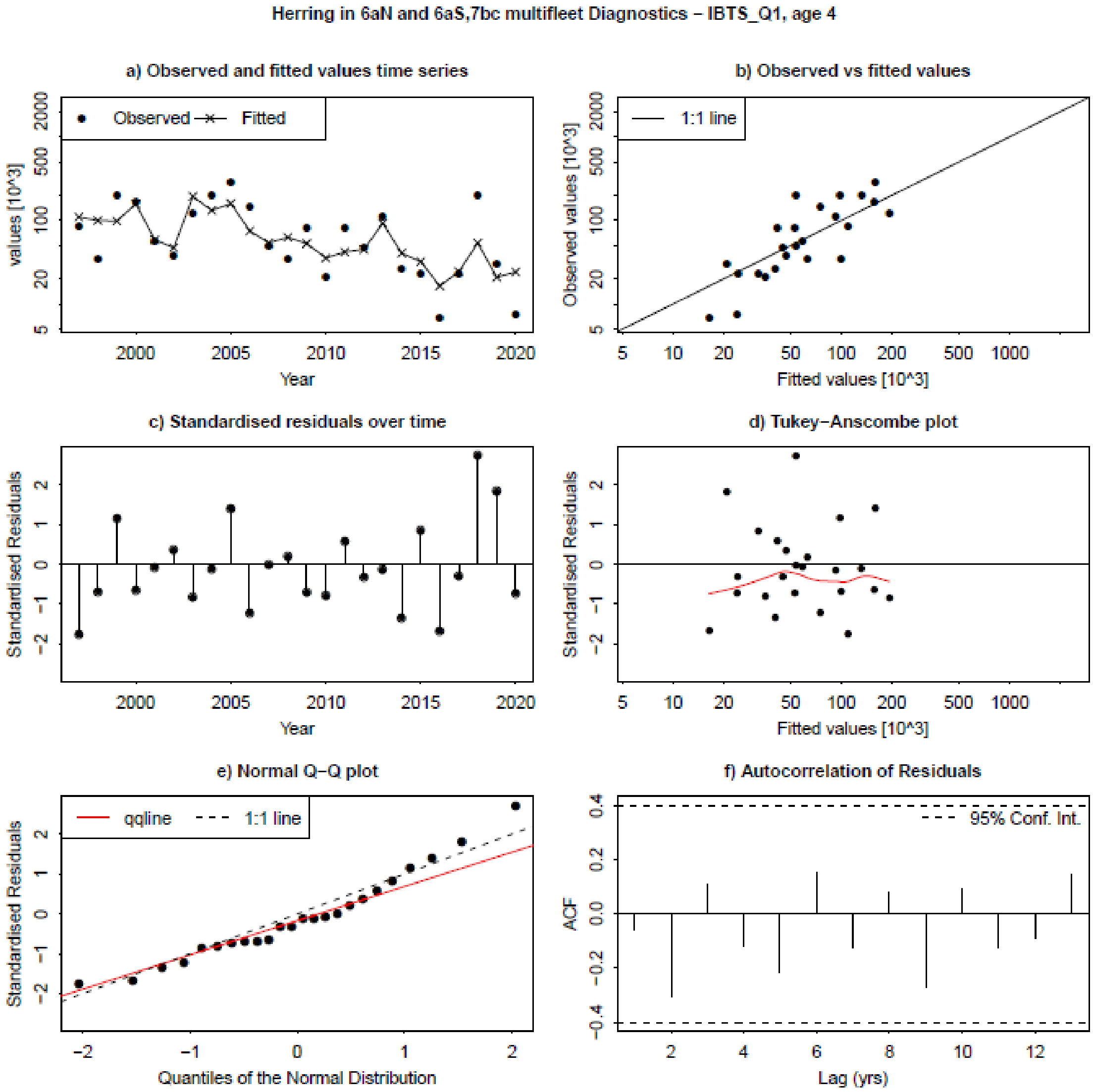


Figure 4.6.44. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

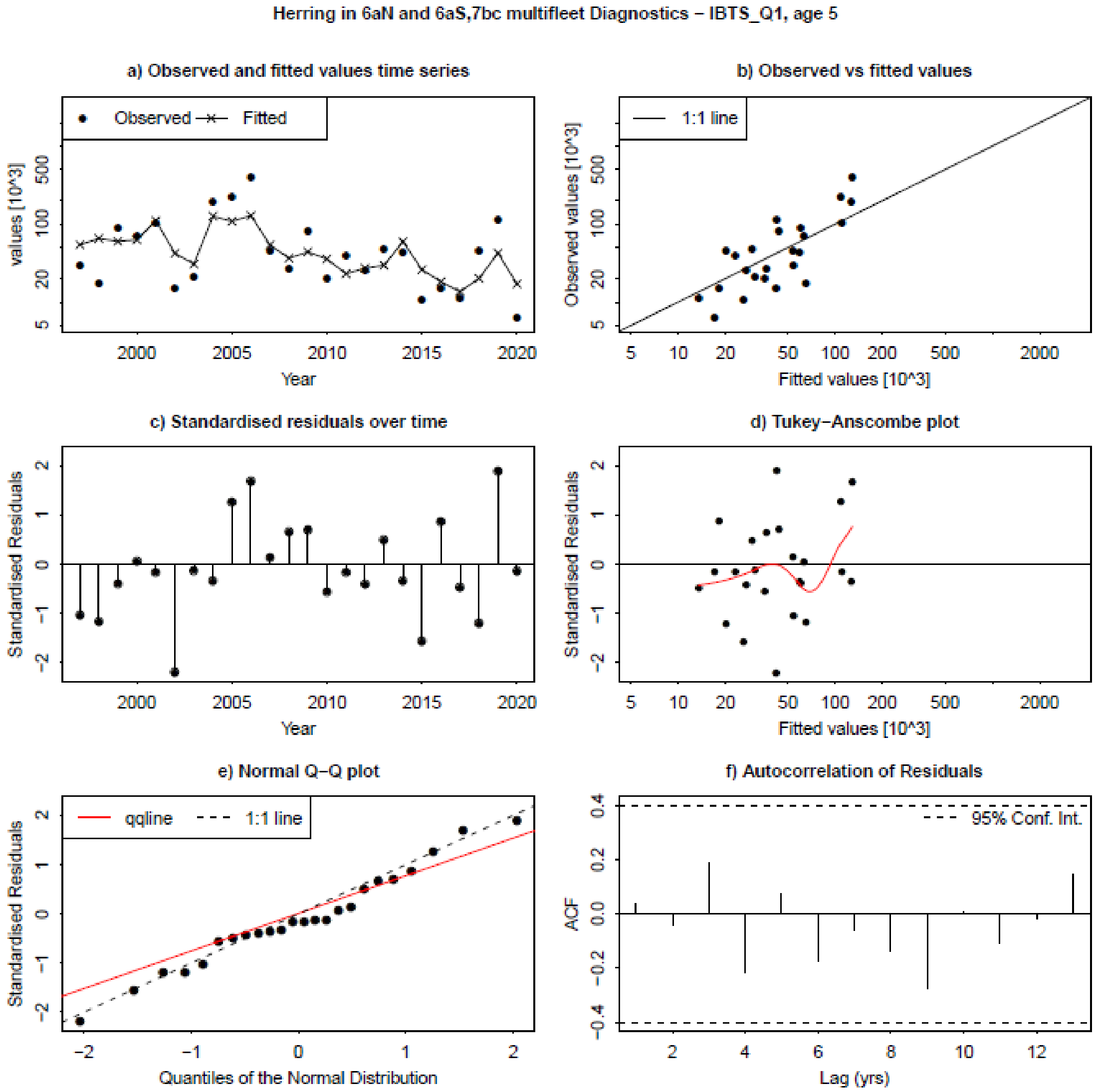


Figure 4.6.45. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

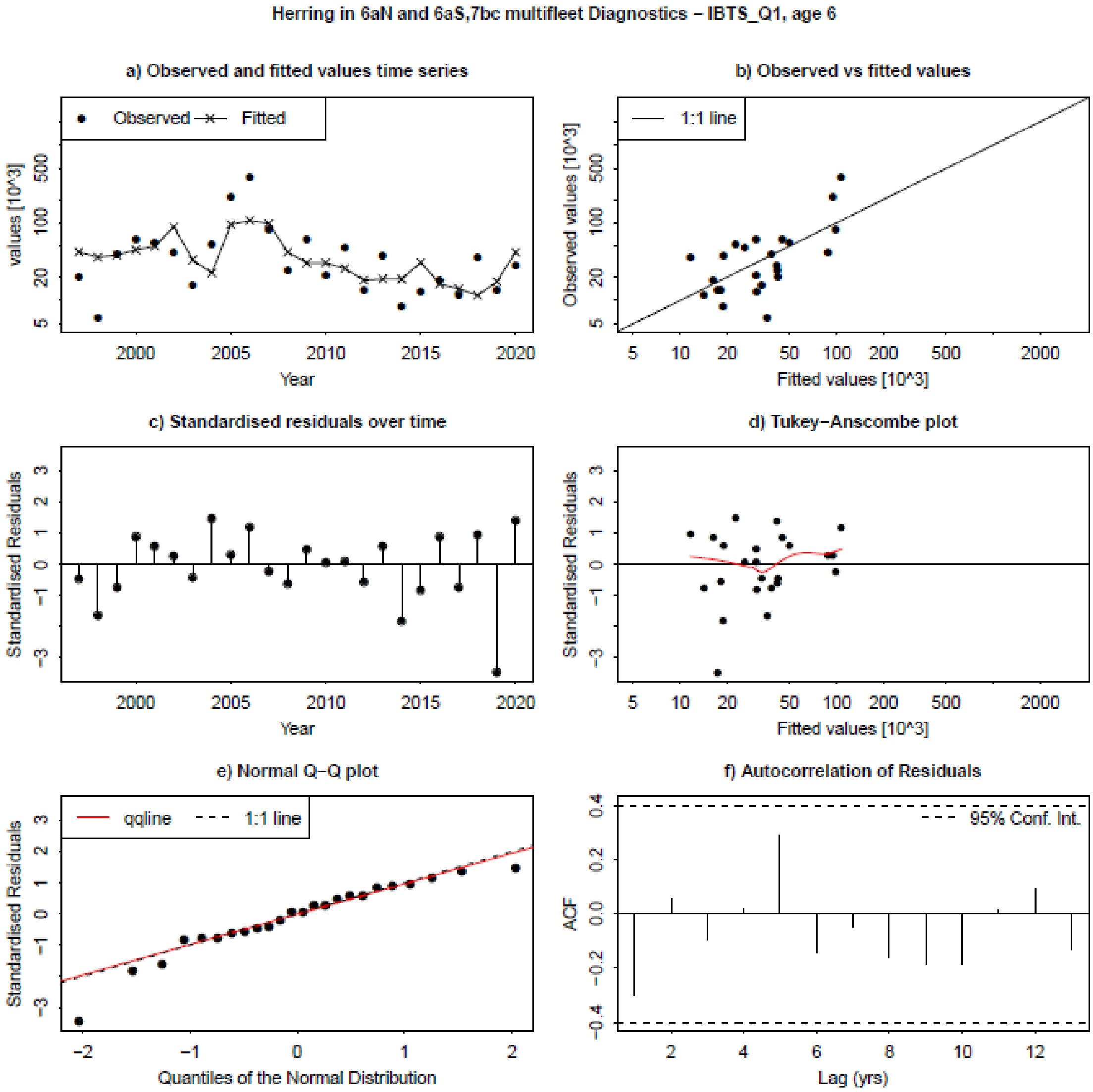


Figure 4.6.46. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

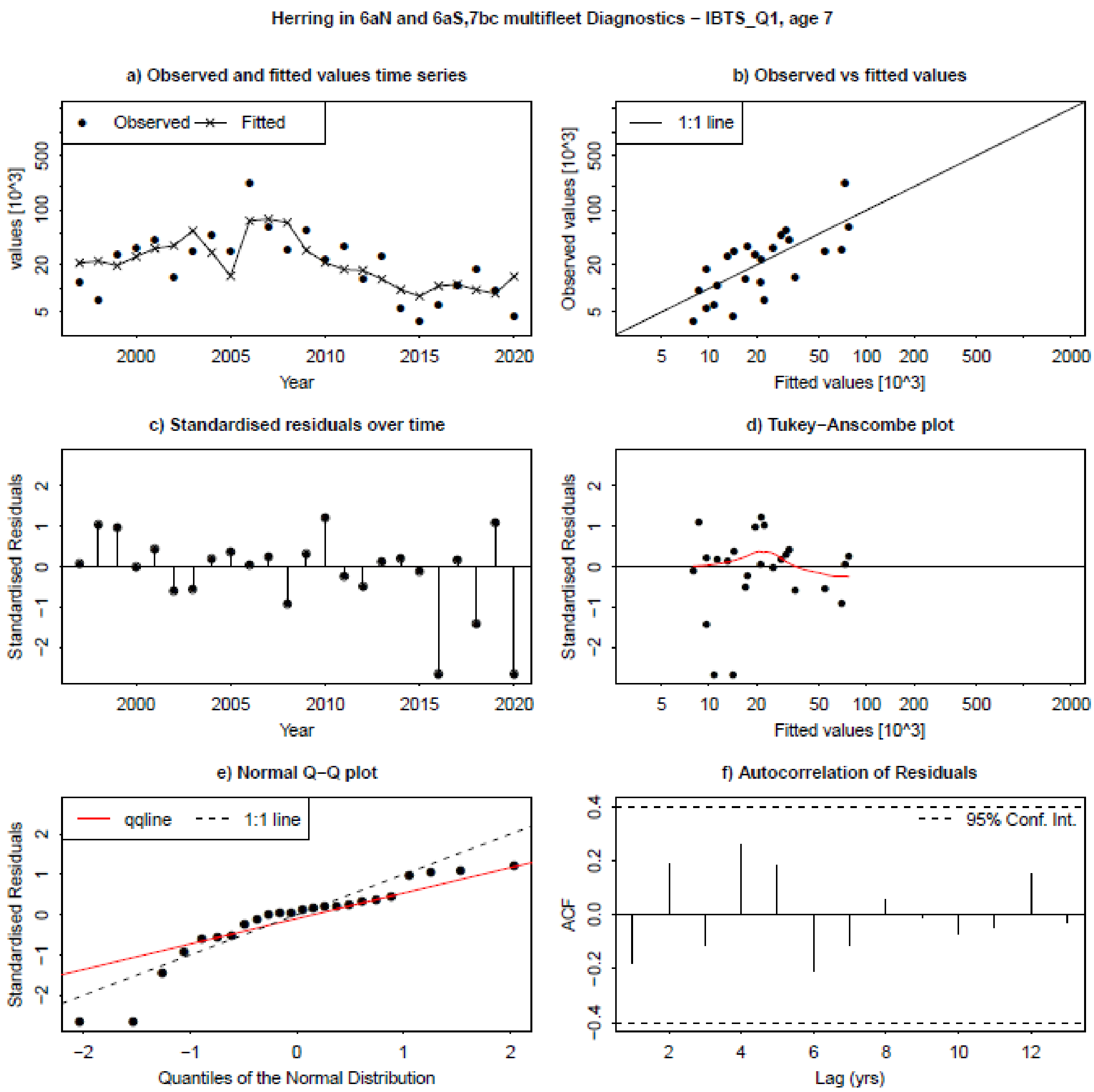


Figure 4.6.47. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

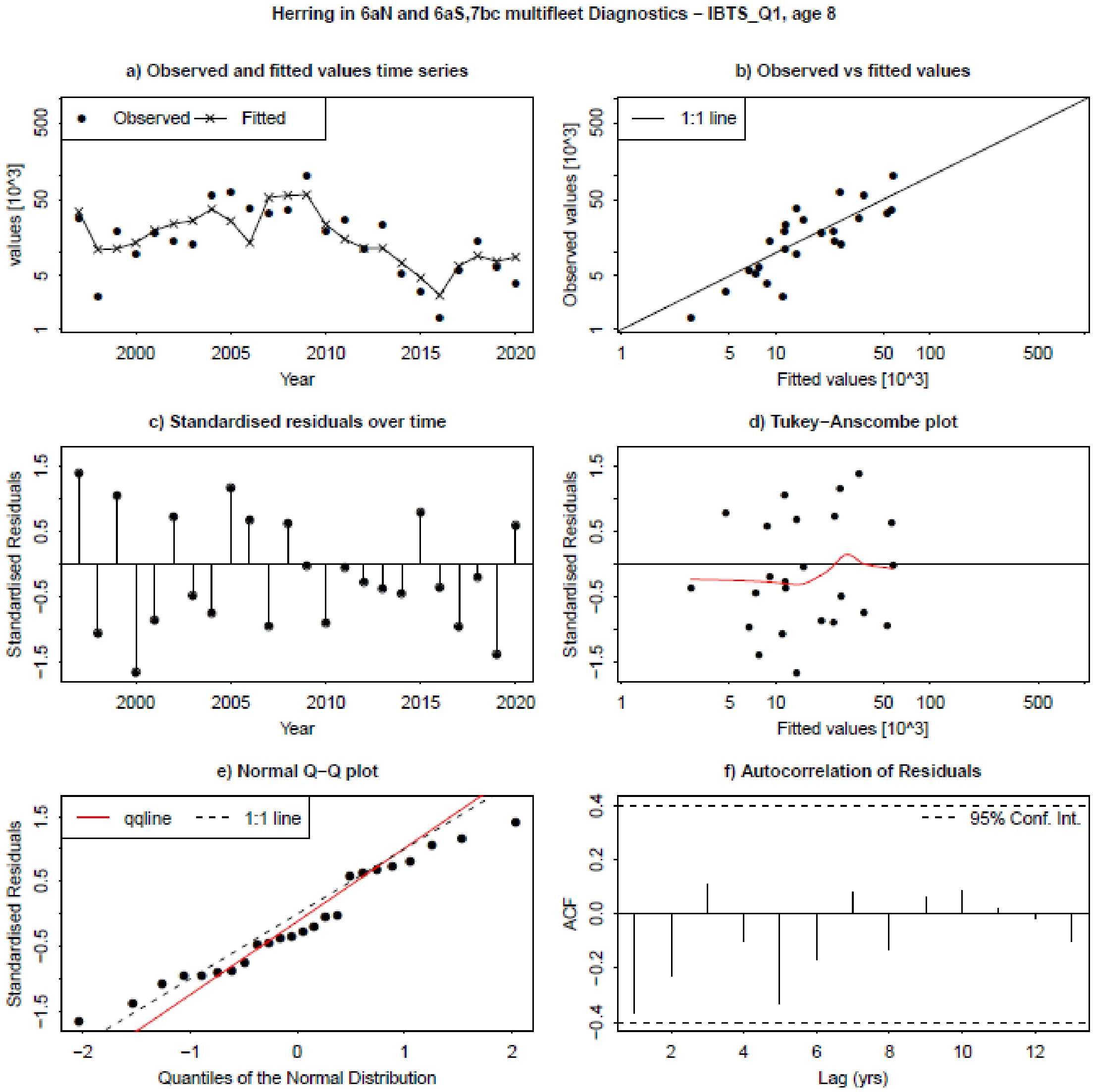


Figure 4.6.48. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

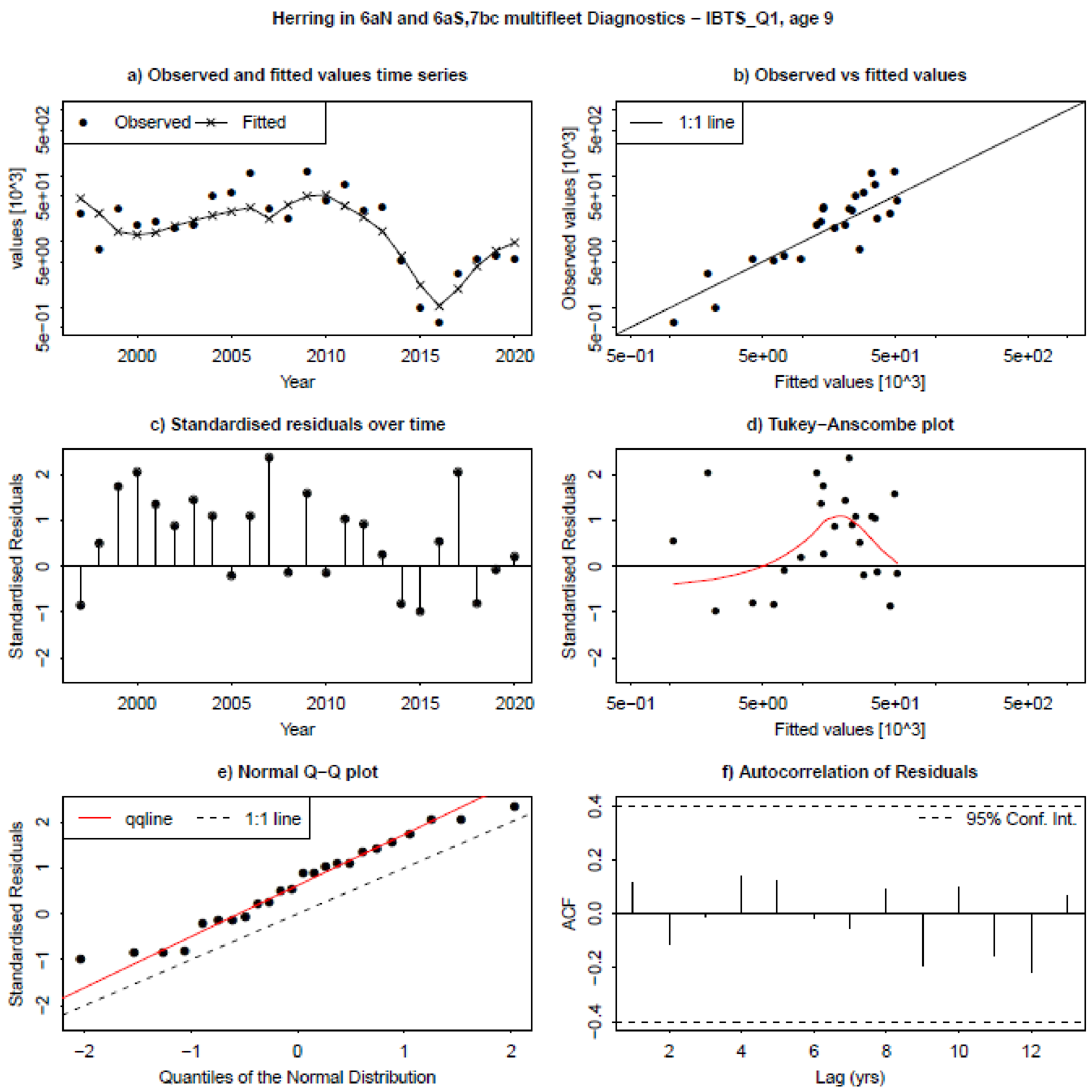


Figure 4.6.49. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

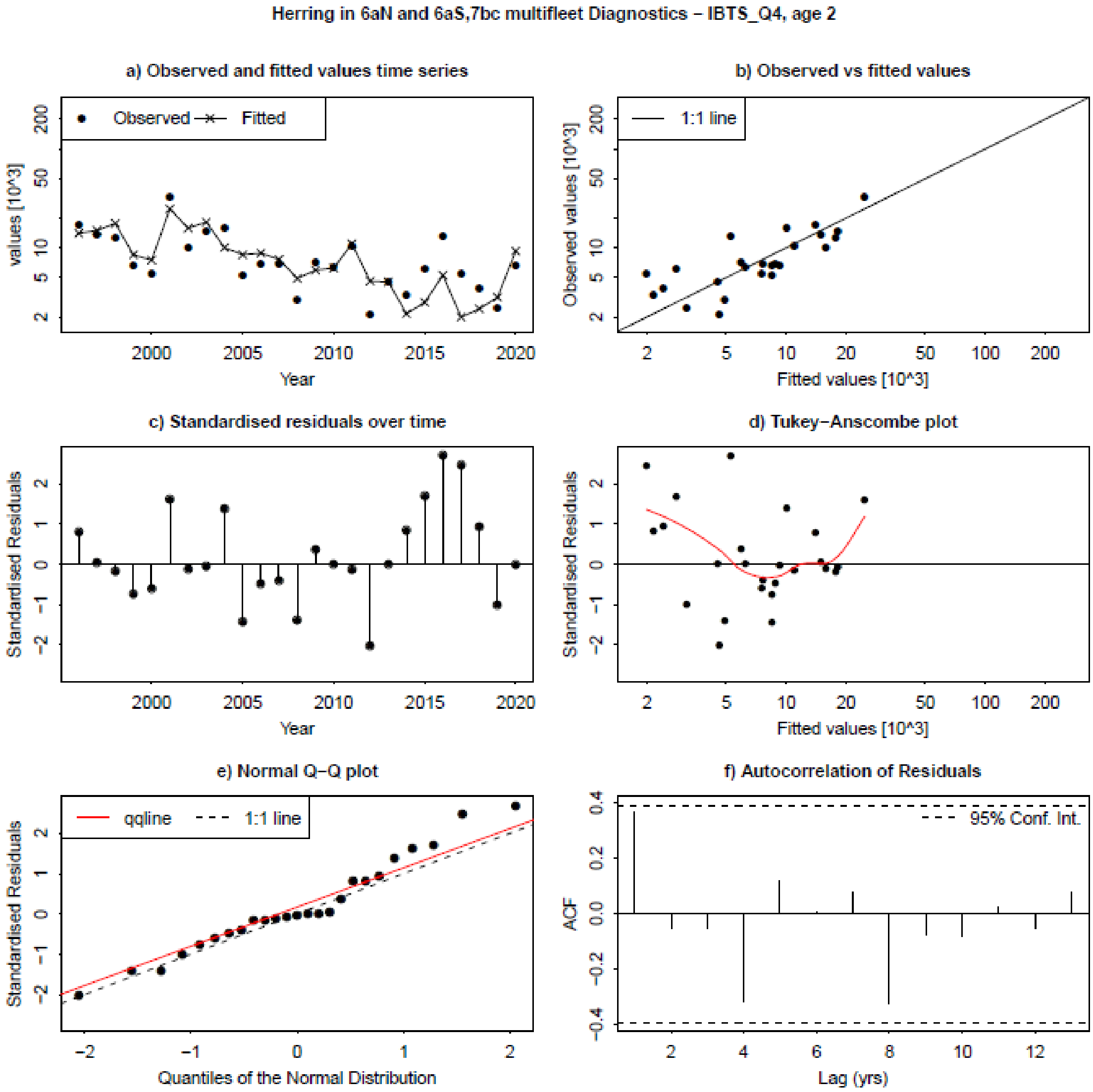


Figure 4.6.50. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

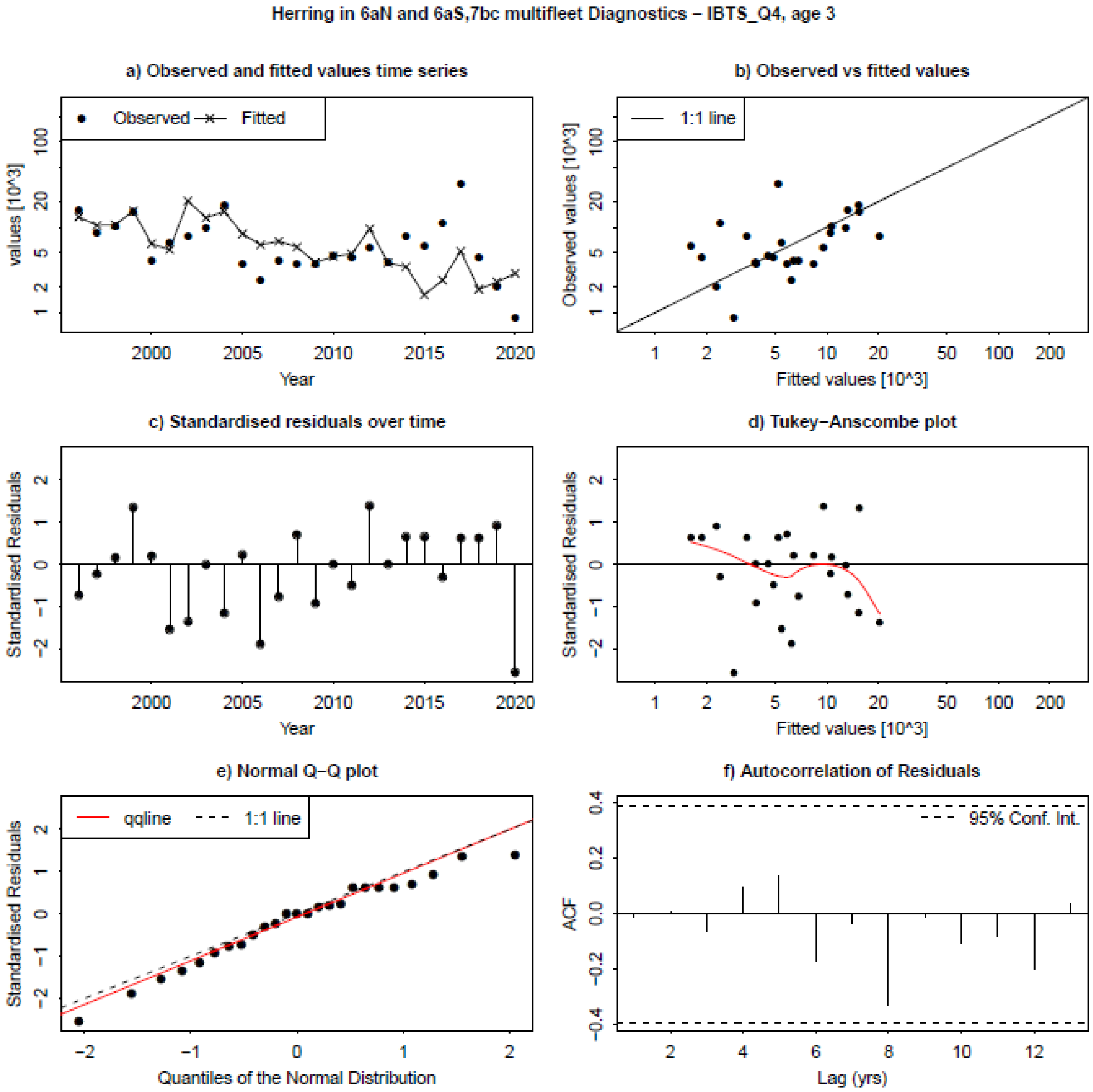


Figure 4.6.51. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

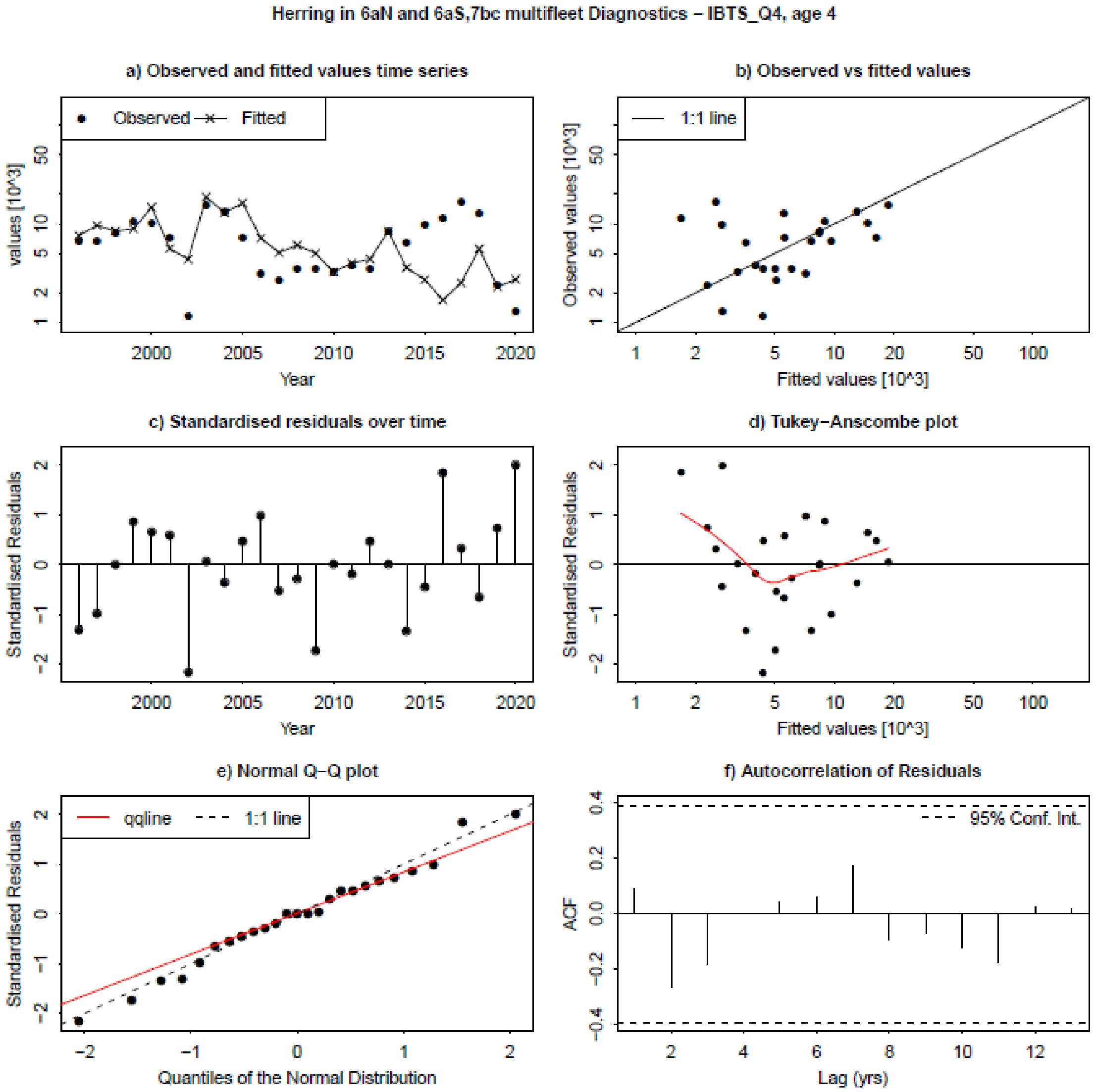


Figure 4.6.52. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

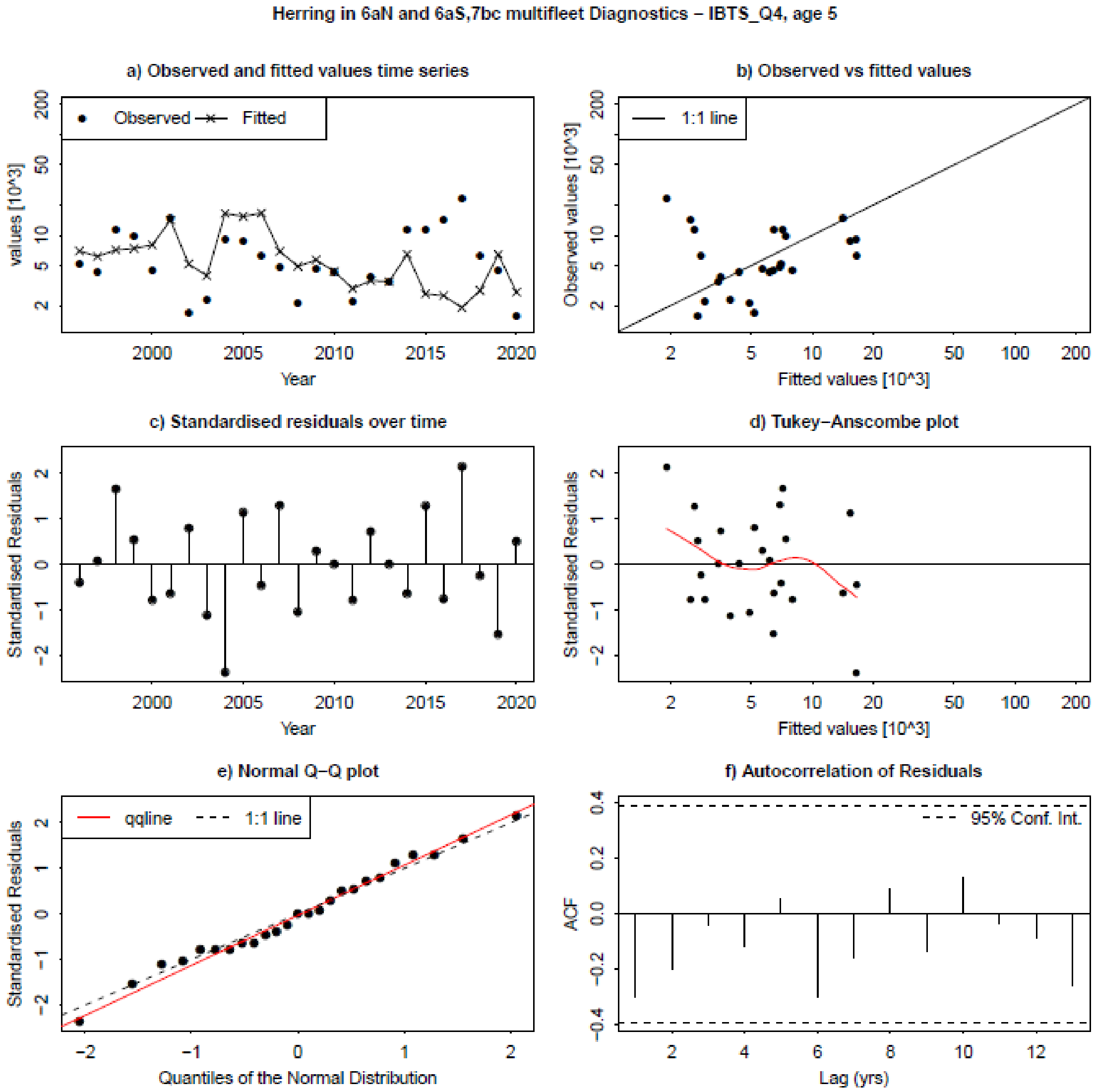


Figure 4.6.53. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

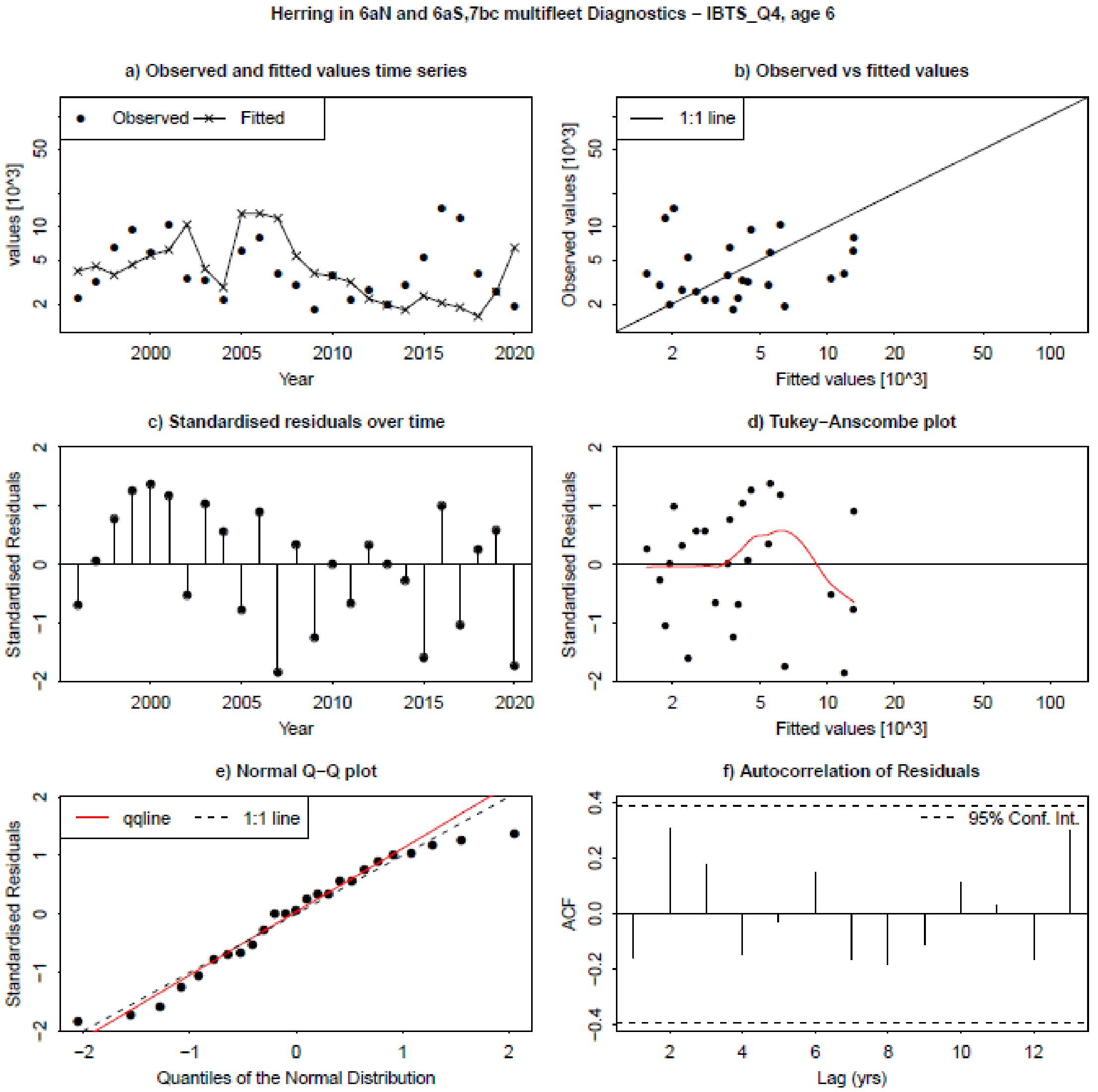


Figure 4.6.54. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

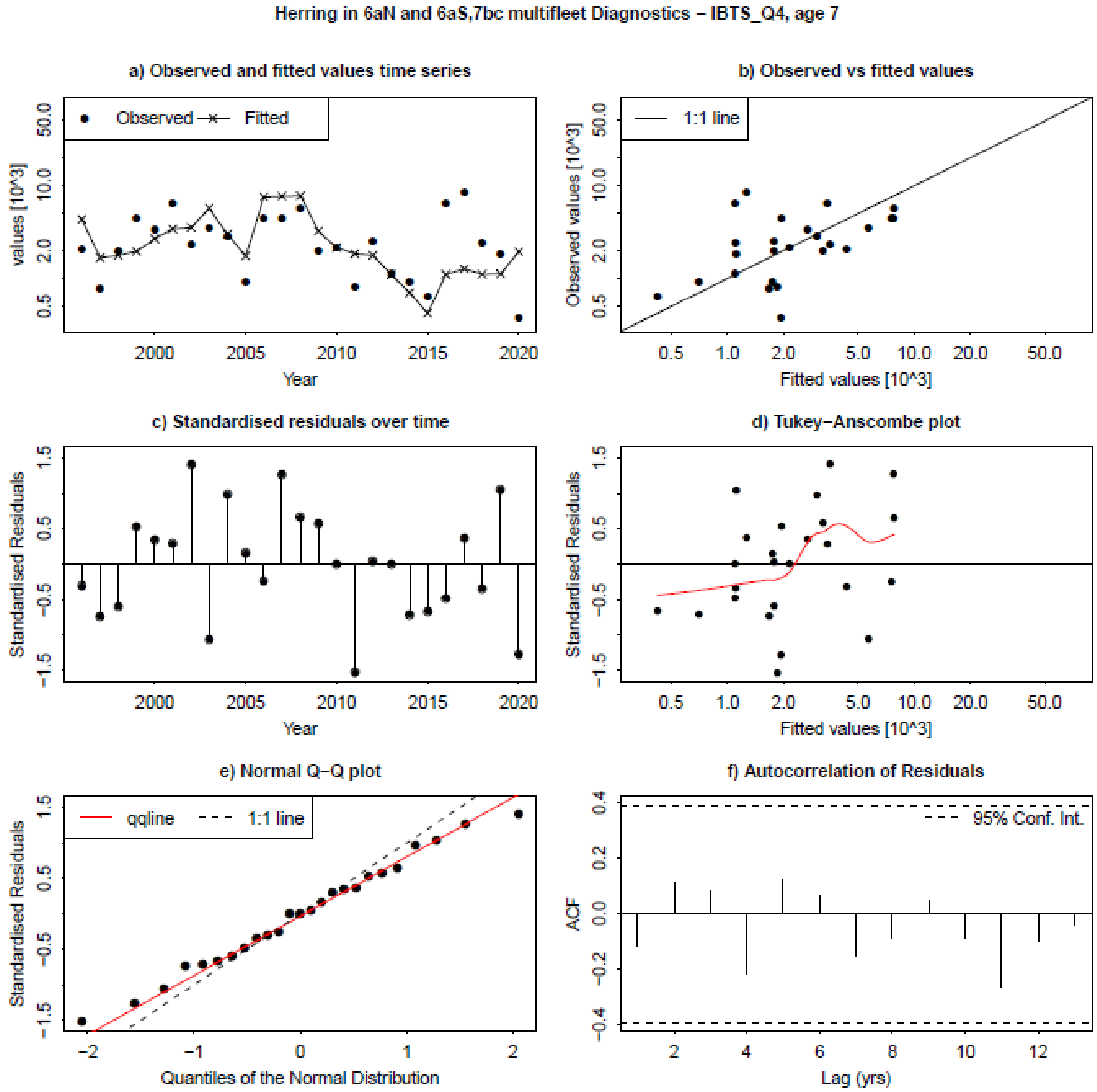


Figure 4.6.55. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

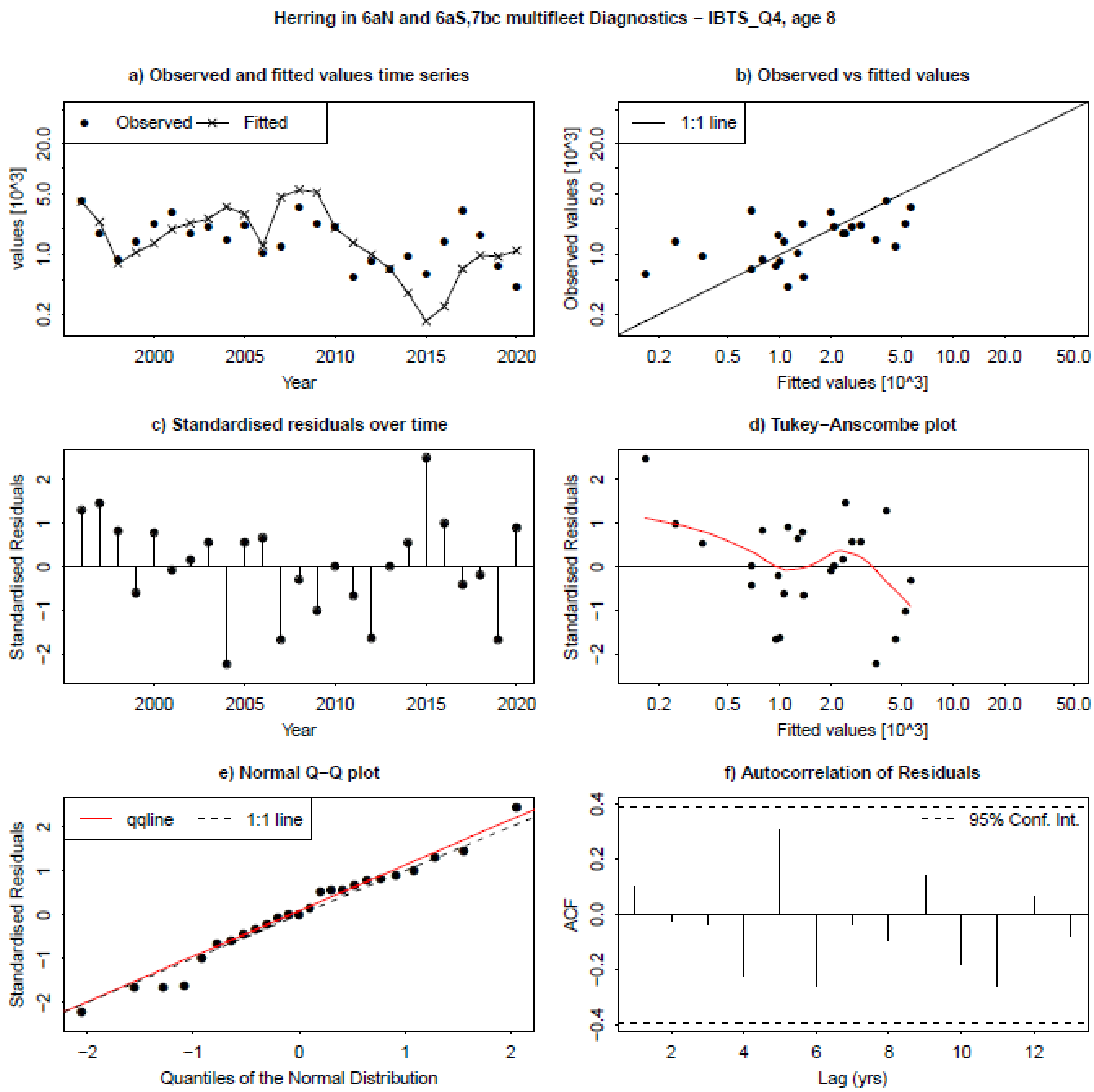


Figure 4.6.56. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

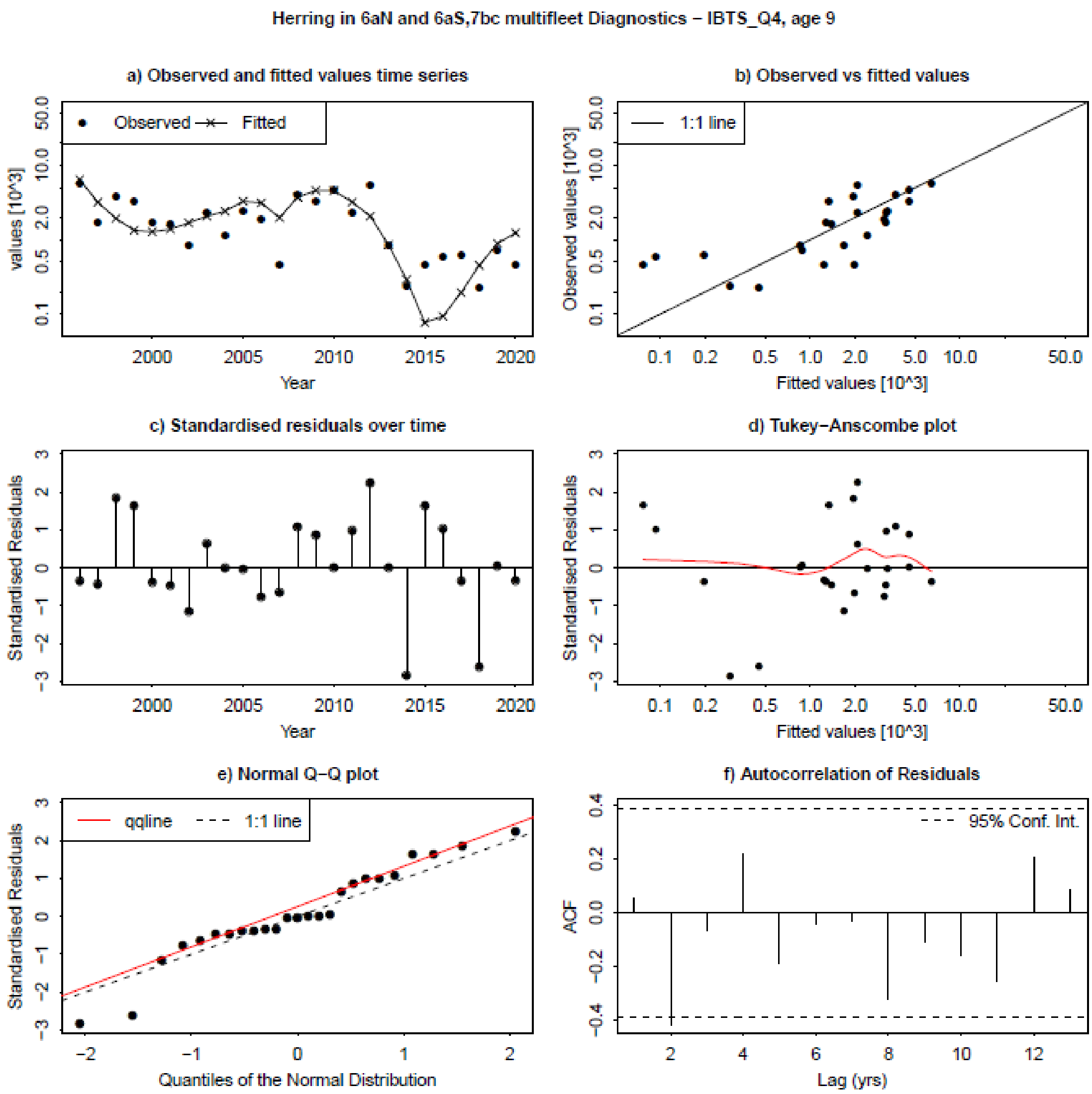


Figure 4.6.57. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

5 Herring (*Clupea harengus*) in divisions 6.a (South), 7.b–c, and 6.a (North), separate

5.1 Herring in divisions 6.a (South) and 7.b-c

Since 2015, this stock has been combined with herring in 6.a.N (Section 5.2) for assessment and advisory purposes. This management unit existed since 1982, when it was separated from 6.a.N. Until that time, 7.b–c was also a separate management unit. The stock comprises autumn, winter, and spring-spawning components.

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 Area 6.a.S, 7.b–c autumn, winter and spring spawners, 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.

5.1.1 The Fishery

5.1.1.1 Advice and management applicable to 2019 and 2020

In 2016 ICES advised TAC of 0 t and that a stock recovery plan be developed for herring stocks in 6.a and 7.b–c stocks (ICES, 2016a). However, in February 2016, the European Commission asked ICES to advise on a TAC of sufficiently small size to allow ongoing collection of fisheries-dependent data. In June 2016, ICES advised on a scientific monitoring TAC of 1360 t for this stock (ICES, 2016b). The EC set a TAC slightly higher than this advice, at 1630 t was established by the EC (EU 2016/0203) for 2016-2019. The TAC for 2020 was reduced in line with the advised value given in 2016 to 1360 t.

Rebuilding plan

A revised proposed rebuilding plan for both 6.a.N and 6.a.S, 7.b–c stocks combined was reviewed by HAWG 2018 (ICES 2018, Annex 9). While the plan was considered to provide a framework for recovery of these combined stocks, it was considered unlikely that the revised proposed plan can aid the recovery of the combined stocks by 2020 as recent poor recruitments hamper a speedy recovery. Furthermore, ICES ACOM considered that further quantitative evaluation would be required to be used as the basis for advice.

5.1.1.2 Catches in 2020

The Working Group estimates of landings from 1991–2020 are given in Table 5.1.2. The catch has declined from 19 000 t in 2006 to 1220 t in 2020.There is a monitoring TAC in place for the combined stocks in 6.a and 7.b–c. In 2020 the majority of the quota taken close inshore. Catches over time are shown in Figure 5.1.1.

In 2020 the majority of the catch was taken in the fourth quarter with subdivision 6.aS accounting for the vast majority of catch (Figure 5.1.9).

5.1.1.3 Regulations and their effects

Within the Irish fishery, the monitoring TAC in 2020 was allocated on a similar basis to 2016-2019. The quota was allocated, to a wide spectrum of small and large vessels. This resulted in more fishing opportunities across the fleet.

5.1.1.4 Changes in fishing pattern

The monitoring TAC, introduced in 2016 and continued in 2020, 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 is now allocated to vessels in six different categories from over 24 m down to under 12 m. The Herring fishery in 2020 opened on 2 November and was concentrated in 6.a.S, primarily in two statistical rectangles. This was similar to the 2019 fishery. In 2020 there was a fishery in January and February to allow for additional data collection. Information provided by the Irish industry reported very good marks of herring in all the bays around the Donegal coast in quarter 1 2020. Similar reports are available for Lough Foyle, Lough Swilly and all areas of Donegal Bay such as Inver Bay and the approaches to Killybegs.

5.1.2 Biological composition of the catch

5.1.2.1 Catch-at-age

Catch-at-age data for this fishery are shown in Table 5.1.3 and Figure 5.1.2 and in percentage terms since 1994 in Table 5.1.4. In 2020, the fishery was dominated by 1- 5-ringers accounting for 90% of the catch (Table 5.1.4). Smaller proportions of 6-9 ringers are evident in the catch data and account for 10% of the total. 2 ringers are the dominant age class 45% followed 3 ringers (24%), 4 (15%), 5 (5%). 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.

The proportion-at-age in the catches from the fishery are similar to the catches from the MSHAS 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 5.1.4).

5.1.2.2 Quality of the catch and biological data

The 6.a.S/7.b–c stock is well sampled, there have been sufficient samples to achieve the precision level sought by the ICES advice on the monitoring fishery since 2016. The numbers of samples and the associated biological data collected by Ireland are shown in Table 5.1.7.

5.1.3 Fishery-independent Information

5.1.3.1 Acoustic Surveys

The Irish Marine Institute conducted acoustic surveys in 6.a.S and 7.b–c on the west and north-west coasts of Ireland between 1994 and 2007 at various times of the year. An acoustic survey has been carried out in Division 6.a.N in June–July since 1991 by Marine Scotland Science. It originally covered an area bounded by the 200 m depth contour and 4°W in the north and west 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.a.N herring since 2002 (ICES, 2015b). In 2008, it was decided that these surveys should be expanded into a larger coordinated summer survey on recommendation from WESTHER, HAWG and SGHERWAY (Hatfield *et al.*, 2007; ICES, 2007; ICES, 2010a). The Scottish 6.a.N 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.a.N.

5.1.3.2 6As/7b Industry acoustic survey in 2020

The 6aS/7b 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. In 6aS/7b herring were distributed similar to the surveys in 2016-2019. Herring were again found in shallow areas close inshore with the overall distribution dominated by aggregations of herring in a few discrete areas. The 2- and 3-wr age class of herring accounted for 54% of the overall numbers in 2020. All of the 6 designated core areas were surveyed, all areas important to the monitoring fishery. Total biomass estimates of herring recorded during the survey in 6aS/7b was 45 046 t. The inshore distribution of herring generally makes containment of the stock difficult in this area, however, the improved survey design, particularly in Lough Foyle and Lough Swilly resulted in a much lower measure of uncertainty (CV), compared to previous years. The CV on the estimates of abundance and biomass was within expected values for an acoustic survey and has benefitted from the change of survey design used. The flexible survey design and focusing on discreet areas was generally successful and should provide a template for future survey designs.

5.1.4 Mean weights-at-age and maturity-at-age

5.1.4.1 Mean Weights-at-Age

The mean weights-at-age (kg) in the catches in 2020 are presented in Figure 5.1.7. In recent years there was a decrease in mean weights relative to the late 1990s. Over the longer time-series there is little trend over time, but they have dropped for all age classes in 2020 relative to 2019.

The mean weights in the stock at spawning time have been calculated from samples taken during the main spawning period that extends from October to February (Figure 5.1.8). The mean weights in the stock have dropped in 2020 relative to 2019 for all ages.

5.1.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

5.1.5 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. Since the mid-1990s recruitment has been low, based on exploratory assessments.

5.1.5.1 Stock Assessment of 6.a (South) and 7.b–c

The ICES, WKWEST 2015 benchmark workshop (ICES, 2015) for the herring stocks in 6.a.N, 6.a.S and 7.b–c concluded that the assessment would be a combined stock assessment. Details of the combined assessment for all of 6.a and 7.b–c are outlined in Section 4 of this report. No separate assessment for herring in 6a (South) and 7.b-c is presented in 2021.

5.1.5.2 State of the stock

Not analytically determined.

5.1.6 Short-term projections

Not undertaken.

5.1.7 Medium-term simulations

Not undertaken.

5.1.8 Long-term simulations

Not undertaken.

5.1.9 Precautionary and yield based reference points

Not determined.

5.1.10 Quality of the assessment

Not ascertained.

5.1.11 Management considerations

There is no new information to alter the previous perception that this stock.

Fishing mortality has been kept low to allow rebuilding. The monitoring TAC should be maintained allowing sampling to continue.

The combined assessment (6.a, 7b,c) shows SSB and recruitment at very low levels. F has reduced since the introduction of the monitoring TAC in 2016. The working group advocates maintaining separate management of each component.

The population structure of herring stocks in 6.a/7bc was examined in an EASME funded project using genetics, body morphometric and otolith shape techniques. This project was completed late 2020 and the final report published in April 2021 (Farrell *et al.*, 2021). The genetic assignments developed during this project will be used as the basis for splitting survey indices into the different populations. This results of this will be presented at the benchmark data meeting late 2021.

5.1.12 Environment

5.1.12.1 Ecosystem considerations

Grainger (1978; 1980) found significant negative correlations between sea surface temperature (SST) 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 favorably to cooler temperatures. Cannaby and Hosrevoglu (2009) present long time-series of sea surface temperature for this stock area, showing an increasing trend. Their data when compared with herring biology and fisheries data show that strong historic herring recruitments/fisheries correspond to cooler temperatures (Clarke *et al.*, WD 02 to HAWG 2012).

5.1.12.2 Changes in the environment

Since the mid-1990s the AMO has been in a positive phase, indicating warmer sea temperatures in this area. In recent year the AMO has mostly been in a positive phase, see: http://www.esrl.noaa.gov/psd/data/timeseries/AMO/. Warmer temperatures associated with positive AMO are considered detrimental to herring recruitment.

Table 5.1.2. Herring in divisions 6.a.S and 7.b–c. Estimated Herring catches in tonnes, 1991–2020. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999
France	-	-	-	-	-	-	-	-	-
Germany, Fed. Rep.	-	250	-	-	11	-	-	-	-
Ireland	22500	26000	27600	24400	25450	23800	24400	25200	16325
Netherlands	600	900	2500	2500	1207	1800	3400	2500	1868
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	50	24	-	-	-	-
UK (Scotland)	+	-	200	-	-	-	-	-	-
Total landings	23100	27150	30300	26950	26692	25600	27800	27700	18193
Unallocated/ area misreported	11200	4600	6250	6250	1100	6900	-700	11200	7916
Discards	3400	100	250	700	-	-	50		-
WG catch	37700	31850	36800	33900	27792	32500	27150	38900	26109

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
France	-	-	515	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-		-	-	-	-	-
Ireland	10164	11278	13072	12921	10950	13351	14840	12662	10237
Netherlands	1234	2088	366	-	64	-	353	13	-
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	6	-	-
Total landings	11398	13366	13953	12921	11014	13351	15199	12675	10237
Unallocated/ area misreported	8448	1390	3873	3581	2813	2880	4000	5116	3103
Discards	-	-	-	-	-	-	-	-	-
WG catch	19846	14756	17826	16502	13827	16231	19199	17791	13340

Table 5.1.2. Herring in divisions 6.a.S and 7.b–c. Estimated Herring catches in tonnes, 1991–2020 continued

Country	2019	2010	2011	2012	2013	2014	2015	2016	2017
France	-	-	-	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-	-	-	-	-	-	-
Ireland	8533	7513	4247	3791	1460	2933	73	1171	1707
Netherlands	-	-	-	-	40	-	+	72	-
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	5	-	-
Total landings	8533	7513	4247	3791	1500	2933	78	1243	1707
Unallocated/ area misreported	1935	2728	2672	2780	2468	2163	1000	971	520
Discards	-	-	-	-	-	-	-	-	-
WG catch	10 468	10 241	6919	6571	3968	5096	1078	2214	2227

Country	2018	2019	2020
France			
Germany Fed. Rep.			
Ireland	970	1625	1138
Netherlands		65	3
UK (N. Ireland)			
UK (England + Wales)			
UK (Scotland)			
Total landings	970	1690	1141
Unallocated/ area misreported	525		79
Discards			
WG catch	1495	1690	1220

Table 5.1.3. Herring in divisions 6.a.S and 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2020.

	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

	1	2	3	4	5	6	7	8	9
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
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

Table 5.1.4. Herring in divisions 6.a.S and 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%

Table 5.1.5. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the catches 1970–2020.

	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		0.098	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
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

	1	2	3	4	5	6	7	8	9+
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

Table 5.1.6. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2020.

	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

	1	2	3	4	5	6	7	8	9+
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247
2007	0.114	0.133	0.133	0.171	0.186	0.196	0.208	0.228	0.229
2008	0.098	0.136	0.140	0.174	0.185	0.196	0.192	0.205	0.234
2009	0.072	0.141	0.162	0.197	0.215	0.223	0.225	0.221	0.286
2010	0.092	0.128	0.157	0.189	0.208	0.227	0.234	0.239	0.247
2011	0.082	0.118	0.136	0.177	0.199	0.207	0.225	0.239	0.240
2012	0.084	0.135	0.182	0.203	0.214	0.226	0.225	0.21	0.226
2013	0.074	0.114	0.140	0.170	0.188	0.198	0.204	0.223	0.222
2014	0.093	0.128	0.135	0.154	0.169	0.170	0.188	0.169	0.206
2015	0.077	0.112	0.146	0.155	0.165	0.173	0.179	0.183	0.217
2016	0.078	0.119	0.147	0.164	0.185	0.191	0.197	0.21	0.175
2017	0.064	0.099	0.130	0.145	0.163	0.173	0.176	0.185	0.180
2018	0.072	0.097	0.126	0.146	0.156	0.168	0.172	0.169	0.170
2019	0.062	0.098	0.124	0.149	0.164	0.166	0.180	0.180	0.175
2020	0.056	0.088	0.110	0.125	0.144	0.154	0.157	0.164	0.168

Table 5.1.7. Herring in divisions 6.a.S and 7.b–c. Sampling intensity of catches in 2020.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.a.S	1	121	8	309	1859	2554
6.a.S	4	1092	38	2301	10866	2107
7.b	1	4	0	0	0	0
Total		1217	46	2610	12725	2145

Table 5.1.8. Herring in divisions 6.a.S and 7.b–c. Details of acoustic surveys dedicated to the 6a.S/7.b–c stock alone.

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

***reduced survey area**

**** Survey design changed significantly compared to other years, only 6 core areas covered**

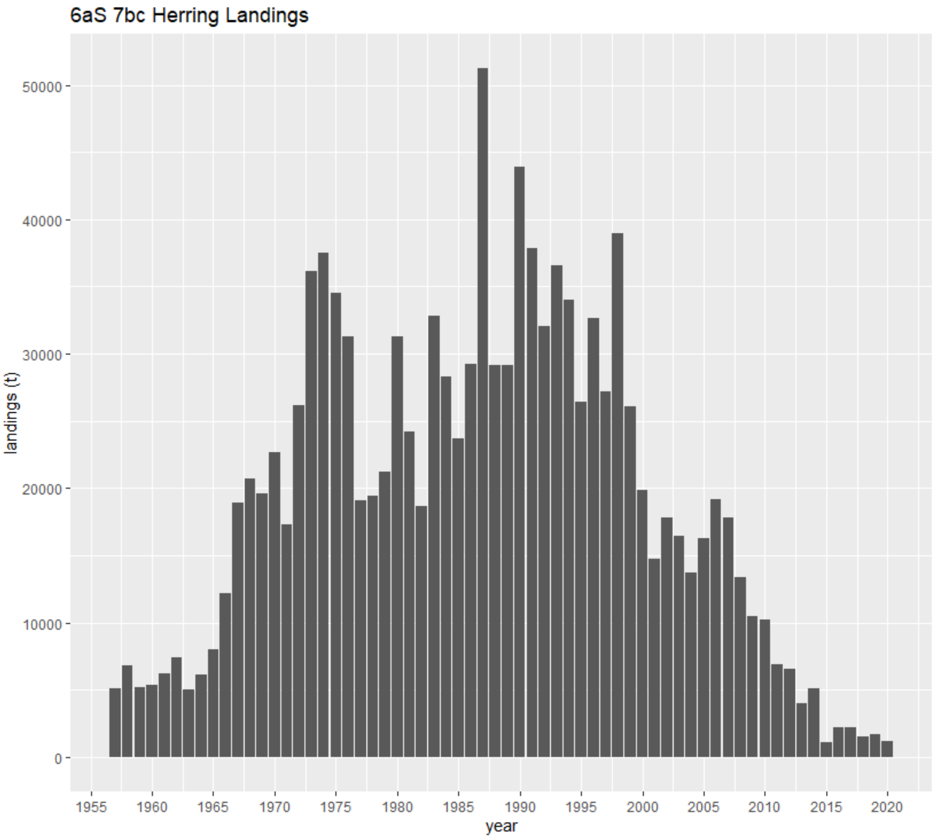


Figure 5.1.1. Herring in divisions 6.a.S and 7.b–c. Working group estimate of catches from 1957–2020.

Figure 5.1.2. Herring in divisions 6.a.S and 7.b–c. catch numbers-at-age standardized by year for the fishery 1957–2020.

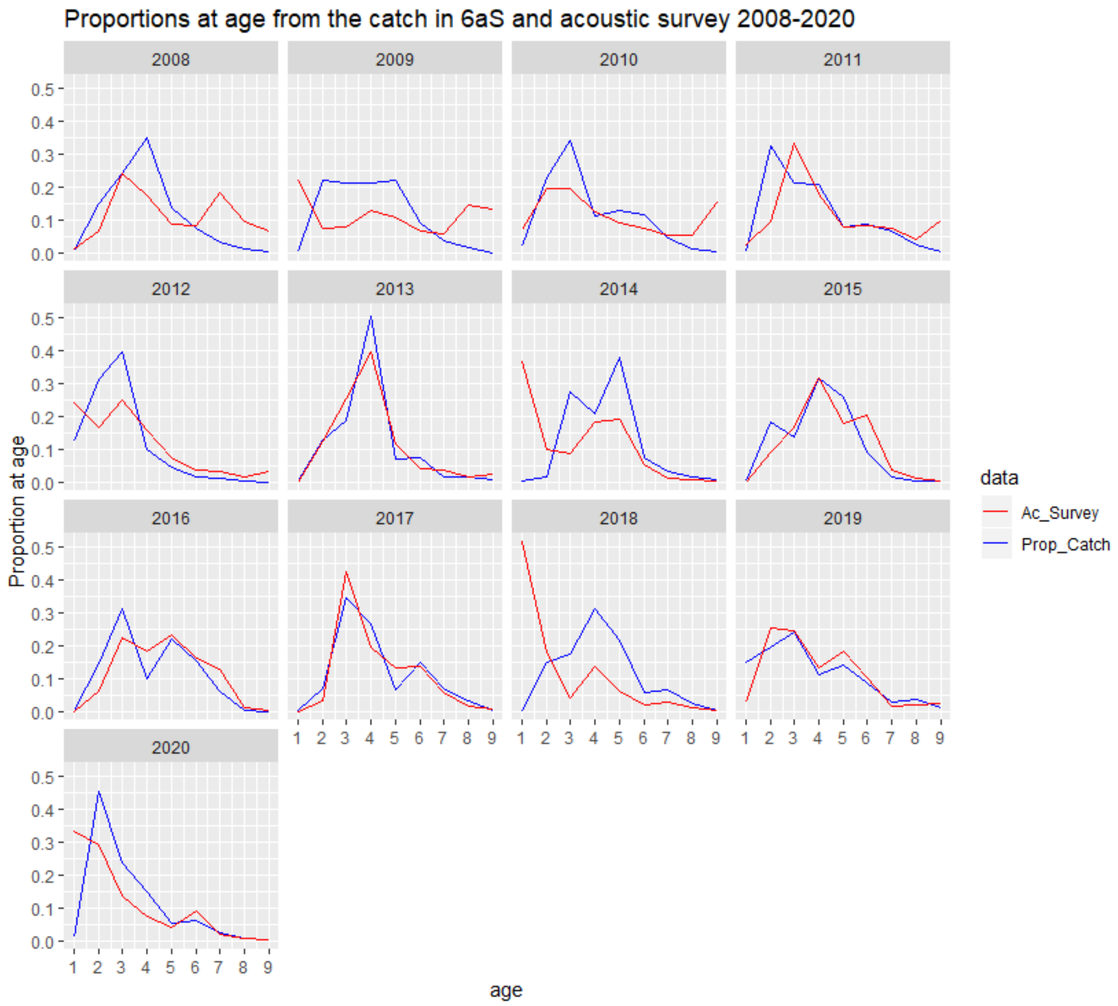


Figure 5.1.4. Herring in divisions 6.a.S and 7.b–c. Percentages-at-age in the 6aS/7.b–c catch and 6aS/7.b–c Malin Shelf acoustic survey (MSHAS) 2008-2020.

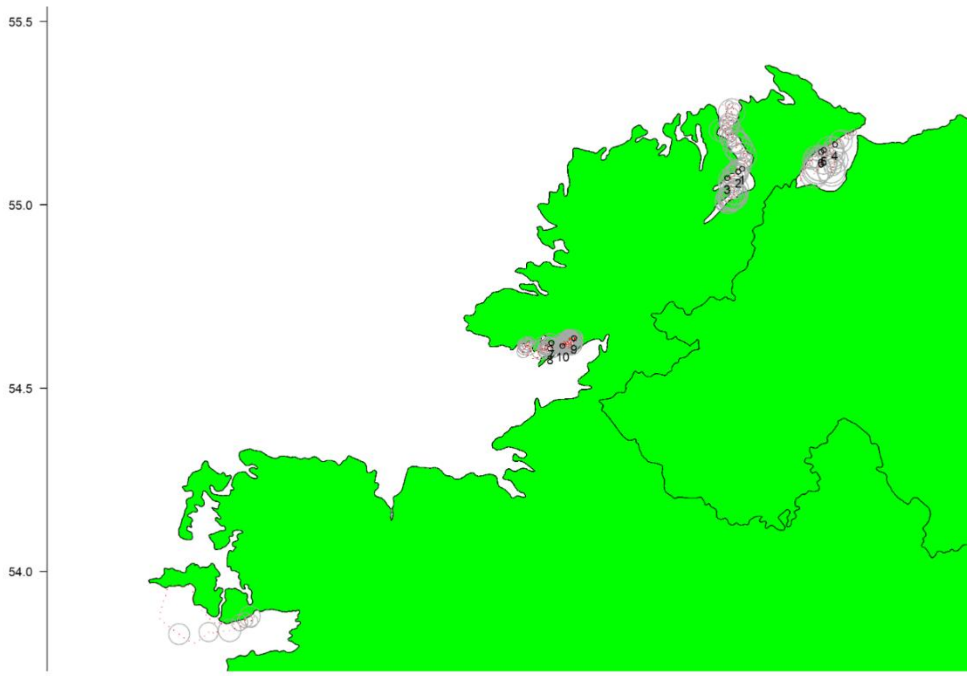


Figure 5.1.5. 6.a.S/7.b industry acoustic survey in 2020: Distribution of biological samples obtained in 6.a.S/7.b - all samples were inshore from the monitoring fishery taking place at the same time.

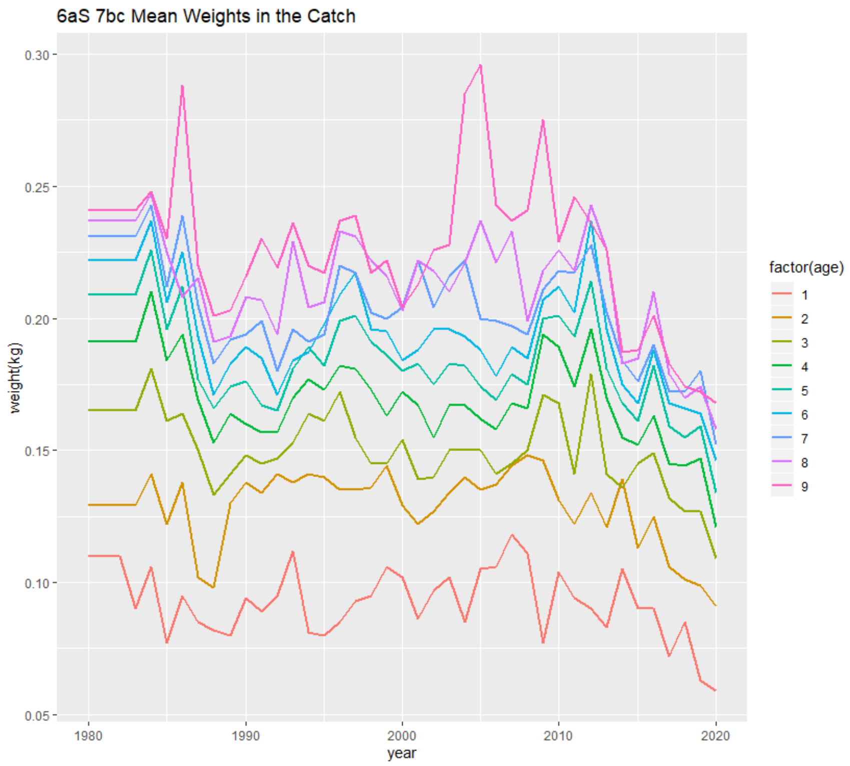


Figure 5.1.7. Herring in divisions 6.a.S and 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2020). Prior to 1981 weights were fixed.

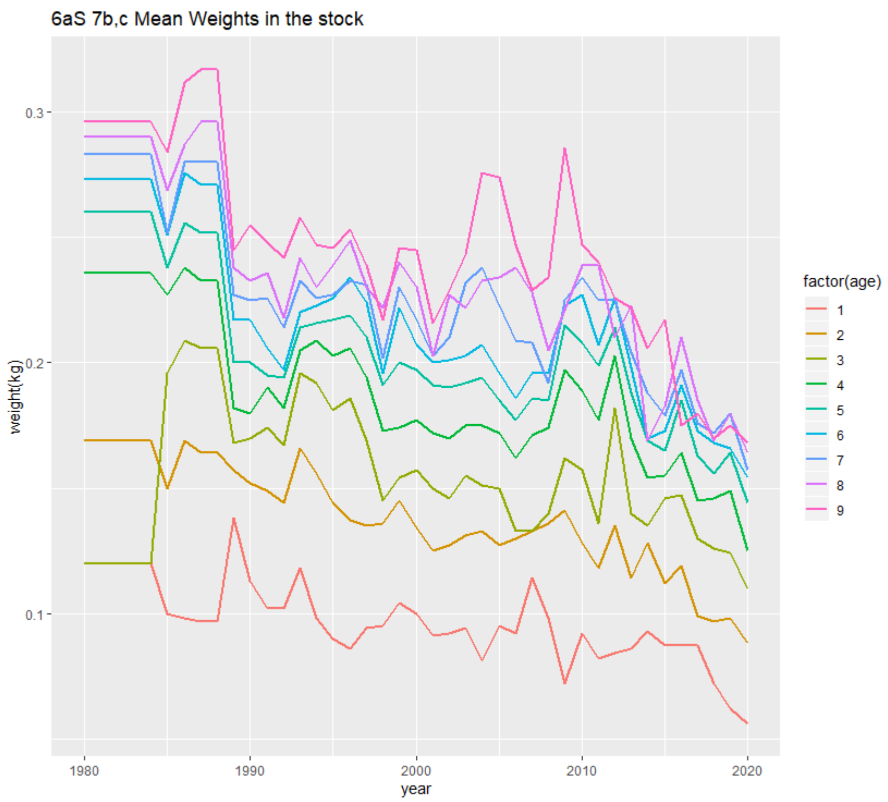


Figure 5.1.8. Herring in divisions 6.a.S and 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2020). Prior to 1981 weights were fixed.

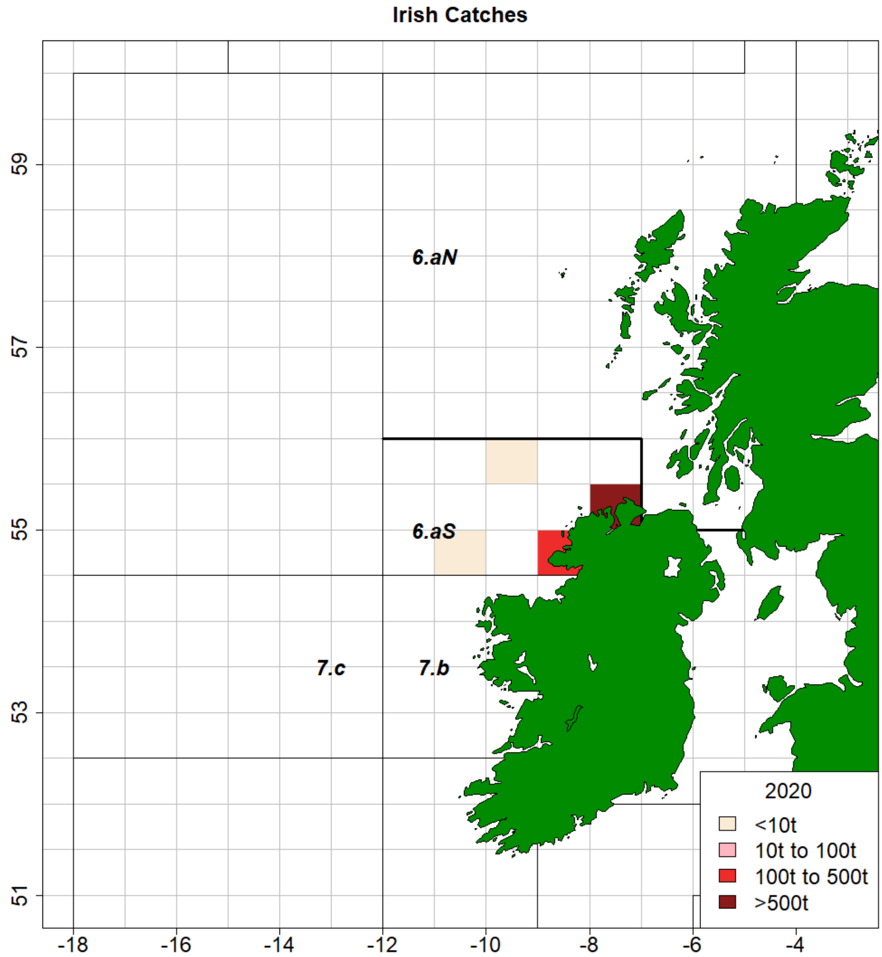


Figure 5.1.9. Herring in divisions 6.a.S and 7.b–c. Irish catches in 2020.

5.2 Herring in Division 6.a (North)

Since 2015 this stock has been combined with herring in 6.a.S 7.b–c (Section 5.1) for assessment and advisory purposes. Prior to 2015 6.a.N existed as a distinct management unit since 1982 when it was separated from 6.a.S 7.b–c.

The location of the area occupied by the stock is shown in Figure 5.2.1. For assessment purposes the stock is considered as an autumn spawning stock only despite spring-spawning components 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 spring spawners. Further elaboration on the rationale behind this specific to Division 6.aN autumn spawners 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.

5.2.1 The Fishery

5.2.1.1 Advice and management applicable to 2020

Since 2016 ICES has advised a TAC of 0 t for the combined stock and that a stock recovery plan be developed for herring stocks in 6.a and 7.b–c (ICES 2018a). In 2016 the European Commission asked ICES to provide advice on a TAC of sufficiently small size to allow ongoing collection of fisheries-dependent data. ICES advised on a scientific monitoring TAC of 3480 t for the 6.a.N stock component (ICES 2016) aiming to take 29 catch samples. Furthermore it was stipulated 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 EC set a monitoring TAC for the 6.a.N stock component slightly higher than this advice at 4170 t (EU 2016/0203) and the same for 2017 (EU 2017/127), 2018 (EU 2018/120), and 2019 ((EU) 2019/124). 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 (EU 2020/123).

5.2.1.2 The monitoring fishery

The industry–science survey aim is to improve the knowledge base for the spawning components of herring in 6.a.N and 6.a.S 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 2016) 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.a.N. 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 2016). 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 in 2020 focused on two principal spawning areas (Figure 5.2.2), with timing planned to coincide with the known spawning period. The new 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. (section 5.2.3.2)

Following a proposal from industry to ensure that commercial catches in 6aN in 2020 were reduced to a bare minimum, the only removal of herring was limited to sample hauls during the acoustic surveys, and 1 commercial haul that was taken outside of the survey area (section 5.2.1.4)

Details of the survey are reported in WGIPS ICES (2021) and Mackinson *et al*. (2021).

5.2.1.3 Stock recovery plan

The Pelagic Advisory Council submitted a revised proposed rebuilding plan for both 6.aN and 6.a.S 7.b–c stocks combined which was reviewed by HAWG 2018 (ICES 2018 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'.*

5.2.1.4 Catches in 2020

Historically catches have been taken from this area by Scottish and Northern Irish pelagic refrigerated seawater (RSW) trawlers and an international freezer-trawler fishery including vessels from the Netherlands Germany and England. The details of these fleets are described in the Stock Annex.

The available 6.a.N monitoring 2020 TAC was not fully utilized in 2020, following pro-active efforts by industry to reduce catches to bare minimum.

The 2020 catches of herring in 6.a.N total 177 t compared with the 3480 t monitoring TAC. There were 0.3 t of non-retained herring catch during the monitoring survey in 2020 under the discard derogation and 0.26 t of other species (Mackinson *et al.*, 2021).

5.2.1.5 Regulations and their affects

There are no new changes to the regulations relevant to the fishery in 6.aN.

5.2.1.6 Changes in fishing technology and fishing pattern

Following a proposal from industry to ensure that commercial catches in 6aN in 2020 were reduced to a bare minimum, the only removal of herring form 6aN was limited to sample hauls during the acoustic surveys, and 1 commercial haul that was taken outside of the survey area.

5.2.2 Biological Composition of the Catch

Catch and sample data by country and by period (quarter) are detailed in tables 5.2.1 and 5.2.2. Biological data sampled from commercial hauls (n = 2) were used to allocate the age distribution for the 6.a.N catches used in the assessment. These samples both came from the Netherlands, with catches taken in quarter 3. The samples were used to allocate catch-at-age (winter rings) (using the sample number weighting) to un-sampled catches in the same or adjacent quarters. Biological parameters for catches in quarter 1 were taken from samples collected in 6a(S). 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 in 2016 can be found in (WD02 HAWG 2017)). The principles described in that document were followed in 2020 as far as possible. While this number of samples meets the requirements for the monitoring fishery as advised by ICES (ICES 2016) of 1 sample per 120 t catch, catches in quarters 1 and 4, and those by all other fleets, were unsampled. Caution should be applied when comparing trends in biological composition of the catch with other years when sampling was more comprehensive.

Catches in 2020 are too low and too sparsely sampled to interpret trends in specific year classes, relative to preceding years (figures 5.2.3 and 5.2.4 Table 5.2.5).

5.2.3 Fishery-independent Information

5.2.3.1 Acoustic survey-MSHAS_N

The survey values for number- weight- and proportion mature-at-age in the stock were revised in 2009 and reported in the 2010 HAWG (see Section 5.6.1 in HAWG ICES 2010). The 2020 survey values are shown in tables 5.2.4 and 5.2.5.

Full details of the 2020 survey are available in the Report of the Working Group for International Pelagic Surveys (WGIPS ICES 2020 Annex 5b).

Vessel	Period	Strata
Celtic Explorer (IRL) EIGB	23 June–12 July	2 3 4 5 6
Scotia (SCO) MXHR6	03 July –26 July	1 91 (North of 58�30’N) 101 111 121

In 2020 the spawning-stock-biomass estimate for the acoustic survey in the area historically used for the 6.a (North) spawning-stock-biomass (Table 5.2.4) was 158 kt, an increase on the historic low of 76 kt seen in 2019.

The proportions of each year class in the catch and the survey are shown in Figure 5.2.5. The large proportion of 6-ringers (2013 year class) observed in the acoustic survey results of previous years is still evident. The acoustic survey encountered only a very small proportion herring above age 7 (wr).

In 2019, a large proportion of the stock was made up of 1 winter ring fish (2018 year class). These were prominent again this year in the 2020 survey as 2 winter ringers (29% of total abundance), along with large numbers of 1 winter ring herring (2019 year class).

5.2.3.2 Acoustic survey- 6.aN herring industry–science survey 2020

Two industry vessels were used to undertake acoustic surveys on spawning ground in September (the 6aSPAWN survey) 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.a.N.

In 2020, the presence of spawning-ready adult herring marks was low, but an abundance of immature, mainly age 1 fish was found in the strata 1 covering the North Minch. In strata 2 on the North coast, very few marks were seen and no samples hauls were made. One feature of the 2020 survey was an apparent 'cleanness' or separation of acoustic mark, compared to the mixed assemblages encountered in the previous two years. Total biomass estimates of herring recorded during the two survey vessels was 33 – 44 kt (Table 5.2.6, Figure 5.2.6).

The survey methods and results were reviewed by ICES WGIPS (2021) who conclude that while the survey provided a reliable estimate the minimum biomass of age 1 (immature) and mature herring at age observed in survey areas during the survey period, but did not provide a reliable estimate of the minimum spawning biomass, because there were no fish sampled in 2020 were in stage 3 or 4 (spawning ready/ spawning), and because of limited sampling coverage in space and time. The survey provides a fifth data point in a new survey series, the details of and utility of which will be explored during the next benchmark.

5.2.4 Mean Weights-at-age and Maturity-at-age

5.2.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the West of Scotland part of the Malin Shelf herring acoustic survey (WGIPS ICES 2021a) and are given in Table 5.2.4 (for the current year). The weights-at-age in the stock in 2020 were similar for all age groups compared to last year (Table 5.2.7). Overall there is a trend of decreasing weights-at-age in the stock for all ages over the last ten years.

Weights in the catch (Table 5.2.8) in 2020 were lower for all age groups compared to recent years, however this is likely an artefact of low sampling levels and use of data from 6.a(S).

5.2.4.2 Maturity ogive

The maturity ogive is obtained from the West of Scotland part of the Malin Shelf herring acoustic survey (Table 5.2.4, WGIPS ICES 2020a). The survey provides estimated values for the period 1992–2019 (Table 5.2.9). In 2020 the level of maturity for 2 winter ring fish continued the trend of later maturation observed since 2017, with only 46% mature. 3 winter ring fish were 75% which is below average of the time-series. At age 4 and above maturity levels were 100%.

5.2.5 Recruitment

There are no specific recruitment indices for this stock. This year both catches and the acoustic survey recorded catches of 1-ringers. Typically the encounter of this age group occurs only incidentally in the survey but has in the past been a small but stable component of the catches. The first reliable appearance of a cohort appears at 3-ring in both the catch and the survey for this stock. In 2020 the proportion of 3-ringers was moderate in the survey (Figure 5.2.4).

5.2.6 Assessment of 6.a (North) Herring

5.2.6.1 Stock Assessment

The ICES WKWEST 2015 Benchmark Workshop (ICES 2015/ACOM:34) for the herring stocks in 6.a.N, 6.a.S, and 7.b–c concluded that a combined stock assessment for these two stocks should be undertaken until it is possible to provide survey indices segregated by stock. Data for this stock were examined in detail by the benchmark group WKWEST (ICES 2015/ACOM:34). Further changes to the assessment input data sources and the assessment were carried out in early 2019 during an interbenchmark procedure ((IBPher6a7bc, ICES 2019). Details of the 2021 assessment for 6.a (combined) and 7.b–c are outlined in Section 4.6 of this report. A benchmark for herring in 6.a, 7.b-c will take place in early 2022.

5.2.6.2 State of the stock

Not determined.

5.2.7 Short-term Projections

5.2.7.1 Deterministic short-term projections

Not undertaken.

5.2.7.2 Yield-per-recruit

Not undertaken.

5.2.8 Precautionary and Yield Based Reference Points

Not determined.

5.2.9 Quality of the Assessment

Not relevant.

5.2.10 Management Considerations

Recruitment has been at a low level since 1998 and even lower since 2013, however there are indications of stronger year classes in 2018 and 2019 (Figure 5.2.3). The 2013 year class (6-wr in 2020) has remained relatively strong in the catches and survey since 2016. This year class was also exceptionally large in the neighbouring North Sea herring stock. There is an 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 acoustic survey index has been decreasing steadily since 2008. Although the 2020 estimates represent a doubling on the 2019 values – the lowest observed in the time-series - the stock remains at a very low level compared to the long-term average.

The overall meta-population (the two stocks in 6.a and 7.b–c) is not in a healthy state and is estimated to be well below the possible candidate Blim values. The working group advocates maintaining separate management of each component.

A monitoring TAC of 4170 t was implemented during 2016-2019, and reduced to 3480 t in 2020, to allow sampling for stock separation and maintaining the time-series of catch composition.

5.2.11 Ecosystem Considerations

Herring fisheries tend to be clean with little bycatch of other fish. Observers monitor some of the fleets. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer program has recorded occasional catches of seals and zero catches of cetaceans in the past. The Scottish pelagic discard observer program is no longer active. It was terminated in 2011.

Herring are an important prey species in the ecosystem west of the British Isles and one of the dominant planktivorous fish in 6.a.N. Bird mammal and stocks of larger predatory fish in the region rely on healthy productive herring populations.

5.2.12 Changes in the Environment

Temperatures in this area have been increasing over the last number of decades (Baxter *et al.*, 2008). There are indications that salinity is also increasing (ICES 2006/LRC:03). It is considered that this may have implications for herring. There is evidence that similar environmental changes have affected the North Sea herring and contributed to the recent changes in productivity of that stock (ICES 2007/ACFM:11).

Table 5.2.1. Herring in 6.a (North). Catch in tonnes by country 1991–2020. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999
Faroes	482			274					
France	1168	119	818	5087	3672	2297	3093	1903	463
Germany	6450	5640	4693	7938	3733	7836	8873	8253	6752
Ireland	8000	7985	8236	6093	3548	9721	1875	11199	7915
Netherlands	7979	8000	6132	8183	7808	9396	9873	8483	7244
Norway	3318	2389	7447	30676	4840	6223	4962	5317	2695
UK	32628	32730	32602	-4287	42661	46639	44273	42302	36446
Unallocated	-10597	-5485	-3753	700	-4541	-17753	-8015	-11748	-8155
Discards*	1180	200					62	90	
Total	50608	51578	56175	54664	61271	64359	64995	65799	61514
Area-Misreported	-22079	-22593	-24397	-30234	-32146	-38254	-29766	-32446	-23623
WG Estimate	28529	28985	31778	24430	29575	26105	35233	33353	29736
Source (WG)	1993	1994	1995	1996	1997	1997	1998	1999	2000

*** Unraised discards.**

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Faroes			800	400	228	1810	570	484	927
France	870	760	1340	1370	625	613	701	703	564
Germany	4615	3944	3810	2935	1046	2691	3152	1749	2526
Ireland	4841	4311	4239	3581	1894	2880	4352	5129	3103
Netherlands	4647	4534	4612	3609	8232	5132	7008	8052	4133
Norway									
UK	22816	21862	20604	16947	17706	17494	18284	17618	13963
Unallocated		277**	6244**	2820**	3490**				
Discards*					123	772	163		
Total	37789	35688**	41649**	31662**	33344**	31392	34230	33735	25216
Area-Misreported	-14627**	-10437**	-8735	-3581	-6885**	-17263	-6884	-4119	-9162
WG Estimate	23162**	25251**	32914	28081**	26459**	14129	27346	29616	16054
Source (WG)	2001	2002	2003	2004	2005	2006	2007	2008	2009

*** Unraised discards.**

**** Revised at WKWEST 2015.**

Country	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Denmark								23	
Faroes	1544	70				360			
France	1049	511	504	244	586	589			
Germany	27	3583	3518	1829	4025	3354	3292	1028	
Ireland	1935	2728	3956	3451	3124	2632	1799	569	10
Lithuania						770			
Norway							0.98		
Netherlands	5675	3600	1684	3523	1775	1641	956	300	829
UK	11076	12018	11696	12249	15906	16769	15260	3254	3356
Unallocated									
Discards*		95			30				
Total	21306	22510	21358	21296	25446	26115	21307	5174	4201
Area-Misreported	-2798	-2728	-3599	-2780	-2468	-4088	-2506	-450	
WG Estimate	18508	19877	17759	18516	22978	22027	18801	4724	4201
Source (WG)	2010	2011	2012	2013	2014	2015	2016	2017	2018

*** Unraised discards.**

Country	**2018**	**2019**	**2020**
Denmark	39	71	
Faroes			4
France	7	46**	
Germany	17	2	
Ireland	84	37	37
Lithuania			
Norway	4	3	
Netherlands	1000	653	85
UK	2911	928	51
Unallocated			
Discards*			
Total	4063	1739	177
Area-Misreported			
WG Estimate	4063	1739	177
Source (WG)	2019	2020	2021

*** Unraised discards. **From ICES preliminary catch statistics database.**

Table 5.2.2. Herring in 6.a (North). Catch and sampling effort by nation in the fishery in 2020.

Country	Quarter	Sampled Catch (t)	Official Catch (t)	No. Hauls	No. of samples	No. meas-ured	No. aged	SOP
UK (Sco)	Q1	0	6	-	-	-	-	0%
	Q4	0	2	-	-	-	-	0%
UK (NI)	Q4	0	43	-	-	-	-	0%
Ireland	Q1	0	29	-	-	-	-	0%
	Q4	0	8	-	-	-	-	0%
Netherlands	Q3	64	64	2	2	276	50	100%
	Q4	0	21	-	-	-	-	0%
Others		0	4	-	-	-	-	0%
Total		64	177	2	2	276	50	100%

Table 5.2.3. Herring in 6.a (North). 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

Year	1	2	3	4	5	6	7	8	9+
1973	51170	235627	808267	131484	63071	54642	18242	6506	32223
1974	309016	124944	151025	519178	82466	49683	34629	22470	21042
1975	172879	202087	89066	63701	188202	30601	12297	13121	13698
1976	69053	319604	101548	35502	25195	76289	10918	3914	12014
1977	34836	47739	95834	22117	10083	12211	20992	2758	1486
1978	22525	46284	20587	40692	6879	3833	2100	6278	1544
1979	247	142	77	19	13	8	4	1	0
1980	2692	279	95	51	13	9	8	1	0
1981	36740	77961	105600	61341	21473	12623	11583	1309	1326
1982	13304	250010	72179	93544	58452	23580	11516	13814	4027
1983	81923	77810	92743	29262	42535	27318	14709	8437	8484
1984	2207	188778	49828	35001	14948	11366	9300	4427	1959
1985	40794	68845	148399	17214	15211	6631	6907	3323	2189
1986	33768	154963	86072	118860	18836	18000	2578	1427	1971
1987	19463	65954	45463	32025	50119	8429	7307	3508	5983
1988	1708	119376	41735	28421	19761	28555	3252	2222	2360
1989	6216	36763	109501	18923	18109	7589	15012	1622	3505
1990	14294	40867	40779	74279	26520	13305	9878	21456	5522
1991	26396	23013	25229	28212	37517	13533	7581	6892	4456
1992	5253	24469	24922	23733	21817	33869	6351	4317	5511
1993	17719	95288	18710	10978	13269	14801	19186	4711	3740
1994	1728	36554	40193	6007	7433	8101	10515	12158	10206
1995	266	82176	30398	21272	5376	4205	8805	7971	9787
1996	1952	37854	30899	9219	7508	2501	4700	8458	31108
1997	1193	55810	34966	31657	23118	17500	10331	5213	9883
1998	9092	74167	34571	31905	22872	14372	8641	2825	3327
1999	7635	35252	93910	25078	13364	7529	3251	1257	1089
2000	4511	22960	21825	51420	15504	9002	3897	1835	576
2001	147	83318	15368	9569	25175	9544	6813	4741	1028
2002	992	38481	93975	9014	18113	28016	9040	1547	1422

Year	1	2	3	4	5	6	7	8	9+
2003	56	33331	46865	53766	7462	4344	12818	9187	1407
2004	0	7235	23483	29421	48394	4151	8100	9023	4265
2005	182	9632	23236	20602	10237	9783	1014	1194	1430
2006	132	6691	9186	13644	41067	27781	20972	3041	5088
2007	130	34326	17754	6555	14264	30566	21517	13585	4242
2008	0	7898	13039	5427	3219	5688	14832	8142	8968
2009	1923	11508	10475	16586	8332	5688	7514	11793	9443
2010	10074	20339	16331	9957	14608	6322	4322	5388	13199
2011	1667	40587	15782	10333	7190	5071	3164	2611	7225
2012	979	14952	46647	9704	8097	6311	3873	1129	4013
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

Table 5.2.4. Herring in 6.a (North). Total numbers (millions) biomass (thousands of tonnes) mean weights mean lengths and fraction mature by winter ring of herring in the 6.a (N) part not including Clyde and North Channel of the MSHAS survey in July 2020.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	657	41.9	0.00	63.7	19.4
2	579	73.2	0.46	126.3	24.1
3	274	41.3	0.75	150.5	25.3
4	150	25.6	1.00	170.7	26.4
5	83	15.3	1.00	184.3	27.1
6	178	36.0	1.00	201.9	28.0
7	38	8.1	1.00	214.6	28.5
8	13	2.8	1.00	216.5	28.8
9+	10	2.4	1.00	231.1	29.6
Immature	1039	88		85.2	21.0
Mature	943	157.902		167.4	26.2
Total	1982	246	0.48	124.3	23.5

Table 5.2.5. Herring in 6.a (North). Estimates of abundance and SSB for the time-series of the West of Scotland acoustic survey in 6.a (N) not including Clyde and North Channel. Since 2008 this index comes from a spatial subset of the MSHAS survey. Thousands of fish at-age and spawning biomass (SSB tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043	410 000
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440	351 460
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450	845 452
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880	533 740
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700	452 300
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810	370 300
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440	175 000
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770	375 890
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400	460 200
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000	444 900
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700	359 200
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500	548 800
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200	739 200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300	395 900
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800	222 960
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300	471 700
2007	-	126000	294400	202500	145300	346900	242900	163500	32100	298 860
2008	47840	232570	911950	668870	339920	272230	720860	365890	263740	788 200
2009	345821	186741	264040	430293	373499	219033	186558	499695	456039	578 800
2010	119788	493908	483152	171452	163436	93289	64076	53116	223311	308 055
2011	22239	184919	733384	451487	204324	219863	198768	112646	263185	457 900
2012	792479	179425	728758	471381	240832	107492	106779	56071	104571	374 913
2013	-	136931	319711	599897	161597	69341	60566	24302	37398	256 089
2014	1031086	243227	217650	469032	519032	143402	30318	18677	11449	272 000
2015	0	121640	324964	649835	377636	442135	83103	22556	2086	387 000
2016	0	29593	108126	87773	111676	79130	62045	5530	957	87 907
2017	0	23287	325407	147112	101785	104599	44927	13004	4569	139 000
2018	964099	322798	92037	330580	152548	50636	72276	26636	12549	152 000
2019	3423	49913	77088	41128	137031	85553	14485	16319	19903	76 146
2020	657378	579031	274156	149760	82797	178119	37644	12815	10495	157 902

Table 5.2.6a. Total Abundance and overall biological composition of herring in 6.a North from the industry acoustic survey on FV Ocean Star in 2020. (Figures in bold are weighted averages based on the numbers in each age group.)

Age (WR)	Numbers (mill)	Biomass (kt)	Maturity	Weight (g)	Length (cm)
0	1	0	0.00	27.49	15.00
1	170	12	0.01	69.87	20.39
2	82	11	0.81	133.03	24.51
3	38	6	1.00	156.10	25.82
4	25	5	0.97	202.94	27.71
5	19	4	1.00	207.36	27.88
6	17	4	1.00	221.19	29.27
7	10	2	1.00	212.21	29.06
8	0	0	0.00	0.00	0.00
9	1	0	1.00	245.00	31.00
Immature	185	14		**75.05**	**20.75**
Mature	178	30		**169.17**	**26.31**
Spawning	0	0			
Total	363	44	**0.49**	**121.09**	**23.47**

Table 5.2.6b. Total Abundance and overall biological composition of herring in 6.a North from the industry acoustic survey on FV Alida in 2020. (Figures in bold are weighted averages based on the numbers in each age group.)

Age (WR)	Numbers (mill)	Biomass (kt)	Maturity	Weight (g)	Length (cm)
0	1	0	0.00	27.26	15.00
1	119	8	0.02	70.76	20.41
2	63	8	0.82	133.41	24.46
3	26	4	1.00	156.85	25.76
4	20	4	0.95	195.37	27.36
5	17	4	1.00	212.98	28.09
6	12	2	0.88	207.60	28.06
7	7	2	1.00	217.94	29.38
8	0	0	0.00	0.00	0.00
9	1	0	1.00	245.00	31.00
Immature	131	10		76.02	20.88
Mature	134	23		169.33	26.11
Spawning	0	0			
Total	266	33	0.51	123.20	23.52

Table 5.2.7. Herring in 6.a (North). Weights-at-age in the stock. Units: kg year

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age/year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.25
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

age/year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

age/year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age/year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	0.0751	0.075	0.0750	0.055	0.059	0.068	0.057	0.066	0.0637	0.064
2	0.1296	0.135	0.1675	0.172	0.151	0.162	0.132	0.150	0.1550	0.108
3	0.1538	0.166	0.1830	0.191	0.206	0.194	0.160	0.183	0.1650	0.158
4	0.1665	0.185	0.1914	0.208	0.223	0.227	0.208	0.189	0.2020	0.180
5	0.1802	0.192	0.1951	0.214	0.233	0.239	0.236	0.206	0.2100	0.206
6	0.1911	0.204	0.1951	0.214	0.231	0.248	0.245	0.217	0.2360	0.214
7	0.2125	0.211	0.2021	0.221	0.232	0.258	0.238	0.214	0.2430	0.231
8	0.2030	0.224	0.2034	0.224	0.232	0.226	0.222	0.218	0.2450	0.244
9	0.2284	0.231	0.2138	0.238	0.238	0.212	0.253	0.215	0.2540	0.264

age/year	2015	2016	2017	2018	2019	2020
1	0.064	0.064	0.064	0.048	0.098	0.064
2	0.155	0.137	0.135	0.110	0.117	0.126
3	0.183	0.140	0.170	0.155	0.149	0.151
4	0.195	0.175	0.181	0.176	0.179	0.171
5	0.204	0.202	0.198	0.190	0.196	0.184
6	0.211	0.208	0.199	0.210	0.205	0.202
7	0.217	0.209	0.214	0.209	0.217	0.215
8	0.215	0.210	0.223	0.218	0.224	0.217
9	0.220	0.242	0.236	0.222	0.218	0.231

Table 5.2.8. Herring in 6.a (North). Weights-at-age in the catch.Units: kg year

age/year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age/year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age/year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age/year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	0.0490	0.1066	0.0609
2	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.1373	0.1398	0.1464	0.1448
3	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.1637	0.1628	0.1625	0.1593
4	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.1829	0.1828	0.1728	0.1690
5	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.2014	0.1922	0.1595	0.1852
6	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.2147	0.1959	0.1780	0.1997
7	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.2394	0.2047	0.1863	0.1942
8	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.2812	0.2245	0.2449	0.1854
9	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.2526	0.2716	0.2802	0.2938

age/year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.0000	0.1084	0.0908	0.1152	0.0000	0.1121	0.0818	0.0613	0.0725	0.0000
2	0.1541	0.1327	0.1667	0.1705	0.1726	0.1549	0.1550	0.1469	0.1441	0.1580
3	0.1732	0.1632	0.1676	0.1881	0.2060	0.2141	0.1883	0.1894	0.1894	0.1746
4	0.1948	0.1845	0.1929	0.1968	0.2310	0.2379	0.2129	0.2178	0.2076	0.1965
5	0.2160	0.2108	0.2076	0.2105	0.2309	0.2457	0.2337	0.2340	0.2161	0.2020
6	0.2197	0.2258	0.2251	0.2214	0.2489	0.2535	0.2394	0.2388	0.2261	0.2124
7	0.1986	0.2341	0.2443	0.2161	0.2529	0.2599	0.2369	0.2470	0.2408	0.2304
8	0.1885	0.2556	0.2615	0.2618	0.2840	0.2549	0.2400	0.2463	0.2817	0.2343
9	0.3030	0.2496	0.2750	0.3030	0.2877	0.2730	0.2549	0.2522	0.2467	0.2476

age	2014	2015	2016	2017	2018	2019	2020
1	0.0000	0.0769	0.100	0.000	0.000	0.089	0.074
2	0.1451	0.1425	0.144	0.137	0.126	0.129	0.125
3	0.1877	0.1795	0.178	0.167	0.151	0.148	0.115
4	0.2030	0.2059	0.204	0.187	0.174	0.182	0.147
5	0.2279	0.2136	0.219	0.204	0.190	0.199	0.180
6	0.2449	0.2307	0.229	0.213	0.208	0.210	0.192
7	0.2608	0.2386	0.237	0.221	0.218	0.220	0.210
8	0.2614	0.2454	0.251	0.233	0.238	0.257	0.140
9	0.2835	0.2685	0.257	0.249	0.246	0.244	0.222

Table 5.2.9. Herring in 6.a (North). Proportion mature. Units: NA year

age/ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	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
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
9	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	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	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
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
9	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	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	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
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
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.92	0.76	0.83	0.84	0.81	1.00	0.98	0.70	0.79	0.46	0.85	0.52	0.18	0.58	0.97	0.89
3	1.00	1.00	0.97	1.00	0.97	1.00	1.00	1.00	1.00	0.92	1.00	0.81	0.73	0.92	0.99	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.98	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
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	0.97	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2018	2019	2020
1	0.00	0.00	0.00
2	0.48	0.36	0.46
3	0.91	0.95	0.75
4	0.98	1.00	1.00
5	0.98	1.00	1.00
6	1.00	1.00	1.00
7	1.00	1.00	1.00
8	1.00	1.00	1.00
9	1.00	1.00	1.00

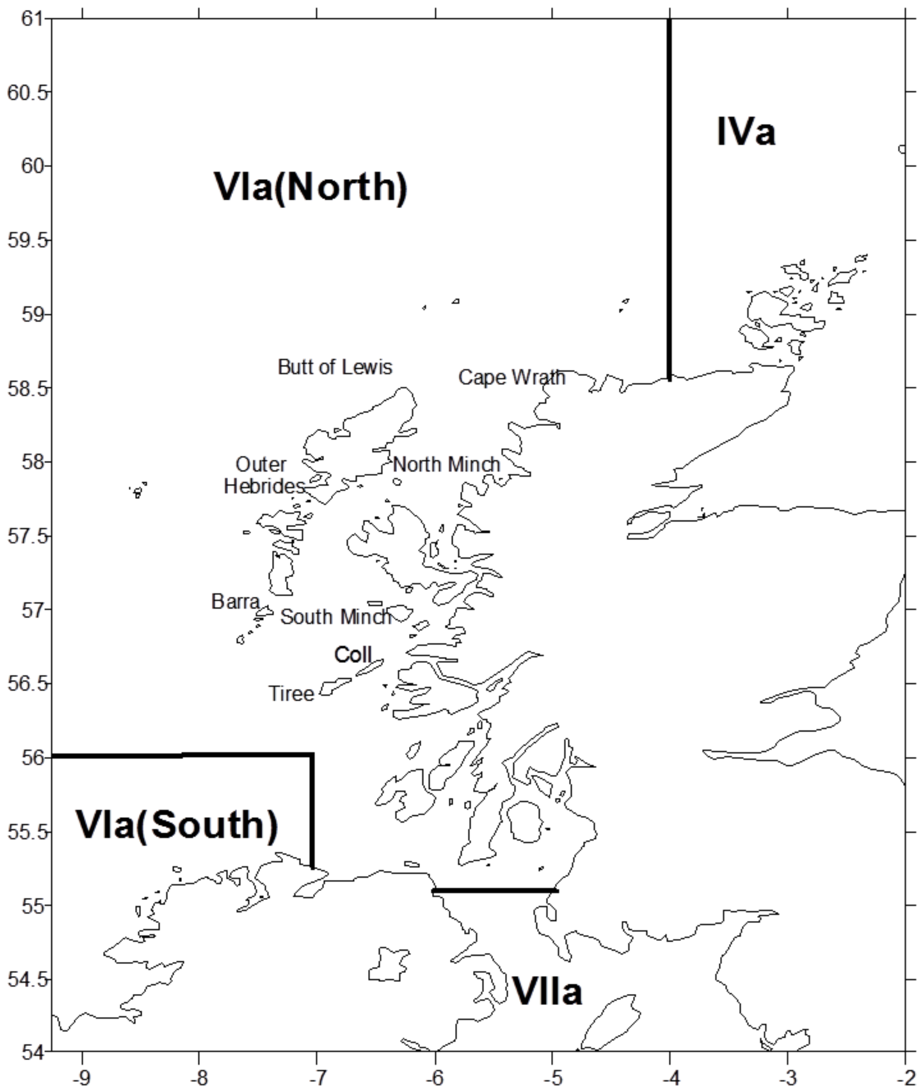


Figure 5.2.1. Location of ICES area 6.a (North) and adjacent areas with place names.

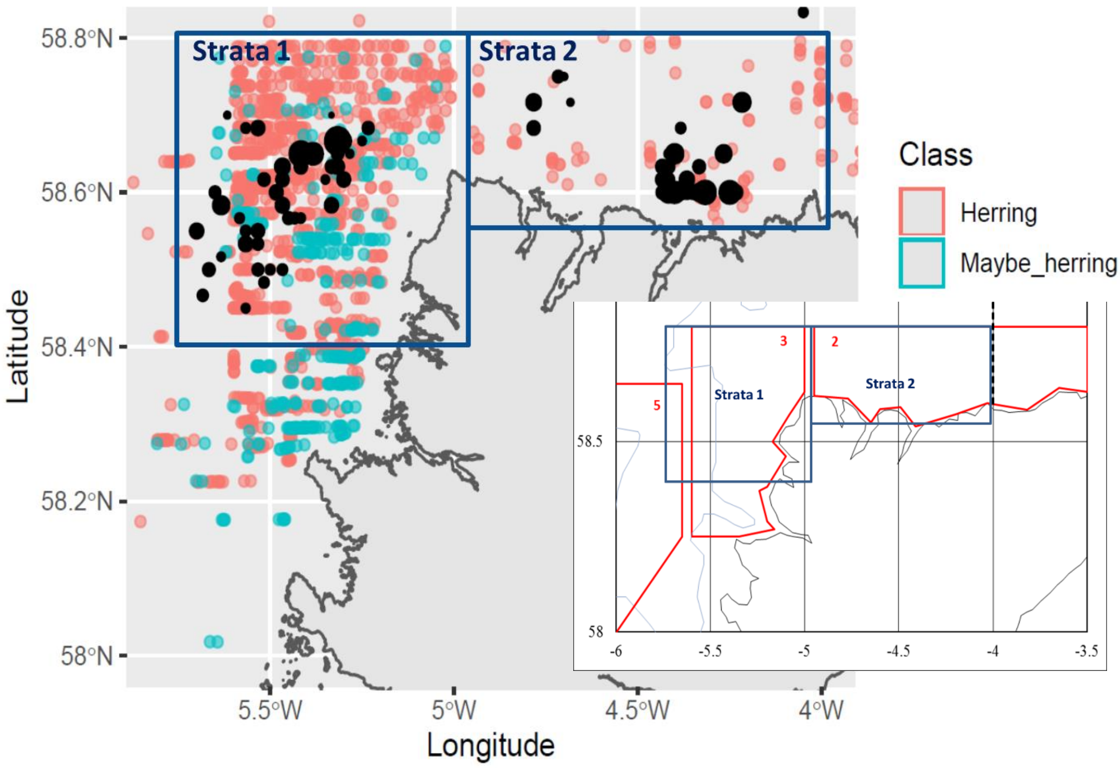


Figure 5.2.2. Acoustic survey recordings of herring and 'maybe herring' marks and locations of commercial catches 2016-2019 in the newly defined Strata 1 and 2, showing overlap with previous survey Areas 2,3,5 (inset) and noting that the distribution of catches reflect spawning grounds. Catches (black dots) scaled proportionally. Acoustic marks are not scaled and denote location only.

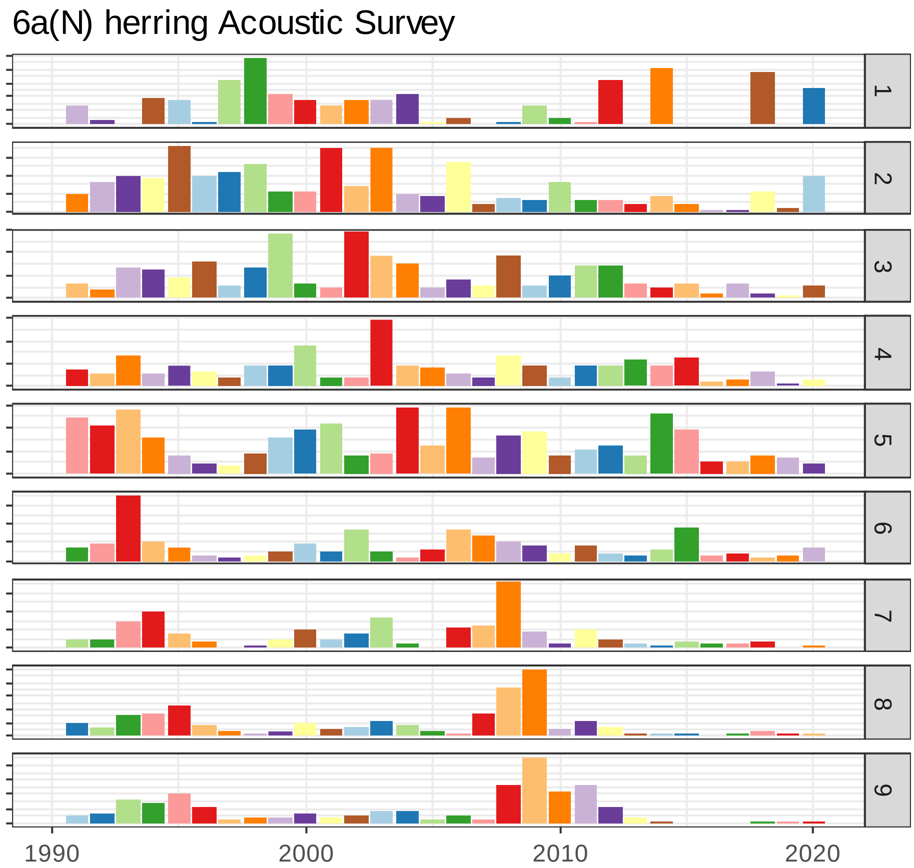


Figure 5.2.3. Herring in 6.a (North). West of Scotland (6.aN) autumn spawning herring subset from MSHAS indices (millions) by age (winter rings) and year from the acoustic surveys 1991–2020. Age 9 includes ages 9 and older.

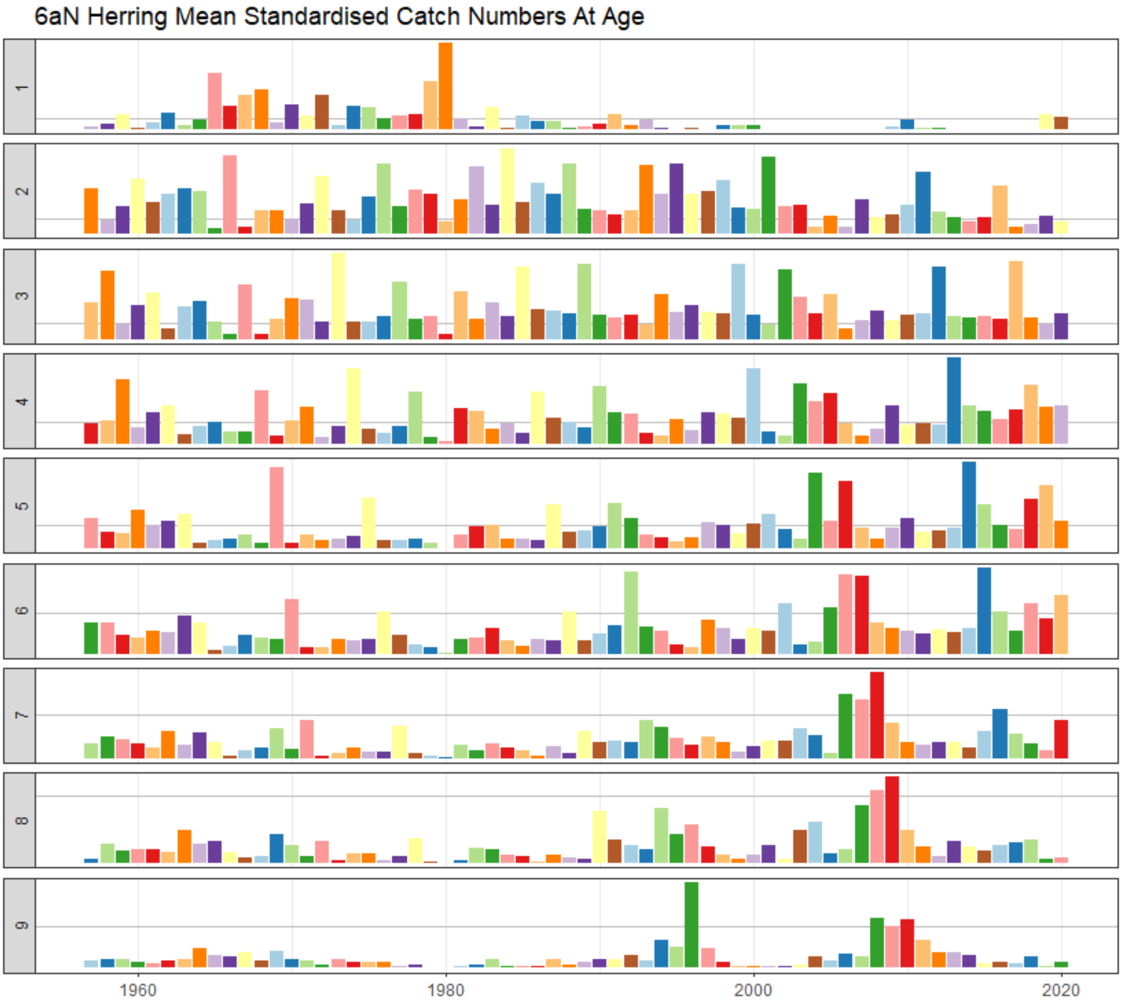


Figure 5.2.4. Herring in 6.a (North). Mean standardized catch numbers-at-age standardized by age 1957 to 2020. Age 9 includes fish at 9+.

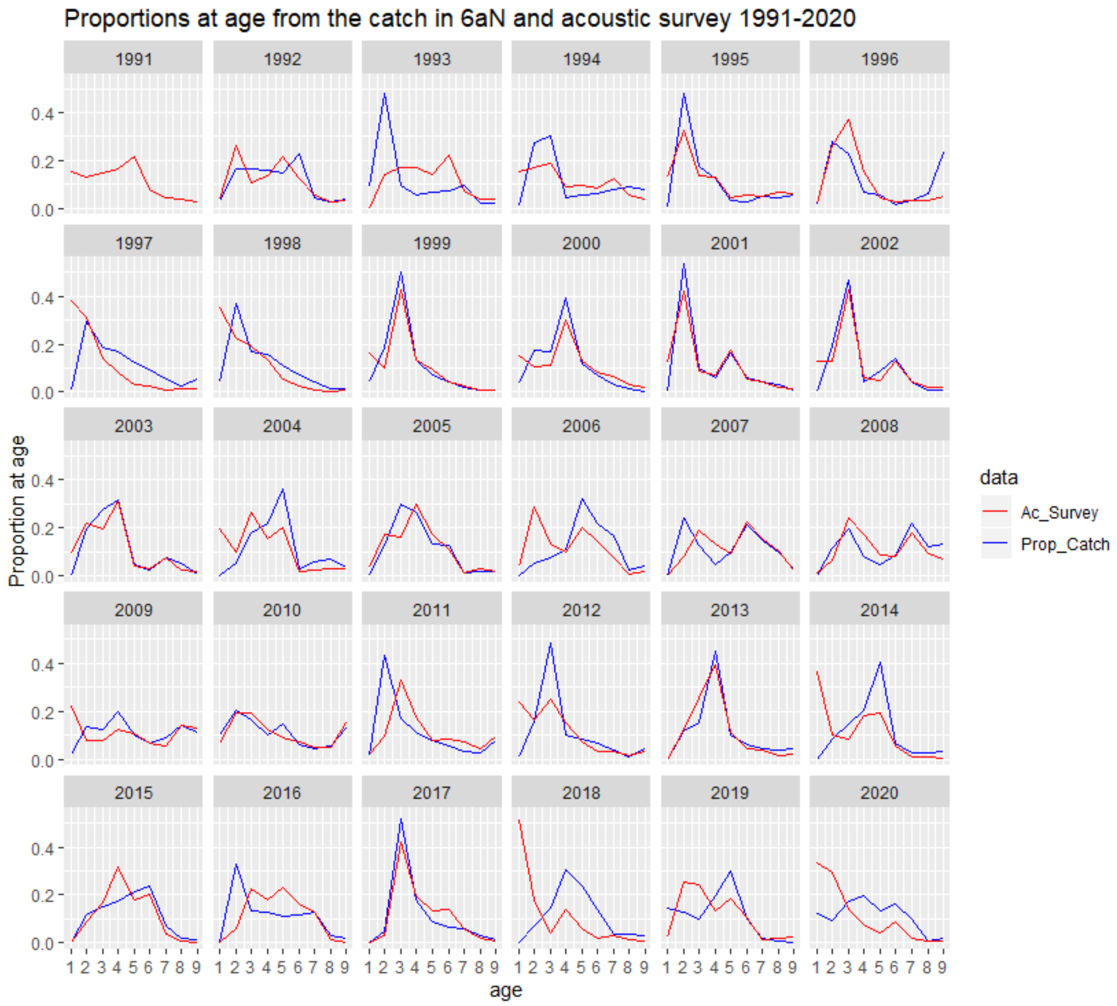


Figure 5.2.5. Herring in 6.a (North). Comparison of the proportions-at-age by year class in the acoustic survey and the catch 1991-2020

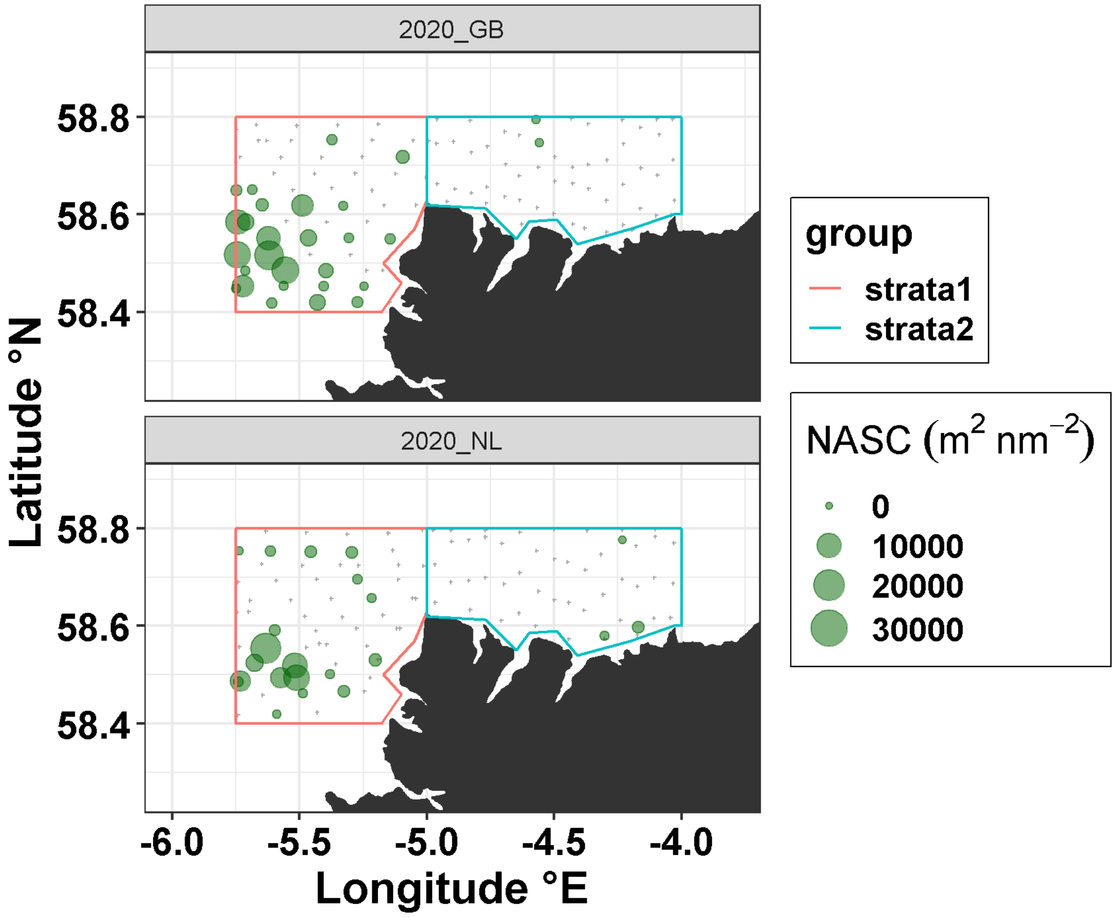


Figure 5.2.6. Relative acoustic densities (NASC m2/mn2) of all fish marks for FV Ocean Star (GB) and FV Alida (NL) recorded during the 2020 6.aN herring industry–science survey. (details in WGIPS 2021).

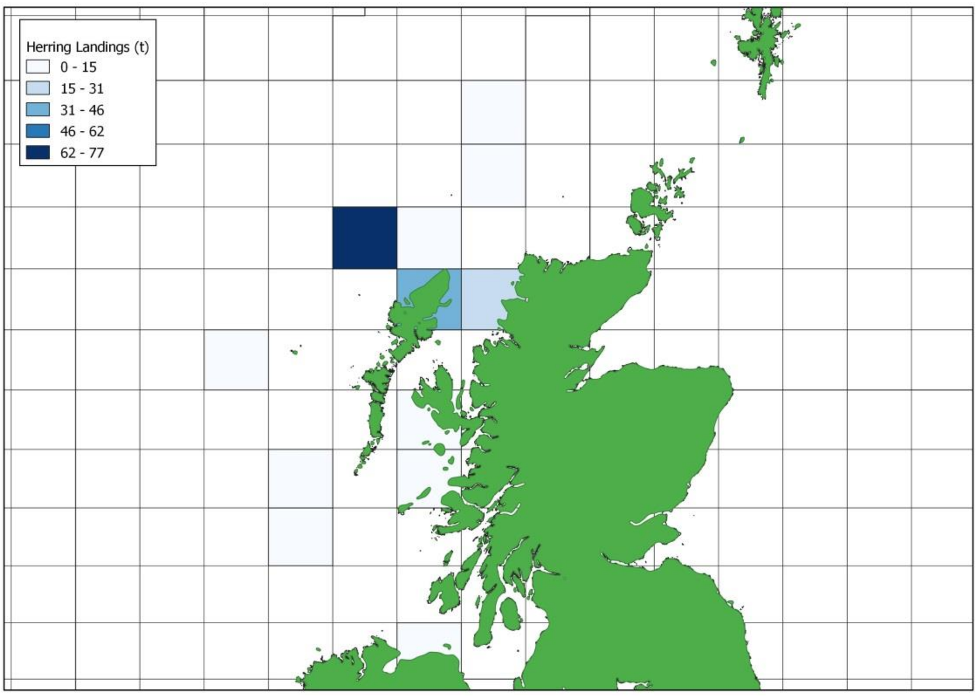


Figure 5.2.7. Herring in 6.a.

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. 2019 refers to the 2019–2020 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 2020–2021

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 2020 was 869 t. At the time of writing the TAC for 2021 had not yet been agreed.

Long-Term Management Plan

A long-term management plan has been proposed by the Pelagic RAC in 2011. The most recent evaluation of this plan took place in 2018 (ICES, 2018).

ICES advises that the harvest control rule in the long-term management plan for Celtic Sea herring is no longer consistent with the precautionary approach. The management plan results in a greater than 5% probability of the stock falling below B_{lim} in several years throughout the 20 year simulated period. The simulations indicate the management plan cannot ensure that the stock is fished and maintained at levels which can produce maximum sustainable yield as soon as or by 2020.

6.1.2 The fishery in 2020–2021

In 2020, the Irish fishery took place in 7.g in Q3 and in 7.g and 7.a.S in Q4 as in previous years, albeit with very low catches, particularly in 7.g.

The Irish fishery is divided in two fleets, the main fleet and the sentinel fleet. The Celtic Sea Herring Management Advisory Committee (CSHMAC) provide inputs to the management of the Celtic Sea Herring. Fishing began in 7.a.S on 23 November and continued at a low level until 8 December, catching less than 40 t in total. The bulk of the catch in 2020 occurred in December in 7.j, when 100 t was reported on one day. Very small catches – under 1 t - were reported from 7.g in September.

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 2020 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2020.

The estimated catches from 1988–2020 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 2020–2021 season decreased again to 132 t (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 limited the main fleet to 5 days and prevented it from catching the quota. There were no issues with < MCRS in 2020, however the monitoring TAC was far from fully utilised. This may have been due to increased searching time due to the low stock biomass and the availability of other species such as sprat in inshore waters.

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. The Marine Institute carried out one herring directed discard trip in 2020 with no discarding observed (reduction in trip numbers due to COVID restrictions).

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 1958-2020. Two winter ringers were the dominant age class in 2020 (61%), followed by 3– and 1– wr respectively (Table 6.2.1.1.). The yearly mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Year classes 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 including 2020. The catch and survey data both show a peak in three winter ring fish in 2018. These samples were taken inshore and are comprised mainly of younger fish. In 2019, a larger proportion of 4–wr was observed in the commercial fishery that might be related to the 3 wr observed in 2018. These fish were caught by the sentinel fleet in Dunmore East's estuary where a significant part of the catch was taken. An enhanced sampling programme was arranged in 2019 to monitor this fleet's catch. Both the survey and the catch were dominated by 2-wr in 2020.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. In the past 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 Q4 7.aS in 2020 did not exhibit a high proportion of below MCRS herring.

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 2020. The number of samples obtained in 2020 was low due to the very low catches.

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 2020, 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 2020–2021 season was carried out from 4 to 24 October 2020, on the Celtic Explorer (O'Donnell *et al.*, 2020, https://oar.marine.ie/handle/10793/1664). Geographical coverage was lower than in 2019. Due to the lack of herring in offshore waters, survey effort was re-allocated to inshore grounds. Core distribution areas were nevertheless comprehensively covered. The acoustic survey track is shown in Figure 6.3.1.1.

The 2020 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. Herring were observed exclusively within coastal waters (10 nmi) and no offshore herring were observed. However, the stock was considered contained within the Celtic Sea survey with no aggregations observed around the survey periphery. Herring TSB (total-stock biomass) and abundance (TSN) estimates from the 2020 survey were 4717 t and 67 368 000 individuals respectively, the second lowest values in the time-series after 2019.

A total of 17 trawl hauls were carried out during the survey in 2020, with four containing herring. Of the four herring hauls, all contained <50% of herring by weight. The survey estimate is dominated by 2-wr fish representing over 57% of the total biomass and 48% of total abundance. This 2-wr cohort is now considered recruited to the spawning stock and has been successfully tracked across both autumn and winter surveys since it was first identified in 2018.

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. 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.

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 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 2 and 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 lesser 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 (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 1.39 over a five–year peel. This is another significant increase compared to the previous update assessments (1.1 and –0.17 in 2020 and 2019 respectively) and it is significantly higher than the 0.2 threshold. Regarding SSB (top panel of Figure 6.6.1.8), 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 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 2020. 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 2020 and the update assessment in 2021 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 11 680 t in 2020, still well below B_{lim} (34 000 t). The 2021 assessment shows a similar SSB trajectory to the 2020 assessment but with SSB in the most recent years revised downwards. The assessment indicates that the stock has been below B_{lim} since 2016.

The update assessment estimated mean F (2–5 ring) in 2020 to be 0.023, decreasing from 1.2 and

0.77 for 2018 and 2019 respectively. 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 that was seen in the 2020 assessment is again evident in the 2021 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 predicted by the model in 2020 was again revised downwards 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 (2019). As this SSB value (5790 t) is below the change-point (13 432 t), the following adjustment is applied.

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

$$Recruitment_{2021} = 381749 \times \frac{5790.48}{13432.22} = 164567.7$$

Interim year catch was taken to be the monitoring TAC (869 t), although at the time of writing this has yet to be agreed for 2021. 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 2022.

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 which 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 leads to SSB ≥ B_{lim} with 95% probability	ICES (2018a)

*F_{pa} changed in 2021; F_{pa} 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 2020 are compared with the assessment outputs in 2021 and are shown in the table below. The assessment in 2021 shows a more pessimistic outlook for this stock with SSB again revised downwards and F revised upwards. This can also be seen in the historical retrospective plot in Figure 6.10.1

2020 Assessment				2021 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2018	6463	4418	1.11	2018	5843	4418	1.20	-10%	8%
2019	11751	1841	0.49	2019	5790	1841	0.77	-51%	58%
2020*	17485	869	0.59	2020	11680	132	0.02	-33%	-96%

*** from intermediate year in STF.**

The 2020 acoustic survey estimate is the second lowest in the time-series after 2019. The survey time-series used in the assessment includes data from 2002 to 2019 (no survey in 2004 and the 2017 survey excluded). Since 2014 herring have 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 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 2022. F is now below F_{MSY} (0.26) and F_{lim} (0.45). The advice provided for this stock for 2022 is based on the ICES MSY approach, as in recent years. The Council of the European Union set the 2020 TAC 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. At the time of writing the 2021 TAC had yet to be agreed.

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 in 2020.

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 and waste from fish cages. There have been several proposals for extraction of gravel and to dump dredge spoil in recent years. Many of these proposals relate to known herring spawning grounds. ICES have consistently advised that activities that perturb herring spawning grounds should be avoided.

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), 1988–2020. (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	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	17 825
2016	-	419	15 107	1025	559	-451	182	16 847
2017	-	298	10 184	648	64		130	11 324
2018			4398	436		-245		4589
2019	-	-	1803	38	-	-	-	1841
2020	-	-	132	+	-	-	-	132

*** 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) 1988/1989–2020/2021. (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	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	18 800
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
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	-	-	132	+	-	-	-	132

*** 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 1970–2020/2021. 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%
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%

Year	1	2	3	4	5	6	7	8	9
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%
2019	60%	18%	8%	10%	3%	1%	0%	0%	0%
2020	13%	61%	15%	4%	4%	1%	1%	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 2020/2021 season.

Length cm	7.a.S Q4
16	1
16.5	
17	
17.5	
18	2
18.5	4
19	8
19.5	12
20	12
20.5	15
21	43
21.5	48
22	47
22.5	60
23	54
23.5	62
24	42
24.5	21
25	17
25.5	15
26	7
26.5	7
27	3
27.5	2
28	
28.5	1
29	97
29.5	27
30	8
30.5	
31	1

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2020–2021). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. Measured	No. aged	Aged/1000 t
7.aS	2020	4	40	3	483	150	3750
7.j	2020	4	92	-	-	-	-
7.g	2020	3	<1	-	-	-	-
Total			132	3	483	150	1136

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	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**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
0	0	0	0	0	109	98	1
1	41	0	125	0	55	22	27.2
2	117	40	21	6	16	8	32.2
3	112	48	43	3	27	0.5	5
4	69	41	40	7	6	0.3	1
5	20	38	36	5	0	0.1	0
6	24	7	25	4	0	0	0
7	7	6	5	1	-	0	0
8	17	5	6	1	-	0	0
9	1	0	0	0		0	0
Nos.	408	184	301	27	213	129	67
SSB	48	25	30	4	8	0.3	3.1
CV	0.59	0.18	0.33	-	0.49	0.55	0.51

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

	1	2	3	4	5	6	7	8	9
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	0.185	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

	1	2	3	4	5	6	7	8	9
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
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

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

	1	2	3	4	5	6	7	8	9
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
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

	1	2	3	4	5	6	7	8	9
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
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

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

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

Year	1	2	3	4	5	6	7	8	9	Total catch
1984	19517	92892	41121	16043	2450	1085	376	231	180	26779
1985	17916	57054	36258	16032	2306	228	85	173	132	20426
1986	4159	56747	42881	32930	8790	1127	98	29	12	25024
1987	5976	67000	43075	23014	14323	2716	1175	296	464	26200
1988	2307	82027	30962	9398	5963	3047	869	297	86	20447
1989	8260	42413	68399	19601	8205	3837	2589	767	682	23254
1990	2702	41756	24634	35258	8116	3808	1671	695	462	18404
1991	1912	63854	38342	16916	28405	4869	2588	954	593	25562
1992	10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1993	1608	94061	9372	10221	4491	2790	5932	855	508	18618
1994	12130	35768	61737	3289	3025	4773	1713	1705	474	19300
1995	9450	79159	22591	36541	3686	3420	2651	1859	842	23305
1996	3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
1997	3849	37440	53040	31442	8318	6142	1148	827	603	20496
1998	5818	41510	27102	28274	13178	3746	2675	597	387	18041
1999	14274	34072	36086	14642	15515	8877	1865	2012	551	18485
2000	9953	77378	18952	12060	5230	6227	2320	662	578	17191
2001	15724	62153	35816	5953	4249	1774	1145	466	386	15269
2002	3495	26472	18532	5309	1416	1269	437	154	201	7465

Year	1	2	3	4	5	6	7	8	9	Total catch
2003	2711	37006	24444	14763	5719	3363	2335	388	542	11536
2004	4276	9470	46243	21863	8638	1412	473	191	75	12743
2005	15419	30710	5766	18666	7349	1923	435	77	60	9494
2006	1460	33894	10914	2469	6261	2331	561	57	48	6944
2007	8043	11028	36223	5509	1365	2040	410	56	4	7636
2008	1288	12468	8144	15565	2328	518	321	58	11	5872
2009	10171	4465	12859	4887	8458	971	279	247	80	5745
2010	2468	20929	8183	15917	4846	10080	919	273	321	8370
2011	6384	17151	33453	7301	13087	5347	5165	1089	141	11470

Year	1	2	3	4	5	6	7	8	9	Total catch
2012	11712	62528	44819	37500	6303	11811	5549	3540	347	21820
2013	6191	30471	42133	22649	16687	3305	5463	1778	535	16247
2014	16664	24120	39102	33320	22450	11165	3047	2774	1022	19574
2015	286	12247	23835	32140	27382	19861	9820	4207	3279	18355
2016	2023	9822	25030	22800	25310	22447	10484	4684	1464	16318
2017	707	14144	31912	16004	10718	8963	6722	2401	1473	10767
2018	1654	7646	20545	5974	2296	1011	264	380	188	4418
2019	14146	4371	1857	2265	612	212	88	73	33	1841
2020	213	979	242	57	70	24	12	3	1	132

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
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

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	2002–2020 (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, 2016, 2017, 2018 and 2019
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	203775	277424.3	0.130542	410779
1959	15086	196418	322458.2	0.112169	1580370
1960	18283	188191	254728.9	0.125647	364196
1961	15372	159220	220771.2	0.11927	394746
1962	21552	156166	252622.6	0.192247	845346
1963	17349	144911	207202.4	0.153106	403789
1964	10599	165008	288355.1	0.096127	1383720
1965	19126	169945	239809.1	0.139028	417477
1966	27030	165303	265992.3	0.198216	736461
1967	27658	159195	260351.9	0.224958	769688
1968	30236	162483	274992.7	0.242217	900913
1969	44389	142099	229588.1	0.361913	462667
1970	31727	107237	165958	0.330186	249296
1971	31396	98065.6	192953.9	0.4529	821736
1972	38203	85942.2	148694.9	0.5589	279864
1973	26936	64608.9	118163.8	0.517814	325791

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
1974	19940	50102.5	86146.88	0.494291	160634
1975	15588	39673	73819.18	0.51627	202410
1976	9771	36855.1	68599.61	0.387255	226633
1977	7833	37480.6	64495.77	0.289889	185181
1978	7559	36244.6	59134.35	0.267289	145900
1979	10321	36101.6	70719.33	0.424242	278995
1980	13130	33082.5	60069.54	0.543188	166827
1981	17103	36587.7	86836.16	0.835485	465534
1982	13000	57523.1	126606	0.456934	725162
1983	24981	76477.4	159058.2	0.55518	785160
1984	26779	79074.5	148721.1	0.471657	666802
1985	20426	85166.3	154078.8	0.319314	643131
1986	25024	93167.1	170755	0.365799	654874
1987	26200	105573	211460.4	0.389082	1201270
1988	20447	109082	170787.1	0.231621	476003
1989	23254	95798.4	164507.2	0.285226	576335
1990	18404	89314.2	147300.7	0.247916	503907
1991	25562	71121.5	111778	0.3809	207728
1992	21127	71017.1	152933	0.484749	963301
1993	18618	73702.4	119560.5	0.325528	360216
1994	19300	80473.6	151898	0.321692	769446
1995	23305	81966.8	150029.8	0.387423	722547
1996	18816	72473	116636.3	0.308523	352563
1997	20496	59908.6	104869.3	0.408143	372999
1998	18041	47982.8	83155.25	0.446028	248744
1999	18485	41943.6	87753.78	0.625021	485934
2000	17191	41908.5	87102.54	0.635137	474998
2001	15269	41400.6	82862.82	0.537251	489171
2002	7465	53317.6	98904.43	0.211627	535959
2003	11536	42362.4	64480.49	0.31016	140532

Year	Catch	SSB	TSB	F_{bar} 2-5	Recruitment
2004	12743	38490.5	70006.27	0.398596	356132
2005	9494	53465.7	115011	0.313671	1039870
2006	6944	65778.2	100800.4	0.135799	349711
2007	7636	68378	114724.6	0.134257	710921
2008	5872	80992.8	114491.2	0.081019	289372
2009	5745	92306.8	158019.6	0.077727	996276
2010	8370	100208	157919.2	0.102576	741184
2011	11470	108341	173699.6	0.131732	945168
2012	21820	98303	153289.1	0.256907	624414
2013	16247	86567.4	126340.1	0.216692	363192
2014	19574	66929.7	103649.2	0.326956	303332
2015	18355	43140.2	69437.81	0.466124	173758
2016	16318	25479.6	48755.67	0.777756	209358
2017	10767	11527.3	23794.11	1.19019	59868.5
2018	4418	5842.67	12689.86	1.19957	49855.8
2019	1841	5790.48	13703.94	0.772736	169991
2020	132	11679.5	23016.05	0.022633	320017

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

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	164568	0.767	0.5	0.5	0.5	0.056	0.047	0.060
2	148320	0.385	1	0.5	0.5	0.088	0.518	0.085
3	50006	0.356	1	0.5	0.5	0.109	0.714	0.105
4	5430	0.339	1	0.5	0.5	0.129	0.714	0.121
5	1454	0.319	1	0.5	0.5	0.136	0.714	0.130
6	1056	0.314	1	0.5	0.5	0.148	0.714	0.143
7	252	0.307	1	0.5	0.5	0.156	0.680	0.153
8	180	0.307	1	0.5	0.5	0.167	0.686	0.156
9	2335	0.307	1	0.5	0.5	0.164	0.201	0.157

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	164568	0.767	0.5	0.5	0.5	0.056	0.047	0.060
2	-	0.385	1	0.5	0.5	0.088	0.518	0.085
3	-	0.356	1	0.5	0.5	0.109	0.714	0.105
4	-	0.339	1	0.5	0.5	0.129	0.714	0.121
5	-	0.319	1	0.5	0.5	0.136	0.714	0.130
6	-	0.314	1	0.5	0.5	0.148	0.714	0.143
7	-	0.307	1	0.5	0.5	0.156	0.680	0.153
8	-	0.307	1	0.5	0.5	0.167	0.686	0.156
9	-	0.307	1	0.5	0.5	0.164	0.201	0.157

2023								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	164568	0.767	0.5	0.5	0.5	0.056	0.047	0.060
2	-	0.385	1	0.5	0.5	0.088	0.518	0.085
3	-	0.356	1	0.5	0.5	0.109	0.714	0.105
4	-	0.339	1	0.5	0.5	0.129	0.714	0.121
5	-	0.319	1	0.5	0.5	0.136	0.714	0.130
6	-	0.314	1	0.5	0.5	0.148	0.714	0.143
7	-	0.307	1	0.5	0.5	0.156	0.680	0.153
8	-	0.307	1	0.5	0.5	0.167	0.686	0.156
9	-	0.307	1	0.5	0.5	0.164	0.201	0.157

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

Rationale	F_{bar} (2021)	Catch (2021)	SSB (2021)	F_{bar} (2022)	Catch (2022)	SSB (2022)	SSB (2023)
Catch(2022) = Zero	0.062	869	19278	0.000	0	21902	24171
$F_{bar(2022)} = F_{MSY}$	0.062	869	19278	0.260	4214	19639	18507
$F_{bar(2022)} = F_{pa}$	0.062	869	19278	0.260	4214	19639	18507
$F_{bar(2022)} = F_{lim}$	0.062	869	19278	0.450	6724	18159	15483
$F_{bar(2022)} = F_{2021}$	0.062	869	19278	0.062	1090	21340	22637
F_{bar}(2022) = F_{msy} * SSB(2021) /MSY $B_{trigger}$	0.062	869	19278	0.093	1620	21061	21909
Catch(2022) = 2021 TAC	0.062	869	19278	0.049	869	21455	22982

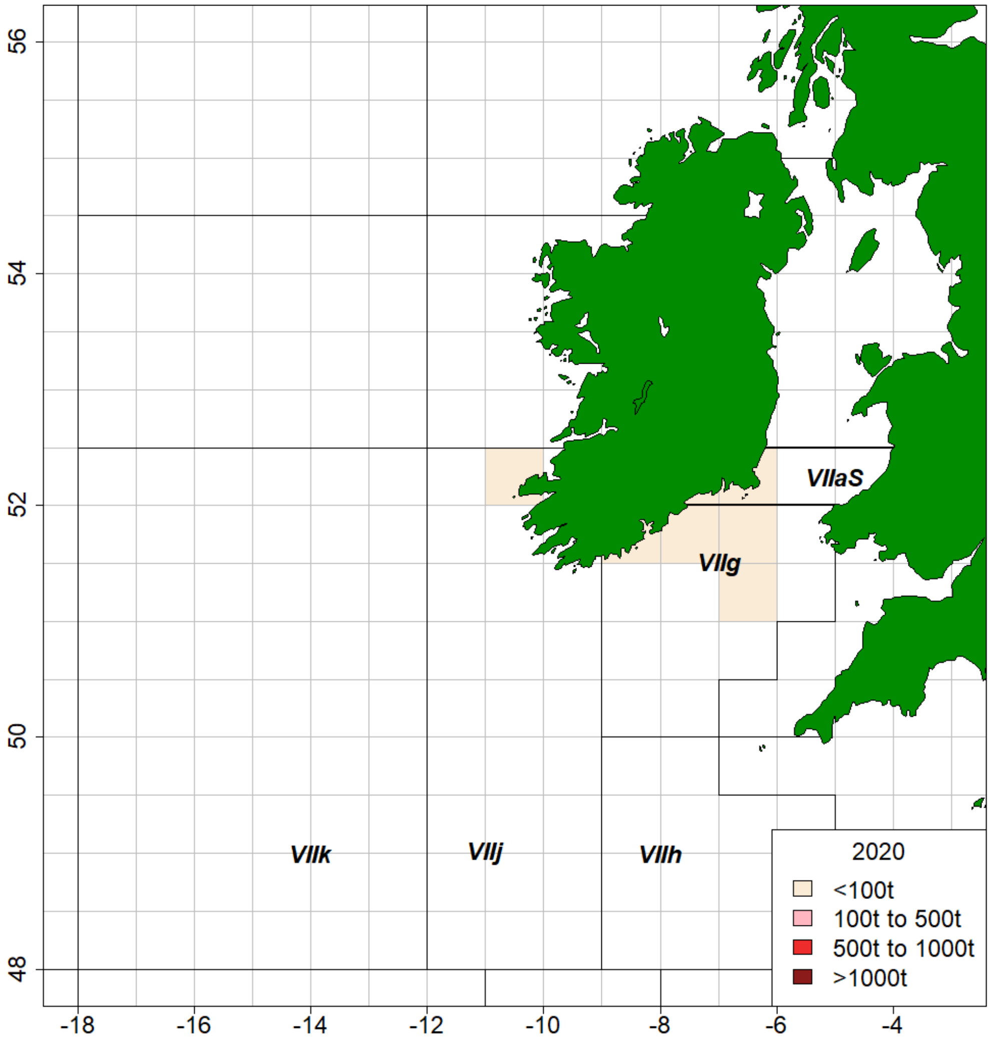


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2020/2021.

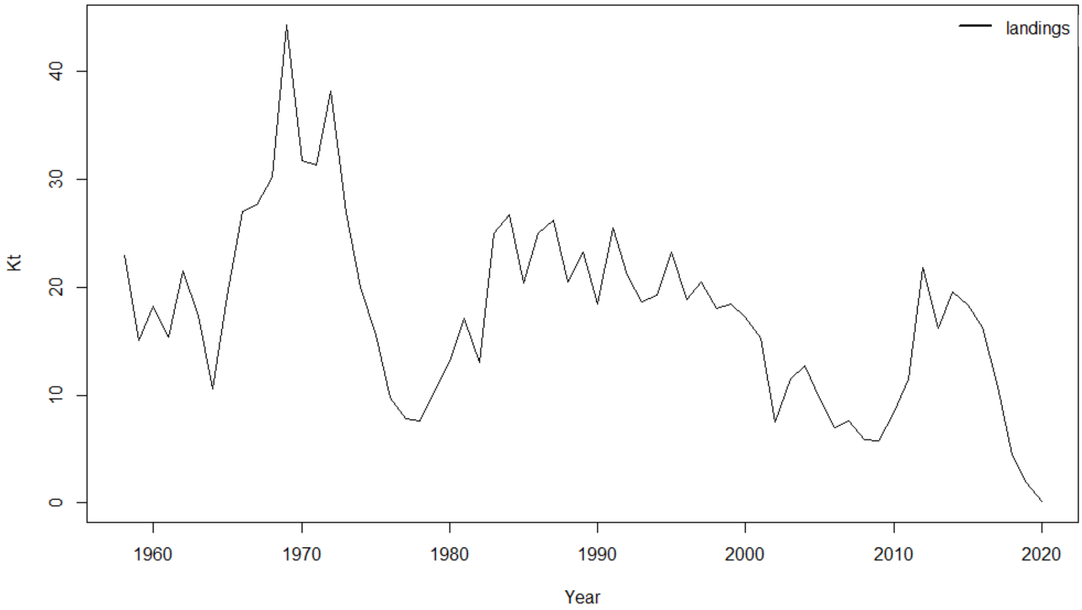


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

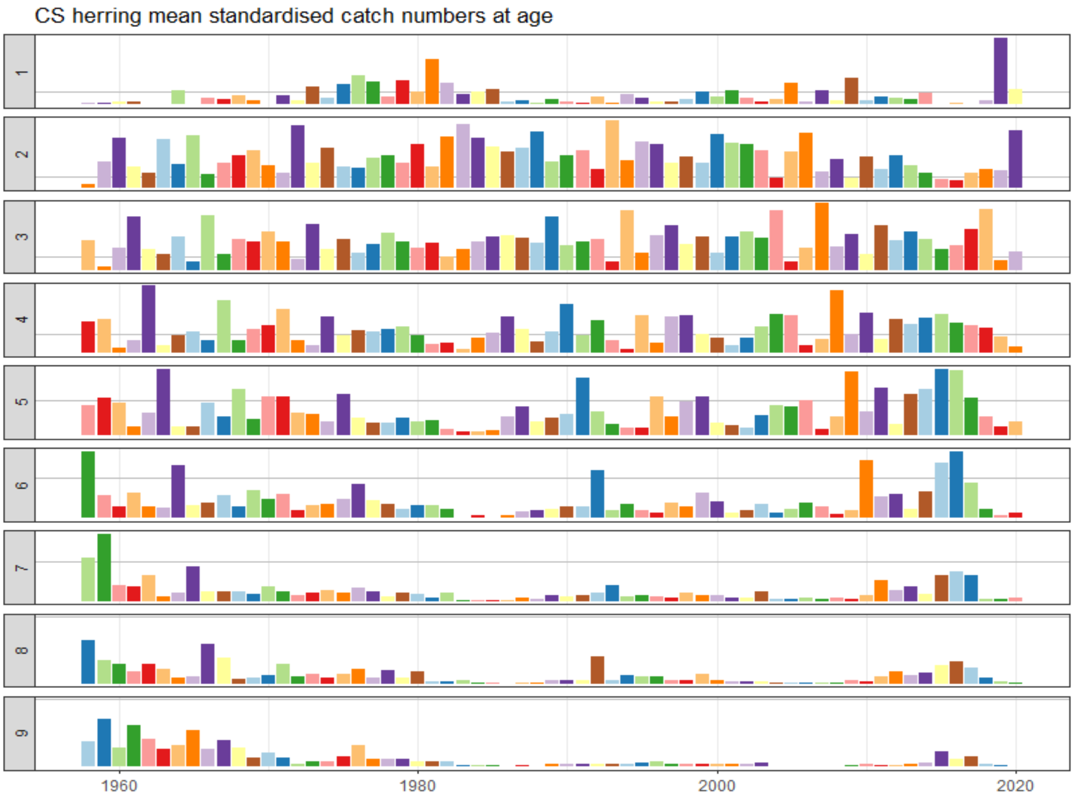


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardized by yearly mean. 9-wr is the plus group. Age in winter rings.

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

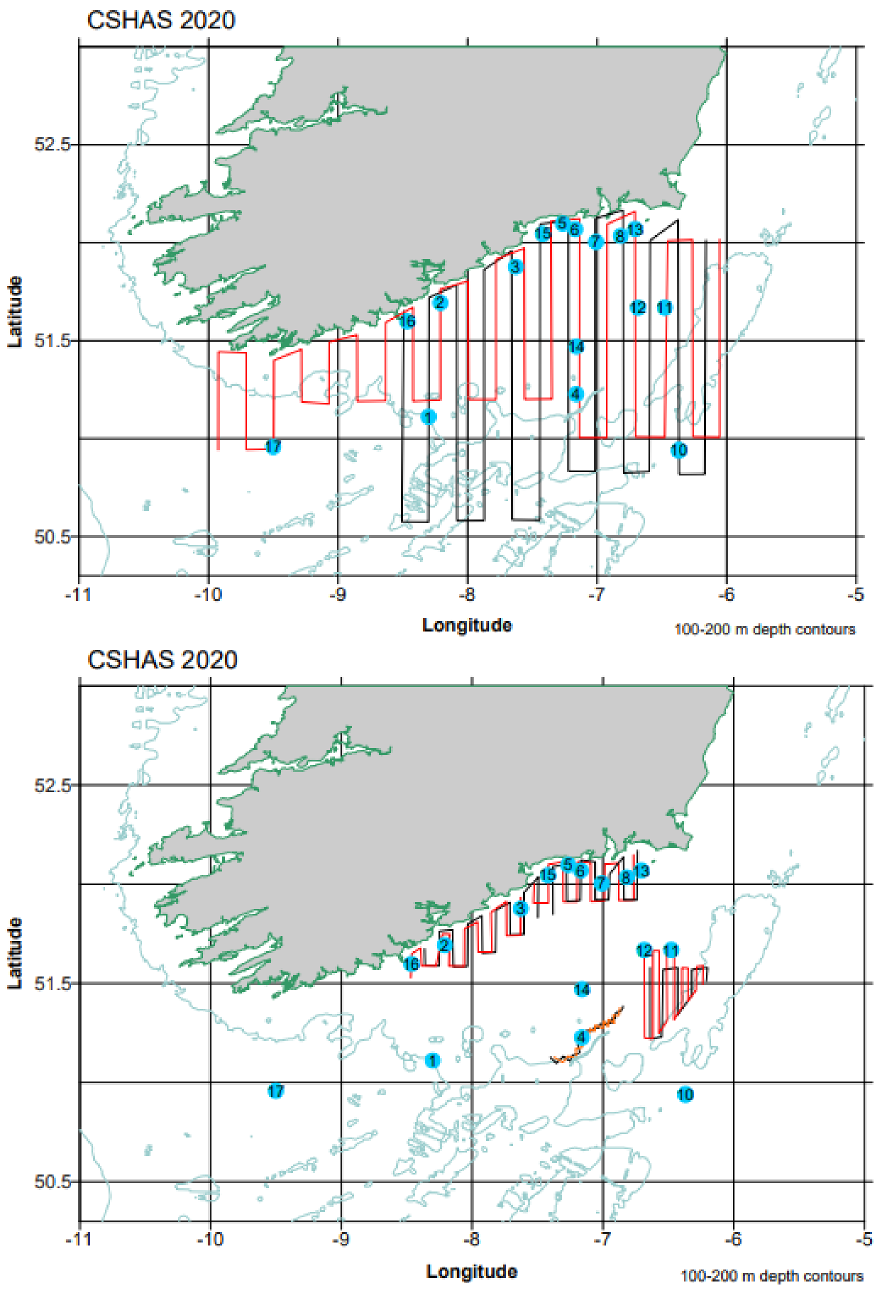


Figure 6.3.1.1. Herring in the Celtic Sea. Top panel: Core replicate acoustic survey effort cruise tracks and numbered haul stations. (Pass 1: black track, Pass 2: orange track). Bottom panel: Adaptive and scouting survey effort mini surveys 1-6. Replicate coverage shown as orange track.

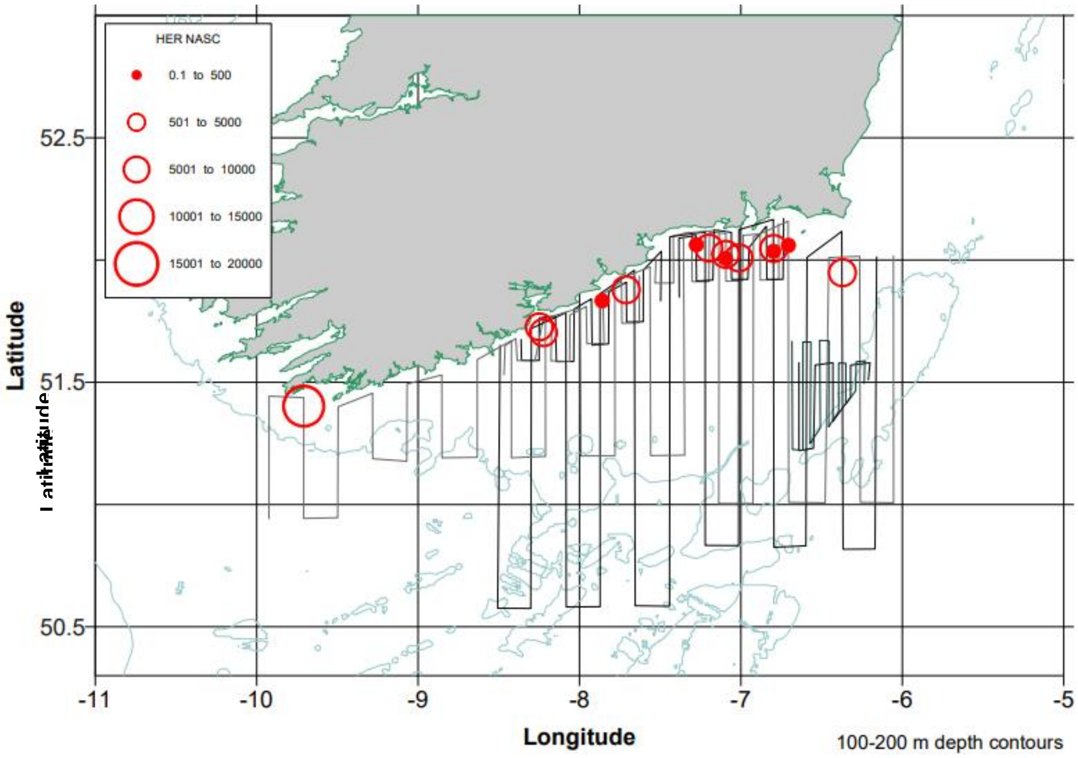


Figure 6.3.1.2. Herring in the Celtic Sea. NASC (Nautical area scattering coefficient) distribution plot of the distribution of herring in 2020fromcombined survey effort.

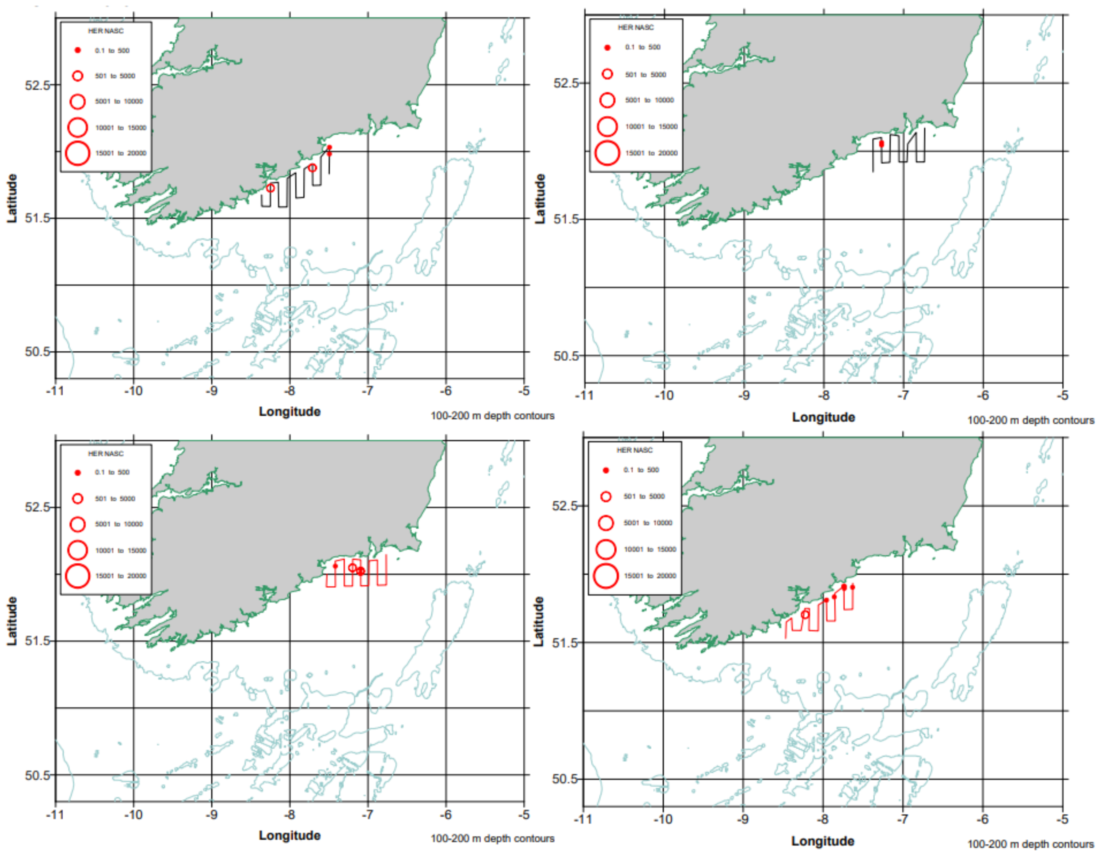


Figure 6.3.1.3. Herring in the Celtic Sea. NASC (nautical area scattering coefficient) plot of the distribution of herring in 2020 in the adaptive mini-surveys.

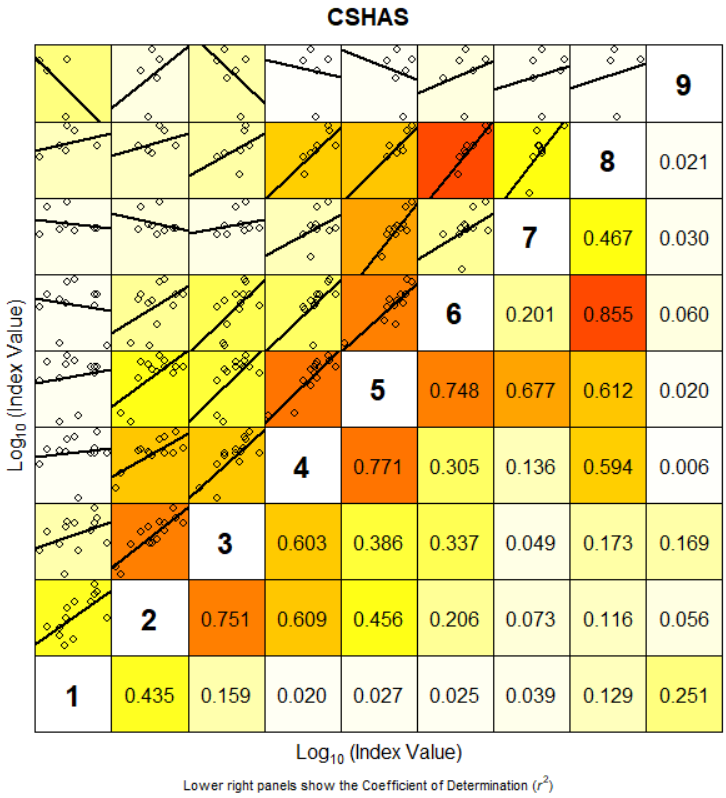


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

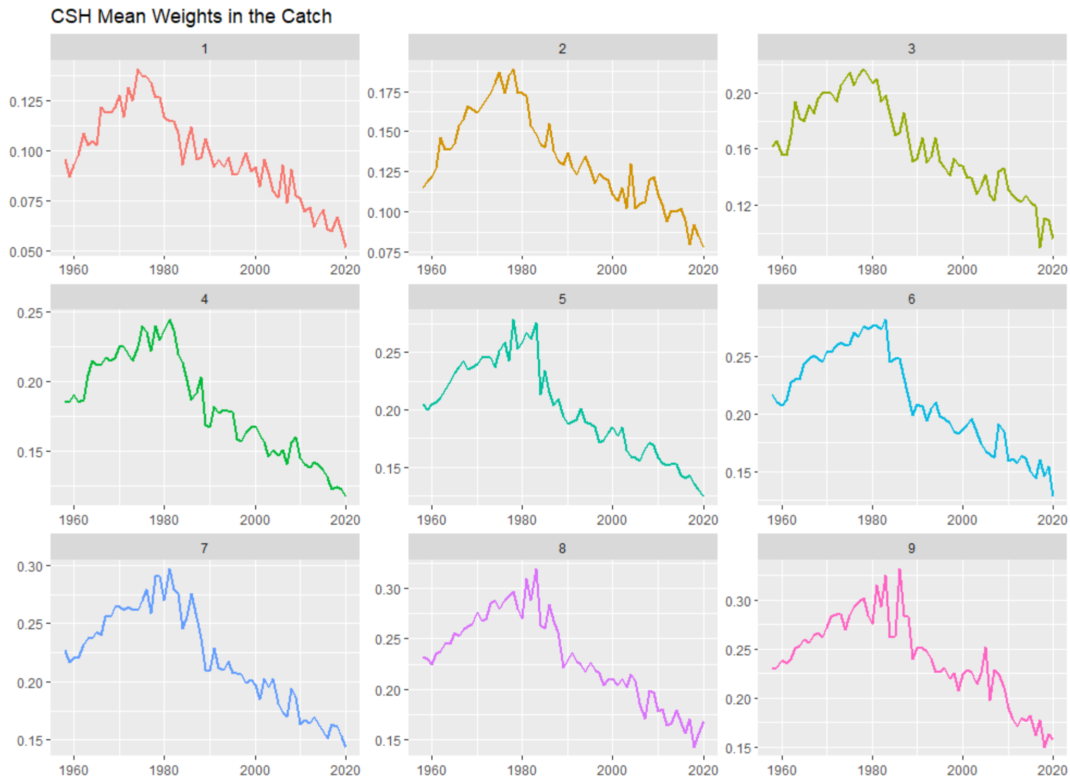


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2020 for 1–9+.

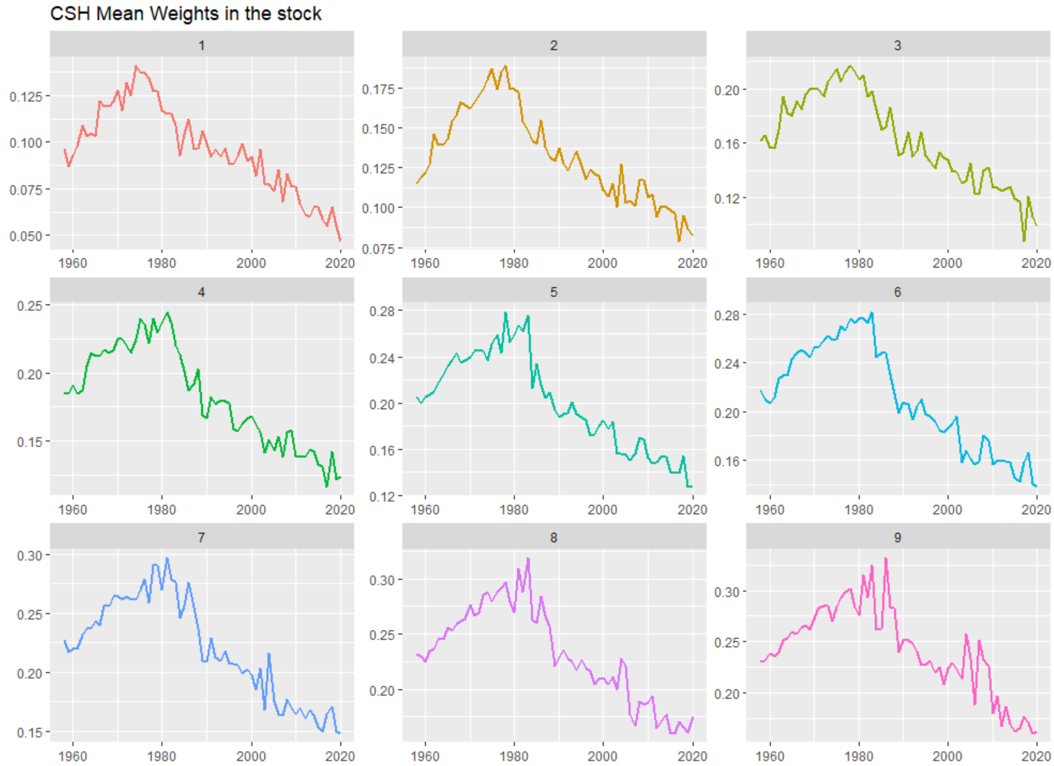


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2020 for 1–9+. Age in winter rings.

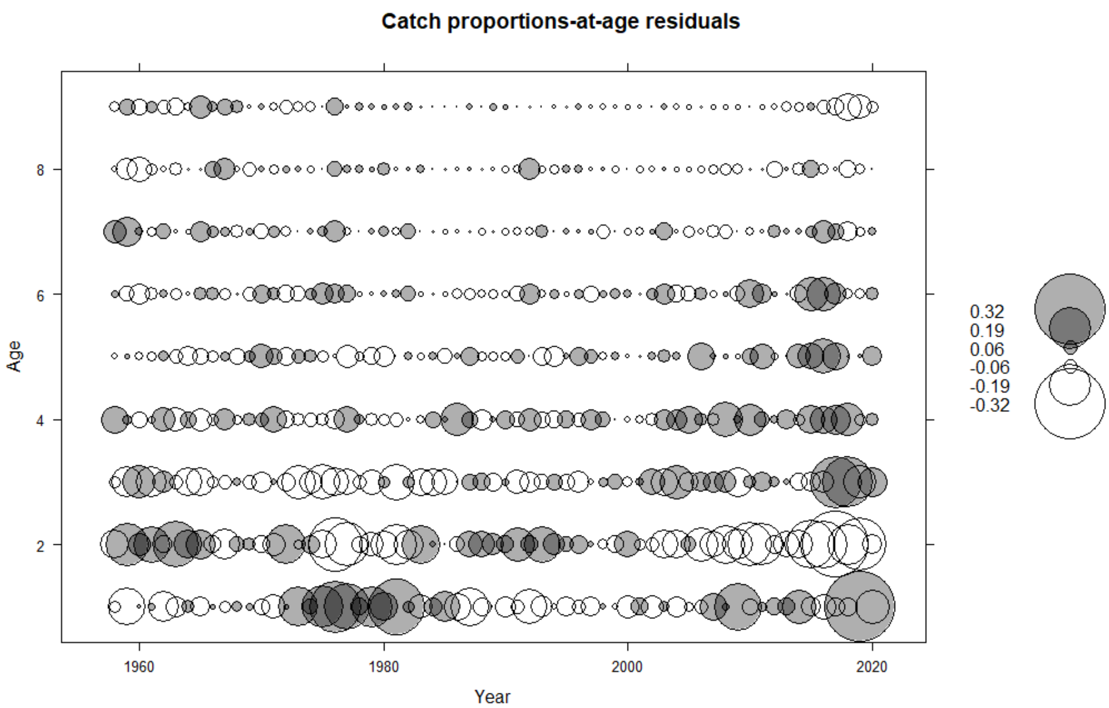


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

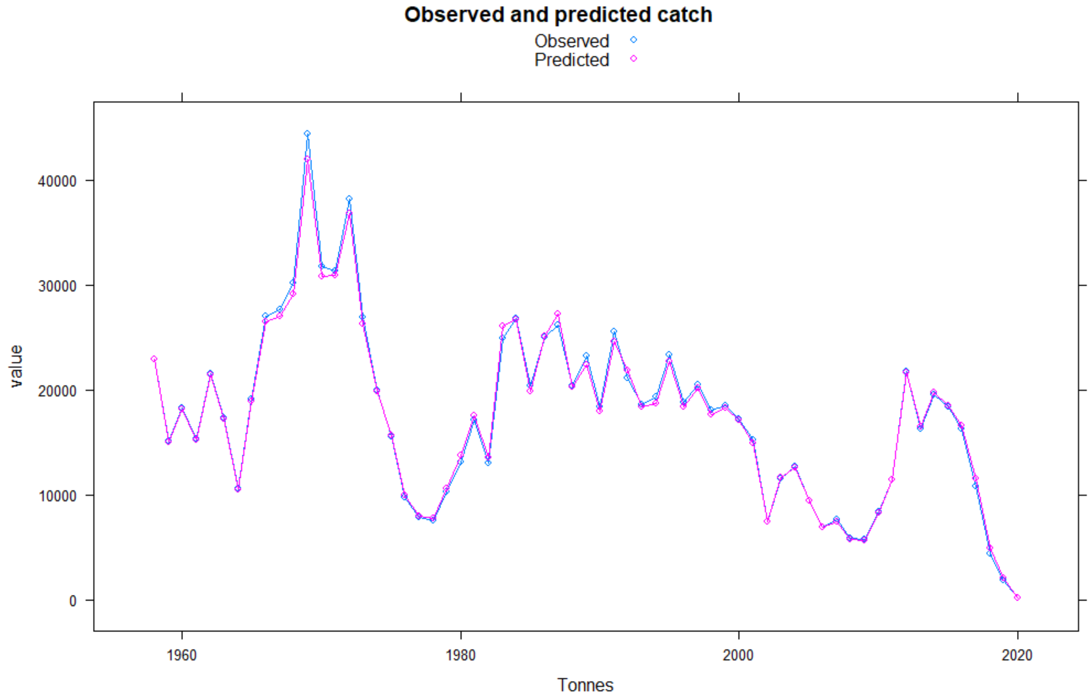


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

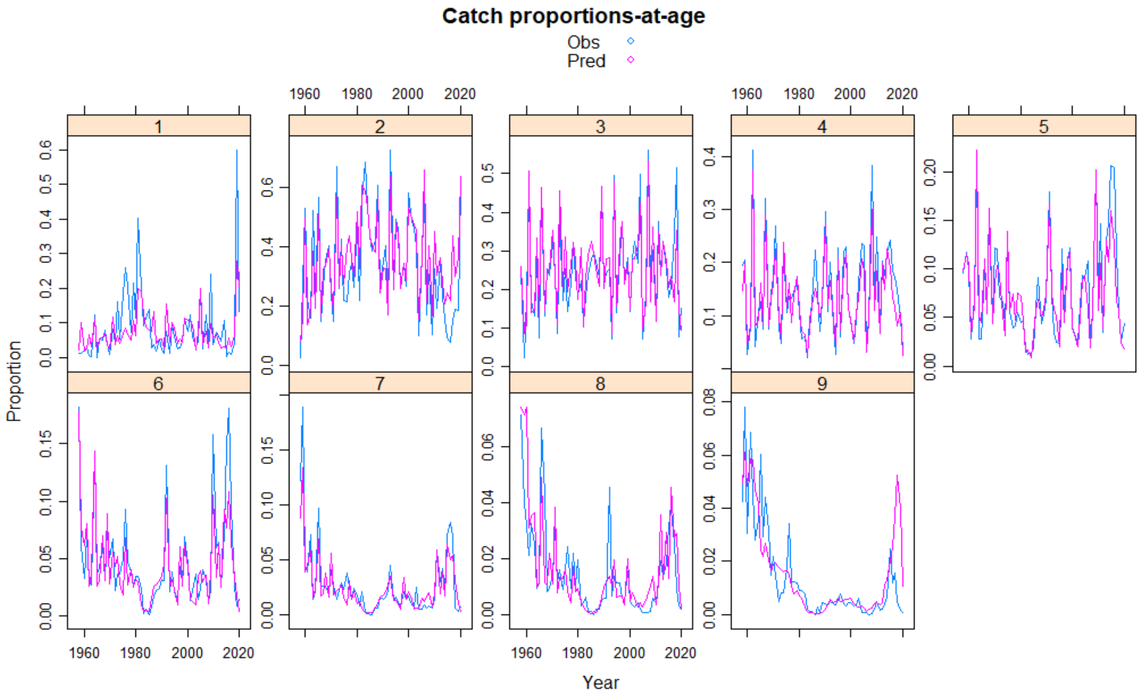


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

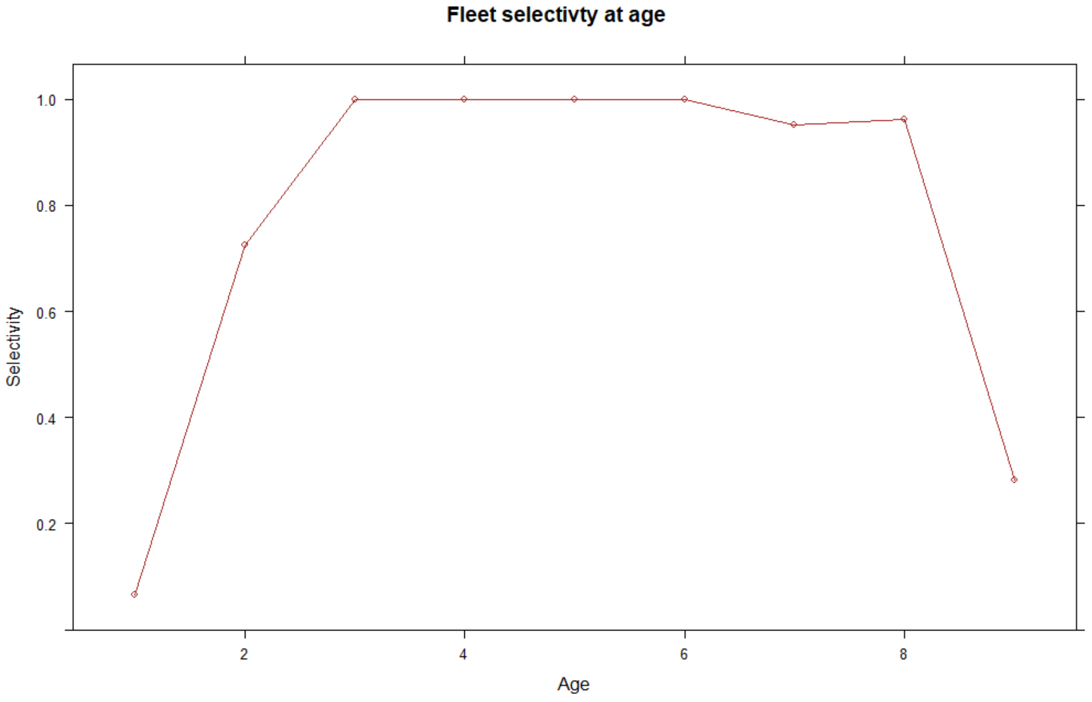


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

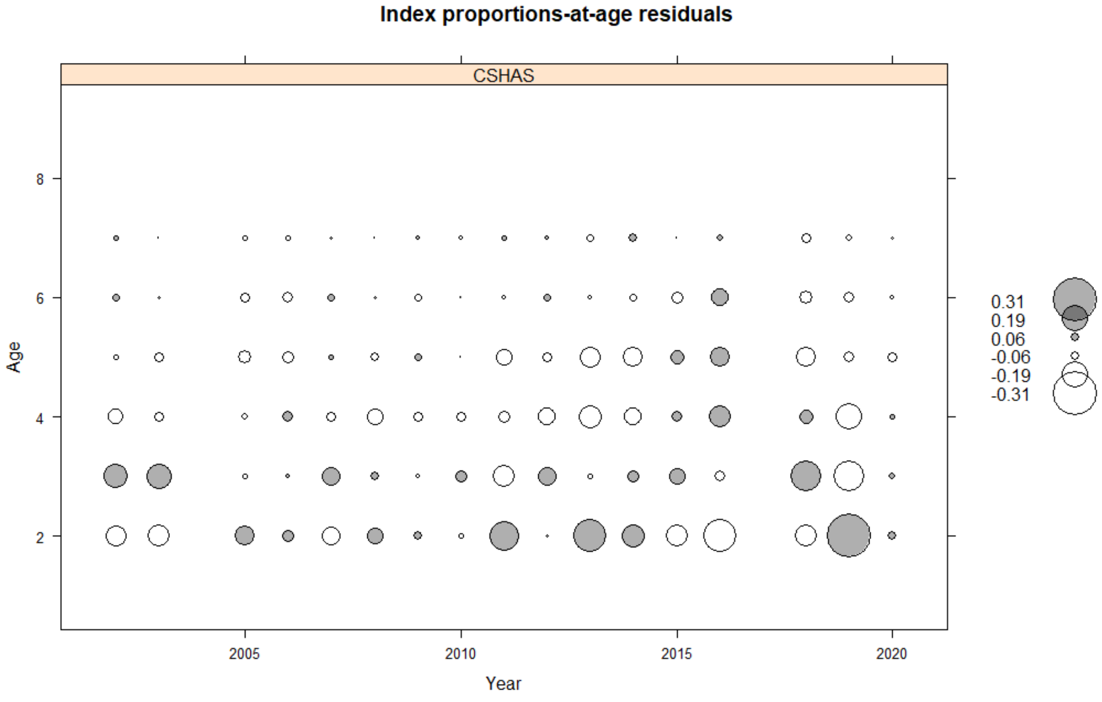


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

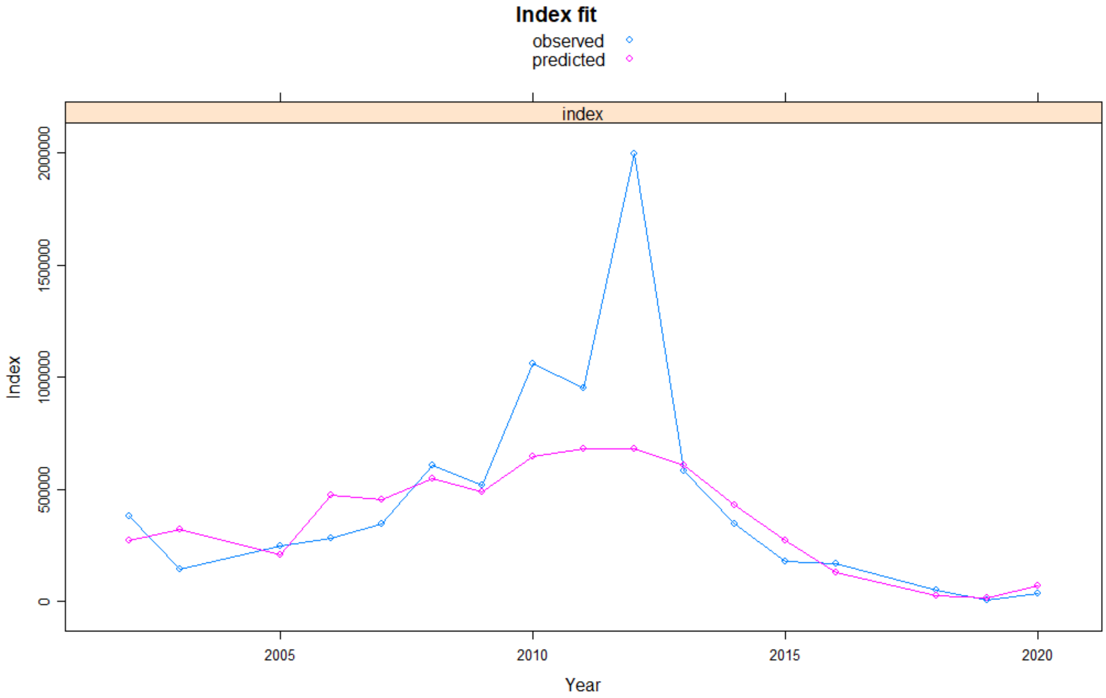


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

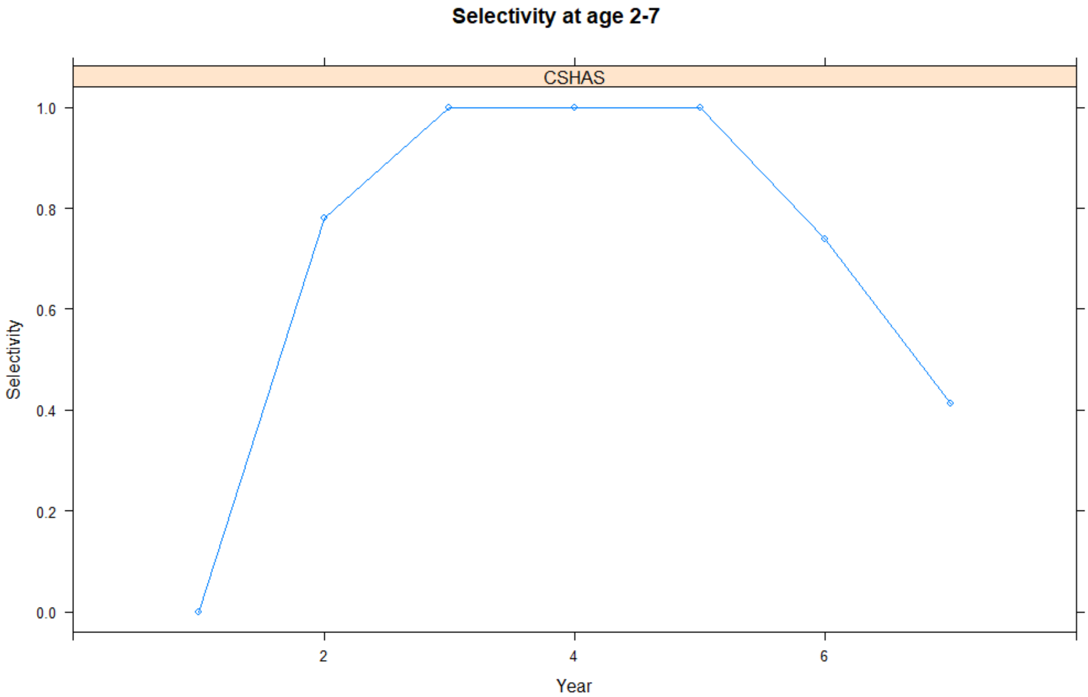


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

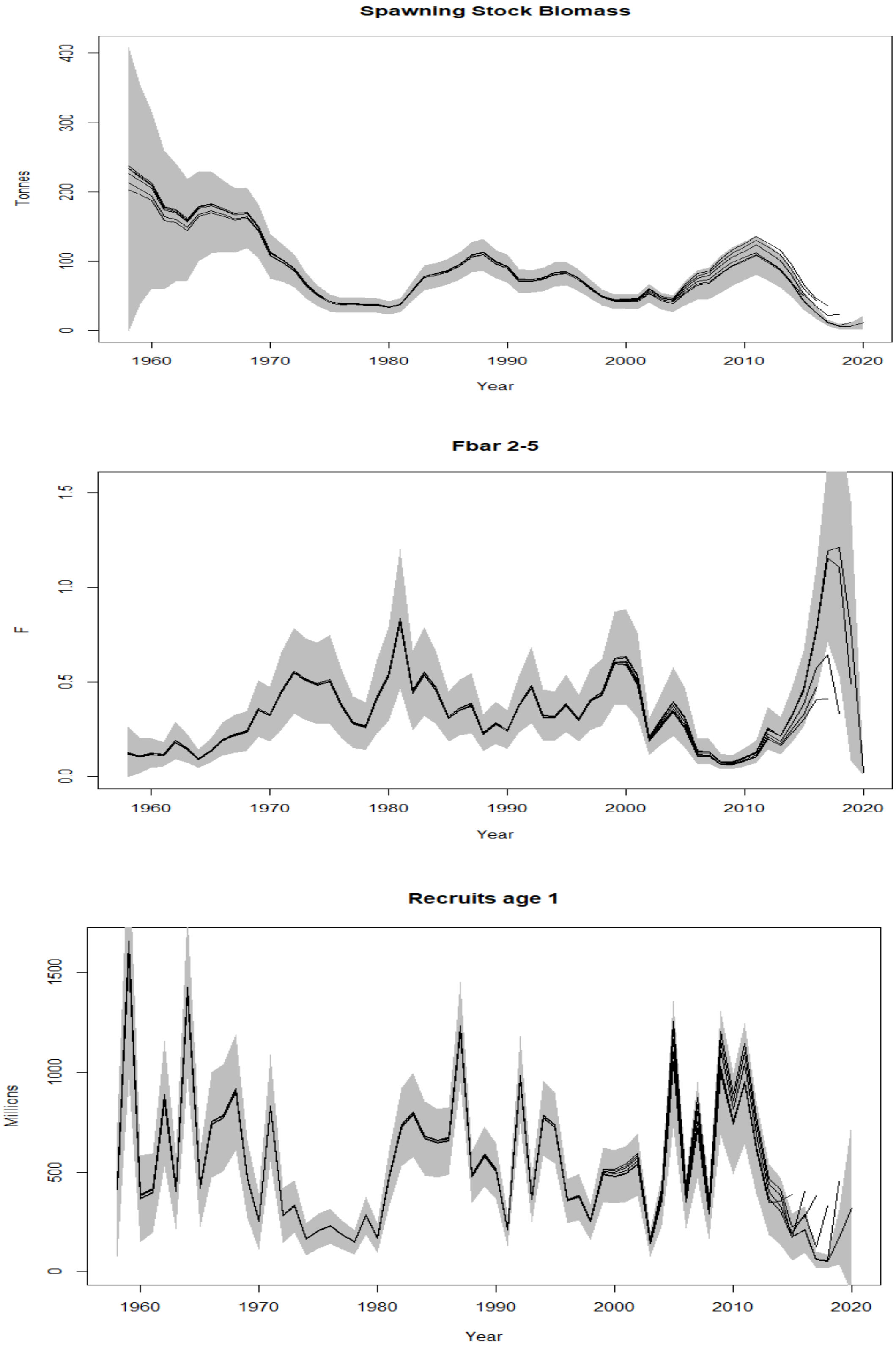


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), and Recruitment (bottom). The shaded area is the 95% confidence interval.

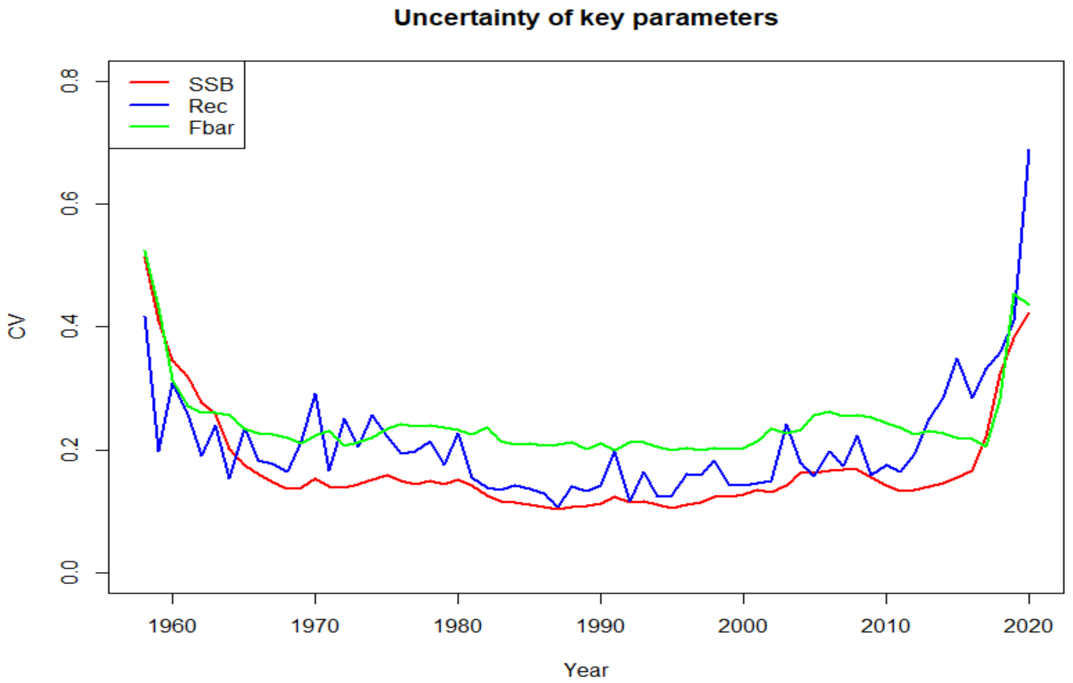


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

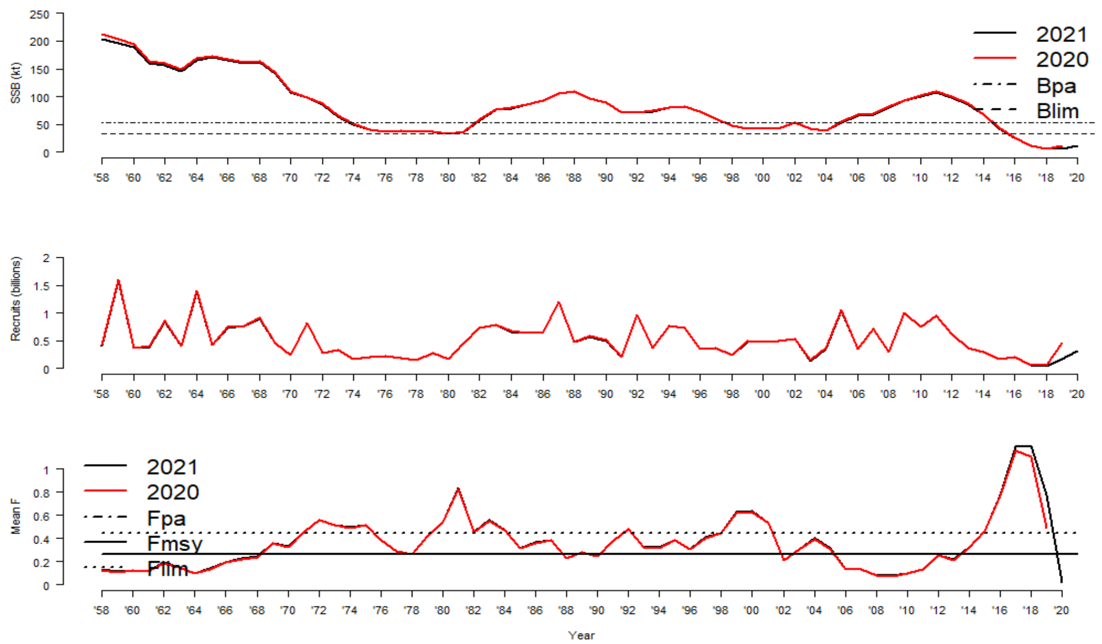


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top), Recruitment (middle) and Mean F_{2-5} (bottom)

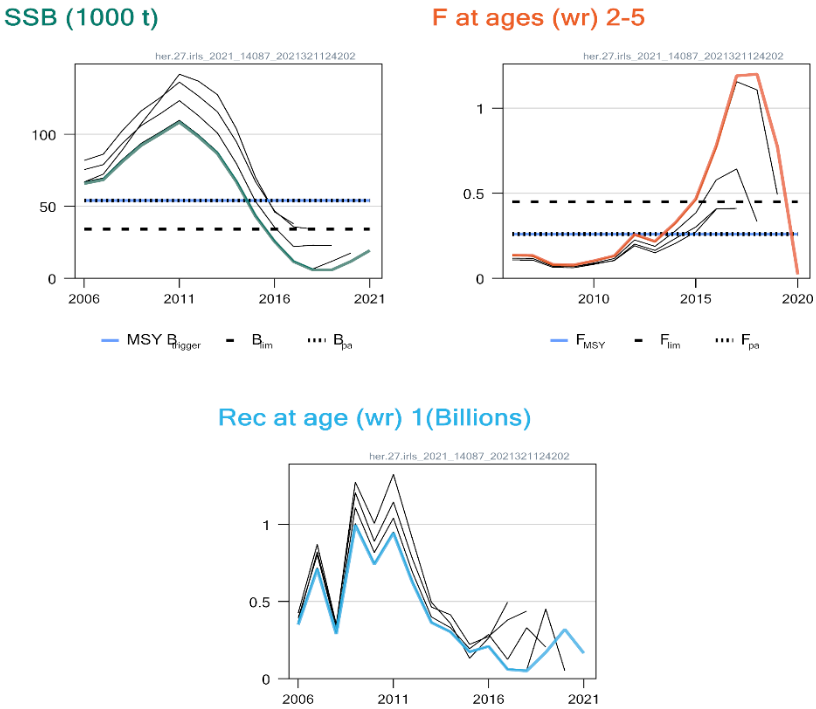


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospective from the final assessments 2016–2021

7 Herring in Division 7.a North (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 Advice and management applicable to 2020 & 2021

ICES advised that when the MSY approach is applied, catches in 2020 should be no more than 8064 tonnes. ICES advised that when the MSY approach is applied, catches in 2021 should be no more than 7341 tonnes.

7.1.2 The fishery in 2020

The catches reported from each country for the period 1987 to 2020 are given in Table 7.1.1, and total catches from 1961 to 2020 in Figure 7.1.1. Reported international landings in 2020 for the Irish Sea amounted to 7927 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2020 were taken during the 3rd quarter, with landings also made in quarter 4.

As in previous years the 2020 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 a UK pair-trawlers and by midwater pelagic fishing vessels from Ireland. In previous years a 'Mourne' fishery, limited to boats under 40 ft usually in October and November, this fishery landed 33 t in 2020.

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 and 33 t in 2020. 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 compared to an 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 2020. 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 2020 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 2020, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 26 in 2020, 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. 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 2020 was carried out over the period 26 August–9 September. The survey conditions were good. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1). Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1). Highest abundance of 1+ herring targets in 2020 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 2020 survey with 34 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). The 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. The survey only concentrates on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (Figure 7.3.4). Herring found in this area represents >75% of the SSB index generated from the routine survey. In 2020 the survey was conducted during the 5th to 8th of October. This is the latest the survey has been carried out a delay of around 5 days compared to previous year. The predominant maturity stage of herring sampled during the survey were spent compared to maturing and ripe fish in other years. The spawning biomass to be 47.9kt, this is a small increase from 2019 (44.3kt) and within the previously observed range (28.4 – 114.0kt).

The density historic 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 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 age 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). The survey is included in the assessment as a 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 2020 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 whole 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 Northern Ireland 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 2021. 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 was reduced from 13.3 to 9% under shortened time-series, which will improve the basis for advice;
- 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 9 years of repeat 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. 2020 catch-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. 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 reflects 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 2016–18 (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.

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 software. Population abundances, F at age and input data were taken from the final SAM assessment, 1980–2020 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2009–2018) replaced recruitment for 1-ringers in 2020 and is used as the intermediate year assumption. The forecast was based on catches (2021 advice = 7341 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 2021–2023, but is predicted to decrease if fishing at F_{MSY}. SSB with zero catch is forecast to increase (+10.2%). This is largely in response to maturation of the 2020 year class, which will contribute more than 32% of the SSB in 2022.

7.7.2 Yield per recruit

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

7.8 Medium term projections

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

7.9 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2017 assessment (WKIRISH3 and HAWG 2017). B_{lim} was set to the lowest SSB that generate above average recruitment, 8500 t. B_{pa}, 11 800 t calculated from B_{lim} with assessment error (σ = 0.201, based on the average CV from the terminal assessment year) MSY $B_{trigger}$ is set to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.266). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35(0.345) and the lower bound at 0.20(0.198). F_{lim} is estimated to be 0.40 (0.397) as F with 50% probability of SSB <B_{lim} with F_{pa} was modified to 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 (3) estimated for the acoustic survey. Currently, the model doesn't have the structure to specifically deal with the emigration of small herring from other stocks.

The F_{bar} range 4–6 is considered representative of the mortality on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components.

The survey data quality is good, but the survey index is variable 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 validations of the assumption 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.

In 2020 the Spawning Stock Biomass survey was delayed (9 days compared to 2019) due to the impact of Covid-19 restrictions, this delay was considered to not have a negative effect on the quality of the assessment.

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 and forecast indicate SSB to be the highest in the time-series and fishing mortalities below F_{MSY}. 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 forwarded 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

No additional information presented (see Stock Annex).

Table 7.1.1 Herring in Division 7.a North (Irish Sea). Working Group catch estimates in tonnes by country, 1987–2020. 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
Ireland	119	0	82	200	1299	1317	1957
UK	5089	4868	4245	3696	5504	5061	5969
Unallocated	-	22	-				
Total	5208	4891	4327	3896	6804	6378	7927

Table 7.2.2 Herring in Division 7.a North (Irish Sea). Catch at length data 1995–2020. 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
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
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
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301	533	1644	72	326	148	594	1532	1934
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
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
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
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
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

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
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
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

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
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
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
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
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
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
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
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
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
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
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

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
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
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
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
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
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		
30	40	32	8	84		6	9		43						-			17		0	8					

Table 7.2.3 Herring in Division 7.a North (Irish Sea). Sampling intensity of commercial landings in 2020.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	722	3	1225	150
	UK (N. Ireland)	5571	18	2181	826
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	0	0	0
4	Ireland	1235	4	1060	200
	UK (N. Ireland)	398	1	143	50
	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 in Division 7.a North (Irish Sea). Summary of acoustic survey AC(7.aN) information for the period 1989–2020. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38 kHz except December 1996, which was at 120 kHz.

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
1989	Douglas Bank	25/09–26/09			18 000	-	-	-
1990	Douglas Bank	26/09–27/09			26 600	-	-	-
1991	W. Irish Sea	26/07–8/08	12 760	0.23			66 0001	0.20
1992	W. Irish Sea + IOM E. coast	20/07–31/07	17 490	0.19			43 200	0.25
1994	Area 7.a(N)	28/08–8/09	31 400	0.36	25 133	-	68 600	0.10
	Douglas Bank	22/09–26/09			28 200	-	-	-
1995	Area 7.a(N)	11/09–22/09	38 400	0.29	20 167	-	348 600	0.13
	Douglas Bank	10/10–11/10		-	9 840	-	-	-
	Douglas Bank	23/10–24/10			1 750	0.51	-	-
1996	Area 7.a(N)	2/09–12/09	24 500	0.25	21 426	0.25	-2	-
1997	Area 7.a(N)-reduced	8/09–12/09	20 100	0.28	10 702	0.35	46 600	0.20
1998	Area 7.a(N)	8/09–14/09	14 500	0.20	9 157	0.18	228 000	0.11
1999	Area 7.a(N)	6/09–17/09	31 600	0.59	21 040	0.75	272 200	0.10
2000	Area 7.a(N)	11/09–21/09	40 200	0.26	33 144	0.32	234 700	0.11
2001	Area 7.a(N)	10/09–18/09	35 400	0.40	13 647	0.42	299 700	0.08
2002	Area 7.a(N)	9/09–20/09	41 400	0.56	25 102	0.83	413 900	0.09
2003	Area 7.a(N)	7/09–20/09	49 500	0.22	24 390	0.24	265 900	0.10
2004	Area 7.a(N)	6/09–10/09	34 437	0.41	21 593	0.41	281 000	0.07

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
		15/09–16/09 28/09–29/09						
2005	Area 7.a(N)	29/08–14/09	36 866	0.37	31 445	0.42	141 900	0.10
2006	Area 7.a(N)	30/08–9/09	33 136	0.24	16 332	0.22	143 200	0.09
2007	Area 7.a(N)	29/08–13/09	120 878	0.53	51 819	0.42	204 700	0.09
2008	Area 7.a(N)	27/08–14/09	106 921	0.22	77 172	0.23	252 300	0.12
2009	Area 7.a(N)	1/09–13/09	95 989	0.39	71 180	0.47	175 000	0.08
2010	Area 7.a(N)	28/08–11/09	131 849	0.22	99 877	0.22	107 400	0.10

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
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

[1] **sprat only**

[2]**Data can be made available for the IoM waters only**

Table 7.3.2 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

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

year

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
1	7991	12176	15260
2	22903	23112	29059
3	15657	11083	20869
4	12364	6776	4099
5	3240	6661	3355
6	538	1360	3200
7	391	182	777
8	50	194	209

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
1	0.054	0.072	0.060	0.057	0.057
2	0.102	0.093	0.096	0.096	0.095
3	0.126	0.121	0.120	0.119	0.119
4	0.143	0.140	0.132	0.137	0.138
5	0.159	0.147	0.147	0.143	0.143
6	0.161	0.154	0.159	0.156	0.152
7	0.167	0.154	0.164	0.159	0.160
8	0.177	0.162	0.204	0.181	0.174

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
1	0.054	0.072	0.060	0.057	0.057
2	0.102	0.093	0.096	0.096	0.095
3	0.126	0.121	0.120	0.119	0.119
4	0.143	0.140	0.132	0.137	0.138
5	0.159	0.147	0.147	0.143	0.143
6	0.161	0.154	0.159	0.156	0.152
7	0.167	0.154	0.164	0.159	0.160
8	0.177	0.162	0.204	0.181	0.174

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
1	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304
8	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
1	0.11	0.08	0.10	0.06	0.16	0.11	0.07	0.10	0.08	0.16	0.04
2	0.92	0.90	0.84	0.82	0.94	0.87	0.81	0.85	0.67	0.90	0.80
3	1.00	1.00	1.00	0.99	1.00	1.00	0.99	1.00	0.97	1.00	0.97
4	0.98	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
6	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
8	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
1	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
3	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
5	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
7	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

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
1	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
3	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
5	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
7	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

Table 7.6.3.8. Irish Sea Herring. Survey indices

AC(VIIaN) - Configuration

Irish Sea herring (Division VIIa) (run name: ICAMDC20) . Imported from VPA file.

min max plusgroup minyear maxyear startf endf

1.0 8.0 8.0 1994.0 2020.0 0.7 0.8

Index type : number

AC(VIIaN) - Index Values

Units : NA

year

age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1	66830	319116	11340	134146	110438	157756	78524	387559	390982	349216	241014
2	68290	82256	42372	49977	27312	77722	103439	93402	71935	220014	115529
3	73529	11935	67473	14812	8083	34017	105291	10194	31701	31984	29593
4	11860	29246	8954	10985	9266	5108	27543	17489	24804	4735	15398
5	9299	4574	26469	1751	6479	10260	8072	7704	31277	3921	2067
6	7550	3500	4171	4553	1778	13521	5432	1372	14830	4089	2299
7	3867	4887	5911	571	2254	1586	4899	626	2756	977	238
8	10118	6894	5815	1910	780	6289	2359	2263	4461	906	240

	year									
age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	94330	374731	1316673	475675	371230	580602	1927032	369094	100023	299689
2	109938	96623	251276	452364	182643	561245	330180	191900	285238	193267
3	97111	15625	46570	114210	177813	117699	43855	160980	81601	127352
4	17023	9982	21101	39076	92741	120777	14978	51363	54347	29691
5	8029	530	20818	26370	32490	34325	21896	21643	41153	43057
6	810	369	1200	17063	15071	16759	6308	19285	13441	17342
7	607	478	718	4254	13940	4336	2715	12105	11132	7848
8	5804	469	556	599	6871	6453	1959	3128	6776	12481

	year					
age	2015	2016	2017	2018	2019	2020
1	491894	131512	42175	237857	148867	247356
2	141854	449316	89653	120683	247509	96674
3	25153	257152	104059	63334	44690	115553
4	17018	110196	56474	110874	21226	16269
5	10340	32232	9007	29555	14595	7807
6	8954	18312	20297	7645	8952	11744
7	1890	8157	4395	7926	1849	2763
8	4342	7042	11779	5053	882	977

VIIaNSpawn - Configuration

FLT05: SSB acoustic (Catch: Unknown) (Effort: Unknown)

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	2007	2020	NA	NA

Index type : biomass

VIIaNSpawn - Index Values

```
Units  :  NA
    year
age      2007     2008     2009     2010     2011     2012     2013     2014
  all 47582.61 41909.97 76786.97 91388.88 61907.54 52071.02 114044.2 28396.84
    year
age      2015     2016    2017    2018    2019  2020
  all 60328.27 74275.73 41683.6 38973.8 44184.9 47933
```

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      2020        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 : C:/Users/Matt Lundy/Documents/GIT_HUB/wg_HAWG/IrishSea/UpdateAssessment/SAM/sam.exe

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

TABLE 7.6.3.12 Irish Sea Herring. STOCK SUMMARY

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
	Age 1					(Ages 4-6)				SOP				
						f	f	f	tonnes					
1980	177017	84186	372210	38638	26477	56385	15297	10178	22990	0.2957	0.2097	0.4171	10613	1.0308
1981	194853	93232	407239	36901	25280	53865	13747	9484	19927	0.2902	0.2084	0.4042	4377	1.0999
1982	207109	99115	432769	40135	27373	58847	13635	9339	19908	0.2844	0.2064	0.3918	4855	1.0166
1983	158103	73995	337812	40255	27905	58072	14451	9895	21103	0.2818	0.2068	0.3839	3933	1.0165
1984	121540	58108	254216	40015	29096	55031	15472	10985	21791	0.2840	0.2120	0.3805	4066	1.0392
1985	168552	80934	351023	45207	32655	62583	15782	11602	21468	0.2919	0.2224	0.3832	9187	0.9802
1986	208147	100078	432914	46817	34131	64217	18337	13505	24898	0.2956	0.2272	0.3846	7440	1.0238
1987	248699	118768	520777	44802	32390	61970	16528	11926	22906	0.2992	0.2311	0.3873	5823	0.9632
1988	111302	53555	231314	42362	31403	57144	19334	13661	27363	0.3053	0.2362	0.3947	10172	0.9505
1989	140505	67304	293320	38177	27850	52335	14439	10433	19984	0.3045	0.2359	0.3931	4949	0.9966
1990	127899	61902	264260	36644	27092	49563	13944	10188	19085	0.3056	0.2370	0.3940	6312	0.9872
1991	81634	39437	168983	28595	21639	37788	9703	7103	13254	0.3049	0.2368	0.3927	4398	0.9994
1992	257816	123920	536386	33323	22574	49190	10557	7734	14409	0.3076	0.2387	0.3964	5270	0.9890
1993	64602	32111	129969	30333	22359	41152	10540	7695	14436	0.3077	0.2380	0.3978	4409	0.9869
1994	160011	82523	310260	31288	22728	43072	12009	8763	16457	0.3093	0.2381	0.4019	4828	0.9757
1995	149194	75418	295138	31445	22586	43779	11802	8480	16426	0.3103	0.2373	0.4057	5076	1.0007
1996	95035	46564	193963	26476	19309	36305	9885	6976	14007	0.3127	0.2371	0.4124	5301	0.9999
1997	139525	70077	277797	26056	18354	36989	9491	6569	13713	0.3172	0.2372	0.4241	6651	0.9996
1998	170587	88221	329853	28226	19706	40431	10467	7458	14691	0.3181	0.2349	0.4307	4905	0.9951

1999 84204 42988 164937 24125 17583 33101 9919 6896 14266 0.3118 0.2294 0.4238 4127
1.0001

2000 87641 44324 173288 21455 15698 29322 9540 6760 13462 0.3046 0.2231 0.4158 2002
0.9993

2001 125492 62209 253150 22720 15479 33348 7852 5315 11599 0.3058 0.2212 0.4228 5461
1.0004

2002 83283 41275 168046 20622 14564 29199 7913 5424 11545 0.2995 0.2151 0.4172 2393
0.9984

2003 145656 74038 286551 23389 15635 34987 6868 4812 9801 0.2944 0.2098 0.4133 2399
1.0010

2004 171271 85922 341397 26291 17733 38980 9779 6672 14332 0.2824 0.2004 0.3981 2531
0.9979

2005 190613 95233 381520 30212 20181 45230 12059 8107 17939 0.2730 0.1925 0.3872 4387
1.0062

2006 319656 162990 626907 38677 25409 58872 12947 8957 18714 0.2597 0.1811 0.3724 4402
1.0005

2007 592437 289728 1211418 70686 43750 114205 20550 14179 29782 0.2417 0.1633 0.3579
4629 1.0012

2008 298343 138847 641055 62944 42944 92259 26187 17807 38510 0.2317 0.1531 0.3507 4895
1.0008

2009 365858 172482 776036 65513 44040 97456 26450 17666 39602 0.2236 0.1447 0.3454 4594
NA

2010 416649 208638 832047 66370 45336 97163 27228 18325 40457 0.2158 0.1368 0.3403 4894
0.9989

2011 283226 134869 594775 58047 40246 83721 26796 18184 39485 0.2112 0.1327 0.3360 5202
1.0014

2012 289816 145970 575413 54339 37910 77888 24077 16097 36013 0.2082 0.1303 0.3326 5693
0.9999

2013 162105 81596 322053 44002 31007 62445 21448 14312 32143 0.2037 0.1258 0.3301 4828
0.9982

2014 357182 175928 725175 55882 37288 83748 22359 15215 32858 0.2001 0.1220 0.3282 5083
0.9405

2015 348363 176465 687708 55603 38242 80846 20511 14024 29997 0.2017 0.1247 0.3262 4891
1.0001

2016 192914 98456 377994 47005 33875 65222 21974 15030 32126 0.2006 0.1237 0.3252 4327
0.9999

2017 181498 90841 362629 43871 31412 61271 19853 13749 28665 0.1986 0.1214 0.3249 3896
0.9999

2018 399512 201047 793894 55105 37450 81084 19090 12831 28401 0.2003 0.1233 0.3253 6804
1.0031

2019 339422 153858 748789 55715 37674 82395 23981 16372 35126 0.2021 0.1248 0.3272 6377
1.0018

2020 470241 124991 1769131 65578 35265 121949 23435 15219 36087 0.2027 0.1246 0.3299
7927 0.9848

TABLE 7.6.3.13 Irish Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

year						
age	1980	1981	1982	1983	1984	1985
1	0.02682825	0.02650293	0.02599113	0.02531647	0.02504202	0.02506958
2	0.30510479	0.28516138	0.26455662	0.24509730	0.23302722	0.23265468
3	0.29912313	0.28390943	0.27225940	0.26355321	0.26077430	0.26423934
4	0.31603573	0.31033591	0.30128458	0.29042788	0.28604676	0.28967375
5	0.27565643	0.26676157	0.25805049	0.25903295	0.26660157	0.27706587
6	0.29546645	0.29346409	0.29384584	0.29585080	0.29939246	0.30912795
7	0.25676346	0.21425251	0.19392186	0.11592637	0.20034788	0.34163922
8	0.25676346	0.21425251	0.19392186	0.11592637	0.20034788	0.34163922

year						
age	1986	1987	1988	1989	1990	1991
1	0.02518769	0.02519021	0.02553513	0.02572994	0.02633912	0.02696003
2	0.23305053	0.23054712	0.23181863	0.23333035	0.24062875	0.24803138
3	0.26360592	0.26168861	0.26300033	0.26059182	0.26053971	0.26077430
4	0.28722195	0.28385265	0.28533253	0.28060705	0.27795390	0.27507816
5	0.28303067	0.28941316	0.29739323	0.29813765	0.30137498	0.30285534
6	0.31657345	0.32432798	0.33333743	0.33484083	0.33742905	0.33682223
7	0.40158342	0.47416970	0.65325351	0.54274808	0.52274056	0.41724571
8	0.40158342	0.47416970	0.65325351	0.54274808	0.52274056	0.41724571

year							
age	1992	1993	1994	1995	1996	1997	1998
1	0.02743324	0.02738938	0.02770063	0.02827153	0.0287879	0.02869306	0.02786455
2	0.25738043	0.26572323	0.28147828	0.29614680	0.3078016	0.31092610	0.29243876
3	0.26365865	0.26535148	0.26893112	0.27155244	0.2721233	0.27274991	0.26874293
4	0.27631880	0.27419932	0.27411707	0.27538091	0.2786497	0.28736560	0.29170858
5	0.30740167	0.30999472	0.31376845	0.31584617	0.3186379	0.32287178	0.32203340
6	0.33905261	0.33891701	0.34010530	0.33959553	0.3407521	0.34133189	0.34051367
7	0.32200120	0.33753030	0.38902565	0.38946939	0.4897158	0.73256002	0.57156332
8	0.32200120	0.33753030	0.38902565	0.38946939	0.4897158	0.73256002	0.57156332

year						
age	1999	2000	2001	2002	2003	2004
1	0.02709516	0.02626547	0.02559393	0.02483007	0.02513988	0.02613447
2	0.27245005	0.25306725	0.24706594	0.23137859	0.21429537	0.20576923

```
 3 0.26153164 0.25367534 0.25246062 0.24229483 0.23742583 0.23442959
 4 0.28967375 0.28857508 0.29525969 0.29100932 0.28753807 0.27620830
 5 0.31117495 0.29987187 0.29730403 0.28768188 0.28085971 0.27179695
 6 0.33453961 0.32530242 0.32487980 0.31994698 0.31490005 0.29927272
 7 0.37306597 0.20412964 0.42163722 0.44003984 0.73286043 0.45797073
 8 0.37306597 0.20412964 0.42163722 0.44003984 0.73286043 0.45797073
  year
age     2005       2006       2007       2008       2009       2010      2011
 1 0.02714127 0.02766741 0.02824045 0.02848436 0.02847297 0.02846158 0.0283508
 2 0.20219959 0.19429066 0.18222739 0.17197606 0.16806575 0.16376873 0.1613467
 3 0.22836730 0.21969831 0.20690407 0.19732562 0.19251138 0.18753308 0.1847041
 4 0.26585612 0.25024871 0.23066243 0.22027027 0.21483177 0.20965331 0.2086077
 5 0.26268492 0.24954900 0.23103178 0.22126372 0.21246033 0.20417047 0.1973256
 6 0.29034076 0.27923543 0.26350050 0.25359925 0.24341195 0.23354045 0.2276377
 7 0.40810532 0.35686419 0.20894170 0.20835748 0.15902402 0.12115313 0.1635560
 8 0.40810532 0.35686419 0.20894170 0.20835748 0.15902402 0.12115313 0.1635560
  year
age     2012       2013       2014       2015      2016      2017       2018
 1 0.02805467 0.02822633 0.02827436 0.02752667 0.0275735 0.02790359 0.02853568
 2 0.16170202 0.16505113 0.16751205 0.16966998 0.1733574 0.18099244 0.18987297
 3 0.18325072 0.18246444 0.18137293 0.18200884 0.1834157 0.19004393 0.19930878
 4 0.20883726 0.20744273 0.20717322 0.21258784 0.2148533 0.21405977 0.21703427
 5 0.19183877 0.18501840 0.17885140 0.17781706 0.1772135 0.17808399 0.18345241
 6 0.22382294 0.21877751 0.21420967 0.21465998 0.2097162 0.20361995 0.20040800
 7 0.17708950 0.10689588 0.12825946 0.20871199 0.1608312 0.12545602 0.06132302
 8 0.17708950 0.10689588 0.12825946 0.20871199 0.1608312 0.12545602 0.06132302
  year
age     2019      2020
 1 0.02916751 0.0294577
 2 0.19145548 0.1961060
 3 0.20406841 0.2053786
 4 0.21890882 0.2183404
 5 0.18822824 0.1903673
 6 0.19902994 0.1995082
 7 0.07858299 0.0986576
 8 0.07858299 0.0986576
```

TABLE 7.6.3.14 Irish Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1980	1981	1982	1983	1984	1985
1	177016.814	194852.862	207108.8957	158102.684	121540.157	168552.070
2	59874.142	72911.379	82619.4166	88256.268	76956.838	58046.518
3	38139.280	21192.444	34132.3195	41564.429	52575.210	58571.294
4	27391.828	12692.925	9374.9826	18453.328	26317.779	38139.280
5	5000.534	12235.539	4341.1736	4087.137	11988.462	20284.250
6	3572.068	2081.200	6049.9180	2434.265	2469.078	8459.962
7	1697.310	1830.419	988.8078	3172.579	1385.339	1699.858
8	1113.207	1516.560	1858.8253	1275.253	3056.727	2870.955

age \ year	1986	1987	1988	1989	1990	1991	1992
1	208147.033	248699.346	111301.721	140505.231	127899.490	81633.909	257815.631
2	76496.480	89859.265	119850.451	47619.613	68596.720	56669.986	34891.551
3	33894.228	39379.474	52156.287	69772.833	28595.367	39616.461	31319.619
4	35739.078	18568.094	22811.042	26160.345	43217.466	16898.836	24785.151
5	21200.923	20449.220	11720.562	10695.731	14235.584	25719.378	11182.440
6	12713.250	12088.381	12236.762	5779.081	5617.264	7348.122	16176.260
7	5009.543	7462.159	6771.650	5570.834	2916.385	2634.635	4015.833
8	2666.441	4349.865	6549.867	5108.188	4380.420	2887.366	2315.081

age \ year	1993	1994	1995	1996	1997	1998	1999
1	64601.958	160011.345	149193.589	95034.950	139525.129	170586.879	84204.193
2	101823.887	30946.030	81470.804	60779.023	45251.903	53103.600	79459.283
3	17469.294	56050.032	15100.755	46304.758	28566.786	17373.477	28282.542
4	16698.931	9596.944	29231.436	7758.932	25616.706	14537.692	8103.084
5	13489.947	9599.824	5278.515	16488.196	4640.605	14455.063	6717.693
6	6567.575	7465.891	5088.305	2945.400	8447.282	2768.054	7025.488
7	8859.982	3783.860	3783.860	2881.021	1484.747	4448.401	1442.164
8	3439.908	6975.086	5406.191	4433.746	3027.826	1404.870	2410.043

age \ year	2000	2001	2002	2003	2004	2005
1	87640.632	125492.340	83283.023	145655.569	171270.5930	190612.9097
2	34613.533	40619.357	48873.959	41481.383	70052.4832	73203.6089

```
  3 45981.757  19751.802 16527.815  22651.922  23932.6760  46723.3818
  4 15146.125  29643.555  9675.963   7960.125  11367.3444  12012.4633
  5  4370.357   8962.460 14272.644   4023.470   3331.9067   5455.6115
  6  2887.077   2673.116  4354.652   6685.525   1703.0908   1665.8654
  7  2885.923   1522.334  1478.968   1804.610   2463.4054    880.5089
  8  1579.715   2528.800  1710.088   1291.423    730.6248   1503.7240
   year
age       2006       2007       2008       2009       2010       2011
  1 319655.7773 592437.108 298343.265 365857.796 416649.242 283225.874
  2  80821.6375 140927.380 219695.989 119133.501 159691.642 172991.891
  3  35418.8697  40578.758  74682.420 120090.391  59100.815  75207.031
  4  23980.5892  17799.044  23063.349  46119.909  57814.796  28796.237
  5   4668.0654  12354.801  12056.992  14279.782  23837.136  28424.309
  6   2219.1955   2496.388   8155.926   7130.952   7624.332  12549.047
  7    854.3150   1021.268   1771.532   4536.450   3716.732   4258.618
  8    974.1838    822.049   1122.036   1909.124   3180.202   3674.234
   year
age      2012       2013       2014       2015       2016       2017
  1 289815.560 162105.073 357181.738 348362.889 192914.044 181498.016
  2 100307.927 137998.763  72911.379 134995.942 174905.306  93995.294
  3  94560.961  49761.656  69772.833  37797.566  71467.637 103156.239
  4  43608.179  47858.308  21978.061  35918.221  22742.712  37609.050
  5  17181.698  22225.599  23718.248  12237.986  18353.948   8459.116
  6  16383.008   9403.150  10662.626  14625.180   7630.434   9654.699
  7   7876.193   8550.970   4907.893   6135.213   7216.317   3852.972
  8   4427.100   6075.381   8590.395   7174.584   6527.635   6137.667
   year
age      2018       2019       2020
  1 399512.367 339422.187 470240.714
  2  97929.195 183872.893 149791.559
  3  63895.231  53369.783 114691.363
  4  66237.364  33996.063  26608.873
  5  21059.352  34337.729  18040.960
  6   4459.982  11202.587  19728.114
  7   5266.915   2416.076   6804.912
  8   3284.271   3679.382   3164.974
```

TABLE 7.6.3.15 Irish Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

<0 x 0 matrix>

TABLE 7.6.3.16 Irish Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

<0 x 0 matrix>

TABLE 7.6.3.18 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 1

Units : NA

age \ year	1980	1981	1982	1983	1984	1985
1	3248.9268	3533.9447	3685.5683	2740.1830	2085.0539	2892.9442
2	13229.8378	15182.2157	16109.4285	16079.6536	13408.4448	10095.5499
3	8383.9966	4450.2698	6905.9594	8179.0395	10249.5594	11544.5645
4	6363.2212	2902.4486	2089.6670	3984.1928	5608.9566	8217.4893
5	1040.9302	2474.6395	852.6678	805.5216	2423.5289	4241.3632
6	791.3181	458.3807	1333.9904	539.8763	553.2943	1948.8408
7	333.5824	306.0474	151.0287	300.3294	217.9662	427.8788
8	218.7851	253.5802	283.9335	120.7232	480.9580	722.6319

age \ year	1986	1987	1988	1989	1990	1991	1992
1	3590.7989	4291.450	1945.686	2475.877	2304.502	1505.1081	4837.9192
2	13322.2387	15507.360	20788.391	8304.227	12295.148	10435.2002	6641.4793
3	6667.6983	7698.494	10242.387	13586.881	5566.323	7724.3272	6163.9310
4	7642.1939	3930.099	4851.970	5482.300	8979.684	3479.8692	5124.7140
5	4516.4429	4441.334	2606.647	2383.893	3202.349	5808.9784	2559.2000
6	2989.1370	2901.868	3006.975	1425.531	1394.735	1821.7448	4032.7347
7	1443.2460	2458.729	2846.798	2039.520	1037.252	783.1702	961.0054
8	768.1999	1433.336	2753.560	1870.236	1558.096	858.3054	554.0805

```
   year
age      1993      1994      1995      1996      1997      1998      1999
  1  1210.6104  3032.249  2885.317  1870.8722  2736.2674  3251.6570  1561.5747
  2 19924.1930  6373.984 17529.667 13529.5302 10157.6257 11305.3348 15905.4962
  3  3457.2543 11221.311  3049.766  9372.9204  5790.8826  3476.8083  5527.8819
  4  3428.9522  1970.199  6024.080  1615.8396  5482.3548  3150.9523  1745.6461
  5  3109.5708  2235.947  1236.426  3891.4223  1107.7210  3442.8676  1553.5998
  6  1636.8190  1866.275  1270.226   737.4365  2117.8358   692.6259  1731.9444
  7  2207.2441  1061.842  1062.830   973.8819   677.1075  1694.0036   390.8446
  8   857.0104  1957.513  1518.639  1498.7549  1381.1752   534.9589   653.2043
   year
age     2000      2001      2002      2003      2004      2005      2006
  1 1574.9204 2198.9165 1416.6355 2508.1231  3063.5511  3538.1526  6050.7046
  2 6488.2621 7456.3403 8457.3401 6698.5744 10911.7994 11225.2390 11952.3119
  3 8744.8479 3740.4081 3017.7295 4062.3220  4241.4056  8090.5339  5923.4244
  4 3252.1773 6490.0791 2092.9294 1703.6870  2349.1762  2400.4944  4541.0793
  5  978.9201 1992.7881 3083.4365  851.3216   684.9597  1088.4609   890.0966
  6  694.8736  642.6434 1033.4417 1564.5132   381.5378   363.4094   467.8838
  7  461.8915  456.3774  459.0412  823.3736   789.5080   257.0730   223.1044
  8  252.8383  758.3007  530.8821  589.2733   234.1847   438.9695   254.3929
   year
age      2007       2008       2010       2011       2012       2013      2014
  1 11443.1892  5811.3025  8109.8123  5491.7377  5558.6469  3129.1604 6904.9236
  2 19644.2509 29042.0483 20178.4403 21554.2868 12529.6110 17561.0735 9405.2187
  3  6431.1587 11335.4470  8560.7236 10749.4514 13406.4337  7028.0179 9802.6692
  4  3135.7699  3898.3942  9348.3955  4634.2980  7021.7658  7660.6338 3514.9128
  5  2199.6642  2065.0093  3795.0012  4391.1657  2585.6702  3236.6043 3348.6079
  6   500.4211  1580.9323  1373.1738  2208.5247  2840.2575  1597.3000 1776.6769
  7   166.9276   288.9114   366.8085   556.3013  1107.2226   749.5402  511.1586
  8   134.3529   182.8854   313.9331   479.9971   622.3359   532.5144  894.5761
   year
age     2015       2016       2017       2018       2019       2020
  1  6556.748  3637.8932  3464.7647  7791.3545  6767.0464  9467.7825
  2 17617.535 23283.4945 13025.9656 14169.9669 26825.2799 22332.5381
  3  5329.326 10147.9805 15126.9016  9780.8337  8351.6967 18057.0235
  4  5881.752  3758.9314  6195.6332 11052.4787  5716.7172  4464.3102
  5  1718.179  2568.9178  1189.2998  3042.1202  5078.4938  2696.0958
```

6	2441.603	1247.6537	1536.9266	699.7338	1746.3445	3082.0801
7	1001.716	928.2954	393.0355	270.5833	157.7876	552.6694
8	1171.629	839.6625	626.0561	168.7334	240.2308	257.0113

TABLE 7.6.3.19 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 1

Units : NA

year

age	1980	1981	1982	1983	1984	1985	1986
1	0.720021	0.4383130	0.3988190	-0.910845	-0.71153700	-0.21461600	0.27467000
2	1.687190	0.0993729	-0.0125103	-0.707031	-1.17686000	-0.01143810	0.34484300
3	2.138500	-0.8350760	-0.4993010	-0.960046	-0.88119000	1.02941000	0.28495800
4	0.739040	-0.1000550	0.0720620	-0.875049	-0.95868600	1.21668000	0.28421100
5	1.489680	-0.1695580	-2.1993000	-1.374840	-0.20218800	1.22799000	0.00592931
6	0.323754	-0.7613240	-0.4258560	-0.253117	-0.87047700	0.71289600	0.15649100
7	0.176572	-0.1247820	-0.1756830	-0.379068	0.11440000	1.02854000	0.03307230
8	0.115808	-0.1275190	0.6751880	-1.658750	-0.00945762	0.00437792	0.30688800

year

age	1987	1988	1989	1990	1991	1992	1993
1	-0.806531	0.3592430	-0.935167	0.00451954	0.348439	1.1301500	-0.7711900
2	-0.450249	0.0556003	-0.665423	0.10880300	-0.170918	0.0911688	-0.7809950
3	-0.570250	0.6695940	-0.306256	0.07162010	-0.344012	0.2277310	-0.3524520
4	-0.685447	0.9848970	-0.385514	0.19458200	-0.520717	0.6748630	-0.3240760
5	-0.140503	1.3209700	-0.555087	0.26989900	-0.316157	0.5579080	-0.1592660
6	-0.101900	1.2167000	-0.295186	0.40478400	-0.461053	0.5539610	-0.0440359
7	-0.126589	0.2940150	-0.622452	0.01057790	-0.198061	0.1741010	-0.0277202
8	0.355450	0.9853080	0.103882	0.08309660	-0.119948	-0.8017380	-0.0244897

year

age	1994	1995	1996	1997	1998	1999	2000
1	-0.5295340	0.1286400	1.2866400	1.5348700	-0.0709888	0.181272	-0.312534
2	0.2379230	0.4968340	0.6557360	1.8852100	0.1253200	0.157898	-1.392860
3	0.2044570	0.2685490	0.1027320	0.6756520	0.2745430	0.180361	-1.007960
4	-0.1924420	-0.3390900	-0.8391940	0.7391720	0.8740430	-0.274973	-1.150010
5	0.3189770	-0.0712024	-0.1784130	0.9105140	1.5335500	-0.117140	-1.302260
6	0.2777700	-0.2223300	0.1300010	0.1719590	0.9193640	0.320626	-1.608810
7	0.4292920	-0.3193050	-0.0308514	0.4994470	0.4407900	0.295435	-1.412970

```
 8  0.0392923 -0.1039550 -0.2182640 0.0837246 -0.3955350 -0.113417 -1.256440
  year
age    2001      2002      2003      2004     2005      2006     2007
 1 0.257953 -2.5399800 -1.5775600  0.0630618  1.103580 -0.0800030  0.703221
 2 1.091100  0.1633650 -0.9003930 -0.5351220  0.555686  0.6174130 -0.180729
 3 1.640860 -1.1794400 -0.4919270  0.6138360  0.673252  0.8228370 -0.647500
 4 1.768600 -0.2905990  1.0300700 -0.2114140  0.795803  0.8361480 -1.618120
 5 1.228180 -0.5853770  0.0820156 -0.2196580  0.619280  0.9217180 -1.686990
 6 0.871186 -0.1877470  1.4654600 -1.3505200  0.307562  0.5954410 -0.999994
 7 0.819349  0.0743011  0.1329460 -0.3699050  0.295158  0.3723350 -0.726407
 8 0.132706 -1.0528900  0.0610288 -1.4177200 -0.408574 -0.0777181 -0.442362
  year
age      2008      2010      2011      2012      2013      2014      2015
 1  0.5287280  0.2055910  0.375108 -0.985552  0.2669130  1.6913100 -1.691100
 2 -1.0779100 -0.3422910 -0.513453 -0.657514  0.1881760  0.0431915 -0.338311
 3 -1.0501800 -0.6284680 -0.454250 -0.229036 -0.0701307 -0.5409270 -0.243848
 4 -0.9337840 -1.0393600 -0.384114  0.312444 -0.3654630 -1.4315100  0.573180
 5  0.0189918 -0.3951030 -0.415024  0.390987 -0.2536300 -1.4915700 -0.146360
 6  0.2499170 -0.9153520 -0.537823  0.245686 -0.1892700 -1.4165300  1.298270
 7  0.2939810  0.0200694  0.498993  0.839858 -0.4209750 -0.5165800  1.195230
 8  0.3855530 -1.2251800 -0.281947  0.107883 -0.9591140 -0.1735820 -0.121025
  year
age      2016      2017      2018      2019      2020
 1 -0.6086470 -0.6077990  0.0310711  0.721240  0.5860990
 2 -0.5063300 -0.0356279  1.2157000 -0.377324  0.6665880
 3 -1.3339700 -0.4994270  1.1912700  0.716418  0.3664430
 4  0.5533000 -0.8625190  0.2839120  0.430405 -0.2161530
 5 -0.5227800 -1.5506400  0.1460030  0.628441  0.5065750
 6  0.3014010 -0.8498300 -0.6089610 -0.579292  0.0869925
 7 -0.0820283  0.4966410  0.8528870  0.330749  0.7892950
 8 -0.2339980 -0.0113425 -2.8179400 -0.495209 -0.4790810
```

TABLE 7.6.3.20 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 2

Units : NA

age	1994	1995	1996	1997	1998	1999	2000
1	164078.459	152955.147	97372.587	142899.948	174905.306	86404.929	89922.188
2	45597.127	118657.919	87789.747	65186.000	77574.962	117865.568	52067.696
3	62280.272	16750.946	51364.369	31656.539	19311.190	31618.574	51694.155
4	9414.817	28644.021	7585.168	24891.957	14074.079	7856.920	14697.607
5	9279.751	5094.211	15879.433	4455.480	13887.438	6506.715	4268.510
6	7097.728	4838.693	2798.531	8021.735	2630.502	6707.489	2775.094
7	3486.139	3484.988	2461.509	1056.926	3573.604	1344.678	3054.619
8	6426.723	4979.526	3788.138	2155.957	1128.529	2247.334	1672.091

age	2001	2002	2003	2004	2005	2006
1	128862.342	85596.528	149671.7737	175799.6019	195438.2985	327813.4580
2	61402.142	74719.770	64228.3512	109239.7186	114485.1043	127159.8201
3	22225.599	18738.959	25781.1788	27285.2079	53524.7798	40839.2946
4	28609.669	9372.545	7729.8907	11133.1230	11856.7191	23939.8569
5	8771.824	14066.903	3986.1854	3323.2218	5478.6281	4734.7774
6	2570.074	4202.858	6474.5863	1669.1503	1643.2151	2206.9572
7	1368.458	1311.321	1284.1342	2153.4576	799.3589	805.8036
8	2273.760	1516.545	919.0311	638.7672	1364.9731	918.8198

age	2007	2008	2009	2010	2011	2012
1	607252.5220	305742.951	374857.038	427025.923	290308.666	296974.038
2	223641.5889	351406.868	191070.930	256991.940	278841.835	161716.487
3	47263.8022	87596.822	141350.797	69814.709	89071.972	112027.539
4	18039.3363	23559.867	47277.983	59539.784	29670.246	44909.292
5	12708.4194	12492.578	14893.498	25006.723	29998.420	18198.237
6	2513.2198	8274.965	7289.061	7850.873	12977.210	16992.205
7	1076.2951	1869.021	4967.391	4185.661	4644.969	8504.324
8	866.2642	1183.120	2090.106	3582.263	4007.849	4780.020

age	2013	2014	2015	2016	2017	2018
1	166142.312	365967.569	357074.599	197777.907	186111.270	409175.730
2	221837.409	116984.883	216208.825	279372.138	149357.793	154476.923

3	58988.630	82801.379	44850.948	84719.409	121637.428	74787.048
4	49340.474	22670.051	36908.605	23325.443	38595.849	67853.076
5	23666.125	25371.962	13099.247	19654.469	9052.262	22444.480
6	9790.424	11137.911	15270.987	7998.906	10166.365	4707.160
7	9732.344	5497.727	6467.662	7887.070	4324.795	6201.894
8	6914.459	9621.447	7564.715	7134.019	6888.854	3867.447

year

age	2019	2020
1	347597.333	481518.533
2	289873.529	235272.572
3	62286.501	133746.300
4	34773.122	27230.692
5	36464.702	19128.029
6	11833.503	20833.134
7	2807.950	7788.394
8	4275.131	3621.885

TABLE 7.6.3.21 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 2

Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000
1	-0.96179500	0.787502	-2.302470	-0.0677023	-0.492345	0.644638	-0.145133
2	0.64316300	-0.583373	-1.159950	-0.4230830	-1.662230	-0.663029	1.093010
3	0.26443700	-0.539761	0.434364	-1.2093300	-1.386760	0.116364	1.132740
4	0.36763800	0.033043	0.264163	-1.3024500	-0.665552	-0.685619	1.000050
5	0.00330341	-0.171509	0.813576	-1.4871100	-1.213990	0.725163	1.014500
6	0.08034650	-0.421253	0.519033	-0.7366300	-0.509439	0.911769	0.873530
7	0.13485700	0.439757	1.139400	-0.8008420	-0.599422	0.214679	0.614388
8	0.59028800	0.423109	0.557406	-0.1575430	-0.480424	1.338420	0.447631

year

age	2001	2002	2003	2004	2005	2006
1	1.17905000	1.6265700	0.9072310	0.3378820	-0.7800430	0.143216
2	0.66792100	-0.0604315	1.9604700	0.0891841	-0.0645537	-0.437248
3	-1.24106000	0.8371400	0.3433210	0.1293150	0.9484950	-1.529840
4	-0.78368400	1.5496500	-0.7804040	0.5164000	0.5758830	-1.392950

5	-0.20668400	1.2723400	-0.0262552	-0.7560710	0.6085800	-3.486820
6	-0.81636200	1.6399400	-0.5977420	0.4164130	-0.9200280	-2.326270
7	-1.01721000	0.9660310	-0.3555310	-2.8647100	-0.3580410	-0.679230
8	-0.00617483	1.4032900	-0.0185744	-1.2731800	1.8825400	-0.874649

age \ year	2007	2008	2009	2010	2011	2012	2013
1	0.8286870	0.473306	-0.0104153	0.3290130	2.026790	0.232846	-0.5433350
2	0.1855530	0.402089	-0.0718930	1.2436800	0.269147	0.272504	0.4002430
3	-0.0235159	0.422501	0.3654890	0.8317100	-1.128240	0.577323	0.5166580
4	0.2496200	0.805712	1.0729000	1.1261800	-1.088490	0.213857	0.1539340
5	0.7858870	1.189590	1.2420000	0.5043680	-0.501246	0.276038	0.8809550
6	-0.9614840	0.941239	0.9447700	0.9862740	-0.938242	0.164620	0.4121750
7	-0.5265070	1.069700	1.3420800	0.0459015	-0.698421	0.459177	0.1747620
8	-0.5767240	-0.885264	1.5478600	0.7654840	-0.931012	-0.551529	-0.0263036

age \ year	2014	2015	2016	2017	2018	2019	2020
1	-0.213979	0.343033	-0.4369420	-1.58958000	-0.580827	-0.908009	-0.713273
2	0.799368	-0.670999	0.7567040	-0.81273900	-0.393030	-0.251535	-1.416150
3	0.685502	-0.920878	1.7679800	-0.24849400	-0.264640	-0.528591	-0.232846
4	0.429549	-1.232720	2.4723700	0.60610100	0.781969	-0.785958	-0.820105
5	0.842082	-0.376639	0.7876290	-0.00798059	0.438288	-1.458020	-1.426910
6	0.575889	-0.694346	1.0772500	0.89924300	0.630766	-0.362946	-0.745526
7	0.462925	-1.600080	0.0437727	0.02094560	0.319032	-0.543416	-1.347870
8	0.338436	-0.722058	-0.0168883	0.69767400	0.347771	-2.052880	-1.704170

TABLE 7.6.3.22 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 3

Units : NA

age \ year	2007	2008	2009	2010	2011	2012	2013	2014
8	20549.05	26176.05	26452.34	27227.97	26787.75	24074.3	21447.64	22354.88

age \ year	2015	2016	2017	2018	2019	2020
8	20509.63	21973.01	19852.4	19087.71	23971	23444.71

TABLE 7.6.3.23 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 3

Units : NA

	year								
age	2007	2008	2009	2010	2011	2012	2013	2014	2015
8	1.32761	0.744189	1.68499	1.91452	1.32451	1.21973	2.64204	0.378277	1.7059

	year				
age	2016	2017	2018	2019	2020
8	1.92577	1.17286	1.12869	0.966921	1.13073

TABLE 7.6.3.25 Irish Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	0.635940	0.219320
2	logFpar	0.883400	0.175340
3	logFpar	0.572090	0.183600
4	logFpar	0.437640	0.201290
5	logSdLogFsta	-2.151300	0.759090
6	logSdLogFsta	-2.398000	0.505740
7	logSdLogFsta	-2.430900	0.600500
8	logSdLogFsta	-0.725490	0.256910
9	logSdLogN	-1.245500	0.170700
10	logSdLogObs	-0.205260	0.144580
11	logSdLogObs	-0.929000	0.132910
12	logSdLogObs	-0.840200	0.111950
13	logSdLogObs	-0.068398	0.160250
14	logSdLogObs	-0.465170	0.081327
15	logSdLogObs	-0.261910	0.095760

TABLE 7.6.3.26 Irish Sea Herring. NEGATIVE LOG-LIKELIHOOD

571.675

Table 7.7.1. Herring in Division 7.a North (Irish Sea). Input data for short-term forecast.

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	284958.8	0.787	0.093333	0.9	0.75	0.058	0.029054	0.058
2	207843.8	0.38	0.79	0.9	0.75	0.095667	0.192478	0.0956
3	84195.27	0.353	0.98	0.9	0.75	0.11933	0.202919	0.119
4	65619.05	0.335	1	0.9	0.75	0.135667	0.218094	0.135667
5	15300.79	0.315	1	0.9	0.75	0.144333	0.187349	0.144333
6	10883.82	0.311	1	0.9	0.75	0.155667	0.199649	0.155667
7	11840.63	0.304	1	0.9	0.75	0.161	0.079521	0.161
8	6665.277	0.304	1	0.9	0.75	0.186333	0.079521	0.186333
2022								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	284958.8	0.787	0.093333	0.9	0.75	0.058	0.029054	0.058
2	-	0.38	0.79	0.9	0.75	0.095667	0.192478	0.0956
3	-	0.353	0.98	0.9	0.75	0.11933	0.202919	0.119
4	-	0.335	1	0.9	0.75	0.135667	0.218094	0.135667
5	-	0.315	1	0.9	0.75	0.144333	0.187349	0.144333
6	-	0.311	1	0.9	0.75	0.155667	0.199649	0.155667
7	-	0.304	1	0.9	0.75	0.161	0.079521	0.161
8	-	0.304	1	0.9	0.75	0.186333	0.079521	0.186333
2023								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	284958.8	0.787	0.093333	0.9	0.75	0.058	0.029054	0.058
2	-	0.38	0.79	0.9	0.75	0.095667	0.192478	0.0956
3	-	0.353	0.98	0.9	0.75	0.11933	0.202919	0.119
4	-	0.335	1	0.9	0.75	0.135667	0.218094	0.135667
5	-	0.315	1	0.9	0.75	0.144333	0.187349	0.144333
6	-	0.311	1	0.9	0.75	0.155667	0.199649	0.155667
7	-	0.304	1	0.9	0.75	0.161	0.079521	0.161
8	-	0.304	1	0.9	0.75	0.186333	0.079521	0.186333

Table 7.7.2. Herring in Division 7.a North (Irish Sea). Management options table.

Fbar (2021)	Catch (2021)	SSB (2021)	Fbar (2022)	Catch (2022)	SSB (2022)	SSB (2023)
0.209356	7341	27504.38	0	0	31606	34805
0.209356	7341	27504.38	0.1	3411	29100	29729
0.209356	7341	27504.38	0.2	6536	26804	25457
0.209356	7341	27504.38	0.3	9402	24699	21858
0.209356	7341	27504.38	0.4	12032	22770	18819
0.209356	7341	27504.38	0.5	14447	21000	16251
0.209356	7341	27504.38	0.6	16667	19378	14075
0.209356	7341	27504.38	0.7	18709	17889	12229
0.209356	7341	27504.38	0.8	20588	16524	10660
0.209356	7341	27504.38	0.9	22320	15271	9323
0.209356	7341	27504.38	1	23918	14121	8182
0.209356	7341	27504.38	1.1	25392	13065	7205
0.209356	7341	27504.38	1.2	26755	12096	6368
0.209356	7341	27504.38	1.3	28016	11205	5648
0.209356	7341	27504.38	1.4	29184	10387	5028
0.209356	7341	27504.38	1.5	30267	9635	4492
0.209356	7341	27504.38	1.6	31273	8944	4029
0.209356	7341	27504.38	1.7	32207	8309	3626
0.209356	7341	27504.38	1.8	33077	7724	3275
0.209356	7341	27504.38	1.9	33887	7187	2969
0.209356	7341	27504.38	2	34643	6692	2701

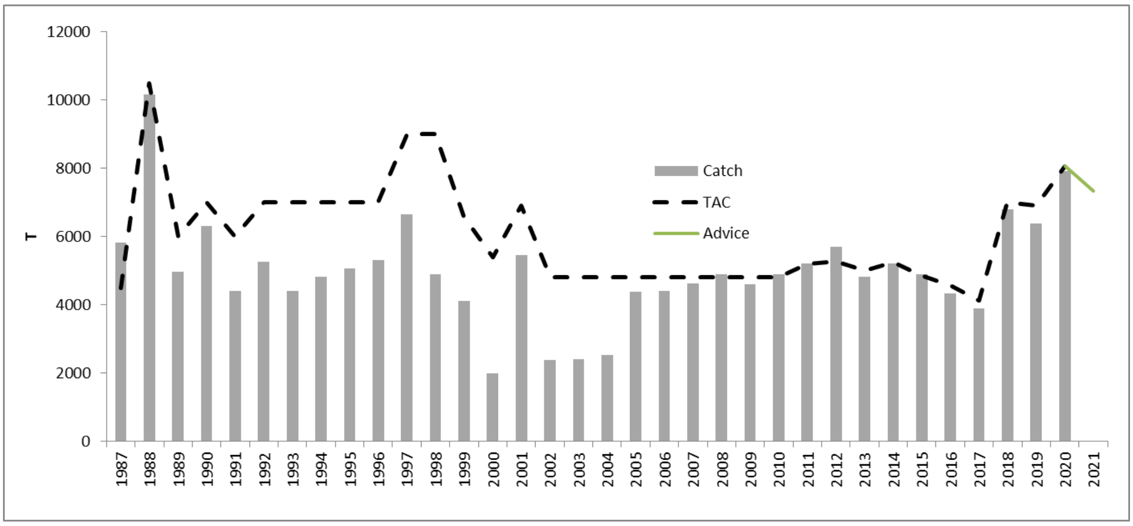


Figure 7.1.1 Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1987 to 2020.

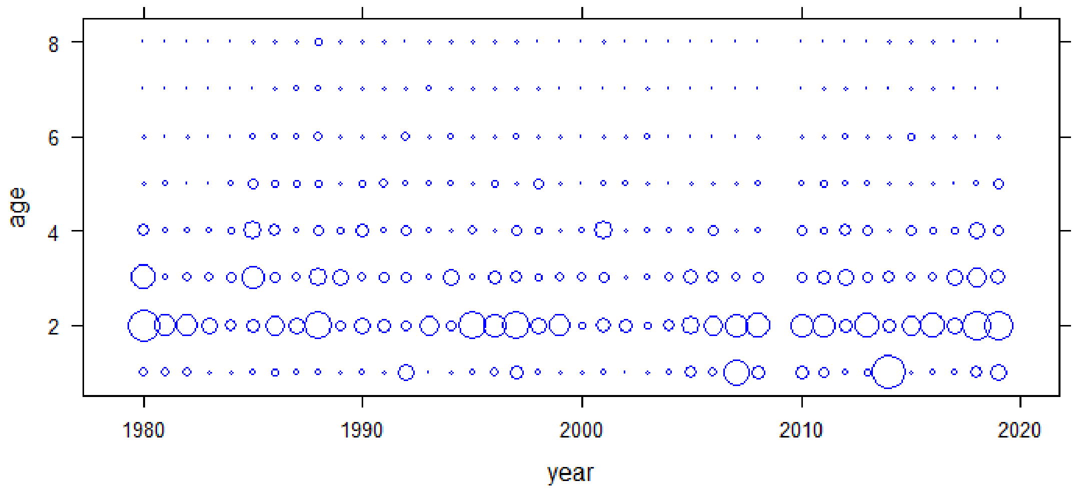


Figure 7.2.1 Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1980 to 2020. No 2009 commercial samples.

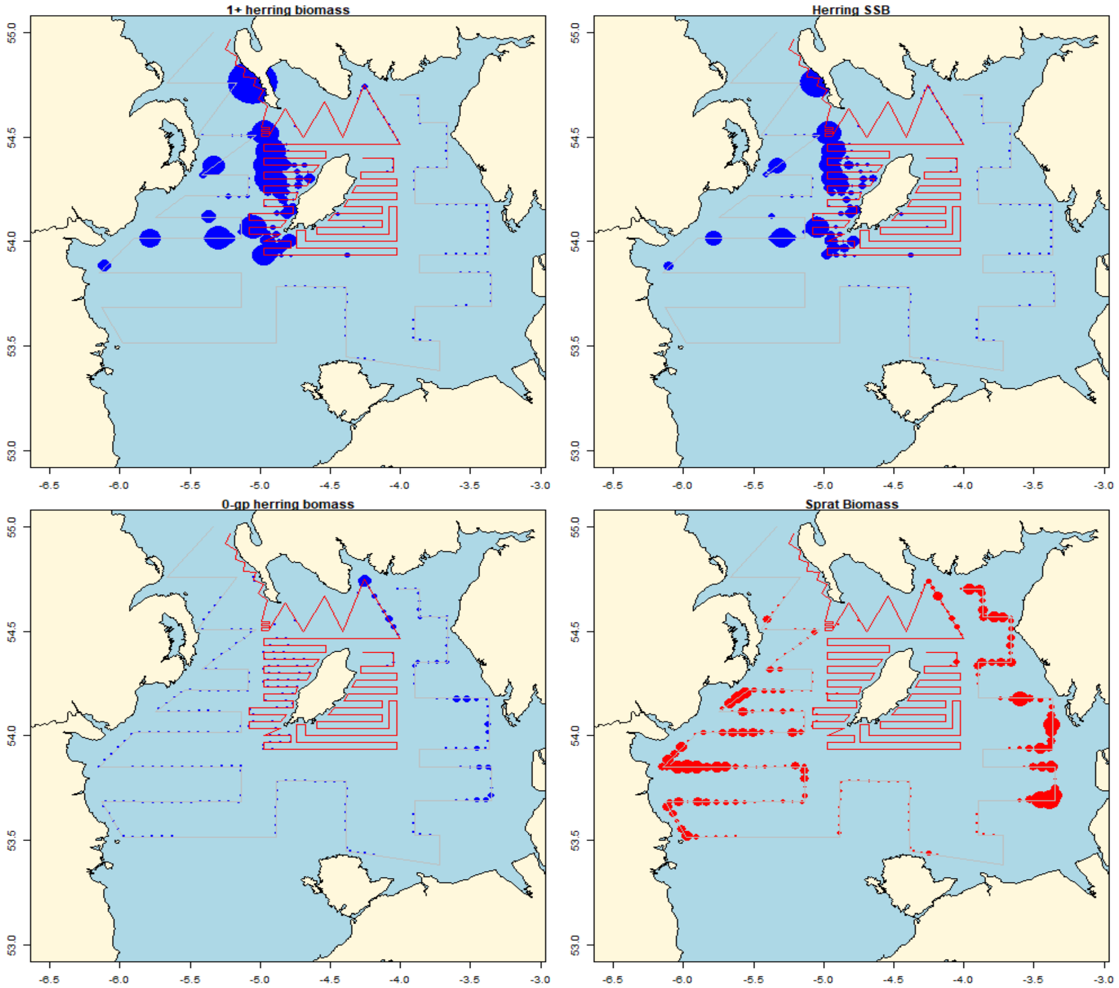


Figure 7.3.1 Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2020 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval and the same scaling is used for all figures.

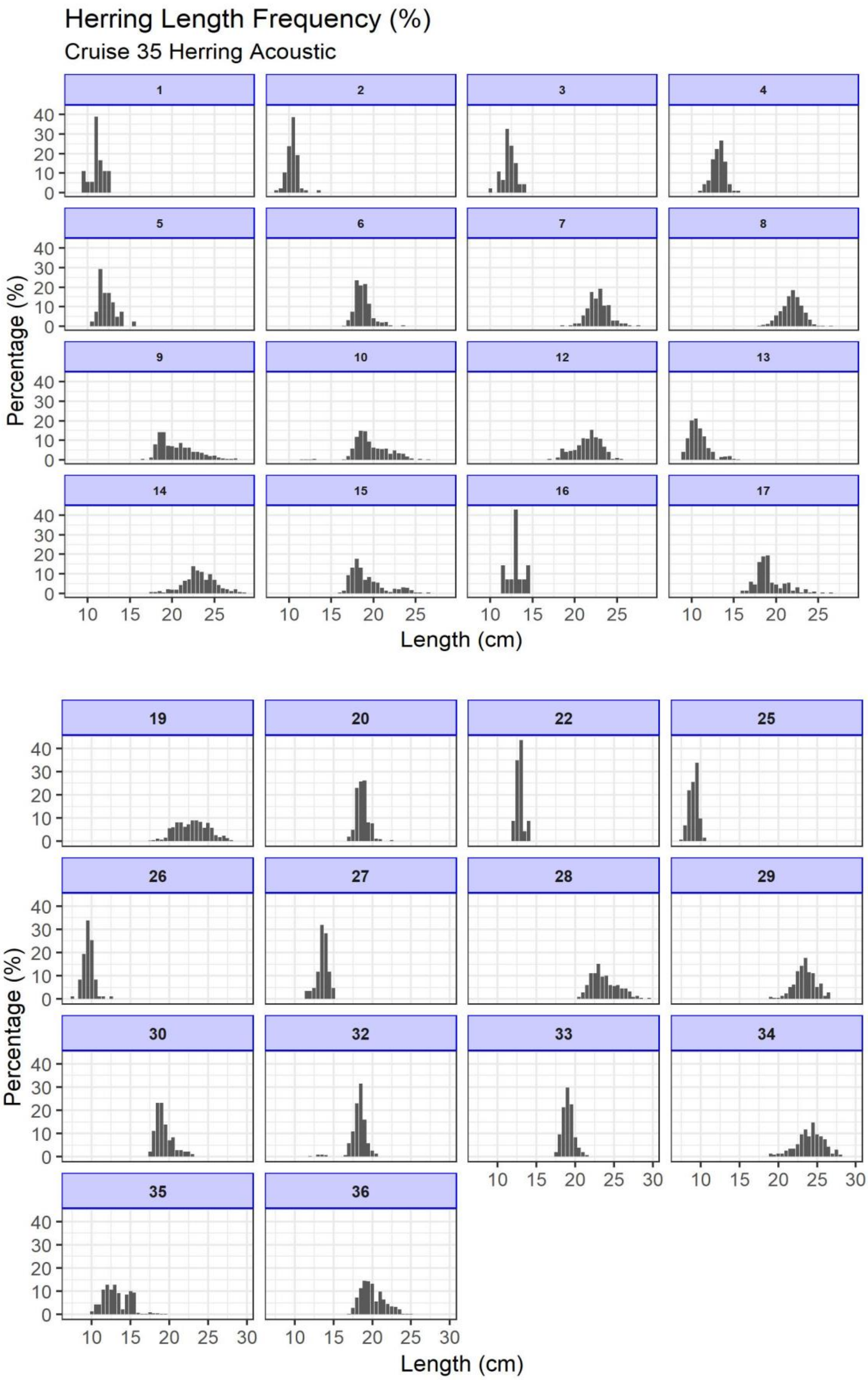


Figure 7.3.2 Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2020 acoustic survey.

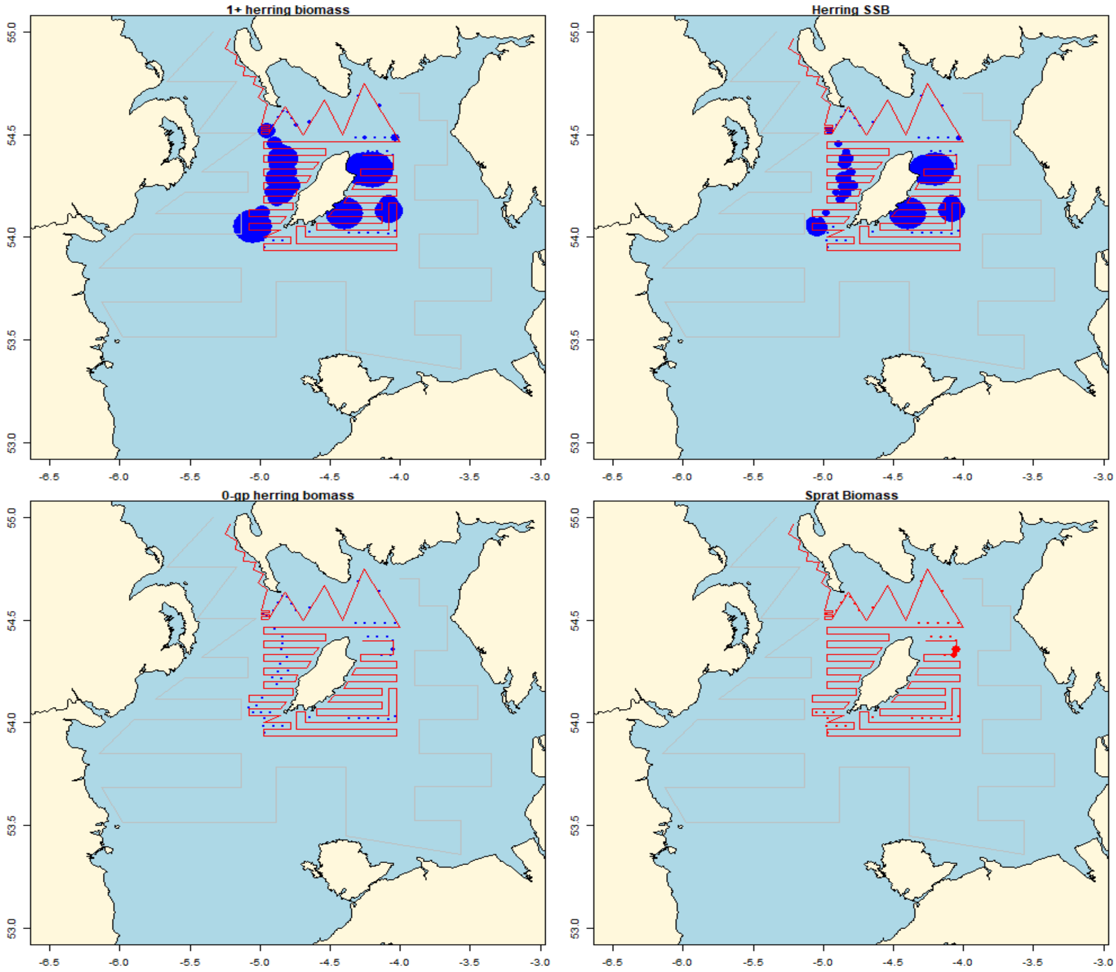


Figure 7.3.3 Herring in Division 7.a North (Irish Sea). Distribution plots for the 7.aNSpawn survey (2008–2020) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).

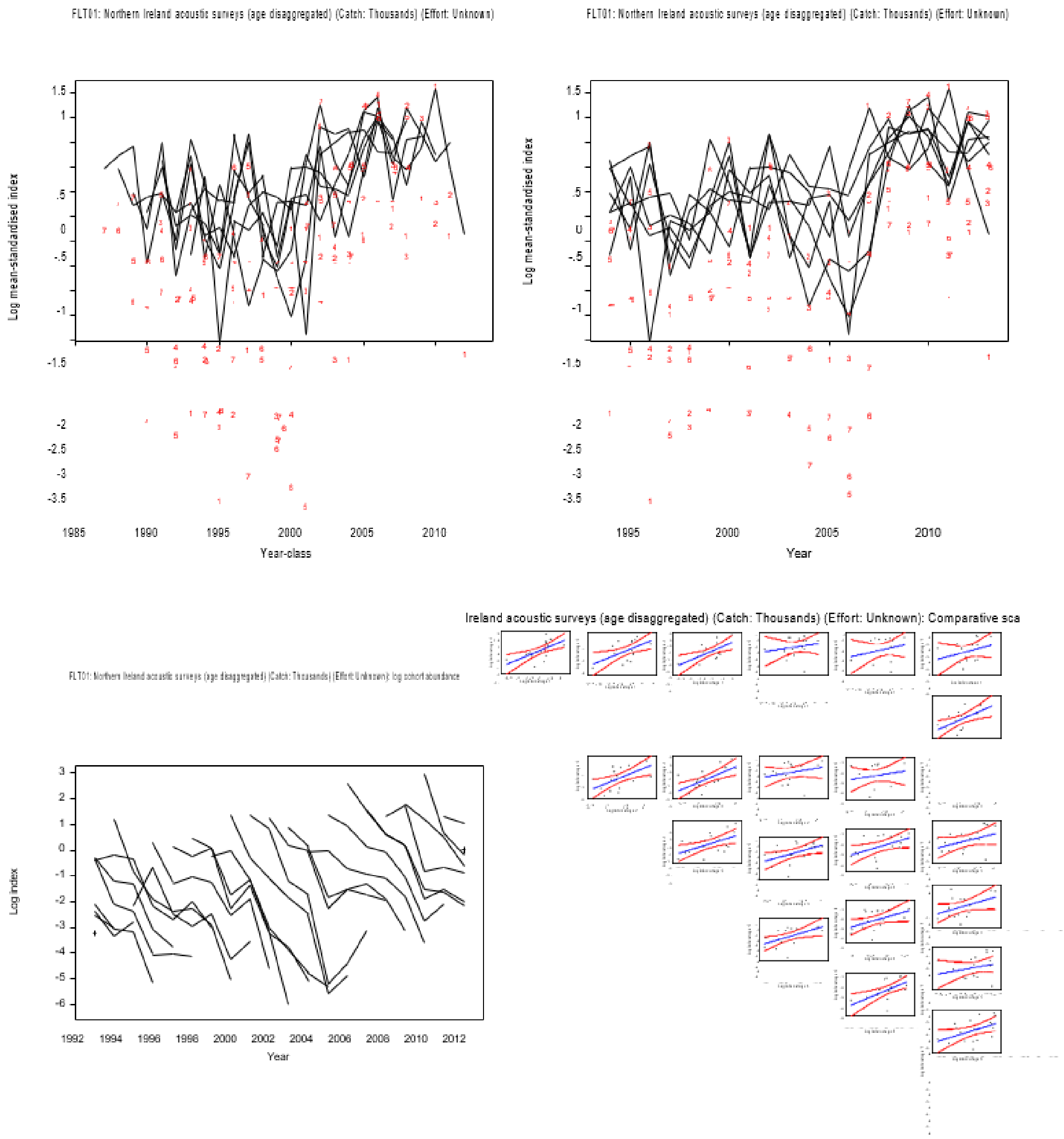
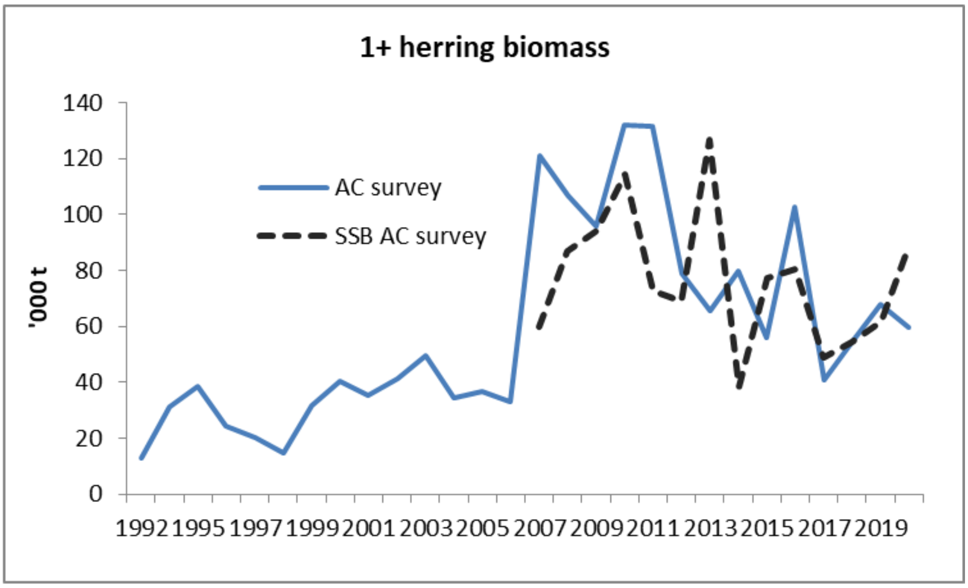


Figure 7.3.4 Herring in Division 7.a North (Irish Sea). Acoustic survey (AC(7.aN)) log mean-standardized indices by year and age class, scatterplots and catch curves.



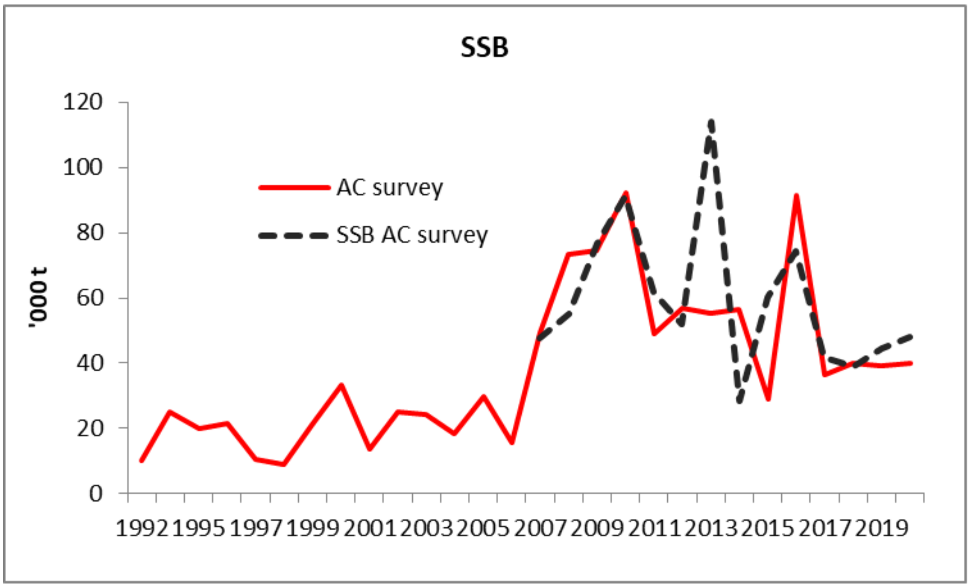


Figure 7.3.5 Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

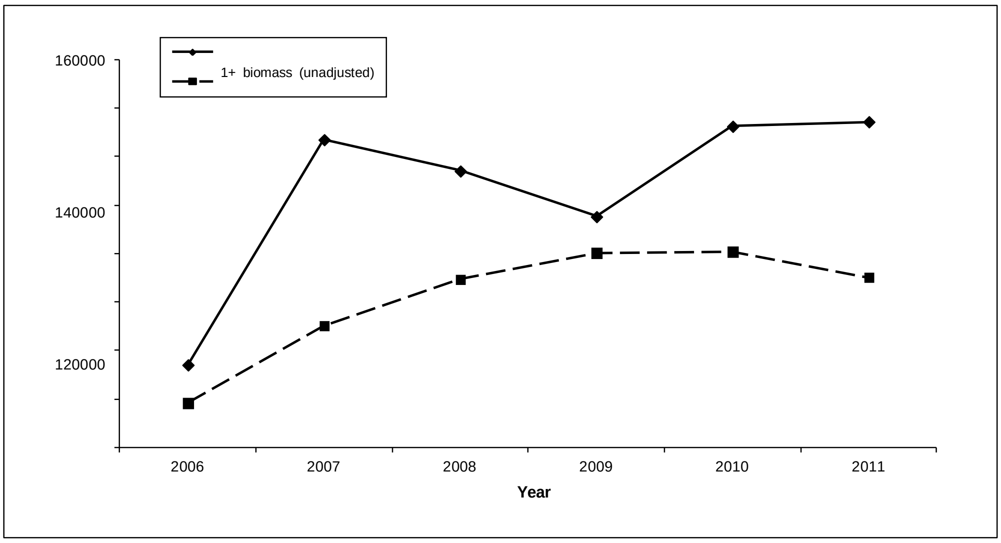


Figure 7.3.6 Herring in Division 7.a North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

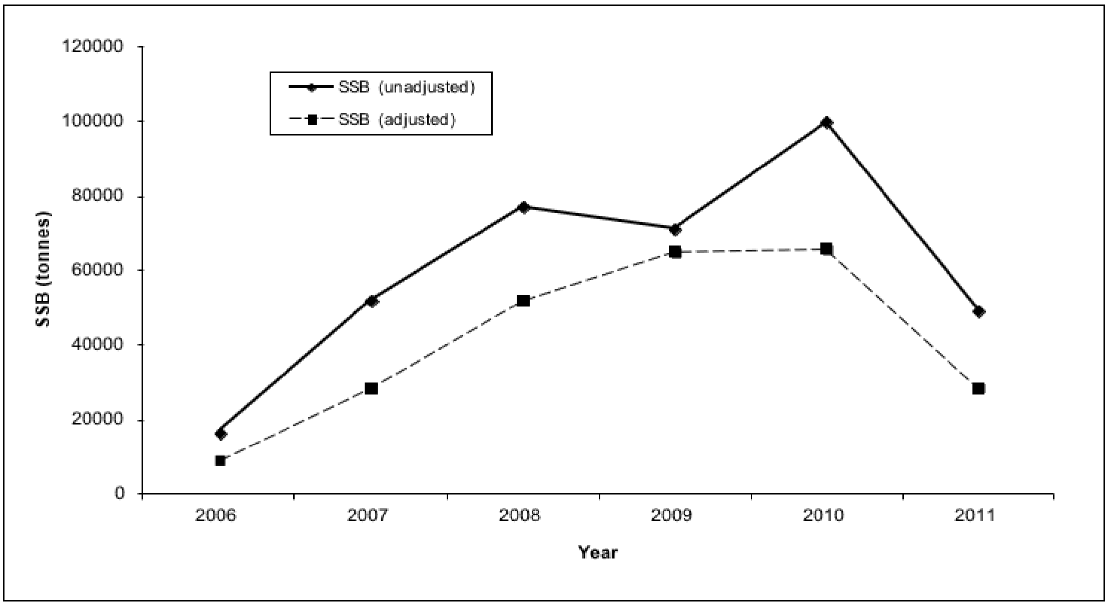


Figure 7.3.7 Herring in Division 7.a North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

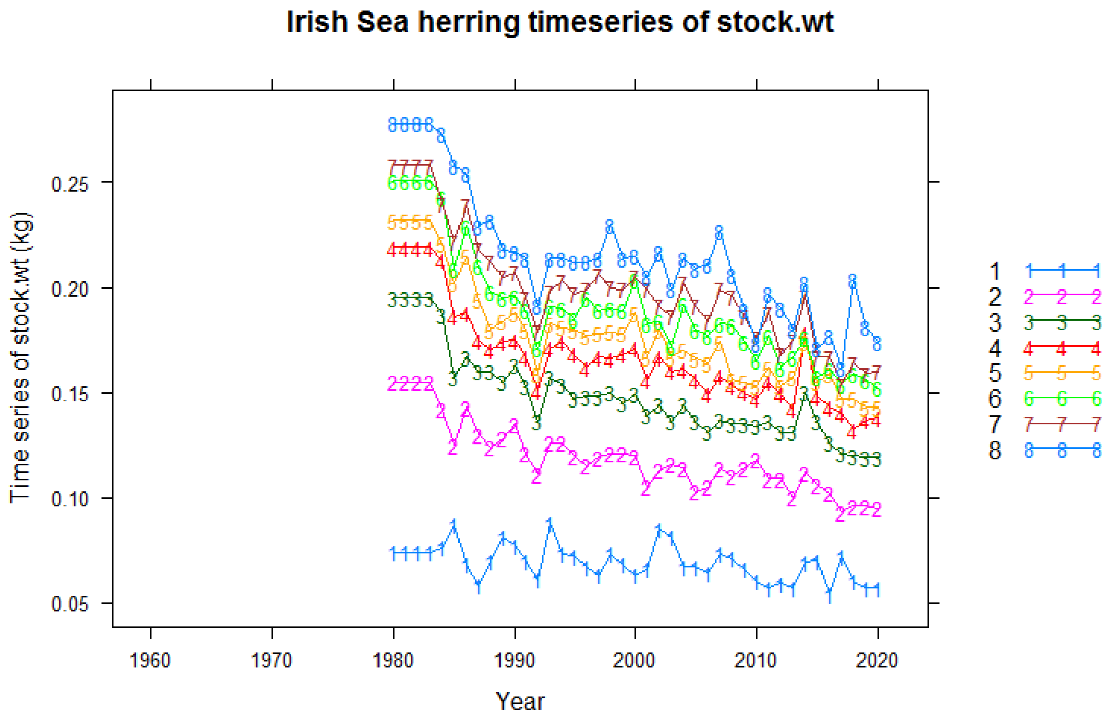


Figure 7.4.1 Herring in Division 7.a North (Irish Sea). Time-series of catch weights at age.

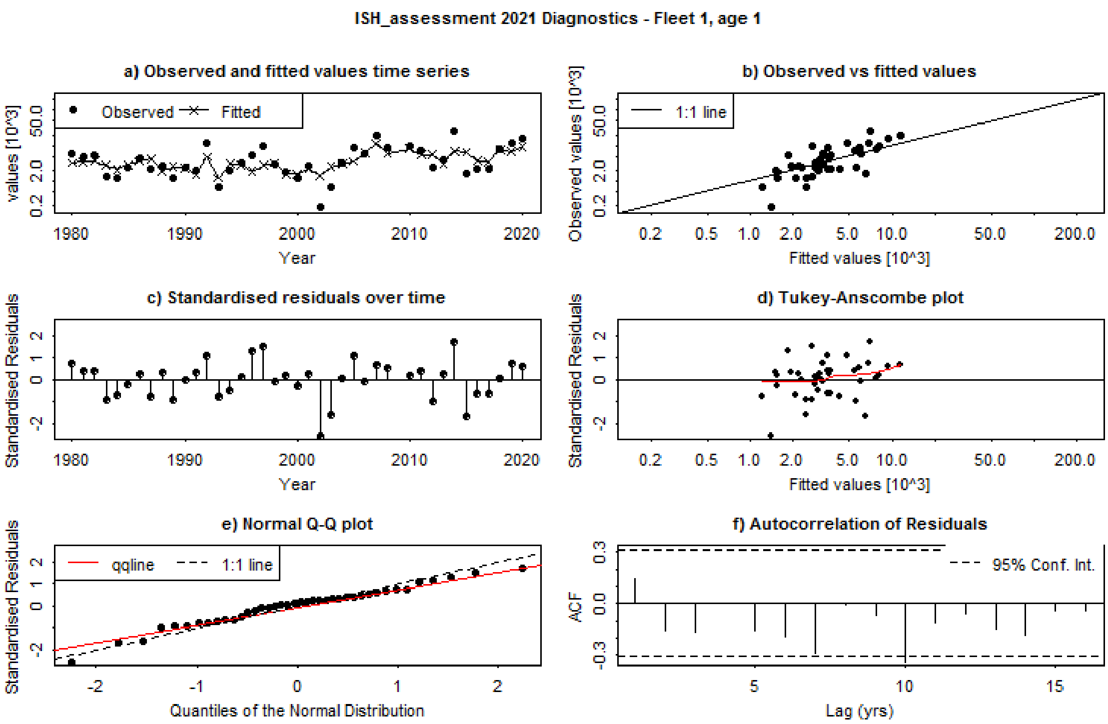


Figure 7.6.1 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

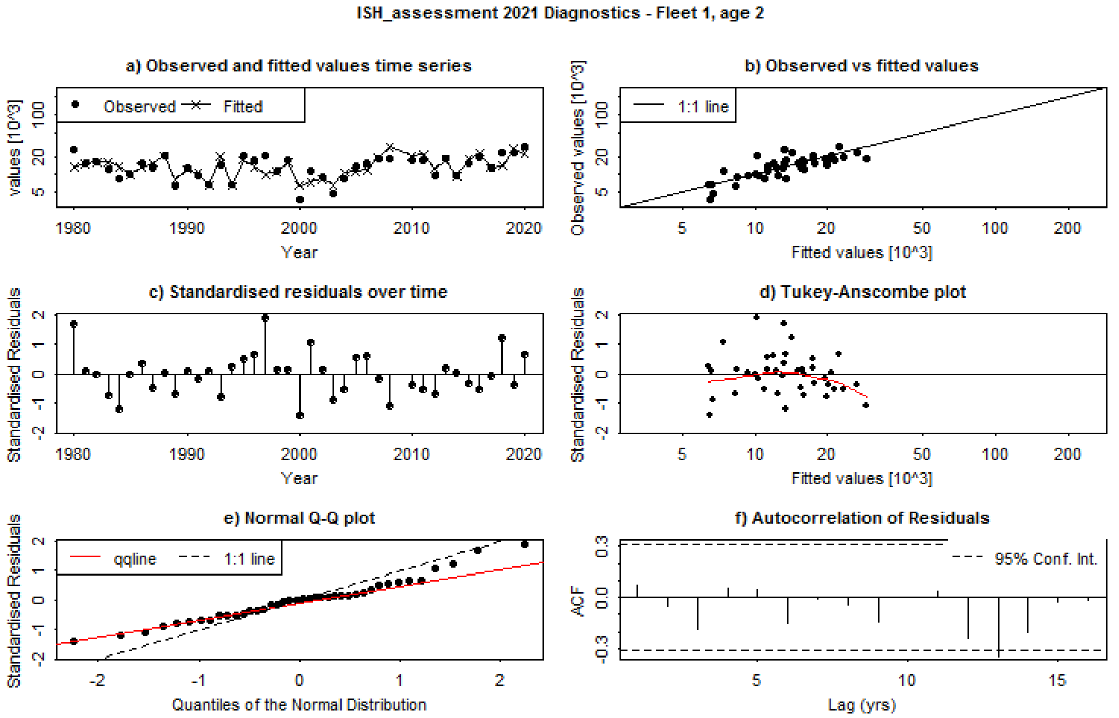


Figure 7.6.2 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.

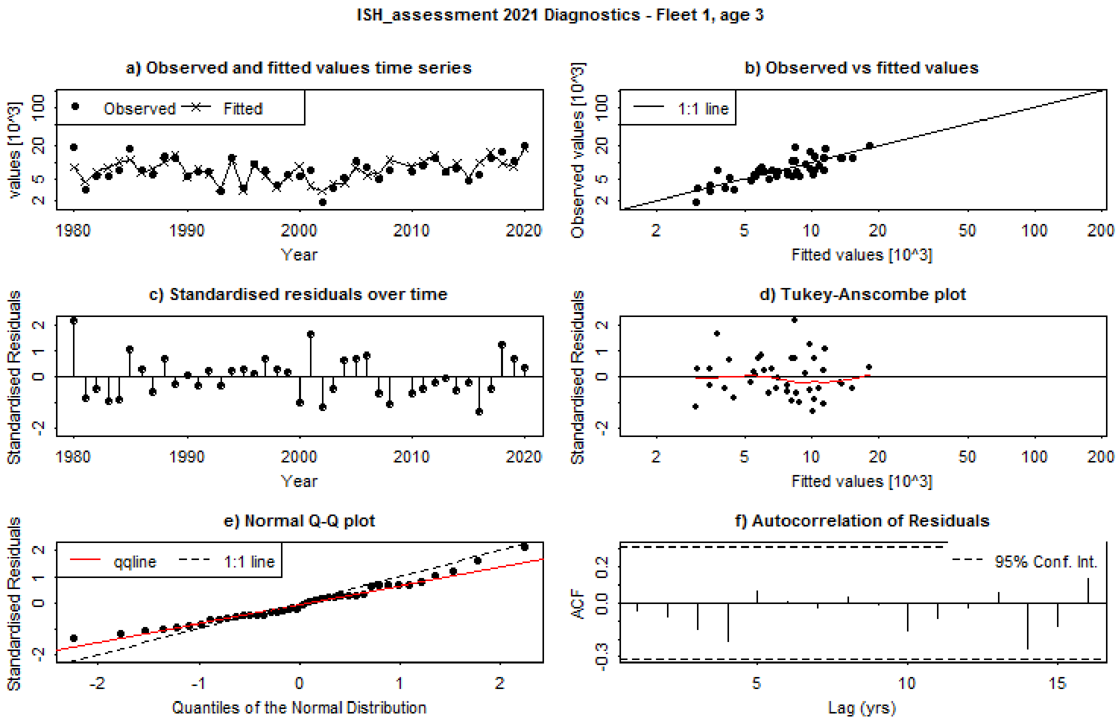


Figure 7.6.3 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

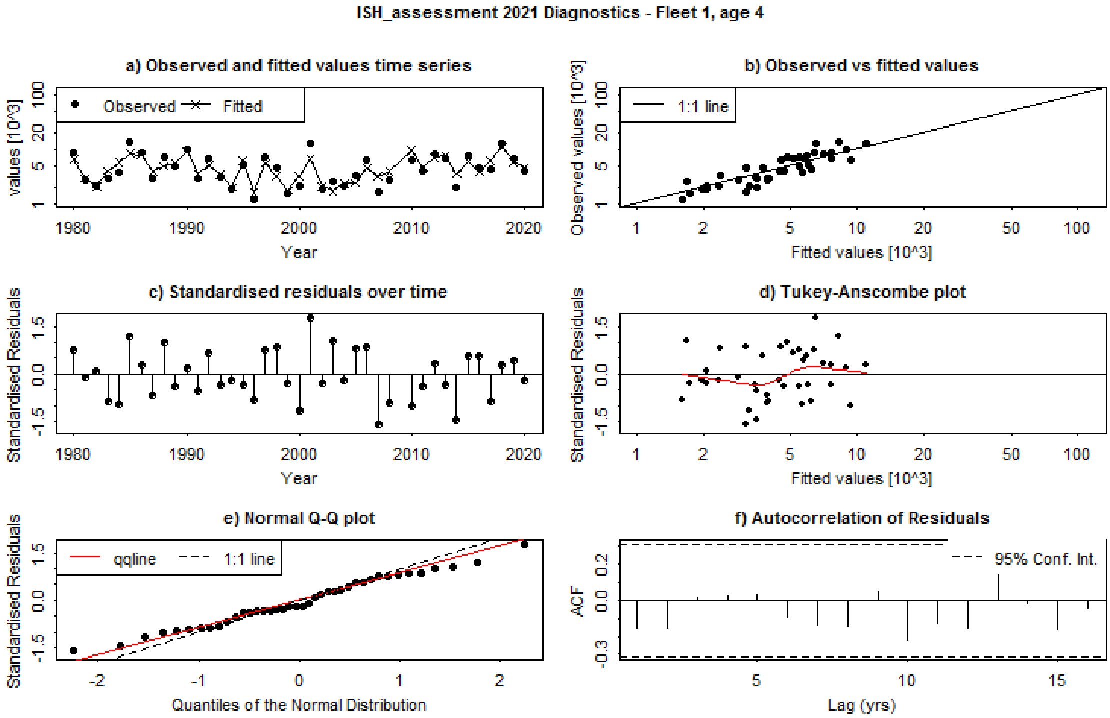


Figure 7.6.4 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.

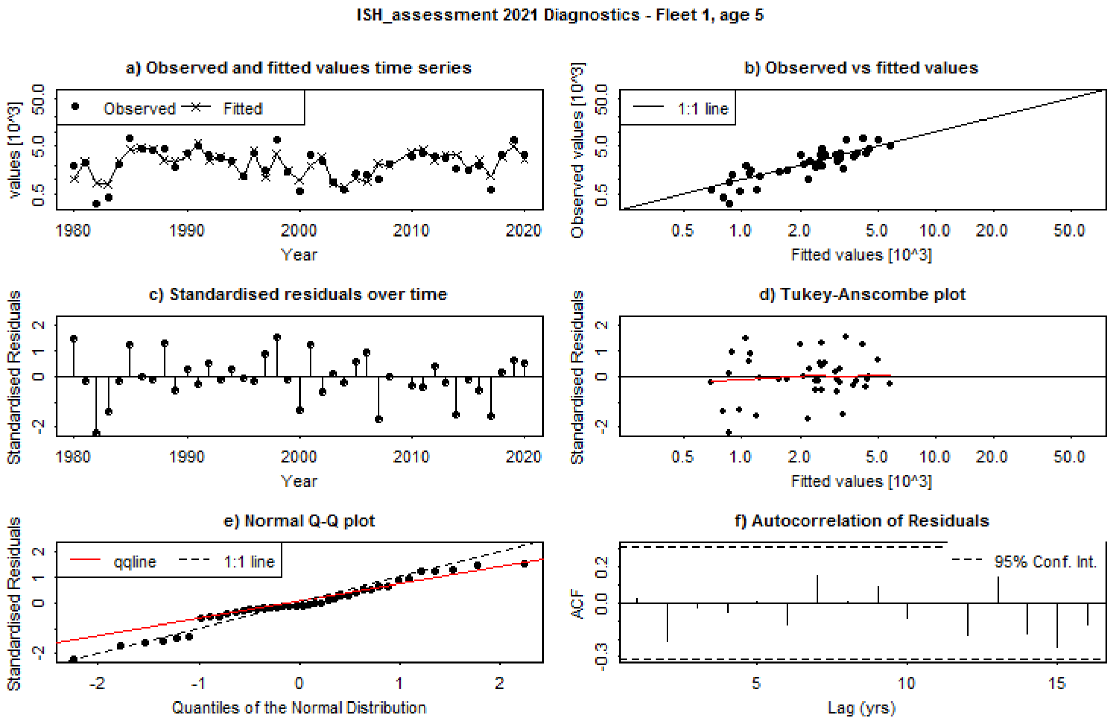


Figure 7.6.5 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.

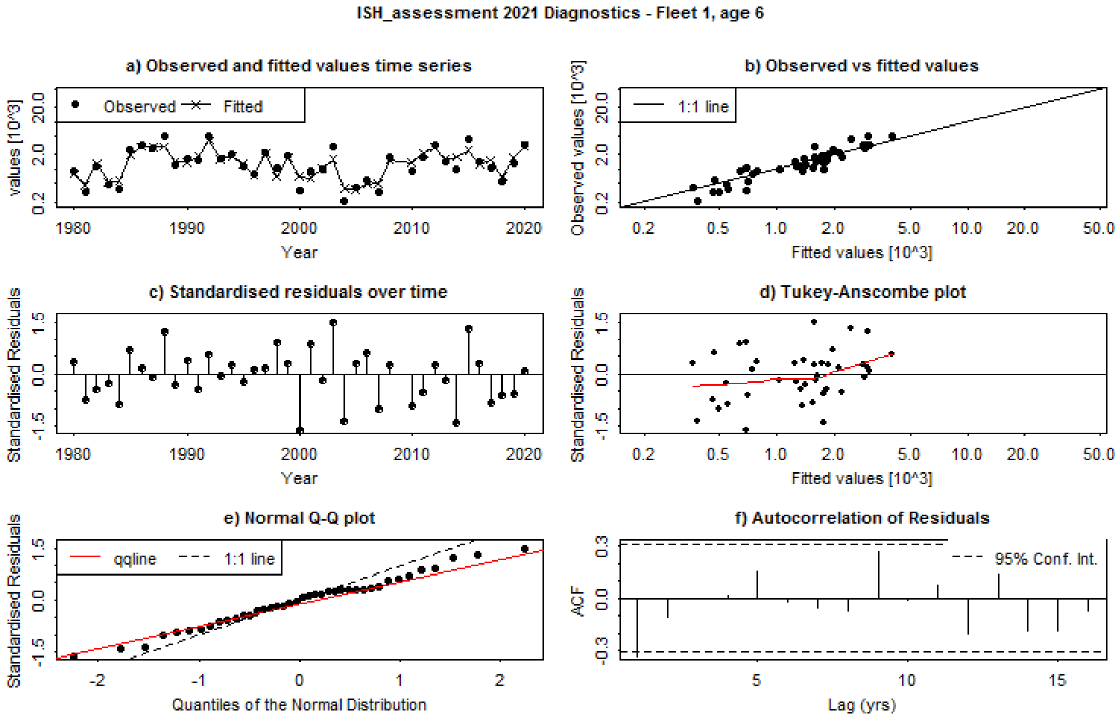


Figure 7.6.6 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

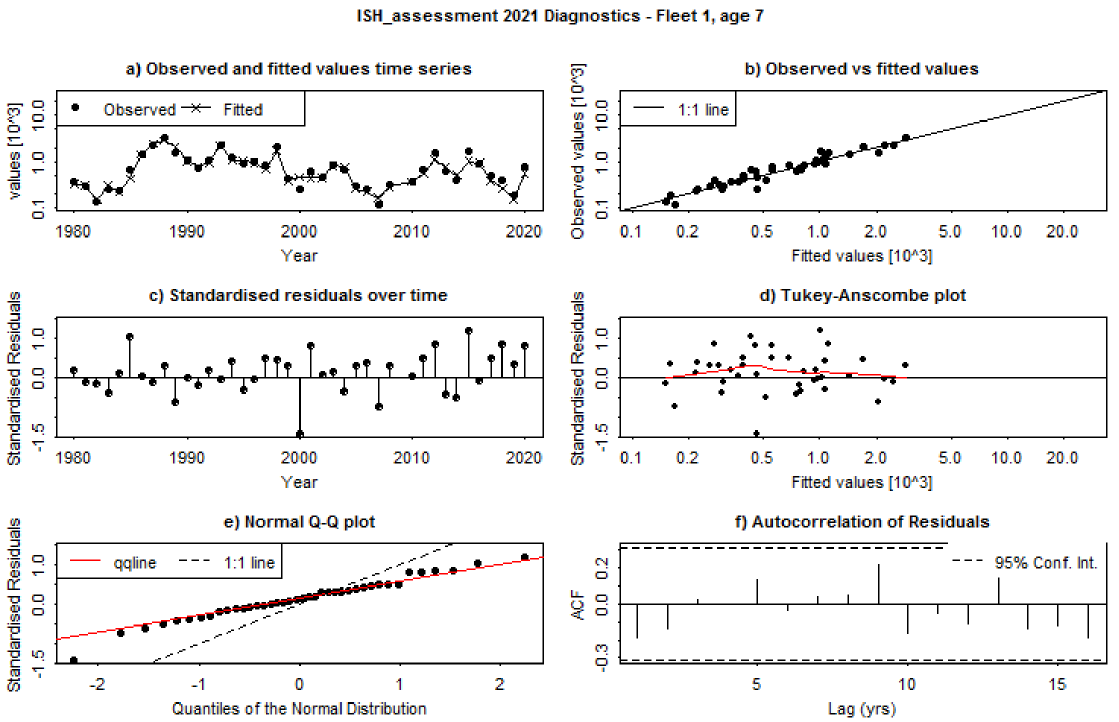


Figure 7.6.7 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

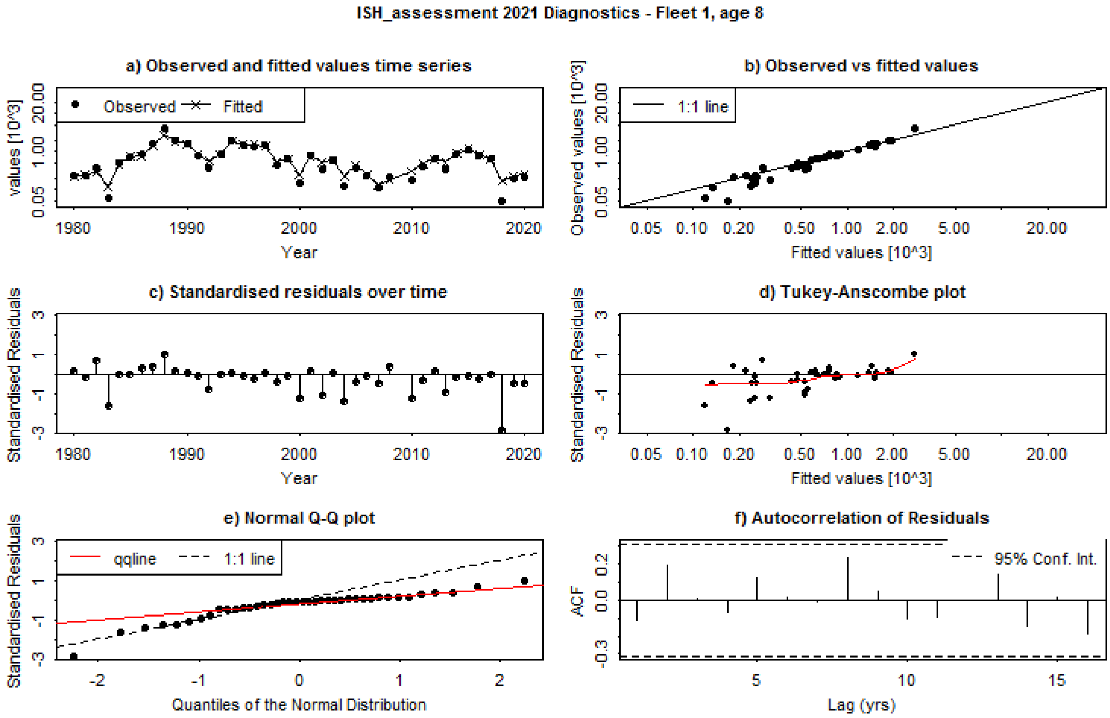


Figure 7.6.8 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.

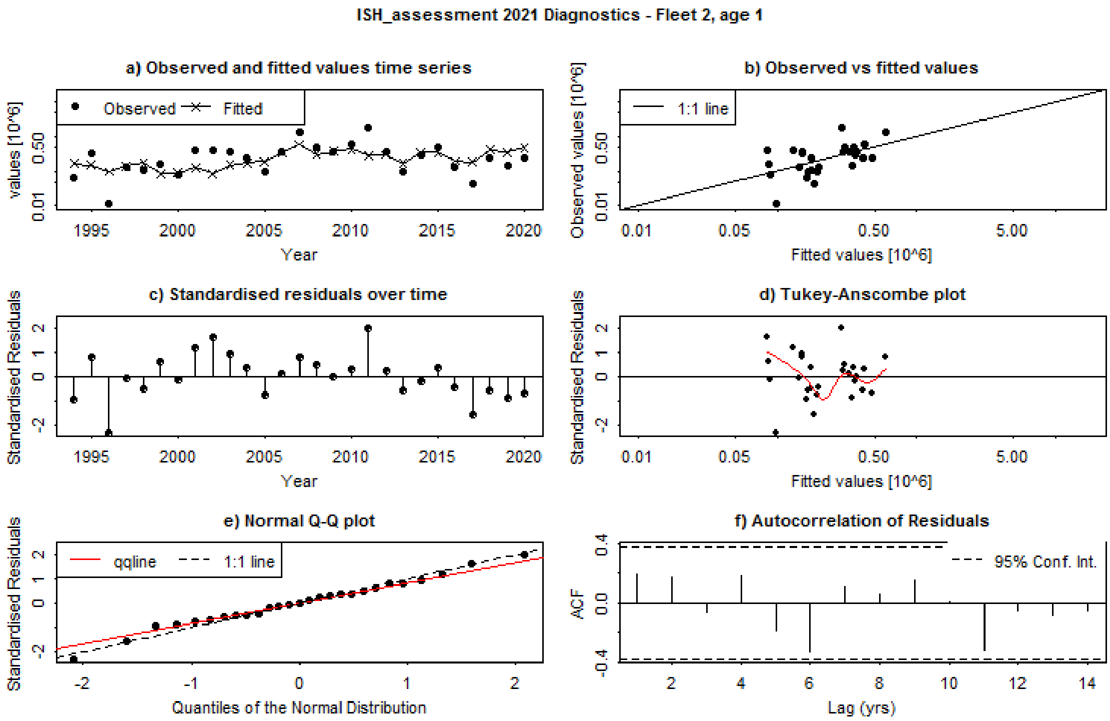


Figure 7.6.9 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age1.

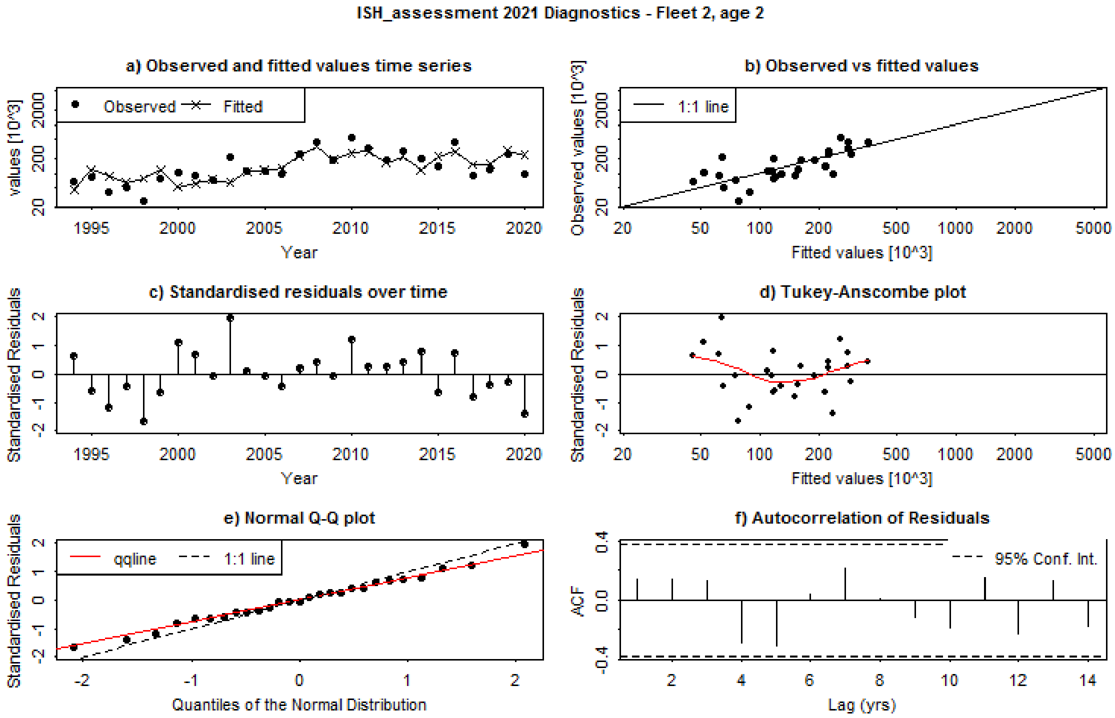


Figure 7.6.10 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age2.

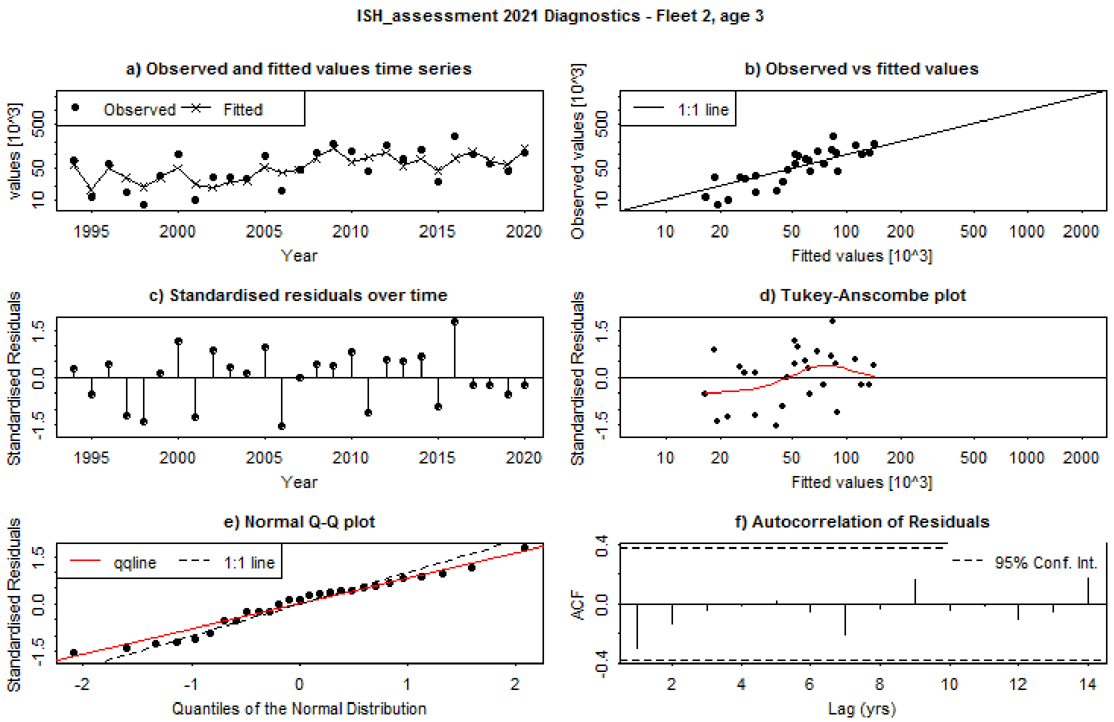


Figure 7.6.11 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age3.

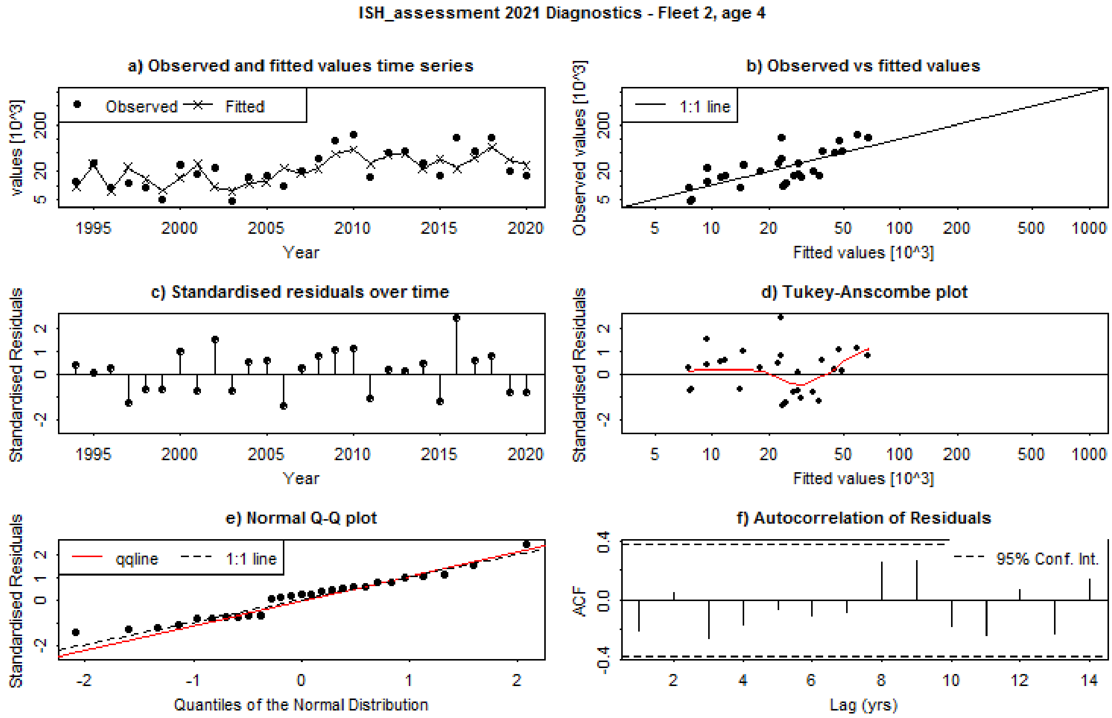


Figure 7.6.12 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age4.

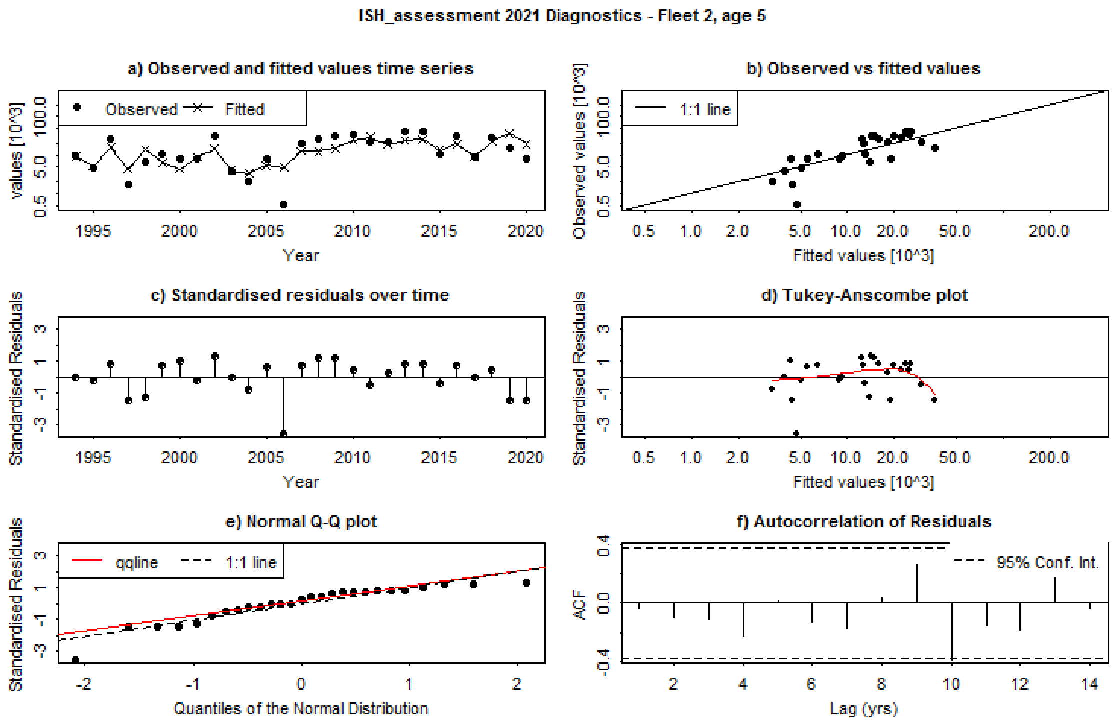


Figure 7.6.13 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age5.

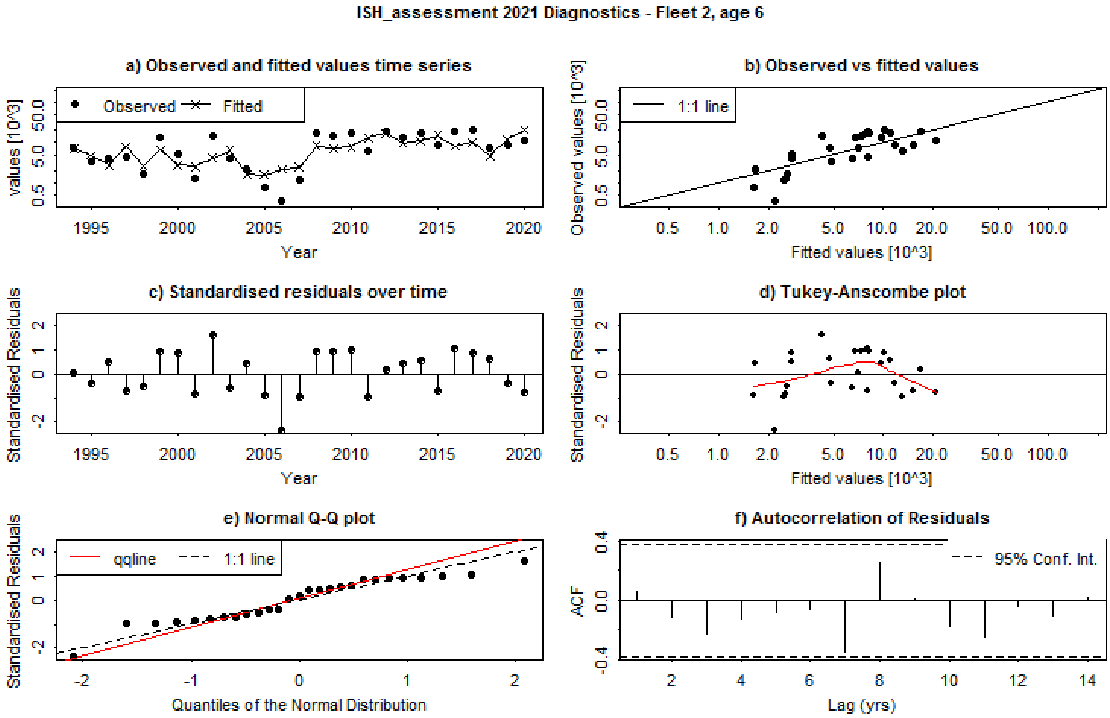


Figure 7.6.14 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age6.

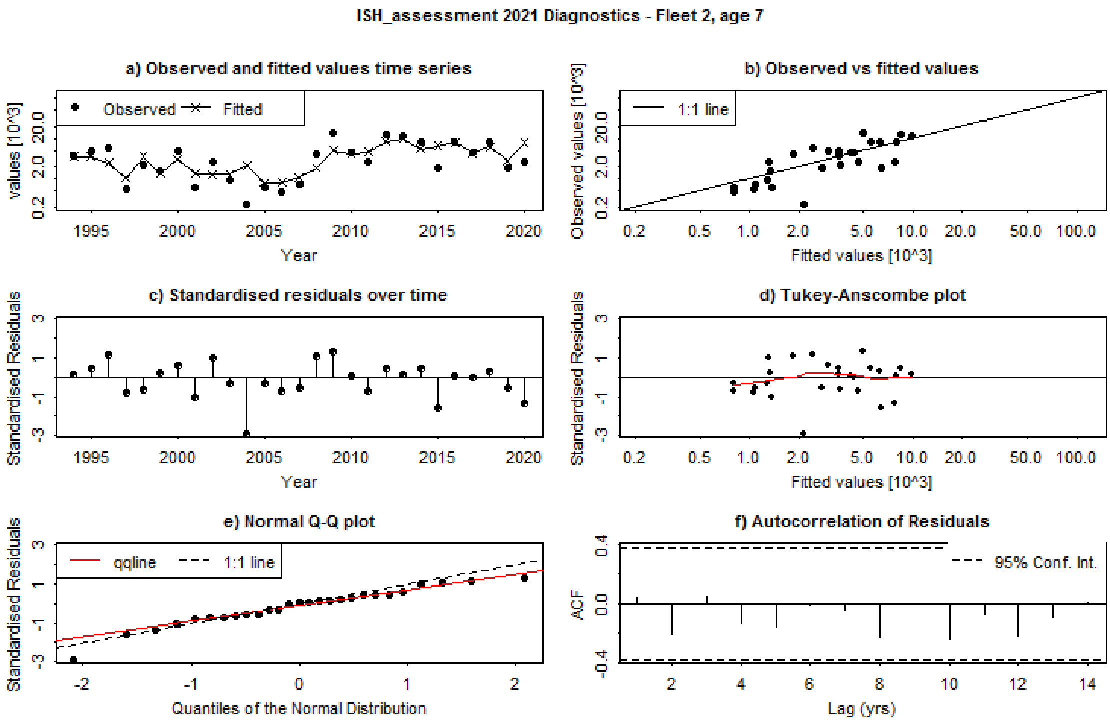


Figure 7.6.15 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age7.

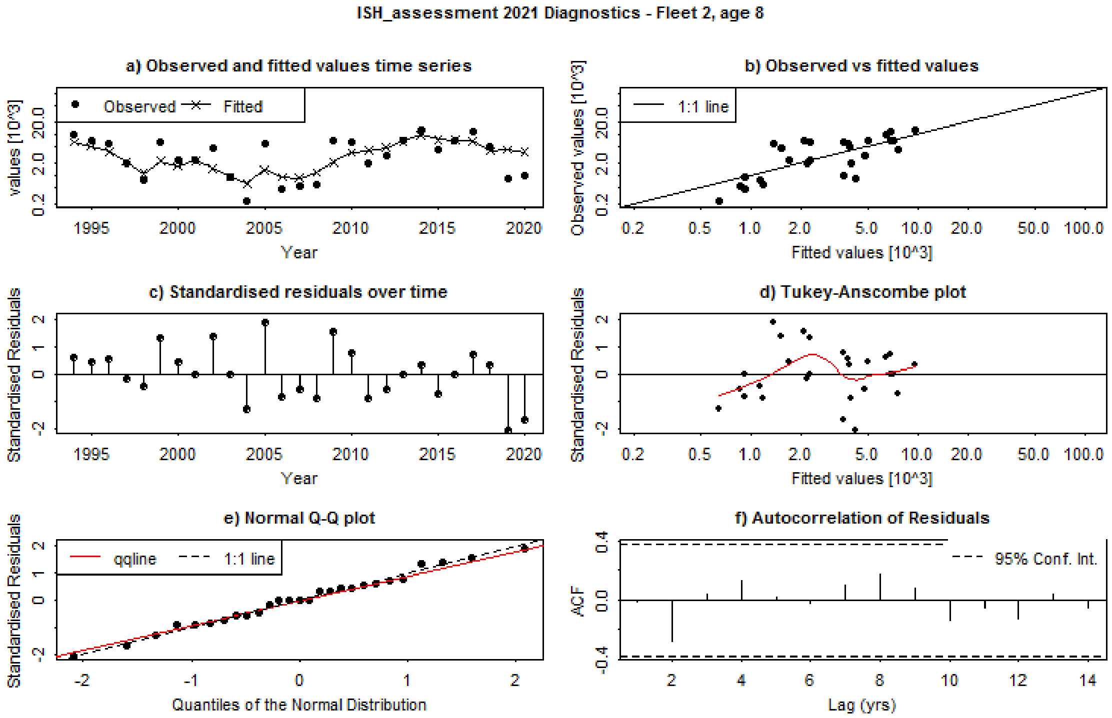


Figure 7.6.16 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age8.

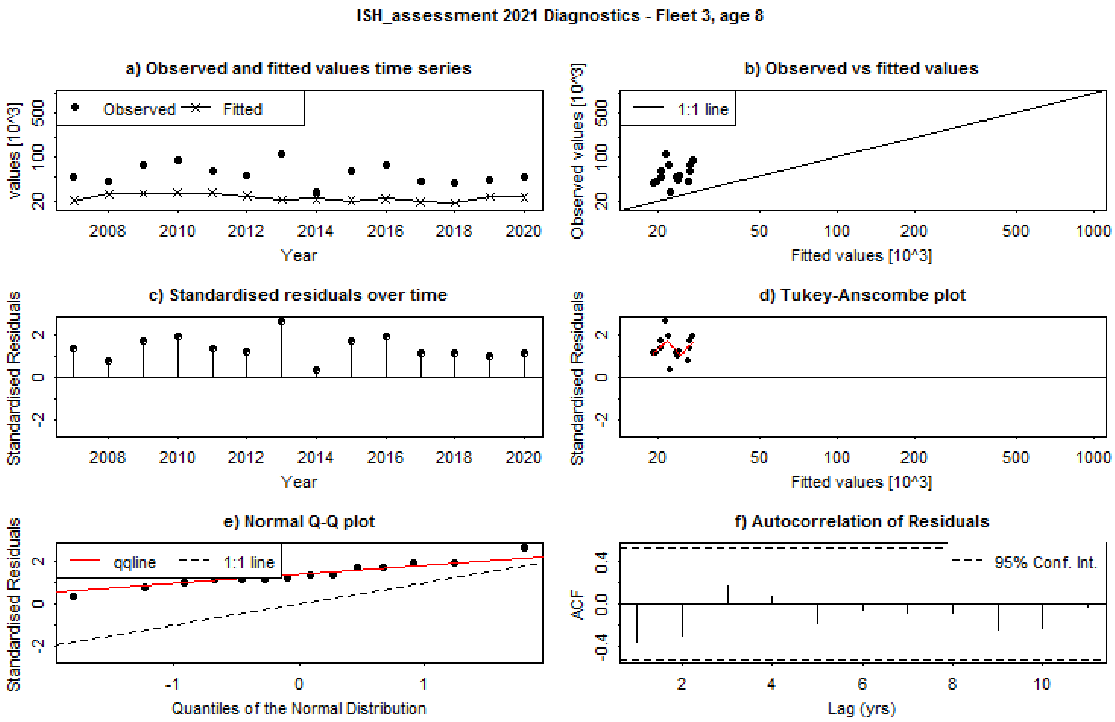


Figure 7.6.17 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the SSB acoustic survey (SSB 7.aN)).

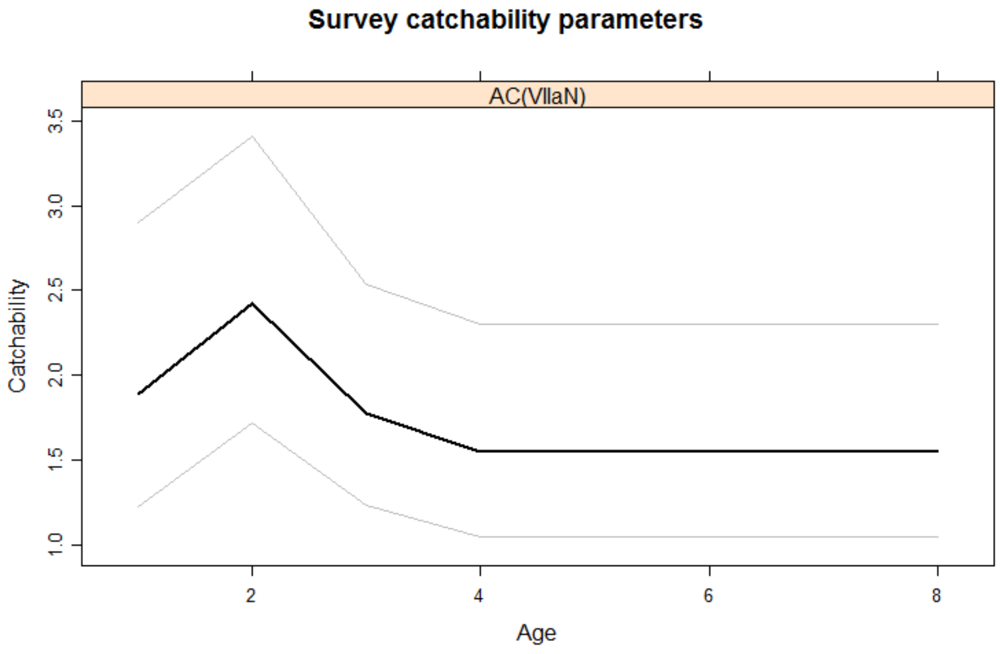


Figure 7.6.18 Herring in Division 7.a North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(7.aN).

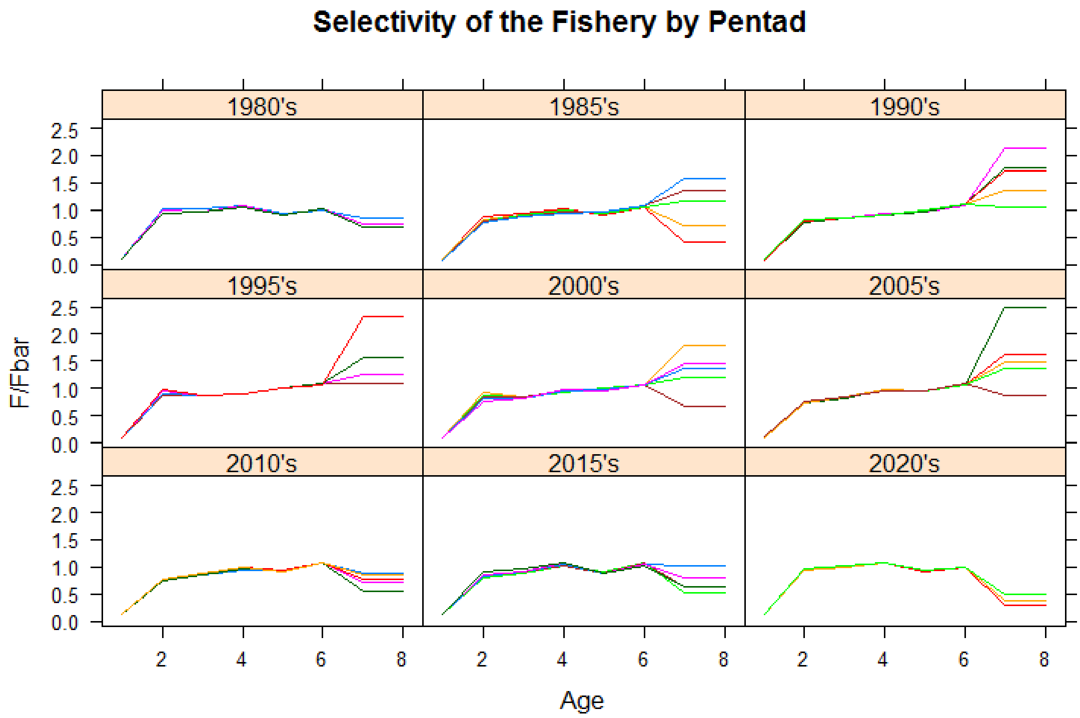


Figure 7.6.19 Herring in Division 7.a North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

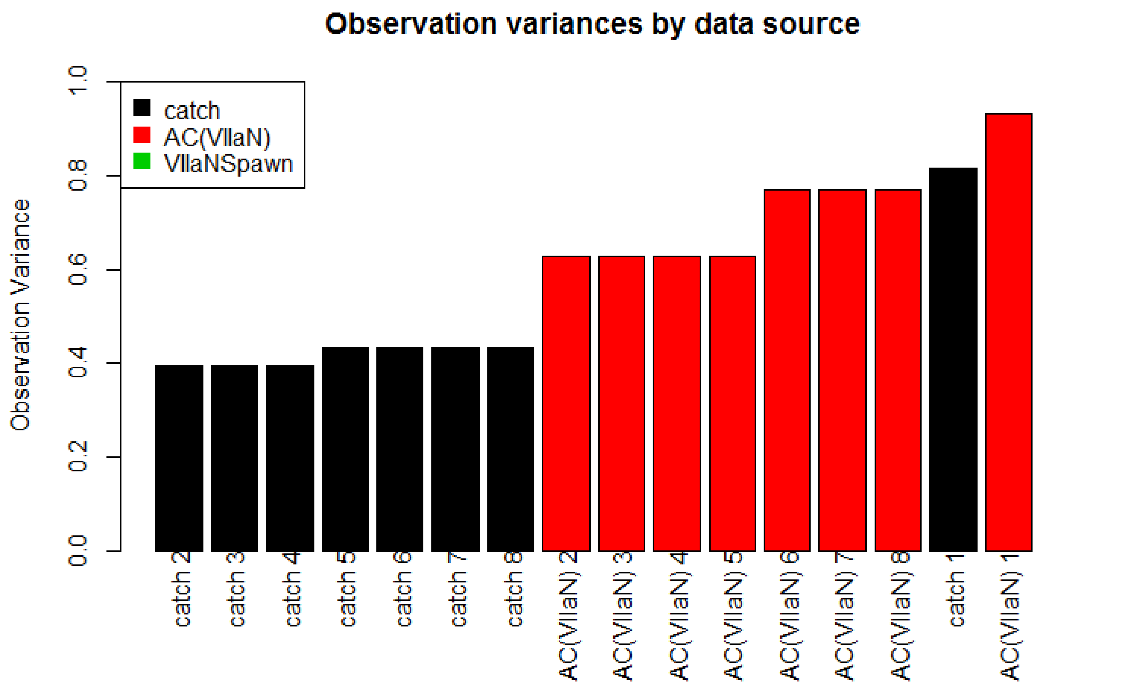


Figure 7.6.20 Herring in Division 7.a North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model. The observation variance of 7.aNSpawn is fixed at 0.4

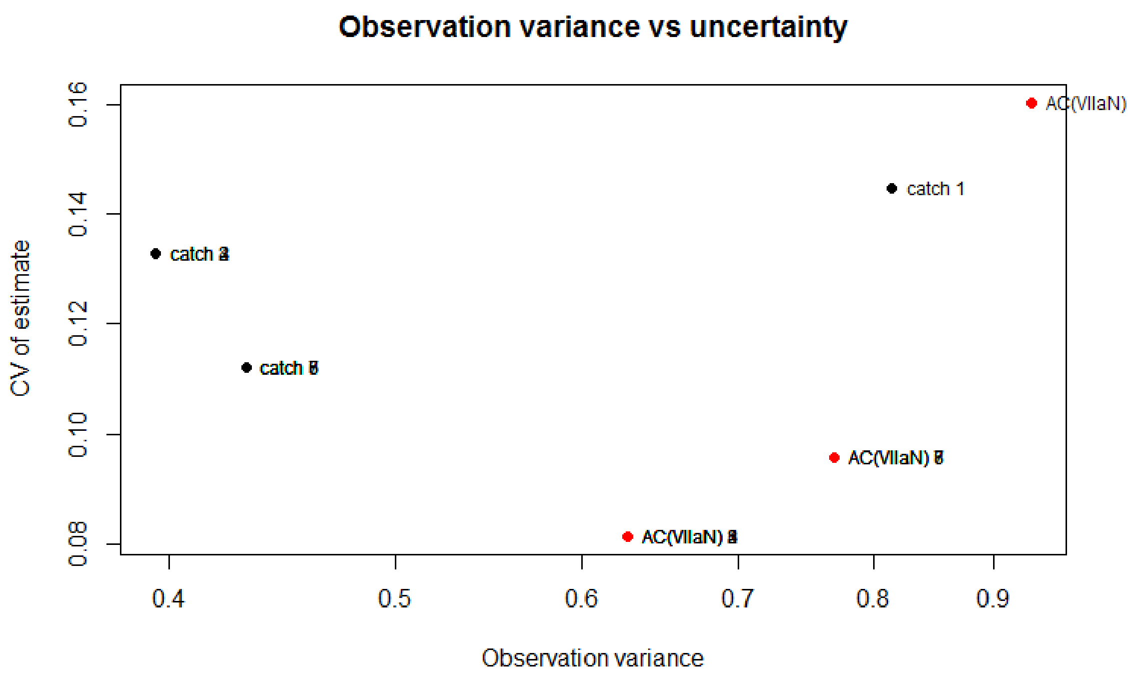


Figure 7.6.21 Herring in Division 7.a North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

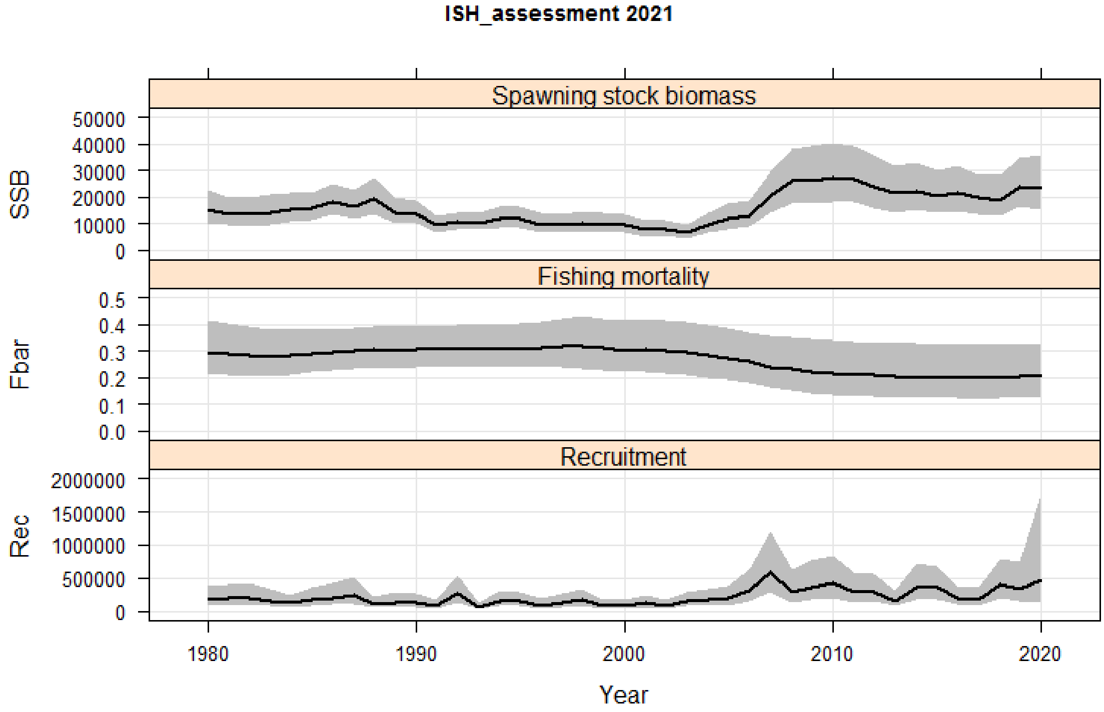


Figure 7.6.22 Herring in Division 7.a North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean $F_{4\text{-}6}$.

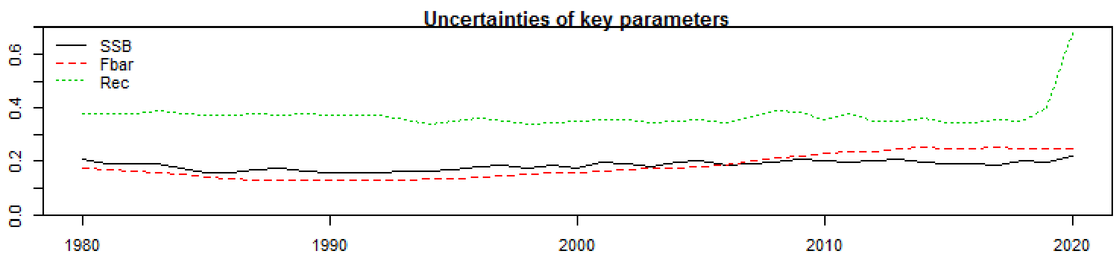


Figure 7.6.23 Herring in Division 7.a North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment 1 winter ring.

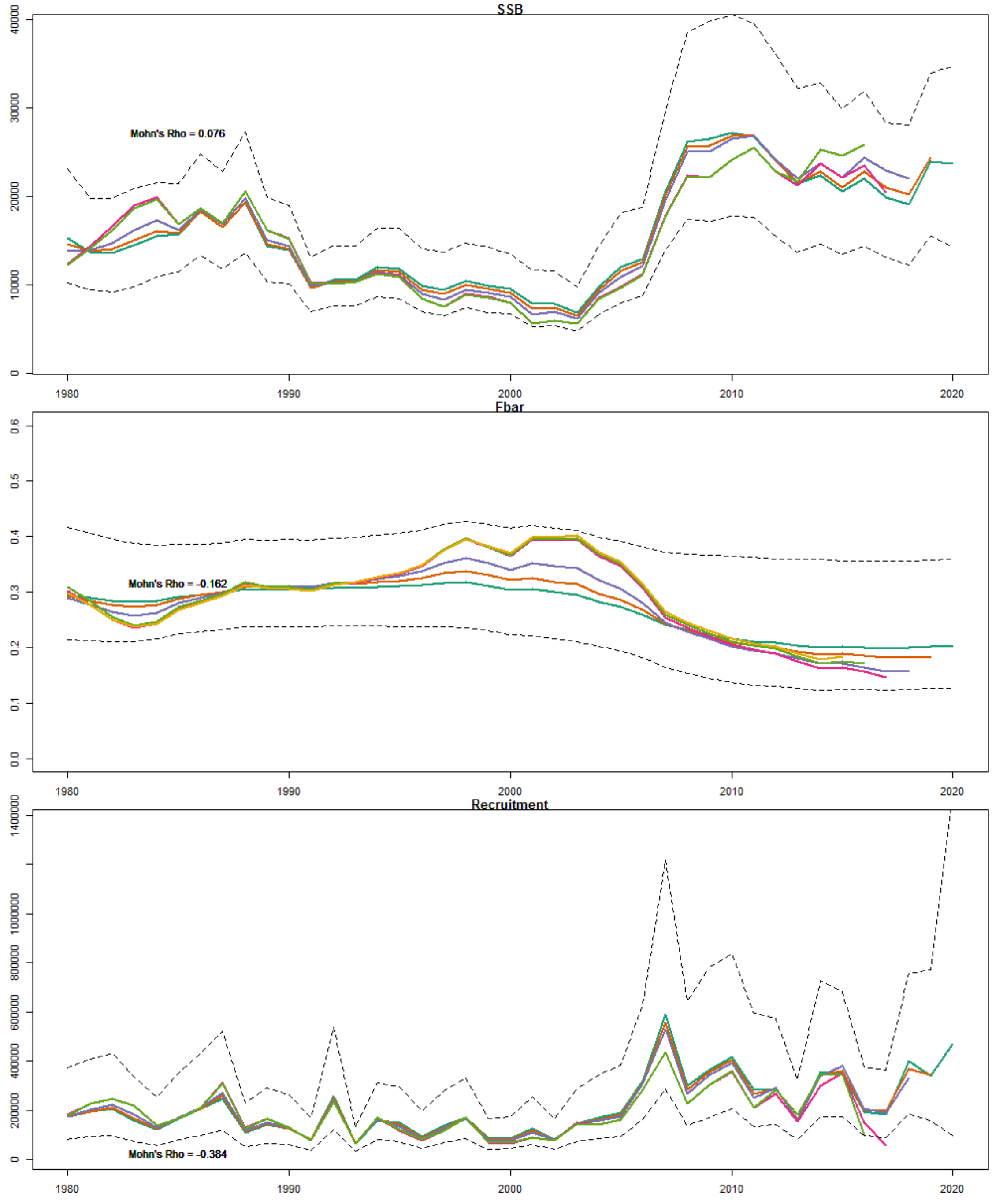


Figure 7.6.24 Herring in Division 7.a North (Irish Sea). Analytical retrospective patterns (2018 to 2013) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment. Confidence limits for the current year assessment are shown with dashed lines.

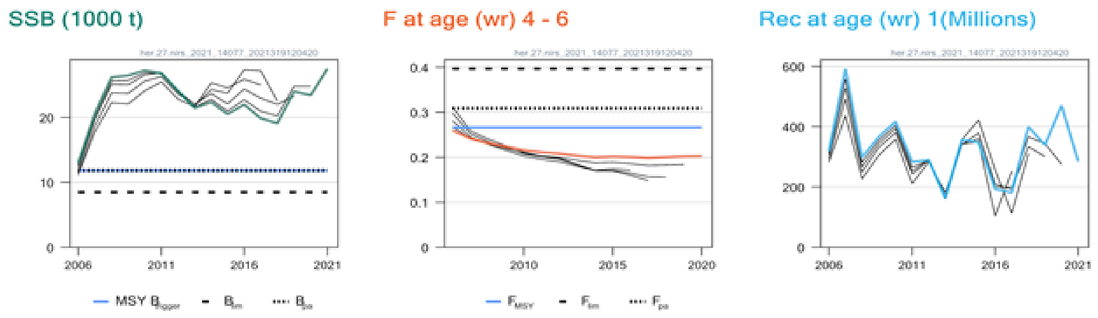


Figure 7.6.25 Herring in Division 7.a North (Irish Sea). Comparison of stock parameters between the 2021 assessment (red line) and previous assessments.

8 Stocks with limited data

Three herring stocks have very little data associated with them and have been poorly described in recent reports. These are Clyde herring, part of Division 6aN (Section 5.11 in ICES 2005a), herring in 7.e,f and herring in the Bay of Biscay (Subarea 8). In this section, only the time-series of landings are maintained.

8.1 Clyde herring

In 2011, under the provisions of the TAC and Quota Regulations (57/2011), the European Commission delegated the function of setting the TAC for certain stocks which are only fished by one Member State, to that Member State. This provision currently applies to herring in the Firth of Clyde with TAC setting responsibility delegated to Scotland. The stock is as such not an ICES stock with limited data, but it has been decided to continue to display the updated historical landings table for reasons of continuity. Since 1998 the agreed TAC for Clyde herring has never been reached. The TAC has been 583 t in 2020. No landings are reported in 2020 (Table 12.1).

8.2 Division 7.e.f

Figure 12.1 shows the time-series of landings over the period 1974–2020 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 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 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. Landings in 2020 amount to just 1 tonne (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.

Table 12.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1959–2019. 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**		
Scotland	163	54	266	-	90	119	21	0	0	0	0	0	0			0
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
Total	621	676	754	301	201	303	21	0	0	0	0	0	0			0

***Calculated from estimates of weight per box and in some years estimated bycatch in the sprat fishery**

****Reported to be at a low level, assumed to be zero, for 1989–1995.**

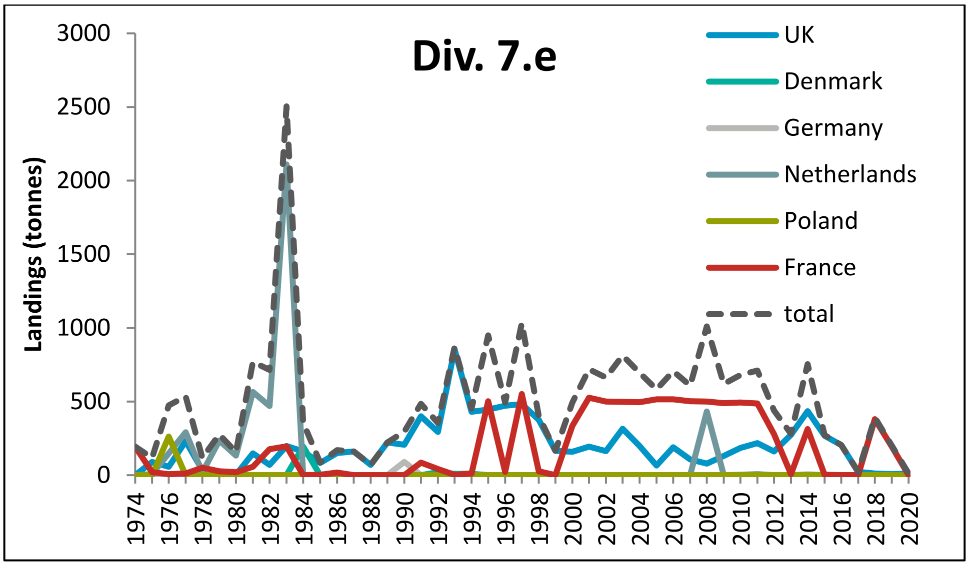
Table 12.2. Stocks with limited data. Landings of herring in Divisions 7.e and 7.f. Source: ICES official landings data- base 2008 – 2018, national databases and ICES preliminary catch statistics 2019 and 2020.

Division	Country	2014	2015	2016	2017	2018	2019*	2020*
7e	UK (Eng,Wal,NI,Scot,Guernsey)	435	268	204	22	11	8	11
7e	Denmark	-	-	-	-	-	-	-
7e	France	314	3	1	1	380	193	-
7e	Germany, Fed. Rep. Of	-	-	-	-	-	-	-
7e	Netherlands	4	0	-	-	-	-	-
	Total	753	271	205	23	391	201	11
Division	**Country**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019***	**2020***
7f	UK (Eng, Wal, Scot, NI)	20	111	227	29	3	5	1
7f	Belgium	-	-	-	-	-	-	-
7f	France	-	-	-	-	-	-	-
7f	Netherlands	-	-	-	-	-	5	-
7f	Poland	-	-	-	-	-	-	-
	Total	20	111	227	29	3	10	1

***Preliminary data**

Table 12.3. Stocks with limited data. Landings of herring in Subarea 8.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
France	50	82	22	7	5	5	4	12	3	1	1
Netherlands	502	222	-	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-
Spain	38	54	2	-	-	-	-	-	-	-	-
UK	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	1	1	-	-
	590	358	24	7	5	5	4	13	13	1	1



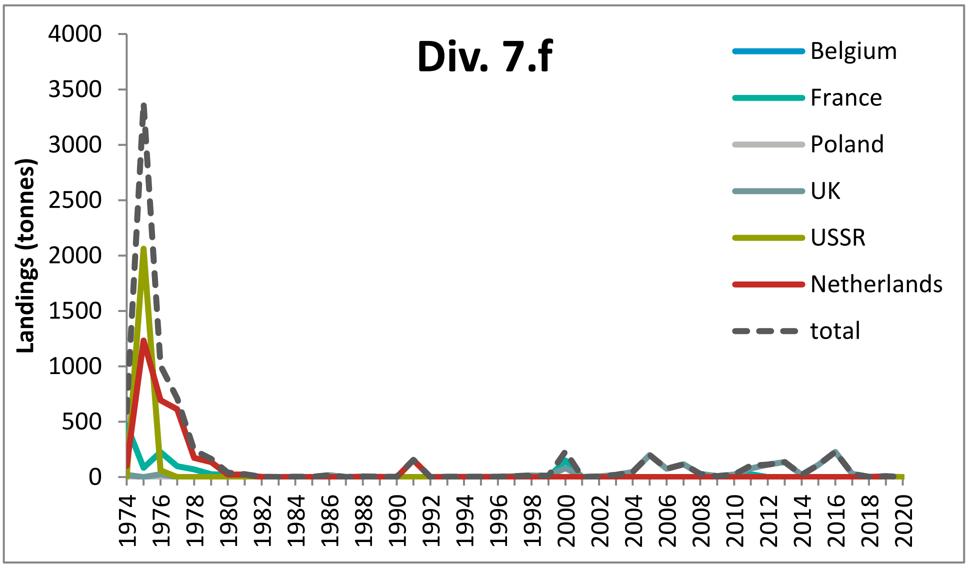


Figure 12.1. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

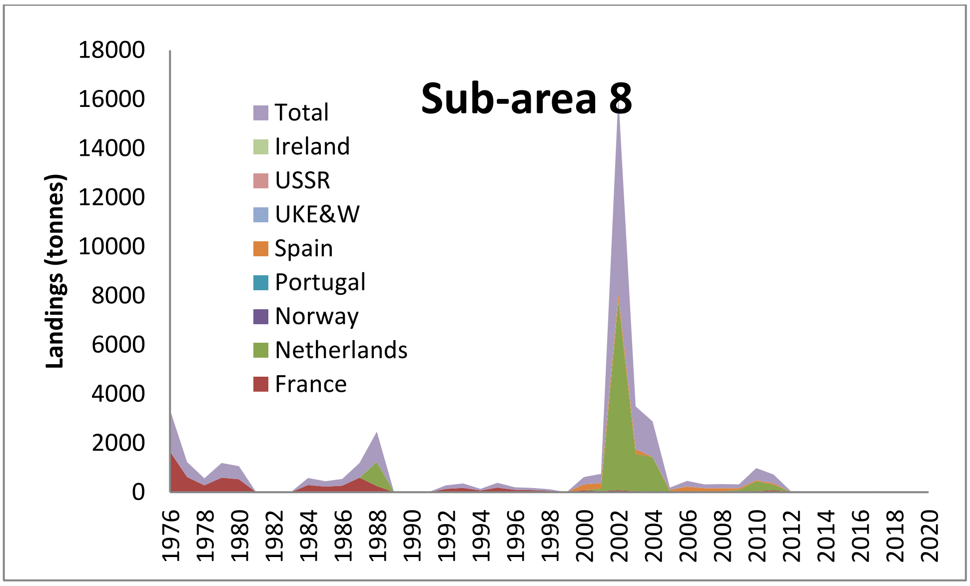


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

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 2020, 1-group dominated the catches (Figure 9.2.1).

9.2.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.2.2 and Figure 9.2.2 by half year. Mean weight-at-age in the first half year increased in 2020 and thereby ending the decreasing trend in weight at age.

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, and 2020.

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 2020 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 2020. 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 (0.48) for age 0 and high (0.80) 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, 0.45, and 0.51). 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 and 2020 (negative catch residuals for all ages).

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.85), 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 and 2020 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, F and SSB estimates show virtually no retrospective pattern in the last three years.

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 the recruitment was below average.

9.2.9 Short-term forecasts

Input

Input to the short-term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2021 is the geometric mean of the recruitment 1983–2019 (111 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2020. 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 2016–2020. Natural mortality is the fixed M as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.2.12) shows that to obtain an SSB equal to MSY $B_{trigger}$, a TAC of 5464 t should be set for 2020. The predicted F that follows from this TAC is 0.022. The TAC according to the escapement strategy is therefore 5464 t in 2020.

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 (van Deurs *et al.*, 2011).

9.2.11.1 Status of the stock

The SSB was below B_{lim} in 2019 and 2020. In 2021 it is estimated to be above B_{lim}, but below B_{pa}. 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 2021 is lower than expected from the forecast in 2020, due to the lower than expected occurrence of age 1 in dredge survey and catches leading to a downscaling of recruitment in 2019.

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 has decreased since 2013 only to increase to the record high level of 98% in 2017 originating from a high recruitment in 2016. This year class is seen in the 2019 catch with highest proportion of 3-group in the time-series (52%). Catches in 2020 were dominated by 1-group (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.

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 2019 was the lowest in the time-series and CPUE was about average. In 2020 effort increased, and there was an overall increase in CPUE to a level similar to 2010 (the year after the strong 2009-recruitment).

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).

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 (0.38) 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 (1.01 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 an overestimation of SSB in 2015 and 2016 as a result of an overestimation of recruitment in 2013 and 2014, and the 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. 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 4^{th} 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 2020. 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 2021 is the geometric mean of the recruitment in 2010–2019 (20 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 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 2016–2020. 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 even with no fishing in 2020 (F=0), the stock will be below Bpa in 2022. Hence, the default advice according to MSY would be 0 catch in 2020. However, in order to achieve data for the assessment model a monitoring TAC of 5000 t is advised to maintain the quality of the assessment consistent with previous year's advice (HAWG 2019).

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 0.45 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex.

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 (2010–2020) and the quality of the assessment will likely improve once a longer time-series becomes available.

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 16 out of the last 20 years and only at or above B_{pa} in 2 out of 20 years., 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.

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 2019, the 3-group provided the second largest contribution to the catches (44%) a bit below the 65% reported in 2012 when the large 2009 year class were 3 years old (Figure 9.4.1). The proportion of group-1 was 67% in 2020.

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 since 2013 but has declined recently. The 2020 mean weight was above the long-term average.

9.4.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey in December as described in the Stock Annex. The values used are given in Table 9.4.3.

9.4.4 Natural mortality

In 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.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2020 show above average indices for both age 0 and age 1 in 2020 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e. $r^2 = 0.37$ on log scales). In 2014, 13 new positions were included in the survey in SA 3r. Only two of the new positions were taken in squares not included before (42F5 and 42F6). All the new positions have been included in the survey index since 2014 (Table 9.4.4) for assessment purposes, to obtain a better spatial coverage. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2016).

The Norwegian acoustic survey (2009–2020) carried out in Norwegian EEZ is used as tuning series in the assessment in SA 3r (Table 9.4.13 and figures 9.4.14-9.4.16). The survey covers the main sandeel grounds in SA 3r. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.13.

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 ro = 0.57) and with density dependent catchability (Mohn's ro = 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.

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 (0.64) and high for age 1 (0.78), 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 (0.68) 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 an increased weight at age in 2020 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 2021 is the geometric mean of the recruitment 1986–2019 (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 2016–2020. 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 161 335 t in 2021 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 299 368 t, well above MSY $B_{trigger}$ of 129 000 t, in 2021. The TAC according to the escapement strategy is therefore 161 335 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.

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. Recruitment estimates for 2018-2020 are all above 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 2020, age group 1 completely dominated the catches to an extent seen previously only in 2000 and 2015 (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 for all ages after the very low levels in 2001 to 2005. The second half year mean weights and mean weights of older ages in some years are affected by the very limited sampling at this time of year.

9.5.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey 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 2018 was the highest since 2004 reflecting the TAC given followed by a much lower effort in 2019 and 2020. CPUE in later years has been around the average prior to 2004 from 2013-2018 but high in 2020.

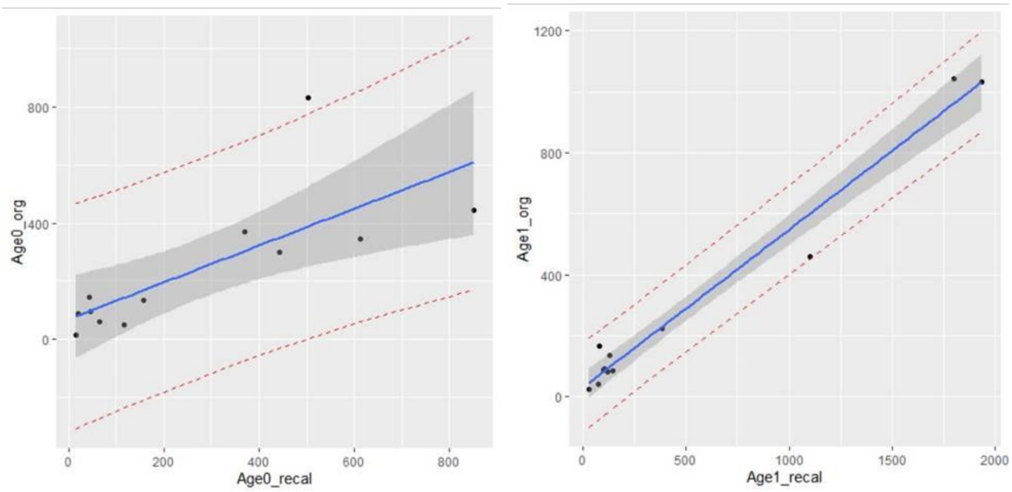
Tuning series used in the assessments

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 the 2019 and 2020 year classes are both among the 6 highest recruitments on record.

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.

In 2020, a substantially lower than usual number of stations was sampled due to limitations in survey time. HAWG conducted an analysis of the relationship between the index based on this limited survey coverage and the index based on all stations sampled in previous years. The analyses showed that there was a high correlation between the two indices but that the 11 stations sampled in 2020 generally resulted in a substantially higher survey index. HAWG concluded that using the 2020 index directly would therefore introduce a positive bias in the 2020 survey index. This was confirmed by performing an explorative assessment using the observed 2020 index from the 11 stations and the 2020 index corrected using the historical relationship between the index on the 11 stations and throughout the area. The assessment based on the 11 stations showed substantial retrospective bias in 2019 and patterns in 2020 survey residuals whereas this was not the case when using the corrected index. Hence, the corrected index was used in the final assessment.



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 2020. 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 very low (0.30 to 0.37) for all ages. In fact, the CV of the dredge survey hits the lower bound for age 0 and this suggests that the model due to very low catches in recent years is essentially only using the survey to estimate stock size etc.

The model CV of catch-at-age ("sqrt(catch variance) ~CV", in Table 9.5.5 is moderate (0.72) for age 1 and age 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 (1.53), 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. This is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years.

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} but below B_{pa} in 2015 only. SSB is estimated at 67,914 in 2020. $F_{(1-2)}$ is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004 and decreased in 2019 and 2020. Recruitment has been high in 2014, 2016, 2017, 2019 and 2020.

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 2021 is the geometric mean of the recruitment 1993–2019 (74 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2020. 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 2016–2020. 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 above the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2021 with an F of 0.15 (= Fcap) and a TAC of 77 512t. The TAC according to the escapement strategy and an Fcap of 0.15 is therefore 77 512 t in 2021.

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, 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 2021 is high (0.40).

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016, 2017, 2019 and 2020 are all above the long-term average, while 2018 is low. 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 between B_{lim} and B_{pa} in 2020. The spawning stock size is above B_{pa} in 2021.

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 criteria 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

ICES 2007. Report of the Ad Hoc Group on Sandeel. ICES CM 2007/ACFM:38

ICES 2008. Report of the Ad Hoc Group on Sandeel. ICES CM 2008/ACOM:59

ICES. 2016. Report of the Benchmark on Sandeel (WKSand 2016), 31 October - 4 November 2016, Bergen, Norway. ICES CM 2016/ACOM:33. 301pp.

ICES 2016 – also reference to WGSAM 2015 (published in 2016?)

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35.60 pp.

ICES. 2019. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 1:2. 971 pp. http://doi.org/10.17895/ices.pub.5460 - WD01 Marine Scotland Science sandeel dredge survey indices for SA4.

Johnsen, E. (2020). Råd for tobisfiskeriet i norsk sone for 2020 og rapport for tobistokt i Nordsjøen 23. april – 13. mai. Toktrapport/Havforskningsinstituttet/ISSN 1503 6294/Nr.9–2020. Summary in English in Vedlegg3. (https://www.hi.no/resources/publikasjoner/toktrapporter/2020/Toktrapport2020281_VersionFinal.pdf)

van Deurs, M., Hartvig, M., & Steffensen, J. F. (2011). Critical threshold size for overwintering sandeels (Ammodytes marinus). Marine biology, 158(12), 2755-2764.

Table 9.1.1 Sandeel. Catches ('000 t), 1952-2020. (Data provided by Working Group Members).

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithuania	Total
1952	1.6	-	-	-	-	-	-	-	-	1.6
1953	4.5	-	-	-	-	-	-	-	-	4.5
1954	10.8	-	-	-	-	-	-	-	-	10.8
1955	37.6	-	-	-	-	-	-	-	-	37.6
1956	81.9	5.3	-	-	-	1.5	-	-	-	88.7
1957	73.3	25.5	-	-	3.7	3.2	-	-	-	105.7
1958	74.4	20.2	-	-	1.5	4.8	-	-	-	100.9
1959	77.1	17.4	-	-	5.1	8	-	-	-	107.6
1960	100.8	7.7	-	-	-	12.1	-	-	-	120.6
1961	73.6	4.5	-	-	-	5.1	-	-	-	83.2
1962	97.4	1.4	-	-	-	10.5	-	-	-	109.3
1963	134.4	16.4	-	-	-	11.5	-	-	-	162.3
1964	104.7	12.9	-	-	-	10.4	-	-	-	128.0
1965	123.6	2.1	-	-	-	4.9	-	-	-	130.6
1966	138.5	4.4	-	-	-	0.2	-	-	-	143.1
1967	187.4	0.3	-	-	-	1	-	-	-	188.7
1968	193.6	-	-	-	-	0.1	-	-	-	193.7
1969	112.8	-	-	-	-	-	-	0.5	-	113.3
1970	187.8	-	-	-	-	-	-	3.6	-	191.4
1971	371.6	0.1	-	-	-	2.1	-	8.3	-	382.1
1972	329.0	-	-	-	-	18.6	8.8	2.1	-	358.5
1973	273.0	-	1.4	-	-	17.2	1.1	4.2	-	296.9
1974	424.1	-	6.4	-	-	78.6	0.2	15.5	-	524.8
1975	355.6	-	4.9	-	-	54	0.1	13.6	-	428.2
1976	424.7	-	-	-	-	44.2	-	18.7	-	487.6
1977	664.3	-	11.4	-	-	78.7	5.7	25.5	-	785.6
1978	647.5	-	12.1	-	-	93.5	1.2	32.5	-	786.8
1979	449.8	-	13.2	-	-	101.4	-	13.4	-	577.8
1980	542.2	-	7.2	-	-	144.8	-	34.3	-	728.5
1981	464.4	-	4.9	-	-	52.6	-	46.7	-	568.6
1982	506.9	-	4.9	-	-	46.5	0.4	52.2	-	610.9
1983	485.1	-	2	-	-	12.2	0.2	37	-	536.5
1984	596.3	-	11.3	-	-	28.3	-	32.6	-	668.5
1985	587.6	-	3.9	-	-	13.1	-	17.2	-	621.8
1986	752.5	-	1.2	-	-	82.1	-	12	-	847.8
1987	605.4	-	18.6	-	-	193.4	-	7.2	-	824.6
1988	686.4	-	15.5	-	-	185.1	-	5.8	-	892.8
1989	824.4	-	16.6	-	-	186.8	-	11.5	-	1039.1
1990	496.0	-	2.2	-	0.3	88.9	-	3.9	-	591.3

Year	Denmark	Germany	Faroes	Ireland	Nether-lands	Norway	Sweden	UK	Lithuania	Total
1991	701.4	-	11.2	-	-	128.8	-	1.2	-	842.6
1992	751.1	-	9.1	-	-	89.3	0.5	4.9	-	854.9
1993	482.2	-	-	-	-	95.5	-	1.5	-	579.2
1994	603.5	-	10.3	-	-	165.8	-	5.9	-	785.5
1995	647.8	-	-	-	-	263.4	-	6.7	-	917.9
1996	601.6	-	5	-	-	160.7	-	9.7	-	776.9
1997	751.9	-	11.2	-	-	350.1	-	24.6	-	1137.8
1998	617.8	-	11	-	-	343.3	8.5	23.8	-	1004.4
1999	500.1	-	13.2	0.4	-	187.6	22.4	11.5	-	735.1
2000	541.0	-	-	-	-	119	28.4	10.8	-	699.1
2001	630.8	-	-	-	-	183	46.5	1.3	-	861.6
2002	629.7	-	-	-	-	176	0.1	4.9	-	810.7
2003	274.0	-	-	-	-	29.6	21.5	0.5	-	325.6
2004	277.1	2.7	-	-	-	48.5	33.2	-	-	361.5
2005	154.8	-	-	-	-	17.3	-	-	-	172.1
2006	250.6	3.2	-	-	-	5.6	27.8	-	-	287.9
2007	144.6	1	2	-	-	51.1	6.6	1	-	206.3
2008	234.4	4.4	2.4	-	-	81.6	12.4	-	-	335.2
2009	285.7	12.2	2.5	-	1.8	27.4	12.4	3.6	-	345.6
2010	275.1	13	-	-	-	78	32	4	0.6	402.7
2011	278.0	9.8	-	-	-	109	32.7	6.1	1.65	437.2
2012	50.1	1.70844	-	-	0.317	42.4804	5.652	-	-	100.2
2013	192.8	7.89833	-	-	0.387	30.44615	26.811	2.436	1.32035	262.1
2014	148.0	5.05196	-	-	-	82.49885	18.815	0.03	0.82463	255.2
2015	163.2	9.09745	-	-	-	100.85862	33.43875	2.00003	-	308.6
2016	27.8	-	-	-	-	40.86736	4.2595	-	-	72.9
2017	316.9	5.7985	-	-	-	120.20534	42.23271	3.32389	-	488.4
2018	167.3	5.937	-	-	-	69.53076	16.655512	1.848779	-	261.3
2019	93.6	3.94972	-	-	-	124.7855	11.5433	1.05792	-	235.0
2020	157.3	4.198	-	-	-	244.379129	25.720324	3.8959461	-	435.5

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839
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
2019	86723	5151	136901	6666	0	96	0	235537
2020	105928	73921	247616	19707	0	177	0	447349
arith. mean	291915	102007	151790	30010	5681	1147	965	583514

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
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	104779	73620	247616	19487	0	177	0	445678
arith. mean	263737	73544	127474	25387	5211	1046	763	497162

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
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	1149	302	0	220	0	0	0	1671
arith. mean	28178	28463	24317	4622	470	101	202	86352

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
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	2779	2089	1230	170	0	0	0	6268
2018	3203	556	1474	537	0	0	0	5770
2019	2889	135	2008	209	0	3	0	5243
2020	2684	1467	3492	165	0	8	0	7817
arith. mean	5382	2635	3060	349	83	44	9	11562

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
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	2728	1834	1230	170	0	0	0	5962
2018	2886	550	1463	537	0	0	0	5436
2019	2551	135	2008	209	0	3	0	4905
2020	2646	1388	3492	165	0	8	0	7700
arith. mean	4720	1850	2466	294	78	41	7	9456

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
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	51	255	0	0	0	0	0	306
2018	316	6	12	0	0	0	0	334
2019	338	0	0	0	0	0	0	338
2020	39	79	0	0	0	0	0	118
arith. mean	662	785	593	55	5	3	2	2105

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
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	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0
Sum	6206	2779	1772	850	39	71	0	11717

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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	91	1699	158	14468	792	971	44	331	10
2019	5947	4703	96	830	18	1885	19	101	0
2020	53	11640	78	1082	12	263	2	442	5
arith. mean	2683	22933	1652	8850	593	2294	189	680	37

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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	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	2.6	4.7	4.3	7.0	6.6	9.5	8.4	11.5	10.0
2019	2.4	4.7	5.2	7.7	7.7	8.4	9.2	10.7	10.8
2020	7.4	7.1	7.1	9.5	9.6	12.3	11.7	13.8	13.2
arith. mean	3.7	5.8	6.3	9.3	10.2	12.9	13.8	14.9	15.7

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

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

```
Date: 01/20/21  Start time:08:58:50 run time:0 seconds

objective function (negative log likelihood):  20.5411
Number of parameters: 79
Maximum gradient: 9.30556e-005
Akaike information criterion (AIC):   199.082
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             342      70      38       0     450

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
               26.6    -6.6    12.7     0.0     0.0      0.00      33


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.08   -0.09    0.33    0.00


contribution by fleet:
----------------------
RTM 2007-2020              total:  -7.277   mean:  -0.202
Dredge survey 2004-2020     total:   0.634   mean:   0.019

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
    2010-2020:   0.000 1.000
age: 1 - 4
    1983-1988:   0.455 0.500
    1989-1998:   0.467 0.500
    1999-2004:   0.374 0.500
    2005-2009:   0.255 0.500
    2010-2020:   0.542 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.259  0.961  1.425  1.425
1989-1998:  0.011  0.538  0.720  0.730  0.730
1999-2004:  0.067  1.027  1.140  1.135  1.135
2005-2009:  0.007  1.422  2.153  2.243  2.243
2010-2020:  0.019  0.269  0.668  1.260  1.260
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.320  1.186  1.760  1.760
          season 2:  0.020  0.105  0.388  0.576  0.576

1989-1998 season 1:      0  0.822  1.100  1.115  1.115
          season 2:  0.001  0.033  0.045  0.045  0.045

1999-2004 season 1:      0  0.807  0.896  0.893  0.893
          season 2:  0.018  0.140  0.156  0.155  0.155

2005-2009 season 1:      0  0.741  1.122  1.168  1.168
          season 2:  0.001  0.055  0.083  0.086  0.086

2010-2020 season 1:      0  0.550  1.363  2.571  2.571
          season 2:  0.004  0.025  0.062  0.117  0.117


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.659
 1       0.348   0.587
 2       0.348   0.587
 3       0.661   1.019
 4       0.661   1.019


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2020                      0.829    1.756    2.769
 Dredge survey 2004-2020       2.550    1.069

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2020                       0.53     0.45     0.51
 Dredge survey 2004-2020        0.48     0.80

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-1r            1054.203   1.100e+005   0.717          0.847
```

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	1.027	1.508	1.517	0.657
1984	0.013	0.324	1.162	1.704	1.712	0.743
1985	0.014	0.347	1.243	1.831	1.826	0.795
1986	0.005	0.244	0.874	1.275	1.270	0.559
1987	0.008	0.182	0.660	0.969	0.967	0.421
1988	0.005	0.265	0.948	1.373	1.368	0.607
1989	0.001	0.819	1.063	1.067	1.059	0.941
1990	0.002	0.815	1.058	1.061	1.057	0.937
1991	0.005	0.548	0.720	0.729	0.729	0.634
1992	0.003	0.823	1.077	1.082	1.083	0.950
1993	0.001	0.363	0.473	0.480	0.479	0.418
1994	0.001	0.300	0.389	0.391	0.390	0.344
1995	0.002	0.562	0.726	0.731	0.728	0.644
1996	0.003	0.527	0.679	0.682	0.681	0.603
1997	0.005	0.497	0.643	0.648	0.651	0.570
1998	0.002	0.653	0.825	0.827	0.827	0.739
1999	0.017	1.023	1.080	1.063	1.065	1.051
2000	0.016	0.818	0.859	0.851	0.850	0.838
2001	0.049	1.237	1.321	1.314	1.317	1.279
2002	0.004	0.948	1.011	0.974	0.967	0.980
2003	0.015	0.788	0.844	0.818	0.821	0.816
2004	0.007	0.832	0.878	0.847	0.848	0.855
2005	0.000	0.893	1.276	1.319	1.316	1.085
2006	0.001	1.091	1.560	1.603	1.599	1.325
2007	0.000	0.412	0.592	0.610	0.605	0.502
2008	0.000	0.769	1.100	1.123	1.120	0.935
2009	0.001	0.949	1.364	1.402	1.394	1.157
2010	0.002	0.389	0.910	1.630	1.620	0.649
2011	0.001	0.443	1.012	1.821	1.804	0.727
2012	0.000	0.083	0.194	0.353	0.350	0.139
2013	0.000	0.506	1.136	2.079	2.069	0.821
2014	0.001	0.294	0.666	1.236	1.234	0.480
2015	0.000	0.282	0.636	1.182	1.172	0.459
2016	0.000	0.020	0.045	0.085	0.084	0.033
2017	0.001	0.377	0.874	1.590	1.574	0.625
2018	0.004	0.373	0.886	1.604	1.599	0.630
2019	0.005	0.364	0.867	1.572	1.567	0.616
2020	0.001	0.352	0.835	1.501	1.494	0.593
arith. mean	0.005	0.547	0.882	1.130	1.127	0.715

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	0.192	0.063	0.712	0.233	1.056	0.346	1.056	0.346
1984	0.013	0.220	0.069	0.814	0.255	1.206	0.378	1.206	0.378
1985	0.014	0.234	0.074	0.868	0.273	1.288	0.405	1.288	0.405
1986	0.005	0.182	0.025	0.676	0.091	1.002	0.135	1.002	0.135
1987	0.008	0.119	0.042	0.441	0.157	0.654	0.233	0.654	0.233
1988	0.005	0.199	0.025	0.738	0.091	1.094	0.135	1.094	0.135
1989	0.001	0.664	0.027	0.889	0.036	0.901	0.037	0.901	0.037
1990	0.002	0.645	0.045	0.863	0.060	0.875	0.061	0.875	0.061
1991	0.005	0.370	0.121	0.495	0.162	0.502	0.164	0.502	0.164
1992	0.003	0.639	0.076	0.855	0.102	0.867	0.103	0.867	0.103
1993	0.001	0.282	0.034	0.377	0.046	0.382	0.047	0.382	0.047
1994	0.001	0.230	0.026	0.307	0.034	0.312	0.035	0.312	0.035
1995	0.002	0.427	0.052	0.571	0.069	0.579	0.070	0.579	0.070
1996	0.003	0.387	0.060	0.518	0.080	0.525	0.081	0.525	0.081
1997	0.005	0.322	0.118	0.431	0.158	0.437	0.160	0.437	0.160
1998	0.002	0.491	0.049	0.657	0.066	0.666	0.066	0.666	0.066
1999	0.017	0.739	0.129	0.821	0.143	0.817	0.142	0.817	0.142
2000	0.016	0.580	0.120	0.644	0.134	0.642	0.133	0.642	0.133
2001	0.049	0.755	0.374	0.838	0.415	0.835	0.414	0.835	0.414
2002	0.004	0.746	0.028	0.828	0.031	0.825	0.031	0.825	0.031
2003	0.015	0.555	0.113	0.616	0.125	0.613	0.125	0.613	0.125
2004	0.007	0.619	0.057	0.688	0.064	0.685	0.063	0.685	0.063
2005	0.000	0.692	0.051	1.047	0.077	1.091	0.080	1.091	0.080
2006	0.001	0.836	0.073	1.267	0.111	1.319	0.116	1.319	0.116
2007	0.000	0.328	0.000	0.496	0.000	0.517	0.000	0.517	0.000
2008	0.000	0.587	0.035	0.889	0.053	0.926	0.055	0.926	0.055
2009	0.001	0.709	0.072	1.074	0.108	1.118	0.113	1.118	0.113
2010	0.002	0.288	0.013	0.714	0.032	1.347	0.061	1.347	0.061
2011	0.001	0.325	0.009	0.806	0.023	1.519	0.043	1.519	0.043
2012	0.000	0.062	0.000	0.154	0.000	0.290	0.000	0.290	0.000
2013	0.000	0.391	0.000	0.969	0.000	1.827	0.000	1.827	0.000
2014	0.001	0.224	0.008	0.556	0.020	1.049	0.038	1.049	0.038
2015	0.000	0.219	0.000	0.543	0.000	1.024	0.000	1.024	0.000
2016	0.000	0.015	0.000	0.038	0.000	0.072	0.000	0.072	0.000
2017	0.001	0.292	0.005	0.724	0.012	1.365	0.023	1.365	0.023

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	0.004	0.280	0.028	0.693	0.070	1.307	0.133	1.307	0.133
2019	0.005	0.270	0.033	0.669	0.082	1.261	0.154	1.261	0.154
2020	0.001	0.280	0.004	0.693	0.009	1.308	0.018	1.308	0.018
arith. mean	0.005	0.405	0.054	0.684	0.090	0.897	0.110	0.897	0.110

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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0.723	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	0.538	0.538	0.454	0.454	0.360	0.360	0.345	0.345
arith. mean	0.629	0.460	0.544	0.386	0.419	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	297690	13338	52047	2853	240
1984	76038	178554	4365	9687	424
1985	513050	45556	56528	719	1154
1986	77447	301050	14253	8723	187
1987	47574	45205	104561	3128	1512
1988	206012	27225	16001	26710	1017
1989	92592	117936	9030	3218	4281
1990	131552	54356	24621	1661	1568
1991	163589	76230	11370	4683	679
1992	37068	92932	19932	2899	1553
1993	155962	21345	19797	3871	976
1994	223793	91628	6914	6610	1818
1995	56293	131574	30844	2466	3393
1996	403944	33371	34841	7965	1748
1997	63135	232044	9286	9566	2945
1998	120886	35635	61974	2527	3754
1999	159236	65197	7933	14324	1641
2000	252914	84231	9856	1387	3168
2001	418489	135611	15079	2118	1172
2002	26773	215731	17156	2071	525
2003	161142	13641	35888	3013	555
2004	68801	79672	2425	6860	804
2005	164045	33598	12533	443	1654
2006	79474	81828	5344	1789	326
2007	198202	38293	10416	571	250
2008	77811	91849	9047	2742	246
2009	560978	37682	15608	1479	567
2010	35039	277327	5998	2153	305

	Age 0	Age 1	Age 2	Age 3	Age 4
2011	43620	17116	65488	1149	289
2012	104200	19828	3480	11502	139
2013	60949	47425	5067	1103	3826
2014	219740	29327	9224	759	384
2015	36922	106556	7537	2169	196
2016	274693	18006	25792	1904	433
2017	19676	133098	5652	11272	1121
2018	36416	10029	31817	1124	1540
2019	122185	19539	2772	6148	327
2020	52633	65515	5430	543	793
2021		28337	16838	1085	176

Table 9.2.10 Sandeel Area-1r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	297820049	625560	460469	378795	0.600
1984	76057485	1161140	196025	498626	0.678
1985	513109587	781239	451802	437114	0.725
1986	77438916	1865050	270493	382844	0.487
1987	47583661	1513710	975787	373021	0.380
1988	205920350	777165	576079	413646	0.526
1989	92618550	746348	155127	446028	0.808
1990	131563476	646740	247459	306240	0.807
1991	163610637	945850	329720	332204	0.574
1992	37058192	1041310	284930	558599	0.835
1993	155942826	459259	260146	132024	0.369
1994	223741069	683800	177726	193241	0.299
1995	56288454	1449330	399113	400588	0.560
1996	404030125	606448	364762	265869	0.522
1997	63148522	1896650	233048	426089	0.515
1998	120842669	855882	525445	377073	0.631
1999	159252253	577015	222571	422718	0.916
2000	253025289	677987	142201	299167	0.740
2001	418421560	787972	161458	531265	1.191
2002	26775558	1440670	156530	606466	0.816
2003	161174792	344182	243775	148039	0.704
2004	68819659	493032	93620	203646	0.714
2005	164102206	352620	116891	123422	0.934
2006	79478730	558479	76344	240646	1.144
2007	198242185	322305	94466	109624	0.412

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2008	77827080	714745	130614	234447	0.782
2009	560870164	404737	147709	290995	0.981
2010	35039971	1856400	130875	300508	0.524
2011	43618852	681238	478303	318840	0.581
2012	104218478	291530	159213	46117	0.108
2013	60976555	309383	85391	214359	0.680
2014	219749759	215531	66636	78830	0.404
2015	36910256	672741	87904	163381	0.381
2016	274647770	384531	240867	14613	0.027
2017	19677767	859488	161619	241916	0.517
2018	36433528	299653	208772	129525	0.536
2019	122179276	168832	73718	60678	0.526
2020	52640692	533747	68734	103282	0.493
2021			128284		
arith. mean	153699032	763218	240631	284329	0.616
geo. mean	110662988				

arith. mean for the period 1983–2020

geo. mean for the period 1983–2019

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	110640.139	28337.4	16838.2	1085.1	175.995
Exploitation pattern 1st half		0.280	0.693	1.308	1.308
Exploitation pattern 2nd half	0.001	0.004	0.009	0.018	0.018
Weight in the stock 1st half		5.396	8.291	10.389	12.257
Weight in the catch 1st half		5.396	8.291	10.389	12.257
weight in the catch 2nd half	3.695	5.581	8.146	10.281	11.948
Proportion mature (2021)	0.000	0.021	0.801	0.988	1.000
Proportion mature (2022)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.538	0.454	0.360	0.345
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(2020) = 0.4931; Yield(2020) = 103.282; Recruitment(2020) = 52.640692; Recruitment(2021) = geometric mean (GM 1983–2019) = 110.640139 billions; SSB(2021) = 128.284

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
SSB_{2022} ≥ MSY $B_{escapement}$ with F_{cap}	5464	0.022	145000	32.287	95.683	95.683
Other scenarios						
F = 0	0	0	148321	52.531	-100.000	-100.000
SSB_{2022} = MSY $B_{escapement}$ = B_{pa}	5464	0.022	145000	-49.403	958.466	958.466
B_{lim}	64243	0.30	110000	-76.190	1302.520	1302.520
F = F_{2020}	96104	0.49	91699	45.954	-36.914	-36.914

*** SSB_{2022} relative to SSB_{2021}.**

**** Catch scenario for 2021 relative to TAC in 2020 (113 987 t).**

***** Advice value 2021 relative to advice value 2020 (113 987 t).**

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
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

	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
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	8836	16	436	1	171	1	362	3
arith. mean	2778	7189	1465	1690	306	432	110	170	43

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

	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
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	3.5	4.6	7.4	9.6	11.4	12.4	13.8	14.0	16.1
2019	8.0	7.7	8.7	12.4	12.6	15.4	13.9	18.7	14.1
2020	10.1	6.4	11.4	12.8	16.1	16.2	13.8	20.2	19.3
arith. mean	4.2	6.3	8.3	10.9	13.5	15.1	17.9	17.6	20.1

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

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

```
Date: 01/18/21  Start time:17:30:47 run time:1 seconds

objective function (negative log likelihood):  74.5286
Number of parameters: 74
Maximum gradient: 4.0253e-005
Akaike information criterion (AIC):   297.057
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             342      22      38       0     402

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
               78.6    -6.1    19.5     0.0     0.0      0.00      92


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.23   -0.28    0.51    0.00


contribution by fleet:
----------------------
Dredge survey 2010-2020     total:  -6.060   mean:  -0.275

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
    2010-2020:   0.000 1.000
age: 1 - 4
    1983-1988:   0.471 0.500
    1989-1998:   0.687 0.500
    1999-2004:   0.426 0.500
    2005-2009:   0.185 0.500
    2010-2020:   0.618 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.040  0.278  0.908  1.517  1.517
1989-1998:  0.100  0.334  0.402  0.470  0.470
1999-2004:  0.041  0.600  0.720  0.733  0.733
2005-2009:  0.001  2.016  1.721  1.834  1.834
2010-2020:  0.001  0.232  0.418  0.611  0.611
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.295  0.962  1.607  1.607
          season 2:  0.051  0.174  0.569  0.950  0.950

1989-1998 season 1:      0  0.723  0.870  1.018  1.018
          season 2:  0.110  0.184  0.222  0.260  0.260

1999-2004 season 1:      0  0.312  0.374  0.381  0.381
          season 2:  0.081  0.597  0.717  0.730  0.730

2005-2009 season 1:      0  0.528  0.451  0.480  0.480
          season 2:  0.001  0.551  0.470  0.501  0.501

2010-2020 season 1:      0  0.605  1.091  1.597  1.597
          season 2:  0.001  0.108  0.195  0.286  0.286


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.641
 1       0.376   0.834
 2       0.376   0.834
 3       0.791   1.097
 4       0.791   1.097


Survey catchability:
--------------------
                           age 0    age 1
 Dredge survey 2010-2020       0.616   20.690

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1
Dredge survey 2010-2020        1.27     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Dredge survey 2010-2020        0.30     0.79

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-2r            1080.247   5.600e+004   1.028          1.014
```

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	0.364	1.177	1.958	1.957	0.770
1984	0.033	0.306	0.992	1.657	1.656	0.649
1985	0.022	0.286	0.917	1.516	1.513	0.601
1986	0.025	0.411	1.303	2.136	2.133	0.857
1987	0.008	0.091	0.293	0.487	0.487	0.192
1988	0.026	0.305	0.981	1.627	1.625	0.643
1989	0.076	0.725	0.855	0.987	0.985	0.790
1990	0.037	0.488	0.572	0.659	0.657	0.530
1991	0.071	0.550	0.650	0.753	0.752	0.600
1992	0.052	0.559	0.657	0.758	0.756	0.608
1993	0.081	0.440	0.524	0.612	0.611	0.482
1994	0.051	0.468	0.552	0.638	0.636	0.510
1995	0.043	0.254	0.303	0.353	0.352	0.278
1996	0.133	0.377	0.460	0.549	0.549	0.419
1997	0.084	0.553	0.656	0.763	0.761	0.605
1998	0.046	0.285	0.339	0.394	0.394	0.312
1999	0.036	0.373	0.460	0.481	0.482	0.416
2000	0.017	0.556	0.657	0.665	0.663	0.607
2001	0.037	0.483	0.587	0.608	0.608	0.535
2002	0.020	0.672	0.793	0.802	0.800	0.733
2003	0.037	0.445	0.543	0.564	0.564	0.494
2004	0.030	0.907	1.073	1.087	1.085	0.990
2005	0.001	1.187	1.021	1.102	1.103	1.104
2006	0.001	1.242	1.075	1.166	1.167	1.158
2007	0.000	0.750	0.622	0.647	0.645	0.686
2008	0.000	0.810	0.683	0.724	0.722	0.747
2009	0.000	0.779	0.670	0.722	0.722	0.724
2010	0.000	0.338	0.593	0.852	0.849	0.466
2011	0.000	0.219	0.382	0.547	0.546	0.301
2012	0.000	0.126	0.219	0.313	0.312	0.172
2013	0.000	0.543	0.944	1.347	1.344	0.743
2014	0.000	0.413	0.716	1.019	1.016	0.564
2015	0.000	0.364	0.630	0.895	0.892	0.497
2016	0.000	0.157	0.273	0.389	0.387	0.215
2017	0.001	0.705	1.223	1.743	1.739	0.964
2018	0.000	0.212	0.368	0.524	0.522	0.290
2019	0.000	0.049	0.086	0.123	0.122	0.068
2020	0.000	0.515	0.892	1.267	1.263	0.703
arith. mean	0.026	0.482	0.677	0.880	0.878	0.580

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	0.213	0.126	0.695	0.411	1.161	0.686	1.161	0.686
1984	0.033	0.173	0.115	0.566	0.374	0.946	0.625	0.946	0.625
1985	0.022	0.181	0.075	0.589	0.246	0.984	0.411	0.984	0.411
1986	0.025	0.273	0.086	0.890	0.281	1.487	0.469	1.487	0.469
1987	0.008	0.055	0.028	0.179	0.091	0.298	0.152	0.298	0.152
1988	0.026	0.187	0.091	0.610	0.296	1.019	0.494	1.019	0.494
1989	0.076	0.500	0.127	0.601	0.153	0.703	0.179	0.703	0.179
1990	0.037	0.348	0.062	0.419	0.075	0.490	0.087	0.490	0.087
1991	0.071	0.364	0.118	0.438	0.142	0.512	0.166	0.512	0.166
1992	0.052	0.390	0.086	0.470	0.104	0.549	0.121	0.549	0.121
1993	0.081	0.267	0.135	0.322	0.162	0.376	0.190	0.376	0.190
1994	0.051	0.319	0.085	0.383	0.102	0.448	0.119	0.448	0.119
1995	0.043	0.157	0.073	0.189	0.087	0.221	0.102	0.221	0.102
1996	0.133	0.167	0.223	0.201	0.269	0.236	0.314	0.236	0.314
1997	0.084	0.354	0.140	0.426	0.168	0.498	0.197	0.498	0.197
1998	0.046	0.178	0.078	0.215	0.093	0.251	0.109	0.251	0.109
1999	0.036	0.140	0.268	0.168	0.321	0.171	0.327	0.171	0.327
2000	0.017	0.364	0.127	0.437	0.153	0.445	0.156	0.445	0.156
2001	0.037	0.225	0.268	0.270	0.322	0.275	0.328	0.275	0.328
2002	0.020	0.447	0.144	0.536	0.173	0.546	0.176	0.546	0.176
2003	0.037	0.194	0.269	0.233	0.323	0.238	0.329	0.238	0.329
2004	0.030	0.588	0.223	0.706	0.268	0.719	0.272	0.719	0.272
2005	0.001	0.581	0.607	0.496	0.518	0.529	0.552	0.529	0.552
2006	0.001	0.556	0.725	0.475	0.619	0.506	0.659	0.506	0.659
2007	0.000	0.598	0.000	0.511	0.000	0.544	0.000	0.544	0.000
2008	0.000	0.527	0.194	0.450	0.166	0.480	0.177	0.480	0.177
2009	0.000	0.389	0.386	0.332	0.329	0.354	0.351	0.354	0.351
2010	0.000	0.241	0.043	0.434	0.078	0.635	0.114	0.635	0.114
2011	0.000	0.162	0.016	0.293	0.028	0.429	0.041	0.429	0.041
2012	0.000	0.095	0.006	0.171	0.010	0.250	0.015	0.250	0.015
2013	0.000	0.403	0.045	0.726	0.080	1.063	0.118	1.063	0.118
2014	0.000	0.316	0.017	0.569	0.030	0.833	0.044	0.833	0.044
2015	0.000	0.284	0.004	0.512	0.008	0.749	0.012	0.749	0.012
2016	0.000	0.120	0.004	0.217	0.006	0.318	0.009	0.318	0.009
2017	0.001	0.525	0.059	0.947	0.106	1.386	0.155	1.386	0.155

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	0.000	0.165	0.001	0.298	0.002	0.436	0.003	0.436	0.003
2019	0.000	0.038	0.000	0.069	0.000	0.102	0.000	0.102	0.000
2020	0.000	0.397	0.018	0.715	0.033	1.047	0.048	1.047	0.048
arith. mean	0.026	0.302	0.133	0.441	0.174	0.585	0.219	0.585	0.219

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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	0.92	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
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	158074	16256	14431	699	33
1984	47887	60736	3632	1884	55
1985	284653	18459	14274	559	192
1986	62145	110982	4480	2442	89
1987	35828	24155	24304	548	171
1988	176792	14163	6972	7322	220
1989	88517	68625	3364	1112	793
1990	158512	32691	11493	624	379
1991	110362	60871	6801	2769	271
1992	116043	40981	11780	1502	737
1993	228332	43923	7976	2619	550
1994	109306	83955	9210	1940	862
1995	77036	41406	17578	2236	762
1996	416172	29396	10315	5260	1041
1997	16087	145141	6235	2544	1741
1998	26467	5897	27766	1358	1029
1999	75439	10070	1431	8052	801
2000	43490	28987	2101	346	2572
2001	132993	17033	5561	460	777
2002	10253	51101	3262	1214	327
2003	46668	4007	8874	633	359
2004	19249	17928	790	2007	271
2005	19241	7442	2499	118	404
2006	27032	7662	711	358	86
2007	41197	10763	667	94	66
2008	25410	16418	1855	158	45
2009	80369	10124	2502	395	50
2010	9437	32013	1463	510	105

	Age 0	Age 1	Age 2	Age 3	Age 4
2011	12789	3759	7557	346	139
2012	50386	5096	986	2163	146
2013	27845	20079	1445	325	846
2014	19281	11092	4024	254	174
2015	5445	7683	2495	872	86
2016	144917	2170	1805	585	214
2017	4078	57750	601	570	276
2018	11716	1624	10097	83	87
2019	69684	4669	431	2950	53
2020	31049	27770	1408	159	1295
2021		12372	5750	263	236

Table 9.3.10 Sandeel Area-2r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1983	158141380	249343	140646	155664	0.722
1984	47870021	408634	70827	133343	0.614
1985	284715217	279021	134188	110546	0.546
1986	62146186	729160	83952	225470	0.765
1987	35819393	422562	238470	49070	0.176
1988	176706372	278751	188905	149466	0.592
1989	88543100	445320	54068	223507	0.690
1990	158457979	358610	112758	133874	0.452
1991	110331497	654165	182590	215508	0.531
1992	115988314	435054	136489	184033	0.525
1993	228260939	514683	163244	139826	0.443
1994	109342968	594799	135673	244939	0.445
1995	77052688	584611	237518	113899	0.253
1996	416334674	451991	228662	182562	0.430
1997	16094691	877164	117712	242094	0.544
1998	26456171	390689	301040	99814	0.282
1999	75451453	238135	155282	69427	0.448
2000	43488192	270271	72984	92908	0.540
2001	133018663	196839	85136	90200	0.542
2002	10252171	333860	45752	117388	0.650
2003	46688106	140240	99708	53710	0.510
2004	19249584	151674	36901	110546	0.892
2005	19249584	92730	33323	34396	1.101
2006	27044656	72273	14192	37860	1.187
2007	41202109	77071	10800	43090	0.555

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean $F_{1\text{-}2}$
2008	25418810	117590	24367	35604	0.668
2009	80357822	90144	26344	35687	0.718
2010	9435597	205142	23435	51670	0.398
2011	12787773	116978	77111	24896	0.250
2012	50374719	89241	46212	10594	0.141
2013	27840434	146256	28424	47814	0.627
2014	19288122	104842	40660	48033	0.465
2015	5443866	98287	41606	37902	0.404
2016	144964581	41035	30364	5230	0.174
2017	4077522	336480	21820	141314	0.818
2018	11710542	107067	83200	20239	0.233
2019	69650470	87561	51534	5090	0.054
2020	31046604	224808	47240	72612	0.581
2021			61329		
arith. mean	79478481	289818	94472	99732	0.525
geo. mean	47063109				

arith. mean for the period 1983–2020

geo. mean for the period 1983–2019

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2021)	19648.759	12371.6	5749.69	263.042	236.226
Exploitation pattern 1st half		0.397	0.715	1.047	1.047
Exploitation pattern 2nd half	0.000	0.018	0.033	0.048	0.048
Weight in the stock 1st half		5.497	10.949	14.321	16.739
Weight in the catch 1st half		5.497	10.949	14.321	16.739
weight in the catch 2nd half	5.423	8.173	11.924	12.738	15.609
Proportion mature(2021)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2022)	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(2020) = 0.5814; Yield(2020) = 72.612; Recruitment(2020) = 31.046604; Recruitment(2021) = geometric mean (GM 2010-2019) = 19.648759 billions; SSB(2021) = 61.329

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
SSB_{2022} ≥ MSY $B_{escapement}$ with F_{cap}	0	0	72623	18.415	-100%	-100.000
Other scenarios						
F = 0	0	0	72623	18.415	-100%	-100.000
SSB_{2022} = MSY $B_{escapement}$ = B_{pa}	0	0	72623	18.415	-100.000	-100.000
B_{lim}	25615	0.26	56000	-8.689	-59.119	-59.119
F_{2021} = F_{sq}	49562	0.58	40867	-33.364	-20.901	-20.901
5000 t monitoring TAC	5000	0.045	69351	13.080	-92.020	-92.020

*** SSB_{2021} relative to SSB_{2020}.**

**** Catch scenario for 2021 relative to TAC in 2020 (62 658 t).**

***** Advice value 2021 relative to advice value 2020 (62 658 t).**

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
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

	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
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	17857	0	2268	0	482	0	1643	0
arith. mean	3436	11339	999	3423	93	707	29	252	16

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
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

	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	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	5.6	8.3	11.7	12.7	18.8	19.3	25.7	30.1	27.7
2016	1.5	4.0	3.1	12.4	5.0	19.8	6.8	32.1	7.4
2017	4.3	7.7	8.8	11.9	14.1	17.7	18.9	24.2	20.5
2018	3.9	5.8	7.0	9.9	10.7	13.5	13.6	20.6	15.2
2019	6.9	8.5	9.6	11.6	14.8	15.2	16.6	20.2	19.2
2020	0.0	9.3	0.0	15.6	0.0	20.1	0.0	22.0	0.0
arith. mean	4.6	7.0	9.2	12.5	15.4	18.2	20.4	23.1	22.2

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

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

```
Date: 01/22/21  Start time:09:53:17 run time:1 seconds

objective function (negative log likelihood):  119.868
Number of parameters: 60
Maximum gradient: 3.0805e-005
Akaike information criterion (AIC):   359.736
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                              315      79      35       0     429

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
              101.4    18.3    18.7     0.0     0.0      0.00     138


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.32    0.23    0.53    0.00


contribution by fleet:
----------------------
Acoustic survey             total:  13.733   mean:   0.286
Dredge survey 2004-2020     total:   4.570   mean:   0.147

F, season effect:
-----------------
age: 0
    1986-1998:   0.000 1.000
    1999-2020:   0.000 1.000
age: 1 - 4
    1986-1998:   0.883 0.500
    1999-2020:   1.036 0.500

F, age effect:
--------------
                0      1      2      3      4
1986-1998:  0.103  0.372  0.412  0.336  0.336
1999-2020:  0.057  0.173  0.266  0.256  0.256


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1986-1998 season 1:      0  0.641  0.709  0.579  0.579
          season 2:  0.170  0.308  0.341  0.278  0.278

1999-2020 season 1:      0  0.544  0.839  0.807  0.807
```

```
          season 2:  0.160  0.243  0.374  0.359  0.359


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0               1.141
 1       0.678   1.036
 2       0.678   1.036
 3       1.019   1.226
 4       1.019   1.226


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                        2.808    5.491    4.550    4.550
 Dredge survey 2004-2020       0.504    0.504

Stock size dependent catchability (power model)
-----------------------------------------------    age 0    age 1    age 2    age 3    age 4
Acoustic survey                           1.00     1.00     1.00     1.00
Dredge survey 2004-2020        1.03     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                         0.60     0.60     1.08     1.08
 Dredge survey 2004-2020        0.64     0.78

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-3r            1533.600   8.000e+004   1.070          1.035
```

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	0.403	0.404	0.474
1987	0.001	0.715	0.758	0.603	0.601	0.736
1988	0.051	0.917	0.974	0.785	0.784	0.946
1989	0.003	1.035	1.097	0.893	0.890	1.066
1990	0.050	0.581	0.623	0.507	0.506	0.602
1991	0.040	0.702	0.752	0.608	0.607	0.727
1992	0.003	0.326	0.345	0.272	0.273	0.336
1993	0.042	0.605	0.651	0.523	0.522	0.628
1994	0.016	0.647	0.691	0.545	0.541	0.669
1995	0.007	0.515	0.553	0.438	0.436	0.534
1996	0.043	0.504	0.546	0.435	0.435	0.525
1997	0.066	0.908	0.981	0.797	0.793	0.945
1998	0.140	1.151	1.254	1.022	1.016	1.202
1999	0.141	0.747	1.142	1.081	1.076	0.944
2000	0.004	0.770	1.142	1.047	1.040	0.956
2001	0.147	0.481	0.747	0.716	0.719	0.614
2002	0.000	0.506	0.743	0.710	0.706	0.625
2003	0.019	0.270	0.401	0.388	0.386	0.335
2004	0.019	0.188	0.281	0.272	0.272	0.234
2005	0.000	0.091	0.134	0.127	0.126	0.113
2006	0.000	0.039	0.057	0.054	0.054	0.048
2007	0.000	0.229	0.339	0.319	0.318	0.284
2008	0.000	0.247	0.366	0.350	0.349	0.306
2009	0.000	0.021	0.031	0.029	0.029	0.026
2010	0.000	0.268	0.400	0.378	0.376	0.334
2011	0.000	0.173	0.259	0.246	0.243	0.216
2012	0.000	0.105	0.157	0.151	0.150	0.131
2013	0.000	0.051	0.076	0.074	0.073	0.064
2014	0.000	0.204	0.304	0.293	0.291	0.254
2015	0.000	0.268	0.400	0.384	0.382	0.334
2016	0.000	0.105	0.157	0.151	0.150	0.131
2017	0.000	0.232	0.346	0.333	0.331	0.289
2018	0.000	0.248	0.370	0.356	0.353	0.309
2019	0.000	0.372	0.554	0.533	0.530	0.463
2020	0.000	0.641	0.953	0.917	0.911	0.797
arith. mean	0.025	0.438	0.545	0.478	0.476	0.491

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	0.286	0.138	0.316	0.152	0.258	0.124	0.258	0.124
1987	0.001	0.577	0.002	0.639	0.002	0.521	0.002	0.521	0.002
1988	0.051	0.687	0.093	0.761	0.103	0.620	0.084	0.620	0.084
1989	0.003	0.864	0.006	0.957	0.007	0.780	0.005	0.780	0.005
1990	0.050	0.426	0.091	0.472	0.100	0.385	0.082	0.385	0.082
1991	0.040	0.541	0.072	0.599	0.079	0.489	0.065	0.489	0.065
1992	0.003	0.261	0.006	0.289	0.007	0.236	0.005	0.236	0.005
1993	0.042	0.450	0.076	0.498	0.084	0.406	0.068	0.406	0.068
1994	0.016	0.503	0.029	0.556	0.032	0.454	0.026	0.454	0.026
1995	0.007	0.409	0.013	0.453	0.014	0.369	0.012	0.369	0.012
1996	0.043	0.359	0.078	0.397	0.086	0.324	0.070	0.324	0.070
1997	0.066	0.672	0.120	0.743	0.132	0.606	0.108	0.606	0.108
1998	0.140	0.795	0.254	0.880	0.281	0.718	0.229	0.718	0.229
1999	0.141	0.480	0.214	0.740	0.330	0.711	0.317	0.711	0.317
2000	0.004	0.605	0.006	0.933	0.009	0.897	0.008	0.897	0.008
2001	0.147	0.252	0.222	0.389	0.342	0.374	0.328	0.374	0.328
2002	0.000	0.376	0.000	0.580	0.000	0.558	0.000	0.558	0.000
2003	0.019	0.187	0.029	0.288	0.045	0.277	0.043	0.277	0.043
2004	0.019	0.129	0.029	0.199	0.045	0.191	0.043	0.191	0.043
2005	0.000	0.070	0.000	0.108	0.000	0.104	0.000	0.104	0.000
2006	0.000	0.030	0.000	0.046	0.001	0.044	0.001	0.044	0.001
2007	0.000	0.182	0.000	0.280	0.000	0.269	0.000	0.269	0.000
2008	0.000	0.201	0.000	0.310	0.000	0.298	0.000	0.298	0.000
2009	0.000	0.017	0.000	0.026	0.000	0.025	0.000	0.025	0.000
2010	0.000	0.217	0.001	0.335	0.001	0.322	0.001	0.322	0.001
2011	0.000	0.138	0.000	0.213	0.000	0.205	0.000	0.205	0.000
2012	0.000	0.084	0.000	0.129	0.000	0.124	0.000	0.124	0.000
2013	0.000	0.041	0.000	0.063	0.000	0.061	0.000	0.061	0.000
2014	0.000	0.164	0.000	0.252	0.000	0.242	0.000	0.242	0.000
2015	0.000	0.216	0.000	0.332	0.000	0.319	0.000	0.319	0.000
2016	0.000	0.084	0.000	0.129	0.000	0.124	0.000	0.124	0.000
2017	0.000	0.186	0.000	0.287	0.000	0.276	0.000	0.276	0.000
2018	0.000	0.199	0.000	0.307	0.000	0.295	0.000	0.295	0.000
2019	0.000	0.300	0.000	0.463	0.000	0.445	0.000	0.445	0.000
2020	0.000	0.522	0.000	0.805	0.000	0.774	0.000	0.774	0.000
arith. mean	0.025	0.329	0.042	0.422	0.053	0.374	0.046	0.374	0.046

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	0.600	0.600	0.470	0.420	0.370	0.360	0.350
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.340
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.340
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.320
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.290
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.280
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.290
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.310
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.320
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.340
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.350
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.360
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.330
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.300
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.370
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.490
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.610
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2019	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2020	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.165	0.712	0.571	0.565	0.463	0.419	0.405	0.386	0.388

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	509547	80884	5591	273	692
1987	116894	123691	13592	1200	317
1988	359557	27943	18516	2531	423
1989	107723	73235	3525	2872	702
1990	197118	28397	9519	541	799
1991	124635	52141	5583	2320	454
1992	258379	35370	9401	1223	864
1993	190474	78345	8406	2902	893
1994	179393	58430	14088	1891	1217
1995	154365	58198	9647	2908	971
1996	750882	55823	10825	2202	1252
1997	64175	267325	10548	2457	1117
1998	93100	24429	37605	1699	812
1999	121047	30685	2735	4784	474
2000	132155	37144	4138	342	949
2001	124438	42959	4730	506	241
2002	31203	32697	5399	602	139
2003	70853	9212	4353	753	128
2004	45685	20516	1499	801	194
2005	78537	13364	3718	327	263
2006	114072	24868	2808	985	206
2007	60131	37211	5774	849	467
2008	92488	21042	8045	1482	436
2009	143306	34366	5287	2282	639
2010	15258	53244	11705	2158	1413
2011	11283	5026	14394	3504	1271
2012	79319	3364	1305	4409	1764
2013	203732	24130	895	422	2341
2014	220869	61980	6704	309	1148
2015	7331	67184	15227	1916	503
2016	665706	2230	15672	4018	752
2017	32198	202522	593	5066	1797
2018	224104	9795	48636	164	2232
2019	487420	68177	2323	13161	791
2020	232333	148283	14610	538	3794
2021		70681	25452	2403	883

Table 9.4.10 Sandeel Area-3r. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1986	509530362	563961	73865	282315	0.446
1987	116919942	985434	181680	395296	0.610
1988	359419217	458761	264342	330358	0.822
1989	107715064	540144	98716	350409	0.917
1990	197056294	329578	103673	163224	0.544
1991	124647461	542199	159054	274839	0.646
1992	258395005	350751	119850	86788	0.281
1993	190468998	662990	194464	175786	0.554
1994	179376947	625122	234685	267281	0.560
1995	154391169	473912	139804	173607	0.445
1996	751062929	740454	233515	159024	0.460
1997	64167025	1558000	186093	470670	0.834
1998	93082802	539525	334035	462081	1.106
1999	121084596	333193	109316	191253	0.882
2000	132090784	323214	67171	186837	0.776
2001	124398415	372014	74608	193684	0.602
2002	31202226	344587	73571	116298	0.478
2003	70844649	131166	69148	34673	0.275
2004	45672184	178041	30822	31285	0.201
2005	78530685	177469	63196	13991	0.089
2006	114033178	246715	58105	7094	0.038
2007	60128831	390143	101926	74972	0.231
2008	92525977	333436	142629	74933	0.256
2009	143235402	325833	102950	6261	0.022
2010	15263883	685717	252458	61241	0.277
2011	11285170	333177	253723	92452	0.176
2012	79319932	206126	169397	40116	0.107
2013	203667638	274588	59755	9844	0.052
2014	220851260	640406	109426	90876	0.208
2015	7333768	802634	220136	104631	0.274
2016	665467261	307037	252963	42845	0.107
2017	32184644	1694930	194464	115642	0.237
2018	224188999	584584	417483	75143	0.253

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2019	487597096	821969	258074	135899	0.382
2020	232406837	1697520	318061	246825	0.664
2021			319656		
arith. mean	179991717	559295	167863	158242	0.423
geo. mean	112335445				

arith. mean for the period 1986–2020

geo. mean for the period 1986–2019

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	112353.137	70680.7	25451.8	2402.56	883.364
Exploitation pattern 1st half		0.522	0.805	0.774	0.774
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.050	12.275	17.247	23.809
Weight in the catch 1st half		7.050	12.275	17.247	23.809
weight in the catch 2nd half	3.314	5.691	8.920	11.187	12.454
Proportion mature (2021)	0.000	0.036	0.766	1.000	1.000
Proportion mature (2022)	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(2020) = 0.6638; Yield(2020) = 246.825; Recruitment(2020) = 232.406837; Recruitment(2021) = geometric mean (GM 1986-2019) = 112.353137 billions; SSB(2021) = 319.656

Basis	Total catch (2021)	F_{total} (2021)	SSB (2021)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
SSB_{2022} ≥ MSY $B_{escapement}$ with F_{cap}	161335	0.29	299368	-6.3	-39	4.0
Other scenarios						
F = 0	0	0	396106	24	-100	-100
SSB_{2022} = B_{pa}	468489	1.20	129000	-60	79	202
SSB_{2022} = B_{lim}	569582	1.76	80000	-75	117	267
F_{2020}	316361	0.66	207977	-35	21	104

*** SSB_{2022} relative to SSB_{2021}.**

**** Catch scenario for 2021 relative to the TAC in 2020 (262 406 t – the sum of the Norwegian and EU TAC, 250 000t and 12 406 t, respectively).**

***** Advice value 2021 relative to the advice value 2020 (155 072 t).**

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)

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
2015	0	866	0	29	0	9	0	14	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
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	2333	17	245	0	67	0	80	0
arith. mean	126	1156	169	967	147	613	25	259	48

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	4.7	4.4	7.7	9.5	12.2	11.4	16.6	16.2	19.2
2016	4.7	5.0	7.7	9.9	12.2	18.1	16.6	24.7	19.2
2017	4.7	7.5	7.7	10.2	12.2	13.4	16.6	18.5	19.2

	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
2018	3.3	5.7	4.8	9.4	7.6	13.1	11.1	18.3	13.9
2019	0.0	5.9	0.0	10.2	0.0	13.7	0.0	20.2	0.0
2020	2.7	6.6	7.3	8.6	10.5	12.0	13.6	12.4	14.7
arith. mean	3.6	5.6	7.5	9.4	12.9	13.2	15.6	17.1	20.5

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. No formal survey was in place before 2008, but surveys covering only Firth of Forth have been included for 1999-2003. Years were data is not available (NA) is either because of limited coverage (2003, age 1) or no survey (2004-2007).

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	NA
2004	NA	NA
2005	NA	NA
2006	NA	NA
2007	NA	NA
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

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

```
Date: 01/28/21  Start time:09:23:11 run time:1 seconds

objective function (negative log likelihood):  4.4314
Number of parameters: 47
Maximum gradient: 8.91362e-005
Akaike information criterion (AIC):   102.863
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             252      35      28       0     315

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
               29.1   -25.6    20.0     0.0     0.0      0.00      23


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.12   -0.73    0.71    0.00



contribution by fleet:
----------------------
Old Dredge survey 1999-2003     total:  -9.469   mean:  -1.052
New Dredge survey 2008-2020     total: -16.171   mean:  -0.622

F, season effect:
-----------------
age: 0
    1993-2020:   0.000 1.000
age: 1 - 4
    1993-2020:   0.599 0.500

F, age effect:
--------------
                0      1      2      3      4
1993-2020:  0.003  0.102  0.181  0.226  0.226


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                       0      1      2      3      4
1993-2020 season 1:      0  0.641  1.130  1.411  1.411
          season 2:  0.004  0.083  0.147  0.183  0.183


sqrt(catch variance) ~ CV:
--------------------------
```

```
              season
----------------------
age        1       2

 0               2.004
 1       0.717   0.377
 2       0.717   0.377
 3       0.732   1.256
 4       0.732   1.256


Survey catchability:
--------------------
                           age 0    age 1
 Old Dredge survey 1999-2003       0.745   16.977
 New Dredge survey 2008-2020       0.518    3.059

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Old Dredge survey 1999-2003        0.30     0.30
 New Dredge survey 2008-2020        0.30     0.37

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-4             1585.112   4.800e+004   1.533          1.238
```

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	0.002	0.327	0.561	0.683	0.682	0.444
1994	0.002	0.380	0.648	0.789	0.786	0.514
1995	0.000	0.112	0.191	0.230	0.229	0.151
1996	0.008	0.236	0.429	0.553	0.557	0.333
1997	0.001	0.140	0.243	0.298	0.297	0.191
1998	0.000	0.151	0.258	0.313	0.312	0.205
1999	0.000	0.218	0.371	0.447	0.445	0.295
2000	0.000	0.109	0.184	0.223	0.222	0.147
2001	0.000	0.170	0.289	0.350	0.348	0.230
2002	0.000	0.036	0.062	0.074	0.074	0.049
2003	0.001	0.271	0.462	0.561	0.559	0.367
2004	0.000	0.052	0.089	0.107	0.107	0.070
2005	0.000	0.023	0.039	0.047	0.047	0.031
2006	0.000	0.000	0.001	0.001	0.001	0.000
2007	0.000	0.000	0.000	0.001	0.001	0.000
2008	0.000	0.002	0.003	0.004	0.004	0.003
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.002	0.002	0.002	0.001

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2011	0.000	0.002	0.003	0.004	0.004	0.002
2012	0.000	0.017	0.030	0.036	0.035	0.023
2013	0.000	0.010	0.017	0.020	0.020	0.013
2014	0.000	0.013	0.022	0.026	0.026	0.017
2015	0.000	0.010	0.018	0.021	0.021	0.014
2016	0.000	0.020	0.034	0.041	0.041	0.027
2017	0.000	0.044	0.075	0.091	0.091	0.060
2018	0.000	0.126	0.215	0.259	0.258	0.171
2019	0.000	0.054	0.092	0.110	0.110	0.073
2020	0.000	0.043	0.073	0.088	0.087	0.058
arith. mean	0.000	0.092	0.157	0.192	0.192	0.125

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	0.002	0.243	0.032	0.428	0.056	0.535	0.069	0.535	0.069
1994	0.002	0.285	0.030	0.503	0.053	0.628	0.066	0.628	0.066
1995	0.000	0.088	0.000	0.155	0.000	0.194	0.001	0.194	0.001
1996	0.008	0.105	0.160	0.185	0.282	0.231	0.352	0.231	0.352
1997	0.001	0.099	0.022	0.175	0.039	0.218	0.049	0.218	0.049
1998	0.000	0.116	0.006	0.205	0.010	0.256	0.013	0.256	0.013
1999	0.000	0.172	0.000	0.304	0.000	0.380	0.000	0.380	0.000
2000	0.000	0.085	0.000	0.150	0.000	0.188	0.000	0.188	0.000
2001	0.000	0.133	0.002	0.234	0.004	0.293	0.005	0.293	0.005
2002	0.000	0.028	0.000	0.050	0.000	0.063	0.000	0.063	0.000
2003	0.001	0.208	0.012	0.367	0.021	0.459	0.027	0.459	0.027
2004	0.000	0.041	0.000	0.072	0.001	0.090	0.001	0.090	0.001
2005	0.000	0.018	0.000	0.032	0.000	0.039	0.000	0.039	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.001	0.000	0.003	0.000	0.003	0.000	0.003	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	0.001	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.002	0.000	0.003	0.000	0.003	0.000
2012	0.000	0.014	0.000	0.024	0.000	0.030	0.000	0.030	0.000
2013	0.000	0.008	0.000	0.013	0.000	0.017	0.000	0.017	0.000
2014	0.000	0.010	0.000	0.018	0.000	0.022	0.000	0.022	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.018	0.000	0.018	0.000
2016	0.000	0.016	0.000	0.028	0.000	0.035	0.000	0.035	0.000
2017	0.000	0.035	0.000	0.061	0.000	0.077	0.000	0.077	0.000

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	0.000	0.099	0.000	0.175	0.000	0.219	0.000	0.219	0.000
2019	0.000	0.042	0.000	0.074	0.000	0.093	0.000	0.093	0.000
2020	0.000	0.033	0.000	0.059	0.000	0.074	0.000	0.074	0.000
arith. mean	0.000	0.068	0.009	0.119	0.017	0.149	0.021	0.149	0.021

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
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	119348	22328	24139	7675	1680
1994	260863	38106	4361	5004	2265
1995	70960	83296	7143	841	1618
1996	384442	22694	19591	2055	917
1997	98763	121919	4475	4131	740
1998	43969	31549	27744	1215	1649
1999	235190	14058	7174	7522	988
2000	202006	75218	3040	1780	2571
2001	23996	64606	17745	879	1628
2002	88164	7674	14499	4701	843
2003	152682	28196	1916	4637	2303
2004	12507	48799	5812	437	1906
2005	9897	4000	12033	1817	977
2006	6263	3165	1009	3920	1199
2007	8661	2003	813	339	2272
2008	26359	2770	514	273	1194
2009	400538	8430	711	173	667
2010	69005	128100	2166	239	383
2011	46958	22069	32886	727	281
2012	42814	15018	5662	11030	447
2013	28874	13693	3806	1859	4900
2014	297508	9235	3491	1263	3020
2015	55825	95149	2349	1153	1902
2016	116198	17854	24248	779	1357
2017	130044	37162	4515	7929	934
2018	18334	41591	9222	1428	3623
2019	259495	5864	9674	2602	1843
2020	303835	82992	1444	3019	1814
2021		97172	20620	458	2007

Table 9.5.10 Sandeel Area-4. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1993	119401223	598197	371759	132599	0.379
1994	260991918	582447	156686	158690	0.436
1995	70986480	854498	129444	52591	0.122
1996	384325343	431789	257816	158490	0.366
1997	98739932	908953	84881	58446	0.168
1998	43969202	519333	267533	58746	0.169
1999	235212519	304098	199985	53334	0.238
2000	202044797	383556	86682	37714	0.118
2001	23986459	356866	114921	47902	0.187
2002	88189635	174734	127007	12736	0.039
2003	152702173	205127	72042	63731	0.304
2004	12509514	269071	64151	6882	0.057
2005	9899551	116709	83952	1557	0.025
2006	6261936	105146	84626	0	0.000
2007	8658049	57513	46212	0	0.000
2008	26350558	39831	25642	0	0.002
2009	400410168	72159	21420	0	0.000
2010	69026428	686235	25668	0	0.001
2011	46969077	413384	244507	0	0.002
2012	42797917	218251	146093	2585	0.019
2013	28860949	219101	138690	5225	0.011
2014	297522378	190999	115844	4314	0.014
2015	55839943	481278	61390	4392	0.011
2016	116220522	377265	237518	6188	0.022
2017	129994149	448613	157787	18474	0.048
2018	18329090	410270	153277	42296	0.137
2019	259430655	206080	149941	6651	0.058
2020	303836413	622656	67914	19638	0.046
2021			201592		
arith. mean	125482093	366220	134308	34042	0.106
geo. mean	66852550				

arith. mean for the period 1993–2020

geo. mean for the period 1993–2019

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2021)	73785.221	97172.1	20620.3	457.757	2007.24
Exploitation pattern 1st half		0.033	0.059	0.074	0.074
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.161	9.668	14.075	18.825
Weight in the catch 1st half		6.161	9.668	14.075	18.825
Weight in the catch 2nd half	3.067	5.496	8.484	11.591	13.385
Proportion mature (2021)	0.000	0.000	0.790	0.980	1.000
Proportion mature (2022)	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(2020) = 0.0462; Yield(2020) = 19.637; Recruitment(2020) = 303.836413; Recruitment(2021) = geometric mean (GM 2010-2019) = 73.785221 billions; SSB(2021) = 201.592

Basis	Total catch (2021)	F_{total} (2021)	SSB (2022)	% SSB change *	% TAC change **	% advice change ***
ICES advice basis						
$SSB_{2022} \geq$ MSY $B_{escapement}$ with F_{cap}	77512	0.15	266680	32.287	95.683	95.683
Other scenarios						
F = 0	0	0	307491	52.531	-100.000	-100.000
SSB_{2022} = MSY $B_{escapement}$ = B_{pa}	419269	1.22	102000	-49.403	958.466	958.466
B_{lim}	555552	2.13	48000	-76.190	1302.520	1302.520
F = F_{2020}	24989	0.046	294232	45.954	-36.914	-36.914

*** SSB_{2022} relative to SSB_{2021}.**

**** Catch scenario for 2021 relative to the TAC in 2020 (39 611 t).**

***** Advice value 2021 relative to the advice value 2020 (39 611 t).**

Table 9.6.1. Acoustic survey index (Area-5) is estimated as biomass (tonnes) methods and acoustic target strength described in ICES (2016) (Benchmark report).

Year	Biomass (tonnes)
2009	256.5
2010	6320.9
2011	3300.2
2012	732.2
2013	3949.1
2014	1331.8
2015	10477.6
2016	733.2
2017	493.1
2018	945.0
2019	3844.6
2020	3315.7

Table 9.9.1 Total catch weight by year for sandeel in ICES Division 6.a

Year	Denmark	Faroe Islands	Norway	UK-Scotland	Total
1970	-		-	-	0
1971	-		-	-	0
1972	-		-	-	0
1973	-		-	-	0
1974	-		-	<0.5	0
1975	-		-	<0.5	0
1976	-		17	<0.5	17
1977	-		54	13	67
1978	-			5	0
1979	-		-	-	0
1980	-		-	211	211
1981	-		-	5972	5972
1982	-		-	10873	10873
1983	-		-	13051	13051
1984	-		-	14166	14166
1985	-		-	18586	18586
1986	-		-	24469	24469
1987	-		-	14479	14479
1988	-		-	24465	24465
1989	-		-	18785	18785
1990	-		-	16515	16515
1991	-		-	8532	8532
1992	-		-	4985	4985

Year	Denmark	Faroe Islands	Norway	UK-Scotland	Total
1993	80		-	6156	6236
1994	-		-	10627	10627
1995	-		-	7111	7111
1996	-		-	13257	13257
1997	-		-	12679	12679
1998	-		-	5320	5320
1999	-		-	2627	2627
2000	-		-	5771	5771
2001	-		-	295	295
2002	-		-	706	706
2003	-		-	-	0
2004	-		-	566	566
2005	-		-	-	0
2006	-		-	-	0
2007	.	57	-	-	57
2008	.	-	.	-	0
2009	.	.	.	-	0
2010	.	.	.	-	0
2011	-	-	-	-	0
2012	-	-	-	-	0
2013	-	-	-	-	0
2014	-	-	-	-	0
2015	-	-	-	-	0
2016	-	-	-	-	0
2017	-	-	-	-	0
2018	-	-	-	-	0
2019	-	-	-	-	0
2020	2.7	-	-	-	2.7

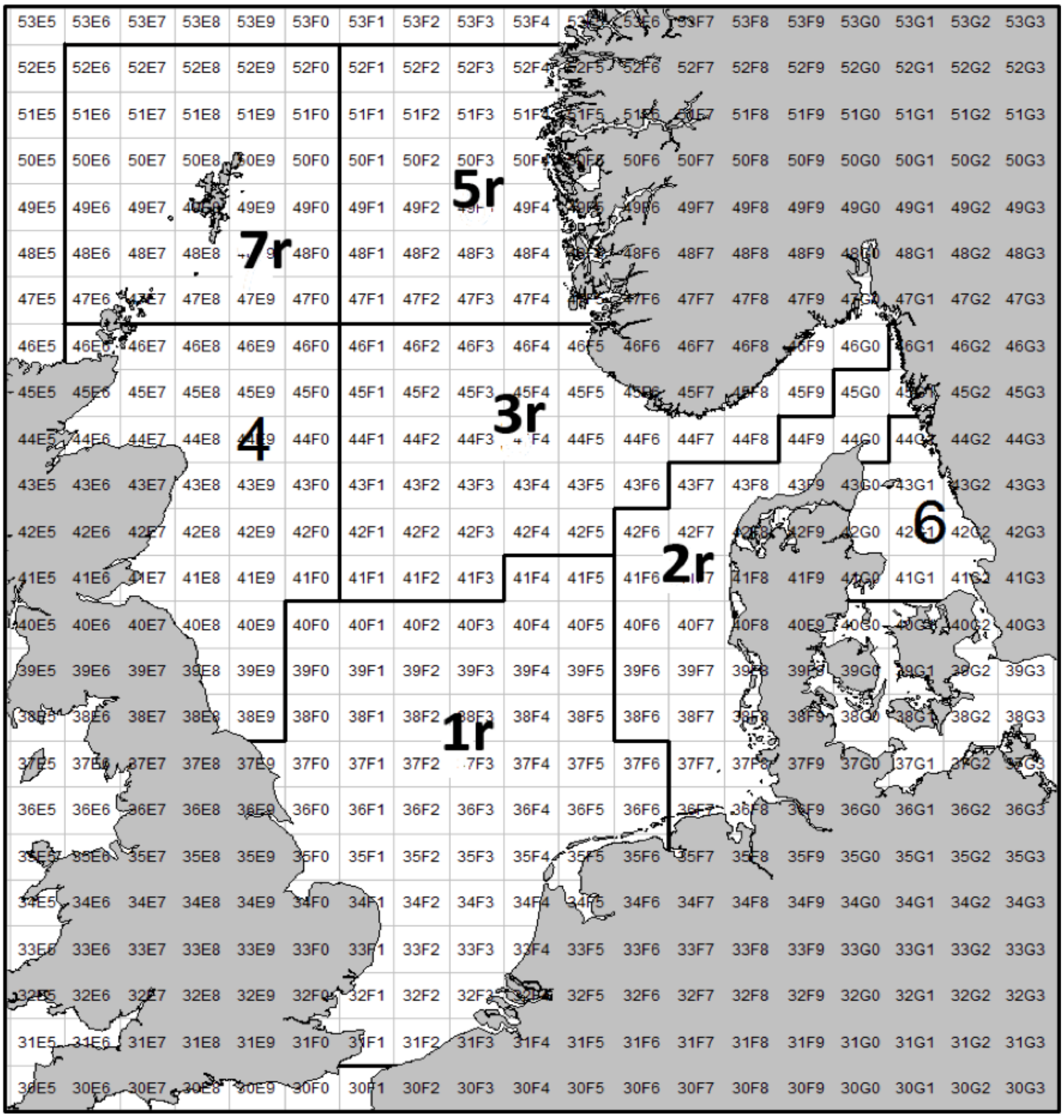


Figure 9.1.1 Sandeel in ICES div IV and IIIa. Sandeel management areas.


2020
2019
2018
2017
2016
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005

Figure 9.1.2 Sandeel in ICES div IV and IIIa. Catch by ICES rectangles 2005–2020 (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.

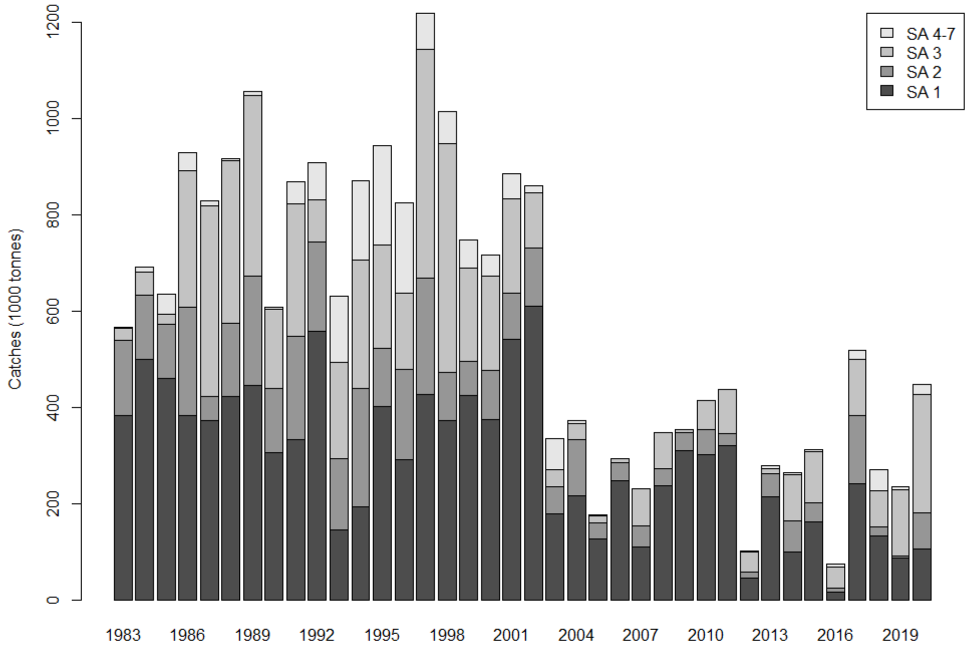


Figure 9.1.3 Sandeel in ICES div IV and IIIa. Total catches by year and area.

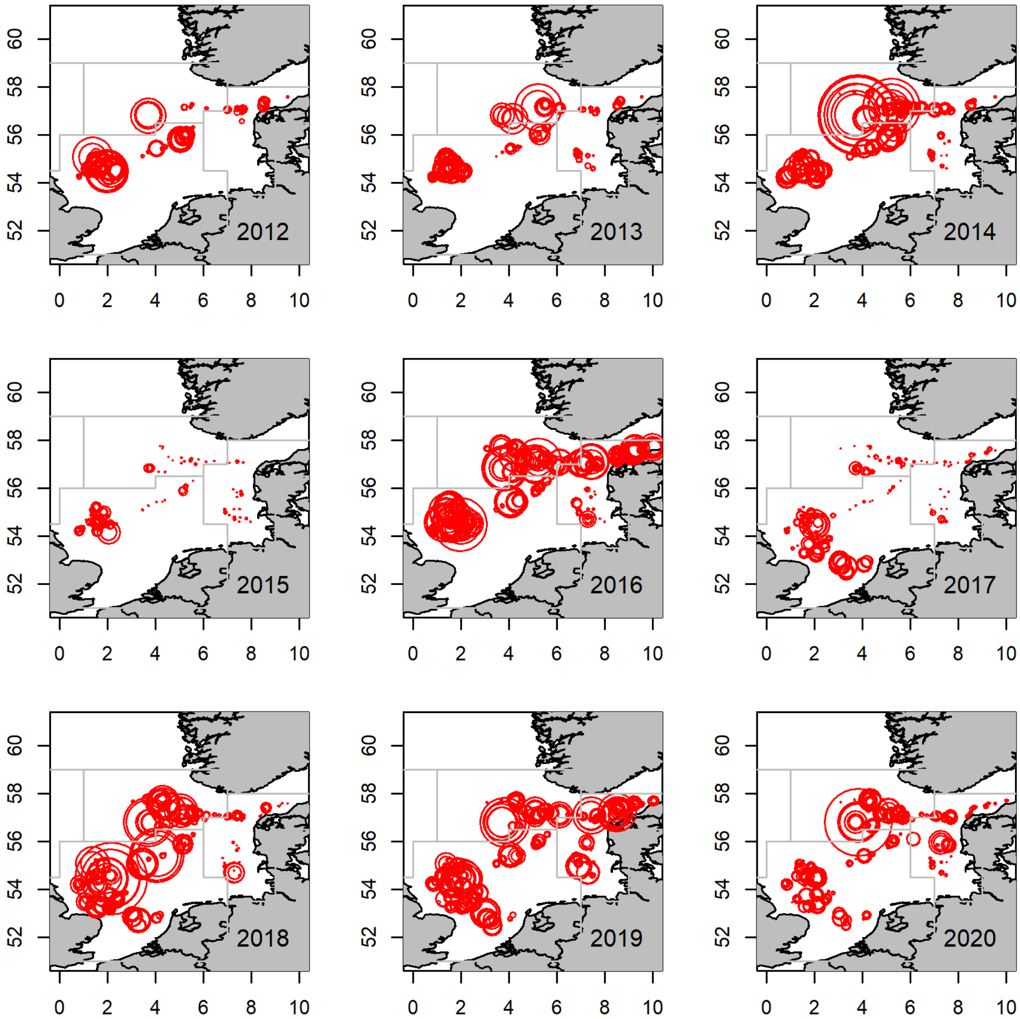


Figure 9.1.4 Sandeel in ICES div IV and IIIa. Danish survey catches by haul for 0-group. Area of the circles is proportional to catch number.

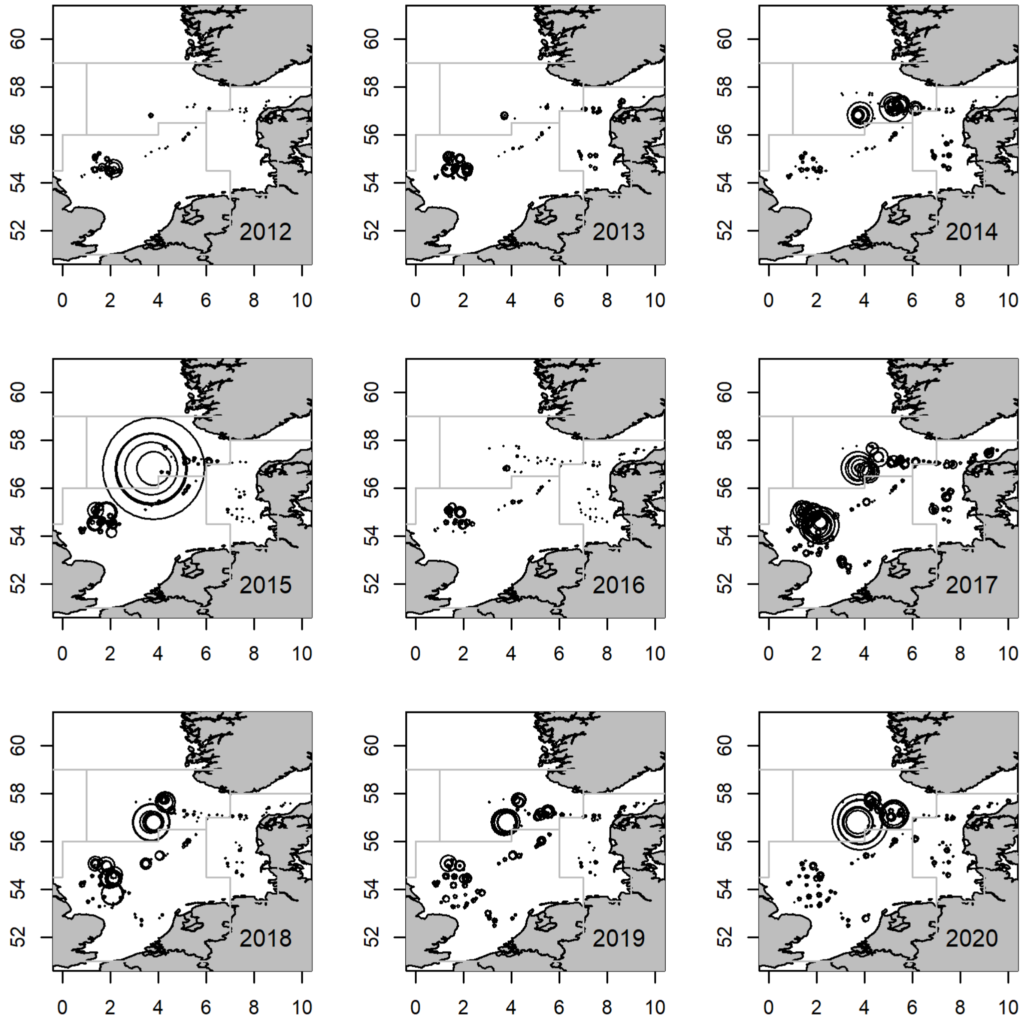


Figure 9.1.5 Sandeel in ICES div IV and IIIa. Danish survey catches by haul for 1-group. Area of the circles is proportional to catch number.

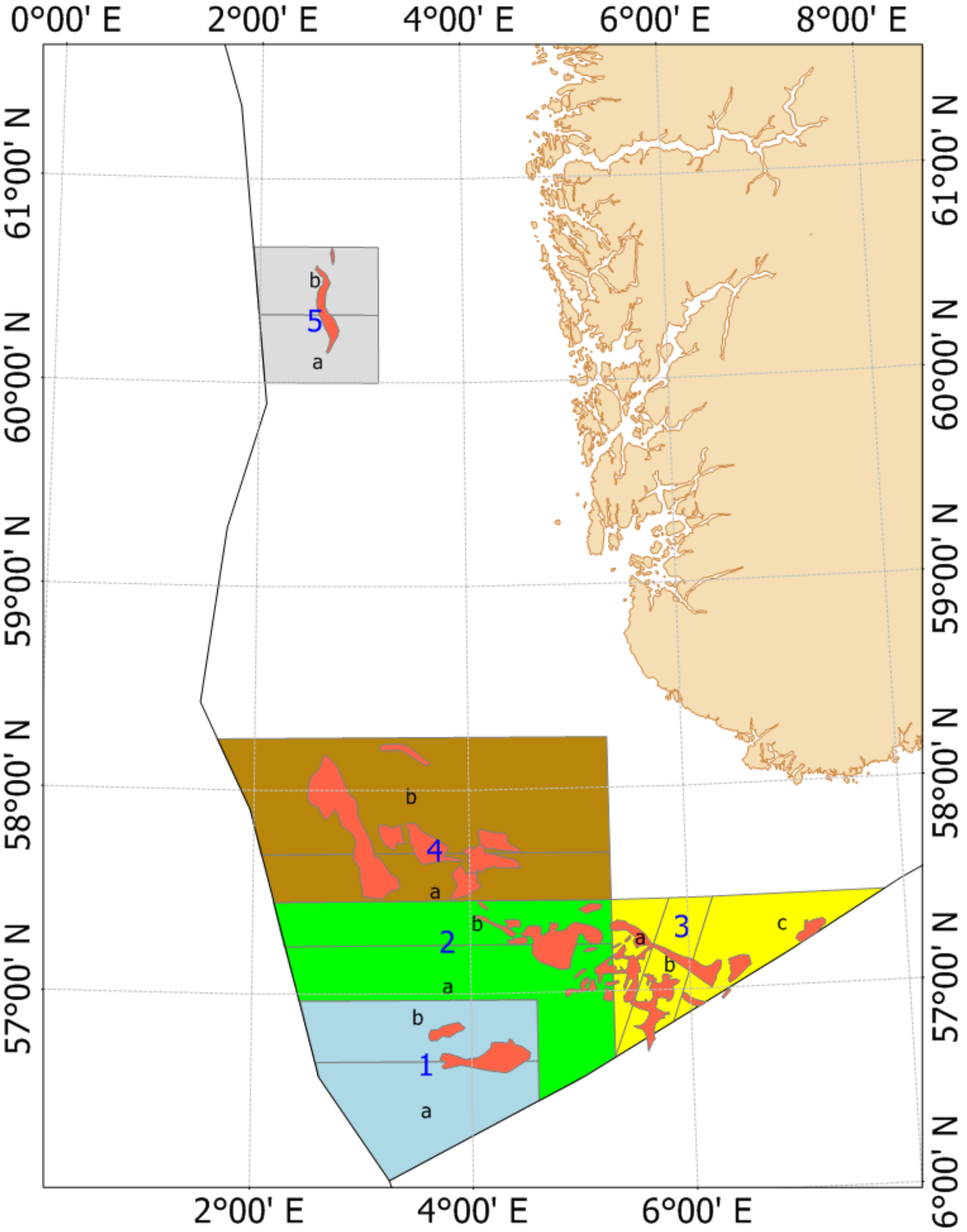


Figure 9.1.6 Sandeel in ICES div IV and IIIa. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.

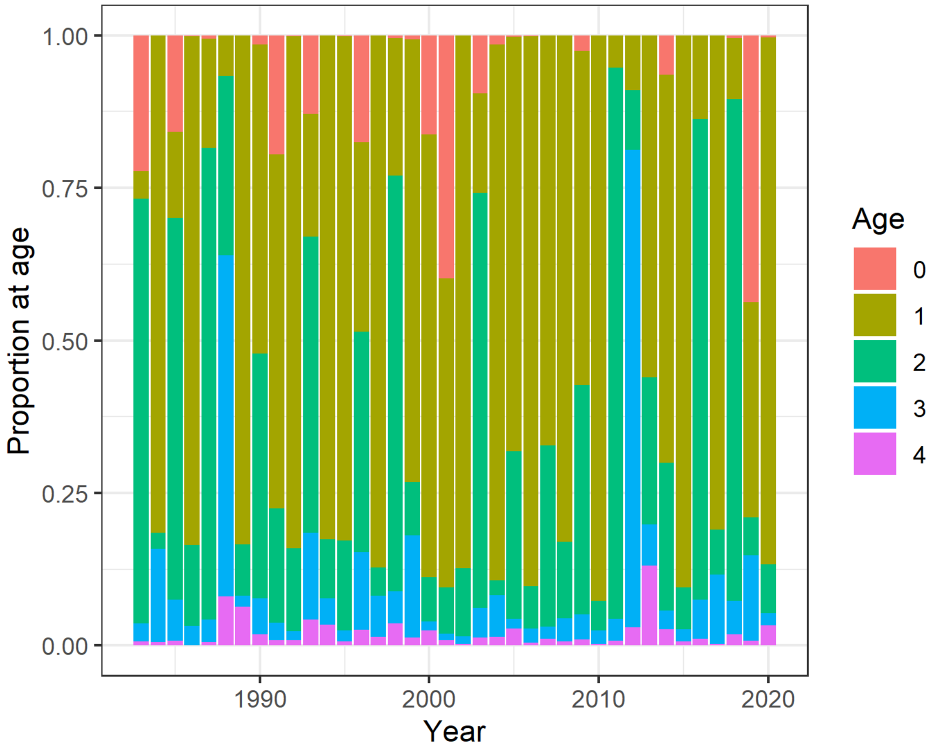


Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

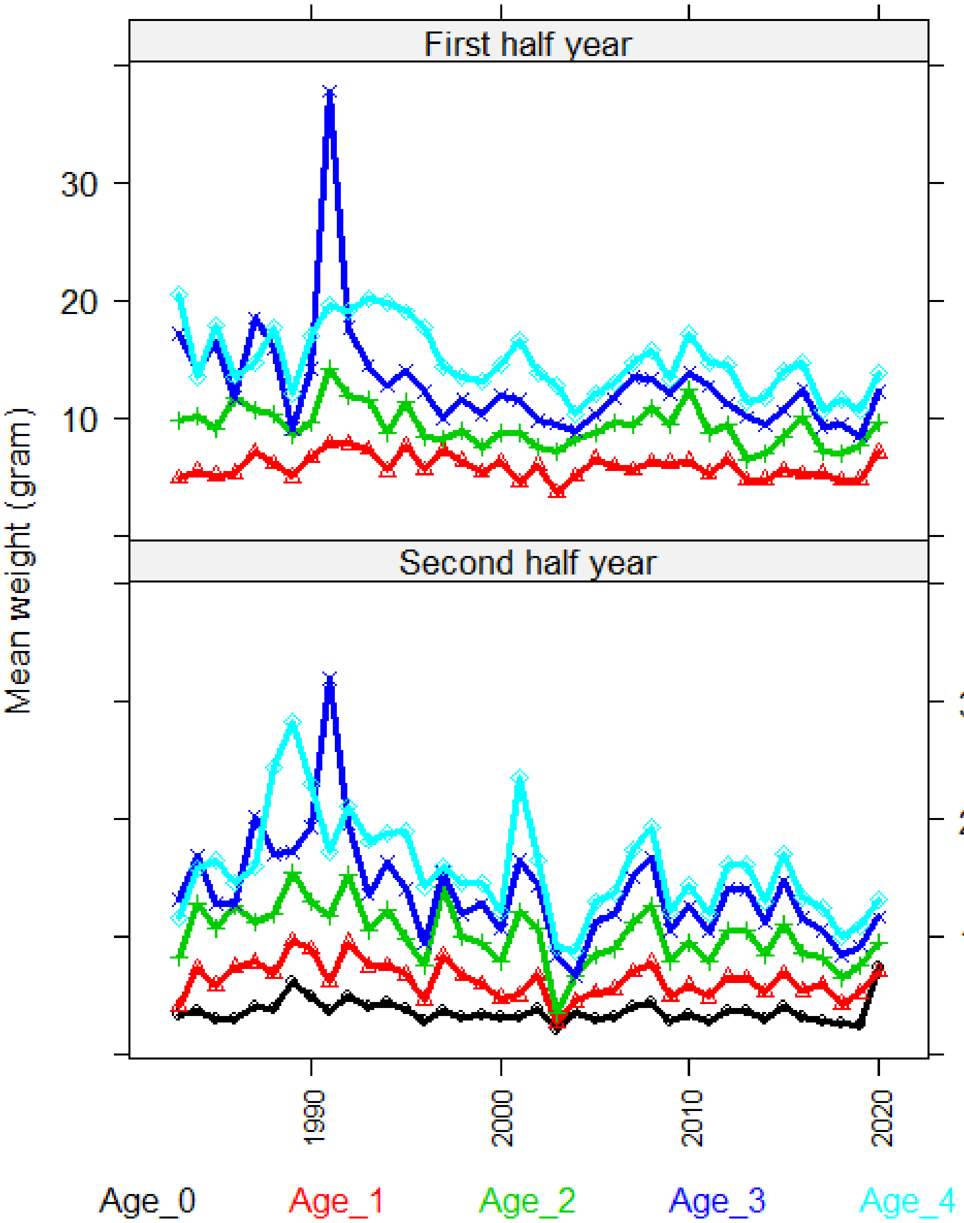


Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

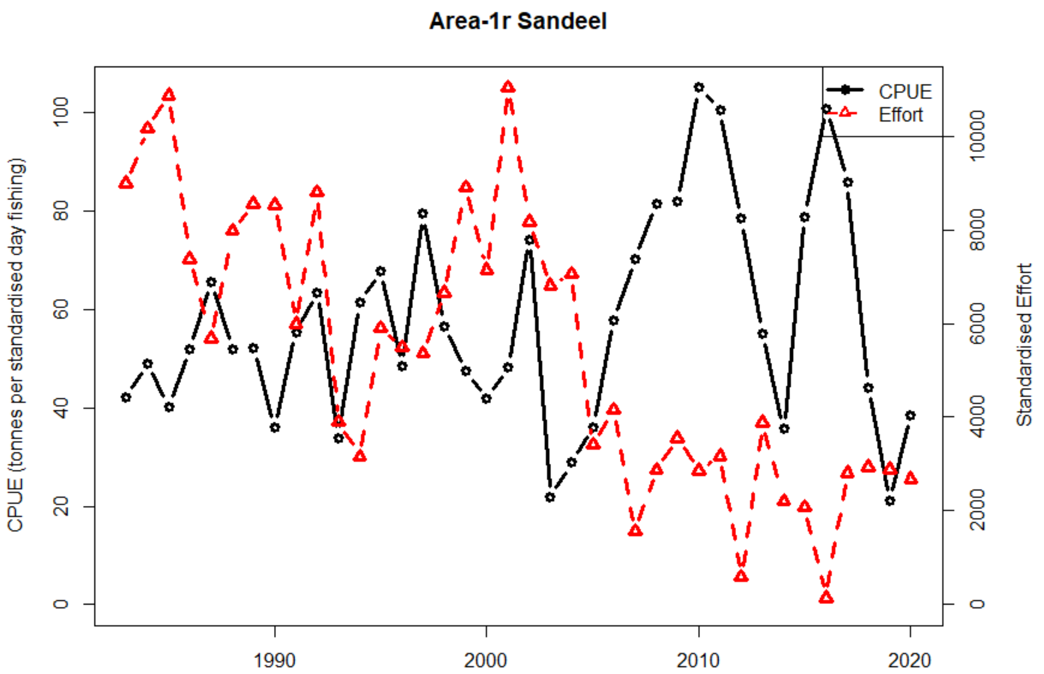


Figure 9.2.3 Sandeel Area-1r. CPUE and effort.

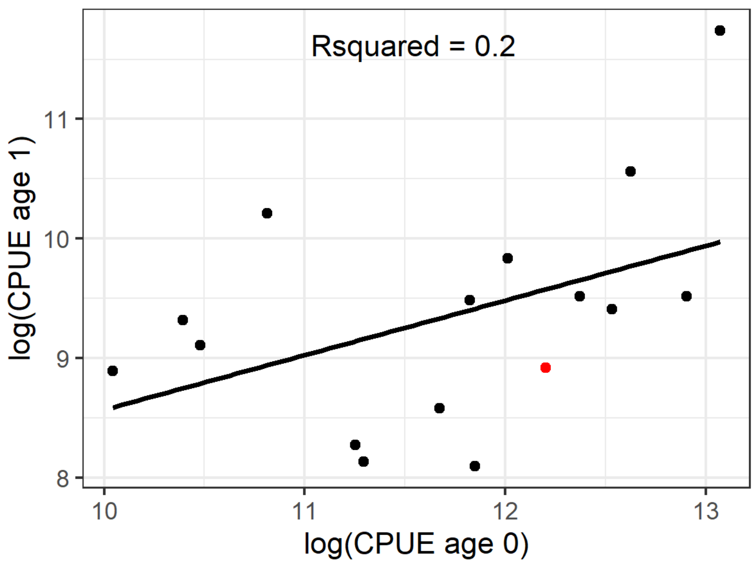


Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

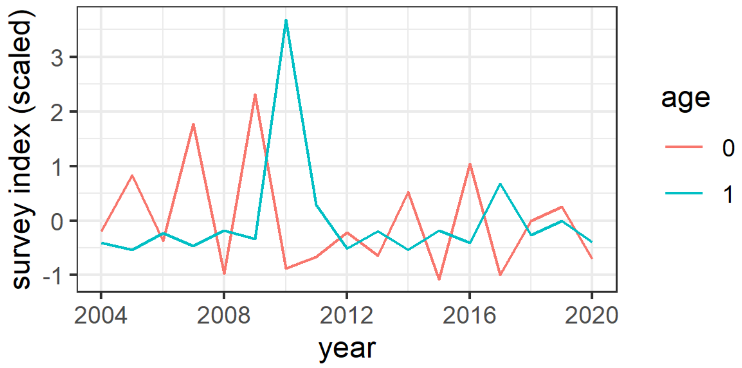


Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.

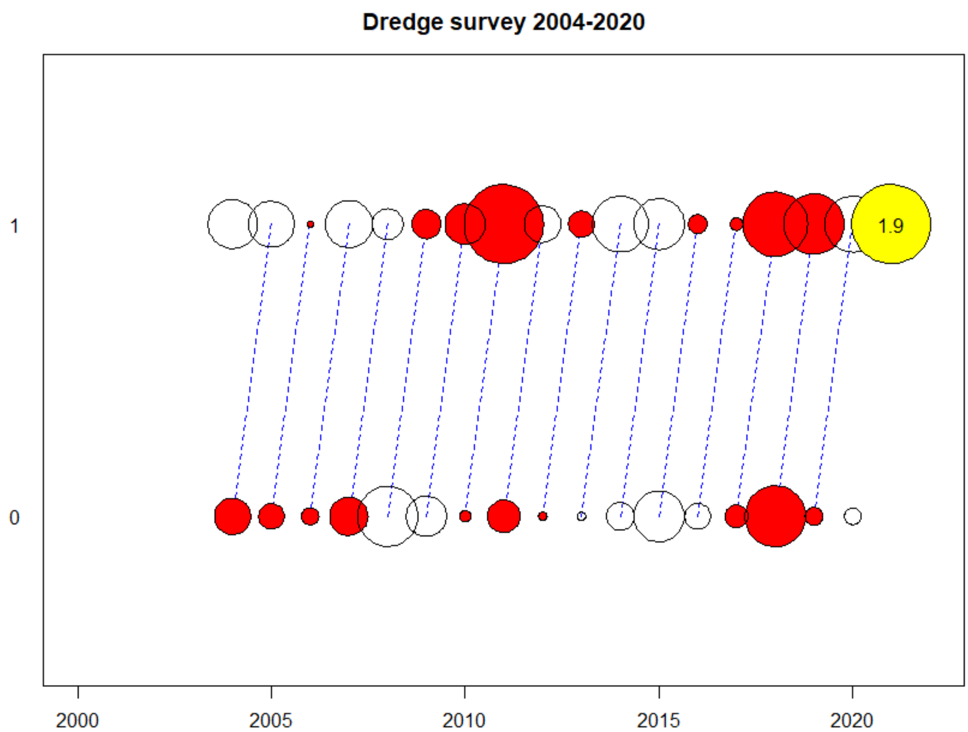


Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

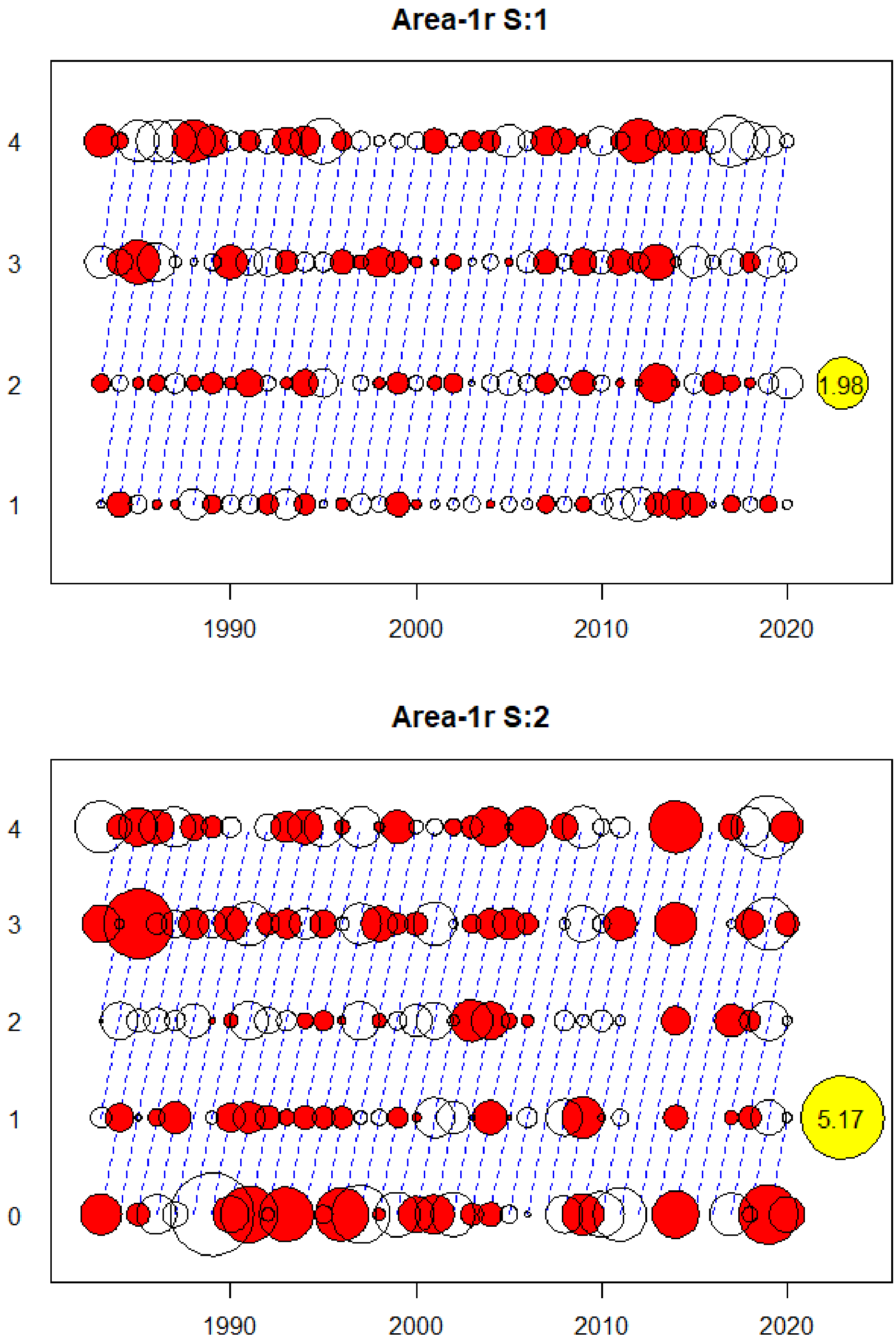


Figure 9.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

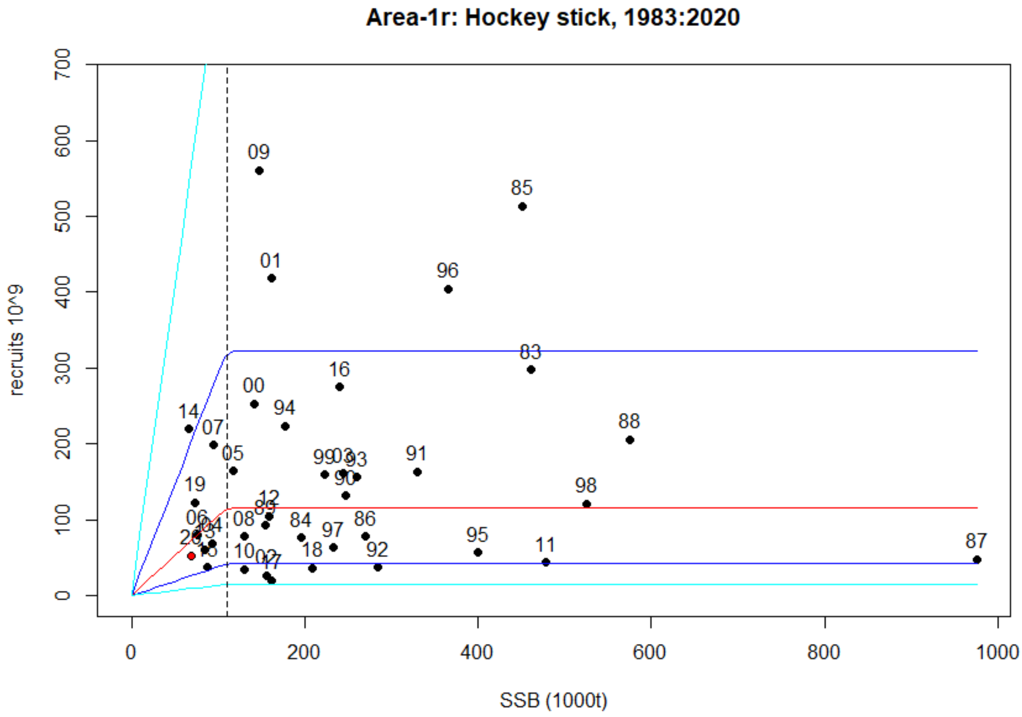


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

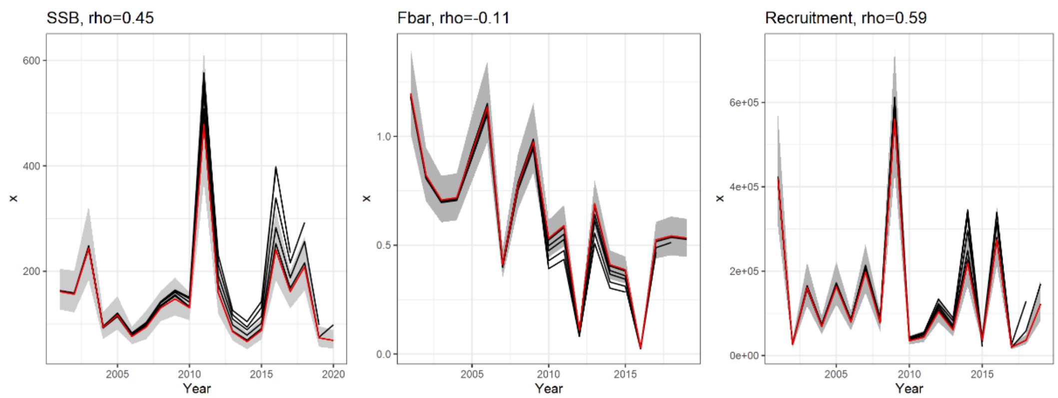


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

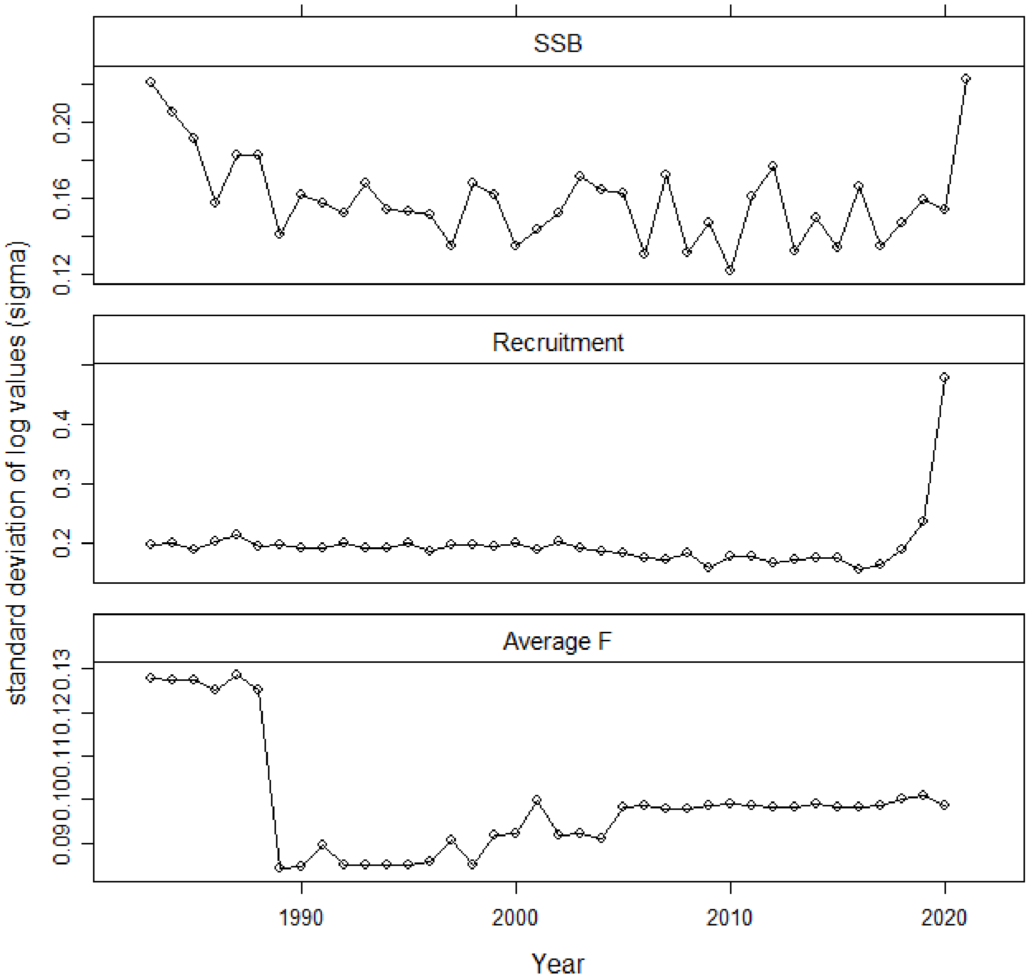


Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

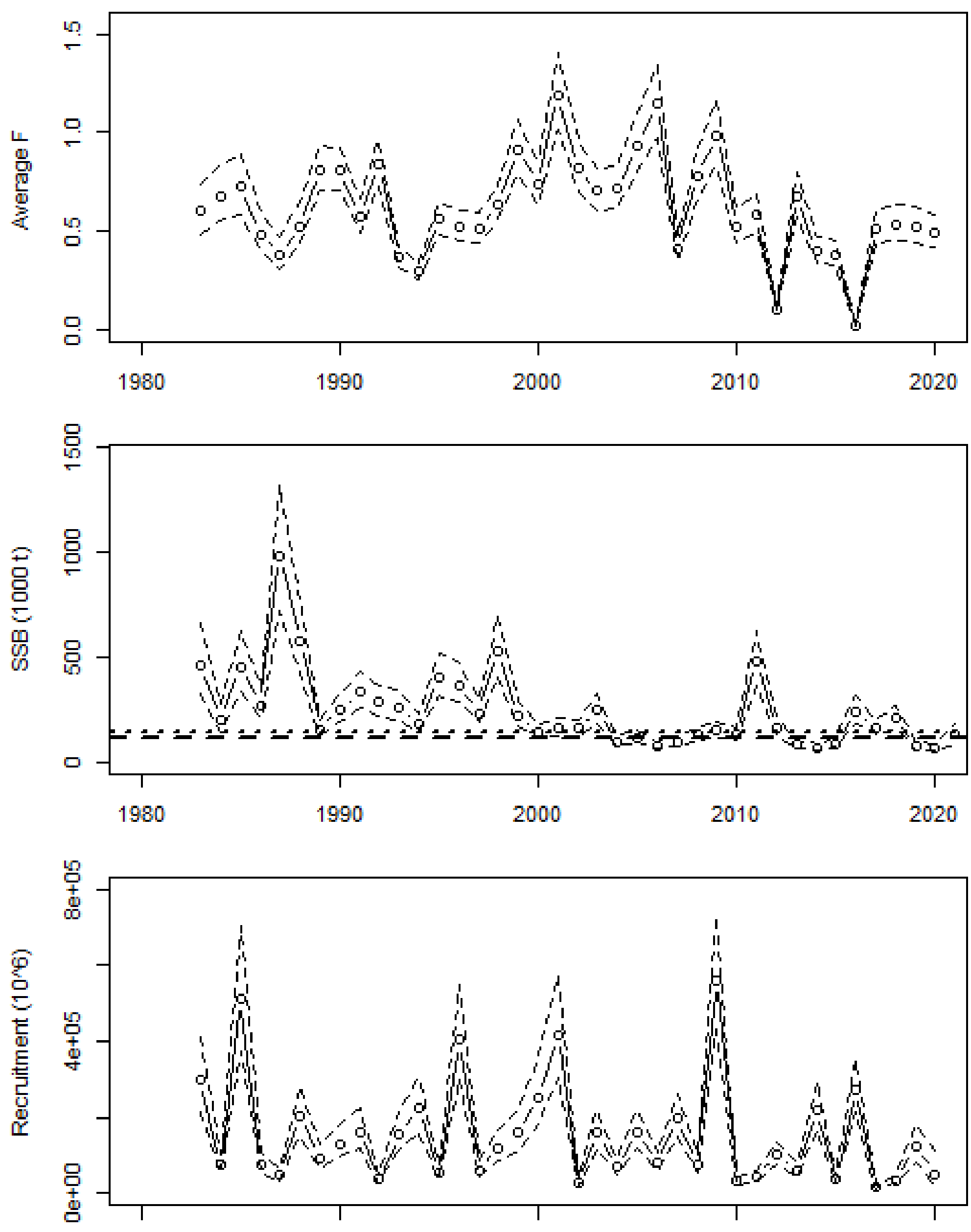


Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

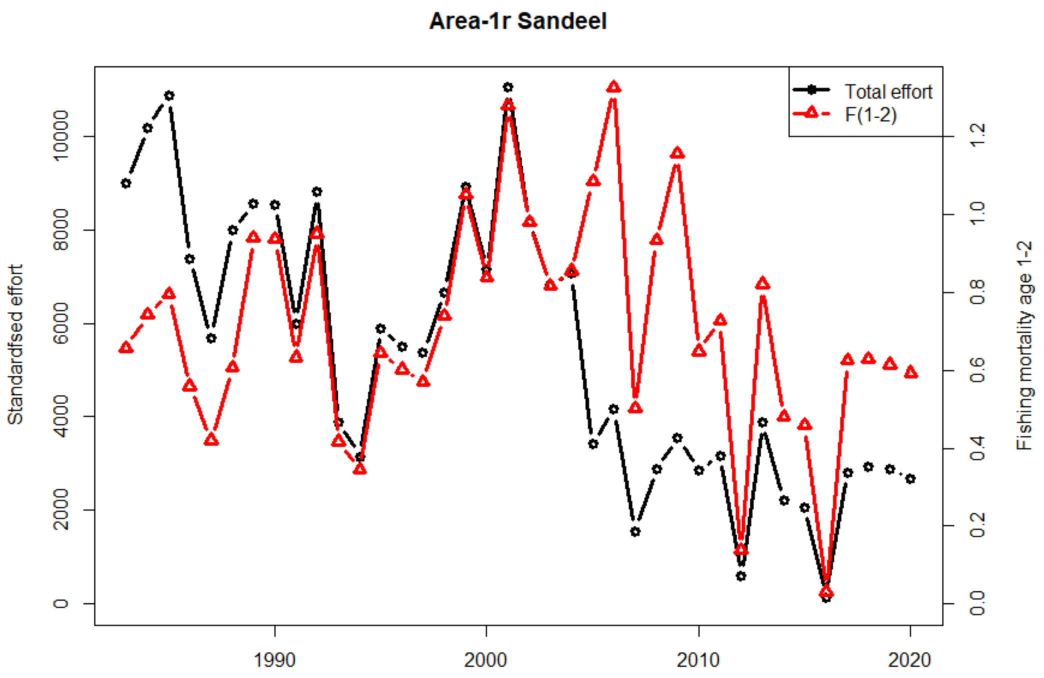


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

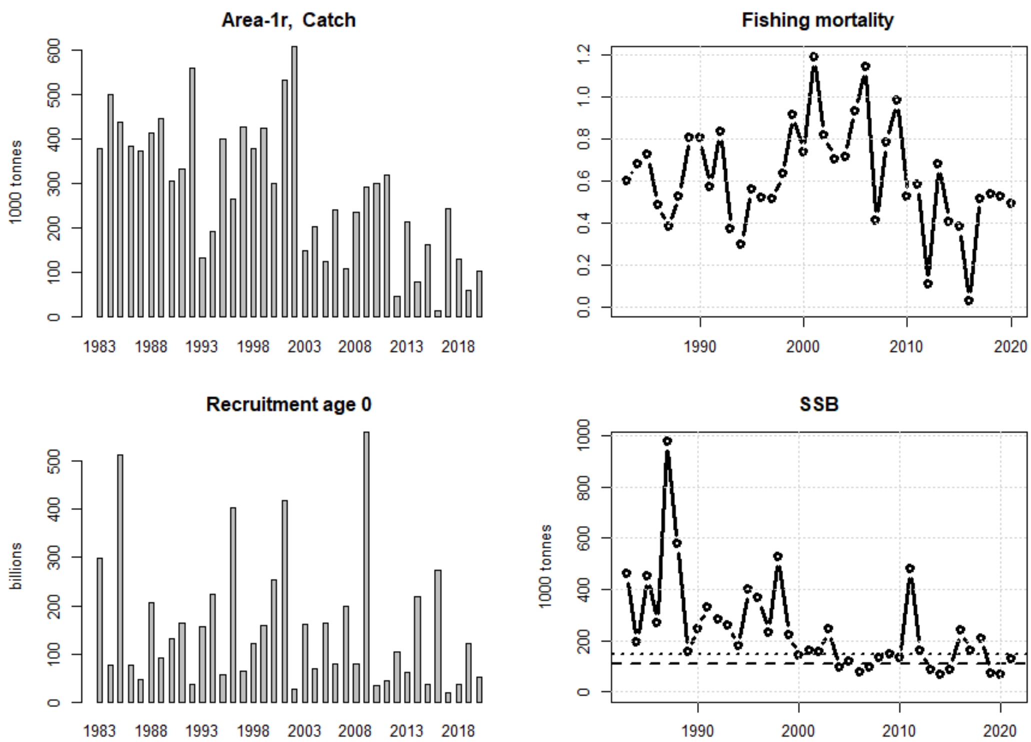


Figure 9.2.13 Sandeel Area-1r. Stock summary.

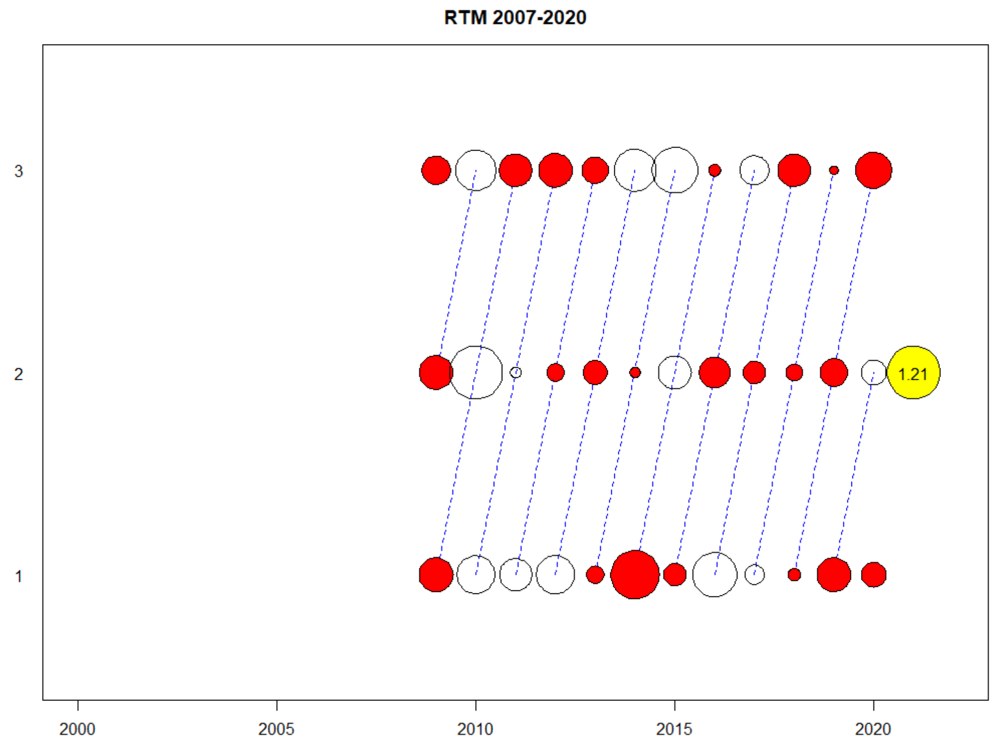


Figure 9.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

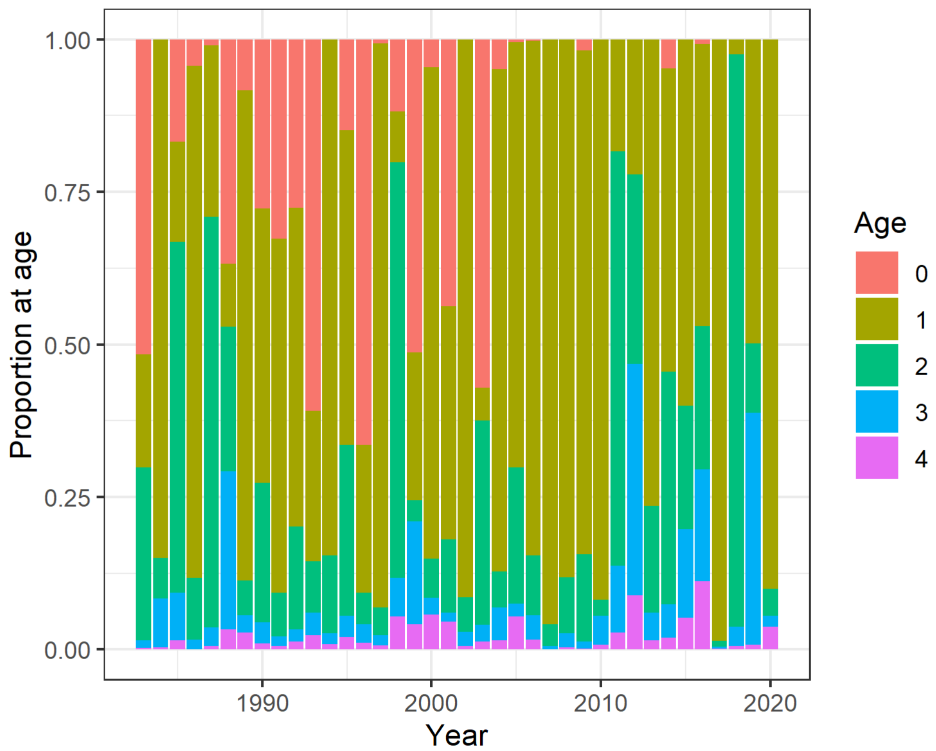


Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

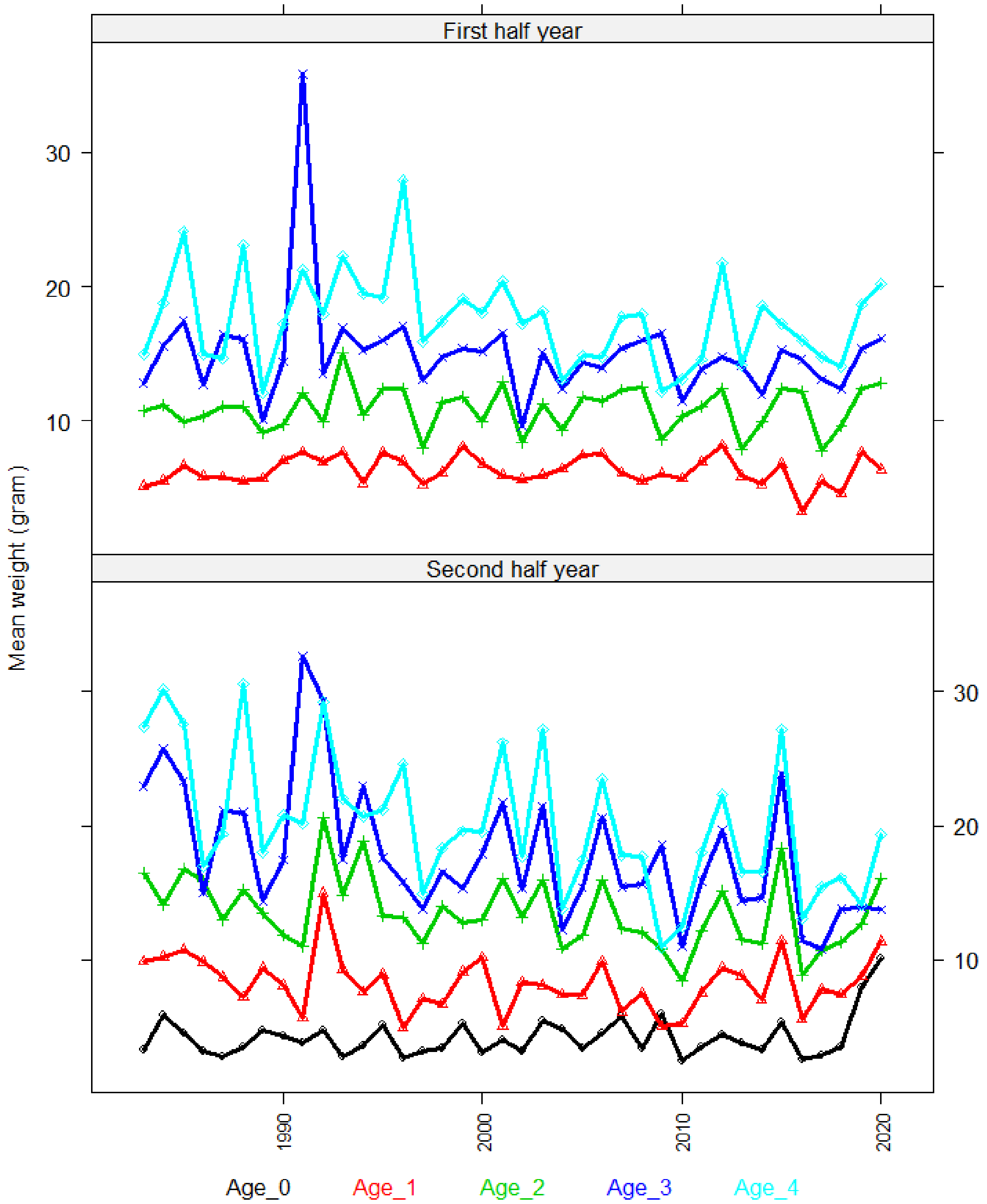


Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

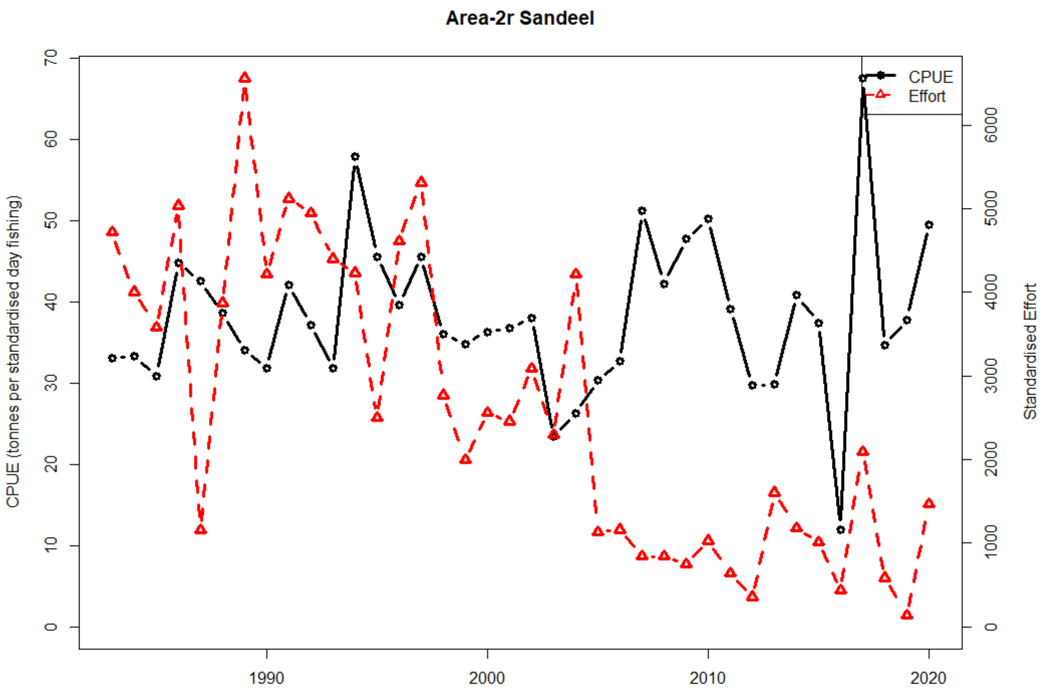


Figure 9.3.3 Sandeel Area-2r. CPUE and effort.

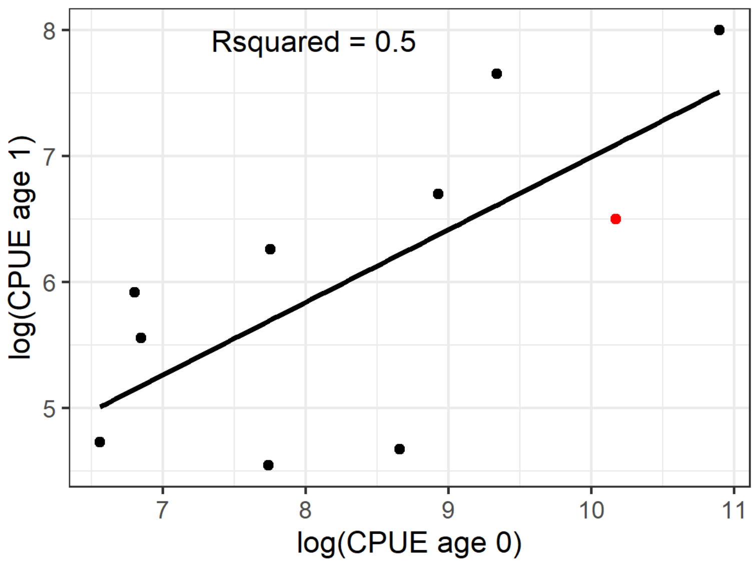


Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

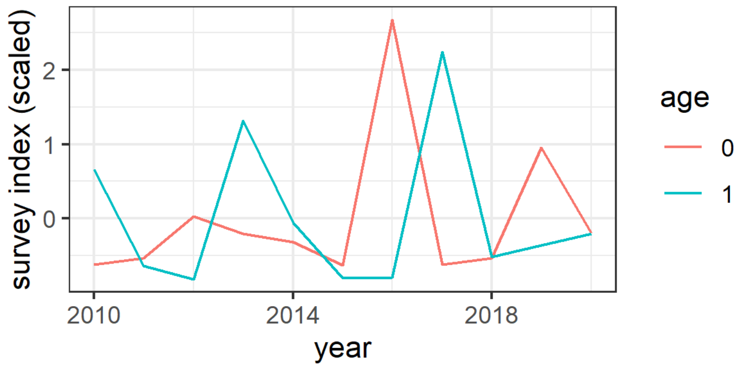


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

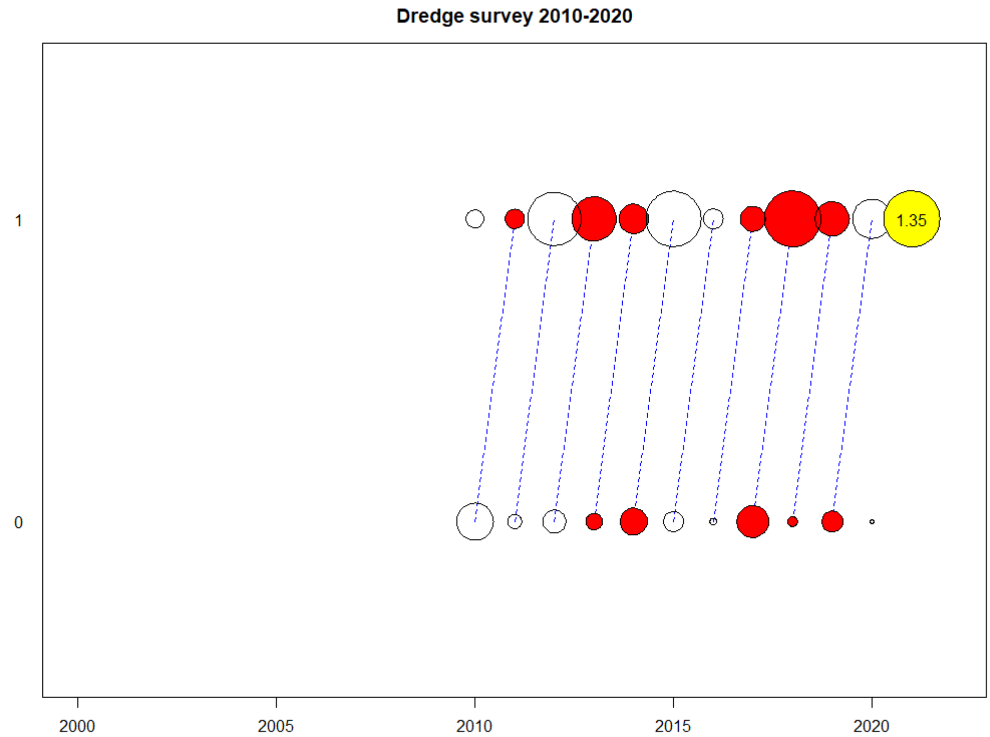
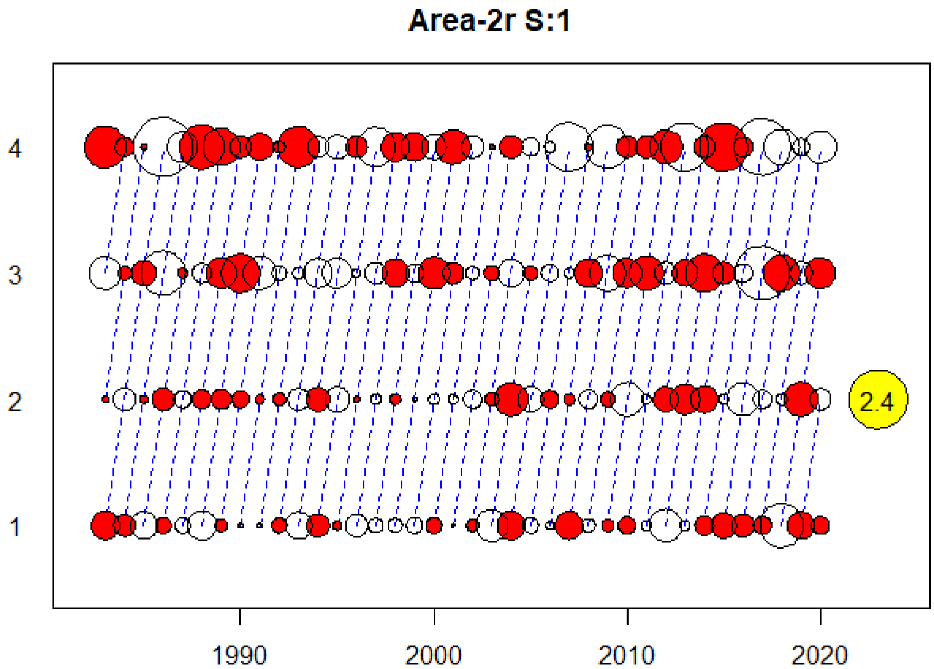


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



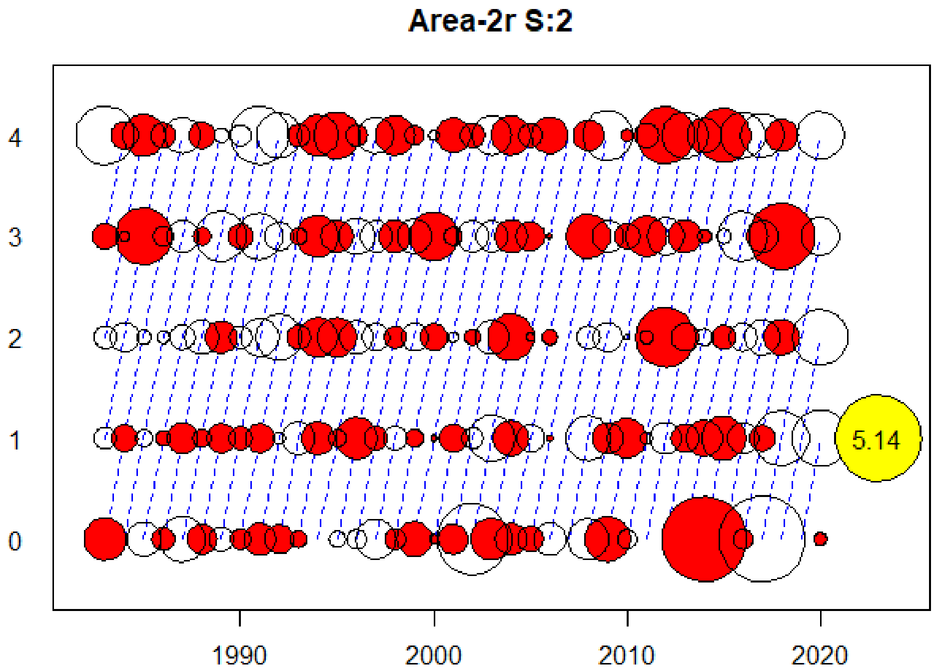


Figure 9.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

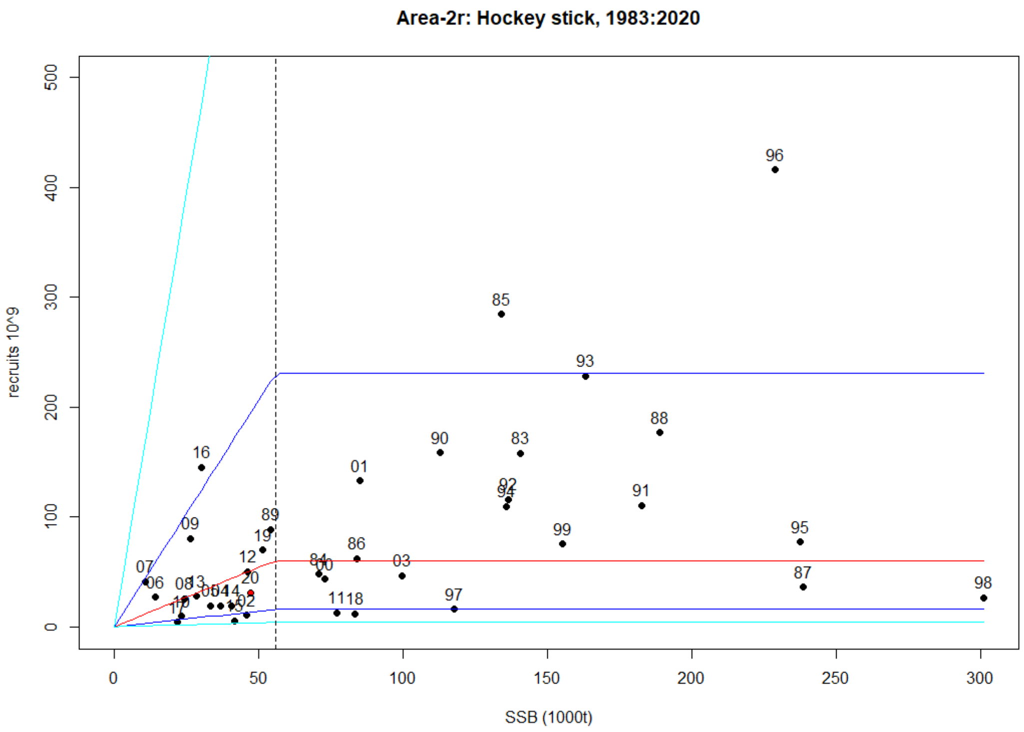


Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

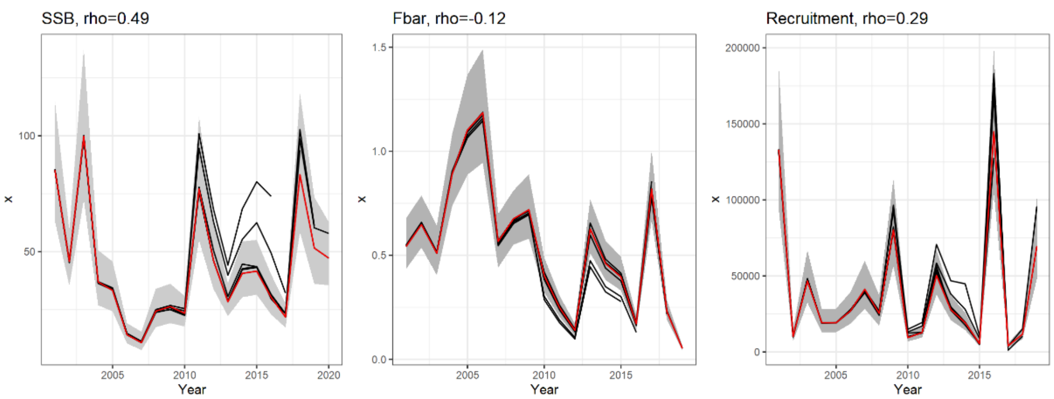


Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.

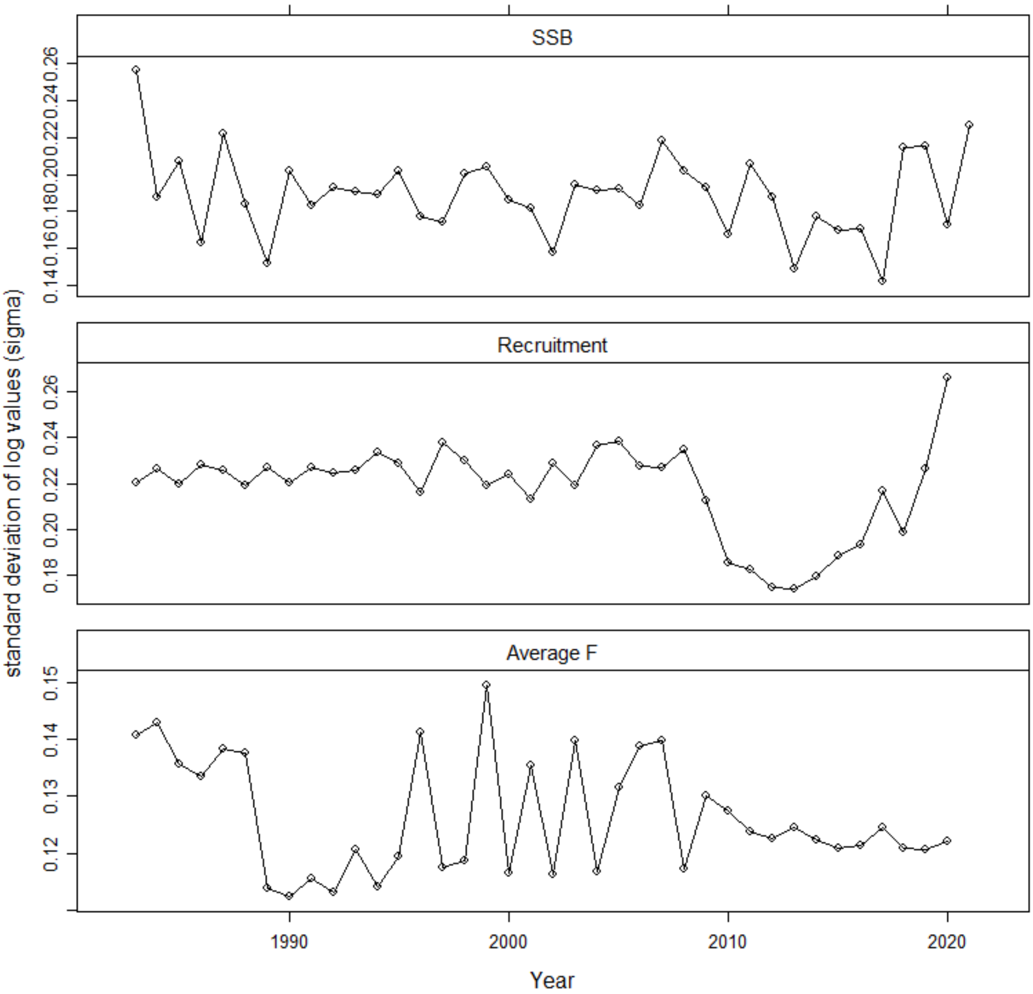


Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

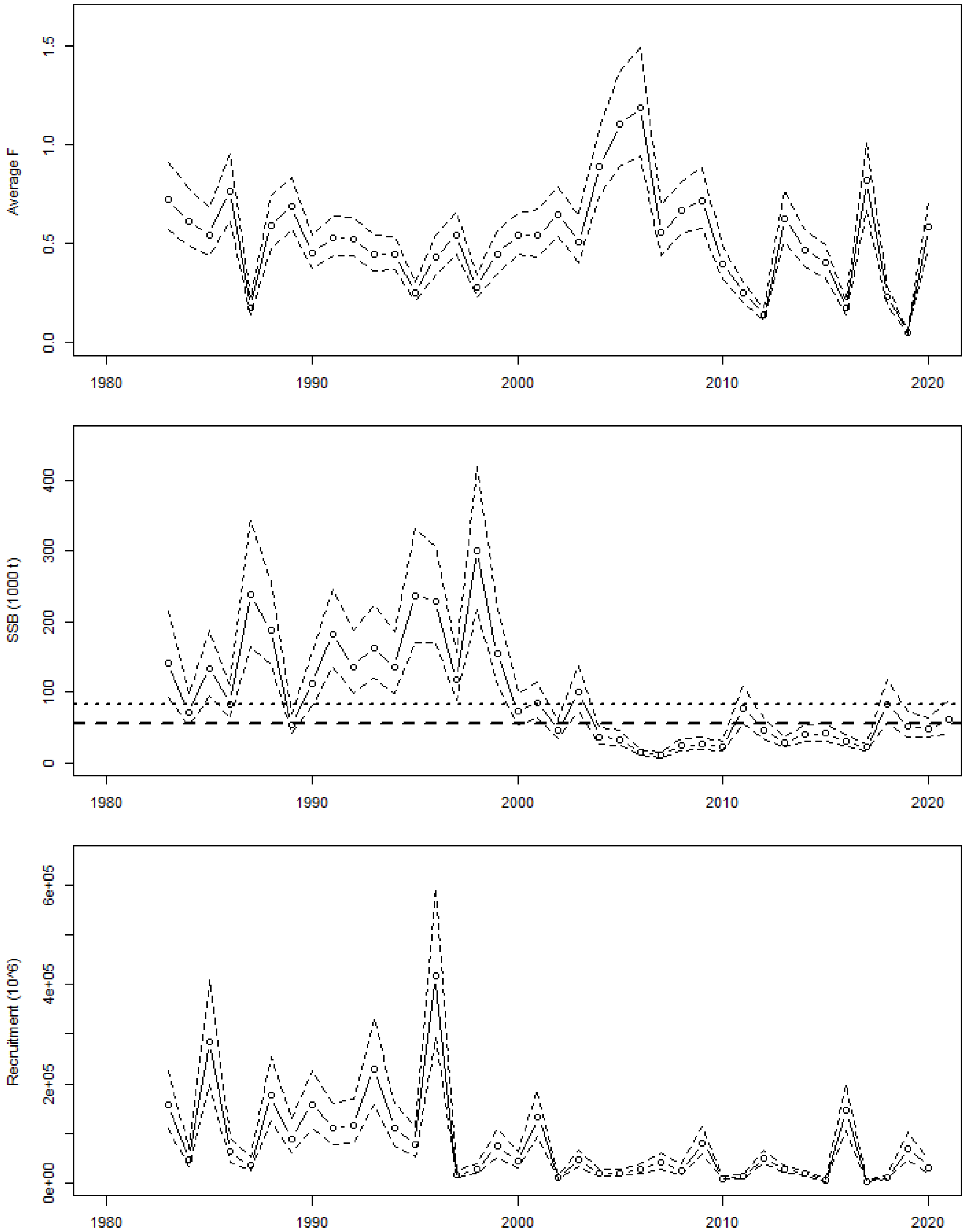


Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

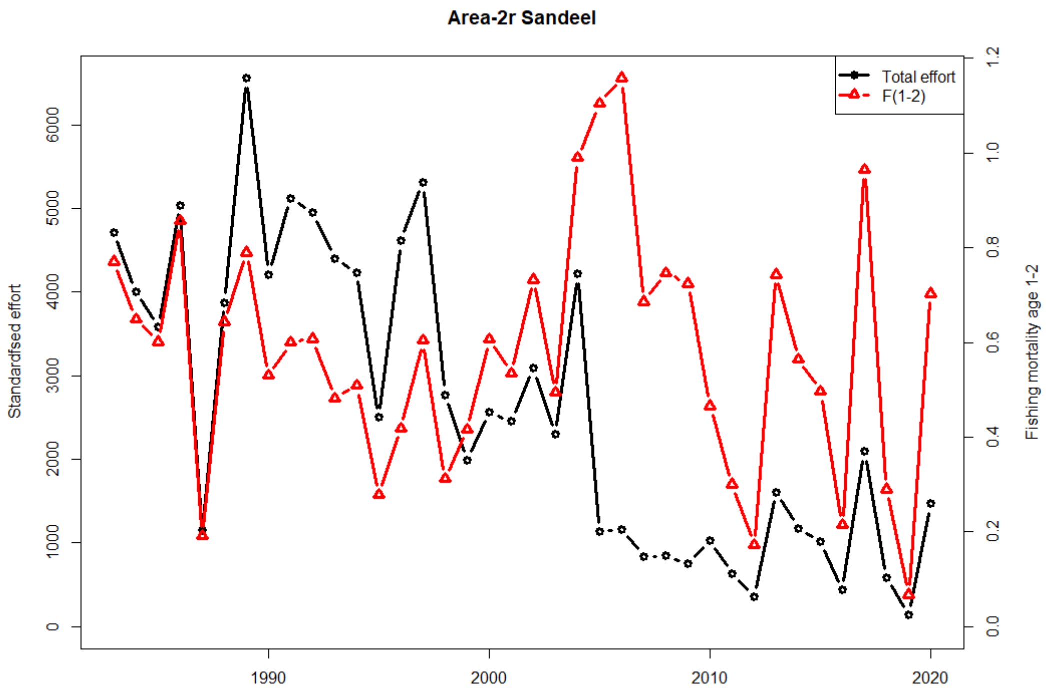


Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

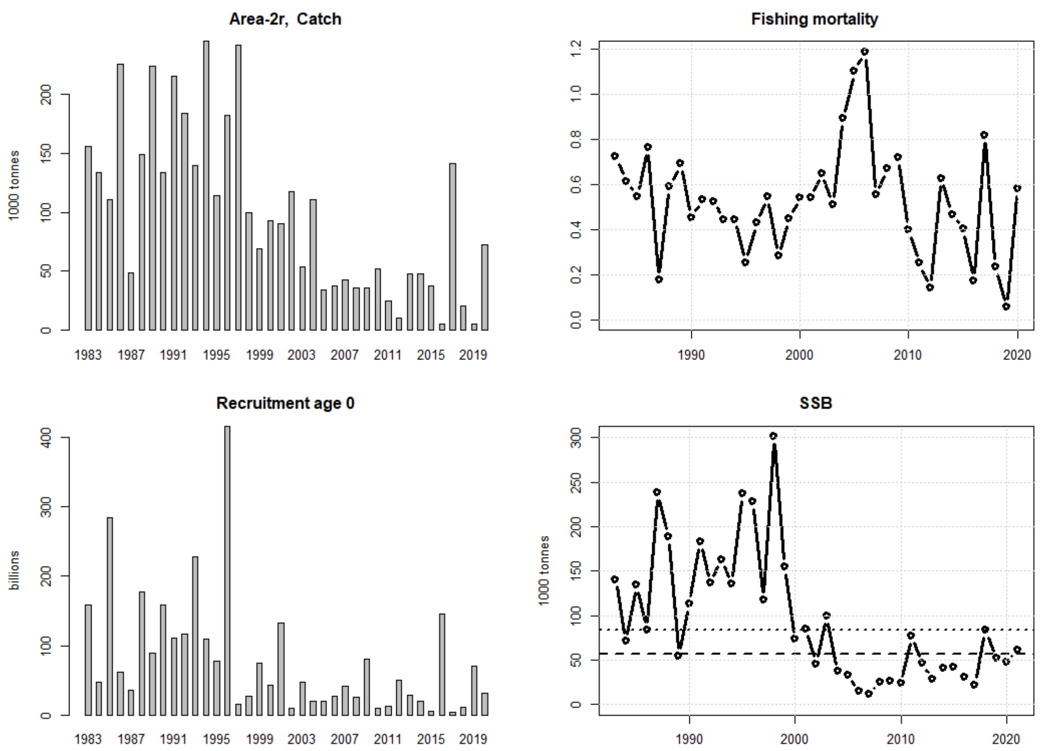


Figure 9.3.13 Sandeel Area-2r. Stock summary.

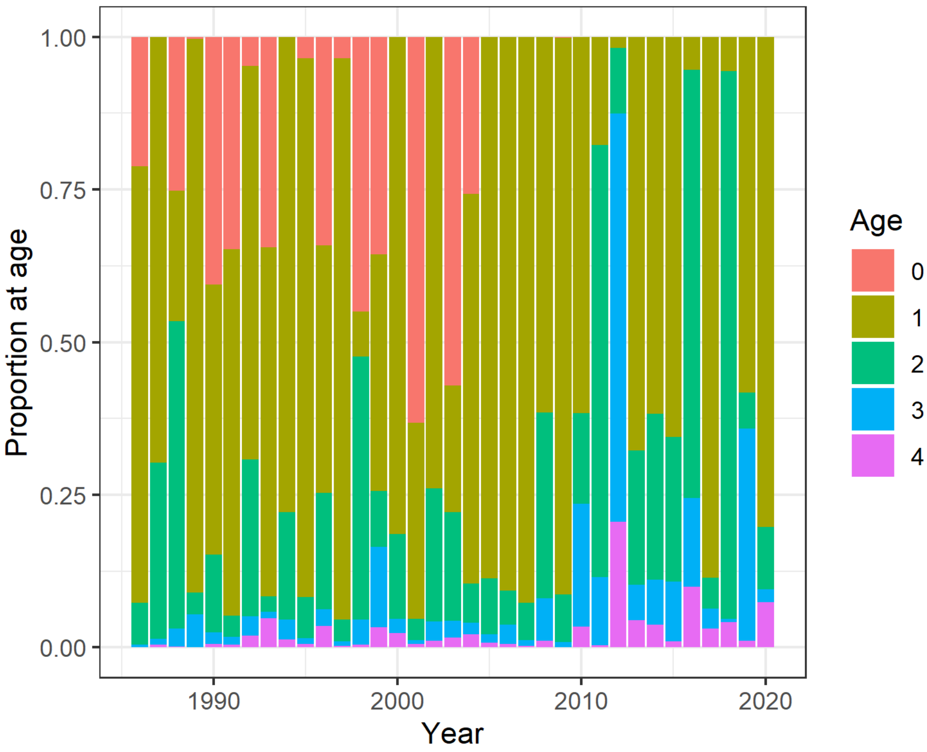


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

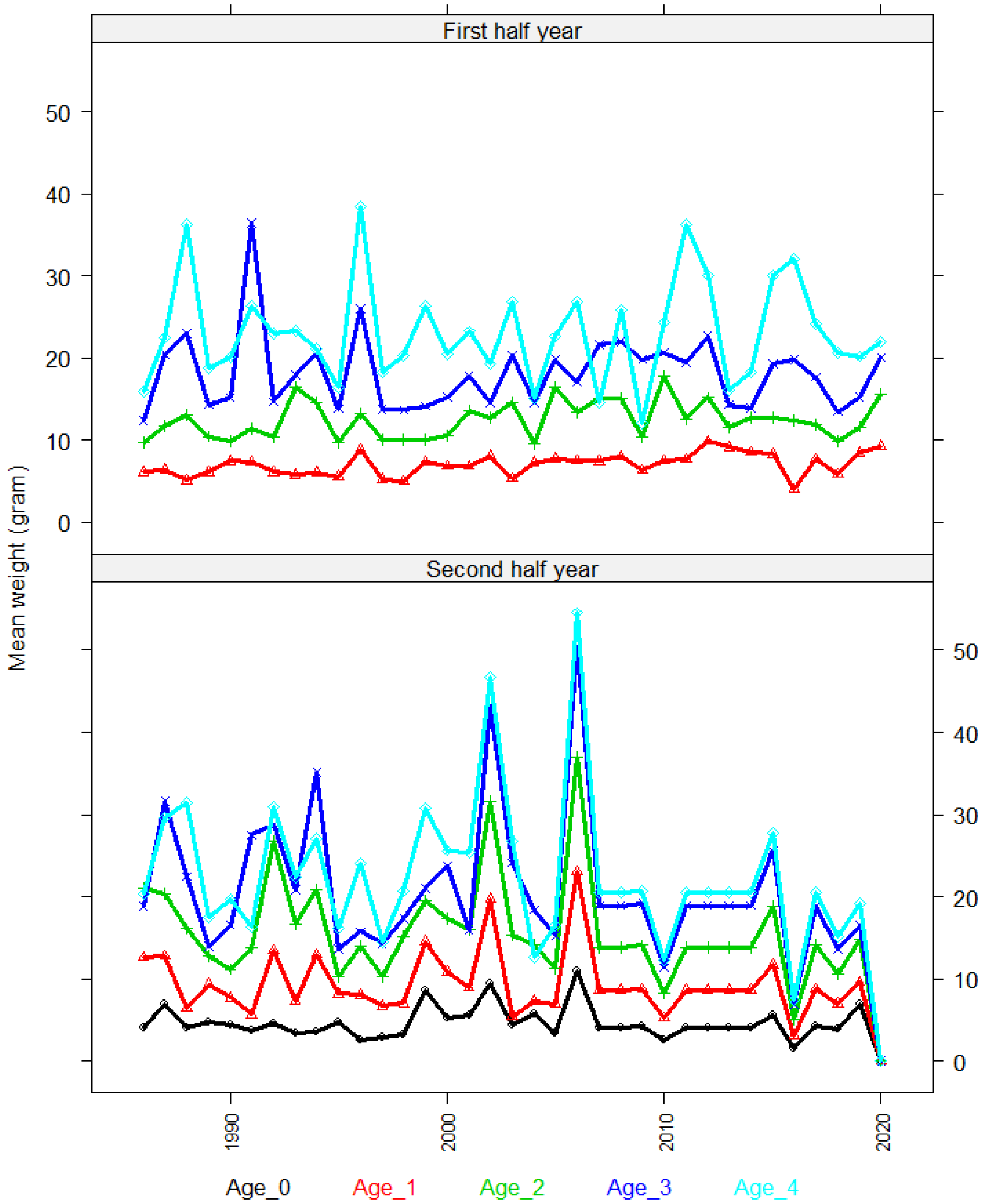


Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

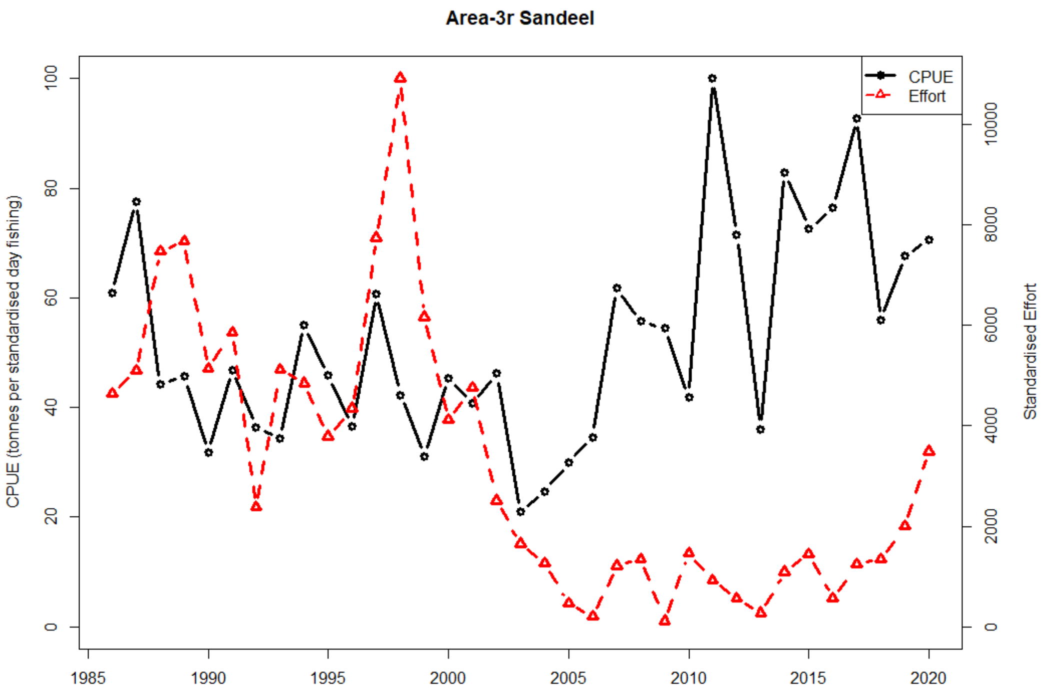


Figure 9.4.3 Sandeel Area-3r. CPUE and effort.

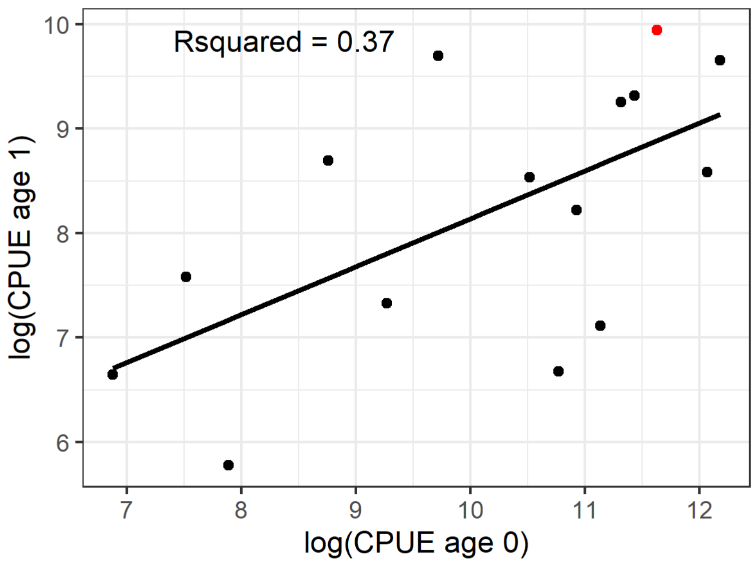


Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

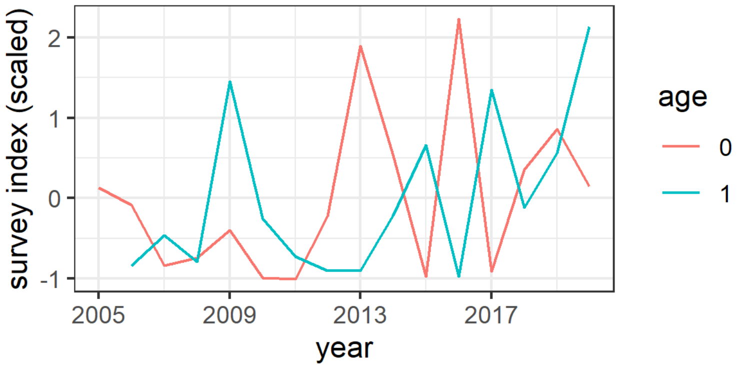


Figure 9.4.5 Sandeel Area-3r. Dredge survey index timeline.

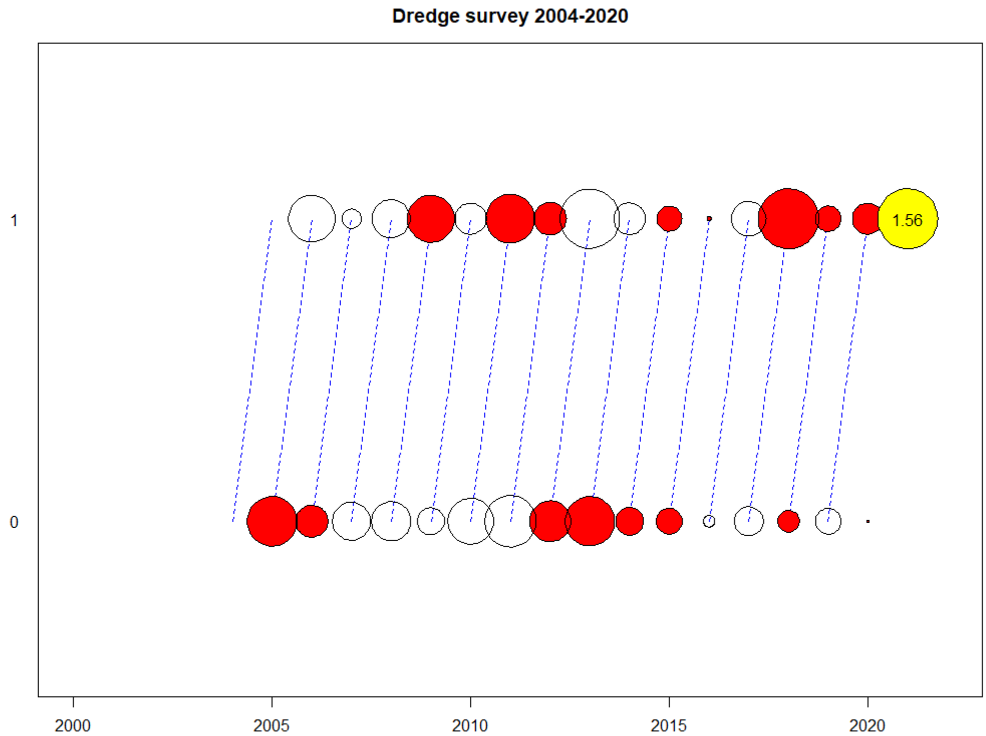


Figure 9.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

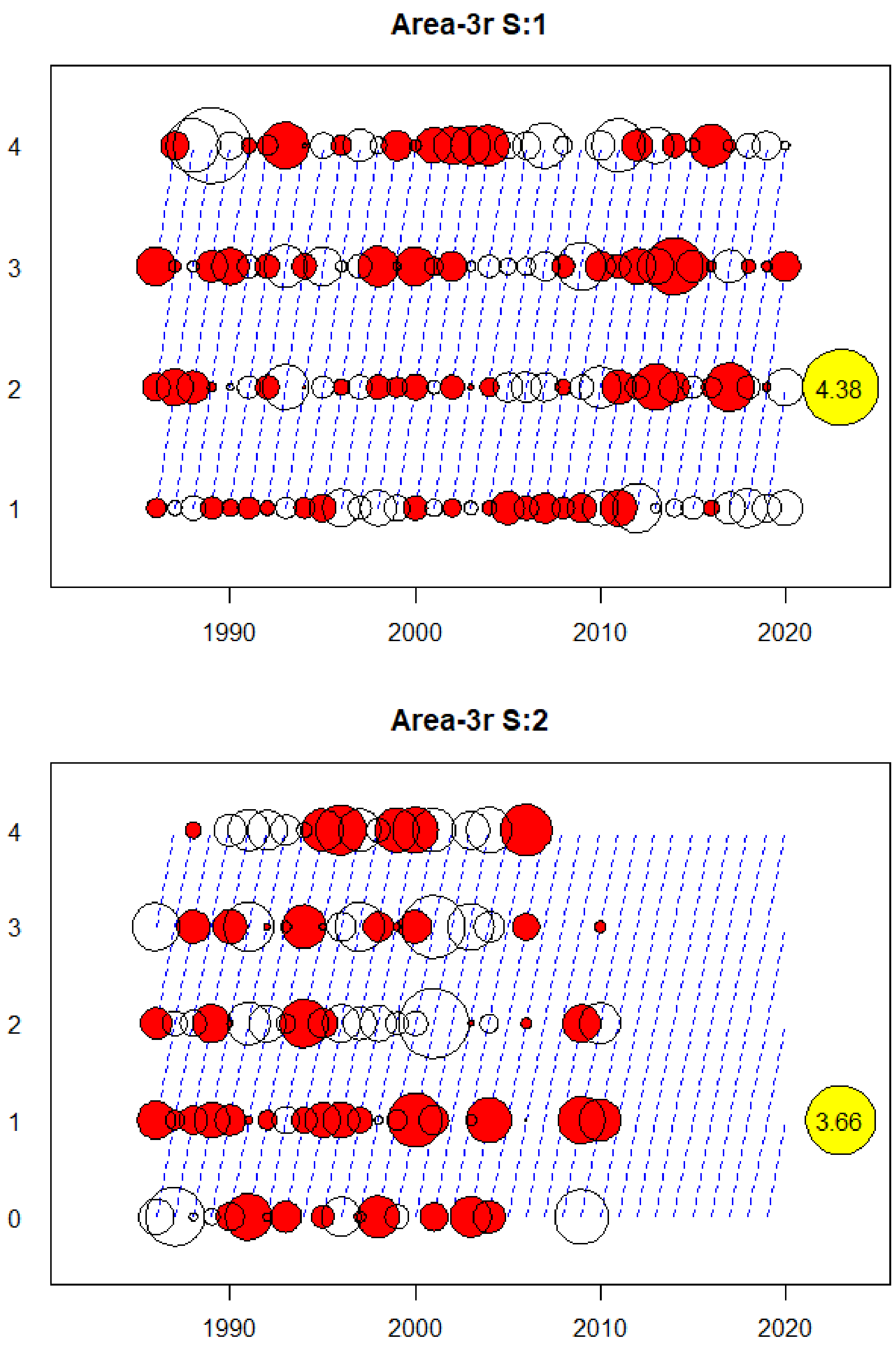


Figure 9.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

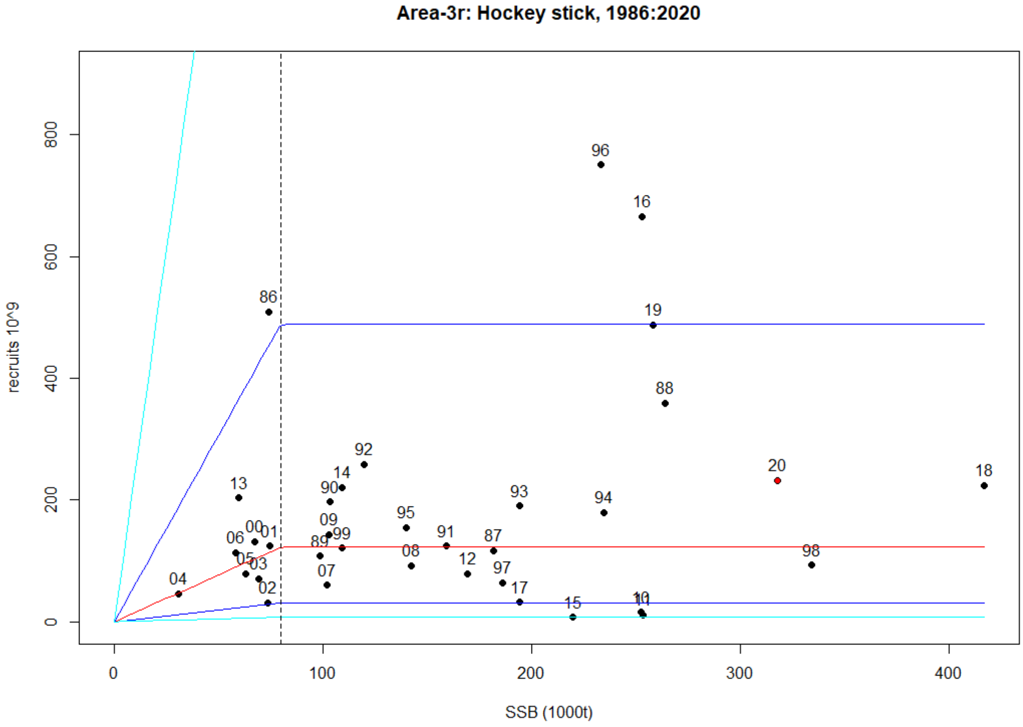


Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

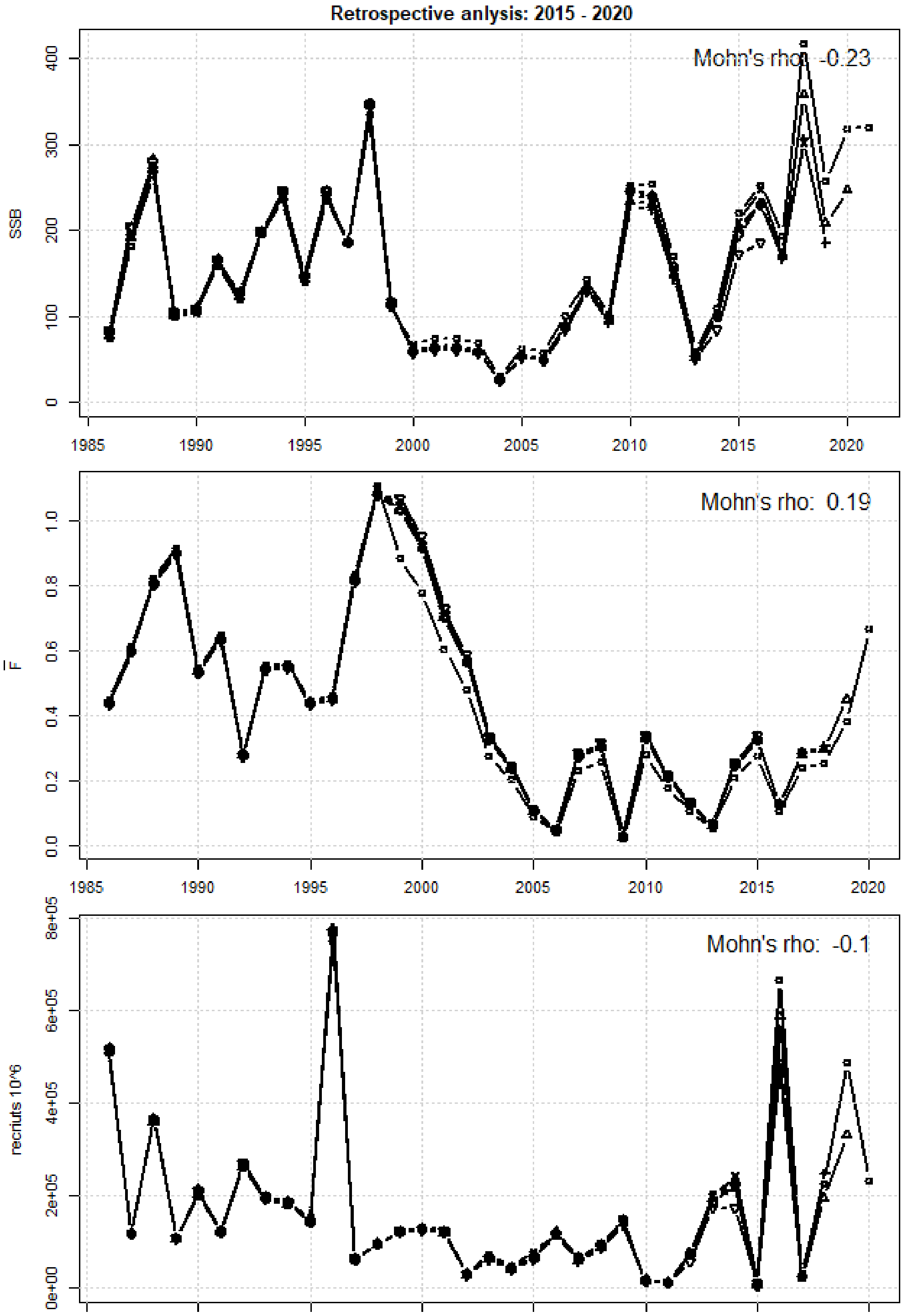


Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.

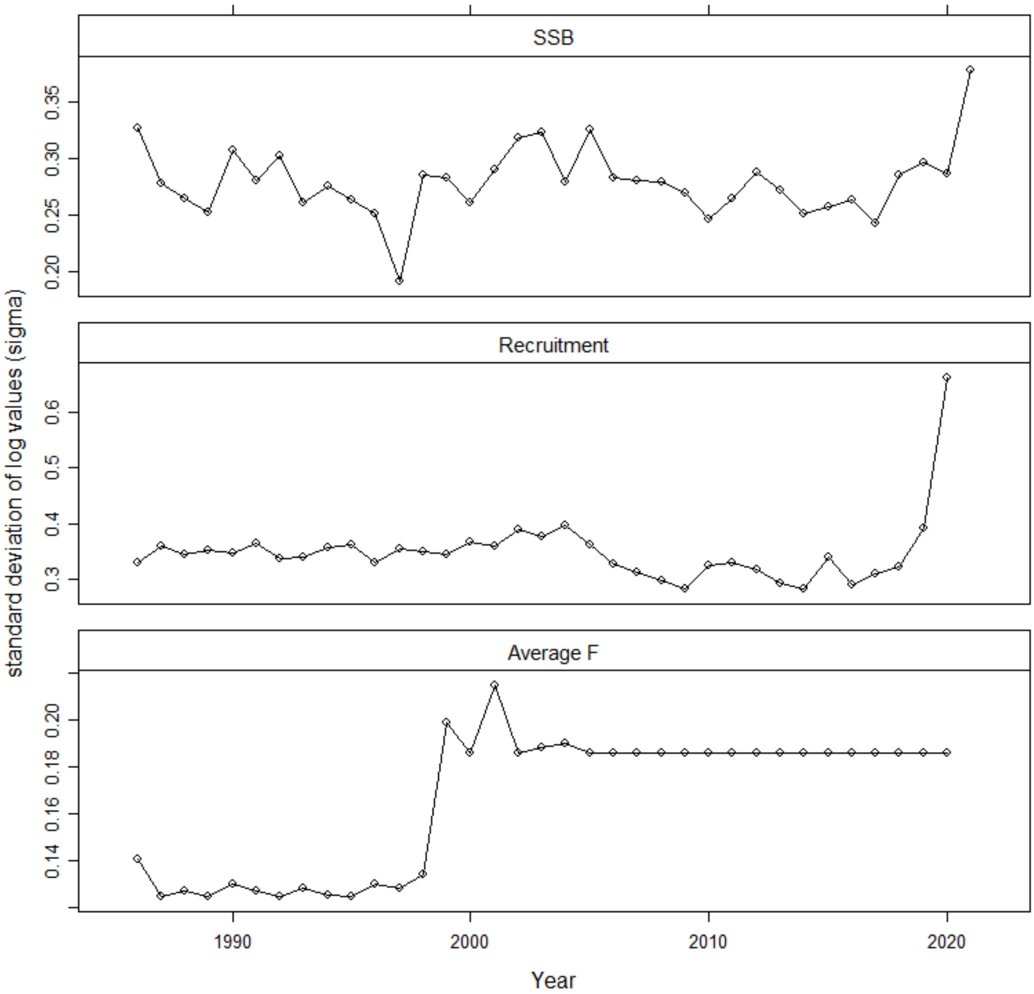


Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

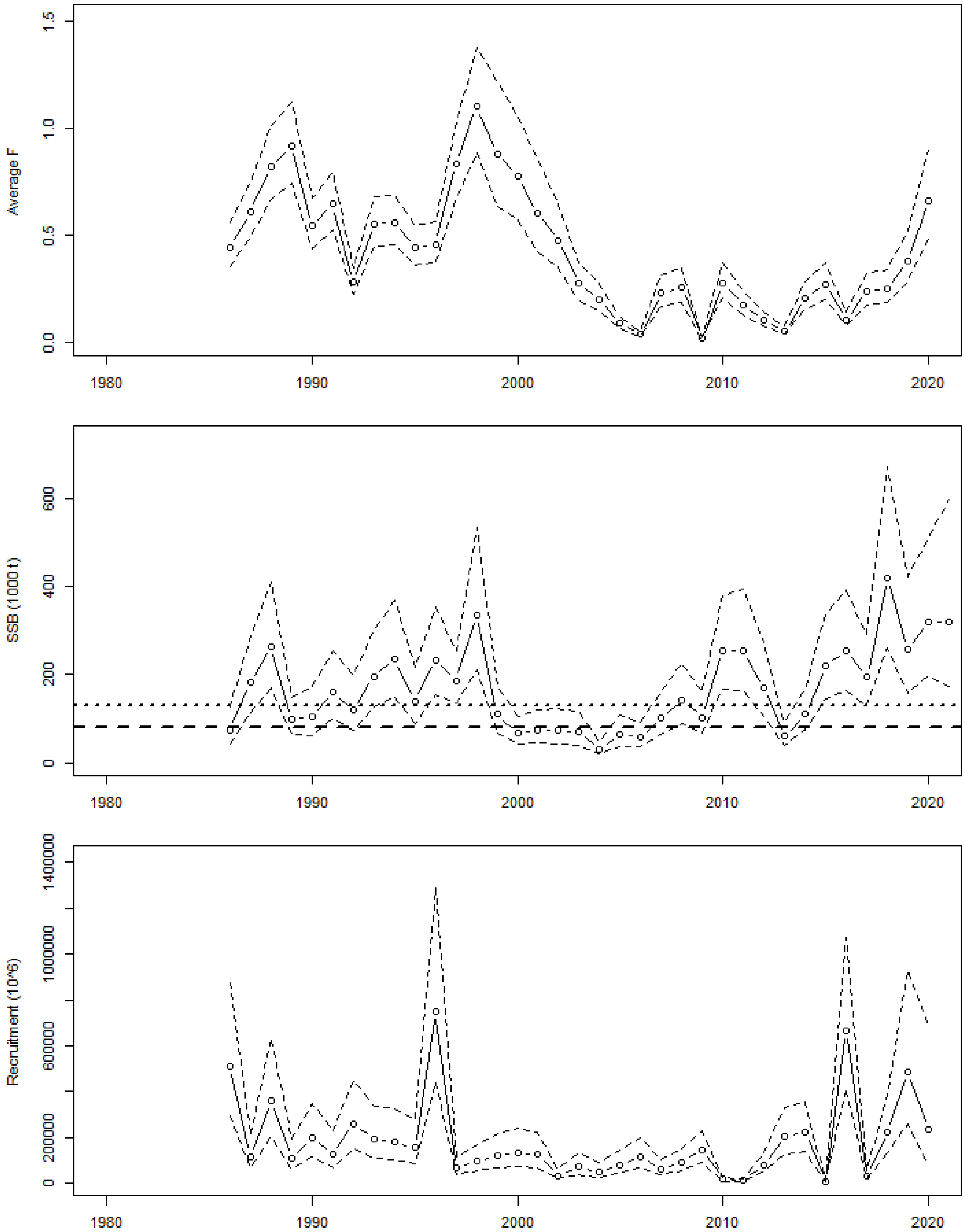


Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

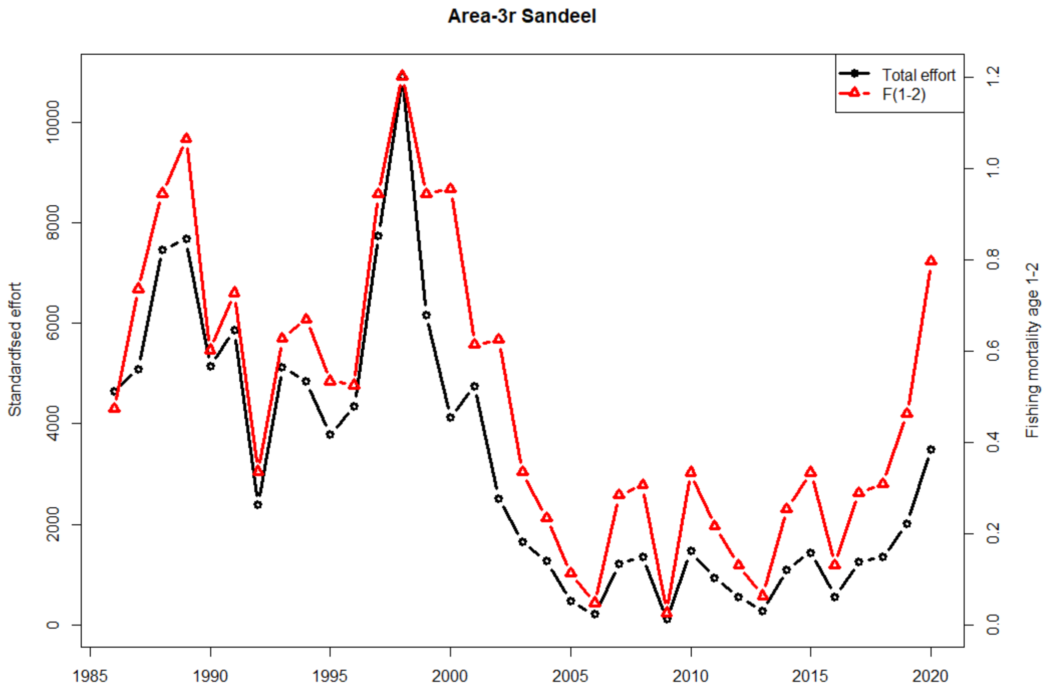


Figure 9.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

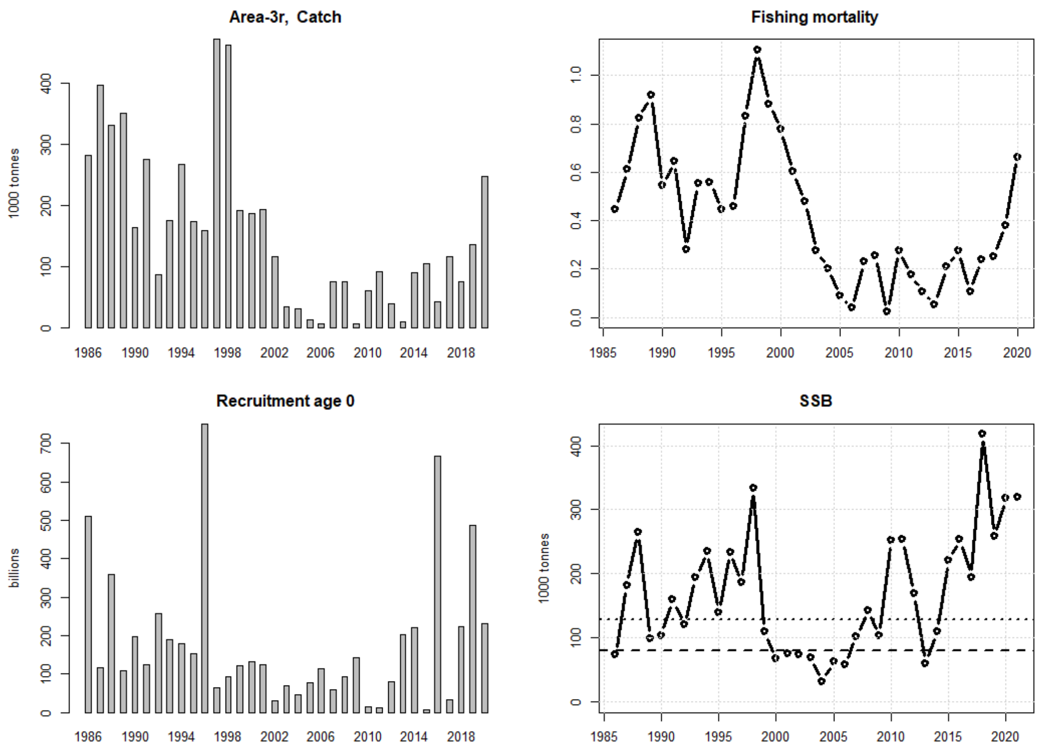


Figure 9.4.13 Sandeel Area-3r. Stock summary.

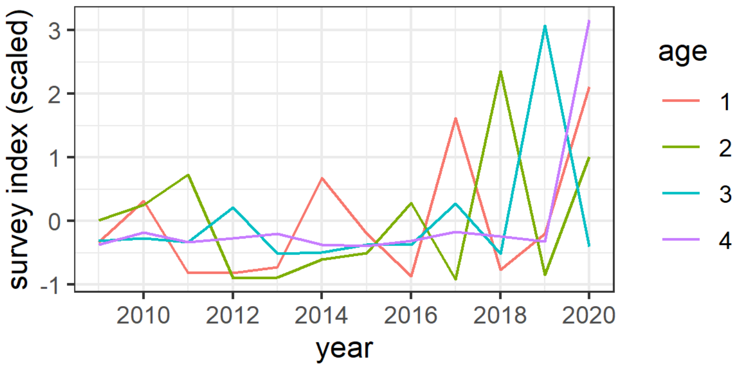


Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.

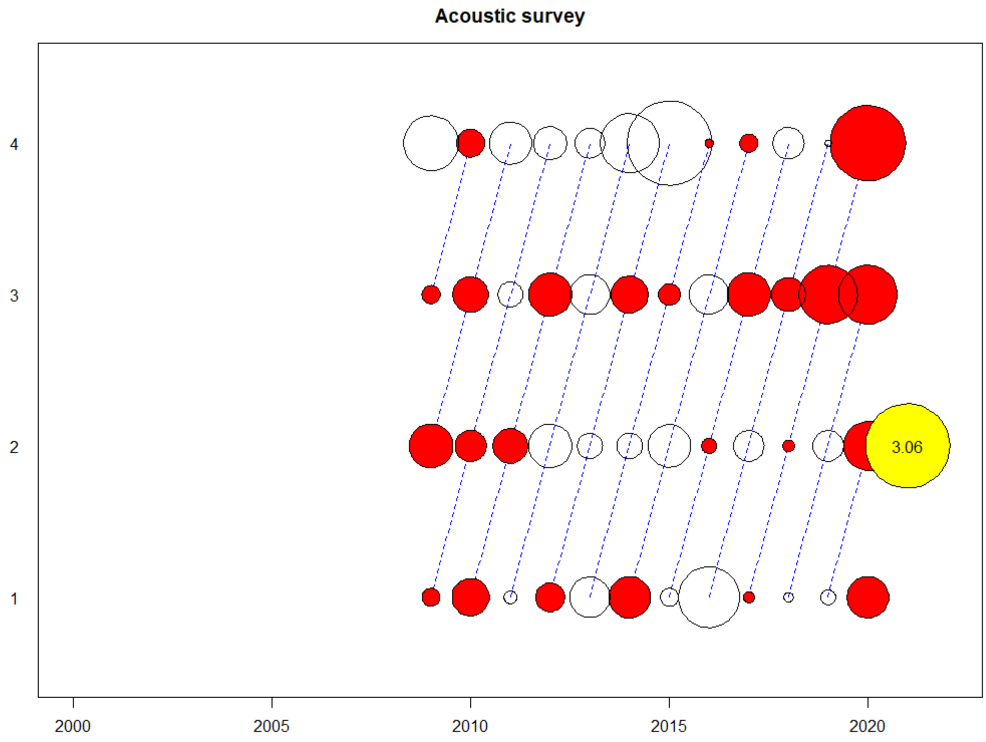


Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

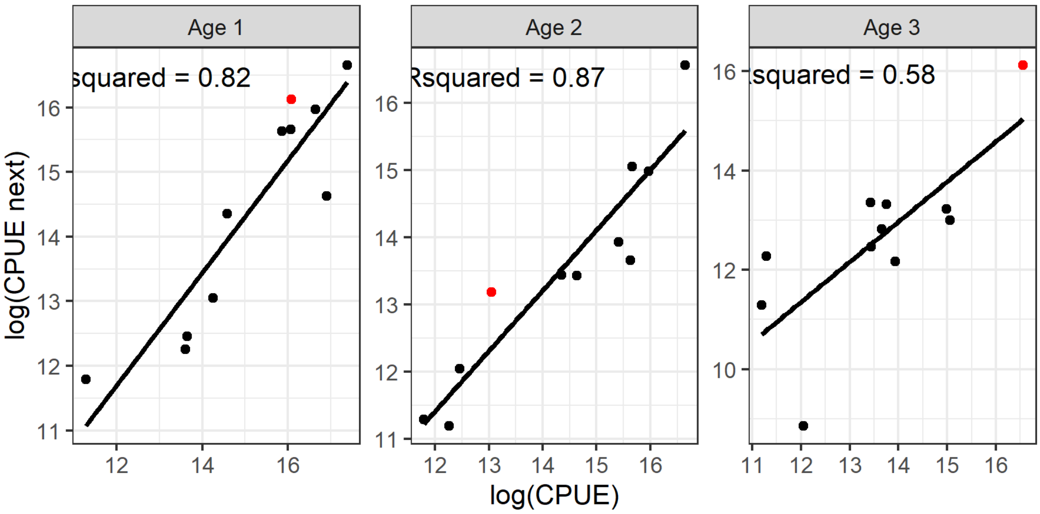


Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

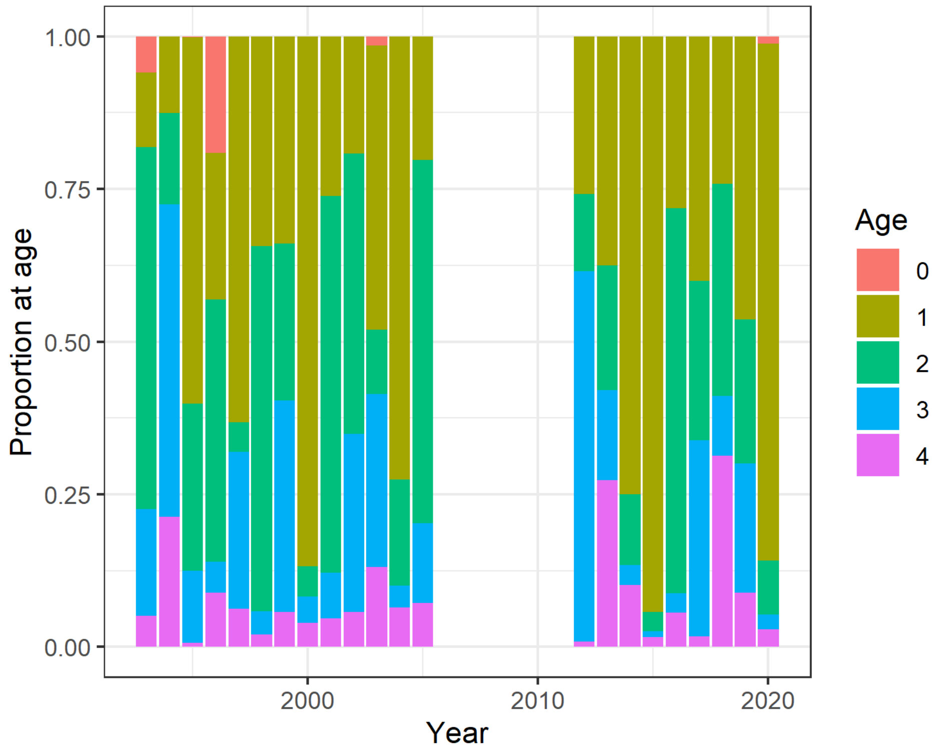


Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.

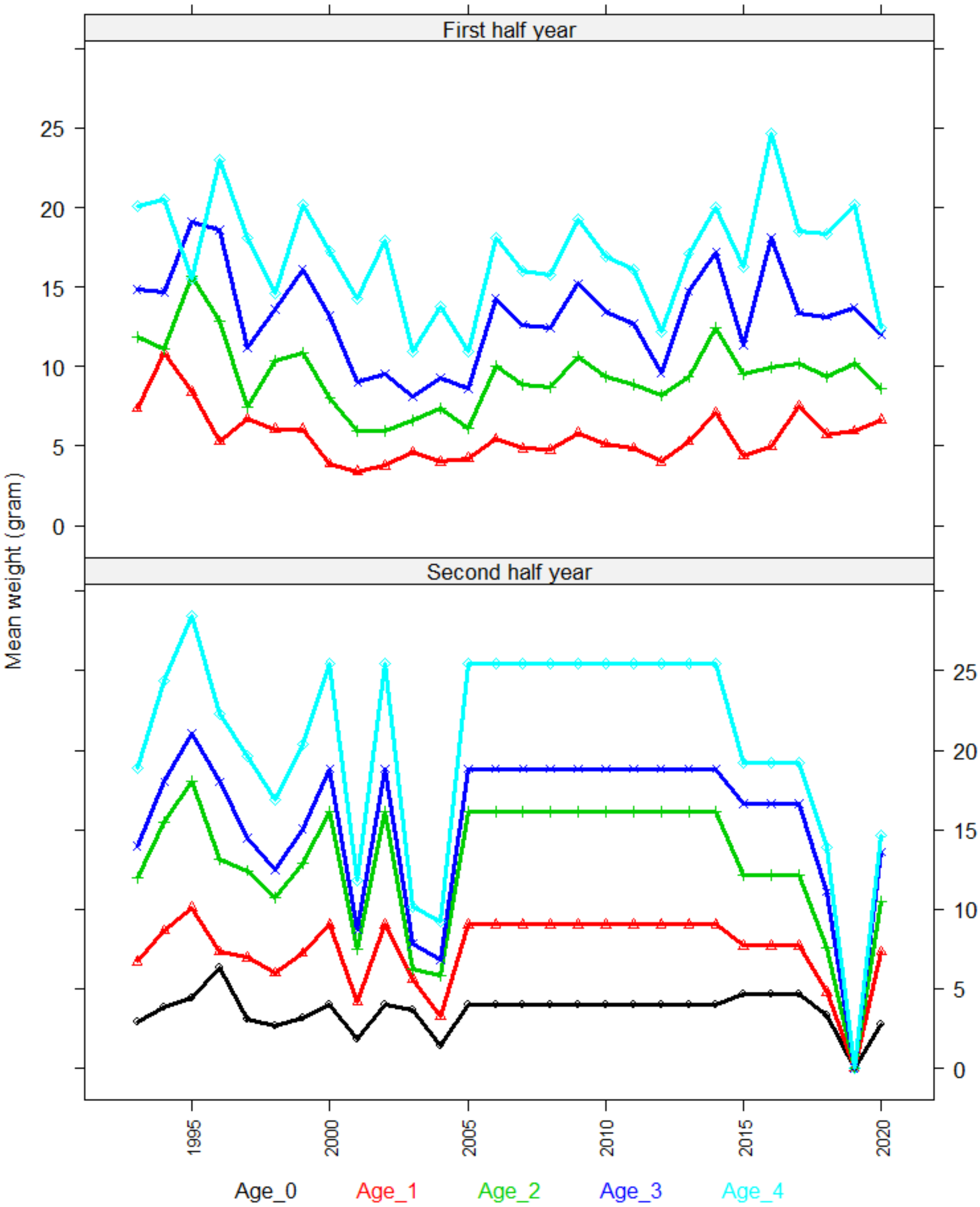


Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

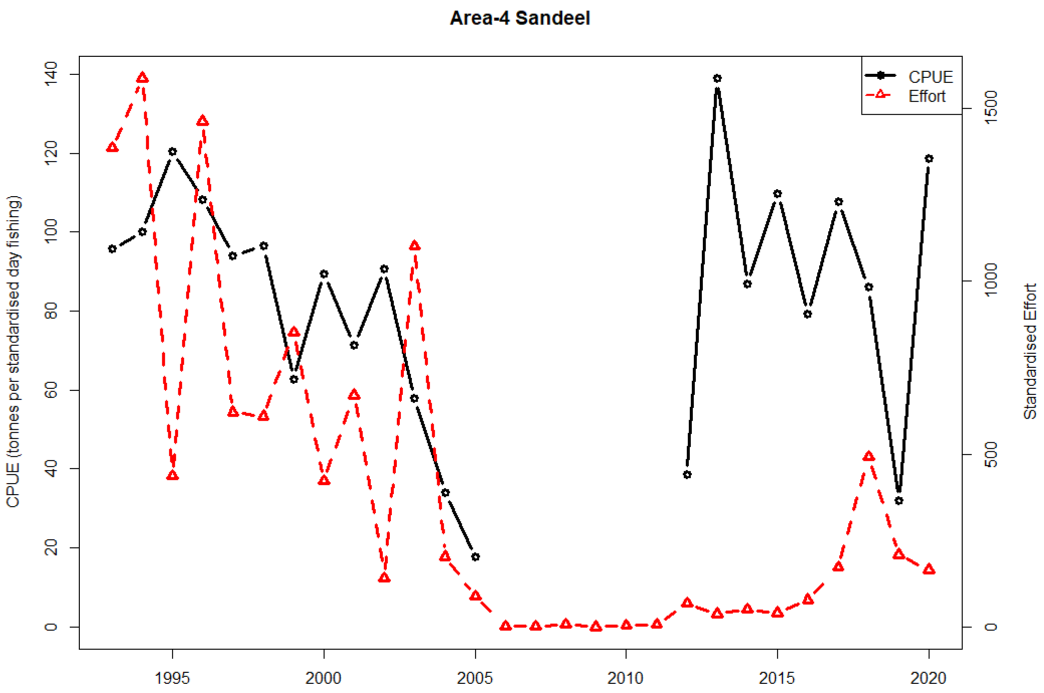


Figure 9.5.3 Sandeel Area-4. CPUE and effort.

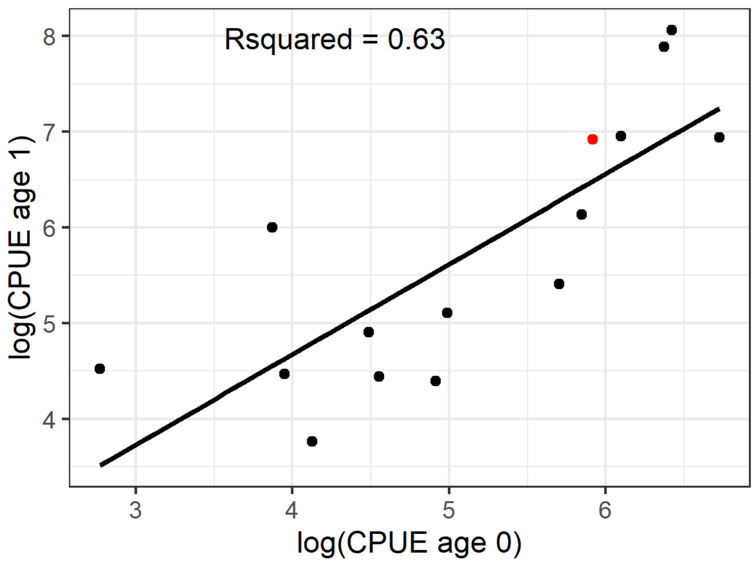


Figure 9.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

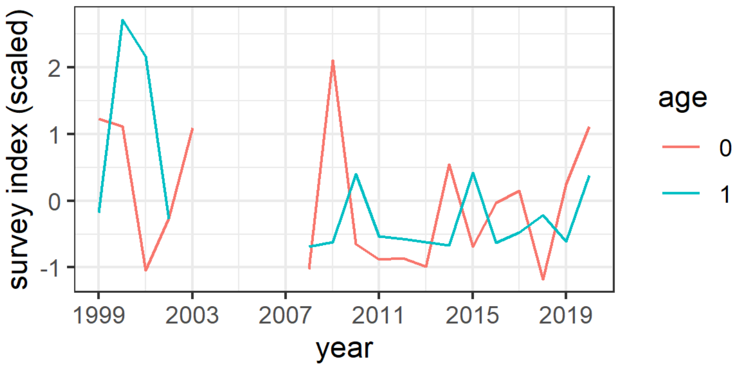


Figure 9.5.5 Sandeel Area-4. Dredge survey index timeline.

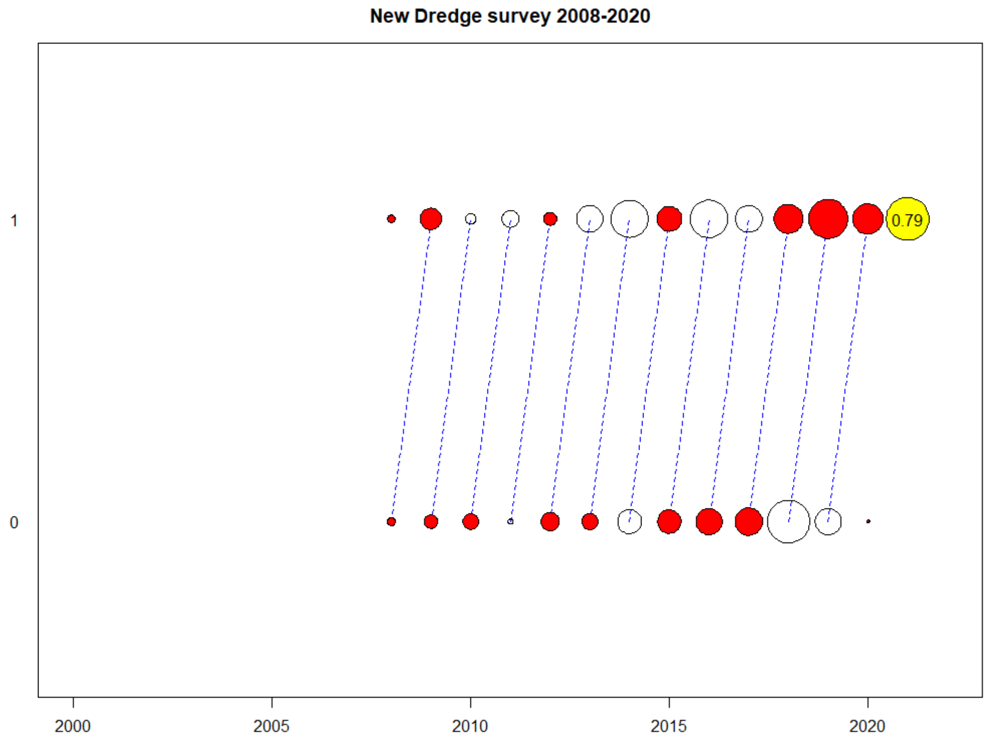
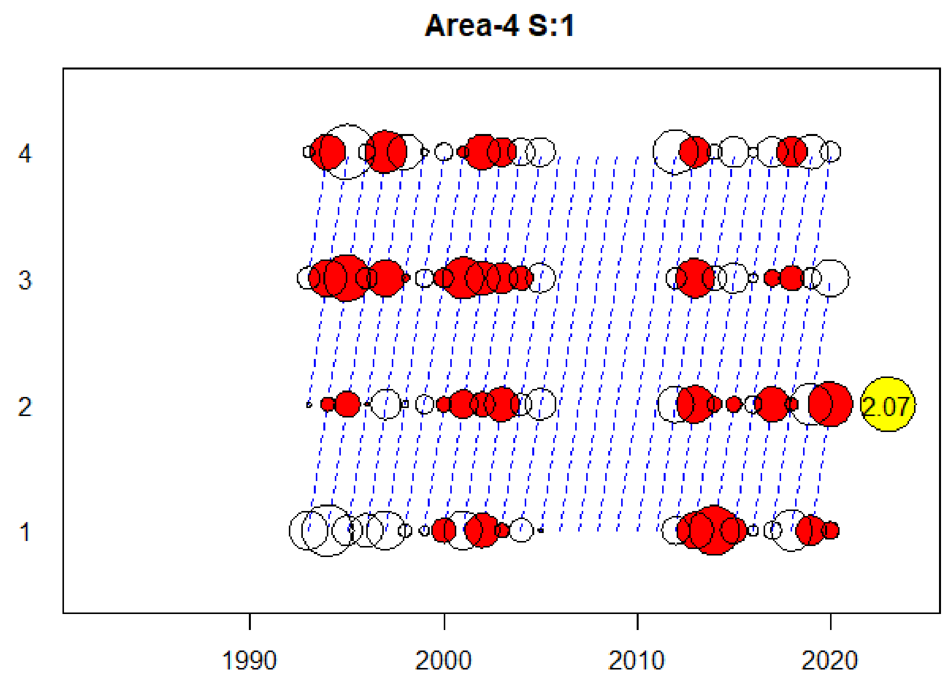


Figure 9.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



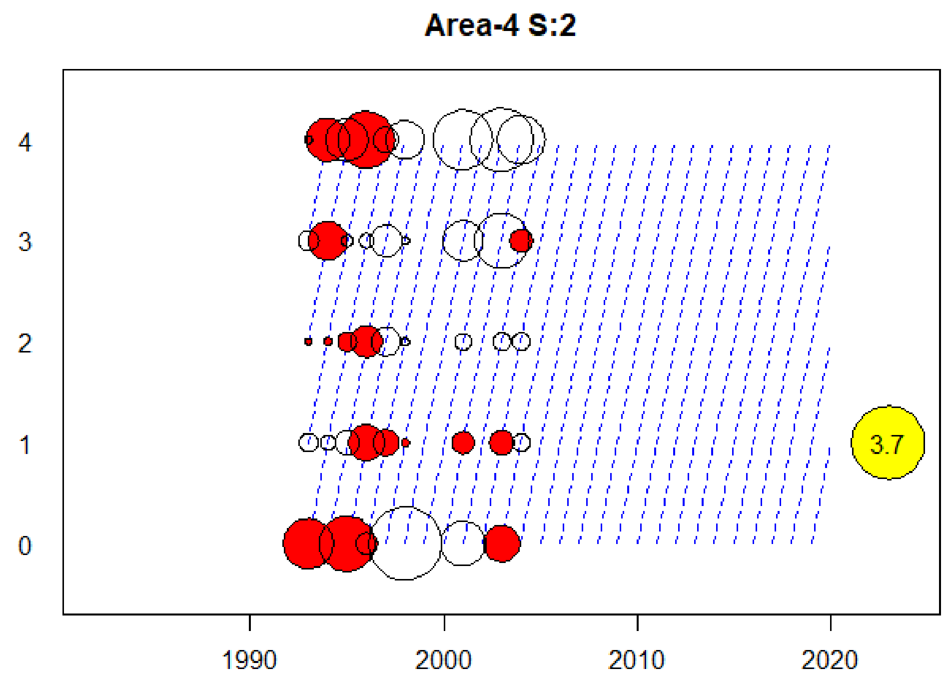


Figure 9.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

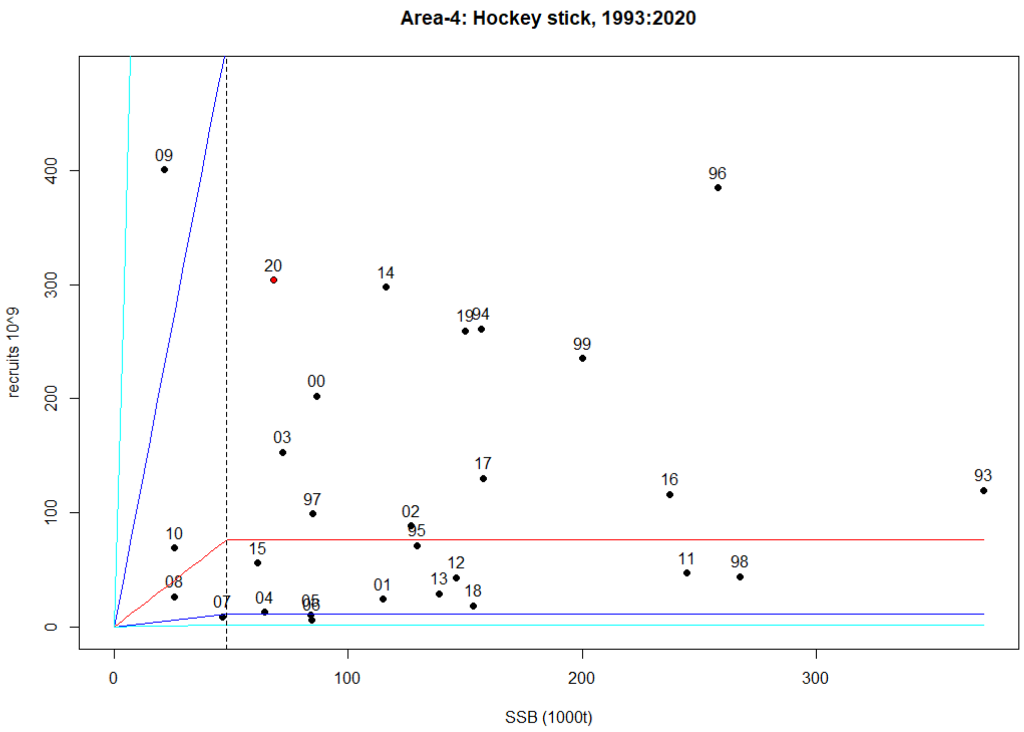


Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

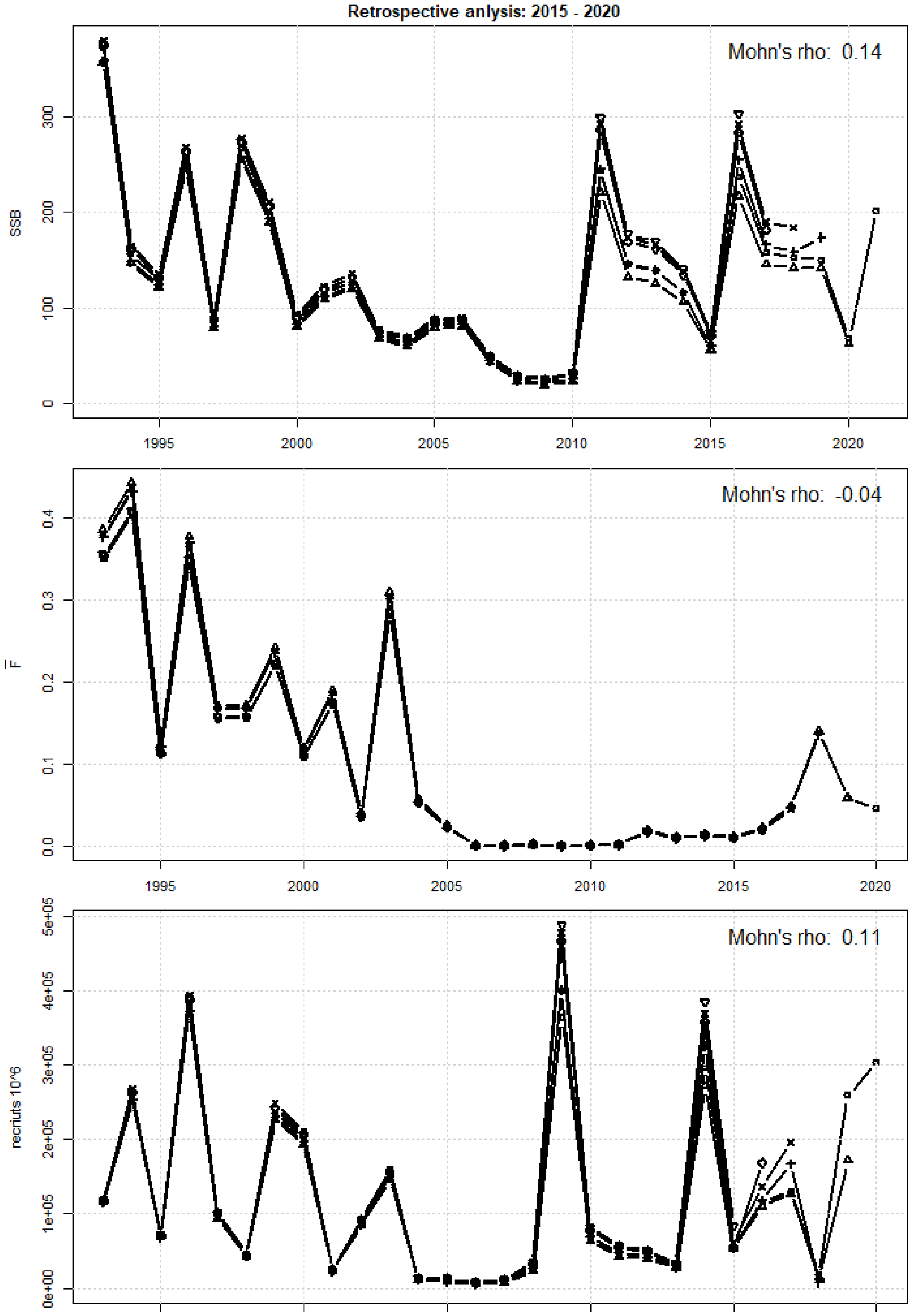


Figure 9.5.9 Sandeel Area-4. Retrospective analysis.

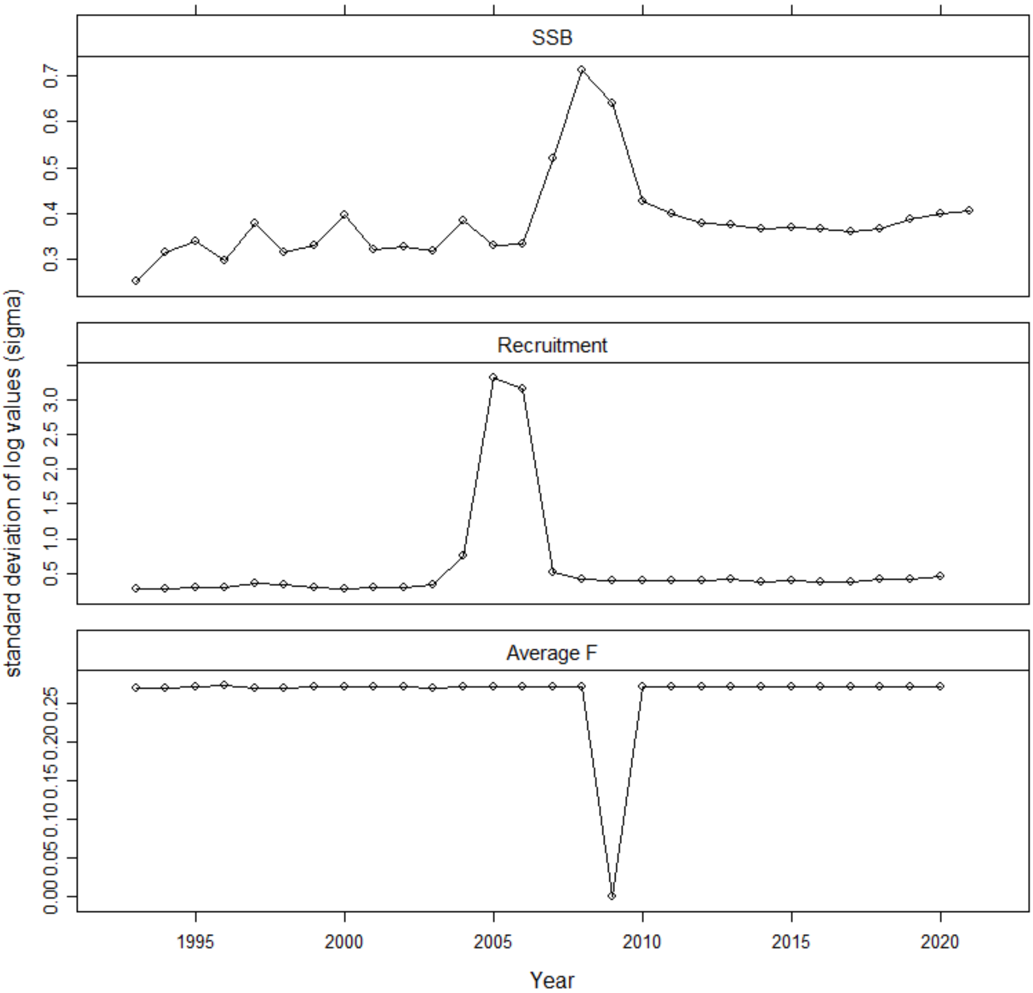


Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

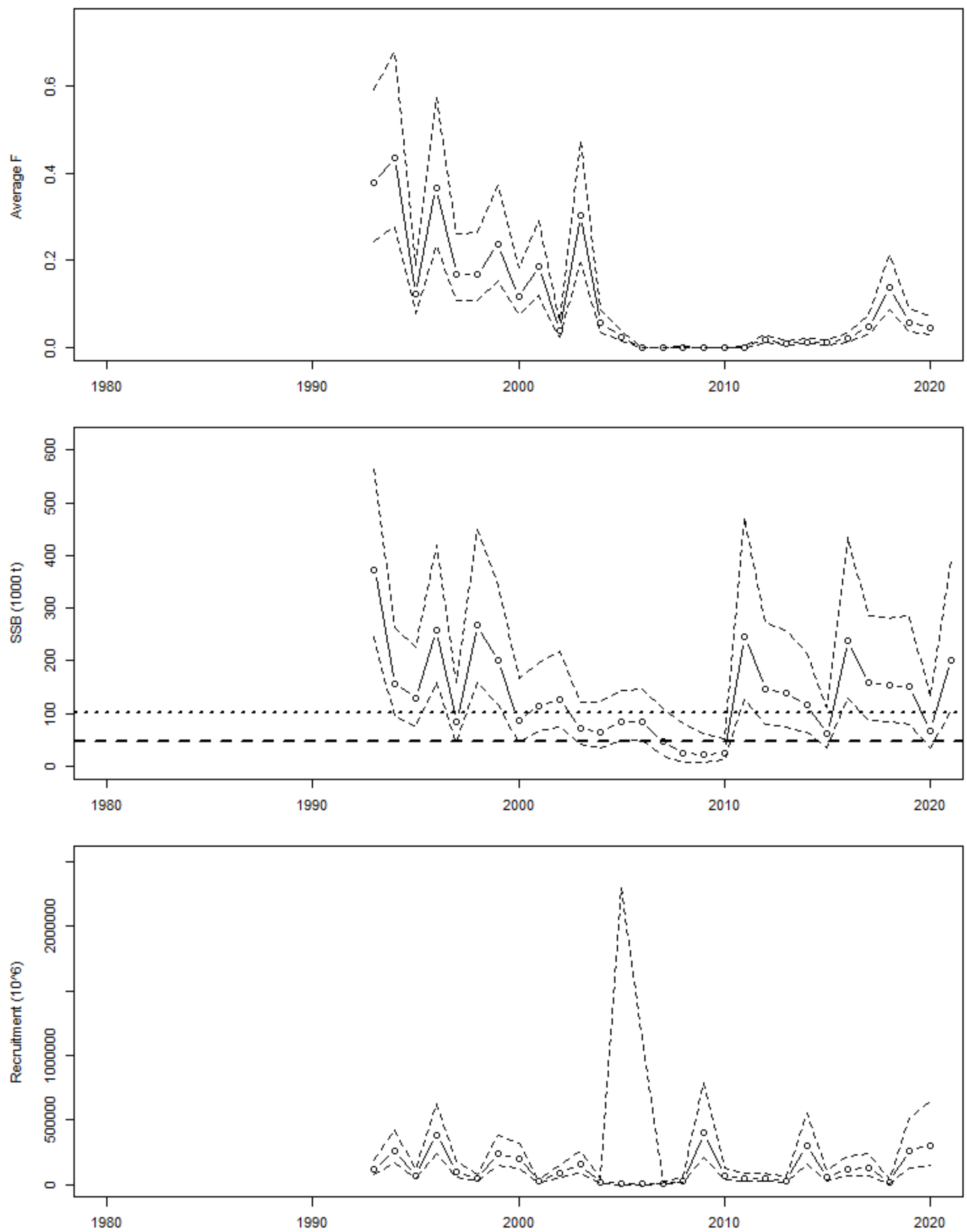


Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

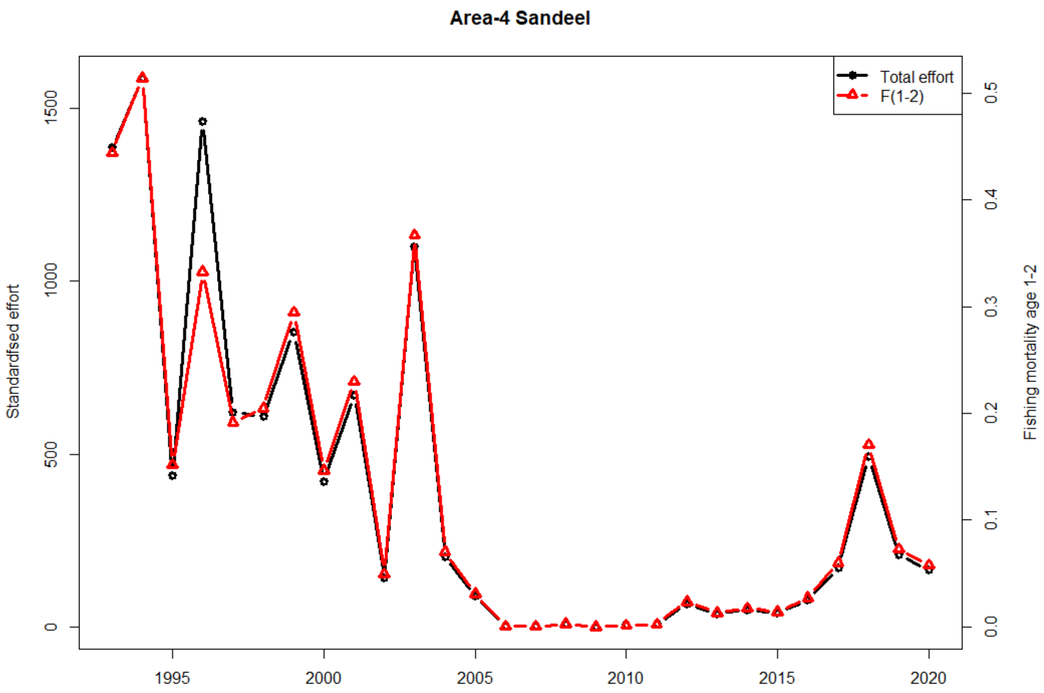


Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

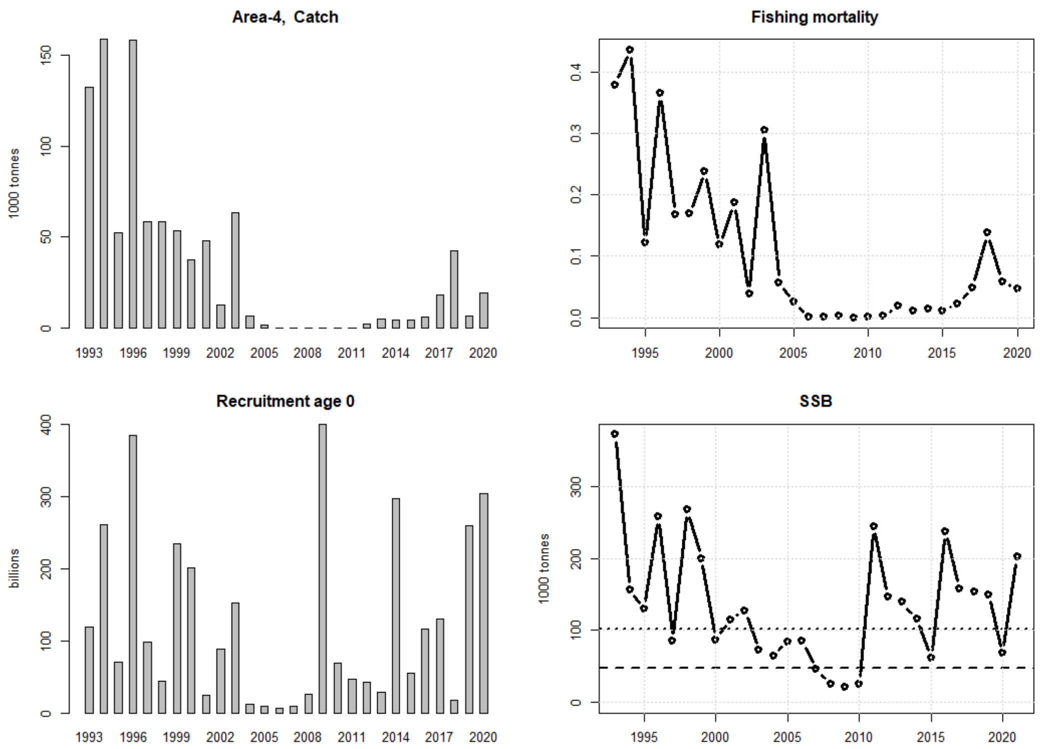


Figure 9.5.13 Sandeel Area-4. Stock summary.

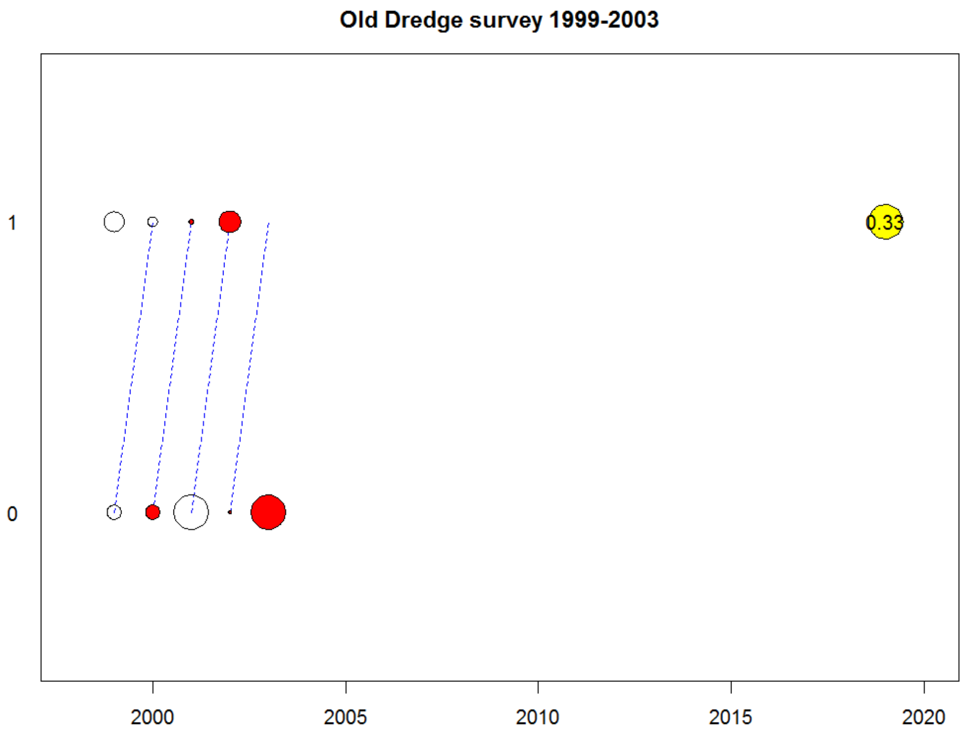


Figure 9.5.14 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

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 2020 to June 2021) was set to 207 807 t for sprat in Subarea 4 and Division 3.a. The 2020 herring bycatch quotas were 8 954 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, a number of other modifications were made to the configurations of the assessment model (see (WKSPRAT: ICES, 2018) for further details).

10.1.2 Catches in 2020

Catch statistics for 1997–2020 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 (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 2020 were 179 399 t (total official catches amounted to 179 746 t). This is a 22% increase compared to 2019, but not far from the average for the time-series. The Danish catches represent 84% of the total catches.

The spatial distribution of landings was similar to 2019 (Figure 10.1.1). A very low percentage (0.5% in 2020) of the catches were landed in the first and second quarter of 2020 (Table 10.1.2).

10.1.3 Regulations and their effects

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.

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.

10.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years, the Norwegian catches were mainly taken by purse-seine, and the catches taken by trawl were low. In recent years, the share of the total Norwegian catches taken by trawl has increased (2020: 92% taken by trawl).

10.2 Biological composition of the catch

Only data on bycatch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 4.1% and 5.3 % bycatch of herring in 2020 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. 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 independent companies and the estimated species composition is reported directly in the sale slips.

The estimated quarterly landings at age in numbers for the period 1974–2020 are presented in Table 10.2.2. In the model year 2020 (1 July 2020–30 June 2021), one-year old sprat contributed 68% of the total landings, which is close to the 1990–2019 average (62%). 2-year olds contributed 26% in 2019 (model year), which is above the 1990– 2019 average (23%). 0-year olds contributed 0.8% of the total landings, which is higher than the 1990–2019 average (9%).

Denmark, Sweden, and Norway provided age data of commercial landings in 2020 (Table 10.2.4). All quarters were covered. Quarter 1 in 2020 and 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 UK-Scotland (2 467 t), Germany (10 144 t) and Belgium (<1 t) were unsampled. 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 is caused by a not fully implemented change in the Danish sampling program. The Danish self-sampling program for sprat has been based on voluntary participation and in first years after implementation a lot of vessels participated. During the last couple of years, the number of vessels delivering samples has decreased dramatic, resulting in a more and more clustered sampling. The clustering was further accelerated by the fact that a lot of the hauls (samples) often came from the same trip. As mentioned above all landings for reduction into Denmark are now subsampled by a 3rd party companies and the Danish institute is able to get samples from most of them. Therefore, Denmark introduced a new sampling strategy in 2020, where vessels above 24 meters are sampled with a higher frequency than vessel below. 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 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 1983–2021. The index for IBTS Q1 1-year old in 2020 (age-0 in the model and the table, serving as a recruitment index) was 19% above average but 55% 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. IBTS Q3 survey indices were also used in the assessment, and the 2020 values were 34% higher for age-1 and 100% higher for age-2, compared to 2019.

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2020) (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 2020 values were 49% lower, 36% lower, and 71% lower (age-1, age-2, and age-3, respectively) compared to the 2019-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 in 2020 this decline was arrested and the mean weight at age 1 in season 1 was restored to the same level as in 2013. Mean weight of age-2 in 2020 was the highest since 2007. Mean weight-at-age was also restored to 2007 level 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

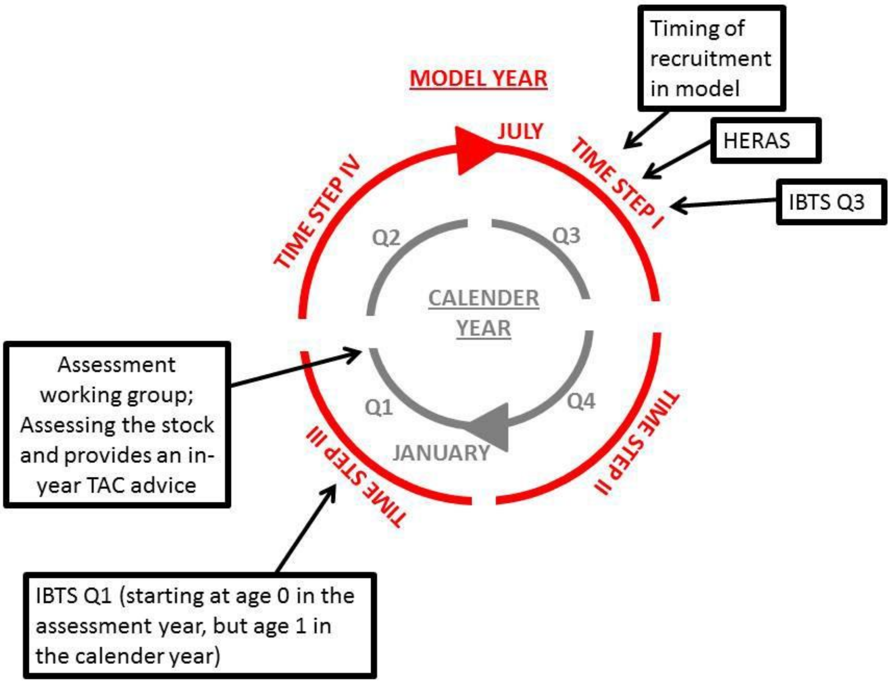
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1) is used as a recruitment index for this stock. The 2021 value, indicative of the 2020 recruitment, was 20% above average, corresponding to 45% of the recruitment index in the previous year. The recruitment estimated by the model for 2020 is 41% lower than the recruitment in 2019 and just below the 2011-2020 geometric mean (65% of the 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, a number of 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 a fishery dominated by 1- and 2-year old fish. This, however, requires information about incoming 1-year old fish. In order 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 2021, only 478 t were taken in quarter 1 and no age samples was 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 35 853 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 2021 assessment. 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 = 0.25) (Figure 10.6.5). As 41% of the recruiting year class contributes to the SSB at the end of the year, there is a similar large retrospective pattern in SSB (5 year Mohn´s rho = 0.28). 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 is abundant 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. The current SSB is 29% above B_{pa}. Fishing mortality has fluctuated without a trend. 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 2022 is expected to be higher than 2021 above the long-term average, and well above B_{pa}. Using the input and assumptions detailed above, the projection for an F = 0 is an SSB in July 2022 of 274 265 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 106 715 t (July 2021–June 2022), which is expected to result in an SSB of 208 733 t in July 2022, 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 0.28 and 0.25, 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 7 750 t and 6 659 t of juvenile herring in 2021 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) 1997–2020. 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	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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 (Scot- land)															0.5						*	*		
Germany																			*	*				
Nether- lands																			*					
Total			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1	0.5
Division 27.4.b																								
Denmark	93.1	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
Norway	3.1	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
UK (Scotland)			1.4								0.1		2.5	1.1	1.9	0.7						*	1.3	1.7
UK (Engl.& Wales)													*								*	*		
Germany															3.3	0.5	0.6	1.5	3.1	5.4	6.0	3.7	3.4	10
Netherlands															1.1	2.7	0.4	2.4	1.2	1.0	1.6	1.6		
Faroe Islands																				4.7	1.0	1.0		
Total	96.2	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	163.0
Division 27.4.c																								
Denmark	5.7	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
Norway	0.1	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
Sweden													0.6	0.6	0.2	0.4	1.3		1.2	0.4				

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
UK(Scotland)												0.2			0.4					*				0.7
UK (Engl.& Wales)	1.4	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	
Germany															*	*	1.0		0.6	0.2				0.1
Netherlands			0.2												4.2	1.0	0.7	*	1.2	0.8	*	0.7		
Belgium															*		*	*	*	*	*		*	*
France																			*		*			
Total	7.2	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	3.9
Division 27.3.a																								
Denmark	11.6	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
Sweden	3.8	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
Germany																		*				*		
Faroe Islands																				*				
Total	15.4	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
Total North Sea and Skagerrak-Kattegat																								
Denmark	110.4	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
Norway	3.2	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	3.8	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
UK(Scotland)			1.4								0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3	2.5
UK (Engl.& Wales)	1.4	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	
Germany															3.3	0.5	1.6	1.6	3.7	5.6	6.0	3.7	3.4	10.1
Netherlands			0.2												5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3		
Faroe Islands																				4.7	1.0	1.0		
Belgium															*		*	*	*	*	*		*	*
France																			*		*			
Total	118.8	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	179.4

* < 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
	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

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
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
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

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
2005	1		11 538	2457	8148	22 143
	2		2515	123	4722	7360
	3		107 530		19 418	126 948
	4		82 474	1033	7296	90 803
	Total		204 057	3613	39 584	247 254
2006	1	47	13 713	33 534	8105	55 399
	2		190	8	324	522
	3		40 051	8	1440	41 499
	4	2	26 579	77	2335	28 993
	Total	49	80 533	33 627	12 204	126 413
2007	1		582	247	2646	3475
	2		241	3	1291	1535
	3		16 603		5357	21 960
	4	769	41 850	23 531	4761	70 911
	Total	769	59 276	23 781	14 055	97 881
2008	1		2872	43	2890	5805
	2		52	*	1017	1069
	3		21 787		636	22 423
	4		27 994	8334	3672	40 001
	Total		52 706	8377	8215	69 298
2009	1		36	1268	2600	3904
	2		2526	1	300	2827
	3	22	41 513		3300	44 835
	4		78 373	9336	2400	90 109
	Total	22	122 448	10 604	8600	141 675

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
2015	1	*	14 816	16 972	1442	33 230
	2		16 843	107	619	17 568
	3		124 512	335	6528	131 375
	4	25	88 395	28 375	4389	121 184
	Total	25	244 566	45 789	12 978	303 358
2016	1	68	18 487	5969	746	25 250
	2		8927	51	669	9 647
	3	*	158 522	111	4664	163 297
	4	2	34 070	14 466	1764	50 301
	Total	70	220 007	20 596	7843	248 516
2017	1	1	3432	1220	92	4 745
	2		1327	0	33	1 360
	3	*	92 885	217	227	93 329
	4	94	29 310	174	849	30 426
	Total	95	126 954	1611	1200	129 860
2018	1	*	8994	1628	168	10 790
	2		11 898	0	224	12 122
	3		112 361	1	1328	113 690
	4		46 411	5922	2249	54 582
	Total	*	179 664	7551	3969	191 184
2019	1		389	9 592	627	10 609
	2	2	3 606	11	379	3 999
	3	2	95 829	7	2 249	98 087
	4	49	32 750	3	2 296	35 098
	Total	53	132 574	9 614	5 551	147 793
2020	1	368	3	190	376	937

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total

* < 0.5 t

Year	Quarter	Division 27.4.a	27.4.b	27.4.c	27.3.a	Total
	2	173		19 430	*	19 603
	3	4 268	2	119 883	*	124 153
	4	7 087	520	23 540	3 559	34 706
	Total	11 896	526	163 043	3 934	179 399

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
%	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
%	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

	Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total		Year	Sprat	Herring	Horse mack	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
%	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

Table 10.2.2. North Sea & 3.a sprat. Catch in numbers by age (1000's) by season and year. (Model year)

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that all catches in S4 has been moved to S1 in the following year					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
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 has 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 has 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 has 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 has 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	163695.6
2019	2	799272.1	2399200	1041391	139590
2019	3	121303.8	19818.84	2252.614	237.2071
2019	4	0	0	0	0
2020	1	206247.2	10088069	3408125	426753.1
2020	2	72133.58	2538201	379017.1	142238.1
2020	3	0	0	0	0
2020	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)

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 is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1974	1	0.0063	0.0083	0.0135	0.0184
1974	2	0.0058	0.0089	0.0150	0.0197
1974	3	0.0050	0.0077	0.0150	0.0197
1974	4	0.0066	0.0107	0.0183	0.0163
1975	1	0.0048	0.0086	0.0129	0.0172
1975	2	0.0075	0.0111	0.0168	0.0216
1975	3	0.0048	0.0106	0.0154	0.0192
1975	4	0.0062	0.0116	0.0170	0.0171
1976	1	0.0049	0.0070	0.0113	0.0134
1976	2	0.0043	0.0090	0.0153	0.0190
1976	3	0.0022	0.0059	0.0104	0.0126
1976	4	0.0034	0.0057	0.0085	0.0106
1977	1	0.0054	0.0082	0.0126	0.0180
1977	2	0.0059	0.0110	0.0146	0.0196
1977	3	0.0023	0.0080	0.0106	0.0138
1977	4	0.0025	0.0063	0.0083	0.0122
1978	1	0.0038	0.0069	0.0122	0.0146
1978	2	0.0044	0.0103	0.0155	0.0196
1978	3	0.0031	0.0089	0.0123	0.0166
1978	4	0.0020	0.0052	0.0087	0.0094
1979	1	0.0050	0.0058	0.0087	0.0113
1979	2	0.0057	0.0105	0.0150	0.0173
1979	3	0.0032	0.0077	0.0129	0.0165
1979	4	0.0029	0.0106	0.0121	0.0153
1980	1	0.0063	0.0052	0.0068	0.0083
1980	2	0.0051	0.0052	0.0069	0.0083
1980	3	0.0032	0.0086	0.0131	0.0168
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156
1981	2	0.0082	0.0126	0.0153	0.0194
1981	3	0.0049	0.0089	0.0157	0.0194
1981	4	0.0060	0.0139	0.0191	0.0192
1982	1	0.0085	0.0089	0.0171	0.0155
1982	2	0.0071	0.0110	0.0160	0.0219
1982	3	0.0029	0.0075	0.0115	0.0174
1982	4	0.0044	0.0078	0.0114	0.0160
1983	1	0.0044	0.0092	0.0128	0.0152

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1983	2	0.0042	0.0124	0.0169	0.0211
1983	3	0.0034	0.0094	0.0174	0.0163
1983	4	0.0038	0.0093	0.0127	0.0156
1984	1	0.0060	0.0081	0.0121	0.0166
1984	2	0.0053	0.0122	0.0168	0.0164
1984	3	0.0093	0.0135	0.0197	0.0197
1984	4	0.0093	0.0135	0.0197	0.0197
1985	1	0.0063	0.0093	0.0135	0.0197
1985	2	0.0051	0.0093	0.0135	0.0197
1985	3	0.0073	0.0099	0.0166	0.0166
1985	4	0.0073	0.0099	0.0166	0.0166
1986	1	0.0063	0.0073	0.0099	0.0166
1986	2	0.0051	0.0073	0.0099	0.0166
1986	3	0.0083	0.0164	0.0228	0.0163
1986	4	0.0084	0.0156	0.0208	0.0156
1987	1	0.0066	0.0086	0.0117	0.0153
1987	2	0.0060	0.0093	0.0112	0.0165
1987	3	0.0064	0.0125	0.0175	0.0206
1987	4	0.0068	0.0125	0.0167	0.0189
1988	1	0.0042	0.0088	0.0115	0.0138
1988	2	0.0046	0.0085	0.0113	0.0137
1988	3	0.0052	0.0132	0.0208	0.0158
1988	4	0.0063	0.0117	0.0155	0.0175
1989	1	0.0054	0.0086	0.0099	0.0170
1989	2	0.0044	0.0082	0.0109	0.0130
1989	3	0.0048	0.0077	0.0125	0.0155
1989	4	0.0046	0.0086	0.0115	0.0129
1990	1	0.0046	0.0070	0.0092	0.0115
1990	2	0.0038	0.0069	0.0092	0.0113
1990	3	0.0044	0.0099	0.0133	0.0156
1990	4	0.0048	0.0089	0.0119	0.0135
1991	1	0.0128	0.0143	0.0154	0.0168
1991	2	0.0048	0.0146	0.0189	0.0168
1991	3	0.0052	0.0101	0.0147	0.0172
1991	4	0.0062	0.0118	0.0152	0.0186
1992	1	0.0081	0.0099	0.0124	0.0148
1992	2	0.0058	0.0121	0.0153	0.0178
1992	3	0.0035	0.0096	0.0141	0.0179

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1992	4	0.0042	0.0078	0.0104	0.0118
1993	1	0.0065	0.0109	0.0123	0.0138
1993	2	0.0075	0.0107	0.0135	0.0164
1993	3	0.0022	0.0080	0.0116	0.0152
1993	4	0.0023	0.0128	0.0154	0.0134
1994	1	0.0068	0.0067	0.0095	0.0129
1994	2	0.0087	0.0104	0.0125	0.0151
1994	3	0.0030	0.0082	0.0097	0.0140
1994	4	0.0038	0.0068	0.0090	0.0131
1995	1	0.0032	0.0082	0.0117	0.0121
1995	2	0.0051	0.0101	0.0133	0.0155
1995	3	0.0084	0.0096	0.0129	0.0158
1995	4	0.0058	0.0107	0.0142	0.0161
1996	1	0.0071	0.0108	0.0142	0.0175
1996	2	0.0079	0.0115	0.0150	0.0169
1996	3	0.0029	0.0062	0.0087	0.0103
1996	4	0.0031	0.0057	0.0077	0.0086
1997	1	0.0071	0.0128	0.0148	0.0163
1997	2	0.0058	0.0120	0.0161	0.0199
1997	3	0.0071	0.0097	0.0122	0.0147
1997	4	0.0052	0.0095	0.0127	0.0144
1998	1	0.0056	0.0139	0.0166	0.0186
1998	2	0.0050	0.0124	0.0153	0.0177
1998	3	0.0043	0.0061	0.0095	0.0094
1998	4	0.0039	0.0073	0.0097	0.0110
1999	1	0.0053	0.0097	0.0115	0.0121
1999	2	0.0046	0.0116	0.0135	0.0164
1999	3	0.0036	0.0094	0.0118	0.0138
1999	4	0.0052	0.0097	0.0129	0.0146
2000	1	0.0067	0.0122	0.0148	0.0185
2000	2	0.0062	0.0149	0.0174	0.0183
2000	3	0.0051	0.0105	0.0131	0.0150
2000	4	0.0036	0.0046	0.0080	0.0135
2001	1	0.0078	0.0109	0.0118	0.0159
2001	2	0.0048	0.0116	0.0136	0.0166
2001	3	0.0062	0.0127	0.0150	0.0162
2001	4	0.0065	0.0120	0.0161	0.0181
2002	1	0.0073	0.0109	0.0141	0.0154

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2002	2	0.0077	0.0122	0.0142	0.0158
2002	3	0.0047	0.0101	0.0133	0.0145
2002	4	0.0060	0.0116	0.0129	0.0155
2003	1	0.0042	0.0125	0.0146	0.0228
2003	2	0.0058	0.0108	0.0145	0.0167
2003	3	0.0049	0.0115	0.0135	0.0141
2003	4	0.0050	0.0092	0.0123	0.0139
2004	1	0.0088	0.0116	0.0139	0.0154
2004	2	0.0041	0.0094	0.0126	0.0153
2004	3	0.0030	0.0097	0.0112	0.0130
2004	4	0.0044	0.0093	0.0115	0.0129
2005	1	0.0076	0.0097	0.0130	0.0154
2005	2	0.0066	0.0103	0.0115	0.0141
2005	3	0.0055	0.0080	0.0114	0.0138
2005	4	0.0047	0.0087	0.0115	0.0130
2006	1	0.0063	0.0108	0.0133	0.0152
2006	2	0.0055	0.0143	0.0158	0.0180
2006	3	0.0041	0.0095	0.0129	0.0134
2006	4	0.0050	0.0093	0.0124	0.0139
2007	1	0.0063	0.0119	0.0131	0.0149
2007	2	0.0065	0.0101	0.0127	0.0151
2007	3	0.0045	0.0075	0.0106	0.0126
2007	4	0.0048	0.0089	0.0118	0.0133
2008	1	0.0088	0.0103	0.0114	0.0131
2008	2	0.0044	0.0076	0.0126	0.0142
2008	3	0.0034	0.0076	0.0082	0.0085
2008	4	0.0044	0.0068	0.0090	0.0081
2009	1	0.0063	0.0096	0.0123	0.0142
2009	2	0.0046	0.0095	0.0130	0.0160
2009	3	0.0043	0.0077	0.0103	0.0135
2009	4	0.0087	0.0096	0.0105	0.0141
2010	1	0.0066	0.0080	0.0097	0.0137
2010	2	0.0047	0.0094	0.0114	0.0148
2010	3	0.0050	0.0072	0.0094	0.0130
2010	4	0.0038	0.0071	0.0095	0.0107
2011	1	0.0052	0.0085	0.0101	0.0134
2011	2	0.0044	0.0089	0.0114	0.0145
2011	3	0.0042	0.0102	0.0128	0.0171

Weight-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
2011	4	0.0050	0.0092	0.0123	0.0139
2012	1	0.0085	0.0087	0.0106	0.0150
2012	2	0.0072	0.0087	0.0119	0.0152
2012	3	0.0040	0.0069	0.0113	0.0146
2012	4	0.0047	0.0087	0.0117	0.0132
2013	1	0.0061	0.0096	0.0120	0.0150
2013	2	0.0043	0.0097	0.0124	0.0156
2013	3	0.0026	0.0051	0.0071	0.0084
2013	4	0.0022	0.0094	0.0128	0.0153
2014	1	0.0086	0.0086	0.0104	0.0168
2014	2	0.0070	0.0079	0.0116	0.0139
2014	3	0.0053	0.0083	0.0116	0.0119
2014	4	0.0065	0.0099	0.0101	0.0115
2015	1	0.0076	0.0082	0.0104	0.0150
2015	2	0.0072	0.0088	0.0109	0.0155
2015	3	0.0038	0.0078	0.0107	0.0153
2015	4	0.0044	0.0082	0.0109	0.0123
2016	1	0.0041	0.0077	0.0112	0.0145
2016	2	0.0051	0.0074	0.0118	0.0145
2016	3	0.0073	0.0143	0.0199	0.0235
2016	4	0.0076	0.0141	0.0188	0.0212
2017	1	0.0064	0.0083	0.0103	0.0139
2017	2	0.0038	0.0078	0.0099	0.0162
2017	3	0.0042	0.0064	0.0098	0.0130
2017	4	0.0076	0.0141	0.0188	0.0212
2018	1	0.0046	0.00664	0.0086	0.0126
2018	2	0.0053	0.0074	0.0097	0.0134
2018	3	0.0041	0.0067	0.0095	0.0136
2018	4	0.0057	0.0065	0.00762	0.0129
2019	1	0.003435	0.006394	0.008787	0.011583
2019	2	0.004131	0.00764	0.009757	0.014115
2019	3	0.005802	0.009995	0.013033	0.016454
2019	4	0.006432	0.007847	0.010513	0.015719
2020	1	0.004874	0.009325	0.012186	0.016226
2020	2	0.007139	0.010805	0.014431	0.017161
2020	3	0.005747	0.010002	0.014331	0.016495
2020	4	0.006462	0.010266	0.013371	0.016135

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2020. 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	0.9	2	194	99
	2	19.6	12	1427	609
	3	103.9	23	2383	1138
	4	26.5	15	1499	746
	Total	150.9	52	5503	2592
Norway	1				
	2	0.0			
	3	7.9	4	379	172
	4	2.1	3	300	149
	Total	10.0	7	679	321
Sweden	1	0.0	4	79	78
	2	0.0			
	3	3.5			
	4	2.3	12	626	626
	Total	5.9	16	705	704
All countries	1	0.9	6	273	177
	2	19.6	12	1427	609
	3	124.2	27	2762	1310
	4	34.7	30	2425	1521
Total		179.4	75	6887	3617

Table 10.2.5. North Sea and Division 3.a sprat. Number of biological samples taken from 1991 and onward. The number of samples may differ from Table 8.2.4, 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).

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	28	0	0

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q1

IBTS Q1 survey index (area 4 and 3a combined; years and ages apply to 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
2008	1526985	803061	47400	8526

IBTS Q1 survey index (area 4 and 3a combined; years and ages apply to the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
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	3308192.90	1977916.75	196830.97	16693.94

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 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	53930015.69	16906066.30	1479519.10

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 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	38415.20	17993.10	2055.10

Table 10.6.1. North Sea and Division 3.a sprat. Natural mortality input (Model year). 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

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 04/06/21 Start time:13:38:50 run time:5 seconds

objective function (negative log likelihood): 291.264
Number of parameters: 141
Maximum gradient: 0.240436
Akaike information criterion (AIC): 864.528
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
752	288	47	0	1087

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
397.3	-107.2	11.5	0.0	0.0	0.00	302

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.53	-0.37	0.25	0.00

contribution by fleet:

IBTS Q1 total: -65.594 mean: -0.420
IBTS Q3 total: -33.129 mean: -0.381
Acoustic total: -8.449 mean: -0.188

F, Year effect:

1974: 1.000
1975: 1.759
1976: 1.828
1977: 1.586
1978: 1.043
1979: 0.676
1980: 2.405
1981: 1.175
1982: 1.060
1983: 1.745
1984: 1.020
1985: 1.412
1986: 1.184
1987: 0.388
1988: 1.358
1989: 0.381
1990: 1.595
1991: 0.818
1992: 0.904

1993: 1.682
1994: 0.812
1995: 1.495
1996: 1.490
1997: 1.071
1998: 1.835
1999: 0.940
2000: 1.572
2001: 1.672
2002: 1.734
2003: 1.351
2004: 2.103
2005: 1.395
2006: 1.741
2007: 1.779
2008: 1.575
2009: 0.917
2010: 1.128
2011: 1.000
2012: 1.484
2013: 1.437
2014: 0.650
2015: 1.415
2016: 2.450
2017: 1.531
2018: 1.539
2019: 1.219
2020: 2.183

```
F, season effect:
-----------------
age: 0
   1974-2020:   0.036 0.206 0.387 0.250
age: 1
   1974-2020:   0.533 0.535 0.206 0.250
age: 2
   1974-2020:   0.250 0.491 0.125 0.250
age: 3
   1974-2020:   0.226 0.541 0.312 0.250

F, age effect:
--------------
              0      1      2      3
1974-2020:  0.037  0.410  1.473  1.473

Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                     0      1      2      3
1974-2020 season 1:  0.001  0.193  0.325  0.293
          season 2:  0.007  0.193  0.637  0.702
          season 3:  0.013  0.074  0.163  0.404
```

season 4: 0.008 0.090 0.324 0.324

sqrt(catch variance) ~ CV:

----

age	season 1	2	3	4
0	1.414	1.414	1.185	0.100
1	0.854	0.726	1.414	0.100
2	1.016	1.078	1.414	0.100
3	1.016	1.078	1.414	0.100

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.000	1.546	2.989	5.229
IBTS Q3		0.837	1.087	1.039
Acoustic		1.114	2.433	6.329

Stock size dependent catchability (power model)

	age 0	age 1	age 2	age 3
IBTS Q1	1.64	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	0.44	0.39	0.39	0.39
IBTS Q3		0.47	0.39	0.39
Acoustic		0.45	0.53	0.53

Average F:

----

	sp. 1
1974:	1.124
1975:	1.697
1976:	1.784
1977:	1.596
1978:	1.040
1979:	0.681
1980:	2.262
1981:	1.108
1982:	0.987
1983:	1.596
1984:	0.972
1985:	1.293
1986:	1.081
1987:	0.360

1988: 1.256
1989: 0.366
1990: 1.515
1991: 0.809
1992: 0.897
1993: 1.578
1994: 0.765
1995: 1.367
1996: 1.378
1997: 1.032
1998: 1.754
1999: 0.931
2000: 1.484
2001: 1.612
2002: 1.670
2003: 1.365
2004: 2.057
2005: 1.357
2006: 1.668
2007: 1.688
2008: 1.514
2009: 0.874
2010: 1.048
2011: 0.927
2012: 1.348
2013: 1.331
2014: 0.622
2015: 1.328
2016: 2.258
2017: 1.429
2018: 1.437
2019: 1.145
2020: 1.770

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1354.122	9.000e+04	0.601	0.775

Table 10.6.3. North Sea and Division 3.a Sprat. Assessment output: Stock numbers (thousands) (years, seasons, and age refer to the model year)

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1974	536170000	330380000	236466000	173242000	138697000	70606100	44792700	31279000	10662600	4933560	1924920	1343460	519368	281566	105187	55798
1975	710021000	421816000	311549000	218527000	109995000	45761800	24952400	15956900	18750600	6426120	1473200	855972	704628	309834	64402	23096
1976	329110000	201180000	144353000	97681200	136094000	57230000	30083100	18489500	10260200	3452130	734199	411931	575923	234572	44981	15282
1977	632579000	406329000	276463000	184839000	60119200	28182900	15577400	9589000	11871700	4576260	1156550	673137	280484	121122	28045	10563
1978	1049300000	694613000	486908000	327404000	113288000	60579000	38265800	24533700	6177700	2861730	1081260	724679	443921	225641	81098	40827
1979	537150000	346960000	227678000	152144000	209856000	118454000	79357100	51977100	16504900	8461420	4058780	2841760	526598	280591	130497	75893
1980	331153000	206300000	129470000	84846600	97558800	36263300	16466200	9423750	35214400	9307940	1262610	641877	2001350	593680	69414	18242
1981	90046800	54492800	35861400	24583000	55805000	26552600	15641200	10350600	6495020	2691450	880217	567317	471551	222480	69182	32300
1982	46704700	27990700	19936200	14468400	16872200	8692670	5468830	3968310	7439300	3450160	1289510	883778	459146	252512	90827	46535
1983	61661900	36121200	25462700	18463200	10527500	4680880	2522050	1770330	3008600	1115400	253816	154666	757601	338860	69491	26235
1984	32596500	18996200	12677400	9171790	13511300	7063650	4460940	3224340	1365780	703563	272823	189235	152874	90742	33312	17466
1985	23169700	13352400	8155380	5786850	6650670	2957160	1643900	1137730	2451060	1002370	280524	180955	169694	87017	22889	10021
1986	73957600	40939400	25809600	17951200	4209240	1905320	1074110	750648	869084	368398	117253	78091	161923	84684	26260	12638
1987	39337600	21664700	13495000	9396710	12838900	7269290	4869860	3794930	564821	314310	175964	135445	76599	52099	30332	20989
1988	58120800	31161400	18839100	12741400	6702490	3015330	1589960	1116980	2865230	1101540	300644	187755	130060	63938	16537	7115
1989	51217800	27997000	16508000	11499000	8877360	4908780	3239050	2496100	826319	465531	263410	196782	154433	109837	62468	42037
1990	69271000	41185100	24784000	17290300	7909760	3421930	1731840	1167010	1827430	678590	161141	93567	180247	83050	17953	6730
1991	106179000	66807900	44700300	32387000	11742200	6431060	4104830	2942860	848615	455685	199907	137455	75290	44089	18601	10219
1992	100264000	66453500	48303100	35533100	21952200	12566300	8212390	5778660	2136720	1155300	489794	335224	110813	63576	25829	13794
1993	134538000	85120900	66207600	49216300	24526600	11223000	6295430	4240870	4285070	1639530	401331	242730	266369	112382	24726	9425
1994	118861000	71839600	53296500	40709500	34770200	18626200	12463700	9344240	3223320	1686630	769554	547635	197573	107702	47016	26773
1995	35762400	21387800	15817300	12397600	29627500	13493200	7773350	5661760	7293600	2995840	835090	530314	459638	205534	52086	21948
1996	60740900	36613900	25174500	19874800	9514960	4626550	2657820	1974700	4584990	2034270	565546	369319	456859	224710	57457	24932
1997	47922800	30477500	22449000	17609800	15666300	9246550	5959610	4488880	1625130	887184	338882	234415	337261	202291	73892	38101

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1998	108113000	70183200	48193500	36491800	13455500	6789760	3725780	2589810	3623050	1468230	326058	195475	229679	103117	20660	7486
1999	76081800	49855900	37015700	27749700	26556100	16223500	10907900	7920410	2026520	1135710	485610	337241	166716	98440	39976	21452
2000	73216300	48680200	33718500	25575500	19858100	10007100	5808380	4110430	6063670	2636770	705981	451434	281497	134130	32362	13445
2001	59548200	39477700	28897900	21608700	19356400	9673330	5413970	3752290	3247430	1388350	338190	205112	383640	181874	39492	15139
2002	79517900	51375600	36980300	28034400	15907500	7892720	4316670	3034150	2897750	1202090	276619	165343	177962	84266	17225	6398
2003	102412000	67209100	49531000	37489600	20303000	11543300	6825270	4842380	2335690	1144000	349226	217135	138129	74459	20686	8877
2004	174458000	112451000	83796400	64515900	25571200	12249800	6219050	4213470	3558220	1301030	234270	129096	169805	69635	10837	3354
2005	64052400	41107600	29852300	23466600	44307200	23698400	14017300	10193200	3114100	1483540	450952	291315	100267	50793	14045	6188
2006	82060000	49460600	37453100	29394600	16261400	8112150	4478760	3175650	7617150	3198360	763300	465721	237563	107404	22712	8594
2007	58147300	35891500	26557800	20974700	20420200	10126400	5488390	3965850	2406790	1018130	236948	146521	387433	178330	36587	13886
2008	128823000	79715900	60194600	48153200	15347800	8002000	4619650	3401570	3127560	1450310	396328	250798	134652	67514	16541	6794
2009	106801000	68413200	48982900	39954300	35530900	20241800	13546400	10580500	2715000	1533320	674375	483467	211553	132564	54936	30622
2010	111529000	65731400	43886200	35112600	29820700	15423600	9688560	7341490	8530860	4118260	1520780	1052880	425261	246370	85069	43213
2011	89718700	53764800	36454300	28585200	25780000	13380900	8461860	6353590	5854150	2752360	1099530	764036	900300	538150	202651	107013
2012	68928300	41341400	28278600	22235200	20385900	9571220	5444330	4029280	4930350	2022340	570907	375387	696021	356270	91401	40002
2013	155911000	104400000	78736700	62729500	16608200	8401680	4974320	3698770	3217070	1423630	427125	282422	347095	185316	50365	22451
2014	177282000	122715000	94392600	75683800	47888100	29714000	21125000	16688400	2965800	1826330	965356	734362	255089	178653	91262	58081
2015	96607400	66930000	52231000	41383700	57663800	30139800	18202000	13529800	13298100	6151850	1875530	1244330	659464	358271	99946	44976
2016	137568000	94042200	71500800	55807800	31343100	12959300	6193150	4218170	10810800	3377110	486027	266322	1076340	412906	50252	14057
2017	167918000	114932000	88003500	69609500	42267600	21368500	12496500	9198070	3370460	1477750	413687	268625	234068	121910	30864	13166
2018	167007000	114307000	87519900	69219000	52720600	26607200	15533300	11425700	7349570	3213020	894354	579900	235247	122204	30745	13068
2019	158211000	108334000	83150300	66068600	52424900	28375100	17770700	13429100	9129520	4490730	1575570	1083750	495025	286012	92842	45703
2020	94106900	64355100	49030400	39652400	50038800	21937700	11119100	9313420	10730300	3699940	646402	556926	942898	395419	59573	51327
2021	0				30031800				7441740				507785			

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.

Year	Recruitment	High	Low	SSB	High	Low	Catches	F ages 1-2	High	Low
	(thousands)			(tonnes)			(tonnes)	(per year)		
1974	536170000	952463587	301825994	607475	980398	376404	443039	1.135	1.784	0.723
1975	710021000	1236886331	407579749	610393	978228	380872	731782	1.583	2.413	1.026
1976	329110000	566535718	191185461	499002	803640	309844	629980	1.646	2.44	1.096
1977	632579000	1068754769	374413479	338213	518539	220597	385214	1.428	2.162	0.925
1978	1049300000	1959229159	561971266	390121	611605	248844	459295	0.939	1.646	0.519
1979	537150000	939377602	307150311	630106	1071834	370425	464139	0.609	1.224	0.285
1980	331153000	518996660	211296754	432865	728812	257093	387443	2.165	3.036	1.536
1981	90046800	133815694	60593985	304926	450169	206544	280227	1.058	1.646	0.674
1982	46704700	66759109	32674627	178741	266747	119770	163008	0.954	1.396	0.649
1983	61661900	83818794	45362021	84056	113334	62341	115430	1.571	1.948	1.266
1984	32596500	46187809	23004594	61532	80166	47229	113527	0.918	1.309	0.639
1985	23169700	31655740	16958536	57379	74895	43959	62514	1.271	1.643	0.982
1986	73957600	102969648	53119795	22533	29494	17215	27520	1.066	1.449	0.783
1987	39337600	53434042	28959943	52143	70296	38678	53976	0.349	0.538	0.225
1988	58120800	82847863	40773863	54619	69968	42637	103655	1.222	1.551	0.961
1989	51217800	70180667	37378713	40925	54749	30591	58442	0.343	0.667	0.172
1990	69271000	93616860	51256488	39137	52261	29309	78254	1.436	1.828	1.125
1991	106179000	138966498	81127323	81366	106479	62176	125815	0.736	1.071	0.499
1992	100264000	132698924	75756980	113659	143615	89951	156472	0.814	1.138	0.577
1993	134538000	200667428	90201353	158825	202183	124765	209083	1.514	1.834	1.248
1994	118861000	158684269	89031745	124251	174829	88305	425104	0.731	1	0.532
1995	35762400	47667352	26830718	178926	237897	134573	447604	1.345	1.688	1.071
1996	60740900	80418066	45878459	106678	133732	85097	95522	1.341	1.663	1.079
1997	47922800	63600076	36109937	108100	136940	85334	125227	0.964	1.279	0.722
1998	108113000	144965821	80628804	133319	166819	106546	189063	1.652	1.97	1.382
1999	76081800	100068068	57845029	127979	166750	98222	243188	0.846	1.169	0.606
2000	73216300	96221572	55711276	182422	230855	144150	222089	1.414	1.768	1.127
2001	59548200	77537383	45732626	125252	158126	99212	153321	1.505	1.86	1.215
2002	79517900	105004649	60217300	108990	136592	86966	175008	1.561	1.891	1.285
2003	102412000	135303427	77516276	136243	173166	107193	175253	1.216	1.558	0.942
2004	174458000	228555156	133165203	166717	211947	131139	231221	1.892	2.239	1.595
2005	64052400	82595370	49672396	212407	271900	165931	280861	1.256	1.578	0.995
2006	82060000	105774346	63662351	164011	205707	130767	78114	1.567	1.91	1.283
2007	58147300	75383943	44851839	132225	165116	105886	99904	1.601	1.933	1.323
2008	128823000	165473206	100290347	97626	121726	78298	69970	1.418	1.772	1.13
2009	106801000	138032550	82635969	171358	214572	136847	171230	0.825	1.132	0.598
2010	111529000	150694551	82542585	175073	217646	140828	147208	1.016	1.331	0.774

Year	Recruitment (thousands)	High	Low	SSB (tonnes)	High	Low	Catches (tonnes)	F ages 1-2 (per year)	High	Low
2011	89718700	117091578	68744869	152787	193212	120820	122537	0.901	1.231	0.658
2012	68928300	88143162	53902202	127752	157647	103526	96182	1.335	1.644	1.084
2013	155911000	207962710	116887493	103778	128902	83551	60313	1.293	1.704	0.978
2014	177282000	237044941	132586283	198774	256369	154118	190700	0.585	0.834	0.408
2015	96607400	127401734	73256379	322777	416576	250098	297105	1.273	1.601	1.01
2016	137568000	178485317	106030876	219369	278939	172521	227902	2.206	2.522	1.929
2017	167918000	217686883	129527578	176860	223327	140061	135544	1.378	1.701	1.115
2018	167007000	222100886	125579589	200477	251249	159965	191543	1.385	1.703	1.124
2019	158211000	218135627	114748429	212573	269822	167471	136794	1.097	1.494	0.802
2020	94106900	146340271	60517235	319474	414196	246414	179386	1.671	2.128	1.308
2021	127373950*			161888	220639	118781				

* 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).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2021) (millions)	127374	30032	7442	508
Exploitation pattern Q1	0.002	0.267	0.450	0.406
Exploitation pattern Q2	0.009	0.268	0.883	0.972
Exploitation pattern Q3	0.018	0.103	0.225	0.560
Exploitation pattern Q4	0.000	0.000	0.000	0.000
Weight in the stock Q1 (gram)	4.286	7.444	9.850	13.462
Weight in the catch Q1 (gram)	4.29	7.44	9.85	13.46
Weight in the catch Q2 (gram)	5.54	8.62	11.29	14.89
Weight in the catch Q3 (gram)	5.23	8.90	12.29	15.53
Weight in the catch Q4 (gram)	6.21	8.20	10.49	14.89
Proportion mature(2019)	0.00	0.41	0.87	0.95
Proportion mature(2020)	0.00	0.41	0.87	0.95
Natural mortality Q1	0.38	0.35	0.26	0.14
Natural mortality Q2	0.26	0.20	0.16	0.15
Natural mortality Q3	0.21	0.18	0.15	0.15
Natural mortality Q4	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.

Catch options. Catches and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2021) = geom average 2011–2020.					
Basis	**Catches(2021)**	**F(2021)**	**SSB(2022)**	**%SSB change***	**%TAC change****
Fcap	106.715	0.69	208.733	29%	-49%
F=0	0	0	274.265	69%	-100%
F=0.1	19.645	0.1	261.836	62%	-91%
F=0.2	37.606	0.2	250.598	55%	-82%
F=0.3	54.067	0.3	240.415	49%	-74%
F=0.4	69.189	0.4	231.167	43%	-67%
F=0.5	83.115	0.5	222.751	38%	-60%
F=0.6	95.970	0.6	215.075	33%	-54%
F=0.7	107.864	0.7	208.059	29%	-48%
F=0.8	118.893	0.8	201.634	25%	-43%
F=0.9	129.142	0.9	195.736	21%	-38%
F=1.0	138.689	1	190.313	18%	-33%
Bescapement without Fcap	271.609	3.859	125.000	-23%	31%

* SSB in July 2022 relative to SSB in July 2021

** catch (July 2021-June 2021) relative to the sum of the TACs (207807 tonnes) for July 2020–June 2021 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.

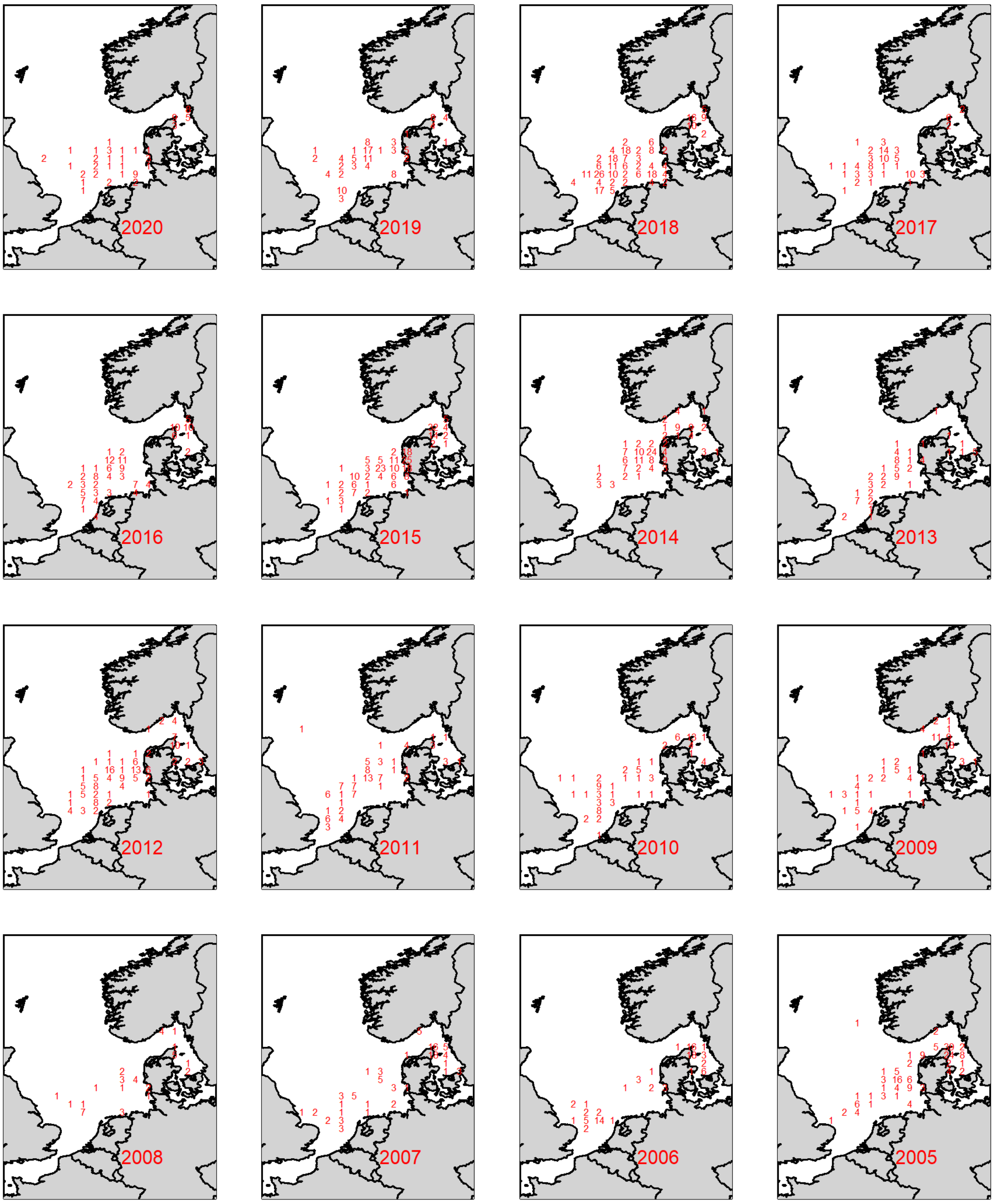


Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

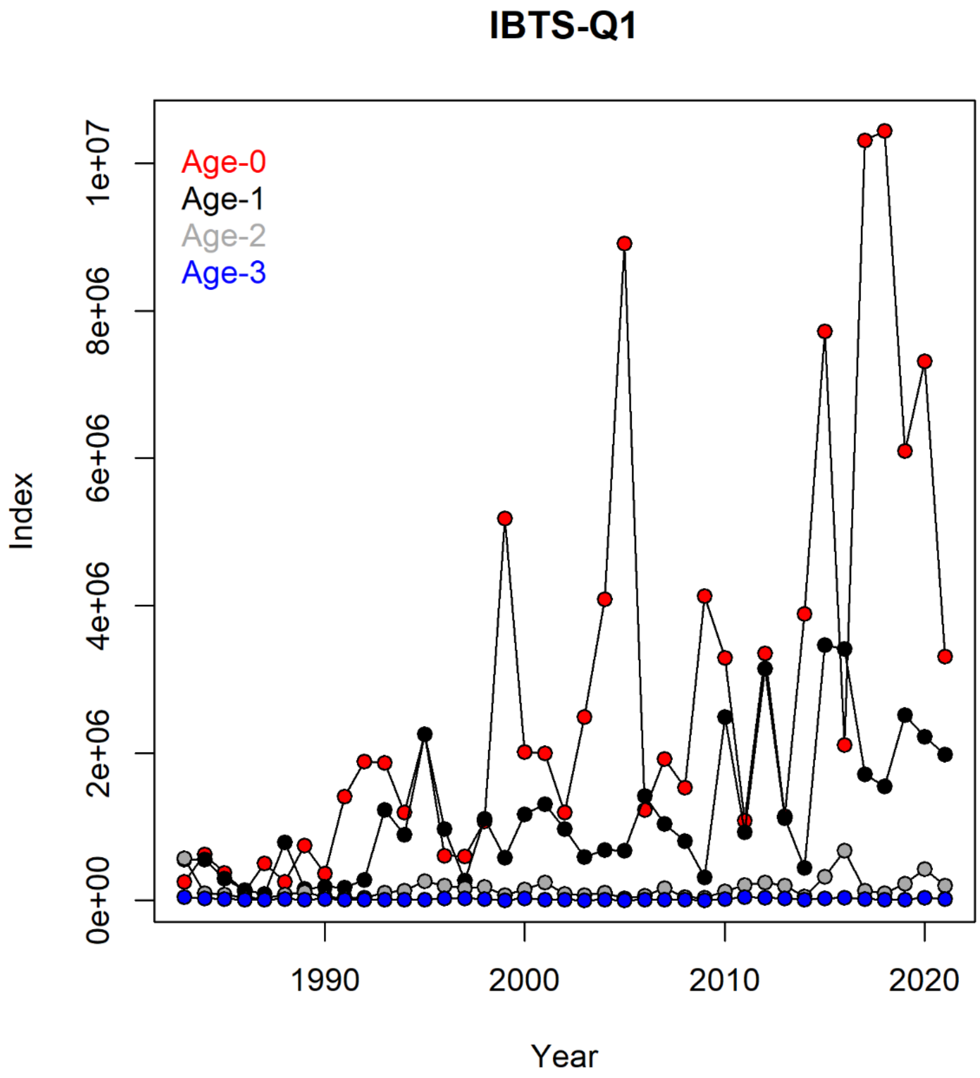


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

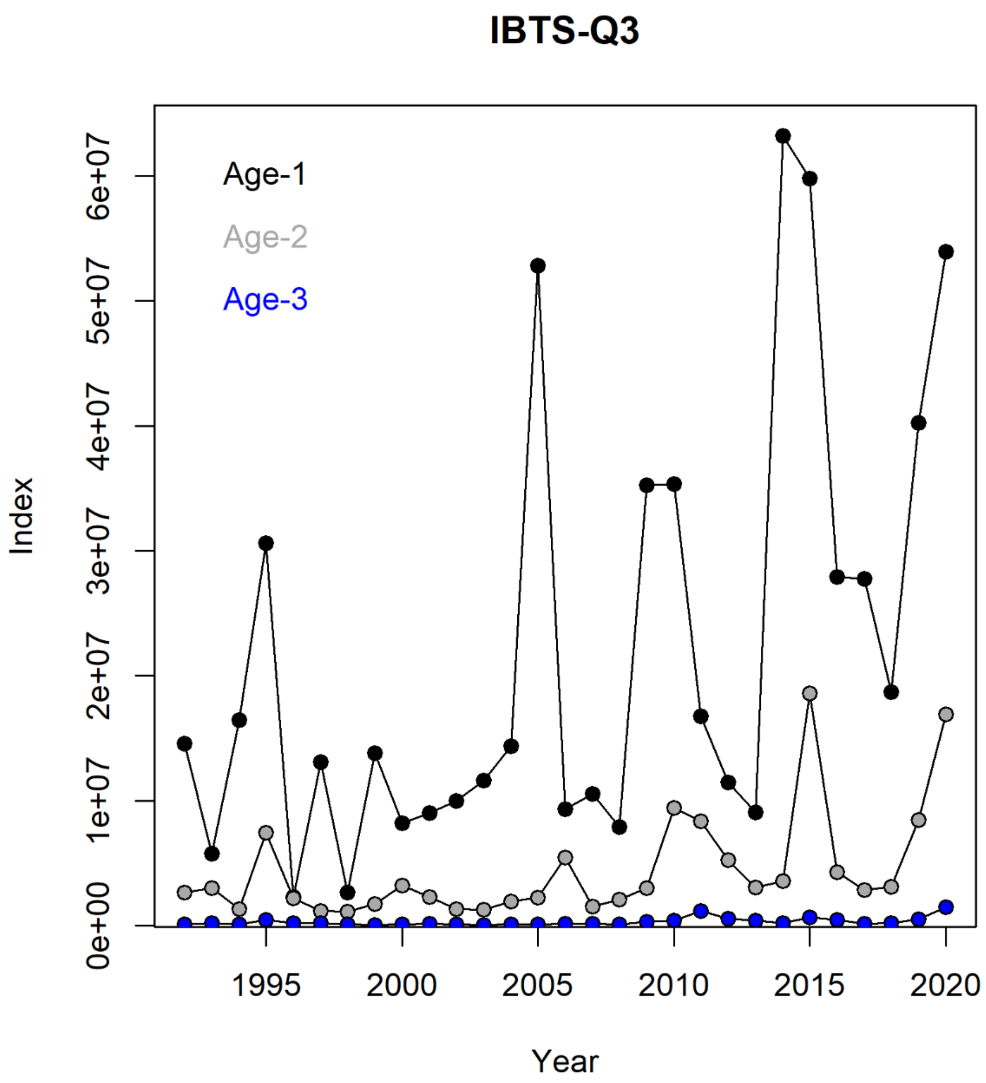


Figure 10.3.2a. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

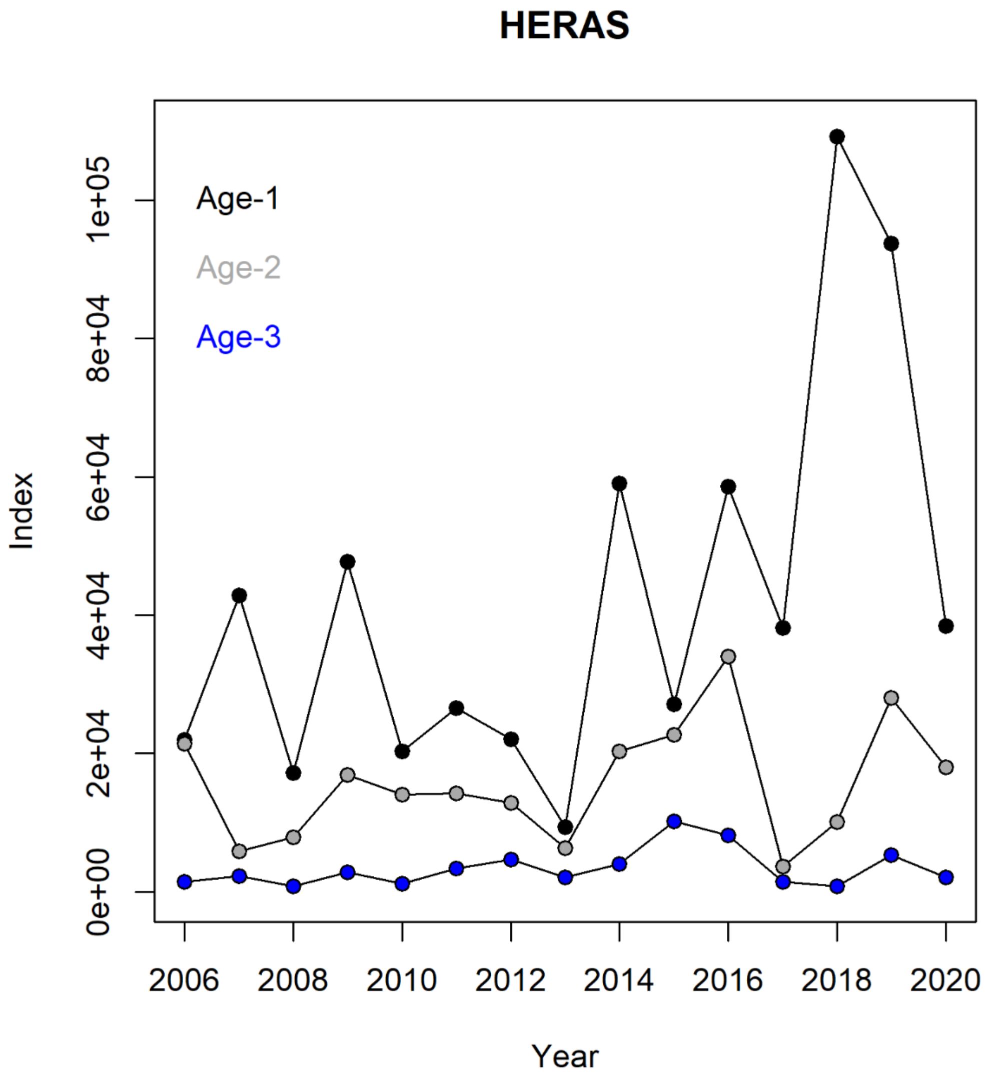
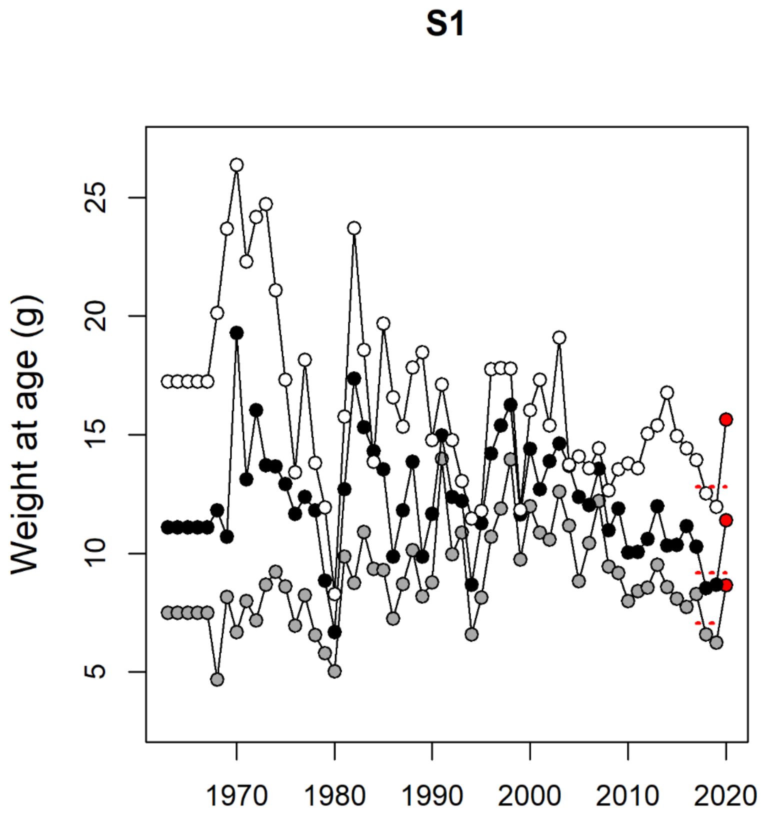
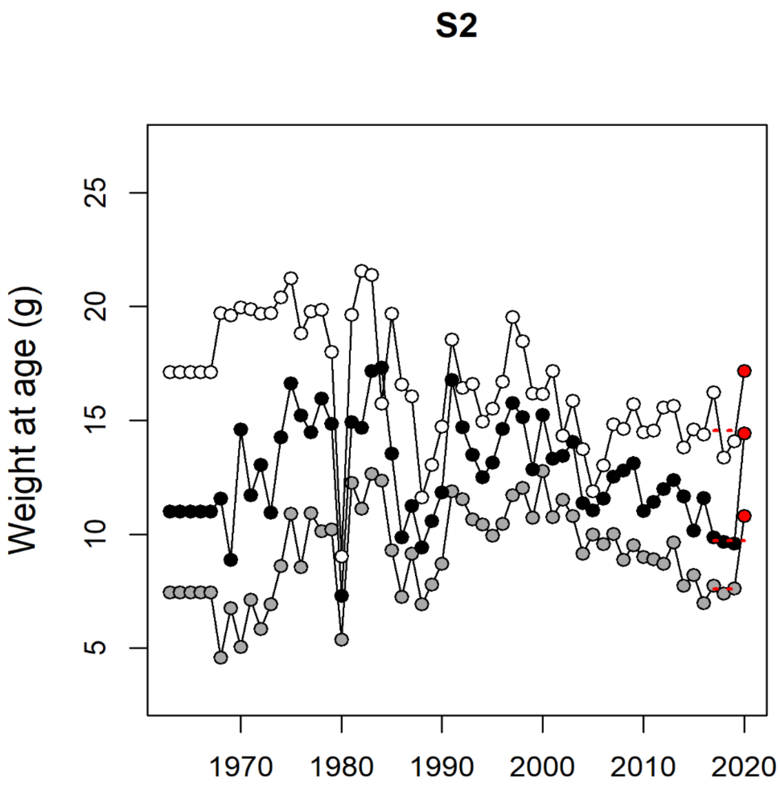
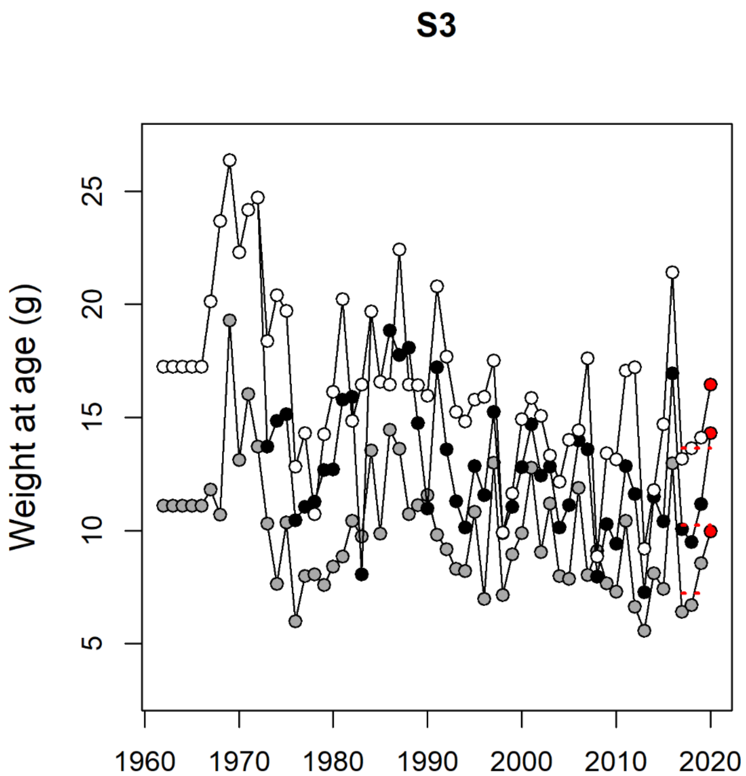


Figure 10.3.2b. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS). Years refer to the calendar year.


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



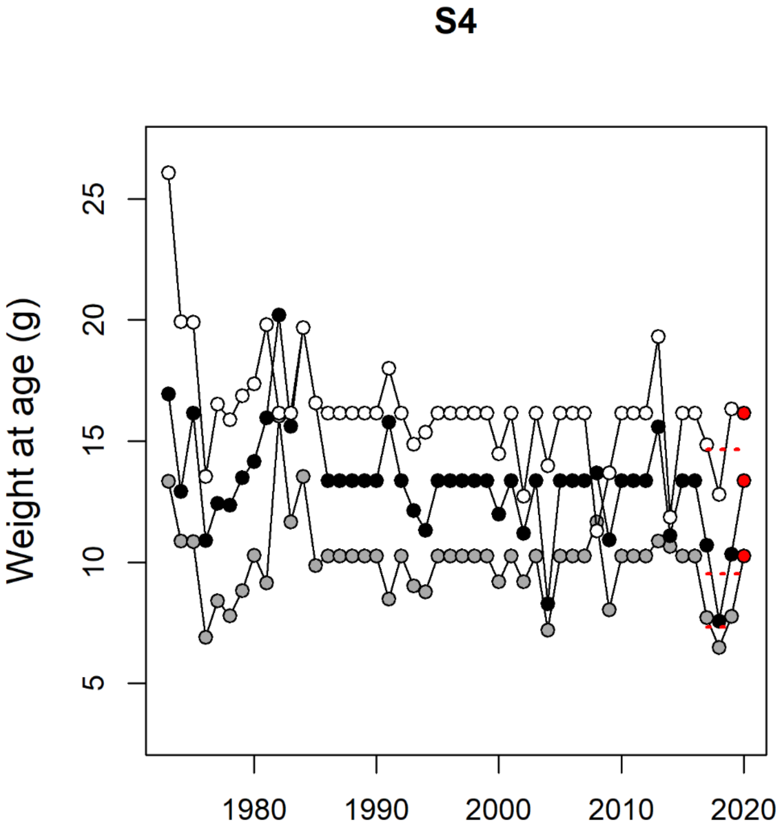


Figure 10.4.1. North Sea & 3.a sprat. Mean weight at age in season 1-4 (S1-S4) (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year.

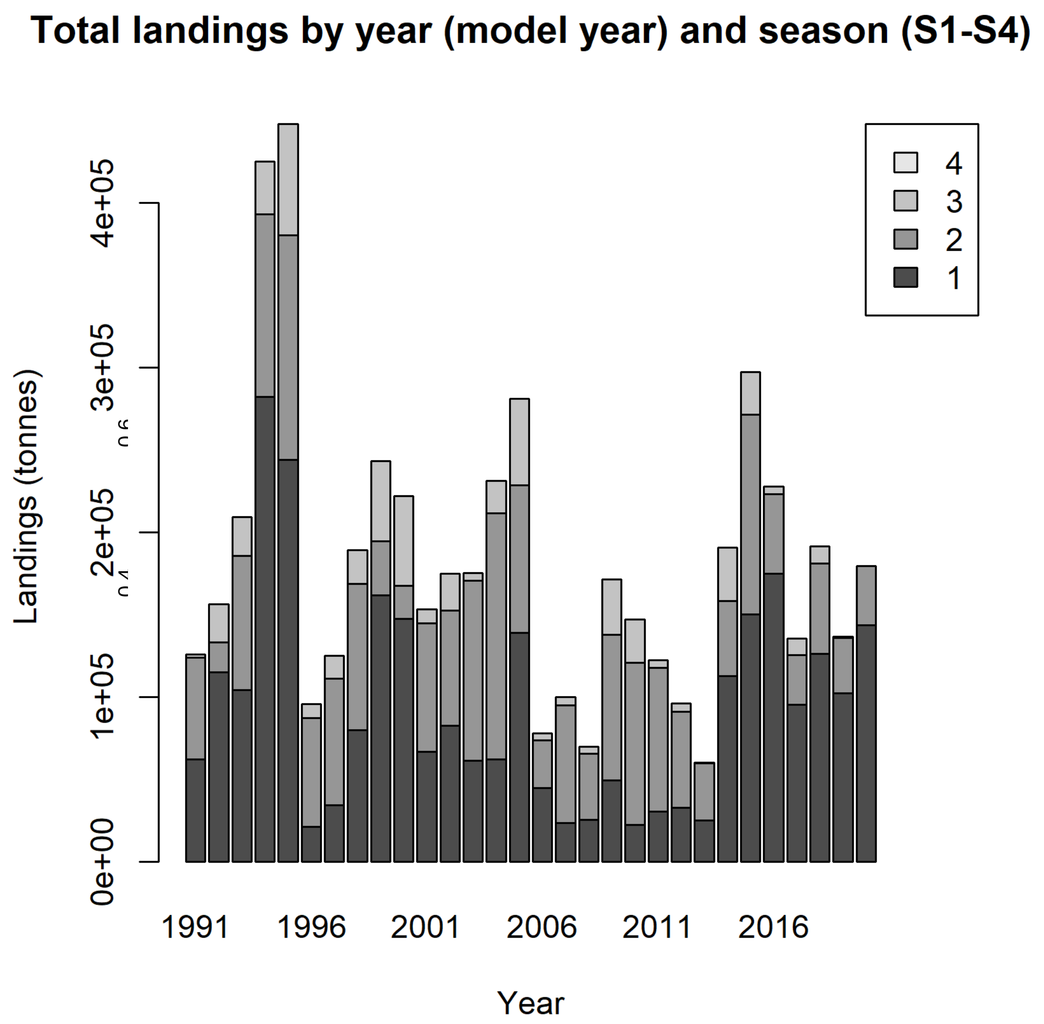


Figure 10.6.1a. North Sea & 3.a sprat. Seasonal distribution of catches (Calendar year). Year and season 1-4 refer to the time-steps of the model. Note that since the model year of 2020 is not yet finished, the 2020 column will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT 2018 report (ICES, 2018) for details).

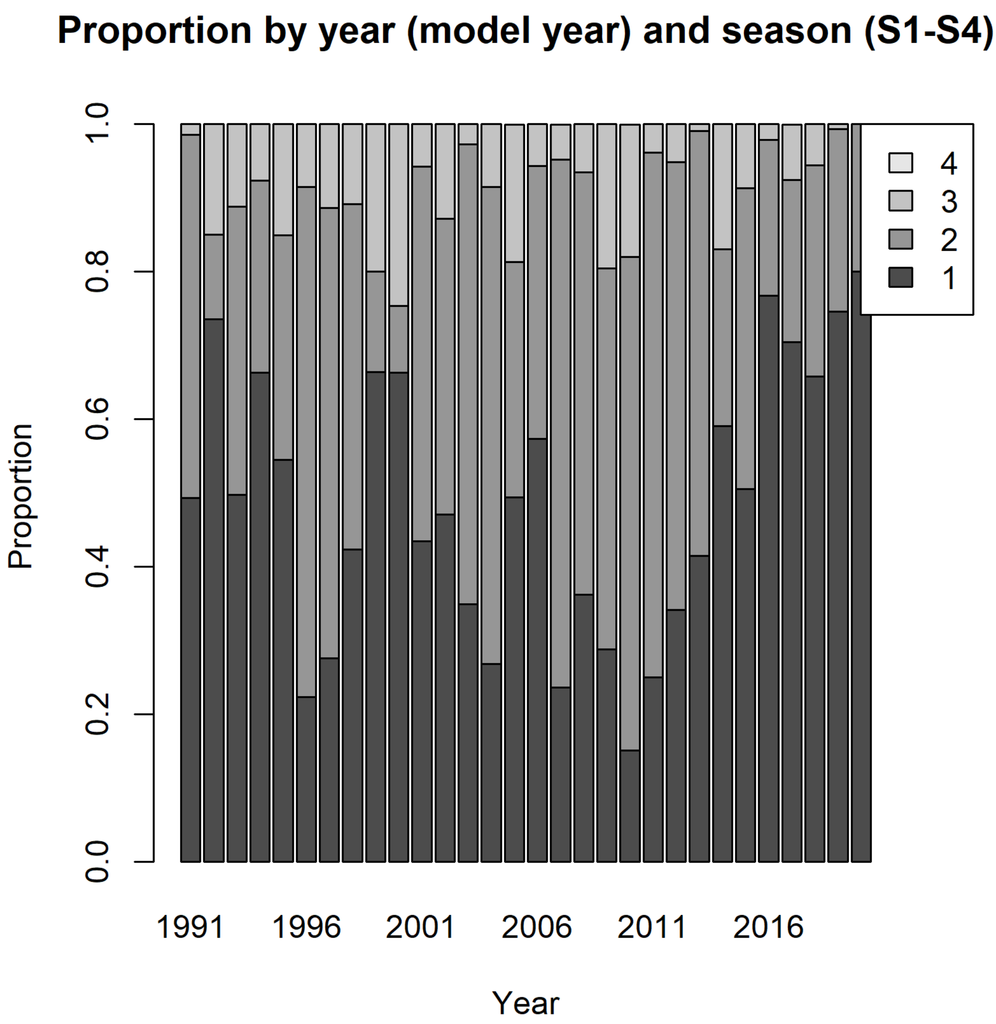


Figure 10.6.1b. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year.

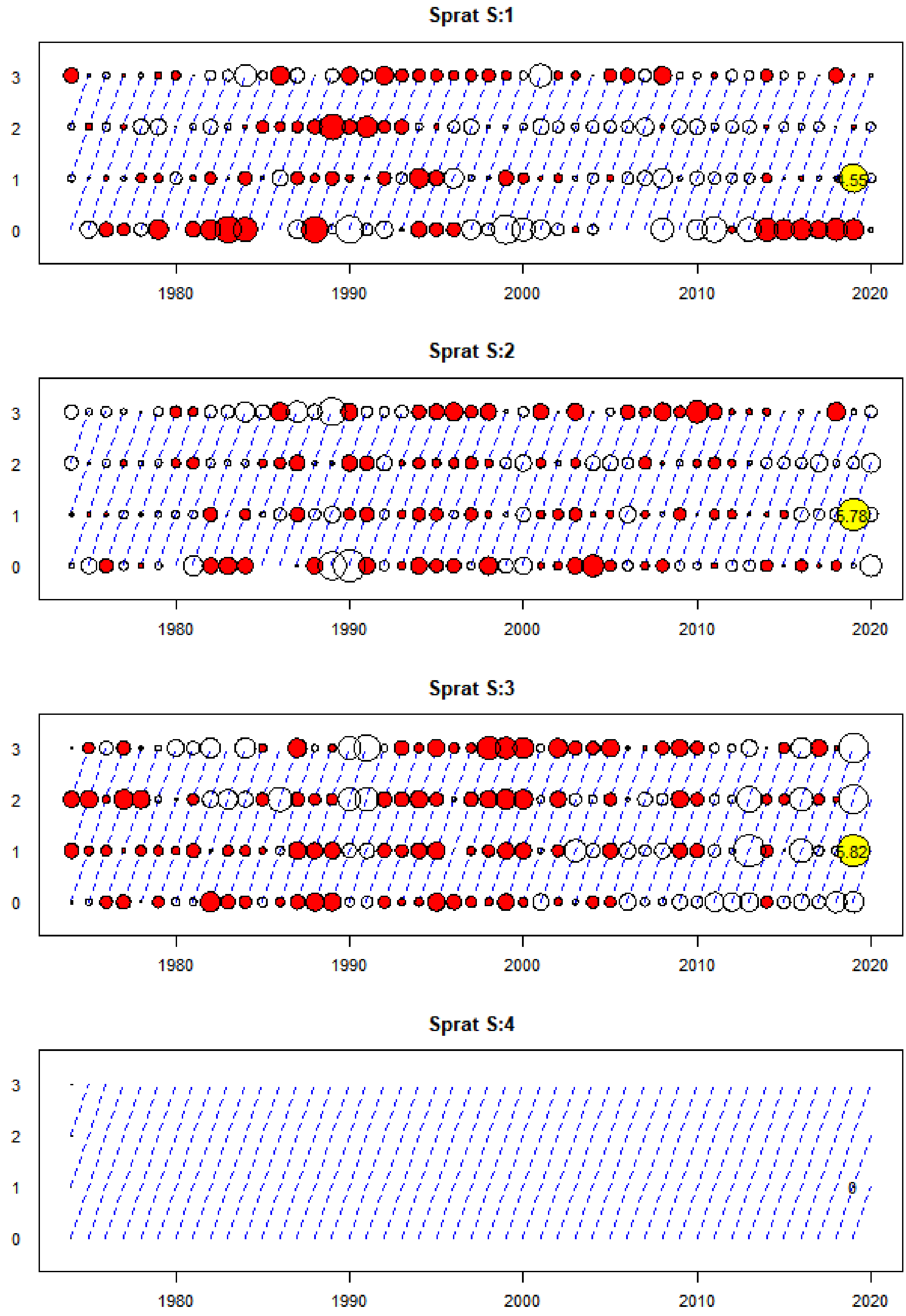


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year)

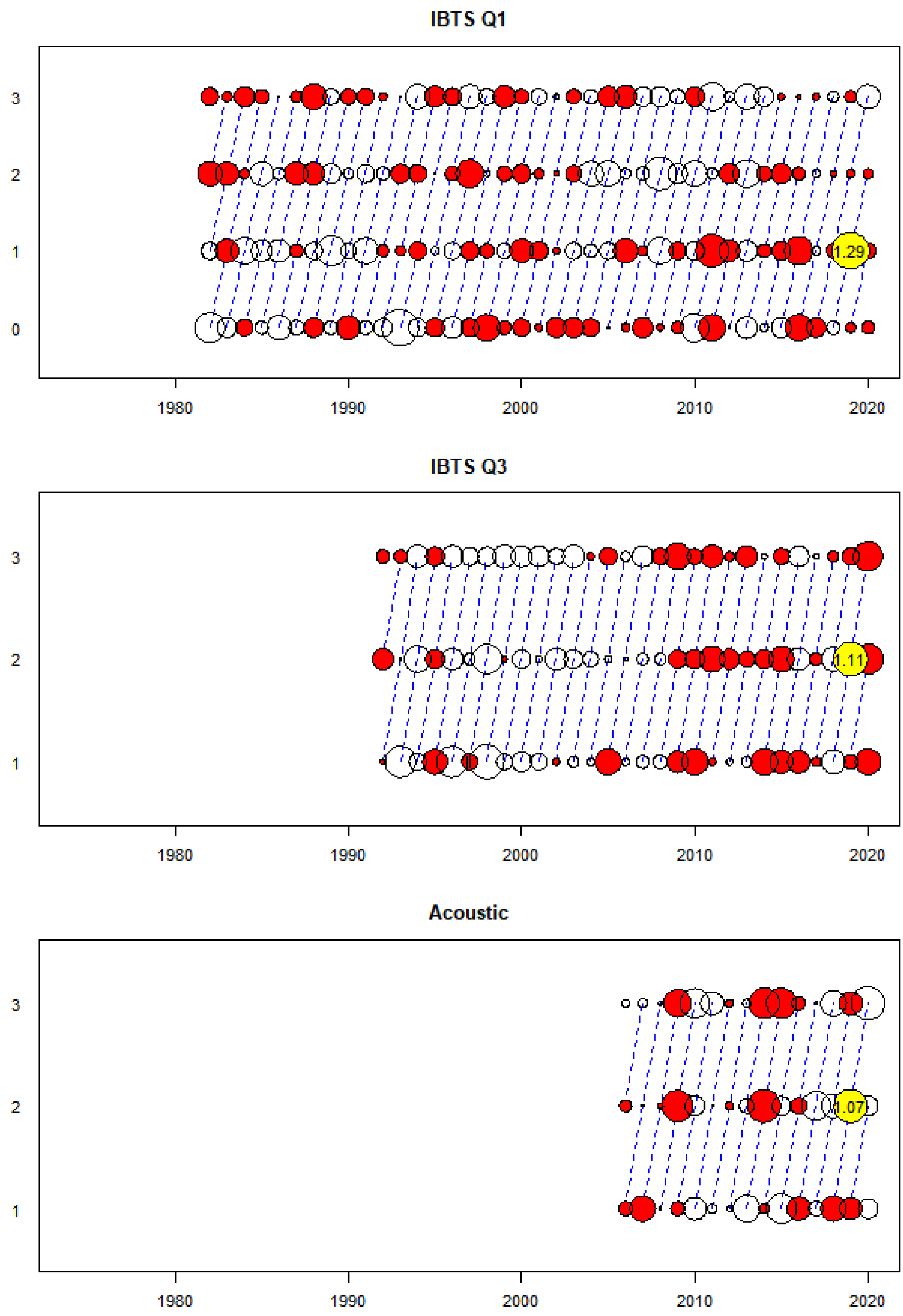


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year)

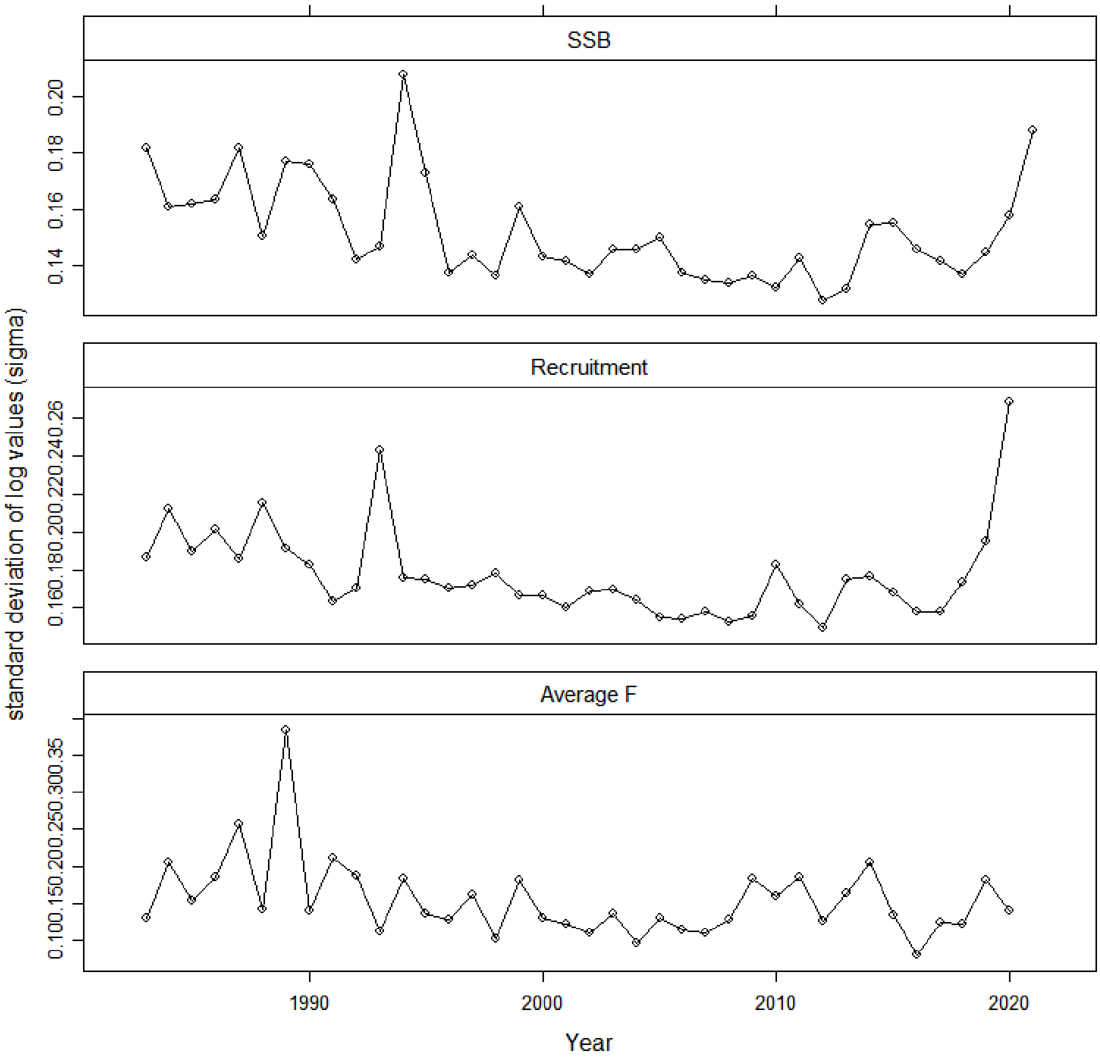


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year).

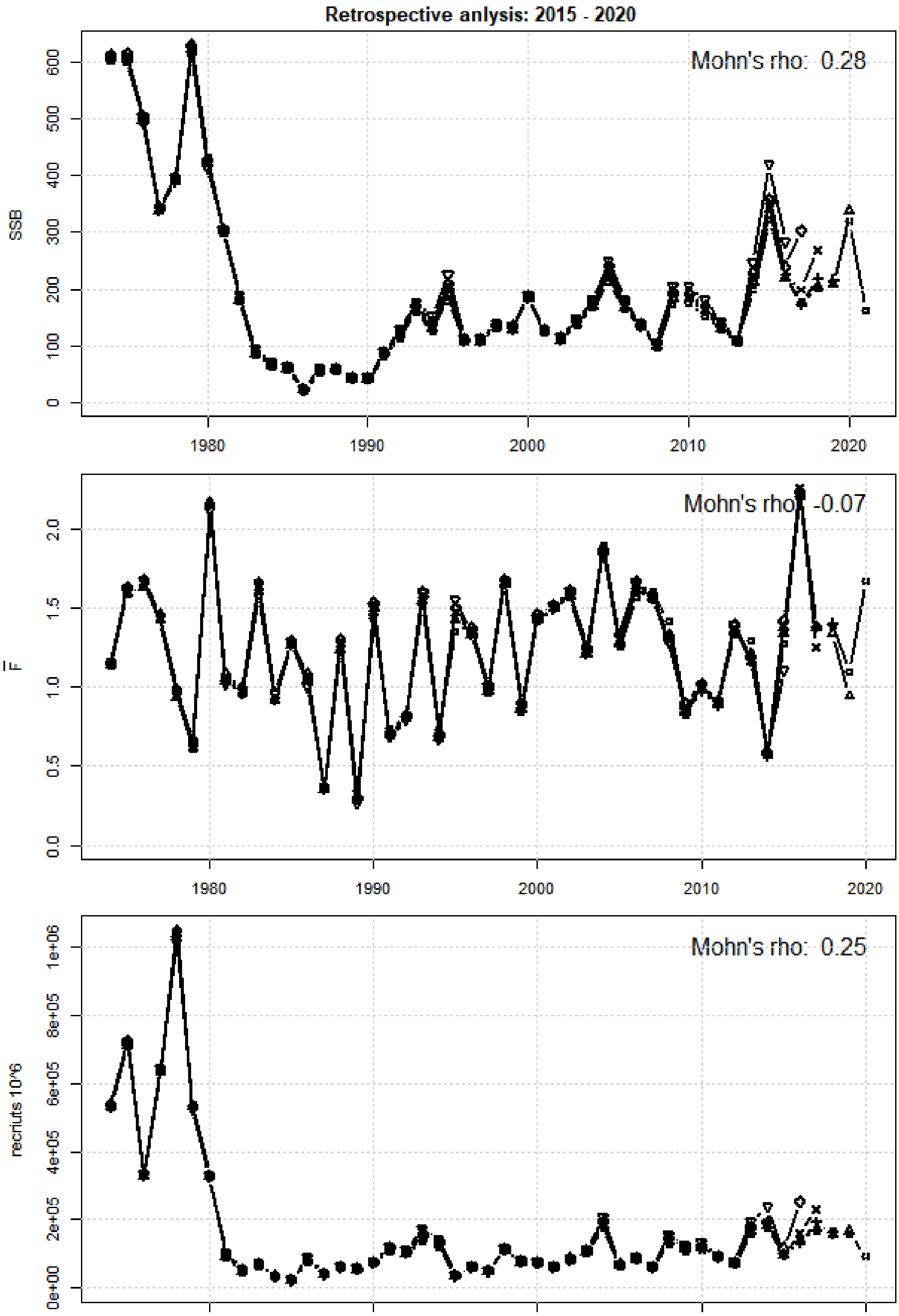


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year)

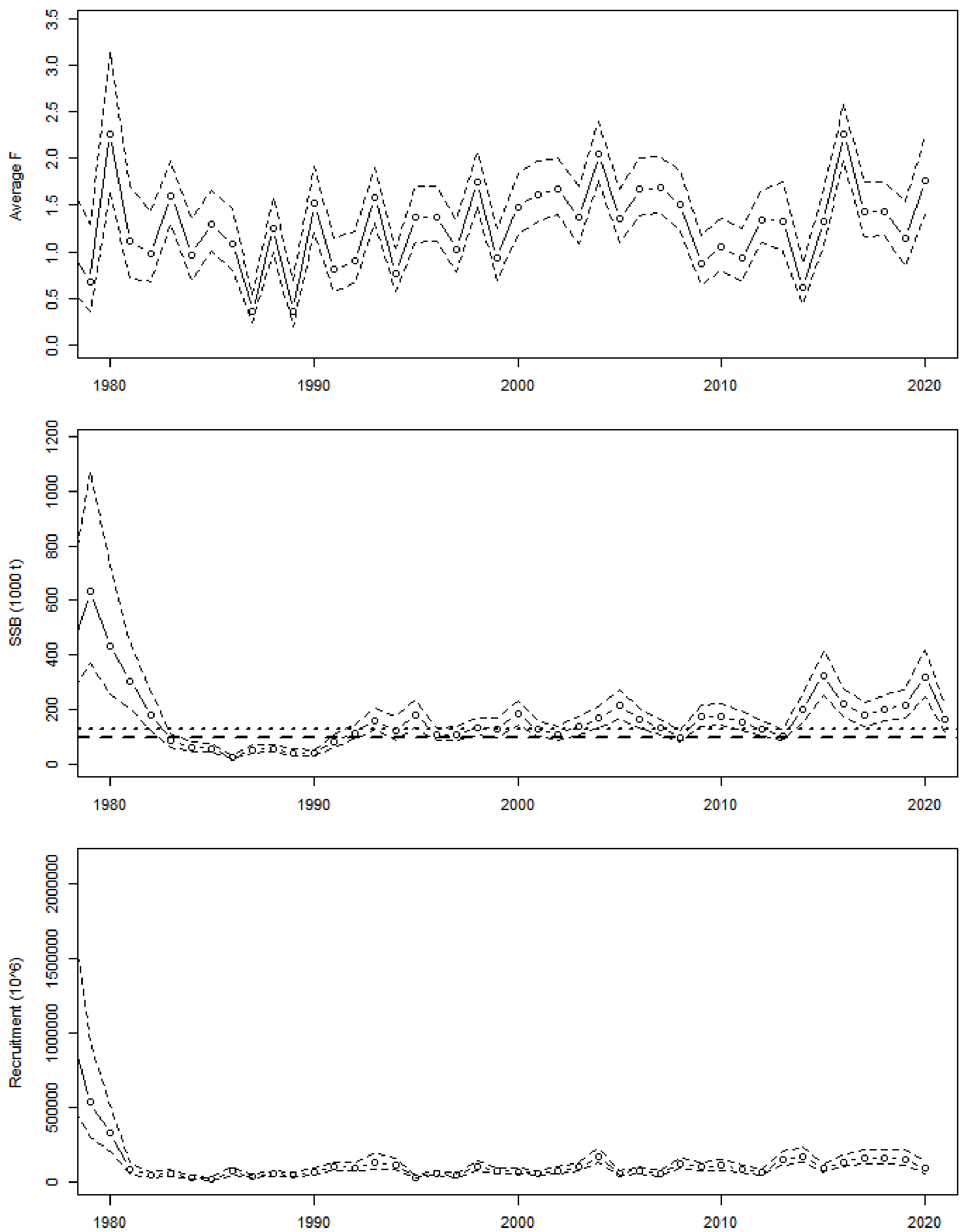


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

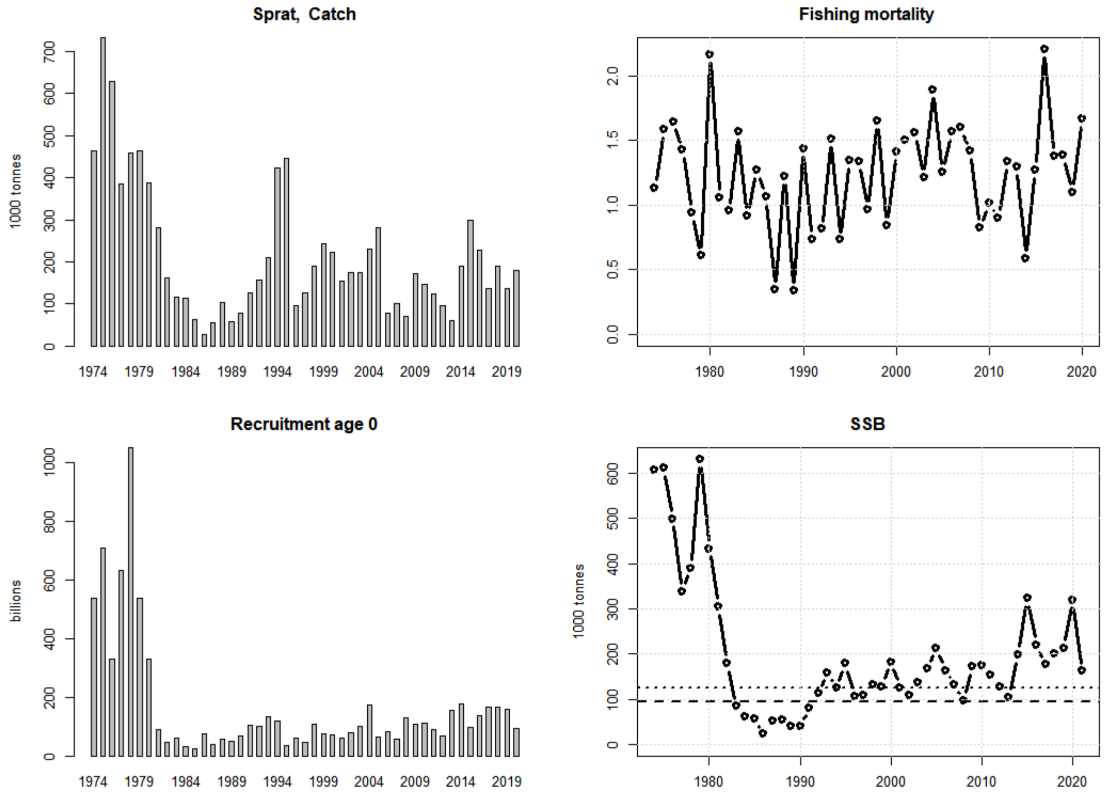


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year).

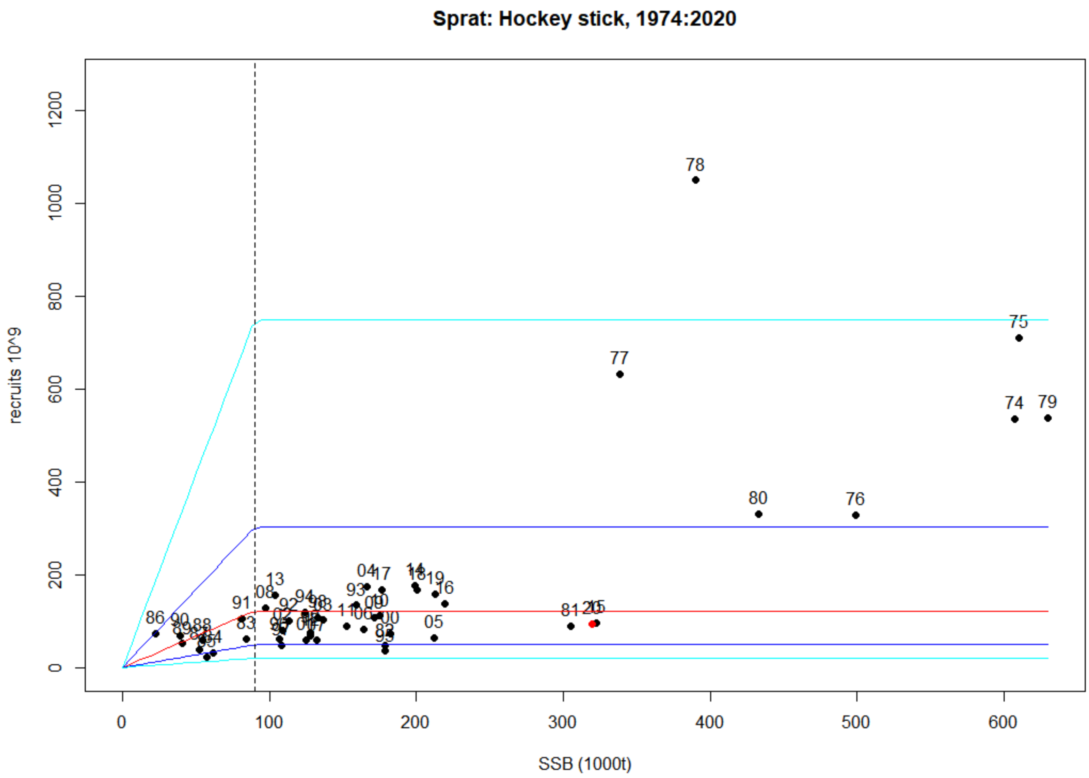


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year).

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

WKSPRAT 2018. Report of the Benchmark Workshop on Sprat. ICES CM 2018/ACOM:35. 60 pp

ICES. 2020. 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 North Sea

The information formerly kept in this section is now found in Section 10: "Sprat in the North Sea and 3.a"

12 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.

12.1 The Fishery

12.1.1 ICES advice applicable for 2021

The advised catch for the English Channel (7.d and e) was set equal to 1446 tonnes.

12.1.2 Landings

The total sprat landings by country are provided in Table 12.1.1. Total landings from the international sprat fishery are available since 1950 (Figure 12.1.1.). 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 UK, England and Wales. 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 particular in the Lyme Bay area. In the last decade catch from UK covered about 99% of landed sprat, however in 2015 and 2016 this percentage diminished, with Netherlands, Denmark, and for the first time in the whole time-series, Germany, contributing to about 11% of the reported landings. In 2020, 100% of the catches were by UK (England, Wales and Northern Ireland).

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.

12.1.3 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.

12.1.4 Regulations and their effects

There is a TAC for sprat in ICES divisions 7.de, English Channel. Up until recent years the TAC did not limit the sprat landings in this area (Figure 12.1.2).

12.1.5 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

Due to current restrictions from the COVID-19 pandemic in the UK, it has not been possible to recover the data collected by the fishers (self-sampling), but will be available at a later date. The length frequencies are not expected to differ substantially from those reported for 2019-2020

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 2020 and the participants in the fishery are keen to continue contributing data and are receptive to improving their sampling scheme and providing useful scientific data in the future. The data shown are raw numbers-at-length in the samples, and not raised to the total catches (Figure 12.2.1 and Figure 12.2.2).

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 12.2.1),. 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 again in 2020 (Figure 12.2.2).

12.3 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.

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.

As part of the 2021 sprat IBP, the ability of the survey to capture the sprat stock (catchability) was evaluated, as this feeds heavily into assumptions of the 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. 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. The survey also provides age and length structure for sprat aged 0-6. 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 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 PELTIC acoustic survey, identified 4 age classes from 0 to 3 contributing on average to 25%, 33%, 36%, and 6% respectively in the samples collected. The age structured observed in 2020 is shown in Figure 12.3.2.

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 acoustic surveys may provide an index of sprat recruitment in divisions 7.d–e. However, further work is required.

12.6 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. I 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 remained a risk <5% in the long term under all fishing histories, 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).

12.6.1 Data exploration

Biomass Index

A 9-year time-series of biomass estimates from the PELTIC survey is shown in Table 12.6.1. Despite being a short time-series, the acoustic survey covers a much wider area compared to the original survey, covering the core area, carried out in partnership with the fishery. A partial estimate of biomass from acoustic data collected by a fishing vessels is normally included in the table, due to COVID-19 this was not possible this year. 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 2020 showed a concentration of 0 age sprat in Lyme bay. This year the survey also covered the area around the Channel Islands (Figure 12.6.1).

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 centered in Lyme bay (2020). 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. For more details on the survey design see ICES 2015/SSGIEOM:05.

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. 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 samples 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 suggest further work is needed. Specifically for fisheries management, it should be noted that genetically connected stocks may still be isolated on a the time scale of fisheries management.

12.7 State of the Stock

The acoustic estimates for 2017 (32 751t) show a three-time increase compared to the all-time low value in 2016 (9826 t), although the biomass is still half of the high levels recorded in the period 2013–2015 (70 680 t, 85 184 t and 65 219 t respectively). The PELTIC biomass has decreased to 33 798 tonnes in 2020 from 36 789 tonnes in 2019. The harvest rate has dropped from 4% to 2%. This is due low catches in 2020 which are attributed to the COVID-19 pandemic limiting fishing opportunities.

12.8 CATCH ADVICE

Applying the constant harvest rate of 8.57% to the current estimate of PELTIC biomass gives an advised catch of 2897 tonnes.

12.9 Short-term projections

No projections are presented for this stock.

12.10 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.

12.11 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.

The extent to which the population migrate 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 was 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.

12.12 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 2570 tonnes on average. The average harvest rate for the 9 year time-series is 9%, however if the 2016 value of 34% is removed this drop to 6% over the entire time-series. The average harvest rate is 6% 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 and that the reduced sprat biomass is not due to fishing mortality, but it is most likely caused by environmental factors.

The timing of the advice relative to the PELTIC survey should also be considered, currently the survey runs 1 year prior to the generation of the advice which is implemented 1 year later. This is a 2-year time-lag from data collection to advice and has been identified as a weakness in the advice especially for sprat which only live 3-4 years. The move to a CHR has improved the responsiveness of the advice, however the time lag between survey and advice remains an issue.

12.13 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 12.1.1 Sprat in 7.d-e. Landings of sprat, 1986–2020.

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1986	15	0	0	1 163	0	0	1 178
1987	250	23	0	2 441	0	0	2 714
1988	2 529	2	1	2 944	0	0	5 476
1989	2 092	10	0	1 520	0	0	3 622
1990	608	79	0	1 562	0	0	2 249
1991	0	0	0	2 567	0	0	2 567
1992	5 389	35	0	1 791	0	0	7 215
1993	0	3	0	1 798	0	0	1 801
1994	3 572	1	0	3 176	40	0	6 789
1995	2 084	0	0	1 516	0	0	3 600
1996	0	2	0	1 789	0	0	1 791
1997	1 245	1	0	1 621	0	0	2 867
1998	3 741	0	0	1 973	0	0	5 714
1999	3 064	0	1	3 558	0	0	6 623
2000	0	1	1	1 693	0	0	1 695
2001	0	0	0	1 349	0	0	1 349
2002	0	0	0	1 196	0	0	1 196
2003	0	2	72	1 368	0	0	1 442
2004	0	6	0	836	0	0	842
2005	0	0	0	1 635	0	0	1 635
2006	0	7	0	1 969	0	0	1 976
2007	0	0	0	2 706	0	0	2 706
2008	0	0	0	3 367	0	0	3 367
2009	0	2	0	2 773	0	0	2 775
2010	0	2	0	4 408	0	0	4 410
2011	0	1	37	3 138	0	0	3 176
2012	6	2	8	4 458	0	0	4 474

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	0	3 793	0	0	3 793
2014	45	0	275	3 338	0	0	3 658
2015	0	1	352	2 659	0	0	3 012
2016	185	7	231	2 867	0	49	3 339
2017	0	0	235	2 498	0	0	2 733
2018	474	1	0	1 776	0	0	2 252
2019	0	0.67	0	1544	0	28	1573
2020	0	0	0	873	0	0	873

Table 12.6.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas annual pelagic acoustic sur- vey and partial acoustic survey of Lyme bay from fishing vessel.).

Survey	Area	Season	2013	2014	2015	2016	2017	2018	2019	2020
Partial	Lyme Bay	Oct	62 040	67 538	12 212	6 181	29 996	16 036	30 406	
PELTIC	W Eng Ch	Oct	70 680	85 184	65 219	9 826	32 751	21 772	36 789	33 798

*** ICES rectangles 29E6, 30E6**

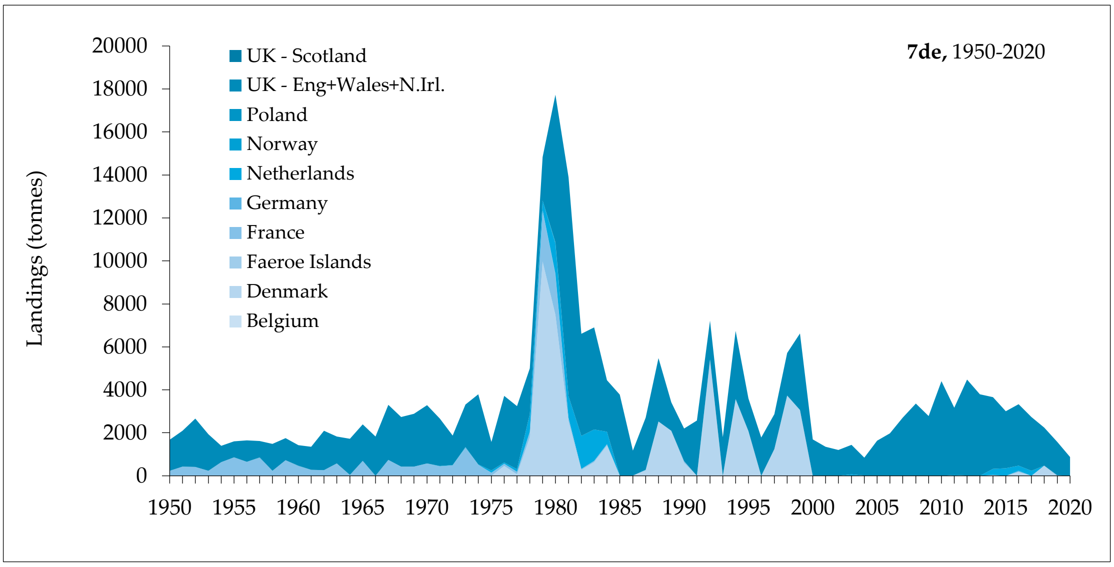


Figure 12.1.1. Sprat in 7.d-e. Landings of sprat 1950–2020.

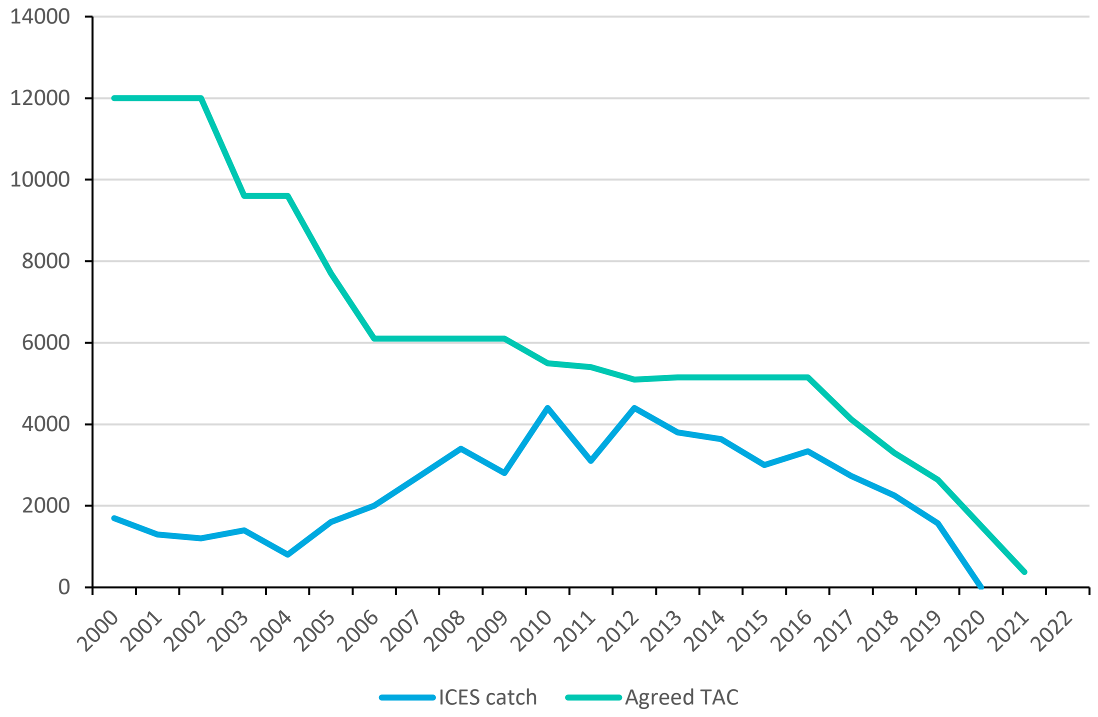


Figure 12.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2021.

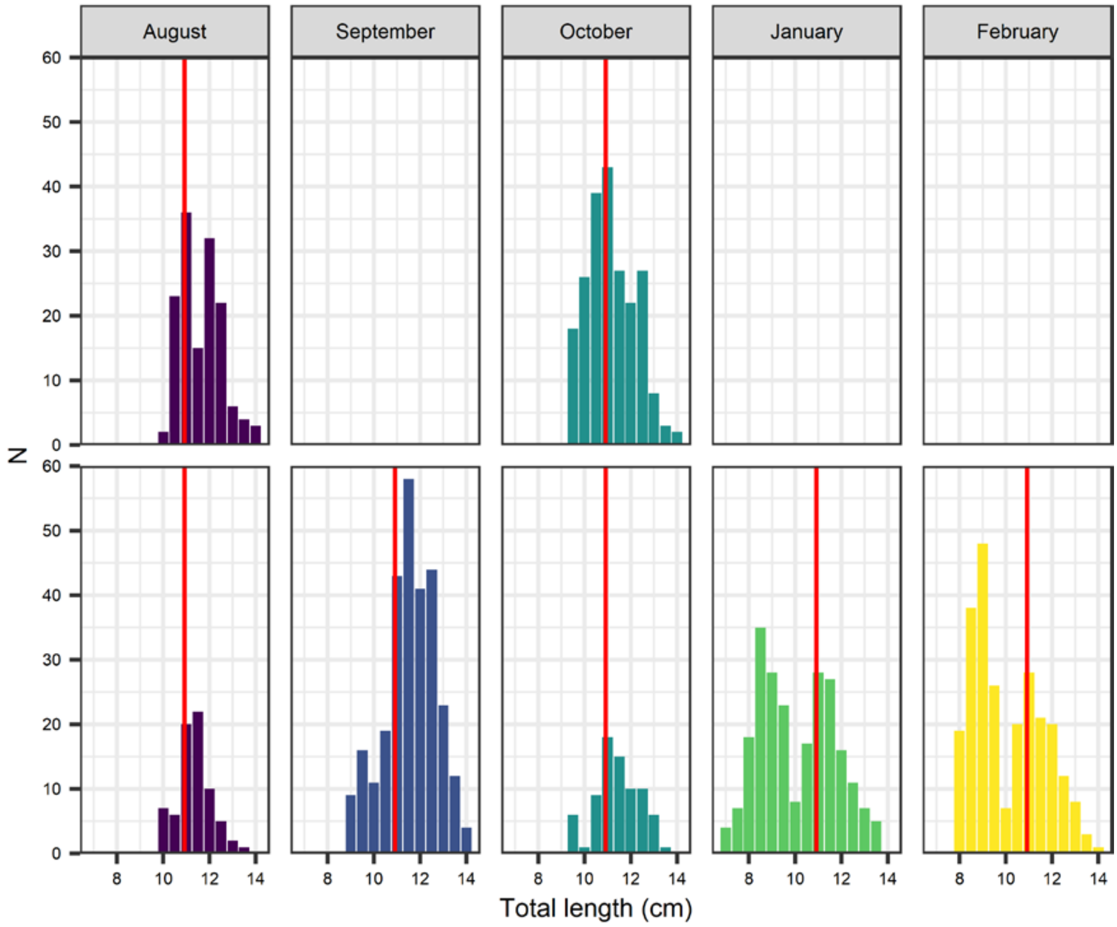


Figure 12.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month 2019–2020.

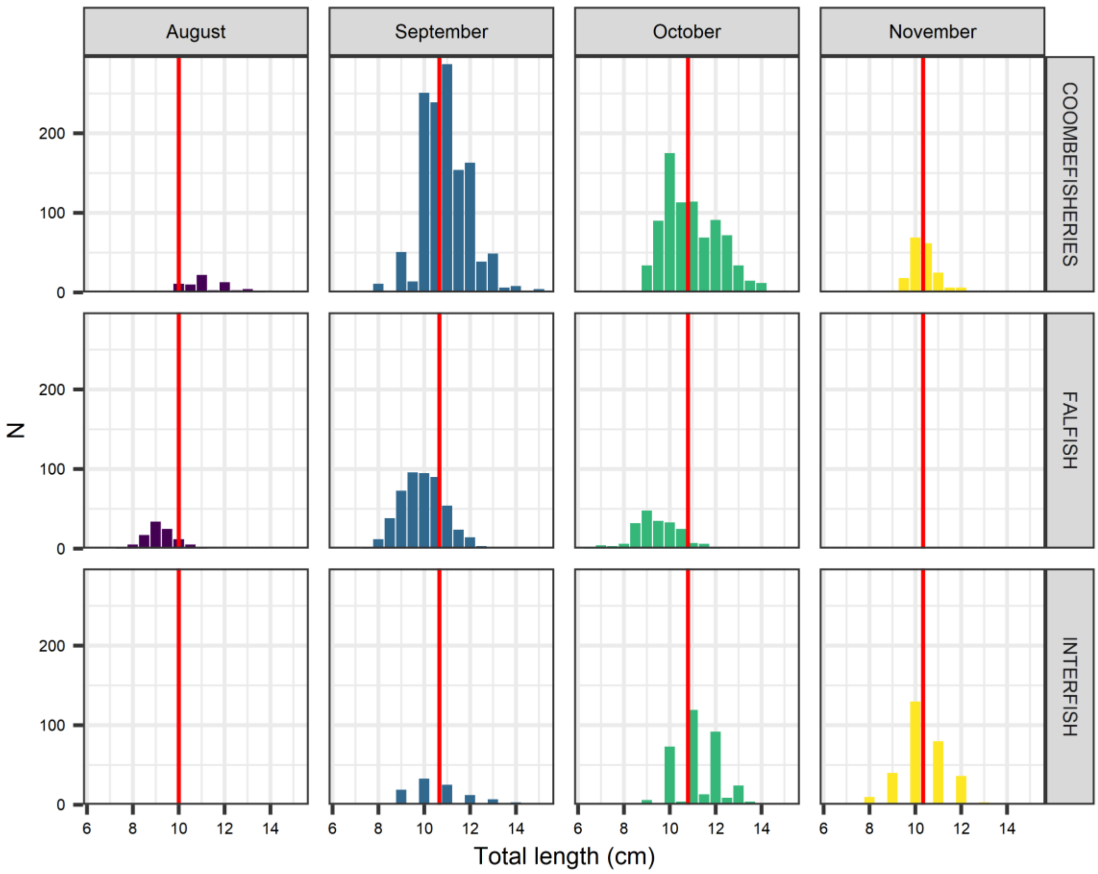


Figure 12.2.2. Monthly collected sprat total length distribution by all processors (3) in season 2019-2020. Red line indicates weighted mean length at each month.

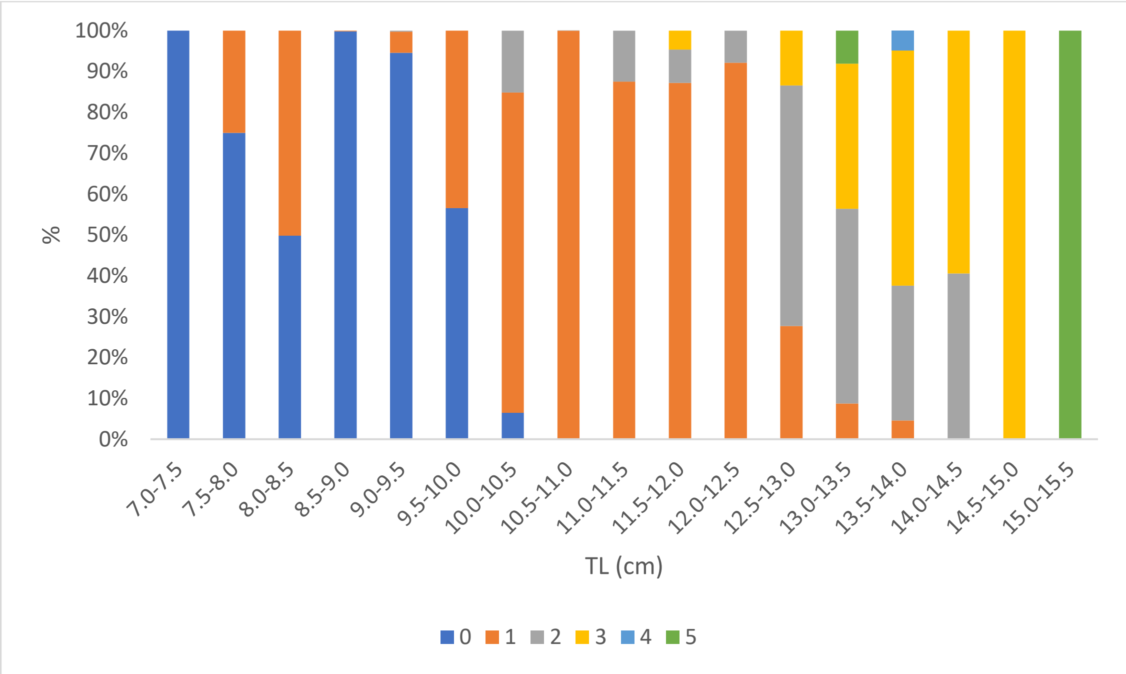


Figure 12.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2020 PELTIC acoustic survey.

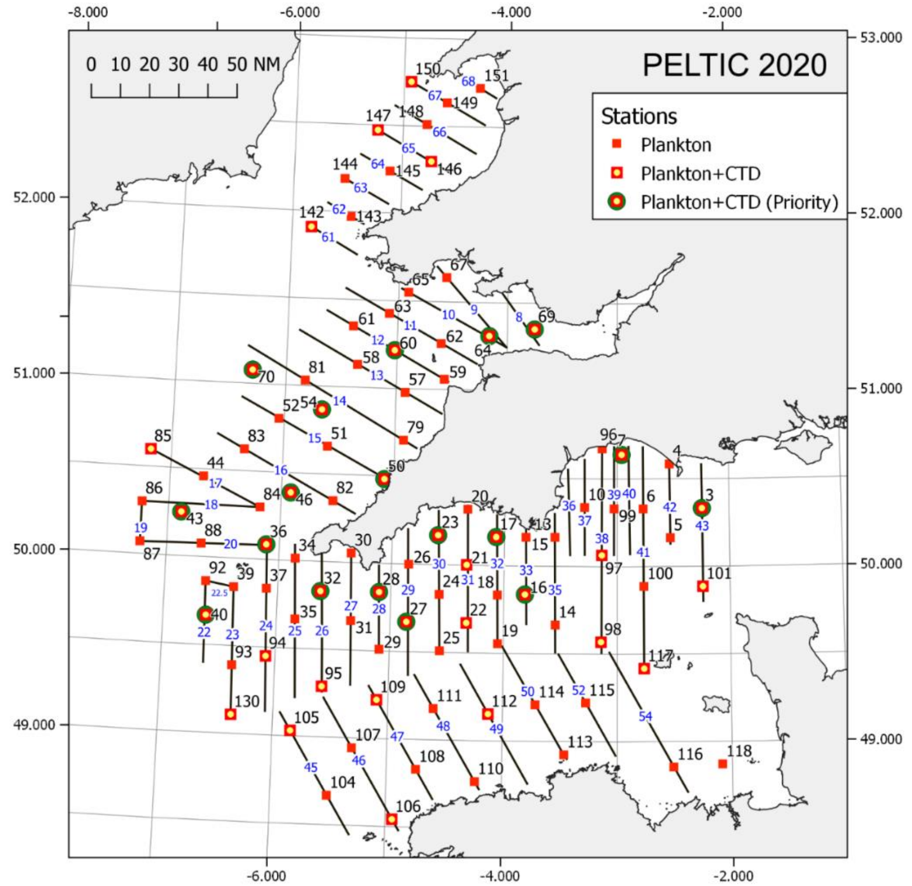


Figure 12.3.1. Sprat in 7.d–e. Survey design (2020) with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

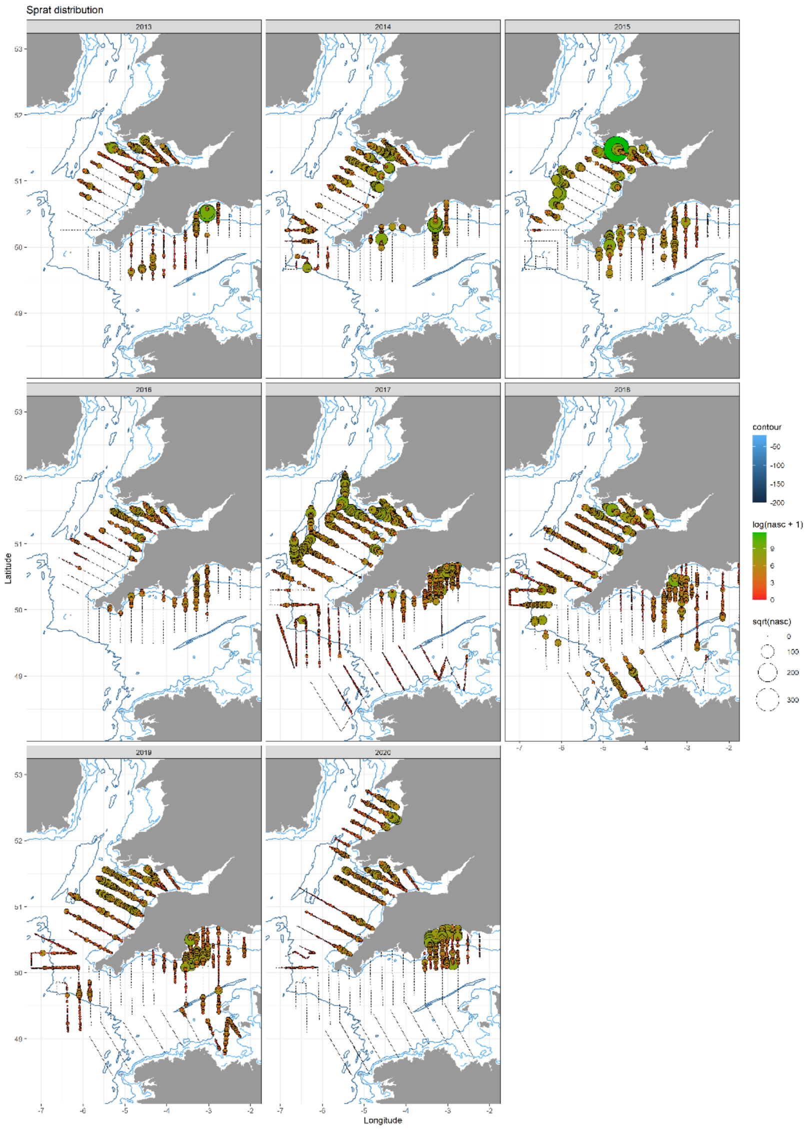


Figure 12.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October from the 2013-2020 PELTIC surveys.

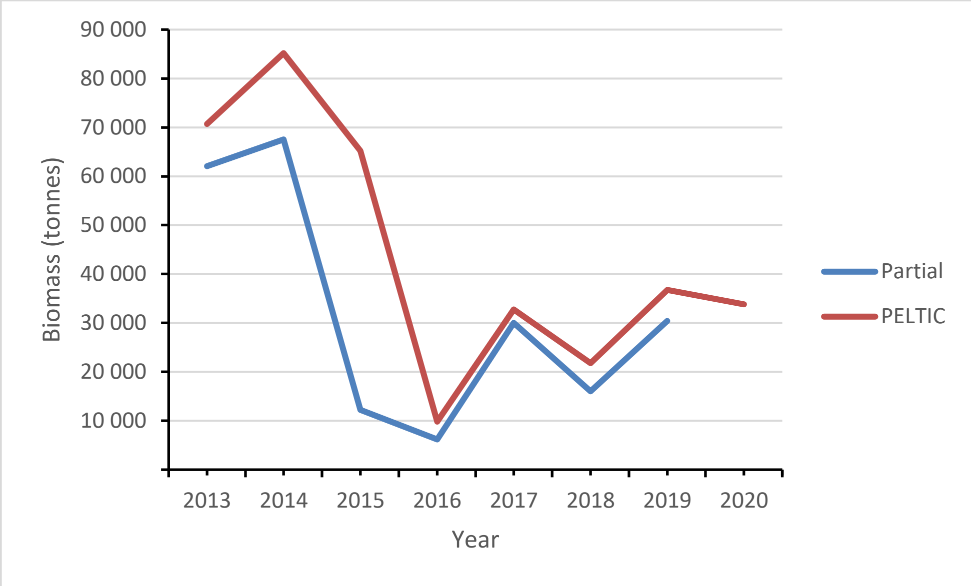


Figure 12.6.2. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2020 for Division 7.e (red line) and the Lyme Bay area (blue line).

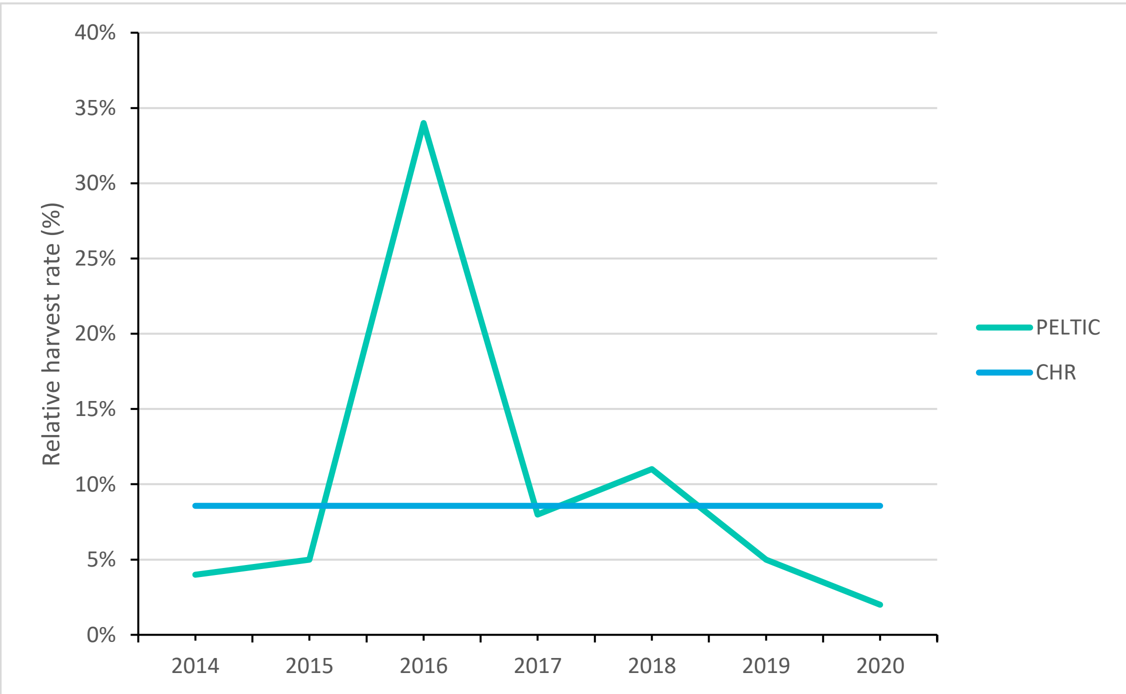


Figure 12.7.1. Sprat in 7.d-e. Constant Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

12.14 References

Doray, M., Boyra, G., and van der Kooij, J. (Eds.). 2021. ICES Survey Protocols – Manual for acoustic surveys coordinated under the ICES Working Group on Acoustic and Egg Surveys for Small Pelagic Fish (WGACEGG). 1st Edition. ICES Techniques in Marine Environmental Sciences Vol. 64. 100 pp. https://doi. org/10.17895/ices.pub.7462

ICES. 2021. Inter-benchmark to revise the advice framework for the Sprat stock in 7.de based on the most recent changes to data-limited short-lived species assessments (IBPSprat). ICES Scientific Reports. 3:23. 42 pp. https://doi.org/10.17895/ices.pub.7918

McKeown, N. J, Carpi, P., Silva, J. F, Healey, A. J E, Shaw, P. W, and van der Kooij, J. Genetic population structure and tools for the management of European sprat (*Sprattus sprattus*). – ICES Journal of Marine Science, doi:10.1093/icesjms/fsaa113.

13 Sprat in the Celtic Seas (subarea 6 and divisions 7 a-c and 7f-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 13.1.

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.

13.1 The Fishery

13.1.1 ICES advice applicable for 2022 and 2023

ICES analyzed 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 2240t 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.

13.1.2 Landings

The total sprat landings, by ICES Subdivision (where available) are provided in tables 13.1.1–13.1.7, with the total landings in table 13.1.8, and in figures 13.2.1–13.2.8. Only Ireland and the United Kingdom landed from the stock in 2020, with Ireland taking the majority of the landings (table 13.1.8).

13.1.3 Division 6.a (West of Scotland and Northwest of Ireland)

Landings have been dominated by UK-Scotland and Ireland (Table 13.1.1). 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 13.2.1). 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 have 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.

13.1.4 Division 7.a

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea. This was an industrial fishery and landings were high throughout the 1970s, peaking at over 8000 t in 1978 (figures for 7.aN are presented in Table 13.1.2 and 7.aS presented in Table 13.1.3). 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 13.1.3) 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 13.1.3)

No landings from 7.aN were reported by Ireland in 2009–2013 or 2018 (Table 13.1.2), 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.

13.1.5 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 13.1.4, Figure 13.2.4). 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. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

13.1.6 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 13.1.7). 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 data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

13.1.7 Fleets

Most sprat in the Celtic Seas Ecoregion are caught by small pelagic vessels that also target herring, mainly Irish, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as other small pelagics. Targeted fishing takes place when there are known sprat abundances. However, the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery around Ireland.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown, but based on a limited number of samples available to the working group this is estimated to be less than 1% of the catch.

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type between two and four vessels under 15 m have actively target sprat and have been responsible for the majority of landings (since 2003 they took on average 96% of the total landings). In the most recent year only three of the vessels have been targeting sprat. Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

In Ireland, larger sprats are sold for human consumption while smaller ones for fishmeal. Other countries mainly land catches for industrial purposes.

13.1.8 Regulations and their effects

There is a TAC for sprat for 7.d–e, English Channel. No other TACs or quotas for sprat exist in this ecoregion. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fishmeal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

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.

13.1.9 Changes in fishing technology and fishing patterns

There is insufficient information available.

13.2 Biological Composition of the Catch

13.2.1 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.

13.2.2 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.

13.3 Fishery-independent information

13.3.1 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 13.3.1 and Table 13.3.1. 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 13.3.1**)**. 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).

13.3.2 Scottish Acoustic Surveys (A9481)

A Clyde herring and sprat acoustic survey was carried out in June/July 1985–1990 and then discontinued (Figure 13.3.2 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 13.3.3. In 2013 the survey was cancelled due to technical problems but has been continued up to 2018.

13.3.3 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 13.3.2). 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).

13.3.4 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.

13.3.5 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 13.3.4 and Table 13.3.2. 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 13.3.5. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

13.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

13.5 Recruitment

The various groundfish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

13.6 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).

13.7 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).

13.8 Short-term projections

No projections are presented for this stock.

13.9 Reference Points

No precautionary reference points are defined for sprat populations in the region

13.10 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.

13.11 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.

13.12 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 13.1.1 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2020, 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

Table 13.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2020 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
2001	0	0	269	3	272

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
2002	0	0	306	0	306

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
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

Table 13.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2020 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

Table 13.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2020, 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
2002	11

Country	Ireland
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

Table 13.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2020, 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

Table 13.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2020, divisions 7.g–k. Irish data may be un- deres-timated 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
2001	0	0	306	0	0	0	306

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
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

Table 13.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2020 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

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
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
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

Country	Denmark	Faroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Total
2019	0	1	0	13018	0	3	0	0	66	1265	14353
2020	0	0	0	14446	0	0	0	0	3	724	15173

Table 13.3.1. 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
2012	35114
2013	44685
2014	54826
2015	83779
2016	42694
2017	70745
2018	47806
2019	60608

Year	Biomass (t)
2020	4523

Table 13.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.a (Source: AFBI annual her- ring acoustic survey).

	Sprat & 0-group herring			Sprat
Year	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
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

Sprat & 0-group herring	Sprat
2018	219 000
2019	146 000
2020	117 000

Figure 13.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

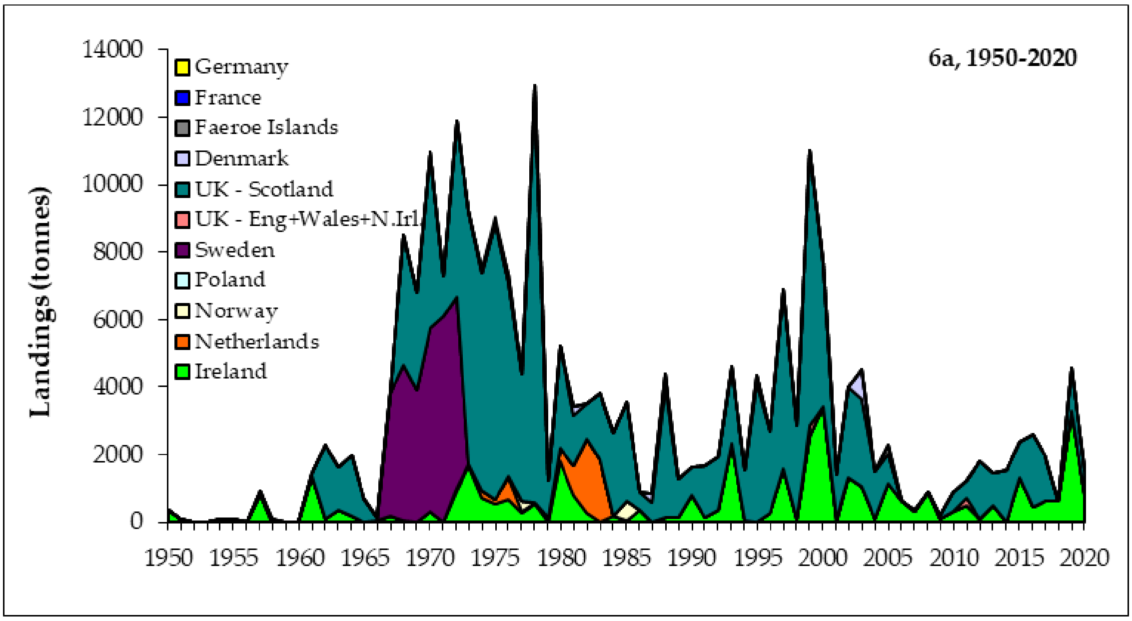


Figure 13.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2020 ICES Division 6.a.

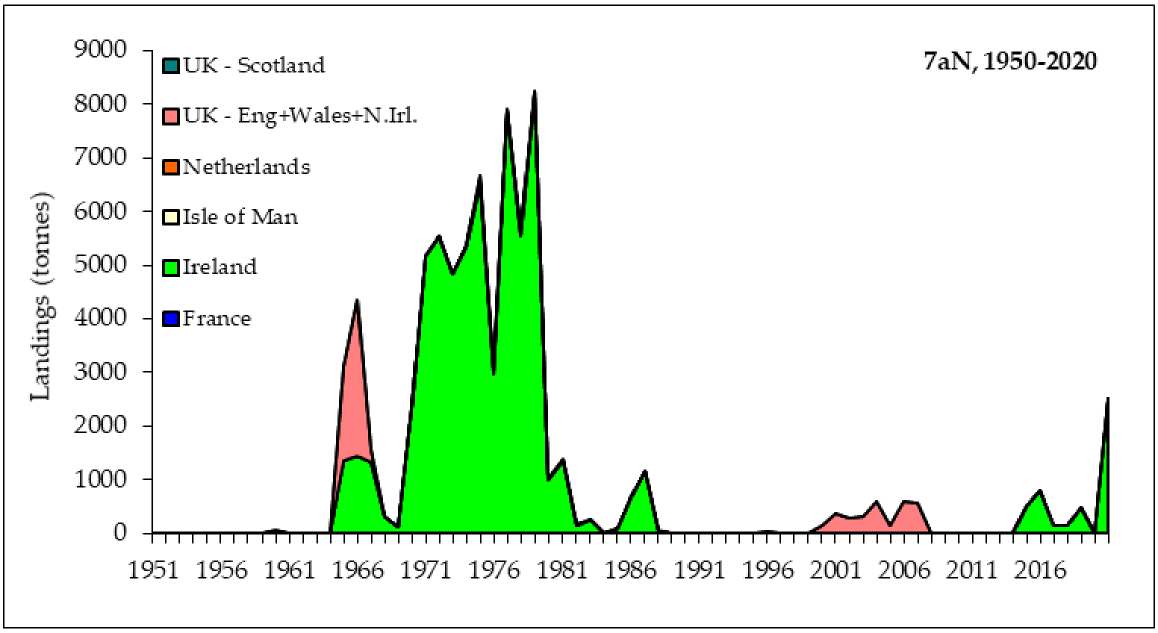


Figure 13.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

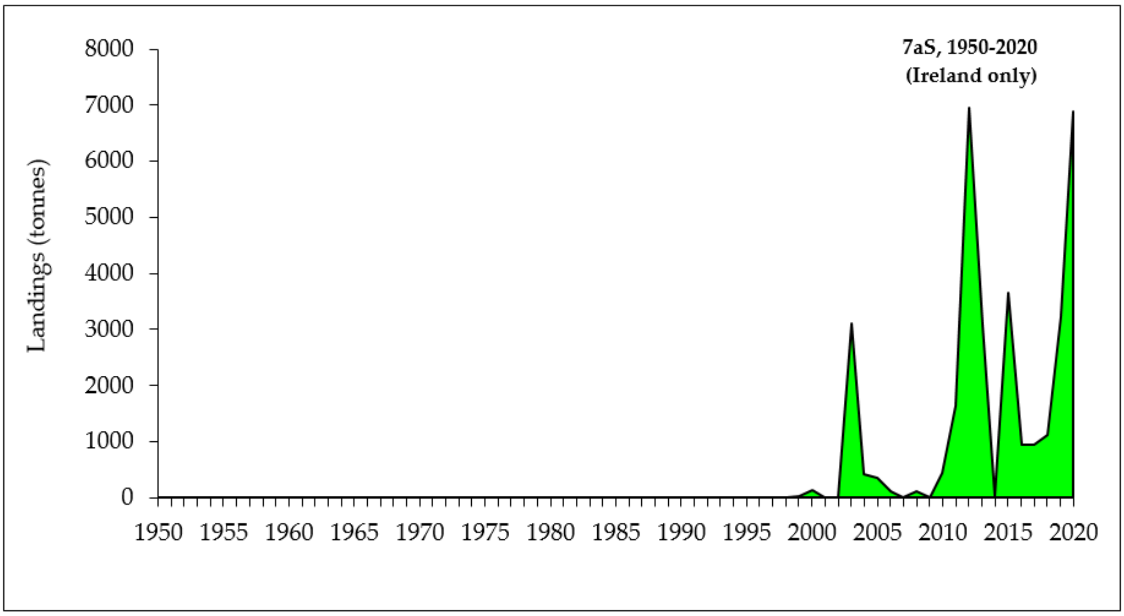


Figure 13.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 7.aS.

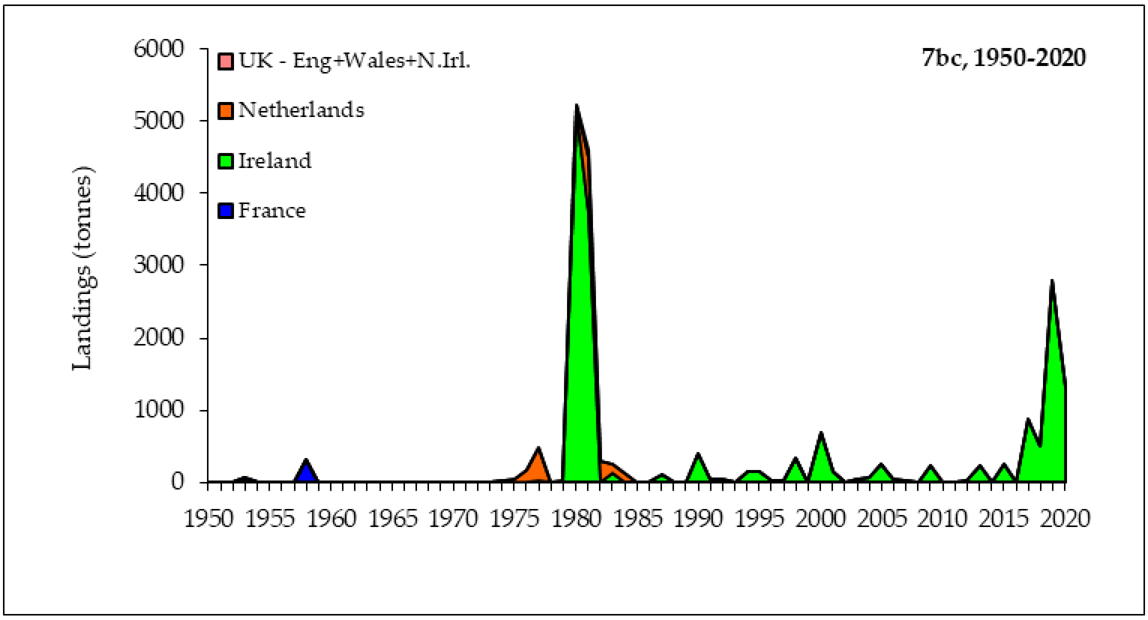


Figure 13.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2020 ICES divisions 7.b–c.

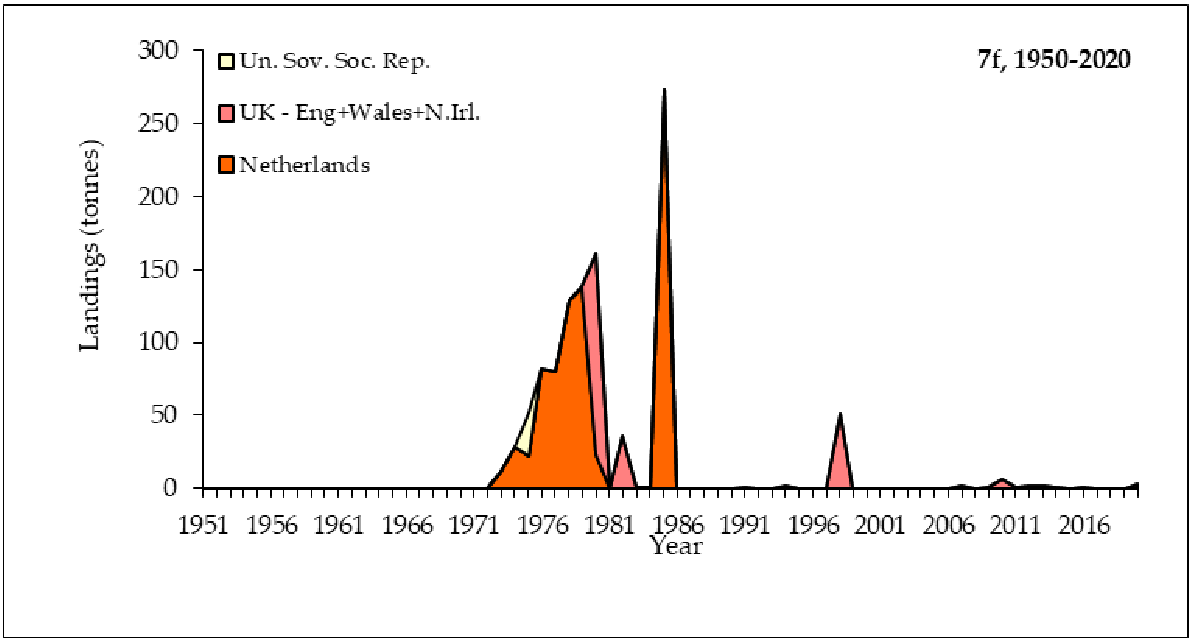


Figure 13.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2020 ICES Division 7.f.

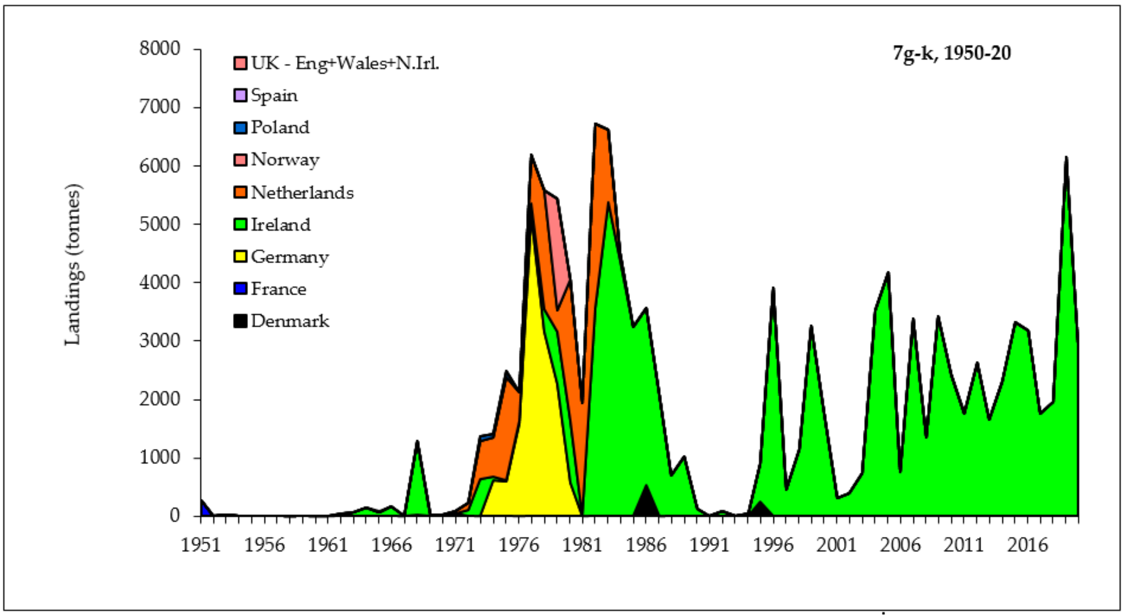


Figure 13.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2020 ICES divisions 7.g–k.

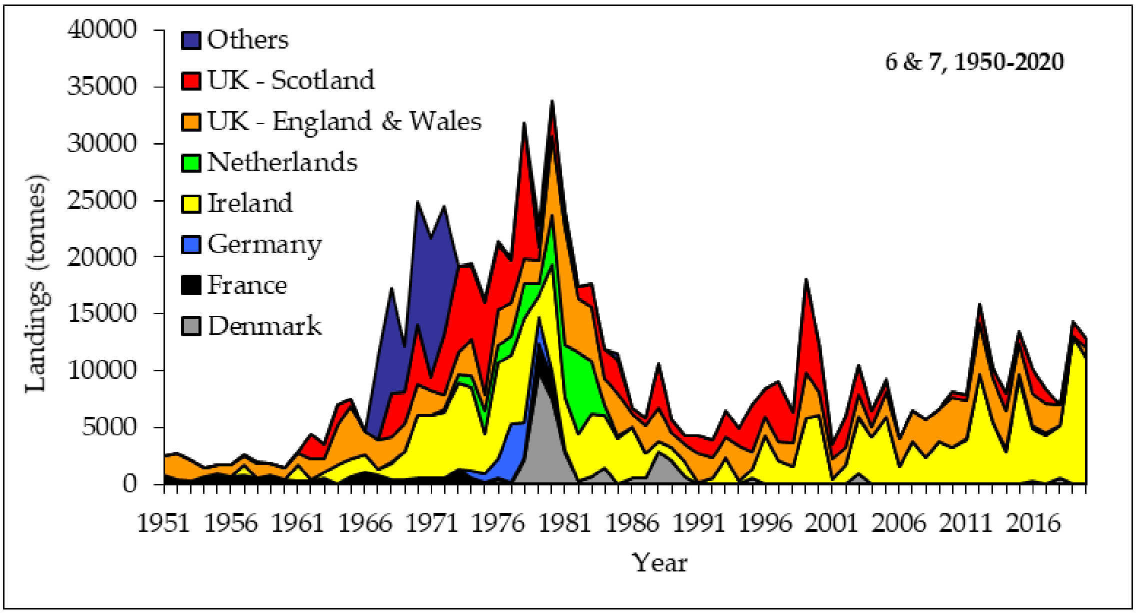


Figure 13.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2020 ICES subareas 6 and 7 (Celtic Seas Ecoregion).

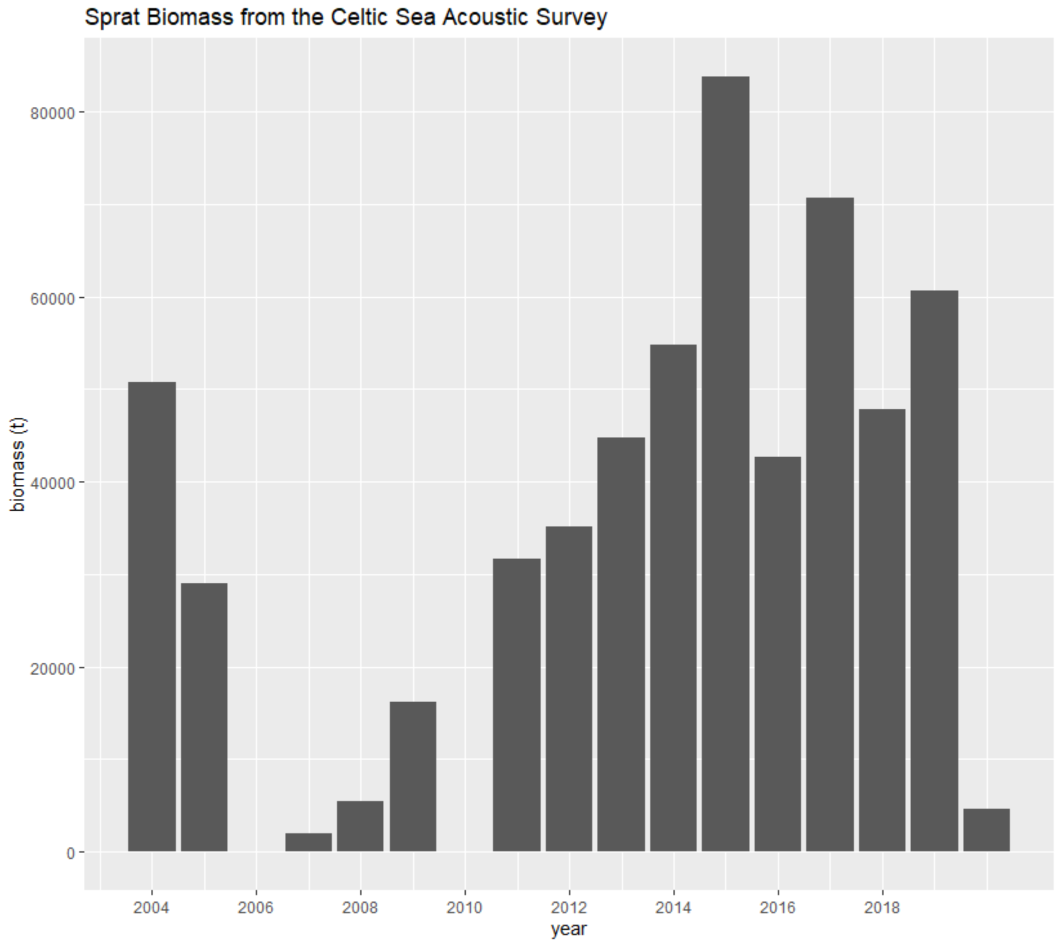


Figure 13.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass from the MI Celtic Sea Herring Acoustic Survey 2004-2020 (A4705).

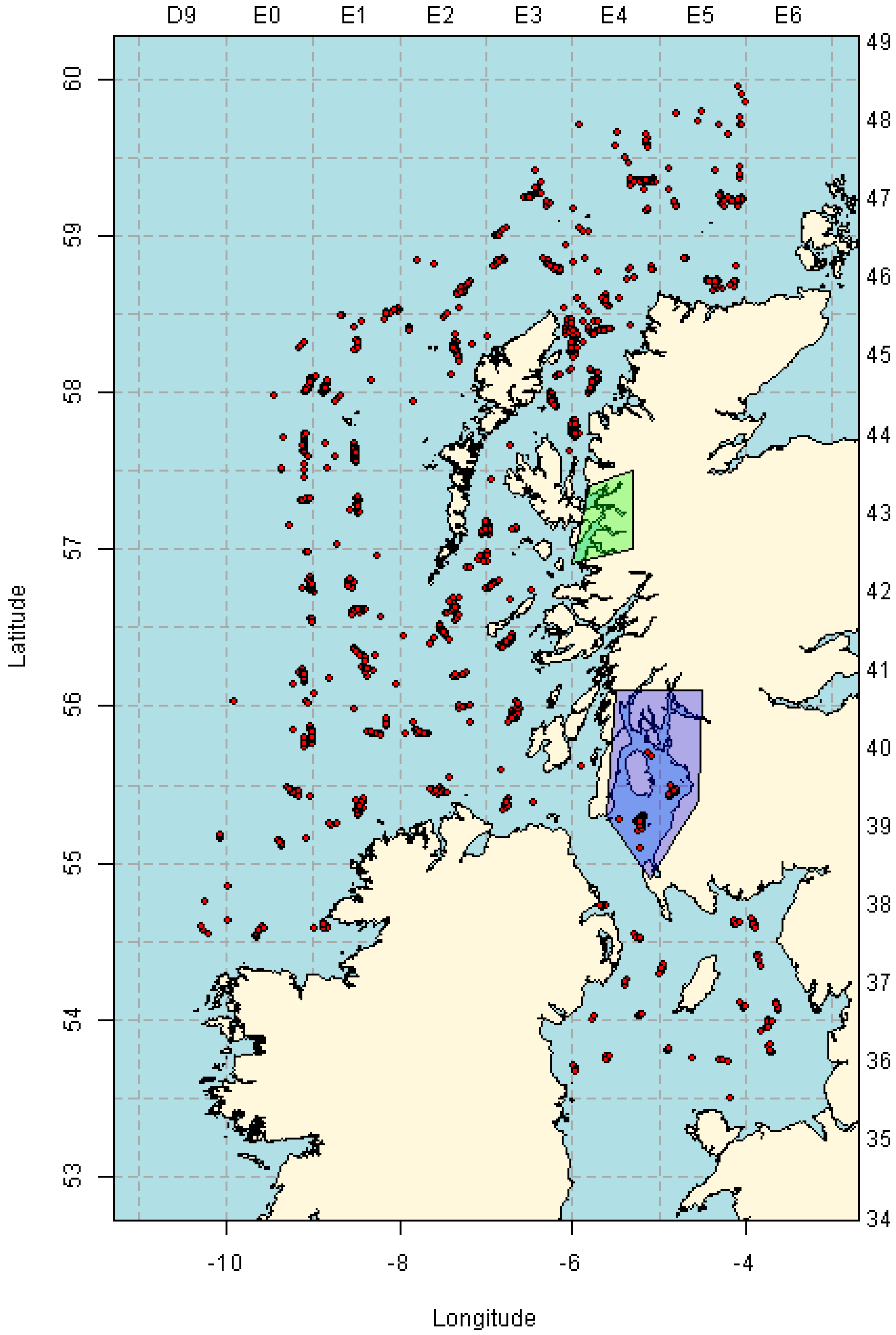


Figure 13.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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).

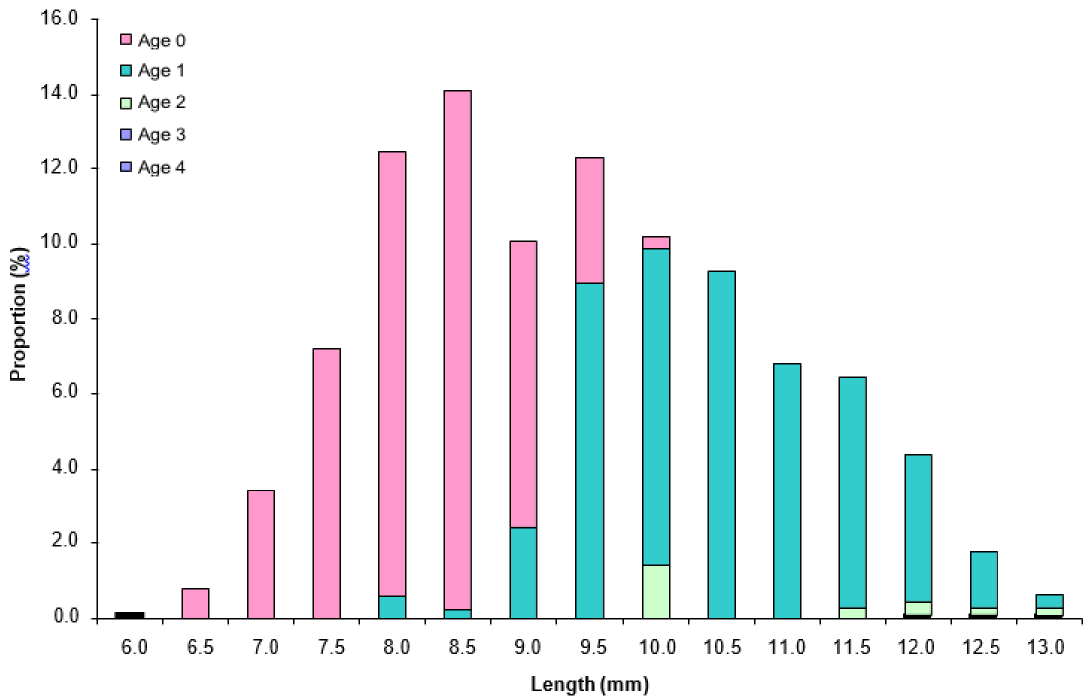


Figure 13.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged (G7144).

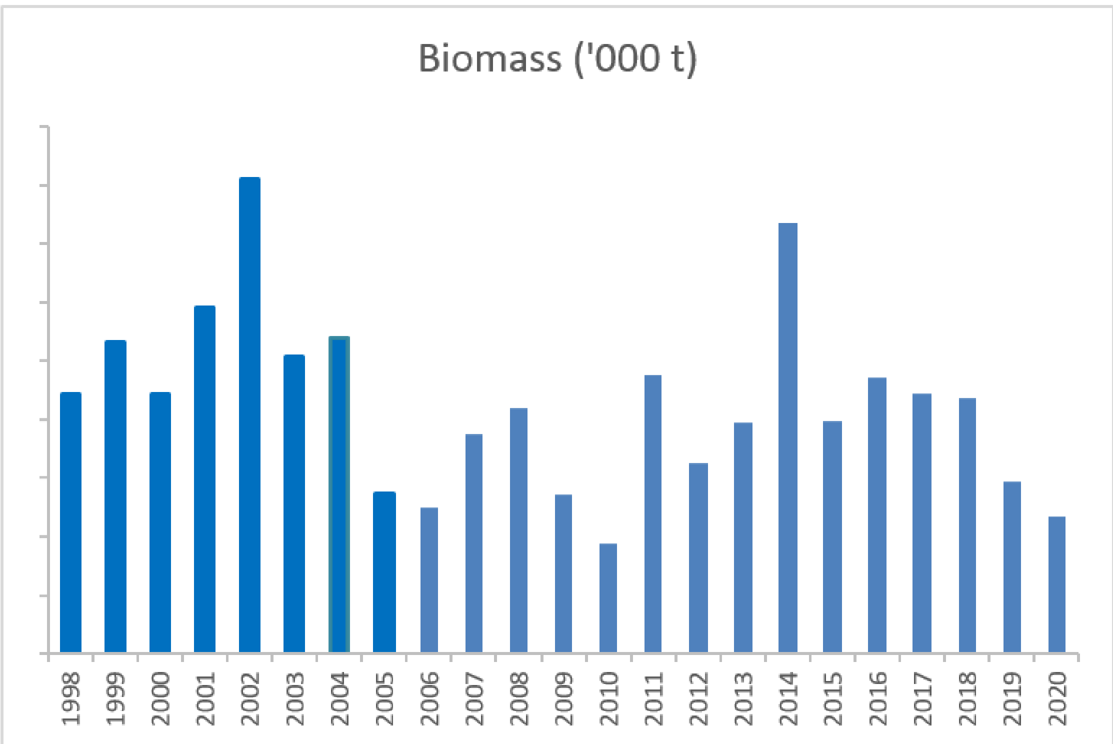


Figure 13.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN from the AFBI Acoustic Survey (A4075)

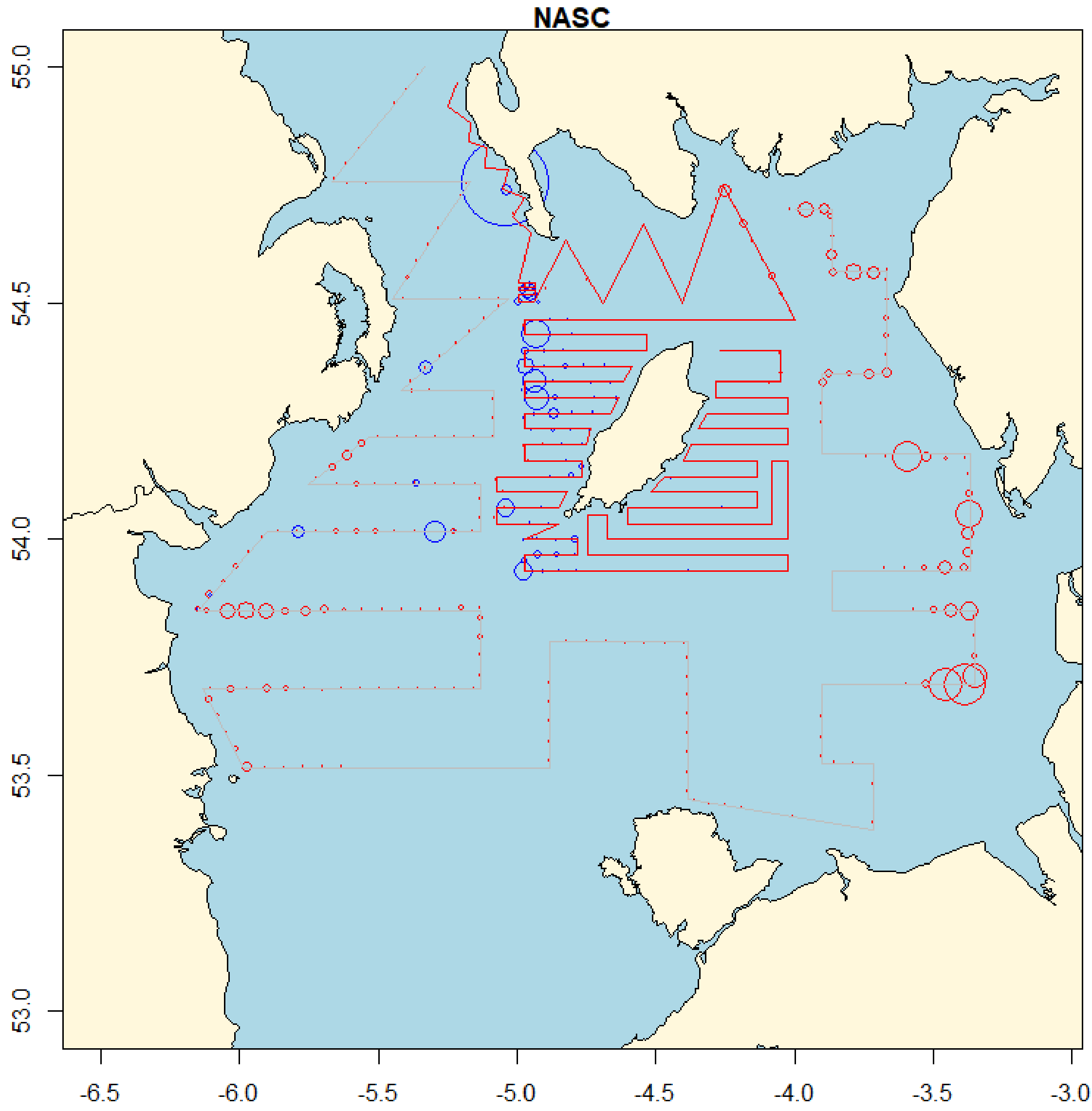


Figure 13.3.5. Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2020 acoustic survey on RV “Corystes”. (a) Open blue circles are for herring NASC 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).

14 References

Adams, D. C. and Otárola-Castillo, E. 2013. geomorph: an R package for the collection and analysis of geometric morphometric shape data. Methods in Ecology and Evolution, 4(4): 393-399.

Alexander, Karen A.; Heymans, Johanna J.; Magill, Shona; Tomczak, Maciej T.; Holmes, Steven J.; Wilding, Thomas A. 2015. Investigating the recent decline in gadoid stocks in the west of Scotland shelf ecosystem using a foodweb model. ICES JOURNAL OF MARINE SCIENCE, Vol. 72, No. 2, 2015, p. 436-449.

Anon. 2013. UK National Data Collection Programmes under Council Regulation (EC) 199/2008, Commission Regulation (EC) 665/2008 and Commission Decision 2010/93/EU for the Collection, Management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy in 2011, 2012 and 2013.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/341475/2011-2013national.pdf

Beggs, S. 2007. Stock Identification of 0-group Herring in the Irish Sea (VIIaN): Otolith microstructure and shape. Working Document to ICES HAWG.

Beggs, S., -Jan Schon, P.-J.,McCurdy, W., Peel, J., McCorriston, P. and McCausland, I. 2008. Seasonal Origin of Irish Sea Herring. Working Document to ICES HAWG 2008. Bowers, A. 1964. 0-group herring in the North Irish Sea. Seasonal Report of the Marine Biological Station Port Erin, 77: 34–42.

Berg, Casper W., Nielsen, Anders and Kristensen, Kasper. 2014. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. Fisheries Research, 151: 91-99.

Berg, F., Almeland, O. W., Skadal, J., Slotte, A., Andersson, L., Folkvord, A. 2018. Genetic factors have a major effect on growth, number of vertebrae and otolith shape in Atlantic herring (*Clupea harengus*). PLoS ONE, 13: e0190995.

Berg, F., Lusseau, S. M., Bartolino, V., Gröhsler, T., Kvamme, C., Nash, R. D. M., Slotte, A. 2019. Using otolith shape analysis and machine learning techniques to discriminate between stocks of Atlantic herring. ICES CM 2019/C:427.

Berg, F., Østgaard, H.D., Slotte, A., Andersson, L., and Folkvord, A. 2020. A combination of genetic and phenotypic characterization of spring- and autumn-spawning herring suggests gene flow between populations. ICES Journal of Marine Science. doi: 10.1093/icesjms/fsaa046.

Berg, F., Seljestad, G., Bekkevold, D., Kvamme, C., Dahle, G., Glover, K. 2021. Stock splitting to estimate individual survey estimates for herring stocks occurring during the HERAS survey – Genetics as new method." In Report of the Working Group of International Pelagic Surveys (WGIPS), 11-15 January 2021

Bergström, U., Olsson, J., Casini, M., Eriksson B.K., Fredriksson R., Wennhage H., Appelberg M. (2015). Stickleback increase in the Baltic Sea - A thorny issue for coastal predatory fish. Estuarine, Coastal and Shelf Science. 163:134 – 142.

Burke, N., Brophy, D., and King, P. A. 2008. Otolith shape analysis: its application for discriminating between stocks of Irish Sea and Celtic Sea herring (Clupea harengus) in the Irish Sea. – ICES Journal of Marine Science, 65: 1670–1675.

Burke, N., Brophy, D., Schön, P-J., and King, P. A. 2009. Temporal trends in stock origin and abundance of juvenile herring (Clupea harengus) in the Irish Sea. ICES Journal of Marine Science, 66: 1749–1753.

Cardinale, M., Möllmann, C., Bartolino, V., Casini, M., Kornilovs, G., Raid, T., Margonski, P., Grzyb, A., Raitaniemi, J., Gröhsler, T., Flinkman, J. (2009). Effect of environmental variability and spawner characteristics on the recruitment of Baltic herring *Clupea harengus* populations. Marine Ecology Progress Series, 388, 221-234.

Chen, K.-Y., Marschall, E.A., Sovic, M.G., Fries, A.C., Gibbs, H.L., Ludsin, S.A. 2018. assignPOP: An r package for population assignment using genetic, non-genetic, or integrated data in a machine-learning framework. Methods in Ecology and Evolution 9: 439-446.

Clarke, M., and Egan, A. 2012. Evaluation of proposed long-term management plan for Celtic Sea Herring.

ICES CM 2012/ACOM:75. 48 pp.

Clarke, M., and Egan, A. 2017. "Good luck or good governance? The recovery of Celtic Sea herring." *Marine Policy* 78 (2017): 163-170.

Darby, C. D., & Flatman, S. 1994. Lowestoft VPA Suite Version 3.1 User Guide. *MAFF: Lowestoft*.

Dodson, J.J., Daigle, G., Hammer, C., Polte, P., Kotterba, P., Winkler, G., Zimmermann, C. (2019). Environmental determinants of larval herring (Clupea harengus) abundance and distribution in the western Baltic Sea. Limnology and Oceanography, Limnology and Oceanography 64, 2019, 317–329

EU 2016/0203 (NLE). Proposal for a COUNCIL REGULATION amending Regulations (EU) 2016/72 and (EU) 2015/2072 as regards certain fishing opportunities.

EU 2017/127. COUNCIL REGULATION (EU) 2017/127 of 20 January 2017 fixing for 2017 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0127

Farrell, E.D., Campbell, N., Carlsson, J., Egan, A., Gras, M., Lusseau S.M., Nolan, C., O'Connell, S., O'Malley, M., White, E. 2021. 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. Final Report. European Commission. Service Contract EASME/EMFF/2017/1.3.2.1/SI2.767459. 251 pp.

Gröger, J.P., Hinrichsen, H.-H., Polte, P. (2014). Broad-scale climate influences on spring-spawning herring (Clupea harengus L.) recruitment in the western Baltic Sea. PLoS One 9, e87525, Doi:10.1371/journal.pone.0087525.

Gröhsler T, Oeberst R, Schaber M, Larson N, Kornilovs G (2013) Discrimination of western Baltic spring-spawning and central Baltic herring (Clupea harengus L.) based on growth vs. natural tag information. ICES J Mar Sci 70(6):1108-1117, doi:19.1093/icesjms/fst064.

EU 2018/120. COUNCIL REGULATION of 23 January 2018 fixing for 2018 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters, and amending Regulation (EU) 2017/127. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0120&from=EN

EU 2019/124. COUNCIL REGULATION of 30 January 2019 fixing for 2019 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters, and amending Regulation (EU) 2017/127 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0124&from=EN

Fernández, A.C. and Prista, N. 2012. Portuguese discard data on anglershouthern*Lophiuspiscatorius* and blackbellied angler *Lophiusbudegassa* (2004-2010). Working document-07 presented at WKFLAT2012. ICES CM: ACOM: 46.

Han, F., Jamsandekar, M., Pettersson, M. E., Su, L., Fuentes-Pardo, A., Davis, B., Bekkevold, D., Berg, F., Casini, M., Dahle, G., Farrell, E. D., Folkvord, A., Andersson, L. 2020. Ecological adaptation in Atlantic herring is associated with large shifts in allele frequencies at hundreds of loci. eLife, 9: e61076.

Harma, C., Brophy, D., Minto, C., and Clarke, M. 2012. The rise and fall of autumn-spawning herring (Clupea harengus L.) in the Celtic Sea between 1959 and 2009: Temporal trends in spawning component diversity. Fisheries Research 121– 122: 31– 42.

Hintzen, N. T., Roel, B., Benden, D., Clarke, M., Egan, A., Nash, R. D. M., Rohlf, N., and Hatfield, E. M. C. 2015.Managing a complex population structure: exploring the importance of information from fisheries-independent sources. – ICES Journal of Marine Science, 72: 528–542.

ICES, 1994. Report of the Study Group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. ICES C.M.1994/H:5. 67 pp.

ICES. 2006. Report of the Herring Assessment Working Group South of 620 N (HAWG), 14–23 March, ICES Headquarters. ICES CM 2006/ACFM:20. 647 pp.

ICES 2007. Report of the Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2007/ACFM:11, 340 pp.

ICES. 2008. Report of the Herring Assessment Working Group South of 62 N (HAWG), 11-19 March 2008, ICES Headquarters, Copenhagen. ICES CM 2008/ACOM:02. 601 pp.

ICES. 2010. Report of the Herring Assessment Working Group for the Area South of 62n (HAWG), 15 - 23 March 2010, ICES Headquarters, Copenhagen, Denmark. 688 pp.

ICES, 2012a. Report of the Anglerfish (*Lophiuspiscatorius*) *illicia* and otoliths exchange 2011. 61 pp.

ICES. 2012b. Report of the Benchmark Workshop on the Flatfish Species and Anglerfish (WKFLAT), 1–8 March 2012, Bilbao, Spain. ICES CM 2012/ACOM:46.

ICES. 2013. Report of the Benchmark Workshop on Sprat Stocks (WKSPRAT), 11–15 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:48. 220 pp

ICES. 2013. Report of the Benchmark Workshop on Sprat Stocks (WKSPRAT), 11–15 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:48. 220 pp

ICES. 2014a. Interim Report of the Working Group on Multispecies Assessment Methods (WGSAM), 20–24 October 2014, London, UK. ICES CM 2014/SSGSUE:11. 104 pp.

ICES. 2014b. Report of the Workshop to consider reference points for all stocks (WKMSYREF2), 8-10 January 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:47. 91 pp.

ICES. 2015b. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG), 10–19 March 2015, ICES HQ, Copenhagen, Denmark. ICES CM 2015/ACOM:06. 864 pp.

ICES. 2016. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 9–13 November 2016, Woods Hole, USA. ICES CM 2016/SSGEPI:20. 206 pp.

ICES 2016a. General context of ICES advice. In Report of the ICES Advisory Committee, 2016. ICES Advice 2016, Book 1, Section 1.2.

ICES. 2016b. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58.

ICES 2016b. Greater North Sea Ecoregion – Ecosystem overview. In Report of the ICES Advisory Committee 2016. ICES Advice, 2016. Book 6. Section 6.1.

ICES 2016. Report of the Working Group on Integrated Assessments of the North Sea (WGINOSE). ICES CM 2016/SSGIEA:06.

ICES. 2016. Report of the Workshop on Blue Whiting (Micromesistius poutassou) Long Term Management Strategy Evaluation (WKBWMS), 30 August 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:53. 104 pp.

ICES 2016a. EU request for advice on a scientific monitoring fishery for herring in ICES divisions 6.a, 7.b, and 7.c. Section 5.4.3 in ICES Special Request Advice Celtic Seas Ecoregion. 29 April 2016.

ICES. 2017. Interim Report of the Working Group of International Pelagic Surveys (WGIPS). 16-20 January 2017. Reykjavik, Iceland. ICES CM 2017/SSGIEOM:15. 577 pp.

ICES. 2017. EU request to assess the effects of lifting the “sprat box”. In Report of the ICES Advisory Committee, 2017. ICES Advice 2017, sr.2017.06.

ICES 2017a. Herring (*Clupea harengus*) in divisions 6.a and 7.b-c (west of Scotland, west of Ireland). *In* Report of the ICES Advisory Committee, 2017. Advice book 5. Section 5.3.33: June 30th 2017. Version 2: 11 July 2017 Version 3: 06 October 2017 DOI: 10.17895/ices.pub.3061. http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/her.27.6a7bc.pdf

ICES. 2017. EU request for ICES to evaluate the recovery plan for herring in divisions 6.a and 7.b–c. *In* Report of the ICES Advisory Committee, 2017. ICES Advice 2017, sr.2017.20. 9 pp.

ICES 2017b. EU request for ICES to evaluate the recovery plan for herring in divisions 6.a and 7.b–c . ICES Special Request Advice Celtic Seas and Bay of Biscay and the Iberian Coast Ecoregions Published 24 November 2017 sr.2017.20 DOI: 10.17895/ices.pub.3599

ICES. 2018a. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2018), 12–16 February 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:32. 313 pp.

ICES, 2018b EU request for ICES to evaluate the long-term management plan for Celtic Sea herring

ICES. 2018. Report of the Working Group on International Pelagic Surveys (WGIPS). ICES WGIPS Report 2018 15–19 January 2018. Den Helder, the Netherlands. 340 pp.

ICES. 2018. Interim Report of the Working Group of International Pelagic Surveys (WGIPS). 13-18 January 2018. Santa Cruz, Tenerife. ICES CM 2018/SSGIEOM:15. 577 pp.

ICES. 2018a. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). 29-31 January 2018 and 12-20 March 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:07. 960 pp. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2018/HAW G/01%20HAWG%20Report%202018.pdf

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35. 60 pp.

ICES. 2018 Report of the workshop on mixing of western and central Baltic herring stocks (WKMixHER). 11–13 September 2018, Gdynia, Poland. ICES CM 2018/ACOM:63. 39 pp.

ICES.2018. Workshop on the management strategy evaluation of the reference point, Fcap, for Sprat in Division 3.a and Subarea 4 (WKspratMSE). 11-12 December 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:69.

ICES. 2019. Interbenchmark Protocol for Herring in 6.a, 7.b-c 2019 (IBPher6a7bc). ICES Scientific Reports. 1:19. 74 pp. http://doi.org/10.17895/ices.pub.5261

ICES. 2019. Workshop on Data-limited Stocks of Short-Lived Species (WKDLSSLS).ICES Scientific Reports. 1:73. 166 pp. http://doi.org/10.17895/ices.pub.5549

ICES. 2019. ICES Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 1:11. 499 pp. http://doi.org/10.17895/ices.pub.5122

ICES. 2019. ICES User Handbook: Best practice for Data Management. 12pp. http://doi.org/10.17895/ices.pub.4889

ICES. 2019. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports, 1(2): 1-936.

ICES. 2019. EU request for advice on a monitoring TAC for herring in ICES divisions 7.a South of 52°30'N, 7.g–h, and 7.j–k. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.20, https://doi.org/10.17895/ices.advice.5614

ICES. 2019a. Greater North Sea Ecoregion – Ecosystem overview. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, Section 9.1, https://doi.org/10.17895/ices.advice.5750.

ICES. 2019b. Celtic Seas Ecoregion – Ecosystem overview. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, Section 7.1, https://doi.org/10.17895/ices.advice.5749.

ICES. 2020. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X).

ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

ICES 2020a. Report of the Working Group on International Pelagic Surveys (WGIPS). ICES WGIPS Report 2020 13–17 January 2020. Bergen, Norway pp.

ICES. 2020c. ICES Workshop on Herring Acoustic Spawning Surveys (WKHASS). ICES Scientific Reports. 2:18. 43pp. http://doi.org/10.17895/ices.pub.6021

ICES. 2020d. Workshop on guidelines and methods for the evaluation of rebuilding plans (WKREBUILD). ICES Scientific Reports. 2:55. 79 pp. http://doi.org/10.17895/ices.pub.6085

ICES. 2020e. Greater North Sea Ecoregion – Ecosystem overview. *In* Report of the ICES Advisory Committee, 2020. ICES Advice 2020 Section 9.1, https://doi.org/10.17895/ices.advice.7632

ICES. 2020f. Celtic Seas Ecoregion – Ecosystem overview. *In* Report of the ICES Advisory Committee, 2020. ICES Advice 2020 Section 7.1– https://doi.org/10.17895/ices.advice.7631

ICES. 2020. Steering Committee of the Regional Fisheries Database (SCRDB). ICES Scientific Reports. 2:24. 57 pp. http://doi.org/10.17895/ices.pub.5992

ICES. 2020. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports, 2(60): 1-1151. http://doi.org/10.17895/ices.pub.6105

ICES. 2020. Workshop on Data-limited Stocks of Short-Lived Species (WKDLSSLS2). ICES Scientific Reports. 2:99. 119 pp. http://doi.org/10.17895/ices.pub.5984

ICES. 2021. ICES Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 1(2): 1-499 pp. http://doi.org/10.17895/ices.pub.5122

ICES. 2021. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.4.3.1. https://doi.org/10.17895/ices.advice.7891

ICES. 2021. Inter-benchmark to revise the advice framework for the Sprat stock in 7.de based on the most recent changes to data-limited short-lived species assessments (IBPSprat). ICES Scientific Reports. 3:23. 42 pp. https://doi.org/10.17895/ices.pub.7918

ICES. 2021. Working Group on Multispecies Assessment Methods (WGSAM; outputs from 2020 meeting). ICES Scientific Reports. 3:10. 231 pp. https://doi.org/10.17895/ices.pub.7695

ICES. 2021. TAF Reporting Workshop (WKREPTAF). ICES Scientific Reports. 3:16. 17 pp. https://doi.org/10.17895/ices.pub.7927

Jombart, T. 2008. adegenet: a R package for the multivariate analysis of genetic markers. Bioinformatics, 24: 1403-1405.

Kanstinger, P., Beher, J., Grenzdörffer, G., Hammer, C., Huebert, K.B., Stepputis, D., Peck, M.A. (2018). What is left? Macrophyte meadows and Atlantic herring (Clupea harengus) spawning sites in the Greifswalder Bodden, Baltic Sea. Estuarine, Coastal and Shelf Science, 201, 72-81.

Kornis, M., S., Mercado-Silva, N., Vander Zanden, M., J. (2012). Twenty years of invasion: a review of round goby Neogobius melanostomus biology, spread and ecological implications. Journal of Fish Biology, 80:2, 235-285

Kotterba, P., Kühn, C., Hammer, C., Polte, P. (2014). Predation of threespine stickleback (Gasterosteus aculeatus) on the eggs of Atlantic herring (Clupea harengus) in a Baltic Sea lagoon. Limnology and Oceanography 59 (2): 578–587.

Kotterba, P., Moll, D., Hammer, C., Peck, M.A., Oesterwind, D., Polte, P. (2017). Predation on Atlantic herring (Clupea harengus) eggs by the resident predator community in coastal transitional waters. Limnology and Oceanography, 62(6), 2616-2628.

Kotterba, P., Moll, D., von Nordheim, L., Peck, M.A., Oesterwind, D., Polte, P. (2017b) Predation on larval Atlantic herring (Clupea harengus) in inshore waters of the Baltic Sea. Estuarine, Coastal and Shelf Science 198, 1-11.

Landa, L., Duarte, R. and I. Quincoces. 2008. Growth of white anglerfish (*Lophiuspiscatorius*) tagged in the Northeast Atlantic, and a review of age studies on anglerfish. ICES Journal of Marine Science 65: 72–80.

Lewy, P. and Vinther, M., 2004. A Stochastic age-length-structured multispecies model applied to North Sea stocks. ICES CM 2004/FF:20

Libungan, L. A., Óskarsson, G. J., Slotte, A., Jacobsen, J. A., Pálsson, S. 2015. Otolith shape: a population marker for Atlantic herring *Clupea harengus*. Journal of Fish Biology, 86: 1377-1395.

Libungan, L. A., and Pálsson, S. 2015. ShapeR: An R package to study otolith shape variation among fish populations. PLoS ONE, 10: e0121102.

Mackinson, S. and Daskalov, G., 2007. An ecosystem model of the North Sea to support an ecosystem approach to fisheries management: description and parameterisation. Sci. Ser. Tech Rep., Cefas Lowestoft, 142: 196pp.

Mackinson, S. 2017. Working Document on the location and timing of spawning for herring in 6.aN for discussion in survey planning 2017. 21 April 2017.

Mackinson, S., Pastoors, M., Lusseau, S., Armstrong, E., O'Connell, S, Haan, D., Burgraaf, D., Berges, B., McClean, A, Langlands, B., Scott, A., Wiseman, A., O'Malley, M., Clarke, M. 2018. The 2017 industry-science survey of herring in the Western British Isles (ICES div 6a, 7bc).

Mackinson, S., Pastoors, M., Lusseau, S., O'Connell, S, Forbes-Birnie, J., Sakinan, S., Berges, B., Brigden, K., O'Malley, M., Farrel, Ed., Brigden, K. 2019. The 2019 industry-science survey of herring in the Western British Isles (ICES div 6a, 7bc). 98pp

Mackinson, S., Pastoors, M., O'Connell, S, Berges, B., Forbes-Birnie, J., McAulay, S., Brigden, K., Fraser, S., O'Malley, M., Farrel, Ed. 2021. The 2020 industry-science survey of herring in the Western British Isles (ICES div 6a, 7bc). 115pp

Marshall, K.N., Koehn, L.E., Levin, P.S., Essington, T.E. and Jensen, O.P. (2019) Inclusion of ecosystem information in US fish stock assessments suggests progress toward ecosystem-based fisheries management. *ICES Journal of Marine Science*, Volume 76, Issue 1, January-February 2019, Pages 1–9, https://doi.org/10.1093/icesjms/fsy152

Moll, D., Kotterba, P., von Nordheim, L., Polte, P. (2018). Storm-Induced Atlantic Herring (Clupea harengus) Egg Mortality in Baltic Sea Inshore Spawning Areas. Estuaries and Coasts 4: 1-12.

Moll, D. (2018). Contribution of coastal nursery areas to the spring-spawning population of Atlantic herring (Clupea harengus) in the Western Baltic Sea. Dissertation, University of Hamburg, p.233.

Möller, H. (1984). Reduction of a Larval Herring Population by Jellyfish Predator. Science, 224:4649, 621-622

Molloy, J. 1980. The assessment and management of the Celtic Sea herring stock. Rapp. P.-V. Reun. Cons. Int. Explor. Mer, 177:159–165.

Molloy, J., and Corten, A. 1975. Young herring surveys in the Irish Sea. ICES CM H:11.

Molloy, J., Barnwall, E., & Morrison, J. 1993. Herring tagging experiments around Ireland, 1991. Department of the Marine Fisheries Leaflet 154. 8 pp.

Moyano M, Illing B, Polte P, Kotterba P, Zablotski Y, Gröhsler T, Hüdepohl P, Cooke SJ, Peck M (2020) Linking individual physiological indicators to the productivity of fish populations: A case study of Atlantic herring. Ecol Indic 113:106146, DOI:10.1016/j.ecolind.2020.106146.

N Bailey, DM Bailey, LC Bellini, PG Fernandes, C Fox, S Heymans, S Holmes, J Howe, S Hughes, S Magill, F McIntyre, D McKee, MR Ryan, IP Smith, G Tyldsely, R Watret and WR Turrell. 2011.: The west of Scotland marine ecosystem: a review of scientific knowledge. MSSR 09/11. 292pp.

Nielsen, J.R., Lundgren, B., Jensen, T.F., Stæhr, K.-J. (2001). Distribution, density and abundance of the western Baltic herring (Clupea harengus) in the Sound (ICES Subdivision 23) in relation to hydrographical features. Fisheries Research 50, 235–258.

Nordheim von, L., Kotterba, P., Moll, D., Polte, P. (2018). Impact of spawning substrate complexity on egg survival of Atlantic herring (*Clupea harengus*, L.) in the Baltic Sea. Estuaries and Coasts 41(2), 549-559.

Nordheim von L, Kotterba P, Moll D, Polte P (2020) Lethal effect of filamentous algal blooms on Atlantic herring (Clupea harengus) eggs in the Baltic Sea. Aquatic Conserv 30(7):1362-1372, DOI:10.1002/aqc.3329

O'Donnell, C., Mullins, E., Lynch, D., Lyons, K., Keogh, N and O'Callaghan, S. (2018). Celtic Sea Herring Acoustic Survey Cruise Report 2018. FSS Survey Series: 2018/04

O'Donnell, C., Mullins, E., Lyons, K., Connaughton, P, and Perez Tadeo, M (2020). Celtic Sea Herring Acoustic Survey Cruise Report 2018. FSS Survey Series: 2020/04

O'Dwyer, P., McKeogh, E. and Berrow, S. 2016. Results of an Independent Observer Study of the Celtic Sea Herring Fishery, 2016. IWDG Consulting, Merchants Quay, Kilrush, Co Clare. 15 pp.

O'Malley, M., Clarke, M., O'Donnell, C., Murphy, I. 2016. Atlantic Herring in 6aS/7b,c Industry Acoustic Survey Cruise Report. FEAS Survey Series: Industry Survey/01/2016

O'Donnell, C., O'Malley, M., Lynch, D., Lyons, K., Keogh, N. and O'Driscoll, D. (2017). Celtic Sea Herring Acoustic Survey Cruise Report 2017, 15-04 November 2017. FSS Survey Series: 2017/04. Marine Institute. http://hdl.handle.net/10793/1338

O'Dwyer, P and Berrow, S (2017). Results of an Independent Observer Study of the Celtic Sea Herring Fishery, 2017

O'Malley, M., Clarke, M., Smith, T. & Mullins, E. (2018). Atlantic Herring and Horse Mackerel in 6aS/7b; Industry Acoustic Survey Cruise Report. FEAS Survey Series: Industry Acoustic Survey/01/2017. Marine Institute. http://hdl.handle.net/10793/1341

O'Malley M. Blaszkowski M. White E. O'Brien S. & Mullins E. (2019). Atlantic Herring and Horse Mackerel in 6aS/7b; Industry Acoustic Survey Cruise Report. FEAS Survey Series: Industry Acoustic Survey/01/2019. Marine Institute

O'Malley M., Mullins E. & Nolan C (2020). Atlantic Herring in 6aS/7b; Industry Acoustic Survey Cruise Report. FEAS Survey Series: Industry Acoustic Sur- vey/01/2020. Marine Institute

O'Sullivan, D, O'Keeffe, E., Berry, A., Tully, O. and Clarke, M (2013) An inventory of Irish Herring Spawning Grounds. Irish Fisheries Bulletin No 42 2013.

Pelagic Advisory Council. 2016. Minutes of the Focus Group meeting on herring in area VIa and VII b,c. 27 January 2016, The Hague, The Netherlands. http://www.pelagic-ac.org/media/pdf/Minutes%20VIa%20herring%2027%2001%202016.pdf

Peck, M.A., Kanstinger, P., Holste, L., Martin, M. Thermal windows supporting survival of the earliest life stages of Baltic herring (Clupea harengus). ICES Journal of Marine Science, 69(4), 529–536 (2012).

Podolska, M., Horbowy, J., Wyszyński, M. (2006). Discrimination of Baltic herring populations with respect to *Anisakis simplex* larvae infection. Journal of Fish Biology, 68:4, 1241-1256.

Polte P, Gröhsler T, Kotterba P, Nordheim L von, Moll D, Santos J, Rodriguez-Tress P, Zablotski Y, Zimmermann C (2021) Reduced reproductive success of Western Baltic herring (Clupea harengus) as a response to warming winters. Front Mar Sci 8:589242, DOI:10.3389/fmars.2021.589242.

Prista, N., Fernandes, A., Pereira, J, Silva, C., Alpoim, R. and F. Borges. 2014. Discards of WGBIE species by the Portuguese bottom otter trawl operating in the ICES division 9.a (2004-2013). Working Document presented at WGBIE2014.

Smoliński, S., Schade, F.M., and Berg, F. 2020. Assessing the performance of statistical classifiers to discriminate fish stocks using Fourier analysis of otolith shape. Canadian Journal of Fisheries and Aquatic Sciences, 77(4): 674-683.

Wiegleb, J., Kotterba, P., Hammer, C., Oesterwind, D. (2018) Predation of the round goby (*Neogobius melanostomus* Pallas, 1814) on Atlantic herring eggs in the Western Baltic Sea. Marine Biology Research, 14:9-10, 989-1003.

Annex 1: List of participants

Name	Institute	Country	Email
Afra Egan (Co- Chair)	Marine Institute	Ireland	afra.egan@marine.ie
Anna Rindorf	DTU Aqua -National Institute of Aquatic Resources	Denmark	ar@aqua.dtu.dk
Bastian Huwer	DTU Aqua -National Institute of Aquatic Resources	Denmark	bhu@aqua.dtu.dk
Benoit Berges	Wageningen University & Re- search	Netherlands	benoit.berges@wur.nl
Campbell Pert	Marine Laboratory Marine Science Scotland	United Kingdom	campbell.pert@gov.scot
Cecilie Kvamme (Co-Chair)	Institute of Marine Research	Norway	cecilie.kvamme@hi.no
Christophe Loots	Ifremer Boulogne-sur-Mer Centre	France	christophe.loots@ifremer.fr
Cindy van Damme	Wageningen University & Re- search	Netherlands	cindy.vandamme@wur.nl
Claus Reedtz Sparrevohn	Danish Pelagic Producers' Organisa- tion	Denmark	crs@pelagisk.dk
Cormac Nolan	Marine Institute	Ireland	cormac.nolan@marine.ie
Eleanor McLeod	Marine Laboratory Marine Science Scotland	United Kingdom	eleanor.mcmeod@gov.scot
Espen Johnsen	Institute of Marine Research	Norway	espen.johnsen@hi.no
Florian Berg	Institute of Marine Research	Norway	florian.berg@hi.no
Henrik Mosegaard	DTU Aqua -National Institute of Aquatic Resources	Denmark	hm@aqua.dtu.dk
Johnathan Ball	CEFAS - Lowestoft Laboratory Cen- tre for Environment, Fisheries and Aqua- culture Science	United Kingdom	johnathan.ball@cefas.co.uk
Kirsten Birch Håkansson	DTU Aqua -National Institute of Aquatic Resources	Denmark	kih@aqua.dtu.dk
Mark Payne	DTU Aqua -National Institute of Aquatic Resources	Denmark	mpay@aqua.dtu.dk
Martin Pastoors	Pelagic Freezer-Trawler Associa- tion	Netherlands	mpastoors@pelagicfish.eu
Mathieu Lundy	Agri-food and Biosciences Institute (AFBI)	United Kingdom	mathieu.lundy@afbini.gov.uk

Name	Institute	Country	Email
Matthias Kloppmann	Thünen Institute of Sea Fisheries	Germany	matthias.kloppmann@thuenen.de
Mikael van Deurs	DTU Aqua -National Institute of Aquatic Resources	Denmark	mvd@aqua.dtu.dk
Neil Campbell	Marine Laboratory Marine Science Scotland	United Kingdom	neil.campbell@gov.scot
Norbert Rohlf	Thünen Institute of Sea Fisheries	Germany	norbert.rohlf@thuenen.de
Ole Henriksen	DTU Aqua -National Institute of Aquatic Resources	Denmark	ohen@aqua.dtu.dk
Richard Nash	CEFAS - Lowestoft Laboratory Centre for Environment, Fisheries and Aqua- culture Science	United Kingdom	richard.nash@ cefas.co.uk
Sarah Millar	ICES Secretariat		sarah-louise.millar@ices.dk
Steve Mackinson	Scottish Pelagic Fishermen's Association	United Kingdom	steve.mackinson@scottishpelagic.co.uk
Susan Mærsk Lusseau	DTU Aqua -National Institute of Aquatic Resources	Denmark	smalu@aqua.dtu.dk
Thomas Regnier	Marine Laboratory Marine Science Scotland	United Kingdom	t.regnier@marlab.ac.uk
Tomas Gröhsler	Thünen Institute of Sea Fisheries	Germany	tomas.groehsler@thuenen.de
Valerio Bartolino	Swedish University of Agricultural Sciences Institute of Marine Research	Sweden	valerio.bartolino@slu.se
Vanessa Trijoulet	DTU Aqua -National Institute of Aquatic Resources	Denmark	vtri@aqua.dtu.dk

Annex 2: Resolutions

Generic ToRs for Regional and Species Working Groups

2020/2/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 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex 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 2020.

iv) Estimate 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) b. 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;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
iii) determine the prioritization score for benchmarks proposed for 2022–2023;
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

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 20–22 January 2021 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 16–24 March 2021 to:

b) compile the catch data of North Sea and Western Baltic herring on 16–17 March;

c) address generic ToRs for Regional and Species Working Groups 18–24 March for all other stocks assessed by HAWG.

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

Material and data relevant for the meeting must be available to the group on the dates specified in the 2021 ICES data call.

HAWG will report by 12 February (sandeel), 29 March (sprat) and 7 April (herring) 2021 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 NWWG Stock Annexes. Stock annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year, ecoregion, species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last up-dated	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)	March 2018	her.27.3a47d SA
her.27.6a7bc	Herring (*Clupea harengus*) in divisions 6.a and 7.b-c (West of Scotland, West of Ireland)	March 2019	her.27.6a7bc 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
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 2021	
WD 01	Pastoors, M and Rolf, N. Utilizing the full time series of herring catch by rectangle.
WD 02	Polte, P and Gröhsler, T. 2020 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey
WD 03	Gröhsler, T. German herring Fisheries and stock assessment data in the Western Baltic in 2020.
WD 04	HAWG 2021. IBPNSAS2021 – Interbenchmark Protocol on North Sea Autumn Spawning Herring 2021
WD 05	Pastoors, M. and Quirijns, F.A. PFA Self sampling report for North Sea herring Fisheries, 2015-2020

Annex 5: Audit reports

Audit of her.27.20-24

Working Group: HAWG Stock Name: her.27.20-24

Date: April 2021

Review of ICES Scientific Report, Review of ICES Scientific Report, Herring Assessment Working Group for the area south of 62N), *2021*, 18-24 March 2021. Section 3.

Reviewers: Claus R. Sparrevohn and Steven Mackinson

Expert group Chair: Afra Egan, Cecilie Kvamme

Secretariat representative: Sarah Millar

Audience to write for: ***advice drafting group****,*

General

Consistent with last year and continue to be a zero-catch advice.

For single-stock summary sheet advice

Stock **her.27.20-24**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: **update**
2) Assessment: **accepted**
3) Forecast: **accepted**
4) Assessment model: SAM
5) Consistency: Consistent with last year assessment
6) Stock status: SSB has been below Blim since 2007;
7) Management plan: No agreed MP. A MAP excist but is not approved by Norway as basis for advice.

General comments

The intermediate assumption, on transfer of catches from 3a to the NS in 2021, has changes. Normally the PELAC AC is asked to provide information on transfer and normally the assumed transfer is around 48%. This percentage has changed for 2021. This is caused by changed expectations due to Brexit. To be specific then the expectation is that there will be no possibility to fish 3a quota, transferred to NS, in UK waters. The alternative, to fish in Norwegian waters, is limited to 3000 tons. Hence the expected transfer is set to 3000 tons as a best guess provided by the PELAC.

Technical comments

- The assessment input data documented in the HAWG report was checked and matched those of the assessment data shown on stockassessment.org
- The assessment setting in the stock annex was checked and match those of the assessment data shown on stockassessment.org
- The stock annex has been updated

Conclusions

Advice is produced in consistency with the benchmark approved assessment and forecast

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. *The colors on the draft advice document makses it difficult to see if it is unshaded or not.*

☒ 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. *I am not able to rerun the forecast*

☒ 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)

In the SSB and Rec. plot other colours are used.

☒ 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"

NA

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.

- In the draft advice, Table 5 refers to Management Plan (2018) with reference to ICES 2018. However, Table 4 refers to MAP (2019) with EC 2019 as reference. This is confusing.
- In the draft advice refences, both 'EU' and 'EC' are used for referencing, which is not consistent

☒ Ensure all references in the advice sheet are referenced in this section

Audit of Her.6a7bc

Working Group: HAWG Stock Name: her.27.6a7bc

Date: April 2021

Review of ICES Scientific Report, Review of ICES Scientific Report, Herring Assessment Working Group for the area south of 62N), *2021*, 18-24 March 2021. Sections 4 and 5.

Reviewers: Mathieu Lundy

Expert group Chair: Afra Egan, Cecilie Kvamme

Secretariat representative: Sarah Millar

General

Herring in this Division is consider to consist of two stocks. At present these are not differentiated although HAWG still considers them to be discrete. They are assessed together as a meta-population. Work is ongoing to toward a new assessment model to address this issue. An annual monitoring TAC has been place since 2016. The TAC for the current year (2021) has not been announced.

For single stock summary sheet advice:

1) **Assessment type:** As Interbenchmark 2019
2) **Assessment**: Analytical assessment
3) **Forecast**: not presented
4) **Assessment model**: Multifleet FLSAM with 3 tuning indices (one acoustic survey, two trawl surveys)
5) **Data issues:** The updated assessment provides the best statistical fit to the input data, but the assessment still has a strong retrospective bias. There is also a pattern of increasing catchability with age for the acoustic survey data
6) **Consistency**: New assessment method following inter-benchmark process.
7) **Stock status**: The assessment does not provide any information on the state of either constituent stock. No reference points defined. Assessment used as indicative of trends only.
8) **Management Plan**: No management plan in place

General comments

The model and decisions of the inter-benchmark process as presented to HAWG were used in the assessment.

Technical comments

None

Conclusions

The assessment has been performed correctly. This stock would benefit from a benchmark which addresses the methods to split stock components.

Checklist for audit process

Quality of the assessment

☒ Are the units in plots correct?

☐ Are the titles in the plots correct including F (age range) recruitment (age). –No. F(wr) is miss- ing -

☐ 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.

Audit of her.27.6a7bc

Review of ICES Scientific Report, (HAWG) *(2021)* (06.04.2021)

Reviewers: Norbert Rohlf

Expert group Chair: Cecilie Cvamme, Afra Egan

Secretariat representative: Sarah Millar

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock: her.27.6a7bc

Herring in this Division consists of two stocks. It is not possible yet to differentiate the two stocks and although HAWG still considers them to be discrete, they will be assessed together as a meta-population until the combined survey indices can be successfully split. A monitoring TAC is in place since 2016.

1) Assessment type: update assessment
2) Assessment: accepted
3) Forecast: not presented
4) Assessment model: Multifleet FLSAM with 3 tuning indices (one acoustic survey, two trawl surveys)
5) Consistency: Following Inter-benchmark procedures. As a result of the 2019 inter-benchmark, the formerly seen large retrospective pattern in the recruitment is reduced due to the inclusion of density-dependent catchability. But catchability in the acoustic surveys remains a concern.
6) Stock status: The assessment does not provide any information on the state of either constituent stock. No reference points defined. Assessment used as indicative of trends only.
7) Management plan: No agreed management plan in place for this stock.

General comments

Technical comments

None

Conclusions

The assessment has been performed correctly. This stock would benefit from a benchmark which addresses the methods to split stock components.

Audit of Her.27.irls

Working Group: HAWG Stock Name: her.27.irls

Date: 25 March 2021

Review of ICES Scientific Report, Review of ICES Scientific Report, Herring Assessment Working Group for the area south of 62N), *2021*, 18-24 March 2021. Section 6.

Reviewers: Richard Nash and Cindy van Damme

Expert group Chair: Afra Egan and Cecilie Kvamme

Secretariat representative: Sarah Millar

General

The spawning-stock biomass (SSB) has decreased significantly in the last decade and is below B_{lim} since 2016. The fishing mortality (F) is above F_{msy} since 2014, above F_{pa} between 2016 and 2019, but in 2020 F is below F_{msy}. Recruitment has been below average since 2013 and is uncertain. The assessment had a substantial historical retrospective revision in the last years, but this year, SSB is very similar to last year. Applying ICES MSY approach advice is zero catch for 2022. However, in order to continue to monitor the stock development ICES advises allowing a monitoring TAC of 869 tonnes, the same as last year.

For single-stock summary sheet advice

Stock **her.27.irls**

1) Assessment type: update
2) Assessment: accepted, but considered highly uncertain, but does not affect the advice outcome
3) Forecast: accepted
4) Assessment model: Analytical assessment using ASAP tuned to a single acoustic survey using ages 2-7 (2002-2020) and catch data (1958-2020)
5) Consistency: Last year's and this year's assessment accepted. The assessment had a substantial historical retrospective revision as in previous years, but is this year the estimate for SSB and F are very similar to last year. The Mohns Rho is still very high, but lower than last year. Recruitment was forecasted to increase in recent years, but the retrospective pattern is of a revision downward each year with an annually decreasing trend.
6) Stock status: $B<B_{lim}$ since 2016, F was above F_{pa} between 2016 and 2019, but in 2020 below F_{msy}, R is uncertain, seems to be high in recent years, but in retrospective is estimated lower and decreasing
7) Management plan: The long-term management strategy for Celtic Sea herring that was proposed by the Pelagic AC in 2011 (Pelagic AC, 2011) was evaluated by ICES in 2018. ICES advises that the harvest control rule is no longer consistent with the precautionary approach.

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No comments

Conclusions

The assessment has been performed correctly

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 was reviewed in 2018 and the harvest control rule was no longer considered to be consistent with the precautionary approach.

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**

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

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

<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.

Catch options table:

☒ The forecast should be re-run to ensure all values are correct.

☒ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☒ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under “Other options”.

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☒ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The coloured line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB 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 **ICES.2109 can be removed and subsequently was removed.**

Audit of Her.27.nirls

Working Group: HAWG Stock Name: her.27.nirs

Review of ICES Scientific Report, Herring Assessment Working Group for the area south of 62N), *2021*, 18-24 March 2021, **Section 7: Herring in Division 7.a North (Irish Sea)**

Reviewers: Martin Pastoors (mpastoors@pelagicfish.eu), Kirsten Birch Håkansson <kih@aqua.dtu.dk>

Expert group Chair: Afra Egan, Cecilie Kvamme

Secretariat representative: Sarah Millar

General

The report section is a straight update from the report section of the 2020 report, using track changes, so that all changes are easy to follow. The assessment procedure is highly standardized, using R-codes that require very few modifications during the assessment working group.

For single-stock summary sheet advice

Herring in Division 7.a North (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: SAM (FLSAM) - tuning by one age-based acoustic survey and one biomass acoustic survey. The age-based acoustic survey is treated as an absolute estimate of SSB (catchability set to 1).
5) Consistency: Consistent with last year's assessment
6) Stock status: B > B_{pa} for a while; F < F_{msy}; R uncertain but seems to be high in recent years
7) Management plan: no management plan applicable

General comments

All input data to the assessment and forecast have been checked for consistency between the values in the report and the input files on github.

The Fpa reference point has been changed according to instructions from ACOM. That change should be documented in the reference point table, e.g. by changing the source or adding a footnote.

The last option in the forecast table is based on achieving MSY Btrigger in 2022 but in fact it is not achieving MSY Btrigger (=Bpa) but instead it is close to applying Fmsy instead.

Technical comments

The assessment uses a specific version of FLSAM that uses a control object that includes a reference to a SAM binary file. This control object is no longer useable in the recent versions of FLSAM. Running the assessment with the recent version of FLSAM, lead to hard failure in R-Studio. For that reason, the assessment and forecast could not be rerun by the auditor. It is recommended that the assessment package for the assessment is upgraded to more recent versions of FLSAM and FLAsher.

Conclusions

The assessment and forecast have been carried out using the default approach for this stock.

Audit of HAWG 2021 her.27.nirs

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.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct. DUE TO THE SPECIFIC VERSION OF FLSAM, THE ASSESSMENT AND FORECAST COULD NOT BE RERUN BY THE AUDITOR

☒ 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. THE LAST OPTION IN THE FORECAST TABLE IS BASED ON ACHIEVING MSY BTRIGGER IN 2022 BUT IN FACT IT IS NOT ACHIEVING MSY BTRIGGER (=BPA) BUT INSTEAD IT IS CLOSE TO APPLYING FMSY INSTEAD.

~~☒ 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. THE COLUMN SSB CHANGE SHOULD BE AFTER THE COLUMN SSB 2023

☒ 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 title for the recruitment plot should have a space before (Millions)*

☒ 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. *The legends are in a poor quality – probably an ICES problem*

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. THE FPA REFERENCE POINT HAS BEEN CHANGED ACCORDING TO INSTRUCTIONS FROM ACOM. THAT CHANGE SHOULD BE DOCUMENTED IN THE REFERENCE POINT TABLE, E.G. BY CHANGING THE SOURCE OR ADDING A FOOTNOTE.

Basis of the assessment

~~☐ If there is no change from the previous year the table should be the same~~. *No similar table in the advice 2020*

☐ Ensure there is no typos wrong acronyms for the surveys – *can't find the link to the new survey codes*

☒ 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. *'Official landings' missing for 2020 and 2018 and 2019 are marked as preliminary and in yellow. 'ICES estimated catch' in 2019 and 2020 do not match Table 7.1.1 in the report and table 7 and 8 in advice*

☒ 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% - *Table 8 – is it on purpose that landings and catch don't match?*

☒ 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) – *don't see this one, but the preliminary landings are 7952 t for all of 7.a*

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.1r

Reviewers: Espen Johnsen

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

- Sandeel Area 1r covers the central and southern North Sea, and the important Dogger Bank.
- The assessment was benchmarked in 2016.
- The natural mortality was updated in 2020 and used in this year's assessment.
- There is an increase in dredge survey coverage with time. The southern banks are better covered in recent years.
- After a long period of decreasing individual weight-at-age, the mean weight-at-age has increased for all age groups bringing it above the 10 years average in 2020.

For single-stock summary sheet advice

Stock: san.sa.1r

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS 2 season model, age based, assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey
5) Consistency: Consistent assessment, however, retrospective is large for R.
6) Stock status: SSB was estimated to be below MSY $B_{escapement}$ and B_{pa}, but above B_{lim}. This is a result of a downward revision of the 2019 recruitment. No reference

points for fishing pressure have been defined for this stock. The uncertainty of the estimated SSB, F and R is low in the assessment.

7) Management plan: No MP for SA1r

General comments: The assessment is well documented.

Technical comments: The assessment and forecast are performed according to the information found in the stock annex.

Conclusions: The assessment has been performed correctly according to the procedure established at the last benchmark.

Audit of san.sa.1r

Reviewers: Claus R. Sparrevohn

Expert group Chair: HAWG, Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

- Natural mortality was updated with the 2020 SMS North Sea Key Run input. The update was not considered to have any effect on the stock recruitment plot and hence would not change reference points. On basis of that it was considered appropriate to update the timeseries.
- A substantial part of SA1r catches is taking in UK EEZ, which in the future could change the spatial exploitation pattern of the stock.
- The catch advice is 5464 tons which is only mariginal above the monitoring TAC of 5000 tons which has been set several times in cases of zero advice (eg. 2016 for SA1). Therefore, the group added a sentence on "ICES advises that samples should be taken from every haul, similar to a monitoring TAC"

For single-stock summary sheet advice

Stock **san.sa.1r**

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, F is scaled with effort, dredge survey index of recruitment
5) Consistency: Consistent assessment with some retrospective issues
6) Stock status: Inbetween MSYBescapement (wich is equal to Bpa) and Blim
7) Management plan: There is no management plan for this stock

General comments

A well-documented assessment

Technical comments

assessment performed according to stock annex.

Conclusions

Both assessment and forecast are appropriate for advice. Natural mortality was updated as it did not have any effect on the stock recruitment plot

Audit of san.sa.2r

Reviewers: Valerio Bartolino

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

- No remarks on the assessment which is conformed to procedures
- The retrospective pattern on R is problematic for the advice as demonstrated by the downward revision in the 2019 year class.
- The combined effect of the 2019 R revision and inter-annual flexibility in the catches (+18% of the 2020 advice) adopted by the fishery maintained the stock at low levels throughout 2020.
- The advice of a monitoring TAC is well supported

For single-stock summary sheet advice

Stock: san.sa.2r

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 assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey
5) Consistency:

- consistent with last year assessment, retrospective moderate for F and R (but remains problematic for the advice), somehow more pronounced for SSB but improved in recent years.
- During an inter-benchmark in 2020 a power function was introduced to account for density-dependent catchability of the dredge survey. This year model estimates a parameter for the power function of 1.27 which confirms some level of density-dependency.
- Commercial CPUEs increase in 2020 which is also corroborated by fishermen's feedback.

6) Stock status: SSB in 2021 is estimated just above Blim. 2020 recruitment is lower than the long-term average, and despite 2019 is confirmed as a relatively good year class, the overall perception is that the stock has been in a low productivity for >20 years. F in 2020 has a substantial jump after the 2019 record low and it's

estimated above Fcap which is well explained by catches exceeding the last year advice.

7) Management plan: No MP for SA2r.

General comments

The text of the advice is in general clear and the advice monitoring TAC fully supported by evaluation of the stock status. The opening sentence on top requires revision according to ICES standards. Model settings are consistent with last year and the procedure appears in line with the stock annex.

TAC for 2020 followed the ICES advice but the realised catches exceeded the TAC of 18%. Inter-annual flexibility in the quota (bank and borrowing) is provided as explanation https://thefishingdaily.com/featured-news/danish-fisheries-association-welcomes-10-increase-in-sandeel-quota/.

2020 catches are dominated by age 1 fish which is consistent with the good 2019 year class.

Technical comments

Confidence bound on SSB, R and F appear unrealistically too narrow.

Retrospective patterns are moderate for F and R, but the downward revision of the 2019 year class is considerable. The 5-years average Mohn's rho for SSB is 0.49 but better in the last 3 peels (i.e., within CI).

A certain amount of catches have been reported from rectangles which are shared by SA2 and SA3. Misreporting cannot be excluded. The issue is mentioned and is expected to be given full attention at the next benchmark.

Conclusions

The assessment has been performed correctly and according to procedure. The retrospective pattern is not particularly severe on the R if compared to other sandeel stocks but the downward revision of the 2019 R and catches exceeding the advice contribute to explain the poor status of the stock.

Audit of san.sa.2r

Reviewers: Christian Kiaer and Mark R. Payne

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

- Assessment procedures followed.
- Short-term forecasts indicate that even with no fishing, SSB will still be below Bpa in 2022.
- Retrospective recruitment patterns still seen.
- Advices a monitoring TAC.

For single-stock summary sheet advice

Stock: san.sa.2r

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS – Dredge and fleet survey
5) Consistency:
- Retrospective analysis shows consistent assessment year to year.
- Consistent results between dredge survey and model outputs.
- The use of the power model for survey catchability, introduced to account for density dependence, seems to have improved the Mohn's rho and reduced the large overestimations of recruitment levels. AIC of models with and without the power model are similar.
- CPUE increased in 2020 to levels similar to 2010.
6) Stock status: SSB is estimated to be just above Blim, up from just below Blim in 2020. The stock has been below Blim 16 out of the 20 last years. While 2019 recruitment was considered around average, the 2020 recruitment is lower. A slow increase in SSB has been seen, compared to the historical lows from 2004 to 2010.
7) Management plan: none

General comments

- Generally, the assessment is considered to be of good quality, although retrospective patterns are seen. Here, it is noted that the short dredge survey time series can be a factor.
- 2020 fisheries followed ICES TAC advice, but was exceeded by 18%.
- Assessment model outputs are consistent with 2020 results.
- SSB level is still just around Blim.

Technical comments

- Revisiting 2019 recruitment led to a large downward revision.
- Power model for density dependence in catchability seems to improve retrospective patterns.

Conclusions

- Assessment quality is considered good and procedures are followed correctly.
- Advices a monitoring TAC.
- SSB estimated at just above Blim, with a generally low SSB trend observed for the last 20 years. The updated lower 2019 recruitment is affecting this negatively.

Audit of San.sa.3r

Working Group: HAWG Stock Name: san.sa.3r

Review of ICES Scientific Report, (HAWG) *(2021)* (02.02.2021)

Reviewers: Norbert Rohlf

Expert group Chair: Cecilie Kvamme, Afra Egan

Secretariat representative: Sarah Millar

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
5) Consistency: consistent with last year's assessment. Model was applied as per stock annex. As a result of the 2020 inter-benchmark, the formerly seen large retrospective pattern in the recruitment is reduced due to the inclusion of density-dependent catchability.
6) Stock status: SSB has been above B_{pa} since 2015, combined with low F. Above recruitment in period 2018 to 2020.
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. The inclusion of density-dependent catchability in the dredge survey reduced the retrospective bias in the recruitment.

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.

Audit of San.sa.4

Working Group: HAWG Stock Name: san.sa 0.4

Reviewers: Espen Johnsen

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

- The dredge survey is an important input time series for the assessment, however, the survey carried out in 2020 was of poor quality due to a low number of station and biased area coverage. Analyses showed that the areas covered in 2020 where the typically high densities areas in previous years. This skewness was adjusted, but the both the low number of stations and the adjustment of indices introduced an additional uncertainty that is not fully considered in the assessment and the prediction.
- A more standardized survey coverage is recommended for future years.
- Except from the dredge survey index adjustment, the assessment was carried out in standard manners.

For single-stock summary sheet advice

Stock: san.sa.4

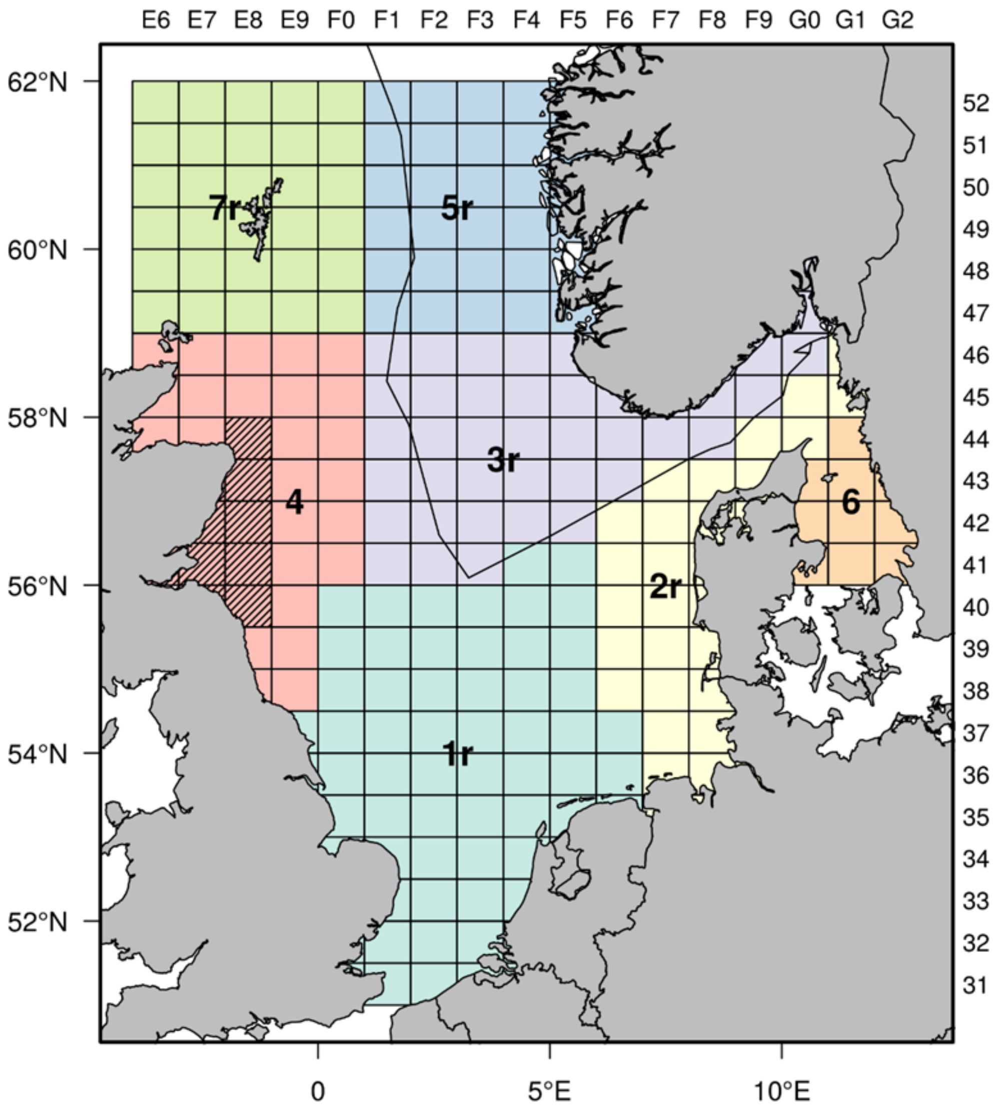
Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS 2 season model, age based, assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey
5) Consistency: consistent with last year assessment except that the dredge survey indices are adjusted to compensated for poor area coverage. Retrospective large for R. Low retrospective pattern for F and SSB in recent years.
6) Stock status: SSB is above MSY Bescapement and Bpa. No reference points for fishing pressure have been defined for this stock. The uncertainty of the estimated SSB and F is large in the assessment, resulting from a period of low commercial fishing effort (2004–2016), no data on catch age composition (2006–2011), and no survey indices (2004–2007).
   Management plan: No MP for SA4, however, the Firth of Forth area (see hatched area in map below) is closed for sandeel trawling as it is important area for breeding seabirds. The advice does not consider that large part of SA4 is closed for fishing. This closure will direct the fishing effort to other areas in SA4.

General comments: It is of concern that there is a very low spatial overlap between the area covered by the dredge survey and the area covered by the commercial fishing fleet as the survey mainly cover the closed area in SA4. If there are spatial differences in recruitment in the two, the dredge survey may not represent the recruitment of the areas open for fishing. The fishing effort has been very for more than 15 years.

Technical comments: The assessment and forecast are performed according to the information found in the stock annex, however, the 2020 dredge survey indices were adjusted downwards to compensate for a skewed survey coverage that seemed to produce too high estimates for age0 and age1 indices.

Conclusions: The assessment has been performed correctly according to the procedure established at the last benchmark.



Audit of San.sa.4

Reviewers: Claus R. Sparrevohn

Expert group Chair: Cecilie Kvamme and Afra Egan

Secretariat representative: Sarah Millar

General

The dredge survey provides important information on the incoming yearclass and consequently the catch recommendation. The latest dredge survey in 2020 differed from the previously surveys since only few stations was completed resulting in an altered spatial coverage. That the coverage can influence the index is known and for SA1r and SA2r the index is calculated using a special correlation model. This is not the case for area 4. Therefore, it was found prudent to account for the skewness in spatial coverage in an ad hoc way, as described in the report.

It is recommended that the index calculation is evaluated during next benchmark, potential by using similar method as on SA1r and SA2r.

This index adjustment was only divergent form the normal procedure. No changes to the natural mortality assumption were made.

For single-stock summary sheet advice

Stock **san.sa.4**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS, dredgesurvey+catches
5) Consistency: Consistent except for the dredge survey index
6) Stock status: SSB is above Bescapement which is set equal to Bpa.
7) Management plan: No management plan

General comments

Assessment and forecast well performed

Technical comments

Dredge survey adjusted to account for skewness in the spatial coverage.

Audit of spr.27.3a4

Review of ICES Scientific Report, HAWG 2021 March 16-24

Reviewers: Henrik Mosegaard and Christophe Loots

Expert group Chair: *Afra Egan, Cecilie Kvamme*

Secretariat representative: Sara Millar

General

During the the last benchmark in 2018 the stock unit was re-defined, combining division 3.a and subarea 4.

For single-stock summary sheet advice

Stock

spr27.3a4

Short description of the assessment as follows (examples in grey text):

1) Assessment type: analytical update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: SMS in quarterly step, assessment year July-June, tuning data catches 0-3+, IBTS Q1 (age 0-3), IBTS Q3 (age 1-3), HERAS (age 1-3). 3 y average M from the 2017 WGSAM key run, according to recent guidance from ACOM LS (March 2021).
5) Consistency: The assessment was accepted similar to last year. There has been a large improvement in retrospective pattern after the benchmark but as 41% of the recruiting year class contributes to the SSB at the end of the year, the still high retrospective pattern in SSB (5 year mohn´s rho = 0.19) is not unexpected.
6) Stock status: SSB > MSY $B_{escapement}$, no precautionary F-reference points are defined for the stock. F is estimated higher than Fcap in recent 7 years.
7) Management plan: No agreed precautionary management plan for sprat, advice according to MSY approach (escapement strategy with Fcap = 0.69).

General comments

Technical comments

There is no technical issue with this stock

Audit of Spr.27.7de

Working Group: HAWG Stock Name: spr.27.7.de

Review of ICES Scientific Report, *HAWG 2021, 16th-24th March 2021*

Reviewers: *Christophe Loots, Campbell Pert*

Expert group Chair: *Afra Egan, Cecilie Kvamme*

Secretariat representative: *Sarah Louise Millar*

General

This is a category 3 stock for which the assessment is based on the trend and absolute estimate of biomass in the PELTIC acoustic index from 2013 onward. The acoustic survey covers a much wider area than the Lyme Bay area where the stock is defined and the fishery is focused.

The stock was treated inconsistently in the past (2 over 3 or 1 over 2 rule) which was not precautionary. The stock was sent to IBP to resolve implementation of the new guidance for short lived data limited species. It was decided to use a constant harvest rate of 8.57 % applied to the PELTIC survey index to calculate the biomass that can be taken.

For single-stock summary sheet advice

Sprat in the English Channel (spr.27.7de)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: *update*
2) Assessment: *accepted. Based on biomass trends from the PELTIC survey.*
3) Forecast: *No forecast*
4) Assessment model: *There is no assessment model for this stock.*
5) Consistency: *The stock was treated inconsistently in the past. From this year, a constant harvest rate of 8.57 %, which was shown to be precautionary, is used.*
6) Stock status: *No reference points, but a small decrease in the stock biomass index and harvest rate in 2020.*
7) Management plan: *There is no management plan for this stock.*

General comments

The draft report is well documented and easy to read. The ways the assessment is performed and the catch advice is provided are clear and well explained.

In table 1 "Constant Harvest Rate" there is an additional space between in the number "8.57%" which needs removed.

In "Issues relevant for the advice" section "Stock" is a capital and should be small "s".(?)

Technical comments

The assessment appears to be done according to the stock annex.

A constant harvest rate of 8.57% is now used to calculate the biomass that can be taken, accordingly to recommendations from IBP.

Conclusions

The assessment has apparently been performed correctly according to the Stock Annex and the advice was given following the new rule for this category 3 stock.

Audit of Spr.27.67a-c,f-k

Working Group: HAWG Stock Name: spr.27.67a-c,f-k

Date: 25/03/2021

Auditor: Eleanor MacLeod, Cormac Nolan

General

This is a category 5 'stock' with no assessment and two-year advice following the precautionary approach. A precautionary buffer was last applied in 2017 and has again been applied in 2021 for the following two years. The stock structure of sprat populations in these subareas is not clear.

For single stock summary sheet advice:

1) **Assessment type:** NA
2) **Assessment**: NA
3) **Forecast**: NA
4) **Assessment model**: NA
5) **Data issues:** No data issues
6) **Consistency**: Precautionary buffer applied. Last applied in 2017.
7) **Stock status**: Unknown
8) **Management Plan**: There is no management plan for this stock.

General comments

The draft report is well documented and easy to understand. The advice sheet for this 'stock' refers to subarea 6 and divisions 7a-c,f-k. However, the title of the report section -and some of the tables within it - refer to the whole of subareas 6 and 7. As Channel sprat in 7d,e now has its own report section, the auditors suggest working towards removing 7d,e from the Celtic Seas section.

Technical comments

Suggested edits were made directly in the draft advice sheet and report. Any queries or clarifications were directed to the author.

Conclusions

The same procedure as last year has been appropriately followed and the latest ICES guidelines for single stock advice have been met.